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RESEARCH THEME

IMPACT AND ADAPTATION STRATEGIES ON WATER RESOURCES:

THE CASE OF THE BEKAA VALLEY- LEBANON

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Declaration

This work has not been previously submitted for a degree or diploma in any other university. To the best of our knowledge, the research does not contain any material published or written by another researcher except where references are mentioned.

Abstract

Potato crops are one of the main sources of income for farmers living in the Bekaa Valley of Lebanon. Given their high sensitivity to water stress, water shortages can cause considerable losses in terms of potato yield and quality. To overcome this challenge, the use of water-saving technologies such as micro-irrigation systems are highly important. However, the adoption of this technique remains quite low among potato farmers in the Bekaa region, who still use ordinary sprinkler systems. In this study, the unified theory of acceptance and use of technology (UTAUT) served as the conceptual framework for investigating these farmers' behaviour in adopting a new micro-irrigation system. Therefore, this study critically assesses key factors that influence micro-irrigation acceptance among the potato farmers in the Bekaa region.

The first phase of the research adopted a qualitative paradigm that utilized focus group discussion. The second phase of the research consisted of using a quantitative questionnaire to support and validate the focus groups' findings. In the second phase, we extended the UTAUT model by considering farmers' risk perception of the use of a new micro-irrigation technology.

The results indicate that performance expectancy, effort expectancy, facilitating conditions and risk perception strongly impact the potato farmers' behavioural intentions and use behaviour related to the new technology. The policy implications of these findings are discussed.

Keywords: Behavioural models, Water scarcity, Micro-irrigation, Technology adoption, Focus groups, Structural Equation Models

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With love, I dedicate this thesis to my brother Gabriel.

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List of Acronyms

AVE	Average Variance Extracted
BI	Behavioural Intention
CA	Cronbach's alpha
COVID-19	Coronavirus Disease 2019
CR	Composite Reliability
C-TAM-TBP	Combined Theory Acceptance Model and Theory of Planned Behaviour
EE	Effort Expectancy
Educ	Educational Level
ExpMI	Experience in micro-irrigation
FC	Facilitating Conditions
FG	Focus Group
FGD	Focus Group Discussion
FRP	Farmers' Risk Perception
HTMT	Heterotrait-monotrait ratio
IDT	Innovation Diffusion Theory
IS	Information Systems
MM	Motivational Model
MPCU	Model of PC Utilization
PE	Performace Expectancy
SCT	Social Cognitive Theory
SD	Standard Deviation
SEM	Structural Equation Modelling
SI	Social Influence
TAM	Theory Acceptance Model
TBP	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
UB	Use Behaviour
UNMARG	Gross Margin
UTAUT	Unified Theory of Acceptance and Use of Technology
VIF	Variance Inflation Factor
VoUS	Voluntariness of use

Introduction

Climate change is having a huge detrimental impact on freshwater availability on a worldwide scale, affecting water resources quantitively and qualitatively (IPCC, 2014b). Water scarcity is one of the most dangerous threats which has already resulted in catastrophic losses, notably in the arid regions. Moreover, climate change is seriously threatening the agricultural sector and poses major risks for both developed and developing countries (Field & Barros, 2014; Niles & Mueller, 2016).

High temperatures, increased evaporation and fluctuations in precipitation are altering water availability and reducing crop yields (Arbuckle et al., 2013; Niles & Mueller, 2016). These factors affect the management of farms, especially in arid and semi-arid regions (Scoville-Simonds et al., 2020).

In Lebanon, the current levels of water consumption are not sustainable in light of population growth, industrial development, the expansion of irrigated agricultural land and the escalating uncontrolled use of groundwater (El-Fadel et al., 2010). According to a recent report from the United Nations Development Programme (UNDP, 2021), Lebanon is expected to face an increase in mean annual temperatures of between 1.2 and 1.7 ºC by mid-century, as well as a 4–11% decrease in precipitation by 2100. The increased frequency of heatwaves and incidence of drought conditions are also projected to affect the country (Trærup & Stephan, 2015; UNDP, 2021). Thus, various conditions threatening water balance make adaptation to climate change more difficult in Lebanon.

The Bekaa Valley region of Lebanon is rapidly facing the effects of drought and decreased water availability (MoE, 2016). This region lies to the East of the Lebanon range and is a fertile valley approximately 16 km wide and 129 km long that gently slopes from North to South from an altitude of 900 to 1,100 m and represents 42% of Lebanon's area. It is divided into three main zones: North Bekaa, Central Bekaa and West Bekaa. The Bekaa Valley is the most important production area in Lebanon, accounting for the highest percentage of seasonal crops (60%), which include cereals, potatoes, vegetables and grapevine. The production of potatoes typically ranks first among the top 10 commodities produced in Lebanon each year, with a total production of 390,000 tonnes in 2017 (FAOSTAT, 2017). Two-thirds of Lebanon's potato production comes from the Bekaa Plain, which is entirely irrigated (EC, 2006; MoA, 2007). Potato is one of the most sensitive crops to soil moisture stress and requires a systematic irrigation schedule (Ayas, 2013).

Unfortunately, long- and short-term environmental challenges in the Bekaa Valley are related to water shortages, water quality problems, groundwater table depletion and the impacts of climate change (MoE, 2011). All of these factors are severely threatening the sustainability of irrigated

crops in the Bekaa Valley. Repeated droughts characterised by low precipitation in 2008 and 2014 have augmented the effects of water stress (Jaafar et al., 2016). In this context, the improvement of water use efficiency in irrigation and the conservation of water resources are becoming strategic priorities. Currently, the majority of farmers in the Bekaa Valley use surface water and ordinary sprinkler irrigation to irrigate potatoes affected by water availability, especially in spring and summer (MoA, 2008). Notably, the adoption of micro-irrigation in potato cultivation can result in irrigation water savings of up to 40% (Darwish et al., 2003; Darwish et al., 2006), which can provide water and energy savings as well as increased crop quality and yields (Karam & Karaa, 2000; Shah, 2011; Varma & Namara, 2006).

This research aimed to investigate the importance of farmers' perceptions, motivations and socio-economic factors in affecting the investment in and adoption of a new micro-irrigation system. To this end, we adopted the unified theory of acceptance and use of technology (UTAUT) model (Venkatesh et al., 2003), which facilitates the analysis of individual acceptance and the use of new technology by disentangling and evaluating the influencing factors.

The structure of the thesis is as follows: in Chapter 1, we present the UTAUT model and the study area while Chapter 2 illustrates the qualitative research part using focus group discussion. Chapter 3 presents the quantitative research part where we modified the UTAUT model to include the impact of risk factors on the acceptance of a new micro-irrigation system. The partial least squares structural equation model (PLS-SEM) (Hair et al., 2016; Hair et al., 2017) was also employed to quantify the relevance of these factors for a sample of farmers producing potato crops in the Bekaa Valley. In Chapters 2 and 3, we provide some policy interventions and management recommendations to enhance the use of a new micro-irrigation system. At the end of the thesis, a part is dedicated for the main conclusions and limitations.

To the best of our knowledge, this is the first study to use a UTAUT model to shed light on the impact and importance of behavioural factors in influencing the adoption and use of a micro-irrigation system on potato crops.

Chapter 1

Literature Review and Study Design

1.1. The Research Model

In this section we will provide a short introduction to the main behavioural models which have been proposed for the analysis of individuals' behaviour in adopting a new technology. A number of theories have been put forward to explain the individual behavioural intention to introduce a new technology. The current study employed as technology adoption model, the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003). The work of Venkatesh et al. (2003) integrated previous technology acceptance models. Thus, UTAUT is basically a synthesis through unifying at least eight existing technology acceptance and use models and specifically i) the Theory of Reasoned Action (TRA) from Fishbein et al. (1975); ii) the Theory of Planned Behaviour (TPB) from Ajzen (1991); iii) the Technology Acceptance Model (TAM) from Davis (1989), Venkatesh and Davis (1996) and Venkatesh and Davis (2000); iv) the Combined TAM and TPB (C-TAM-TPB) from (Taylor & Todd, 1995); v) the Innovation Diffusion Theory (IDT) from Moore and Benbasat (1991); vi) the Motivation Model (MM) from Davis et al. (1992); vii) the Social Cognitive Theory (SCT) from Bandura (1986), Compeau and Higgins (1995) and Compeau et al. (1999) and finally viii) the Model of PC Utilization (MPCU) from Thompson et al. (1991).

This chapter reviewed some of these theories and the related models used to frame the individual's behaviour to accept and adopt new technologies. Specifically, we will analyze the Theory of Reasoned Action (TRA) (Fishbein et al., 1975); the Theory of Planned Behaviour (TPB) (Ajzen, 1991); the Technology Acceptance Model (TAM) from Davis (1989), Venkatesh and Davis (1996) and Venkatesh and Davis (2000) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003).

1.1.1. Theory of Reasoned Action (TRA)

The Theory of Reasoned Action (TRA) (Fishbein et al., 1975) was primarily introduced in the field of social psychology. It has been one of the most popular theories in clarifying human behaviours. This theory focused on individuals as "rational" beings who will make a methodical use of the information available to them in order to take actions. This theory has been widely used in different fields as for example healthcare, agriculture, banking, sociology, etc. In the study of technology acceptance, many researchers have proven that this theory model effectively predicts and demonstrates reasons of users using a system (Davis, 1989; Davis et al., 1989).

As illustrated in figure 1, the TRA suggests that behaviour is the consequence of three main factors: attitudes toward behavior, subjective norms, and behavioral intention. Attitudes and subjective norms are posited to cause behavioural intention, which in turn triggers the effective behaviour. In the TRA model, the attitude is for example the good/bad, pleasant/unpleasant, positive/negative that are statistically combined to obtain a general judgment of the performance of a certain act. The attitudes are explained by a combination of two fundamental notions which can be formalized in following equation (Fishbein et al., 1975)

$$\text{Aact} = \sum B \; E$$

The equation states that the attitude toward a behaviour (A_{act}) is the sum of the products of two components: the beliefs (B) and evaluations (E) of all the behavioural outcomes that are considered by the individual (Fishbein et al., 1975). Beliefs (B) represent the possibility of salient outcomes in performing a behaviour, weighted by the evaluation (E) of each of those outcomes (Mathieson, 1991). Salient outcomes are the outcomes that immediately come to the mind of a person when thinking of the behaviour.

Additionally, subjective norm (SN) is also composed of two sub concepts. The normative belief and the motivation to comply that explain which persons and groups are responsible for the normative pressure to perform, or not to perform, a certain behaviour. A normative belief (NB) indicates the extent to which a person thinks that a specific referent person or group wants him or her to perform a behaviour. Referent persons could be family members (e.g., spouse, children, parents), neighbors or colleagues whose opinion is important for many behaviours (Mathieson, 1991). Thus, each normative belief (NB) is weighted for the motivation to comply (MC) which is the degree to which an individual allows this referent person or group to exert an influence on him or her. As before for the attitudes, the subjective norm (SN) can be expressed as the sum of the products of all normative beliefs and the corresponding motivation to comply represented by the equation as

$$SN = \sum NB \; MC$$

According to the TRA, the behavioural intention is then the result of a decision process based on the attitudes and the subjective norms, and both are the best predictors of the behavioural intention which will influence the effective behaviour.

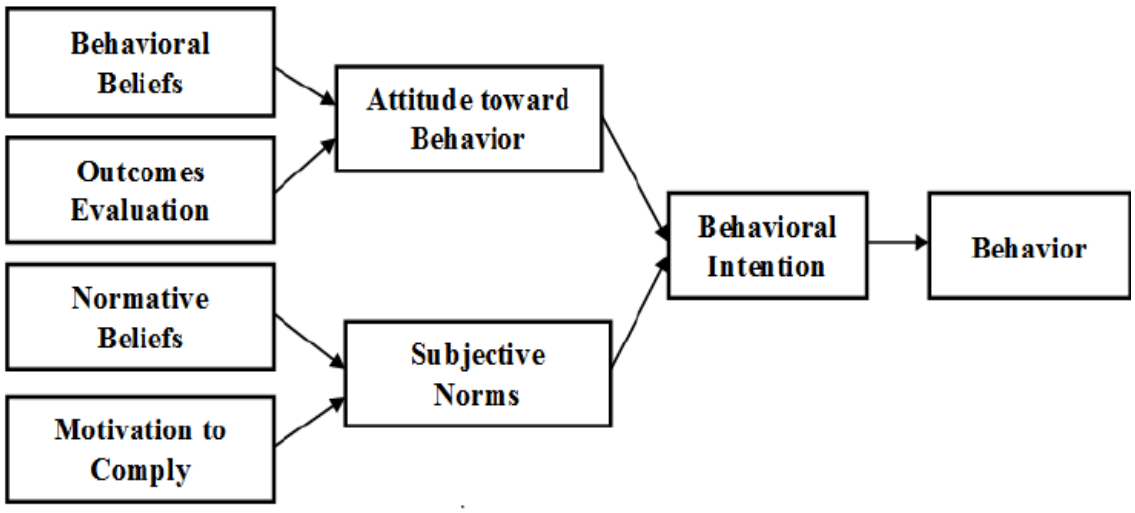


Figure 1 Theory of Reasoned Action (TRA) (Fishbein et al., 1975)

Some criticisms have been advanced to this model. According with (Ajzen, 1985), the theory was limited by what is called "*behaviour correspondence"*. In order for the theory to predict specific behaviour, attitude and intention must correspond to the behavioural criterion in terms of action, target, context, time frame and specificity (Sheppard et al., 1988). The greatest limitation of the TRA theory is that it assumes that behaviour is under volitional control. That is, the theory only applies to behaviour that is consciously thought out beforehand. Irrational decisions, habitual actions or any behaviour that is not consciously considered cannot be explained by the TRA theory.

1.1.2. Theory of Planned Behaviour (TBP)

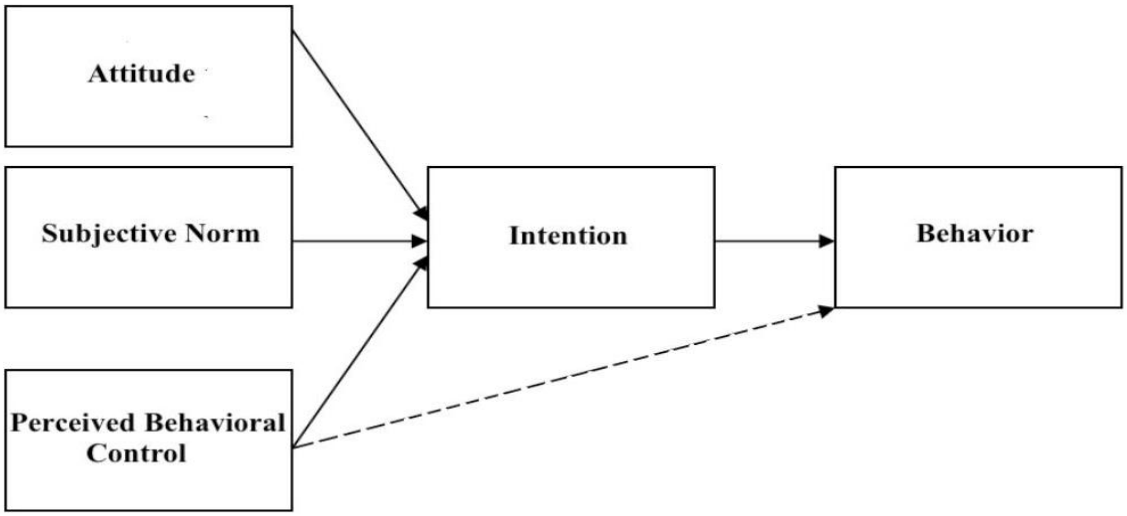


Figure 2 Theory of Planned Behaviour (TBP) (Ajzen, 1991)

In Figure 2 above, we illustrate the Theory of Planned Behaviour (TBP) by Ajzen (1991) that has been expanded from the Theory of Reasoned Action (TRA) (Fishbein et al., 1975). TBP was established to overcome the TRA limitations explaining the human behaviours in different conditions, especially behaviours over which people have incomplete volitional control. Both TBP and TRA assume that the individual's intention is a central factor to perform a given behaviour. However, TBP posits perceived behavioural control (PBC) as an additional determinant both for intention and behaviour. Perceived behavioural control means that people believe they can execute the behaviour based on non-motivational factors such as availability of requisite opportunities and resources/technology facilitating conditions (such as time, skills, money, cooperation of others and knowledge) (Ajzen, 1985). It is very easy to see that this factor can substantially improve the application of the model because there are many behaviours that need specific skills or external facilities. As before in the TRA model for the attitudes and subjective norms, two sub concepts determine the perceived behavioral control. The first sub concept comprises the control beliefs (C), that is, the estimated probability that each factor will facilitate or delay the execution of the behaviour. The second sub concept is the perceived power (P), that is, the weight of the facilitation or delay that each specific control belief represents. Consequently, he equation for the perceived behaviour control will be expressed as :

$$\text{PBC} = \sum C \; P$$

1.1.3. The TAM (Technology Acceptance Model)

An adaptation of Theory of Reasonable Action (TRA) model has been proposed by the Technology Acceptance Model (TAM) which is specifically tailored for modeling users' acceptance in relation with information systems or technologies (Davis, 1989). Davis used TAM to explain computer usage behaviour. As shown in figure 3, the TAM model included two specific key determinants that influence the individual's behavioural intentions for predicting extent of adoption of new technologies: the perceived usefulness and the perceived ease of use. The "perceived usefulness" is defined as the degree a person believes that the use of a certain system would improve his/her job performance and the "perceived ease of use" refers to the degree to which a person expects that the target system would be effortless (Davis, 1989). The belief of the person towards a system may be influenced by other factors referred to as external variables in TAM.

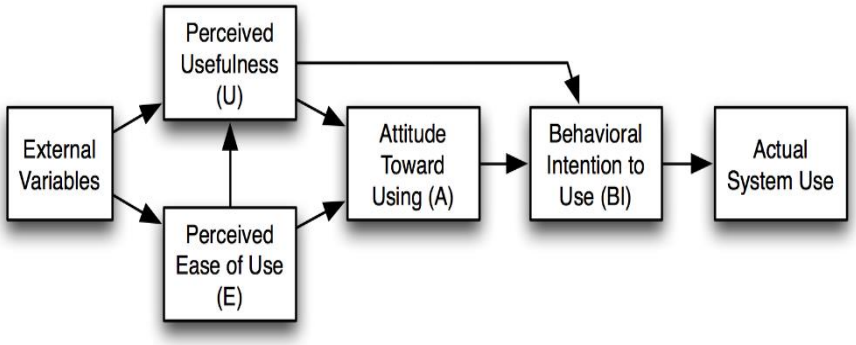


Figure 3 TAM (Davis et al., 1989)

Some researchers as Agarwal and Prasad (1999) and Venkatesh and Davis (2000) have proven that Perceived Usefulness significantly influences attitude greater than Perceived Ease of Use does. Furthermore, Ma and Liu (2004) and Van der Heijden (2003) indicated that perceived ease of use has the greatest effect on acceptance. That is, over experience, the impact of ease of use on intention decreases. Moreover, perceived ease of use may be a causal precursor to perceived usefulness (Davis, 1989). However, based on research by Tornatzky and Klein (1982), the adoption of innovation inspires perceived ease of use producing a possible negative correlation with the adoption rate. In fact, it has been noted that the higher

is the complexity of an innovation, the fewer will be the adopters of that innovation given the low easiness to use of that innovation (Tornatzky & Klein, 1982).

The final version of TAM was formed by Venkatesh and Davis (1996) as shown in the Figure 4 below. The attitude construct was eliminated after the main finding that, both, perceived usefulness and perceived ease of use have a direct influence on behavioural intention.

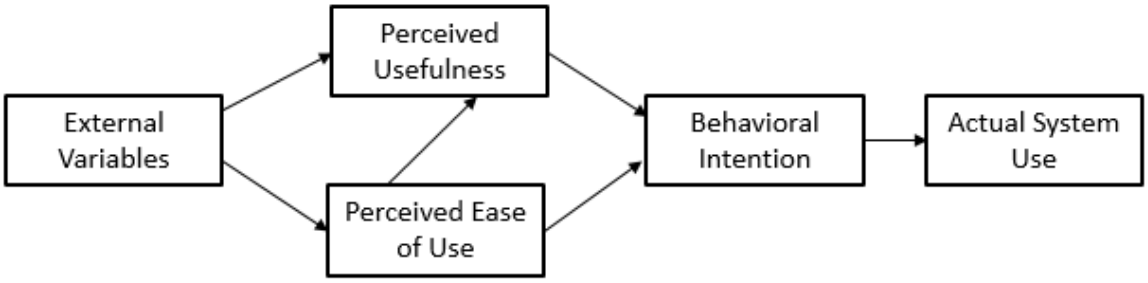


Figure 4 TAM (Venkatesh & Davis, 1996)

1.1.4. Extended TAM or TAM2 model

As an extension of the original TAM, the extended TAM, usually labelled as TAM2, was developed by Venkatesh and Davis (2000) to overcome the limitations of the original theory in terms of explanatory power. The goal of TAM2 was to add new key determinants of TAM's perceived usefulness and usage intention constructs. In the new model, Venkatesh and Davis explained "how the effect of these determinants changed with increasing users' experience with the target system" (Venkatesh & Davis, 2000). TAM2 includes additional constructs that might influence the perceived usefulness of a system such as social influence processes (subjective normand image) and cognitive instrumental processes (job relevance, output quality, result demonstrability and perceived ease of use). Voluntariness and experience were incorporated as moderators in the model. A flow chart of TAM2 is represented in Figure 5.

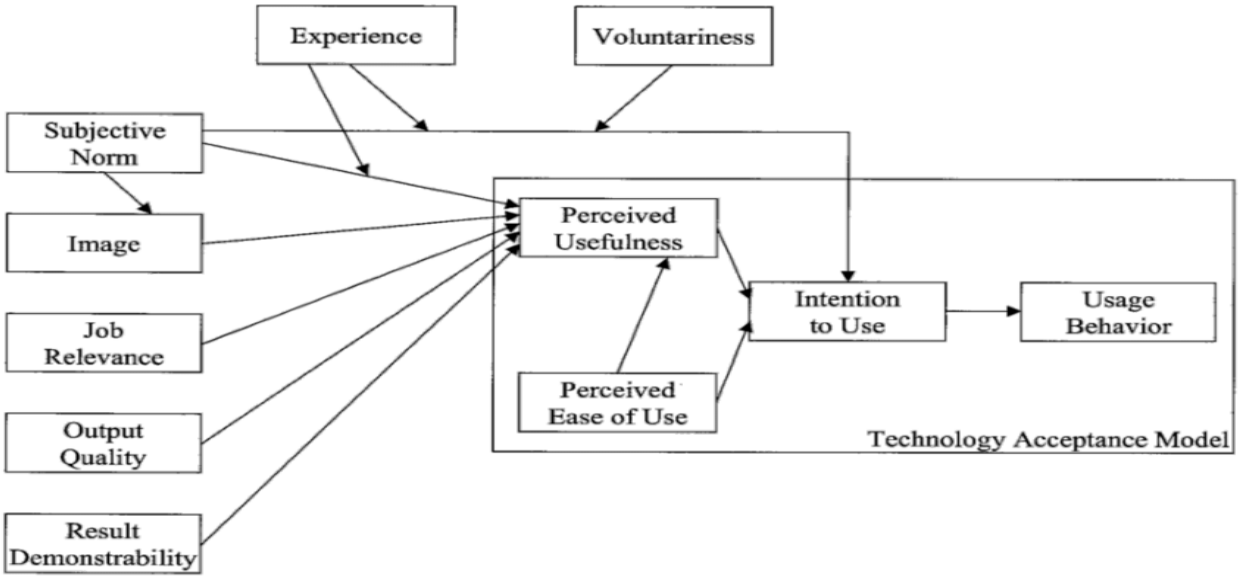


Figure 5 TAM 2 (Venkatesh & Davis, 2000)

The first construct is subjective norm or "peer pressure" which means whether other people believe that an individual should or should not use a particular technology. This construct is consistent with the theory of reasoned action (TRA). The second construct is connected to image. It refers to how someone is viewed by others (status in a social system) when he or she adopts a particular technology (Moore & Benbasat, 1991). Furthermore, job relevance suggests that if something is related to a person's job, it is to be considered more useful than something which isn't (Venkatesh & Davis, 2000). Additionally, the output quality refers to the perception of how good a given technology is performing its tasks (Venkatesh & Davis, 2000).The result demonstrability refers to how the advantages of using a particular technology can be visible. In other words, it means the tangibility of results of adopting a technology (Moore & Benbasat, 1991). Finally, regarding the moderators, voluntariness, means the degree to which an individual considers the use of a particular technology to be non-obligatory (Venkatesh & Davis, 2000). It was suggested to distinguish usage into mandatory and voluntary settings. Experience refers to the current use of a particular technology and how that influences an individual's motivation to continue using this technology (Venkatesh & Davis, 2000). As the experience increases, the acceptance of an innovation could vary. So, the acceptance was evaluated at three time points: the time before system implementation, one month after implementation, and three months after implementation.

1.1.5. Unified Theory of Acceptance and Use of Technology (UTAUT)

The technology acceptance and adoption is a widely researched area in the information systems (IS) domain. A number of models and theories were developed to predict the factors affecting individual's intention to adopt or not adopt a specific technology as we previously cited. The integration in the UTAUT model of the eight theories mentioned above, make it a suitable, valid, recent, and reliable model explaining technology adoption. It explains a high proportion of variances (accounted by the R^2) in usage intention (AlAwadhi & Morris, 2008).

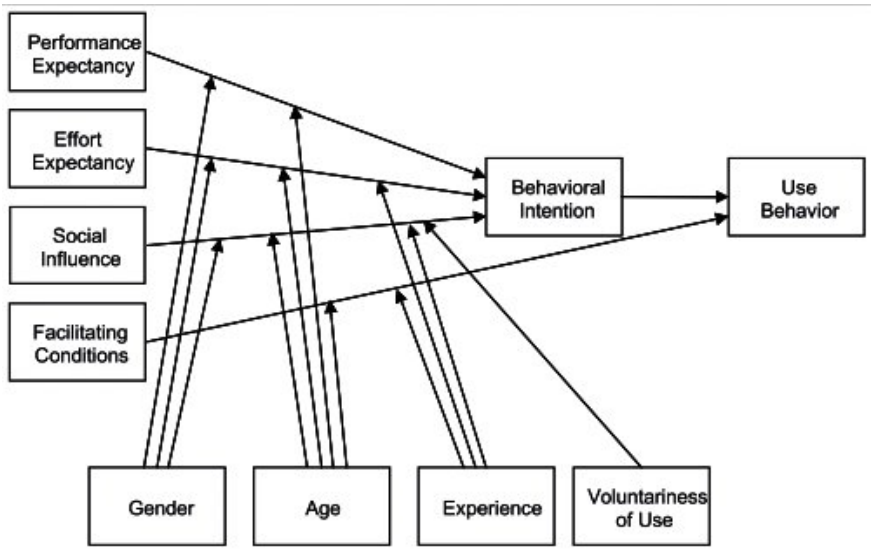


Figure 6 Unified Theory of Acceptance and Use Technology (UTAUT) research model (Venkatesh et al., 2003)

In Figure 6 above, we illustrate the UTAUT research model used in the current study. Formulated in 2003, UTAUT was employed in different areas of research to explore the factors influencing people's behavioural intention to use certain an information system. This model has been adopted by many studies in the areas of e-government, e-banking, e-learning and e-commerce (Dwivedi, 2015). According to UTAUT, an individual's perspectives about the technology impact his or her behavioural intent to use and actual use of the technology. In view of previous researches, Al-Shafi and Weerakkody (2010) and AlAwadhi and Morris (2008) have declared that UTAUT is the most and even the best predictive model in the technology acceptance literature because of its capacity to predict intention and its effective use. Based on the integration of the eight models, UTAUT suggested four major determinants that have an effect on a person's behavioural intention to adopt a technology: performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC). As claimed by UTAUT, these constructs can be affected by four

moderators a) age, b) gender, c) experience with similar technology, and d) voluntariness of use. Moreover, Venkatesh et al. (2003) suggested that use behaviour is significantly influenced by behavioural intention, with no moderating relation assumed between intention and use. Eventually, UTAUT was able to account around 70 percent of the variance in usage intention, while the maximum explained by the eight previous models was around 40 per cent (Venkatesh et al., 2003). This is the explanatory power of the unified model, which is considered a measurement improvement.

Performance Expectancy (PE) refers to the user's level of belief on how much advantageous a system usage will be and how it will help to achieve benefits (Venkatesh et al., 2003). PE is considered the best predictor of usage intention in both voluntary and mandatory contexts (Venkatesh et al., 2003). Based on the findings of the old models, PE will significantly and positively influence behavioural intention and technology acceptance (AbuShanab & Pearson, 2007; Venkatesh et al., 2003). For example, persons with high PE had high intentions to use a new technology (AbuShanab & Pearson, 2007) in the UTAUT, Venkatesh et al. (2003) in the UTAUT, Venkatesh and Davis (2000) in TAM2, Szajna (1996), Davis (1989) in TAM. PE aggregated all job performance related aspects, like usefulness (adapted from TAM/TAM2 and C-TAM-TBP), job fit (from MPCU), relative advantage (from IDT), extrinsic motivation (from MM) and outcome expectations which are related to the consequences of the behaviour (from SCT). They all are important for individuals when they decide on adopting a technology. As each of the eights models has a construct that can be a significant predictor of intention of use, UTAUT has PE. Additionally, the influence of performance expectancy on behavioural intention is suggested to be impacted by the moderating effects of gender and age (Venkatesh et al., 2003).

The second determinant, the Effort Expectancy (EE) suggests that the level of ease of use affiliated with the user's adoption of a system is an important element in the adoption of a new technology (Venkatesh et al., 2003). In this case, it is composed by three constructs that are: perceived ease of use (TAM/TAM2), complexity (MPCU) and ease of use (IDT). On the other hand, the relationship between effort expectancy (EE) and behavioural intention is frequently debated. However, research based on the previous models concluded that EE is a positive predictor of behavioural intention (Bandyopadhyay & Fraccastoro, 2007; Kallaya et al., 2009; Nassuora, 2012; Venkatesh et al., 2003). According to Venkatesh et al. (2003), the influence of effort expectancy on behavioural intentions is moderated by gender, age, and experience.

Furthermore, the third determinant is connected to the social influence (SI) which refers to the extent to which individuals perceive they should adopt the new technology based on inputs from people who hold important positions in their life (Venkatesh et al., 2003). It also consists of "the

degree to which peers influence use of the system", and whether supportive or unsupportive, it is a very important and influential factor (Venkatesh et al., 2003). Klechine et al., (2016) stated that depending on the nature of the technology to be adopted, the person's intention to use this technology is affected by other people like colleagues or employers. Social influence (SI) in predicting behavioural intention have been explored in more than one model (TRA, TPB). This construct of the UTAUT consists of three variables: subjective norms (TRA, TBP, TAM2, and MM), social factors which relates to the coworkers for example using the system (TRA, TBP, TAM2 and MM) and image (TAM2 and IDT). Based on the review of the literature, it is expected that social influence positively influences behavioural intention of using a new technology (Bandyopadhyay & Fraccastoro, 2007; Im et al., 2011; Kallaya et al., 2009; Slade et al., 2015; Šumak & Šorgo, 2016; Venkatesh et al., 2003). As well, Venkatesh et al., 2003 hypothesized that the influence of social influences on behavioural intentions is moderated by gender, age, voluntariness and experience.

At the end, facilitating conditions (FC) represent the organizational and technical conditions/infrastructure that the individual believes would support the use of the system and make it easier for him to apply it (Venkatesh et al., 2003). This definition involves three different constructs in existing models: perceived behavioural control (adapted from TPB and C-TAM-TPB), facilitating conditions (MPCU), and compatibility (IDT). Each one of these constructs is operationalized to incorporate technological and/or organizational aspects that are intended to eliminate obstacles to use. Therefore, the relationship between intention and this construct in each model is similar, in the first training period. However, such influence disappears in the second training period (after one-month implementation). According to Venkatesh et al. (2003), the influence of facilitating conditions on usage is hypothesized to be moderated by age and experience. As mentioned above, UTAUT hypothesized that gender, age, voluntariness and experience would moderate the relationships depicted in their model. These variables have been shown to moderate the intention to adopt new technologies in several studies (Al-Gahtani, 2004; Pearson et al., 2002; Venkatesh et al., 2003).

Firstly, regarding gender, women tend to emphasize ease of use more than men do (AbuShanab & Pearson, 2007; Venkatesh & Morris, 2000; Venkatesh et al., 2003). Studies have shown that male respondents are more driven to discover answers for problems, not at all like female respondents who concentrate more on the magnitude of the effort they put when attaining their targets (Hennig & Jardim, 1977; Rotter & Portugal, 1969; Venkatesh et al., 2003). Hence, when deciding whether to use a new technology, men are minimally dependent on facilitating factors, while women seem to

concentrate on external variables. As a result, males will expect to benefit more by using the new technology, affecting by this fact the performance expectancy.

In addition, according to Venkatesh et al. (2003) young males are more interested in the role of technology in improving their job performance, whereas older males are more interested in the ease of use of such technology. Coffman (2014) added that older males are less knowledgeable in various technologies than their younger male counterparts. Generally speaking, young users can adapt to the use of a new system more easily whereas older users find it harder to adapt to the new system (AbuShanab & Pearson, 2007; Venkatesh et al., 2003). Studies of Morris et al. (2005); (Plude, 1985) have proved that elderly users may encounter challenges in understanding new information, which has an impact on their capacity to learn. Posner (1996) associated those challenges with the deterioration of the cognitive abilities of old users. Therefore, Hall and Mansfield (1975) assumed that elderly users place greater importance on support accessibility to help them.

On the other hand, researchers reported that the importance of ease of use attenuates when users became experienced (AbuShanab & Pearson, 2007; Szajna, 1996). In this context, experience means the number of years that a person claims to use a similar technology. Coffman (2014) explained that users are more likely to use new technologies if they have prior experience using similar or comparable technologies. He stated that users "often employ the knowledge they gained from prior experience with similar technologies to form the basis of their intentions" (Coffman, 2014). In other words, individuals are more comfortable with new technologies if they are familiar with how they generally work. Deep prior knowledge easily improves understanding and minimizes the dependency on outsourcing support (Al-Shafi & Weerakkody, 2010).

Furthermore, the voluntariness of use is defined as the "degree to which the system is used voluntarily" (Moore & Benbasat, 1991). One of the main conclusions of Venkatesh et al. (2003) was that individuals are more likely to try new technologies if it was non-mandatory.

Venkatesh et al. (2003) also explored three other constructs such as "anxiety", "self-efficacy", and "attitude toward using technology". However, these constructs were found unremarkable due to the effect captured by other constructs. According to UTAUT, contrary to many previous studies, self-efficacy and anxiety have no direct influence on behavioural intention. As well, Akbar (2013) has proved that computer anxiety have no significant influence on behavioural intention. However, some other researchers used computer anxiety and computer self-efficacy as factors not as moderators, and found that these factors are significant predictors of computer use (Durrington et al., 2000; Dusick, 1998).

Finally, the UTAUT model posits two dependent variables which are behavioural intention (BI) and use behaviour. Behavioural intention (BI) is defined as the "person's subjective possibility that he or she will perform the target behaviour" (Venkatesh et al., 2003). In this model, BI has a positive and strong influence on use behaviour. Further, use behaviour is defined as the actual use behaviour (UB) of a specific system (Ong et al., 2008). According to Ajzen and Fishbein (1980), the actual use behaviour is dominated by behavioural intention. Venkatesh et al. (2003) additionally proved that the direct influence of behaviour intention on use behaviour has been tested and validated during the development of the UTAUT model.

Nevertheless, Yuen et al. (2019) criticized UTAUT model stating that Venkatesh et al. (2003) have excluded self-efficacy as a direct determinant of behavioural intention and inserted it as an indirect construct; neglecting the fact that inexperienced users perceive a new technology as complex and its adoption is greatly affected by their confidence in their ability to manage the technology. So, a higher degree of self-efficacy can induce higher intentions to adopt and use a specific innovation.

1.2. The Study Design

1.2.1. Study Area

1.2.1.1. Lebanon Overall Characteristics

Lebanon is a small mountainous country on the Mediterranean Sea's eastern coast, covering a total area of 10,452 Km². The country extends along an N-NE / S-SW axis a 225 km wide with a width tapering from 88 km in the North to 35 km in the South. The latitude is 33.2 – 34.7 ºN, while the longitudinal range is 35.2 – 36.6 ºE. The topography is somewhat rectangular in shape; the length nearly three times its width, with alterations of lowlands and highlands running parallel from north to south as follows (Figure 7):

a) The Mediterranean coastal strip which is a sea plain characterized by shallow or deep soils,

b) Mount Lebanon, a rugged western mountain range characterized by its shallow to deep soils,

c) The Bekaa valley, a central highland plateau described by its fertile shallow soils,

d) The mountain range of Eastern Lebanon (also known as Anti-Lebanon) that extends over the eastern border with Syria, having shallow to deep soils.

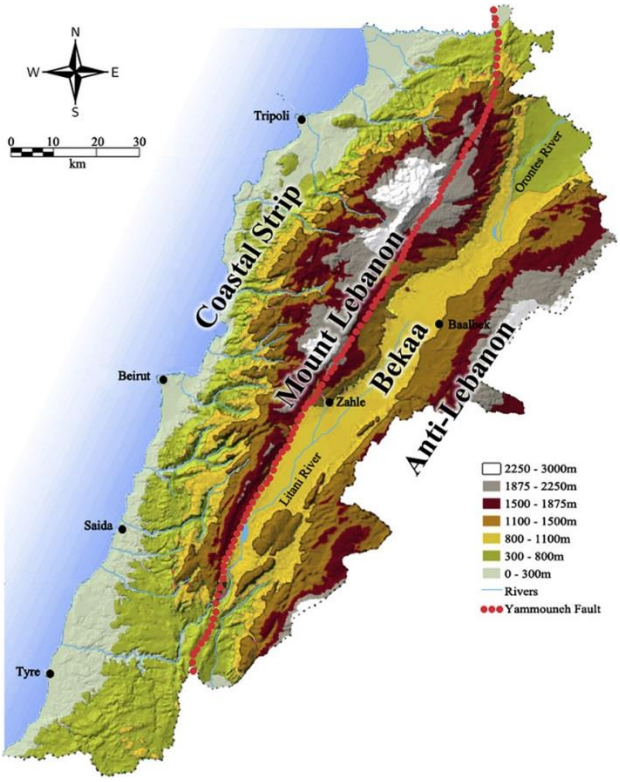


Figure 7 Lebanon's Geographical Map

From a climatic point, Lebanon experiences water shortages during the dry season which reaches out from July through October, with about 60 percent of the country's territory undermined by

desertification (MoA, 2003). This situation is relied upon to turn out to become more severe in the future due to the impact of climate change (Bank, 2014). As LARI (2019) stated, water scarcity rather than land resources is actually the constraining factor in the country's expansion of agricultural production.

It should be noted that Lebanon is dominated by a Mediterranean climate with a cold rainy winter and a semi-hot dry summer. Minor topographical variations throughout the country result in local changes to the regional climate pattern. The mean annual temperature, along the coastal strip, ranges between 19.5 °C and 21.5 °C with hot and humid summers and no precipitation. In Mount Lebanon, colder winters with precipitations and snow are caused by a gradual decrease in temperature with increasing altitude being about 3°C for each 500 m elevation. In a usual manner, lowest temperatures are recorded in the month of January and highest ones in August (MoA, 2003). Because Mount Lebanon shelters the Bekaa Valley and the Anti-Lebanon Mountains from the effects of the Mediterranean Sea, they receive less precipitation and humidity that cause them to encounter a more extensive variation in daily and yearly temperatures (Collelo, 1987). Throughout the winter season, snow normally covers only the top of the two mountains for a period of two months, covering a surface zone of 2500 km² overall (Shaban et al., 2013). As per the National Lebanese Meteorological Service, eight distinctive eco-climatic zones are identified in Lebanon based on the amount of precipitation as a significant measure (Abi-Saleh and Safi, 1998). So on, the coastal strip has three eco-climatic zones: Northern, Central, and Southern zones. However, Mount Lebanon has two zones: Northern and Southern zones, while the Bekaa valley is characterized by three zones: Northern, Central, and Southern.

Generally, the rainy season lasts from November to March followed by a period with little spring rainfall and none in summer. So, Lebanon receives about 800 mm of rainfall in an average year.

At the national level, however, the pattern of precipitation has been decreasing over time, which is a worrying matter. Nevertheless, its water sources are experiencing significant declines, measured at 23% to 29% less from rivers and underground aquifers due to human activity and 12% to 16% less from precipitations and snow cover due to the climate (Shaban, 2009).

1.2.1.2. The characteristics of the study area – the Bekaa Valley

The Bekaa Valley, lying on the East of the Lebanon Range, is a very fertile High Land about 16 km wide and 129 km long, representing 42% of Lebanon's area, gently sloping from North to South from an altitude of 900 to 1,100 m. It is divided into three main zones: North Bekaa composed of Baalbek and Hermel, Central Bekaa which has Zahle as its Governorate and West Bekaa. In this

context, the figure 8 shows in evidence these three main areas with the red spots demonstrating the regions from which the farmers were selected within Bekaa's Valley main zones.

Figure 8 Lebanon's Map showing the Bekaa Valley main participants' zones

Furthermore, the Bekaa is drained to the north by the Orontes River known as the Assi River, with lower reaches extending through Syria and Turkey and to the South by the Litani River (Comair et al., 2013).

Long-term and short-term environmental challenges in the Bekaa Valley relate to water shortage, climate change, water quality problems and groundwater table depletion (MoE, 2011). Thus, the faster water extraction from wells due to the insufficient water availability, and increased informal water removal are exacerbating environmental pressures. Such pressures will make adapting to climate change more difficult and will further threaten community resilience.

Besides, the Bekaa plain has a climate that is vulnerable to the Mediterranean's damping effect. The mean annual rainfall in the Bekaa Valley varies from North to South/West in increasing intensity. Thus, in central and northern Bekaa it ranges from 200 mm to 600 mm per year, while the southern plain reaches 600 mm to 1,000mm (MoE, 2011).

Further, the temperature in the Bekaa presents a noticeable variability especially during the month of August in which the potato crop is in high need of irrigation (min 24°C; max 34°C) in the last 10

years' available data (LARI, 2019). This pattern testifies as in the area an efficient water-saving management plan is essential since the Bekaa region is the most affected by the climate change.

1.2.1.3. Agriculture Sector and Potato crop in the study area

Lebanon is located within the "Fertile Crescent", on the east side of the Mediterranean, a crescent-shaped region comprising the comparatively fertile land among the largely arid or semi-arid areas. It was a significant site for the development of pre-historic farming (Smith, 1995). Lebanon, though small in size, benefits from agriculture as the third main sector due to its variety of micro-climates and soil types resulting of suitable land conditions.

Moreover, local production of agricultural produce in Lebanon is mainly distributed among fruit trees (32%), olives (23%), cereals (20%), vegetables (16%), pulses (4%), industrial crops (4%), and fodder crops (1%) (MoA, 2011). Production of potatoes typically ranks first among the top 10 commodities produced in Lebanon with a total production of 390,000 tons in 2017 (FAOSTAT, 2017). Potato is one of Lebanon's most important cultivated crops. Over 45% (19.5 thousands hectares) of the total irrigated area is allocated to cultivate potato (Salibi, 2006; Wessels, 2009).

The Bekaa, the study area, is the most important production area, accounting for the highest percentage of seasonal crops (60%) which are cereals, potatoes, and vegetables- and in stone fruits, and grapevine. It also includes the highest proportion of cattle population (43%), sheep (72%), goats (51%) and poultry (60%). Regarding potato's cultivation, Bekaa's climatic and topographic conditions of soil and water permit a spring season for cultivation from March-April to August and a late summer season from June-July to September-October. Early potato season benefits from spring rainfall that saves between 20 to 150 mm, depending on the length of the rainy season (Darwish et al., 2016). Further, up to 80% of the total potato yield comes from the irrigated lands in the Bekaa valley and the remaining 20% are produced in Akkar under rain fed and supplementary irrigation conditions (Abou Zaid, 2005). Furthermore, potato production is affected when temperature is outside the 10-30°C range. Thus, winter potato which is cultivated in Akkar is vulnerable, with a higher disease incidence due to higher humidity and milder temperatures. However, spring and autumn potato crops in the Bekaa Valley are mainly affected by the availability of water and extreme temperatures, while summer crops are highly vulnerable as tuber development may be jeopardized, and irrigation lacking.

The overall vulnerability of the potato crop is considered high when projected to changes in the climatic factors. Nevertheless, the growing of potatoes in spring and summer in the Bekaa area is being at risk due to an increase of a minimal temperature in summer nights (T min above 20°C), a scarcity of irrigation water and a high demand for the plants. Hence, this issue clarifies the need for

a micro-irrigation system to be adopted on potato cultivation avoiding the consequences of such vulnerabilities.

Chapter 2

Focus Group Analysis

2.1. Introduction and the Purpose of the Focus Groups Discussions (FGD)

One of the basic premises in economics is considering individuals to be rational beings but every day, people make decisions which deviate from the economists' assumed standards of rationality (Thaler, 2016). Using recent discoveries in psychology, Thaler (2016) develops the basic concept of economics in which participants are not rational beings and promotes the use of psychological studies to understand the consumers' behaviours and the effects they have on the economy as a whole. Thus, this research is focused on the UTAUT model to assess and explain the factors affecting micro-irrigation system adoption among potato farmers. As discussed in section 2, the UTAUT was selected as the base theoretical model for this study because of its comprehensiveness and high explanatory power compared to other technology acceptance model.

In this Chapter we present a qualitative study that utilized Focus Group Discussion (FGD). Focus groups (FG) are defined as "qualitative investigation practice" based on a moderated discussion with a group of individuals.. In this research study, the FGD could be an appropriate tool because of its convenience to draw upon the respondent's knowledge, views, and experiences about the specific topicof introducing micro-irrigation systems in the Bekaa valley. The FGD qualitative tools is a democratic instrument and can make the participant feel more confident about her/his opinion. In fact, unlike close-ended questions in quantitative tools, the use of open-ended questions in interviews allowed the participants to express their thoughts in their own words about the prospeted investment and allowing "transforming the findings into meaningful results" (Lofland & Lofland, 1971) also useful for the quantitative analysis.

2.2. Materials and Methods

The qualitative study was carried out in the months of March and April 2020, among the potato farmers using the ordinary sprinkler irrigation system, in the three main districts of the Bekaa Valley (North, Central, and West Bekaa). Participants were contacted by phone prior to the meeting dates. The farmers, with whom the focus groups were made, were the ones involved in the decisions regarding the agricultural practices, type of crops, and irrigation strategies to be implemented in

their farms. Data were collected from 34 farmers in six focus groups consisting of five or six farmers each. Two focus groups in each of the three main districts of the Bekaa valley were made to help ensure a variety of points of views amongst participants and to test their likeliness or unlikeliness to adopt a micro-irrigation system in their farms; interviewees were chosen from different ranges of age, different educational levels, having different types of land management, and different farm sizes. The proportion of males among the participants was 100% since there were no women running a farm in the area. The focus groups were set up by the researcher in the role of moderator, in addition to a "facilitator", that both are experienced in carrying out a focus group discussion.

The study's purpose was explained to all participants via phone calls. The researcher notified them that participation was voluntary, and the withdrawal was possible at any time. The significance of confidentiality and privacy of all participants was reasserted by the moderator at the beginning of each focus group meeting. The researcher ensured to use coding for participants in the transcriptions, in all reports, and publications. It was explained that all participants were free to reveal their opinions related to the discussion and that all answers were to be accepted.

A test focus group was done with an individual in the agriculture sector in order to guarantee that all the questions were comprehensible. Due to the COVID-19 restrictions and safety limitations, three focus group meetings were conducted via a virtual meeting platform which is "Zoom" among farmers having the IT resources. The three remaining focus groups took place, after the restrictions were minimized, in conference rooms where all the required safety measures were taken. Each focus group discussion lasted between 80 and 90 minutes depending on the farmers' participation and involvement between each other's. Each focus group discussed the behavioural aspects related to the possible shifting from the current irrigation technique (ordinary sprinkler) to micro-irrigation (drip or mini-sprinkler) that saves more water, induces higher production and better quality in the cultivation of potato crops.

All focus groups were audio-recorded and then manually transcribed and analysed qualitatively.

2.3. Participants Characteristics

In Table 1 the demographic characteristics are presented. The focus groups were held among a total of 34 potato farmers from which 11 participants from the West Bekaa, 11 others from the North of the Bekaa and 12 farmers from the Central Bekaa. So on, 100% of the participants were males due to the fact that there is no women running a farm in the area. In the West Bekaa, the average age

was 55 years ranging from 45 to 60 years old for most of the N farmers (N=11). In the North and Central Bekaa most of them were aged having a mean age of 46 (N=11) and 52 (N=12) years, respectively. In the cited 3 regions, the percentage of farmers who were older than 60 years was somehow equal (36% for both West and North Bekaa while 33% in the Central Bekaa). In regards to the educational level, the minority had a primary level (28%) in the West Bekaa, while the majority had a university diploma (64%) in the North Bekaa. However, in the region of Central Bekaa most of participants had a secondary educational level (42%).

As shown also in the Table 1, in each focus group, there was a diversity in the farms' size in order to gather the maximum possible point of views. In this context, in the West Bekaa the average farm was 146 hectares (standard deviation SD, SD=208), whereas in the North Bekaa, the mean farm size was 590 hectares (SD=1,555). In the region of Central Bekaa was 663 hectares (SD=1,556). Furthermore, large farms had the highest percentage in all the three regions since most of the potato farmers are large growers in the area.

Almost all of the participants were not aware of the quantity of water used in the irrigation of their potato crops which is an alarming problem.

Table 1 Basic demographic data presented as sample mean and standard deviation or as the number (n) and the percentage (%).

Characteristics	**West Bekaa**	**North Bekaa**	**Central Bekaa**
	(n=11)	***(n=11)***	***(n=12)***
Gender		100% Males	
	M (SD)	***M (SD)***	***M (SD)***
Age (years)	55 (11)	46 (13)	52 (16)
Farm Size (hectares)	146 (208)	590 (1,555)	663 (1,556)
		Farm's Category	
	n (%)	***n (%)***	***n (%)***
Small	3 (27%)	2 (18%)	3 (25%)
Medium	*2 (18%)*	3 (27%)	4 (33%)
Large	6 (55%)	6 (55%)	5 (42%)
		Age Ranges	
<= 45	2 (18%)	6 (55%)	6 (50%)
>45 and <60	5 (45%)	1 (9%)	2 (17%)
>= 60	4 (36%)	4 (36%)	4 (33%)
		Educational Level	
Primary	3 (28%)	1 (9%)	3 (25%)
Secondary	4 (36%)	3 (27%)	5 (42%)
University	4 (36%)	7 (64%)	4 (33%)

** M= Mean; SD = Standard Deviation; n = count; % = Frequency distribution*

** Farm's Distribution: Small (< = 5 Hectares); Medium (> 5 Hectares and < = 20 Hectares, Large > 20 Hectares).*

2.4. Results of the Focus Groups

This section has as aim to present the findings from the six conducted focus groups. The results are categorized into the investigated determinants affecting the acceptance of the micro-irrigation system in potato farming. Throughout the research, four direct determinants, three key moderators

as well as one indirect determinant of the UTAUT model for the adoption of the micro-irrigation system will be presented. Since the focus groups covered the research issues in perception of the micro-irrigation system from the perspective of potato farmers in the Bekaa Valley region, the issues emerged from these focus groups are discussed below. To further emphasize and distinguish statements analysis from quotes, all direct quotes given by the participants, within the following findings part, will be highlighted in italics.

Before discussing the findings in detail, the relationship of the four direct determinants with use behaviour and behavioural intention, as well as the relationship of the key moderators with each determinant is depicted in the Figure 6 above.

2.4.1. Direct Determinants

2.4.1.1. Performance Expectancy

As defined before, performance expectancy is the degree to which an individual believes that using the system will help him or her to attain gains (Venkatesh et al., 2003). In this research context, performance expectancy refers to the degree to which the user believes that adopting micro-irrigation will be advantageous in potato farming. Performance expectancy was measured by the perceptions of using a micro-irrigation system in terms of providing benefits. To explain the performance expectancy as one of the determinants toward intention to use micro-irrigation, the author stated the following research question:

Is there a positive relationship between performance expectancy and behavioural intentions to use micro-irrigation?

At first, participants were asked about their knowledge of the micro-irrigation system and the reasons behind using the ordinary sprinklers. All the participants showed a basic technological knowledge of the micro-irrigation system stating that it incorporates drip irrigation and mini-sprinklers irrigation. Concerning the reasons of the adoption of the current irrigation system, which is the ordinary sprinklers, the top answer was that sprinklers are less expensive (53%), and changing the ordinary sprinkler network that they have from many years will cost them a fortune. One of the respondents said:

I have been using sprinklers for a very long time, and changing it and buying a micro irrigation network will be very expensive, especially for covering large areas.

Also in the same context a second participants argued

I still use sprinklers because I have had my equipment for a long time and in order to change them I will spend a lot of money because micro irrigation is a big investment, so I prefer to stay on sprinklers.

Also in relation to the cost, 15% of participants stated that they have limited financial means preventing them from buying the expensive new irrigation system. Further, 20% of the participants consider ordinary sprinklers a flexible system in potato farming that allows suitable and effective irrigation on large fields. Additionally, they believe that sprinklers do not need a lot of effort and attention. In this way one participant commented

As for me, the sprinkler is the best way to irrigate potatoes in a suitable and effective way and thus the potatoes get the amount of water that they adequately require only through the sprinkler, this is why I still use it.

Moreover, 3% believed that it is not an economic convenient time in the country to switch to micro-irrigation. Further, 3% told that they do not have a problem of water shortage in their farms so there is no need for a new irrigation technology that saves water. However, 6% believed that they don't have the technological knowledge stating that micro-irrigation is new to potato farming and they do not know how to use other than the ordinary sprinklers.

Furthermore, when participants were asked about their opinion about the following statement *"*adopting micro irrigation can be useful in your farm in terms of increasing potato yield, saving energy, labor, and pesticides quantities and increasing your benefits", 56% of the respondents totally agreed. Some participants reported:

Yes, I totally agree with this sentence in the sense of that micro irrigation controls water, consumes less fuel, and there is more control of fertilizers use. When the quantity of the crop increases, revenues and profits will surely increase.

The more we irrigate the plant with a small amount only as much as it needs and at regular times, the more abundant the production and the better the quality and therefore we use less labor and pesticides. So I agree to this sentence.

Whereas 26% partially agreed about this statement arguing that

Micro irrigation definitely saves energy by saving water and because the water pressure is slight through it. It certainly increases the yield and increases the profits, but I do not think it saves pesticides, as this amount remains the same as the sprinklers.

However, one of respondent asserted:

Since micro-irrigation uses less pressure, this saves energy. Also, when using this irrigation technique we don't need a large amount of pesticides, but the yield won't increase, it remains the same as in the case of sprinklers. Otherwise, 18% of the participants fully disagreed about the statement, as other reported

In practice, micro irrigation cannot be used on potatoes and cannot be adopted. It does not increase yields, nor save energy, nor reduce the amount of pesticides and it could not increase profits

or

Micro irrigation does not increase the yield and does not save energy, nor does it reduce the amount of pesticides and fertilizers. Micro irrigation does not add anything to sprinkler irrigation".

The most relevant statements that underpin this construct are the ones that relate to the general benefits associated with micro-irrigation use. Therefore, participants were asked about their perceptions about the possible advantages and disadvantages deriving from the adoption of micro irrigation systems. Based on the content analysis, the most important benefit mentioned by the respondents was water saving.

As shown in figure 9, the majority (68%) of the participants perceive using micro-irrigation as a water saving technique since it supplies water directly to the soil surface close to the plant roots, rather than the land around, reducing by that water losses occurring through evaporation, flooding and distribution.

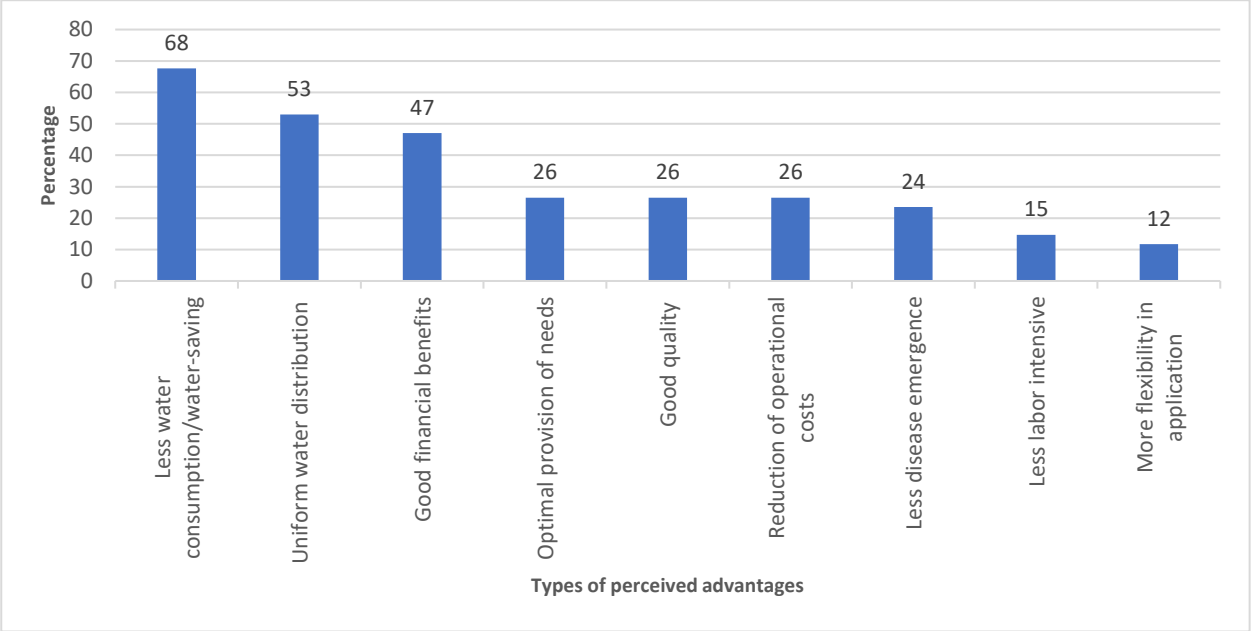


Figure 9 Perceived advantages of micro-irrigation

In this sequence, 53% of respondents perceive micro-irrigation systems to ensure uniform distribution of water by delivering water only wherever necessary and evenly over the whole land despite the presence of weather conditions (strong air). For example, a participant said

There is another advantage that micro irrigation is resistant to strong wind and although this condition it still distribute water evenly over the field. Contrary, as for the case of sprinklers, we can't operate it during these weather conditions, and this leads to the loss of irrigation hours leading in harming the crop.

Further, some of them argued that:

The advantage of micro-irrigation is that it reduces water waste and distributes water in the same quantity and at the same time to all plants on the plot. So on, micro-irrigation does not change as the water direction when there is wind.

The advantages are that micro-irrigation distributes water in a uniform way to all crops, as opposed to sprinklers, which when wind is present, all the water is diverted to only one part of the plot, resulting in plants being irrigated more than others.

Moreover, many participants (47%) believe that micro-irrigation enhances the financial benefits by increasing yield, productivity, and therefore, farm profits. In the same financial context, 26% stated that, compared to the ordinary sprinklers, micro-irrigation reduces operational costs in terms of reducing energy (less energy for water supply/ low pumping needs), and saving pesticides and fertilizers as well as reducing the equipment maintenance cost.

A standard response was

The main advantages of the micro-irrigation is that it saves energy by saving water and because the water pressure is slight through it. Micro irrigation also increases the yield and thus maximizes the profits. If we talk about the quantity of pesticides, it is pretty sure that micro-irrigation saves a lot of it because it only provides the plant with the adequate needs.

Concerning crop quality, some of the participants (26%) stated that micro-irrigation helps producing good crop quality since it permits to grow the plant effectively. They support their opinion by clarifying how micro-irrigation ensures optimal provision of needs. They commented that the micro-irrigation system gives the plant only its need of water, and provides access of water, fertilizers and pesticides to the plants roots. Additionally, 24% of the participants perceive micro-irrigation as having the advantage of less disease emergence interventions, reducing the risk of growing fungal diseases and limiting also the growth of harmful weeds. However, only 15% of the participants consider micro-irrigation as a less labor intensive technique despite it does not only reduce labor amount and efforts but also time, thus saving a lot of agricultural operations associated with potato cropping. Further, 12% of the participants stated that micro-irrigation is a more flexible system in terms of application because it is very practical on large fields, in addition to the ability to irrigate at both day and night.

Overall, it was confirmed that micro-irrigation use has many key advantages in potato farming from saving water, labor, and pesticides to increasing profits. Therefore, we expect that ‘‘performance expectancy’’ will be positively associated with the intention of using micro-irrigation technology.

2.4.1.2. Effort Expectancy

The second determinant, the Effort Expectancy was measured in this study by the perceptions of ease of use of a micro-irrigation system, and if participants will be skillful in using it (Venkatesh et

al., 2003). To explain effort expectancy toward intention to use micro-irrigation, the following research question was investigated:

Is there a positive relationship between effort expectancy and behavioural intention to use micro-irrigation?

During the focus groups discussion, participants were asked about their perceptions of easiness of tasks related to the implementation and operation of the micro irrigation system and how do they perceive the related technical operations.

As depicted in Figure 10, 62% of the participants considered micro-irrigation easy to be extended over the field. Half of the 62% said that it saves labor amount and effort because it is installed once at the beginning of the season and no need to worry about moving it. Moreover, the other half believed that micro-irrigation helps saving time. Hence, the farmer can gain more time to take care of other profitable agricultural operations. Accordingly many participants claimed that

Micro irrigation is easier than sprinkler irrigation, and it is installed only once per season; therefore, the farmer will not worry about moving the network from one place to another such as the case of the sprinklers. Thus, micro irrigation saves labor.

Micro irrigation does not require significant time and effort to extend and remove the network. It is easier than sprinklers, because the network is extended once at the beginning of the season and does not need to be moved from one part to another part of the land as in the case of sprinklers.

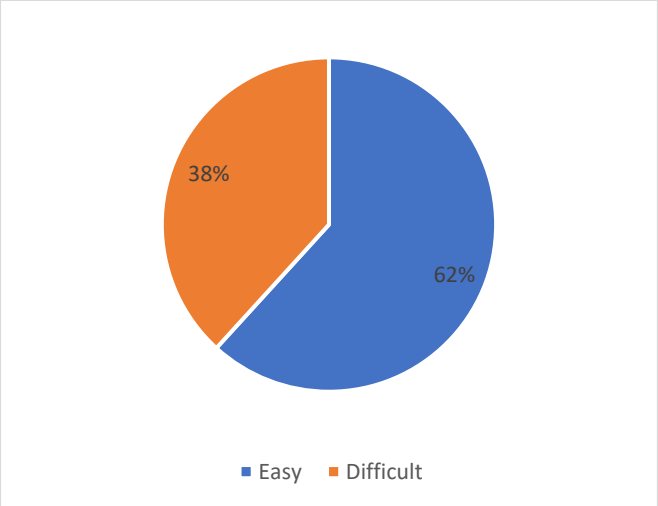


Figure 10 Perceived difficulties or easiness of the related tasks

On the other hand, 38% of the participants perceived a high difficulty in extending the network of the micro-irrigation system on large fields and especially in the case of potato farming. They believed that, once extended, it decreases the efficacy of some agricultural operations.

To highlight this problem some respondents commented

The micro irrigation is very difficult to install and needs a lot of time since the technical process to extend the network takes about a week and more. There is a difficulty in the tasks related to micro irrigation because we 'an't apply pesticides and do all the mechanical agricultural practices when it is installed.

Other than that, they also argued that the installation of the micro-irrigation system needs a lot of attention and a specialized work force which induces a huge effort due to the complexity of the network equipment that should be implemented precisely. Additionally, third of the respondents, who perceived a difficulty in the use of micro-irrigation, claimed that micro-irrigation is time consuming (even a one week installation is considered a lot of time in agriculture). Furthermore, another third of them considered micro-irrigation as labor consuming because the system needs constant attention in order to prevent damage of the hoses. Some participants said

Micro irrigation requires a lot of effort for initially extending the network. Likewise, if the hoses become clogged and we want to replace them then there is great effort and difficulty during the season.

When installing the micro irrigation system, it will no longer be possible to operate properly on the field as the presence of the hoses restrains us. The sprinklers are much easier than micro irrigation, so that, just a day, we can install, remove, and transfer 100 sprays. Sprinklers require less labor because only one worker can do this, contrary to the micro irrigation that needs a lot of labor.

However, only 2 participants stated that the micro-irrigation system needs time to be installed, yet it's an easy technique.

Concerning the time of tasks, micro-irrigation needs more time compared with the sprinklers: at least needs one week v/s less than 1 day for sprinklers. Micro-irrigation is an easy and practical technique but needs a lot attention during the season.

Micro-irrigation allows saving labor, as it is very easy. It requires about a week in the beginning, but it spares you the daily work related to moving the equipment throughout the season, as in the

case of sprinklers. But it requires a lot of attention for the hoses not to be clogged due to the possibility of water sediments (despite the filter setting).

Furthermore, the Effort Expectancy construct is relevant to the question asking participants whether they think they will become skillful in using micro-irrigation on potato crops.

The findings were depicted in Figure 11.

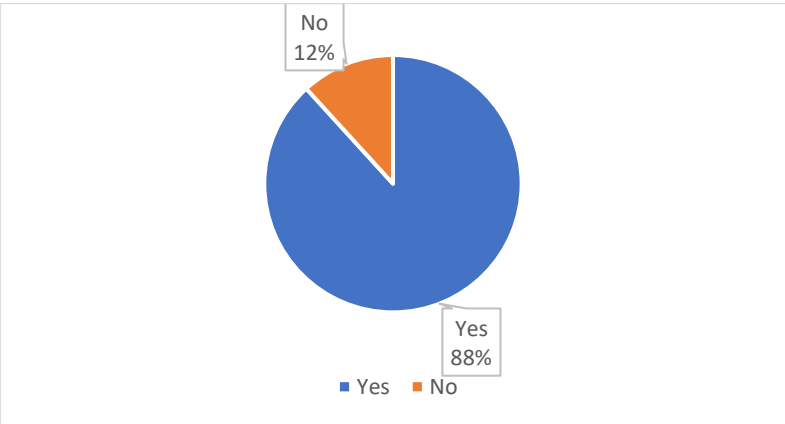


Figure 11 Skillfulness in using micro-irrigation

On one hand, 88% claimed that they will be skillful in using micro-irrigation. Approximately one third of respondents believed they will do their best to develop their knowledge in order to improve the yield, and possibly to increase their profits; they will get used on any new agricultural practices that give positive results. One-fifth of the 88% participants described the micro-irrigation as an easy technique and it is not difficult to be implemented on potatoes. These responses can be summarized with the following comment

Of course, it can be used in a successful way on potato and personally I will use it in a great way since'it's not difficult to manage.

Moreover, another fifth thought they will surely become skillful in micro-irrigation after getting appropriate training and guidance. Further, approximately one fifth of the 88% of the participants assumed that they will improve their skills in every new technique and incite themselves to adopt it properly because it may improve their personal skills, thus their productivity. A respondent said:

As farmers, we are most interested in developing our agricultural practices and noticing their positive results, and we therefore do our utmost to strengthen our skills in any new agricultural technology we adopt.

On the other hand, 12% of the participants thought they will not become skillful in using micro-irrigation technology on potatoes. Half of those participants were not convinced in the technology and believed it has no benefits on potato cultivation at all.

No, since I see that it has no benefit in growing potatoes, obviously I don't improve my skills in using it.

The other half considered micro-irrigation difficult and exhausting to be implemented in potato cultivation.

In sum, we find that the majority of participants agreed that ‘‘effort expectancy” plays a positive role in user’s intention to use micro-irrigation technology.

2.4.1.3. Social Influence

Further, the Social Influence was measured in the study by the perception of how people, whose opinion is important to the farmers, influence the adoption of micro-irrigation systems, the degree to which peers could affect the use of this new system, and the effect of personal moral obligation norms to adopt a micro-irrigation system for the sake of protecting the environment by preserving water resources. In order to investigate the relationship between social influence and behavioural intentions, the following research question was analyzed:

Is there a positive relationship between social influence and behavioural intention to use micro-irrigation?

In the context of this construct, participants were asked to list people whose judgment is important to them that they would approve and disapprove their adoption of a micro-irrigation system. 47% of participants stated that they don’t care to others’ opinions, because each one of them prefer to take his own decision concerning his work, and they know better what the soil requirements on their lands are; not every technique can be applied on all types of soil. For example, they said:

I don’t care about someone else’s opinion. When I make my decision, I am convinced and sure that I will take advantage of it.

Since I believe that each one has a different point of view, I have my own.

Moreover, 21% of the respondents considered the opinion of “other farmers” or “nearby farmers” important. They expressed their trust in each other’s objective opinions about potato cultivation needs (irrigation...) based on the soil type and the climate of the region.

I only care about the opinion of the farmers, friends and relatives because I trust them and know they won't suggest anything but useful things to help me in agricultural issues

I am very interested in the opinion of my neighboring farmers in the area, because they express their opinion relatively to our area; as each region is different from the other concerning the soil, water availability, air velocity, etc.

The opinion of other farmers is very important to me because we are in the same sector and we face the same risks and problems.

In addition, 20% of farmers highlighted the importance of their family members' opinion such as fathers, sons and/or cousins. Two participants expressed this sentiment as

My father's opinion is very important to me, because everything I had learned is from him as he has large experience in agriculture as in general and especially in potato agriculture.

I care about my son's opinion, because he is studying agricultural engineering and his opinion is very important to me. My brother is also a potato farmer, and his opinion is very important for me in terms of whether he approves or not my adoption of the micro-irrigation system.

Furthermore, 12% of the farmers were interested in NGO's judgment and advices, as well as agricultural association, organizations and engineers. According to those farmers, those organizations realize the significance of new agricultural practices and support the farmer adopting it to develop his farm. They commented:

I am also interested in the opinion of an agricultural organization (IDAL), because whenever it becomes clear that the farmer improves and adopts new technologies in his land, this agency supports and helps him by exporting cultivated yields.

In a second step, participants responded to the question asking about the importance of collecting information from other farmers and observing what they think about their possible successes before adopting a new irrigation system. Results are shown in Figure 12 below. Nearly all participants, 94%, were very interested to have access to the experiences and suggestions of other farmers. Inside this group, 53% of them voted for the collective benefit, and 47% were interested in continuous development and knowledge of existing and new agricultural practices. Two sentences can represent the general feeling

Collecting information from other farmers is important in order to share experience and increase the development. It helps us in discovering all new agricultural techniques, to test it and find out if it is useful in the region or not; this is a common interest.

For this reason, I created the syndicate of potato farmers to exchange our knowledge and experiences to share with each other every new agricultural practice, as well as our successes and failures so that we can learn more.

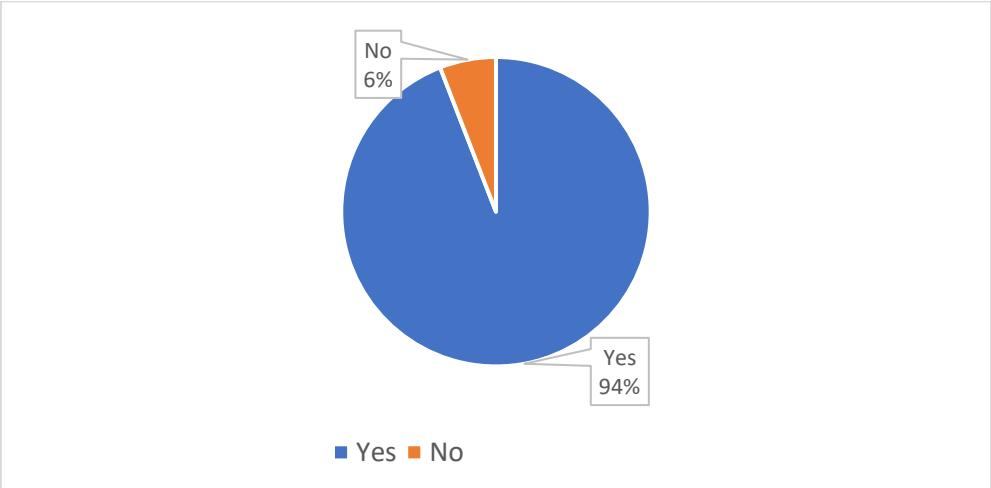


Figure 12 Importance of collecting information from other farmers

On the other hand, 6% of the participants weren't interested in the experience exchange, because they believed that each farmer has his own individual specific agricultural practices and requirements. As per example,

Each farmer has his own technologies and the specification of his land which differ from the other.

Some farmers may give agricultural information that can't be adopted in the same way in my farm.

A detailed chart on the importance of collecting information from other farmers is depicted in Figure 13.

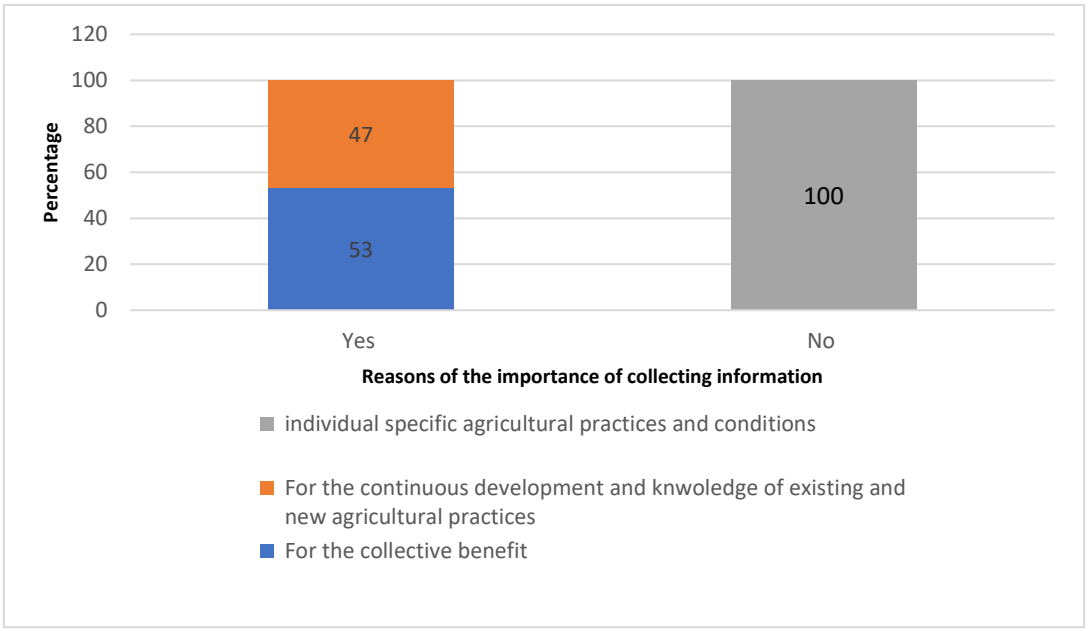


Figure 13 Importance of collecting information from other farmers and observing successes before adoption

Further, getting a better sense of farmers' views on climate change (CC) and water scarcity was also related to this construct. Participants were asked to define what do these two terms mean for them. Firstly, half of the farmers believed that CC and water scarcity lead to loss in yield, thus in profits. According to them, the scarcity of water resulting from climate change is compelling so that cultivated areas are minimized, resulting in huge losses. They also stated that climate change and water scarcity have negative consequences on agriculture in terms of the quality of yields. Moreover, 16% argued that CC and water scarcity affect potato farming in particular because potato crops are very sensitive to high temperatures and to low precipitations. This group of farmers confirmed that CC directly and negatively affects the cultivation, especially potato crops, because it makes it vulnerable to climatic fluctuations. That may force them on some point to move from growing potatoes to rain-fed agriculture. Further, 16% of the participants claimed that CC and water scarcity put agriculture continuity at risk, because they lead to disasters that negatively affect agriculture. Furthermore, 9% defined CC as a fluctuation of precipitation and temperature during seasons. According to them, CC lead to changing temperatures during seasons, therefore to low precipitation rates, and consequently water scarcity. They also believed that CC induced the reduction of groundwater**.** Finally, 3% of the participants argued that CC and/or water scarcity do not exist because they still find water in abundance.

In the same context of social influence, 91% of the respondents affirmed that a farmer should have moral norms and personal obligation of preserving water for the environment, the future generations

and for continuing appropriate agricultural practices (see Figure 14**).** They stated that *"It's compulsory to have ethical and personal values to be forced to save water in order to preserve nature, water wealth and to keep the water resource to our children as well as to ensure the natural and continuous development of agriculture.*

Personally, as I'm worried about climate change, if the government or a non-profit organization will support us, I will adopt a micro-irrigation technique to conserve water for *the ecosystem's well-being* and *to maintain a normal life-sustaining atmosphere.*

Further, the remaining 9% of the participants did not believe in the importance of moral obligations because water should be used as long as it is present. They commented

Nobody abides by these standards because we live day by day and do not think about tomorrow. However, when there is water we use it all.

If the farmer is in an area with a high water quantity, he does not care about this moral standard and continues to irrigate and use water without calculation.

Summarizing, it seems that participants did not agree with the research question stating that social influence may have a positive influence on the intention to use a micro-irrigation system.

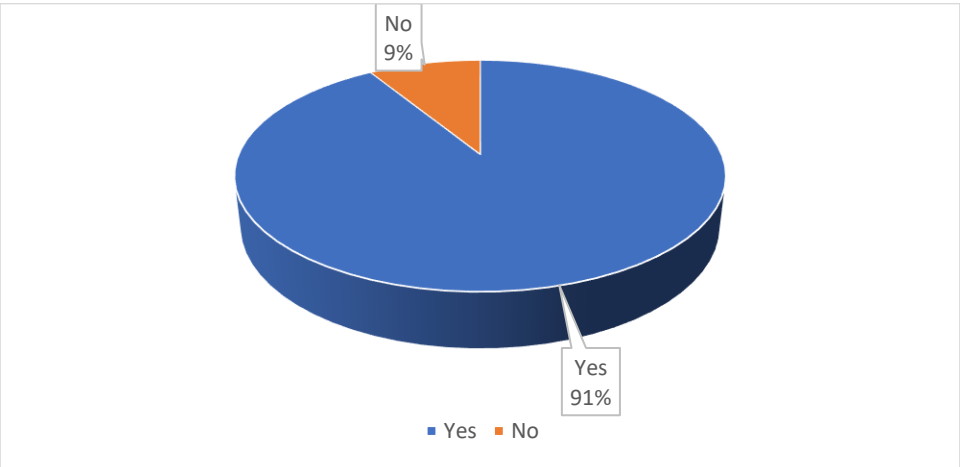


Figure 14 Moral Obligations affecting adoption of a water-saving irrigation system

2.4.1.4. Facilitating Conditions

The Facilitating Conditions, the fourth component, differently from all other determinants, had a direct influence on use behaviour. Facilitating conditions was measured by the perception of being

able to access required resources, as well as to obtain knowledge, trainings and the necessary support needed to use micro-irrigation systems. It also relates to the perception of the technology fitting into the land characteristics and agricultural practices. The following research question was investigated:

Is there a positive relationship between facilitating conditions and use behaviour of a micro-irrigation system?

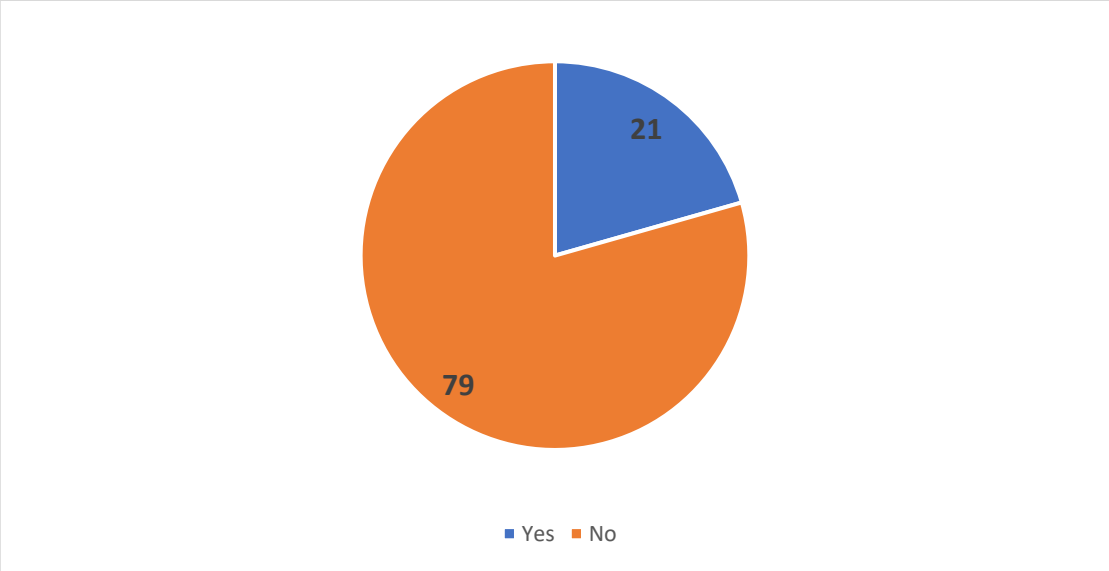


Figure 15 Guidance role of the agricultural/irrigation extension services

This construct is relevant to the question about the guidance role of the agricultural/irrigation extension services in the area. As Figure 15 shows, 79% claimed that there was no presence, neither of agricultural guidance and extension nor of training courses. They assured that the agricultural sector is marginalized and neglected; therefore, the farmers had to rely on their personal experiences or the experiences of other farmers in the surrounding. They added that the non-presence of extension services made them unaware of the existence of new agricultural practices. They stated that

The agricultural sector is marginalized, there are no agricultural policies, not even agricultural extension, and *we have become used to relying on ourselves, our individual information,* and *the information we take from each other.*

In Lebanon, we do not have agricultural policies, and farmers are not supervised by the Ministry of Agriculture which does not provide any guidance. Every farmer in this area depends on himself and on his personal experience.

The other 21% of the participants stated that there was limited agricultural extension from some companies and institutions for the purpose of marketing. That is why they do not trust that type of companies and they rely on their personal experience. This common feeling can be summarized from the word of participants:

There is no appropriate agricultural extension role, there are some agricultural companies that deal with pesticides, they do some extension courses related only to the subject of insects so as to sell and market their products not more. So *I only rely on my personal information and experiences.*

We have some agricultural guidance from some agricultural associations and institutions; *they are doing all they can for agricultural extension. I take into account the information they provide, because agricultural guidance is necessary and sometimes it is a memory refresh for things I know, but I do not remember.*

In the same context of facilitating conditions, participants were asked about the barriers they thought might prevent them from implementing a micro-irrigation system. Several barriers were mentioned by each participant and results are illustrated in Figure 16. All participants considered the most important barrier as the high initial expenses for installing the system: 53% stated they have a lack of capital in order to cover the whole area; 53% believed they need trainings to raise awareness about the benefits of the system; 44% consider the system needs attention and time for minor repairs; 38% emphasized that micro-irrigation is effort consuming; 38% thought that they need credit facilities as farmers; 35% assured that subsidies are necessary so they can implement this new technique of high cost; 26% they don't have the technical knowledge; 21% perceived that micro-irrigation is not feasible on large fields; 18% find it technologically complicated; 12% stated that they want the spirit among farmers because if they cooperate they can support each other's. However, only 3% need motivation from the family and friends in order to implement micro-irrigation, and another 3% believed that their land is very scattered which impedes the system installation.

Overall, we find that the majority of participants agreed with the research question about "facilitating conditions", stating that it will improve a farmer's use behaviour of a micro-irrigation system.

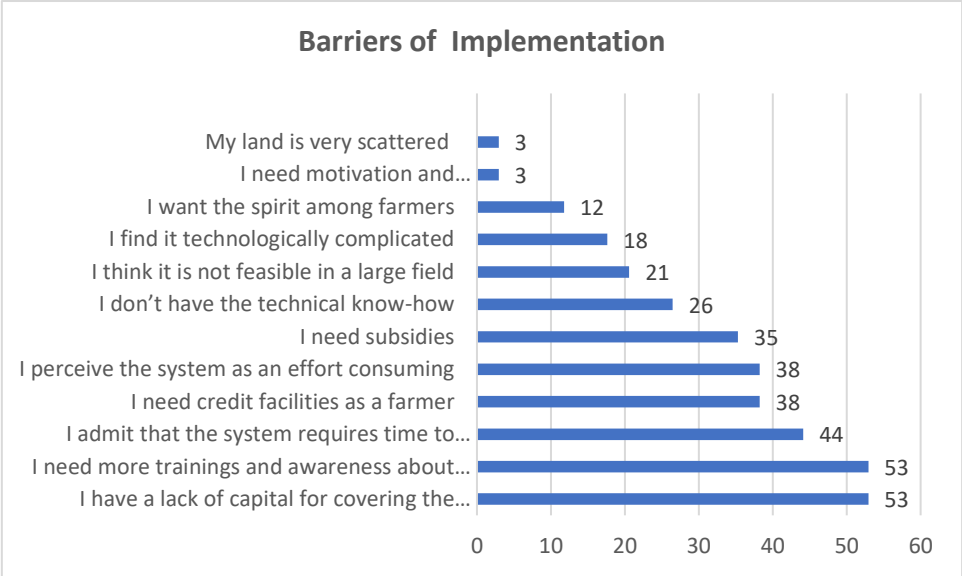


Figure 16 Barriers of implementation of a micro-irrigation system

2.4.2. Key moderators

In addition to the previously mentioned four main determinants, the UTAUT model included four main ‘‘moderating’’ factors: gender, age, experience, and voluntariness of use. Participants in this study were all males because there were no women running a farm in the area. Given that in this research all farmers were of the same gender, the paper included exploration of the possible effects of the age, experience and voluntariness of use as moderating factors on the four main constructs.

2.4.2.1. Age

Firstly, the key moderator “age” was tested by the relation between the age of farmers in the area and the incentive to adopt new irrigation practices. The question that was relevant to this factor was whether the participants believed that the age of the farmers affect their incentive to adopt new irrigation practices and in what way.

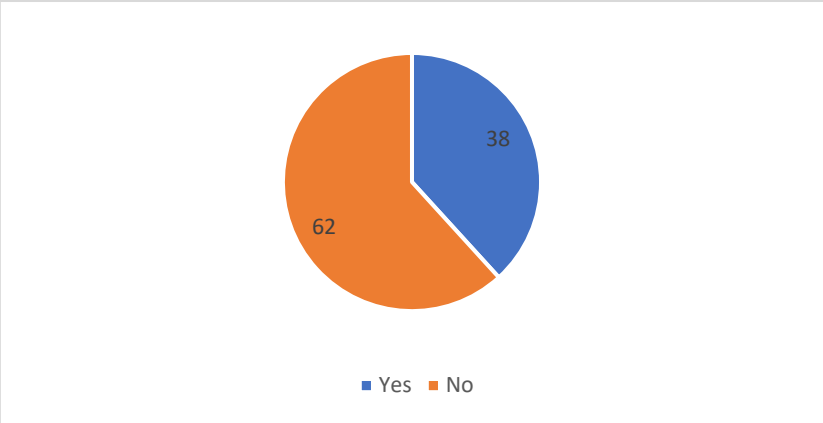


Figure 17 Relation between age of farmers and adopting new irrigation practices

As shown above in Figure 17, 62% of the participants considered that age had no influence on the intention of use of a new agricultural technology. They stated that farmers adopted a new technology once convinced of the advantages of that technology. They asserted that, no matter his age, a farmer remains enthusiastic and encouraged to adopt new technologies, thus developing himself and his land. According to them, if a farmer is convinced of the benefits of a modern technology, he will adopt anything that is beneficial for his land. Some respondents commented that

If it becomes clear to the farmer that the modern irrigation system will give him high profits, he will adopt him no matter what his age is.

No, age does not decrease the incentive of adopting new agricultural technologies. A farmer who is convinced of the benefits of adopting new irrigation practices or other agricultural practices can only be hindered by financial capacity.

No, there are young farmers who can't be convinced of changing and developing, whereas older farmers (70 years and beyond) who always are willing to catch up with development.

It is important to mention that those participants who stated that age has no direct impact on the adoption of a new technology are mostly the elder farmers (42% of them > 60 years).

The figure 17 also shows that 38% of the participants believed that age decreases farmer's incentive to adopt new agricultural practices because the age lessens farmers' enthusiasm. Age was an important moderator in the context of adopting a micro-irrigation system among potato farmers. The younger group affirmed that it would be more difficult to persuade the older generation who doesn't have initiative to try new technologies, contrary to what the elderly said. In fact, the moderation by the age impact was reported in several studier's enthusiasm. Moreover, in their

opinion, elder farmers consider they have the full knowledge and that satisfies them. Thus, it would be very difficult for them to be convinced of adopting new practices. Those participants also added that, the older the farmer the more he rejects new technologies because he has no trust in them. In this case the usual comment was

Yes, when a farmer gets older, adopting a new irrigation system on his land becomes a secondary matter for him. He no longer has a rush to learn agricultural practices.

2.4.2.2. Experience

Secondly, "experience" was worth testing by the familiarity of the farmers of the functioning of the micro-irrigation system either by their own trial on their crops or by observing others using it on potatoes or on other crops. Based on the analysis of the focus group discussion, some participants assumed that adopting micro-irrigation is not difficult for them as they witnessed its usage by other farmers on potato cultivation or on other crops. Therefore, they have the know-how which increases their incentive to implement it on potato cultivation if they have the capital for the investment. In the same context, a participant stated

As a member of my family who uses micro irrigation on watermelon, I have professional and technical knowledge on this subject, and therefore *I will not find great difficulty in using it on potatoes*

Another added

I am adopting micro-irrigation on a small part of my land in vegetables cultivation, so I have the experience on how to install it in efficient way.

2.4.2.3. Voluntariness of use

Moreover, "voluntariness of use" was measured by the tendency to adopt a micro-irrigation system in a situation where there is no external obligation to adopt the technology. External obligations can be defined for example as limited quantity of water usage imposed by the responsible authorities in the region. As figure 18 below shows, almost half of the participants (53%) stated that they can adopt micro-irrigation without external obligations, in order to induce good results and to ensure the continuity of their land cultivation:

Yes, I will move to a micro irrigation system in order to improve the quality of potatoes and *produce more quantities,* and *the most important thing is to reduce water waste*.

However, it is worth mentioning that only one participant asserted that he will gradually adopt micro-irrigation regardless its high initial cost, because he believed that it greatly will improve the quality and quantity of potato yield:

Yes, I move to the micro irrigation system, but in stages, due to the high cost.

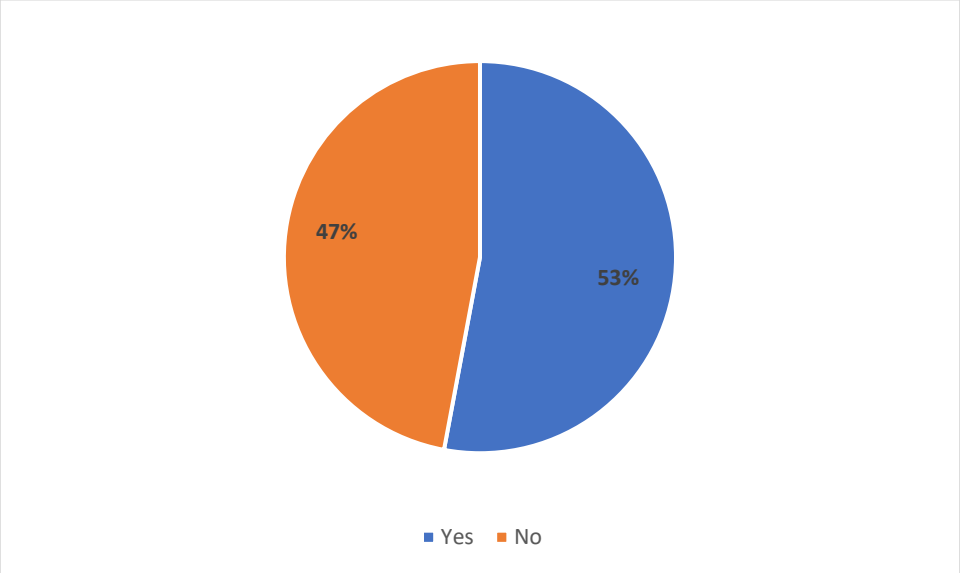


Figure 18 Tendency to adopt a micro-irrigation without external obligations

On the other hand, the other half of the participants (47%) have no tendency to adopt micro-irrigation spontaneously without external obligations: half of them consider it an expensive technology and they do not have the financial resources. The other approximate half does not perceive any benefit from adopting it on potatoes, and only very few have abundance of water so they don't need a saving-water irrigation technology. Those findings were clearly shown in the Figure 19 below. Some comments were

No, because *I am convinced that the sprinklers are better than the micro irrigation on potato crops, and I don't have the financial resources to try and attempt the micro irrigation even on a small part of my land.*

No, because I have enough water and I pay careful attention to the amount of water that the plant needs (manual soil testing) so that I don't waste water and therefore micro irrigation won't help me.

No, I am not convinced that micro irrigation would be better than sprinklers on my land, so I won't implement it.

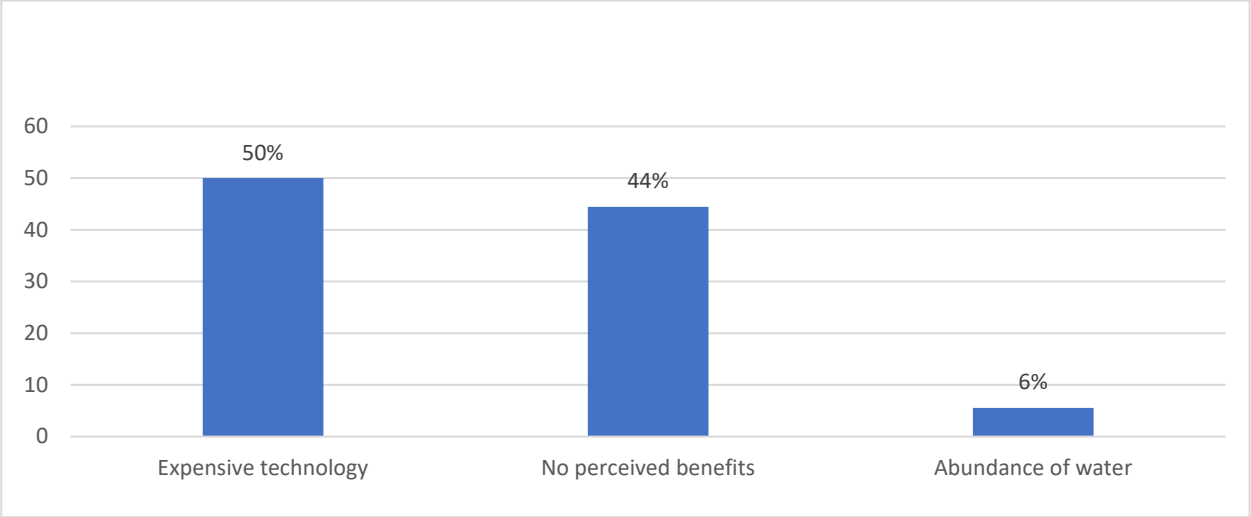


Figure 19 Reasons for no willingness to adopt micro-irrigation without external obligations

Furthermore, participants were asked about the possibility of them adopting micro-irrigation if the government decides to subsidize the use of water-saving irrigation systems. As figure 20 below shows, 85% stated that they tend to adopt micro-irrigation system if there were subsidies from the government. According to them, subsidies reduce the financial burden on them at the beginning of the investment, and encourage them to take the first step toward the total adoption of the micro-irrigation system:

Yes, if the government provides subsidies, conducts training courses and supports us to export our production, of course I will adopt it.

Yes, I agree, because the state and the government have an obligation to take care of the farmer, who is the core of the Lebanese economy. Hence, micro irrigation is essential and necessary in improving the quality of potatoes to become competing with potatoes from other countries.

Nonetheless**,** 15% of the participants insisted on not moving to micro-irrigation system even if there is support, because they do not perceive any benefit from it:

No, I don't agree… At the end, the productivity will be identical to that of the sprinklers.

No, although this technique provides large quantities of crop production, however, it does not match with the large areas I cultivate, and thus the moth will surely appear resulting in high losses.

In this section, it is important to mention that those who first had tendency to adopt micro-irrigation without external obligations tend as well to adopt it if subsidies are introduced because it lessens the

financial burden. Further, participants who said they would not use micro-irrigation because of its expensive cost changed their mind when the interviewer mentioned the subsidies. The most notable change in intentions was that of the participants who had no tendency to adopt the system claiming that it has no benefits. However, 50% of them changed their answers when the question of subsidies was raised. They stated in this section that they will move to micro-irrigation gradually by applying it at first on a small part of the land to test its advantages. For example:

Yes, it will be possible for me to start adopting it on only one hectare. If my results are positive and there are no diseases, then I will gradually adopt it year after year until I have thoroughly checked its benefits.

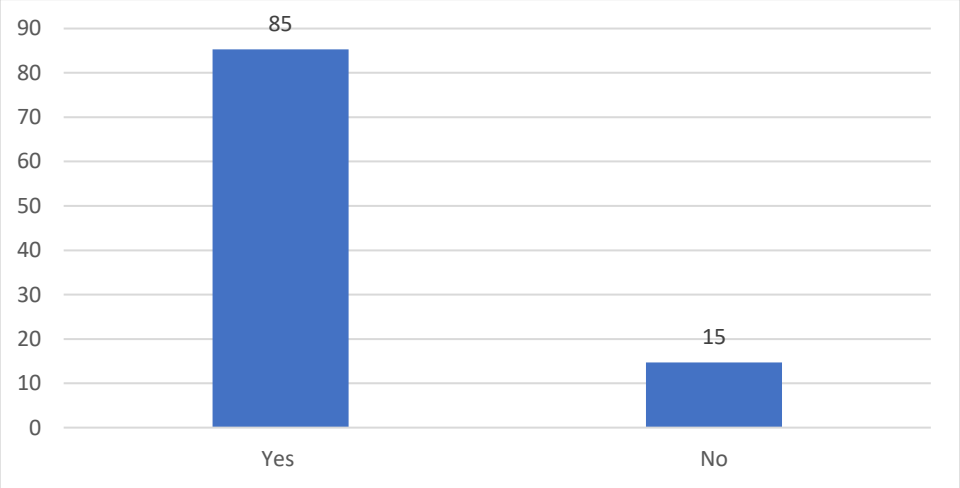


Figure 20 Government's subsidy for using water-saving irrigation systems

2.5.3. Indirect determinants

Venkatesh et al. (2003) explored three other constructs such as anxiety, self-efficacy, and attitude toward using technology that affect the behaviour intention of use of a new technology. However, they were found unremarkable due to the effect captured by other constructs. In this study, only "anxiety" was tested by analyzing the sensations occurring when thinking about the possibility of implementing a micro-irrigation system.

2.4.3.1. Anxiety

In relevance to the construct of anxiety, participants were asked about the sensations they feel when they think of implementing a micro-irrigation system specifically drip or mini-sprinklers. As

depicted in Figure 21, enthusiasm (35%) was the only positive sensation mentioned by the respondents who were convinced that the micro-irrigation will have good results. However, the negative sensations were much more, such as concern (62%), anxiety for investment (41%), indifference (9%), and skepticism (3%).

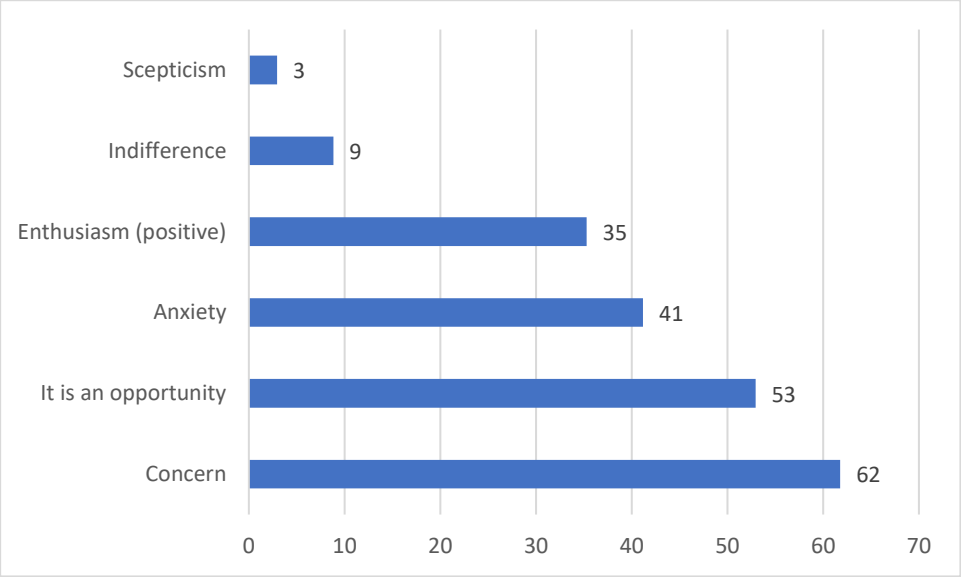


Figure 21 Sensations occurring when thinking of implementing drip or mini-sprinklers

2.5.4. The dependent determinant: The Behavioural intention

The measurement of behavioural intention in this study included the intention and predicted use of micro-irrigation system. The behavioural intention was measured by addressing questions whether the participants have a possible plan for the adoption of a micro-irrigation system in the following 12 to 24 months as well as the major concerns related to this system.

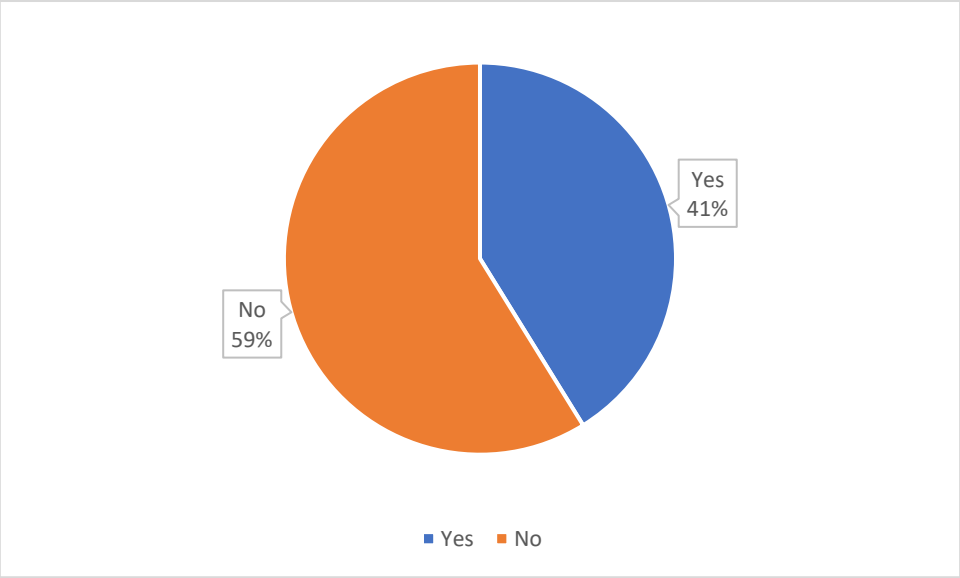


Figure 22 Plan for a possible adoption of a micro-irrigation system in the next 12-24 months

As figure 22 shows, 59% of the participants said that they do not have any plan for the adoption of micro-irrigation in the next 12-24 months. This group of participants was divided into 3 groups according to the reason behind not having a plan for adoption: a) the unstable economic conditions in Lebanon that does not encourage farmers to invest high capitals (the majority); b) the lack of micro-irrigation usefulness in terms of profits and feasibility (the quarter of them); c) lack of financial means (only 10%). The following quotes revealed the participants answers:

No, b*ecause the sprinklers irrigation is more comfortable for the farmer and does not require much effort, and I am satisfied from the quality and productivity that I get.*

No, if the government does not support me, I will not adopt the micro-irrigation system.

On the other hand, 41% of the participants stated that a plan to adopt the micro-irrigation system is possible in the near future. This group also was divided into several groups in terms of implementation conditions: a) presence of subsidies by the government (approximately the half); b) better economic situation in the country (one quarter of them); c) in case of water shortage (6%); d) no conditions at all (14%). The following quotes revealed the participants answers:

In light of the current conditions in the country, I can adopt it in this period if there is protection for our products and if the state provides support.

Yes, if the coun'ry's situation stabilizes, I have an intention to adopt a micro-irrigation system soon;

Yes when necessary, and that means if the water runs out on my land, I will adopt a micro irrigation system."

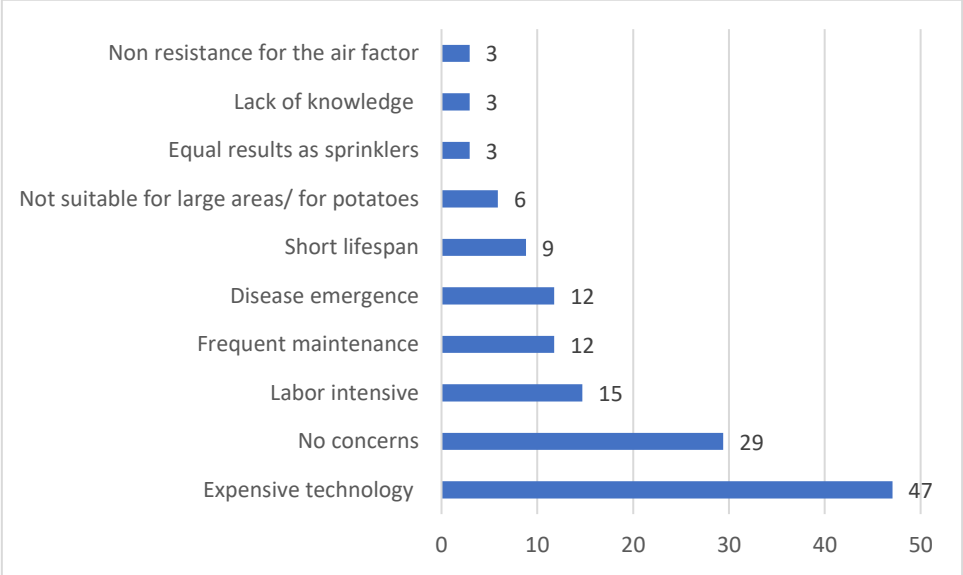


Figure 23 The concerns related to micro-irrigation

Figure 23 above shows the different answers obtained when investigating the concerns of the participants over the micro-irrigation systems. As clear, the top concern was the high cost of initial equipment and the possibility of financial losses (47%). In addition, 15% confirmed that micro-irrigation is labor intensive technique that requires a lot of effort, time and attention. Further, 29% have no concerns at all. The remaining concerns differ in little percentages from the frequent maintenance to the emergence of diseases (fungal and moth), short lifespan, feasibility on large areas, no wind resistance.

At the end of each focus group discussion, participants were asked to fill a questionnaire. It included a table explaining the difference between ordinary sprinkler, drip, and mini-sprinkler with cooling process on many levels such as equipment costs, water waste, etc. After examining the table, participants had to choose their preferable technique of irrigation. Further, when asked about their willingness to adopt a new micro-irrigation system, 82% of the participants said yes and 18% said that they are not willing to as the Figure 24 is showing.

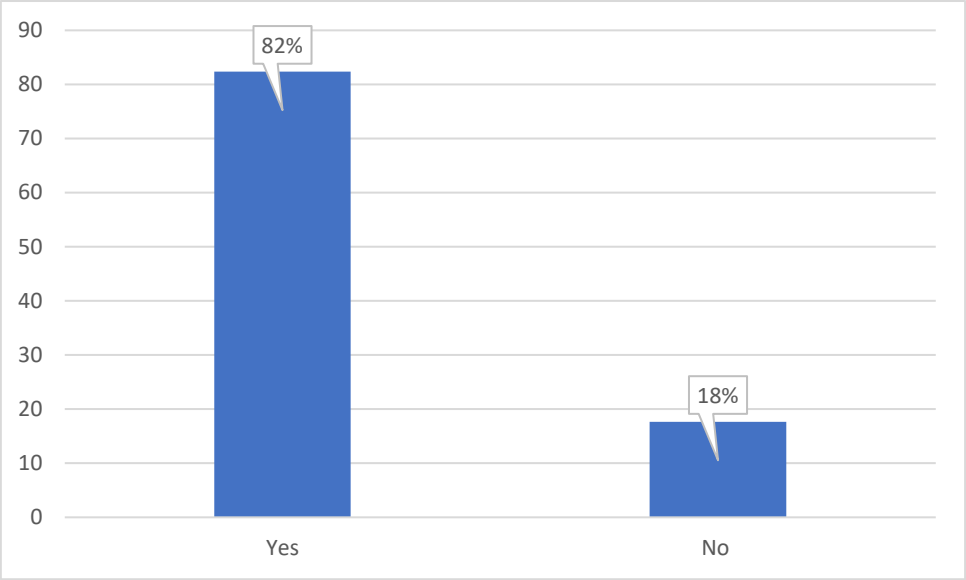


Figure 24 Farmers' Willingness to adopt a new micro-irrigation

The participants who chose to remain on the sprinklers had different stated different reasons: 17% were convinced that micro-irrigation (drip or mini-sprinklers) had equal results as the sprinklers in terms of quality of yield, and profits. Moreover, some participants do not have the willingness to move to micro-irrigation because a) it allows certain emergence of diseases (11%); b) its high cost (6%); c) does not save energy, pesticides fertilizers and labor (6%); d) difficulty in implementation on potato cultivation that prevents other agricultural operations (6%) (see Figure 25 below).

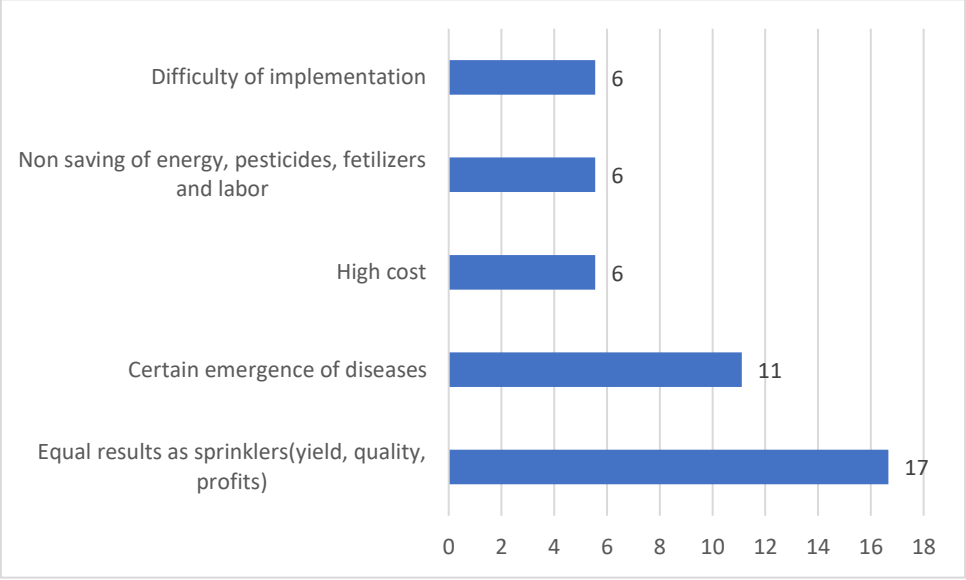


Figure 25 The reasons for remaining on the ordinary sprinkl'rs' choice

With reference to those who had the willingness to adopt a micro-irrigation system on their potato cultivation, Figure 26 shows that 68% have chosen the mini-sprinkler irrigation with cooling effect.

Reasons differ between those participants: better quality (89%), yield (89%), saving water (58%), earliness of harvest (53%), physiological status (5%) and energy costs (5%). However, 32% have chosen the drip for different reasons: saving water (89%), yield (89%), high initial equipment cost (78%), energy costs (22%), better quality (11%) and earliness of harvest (11%).

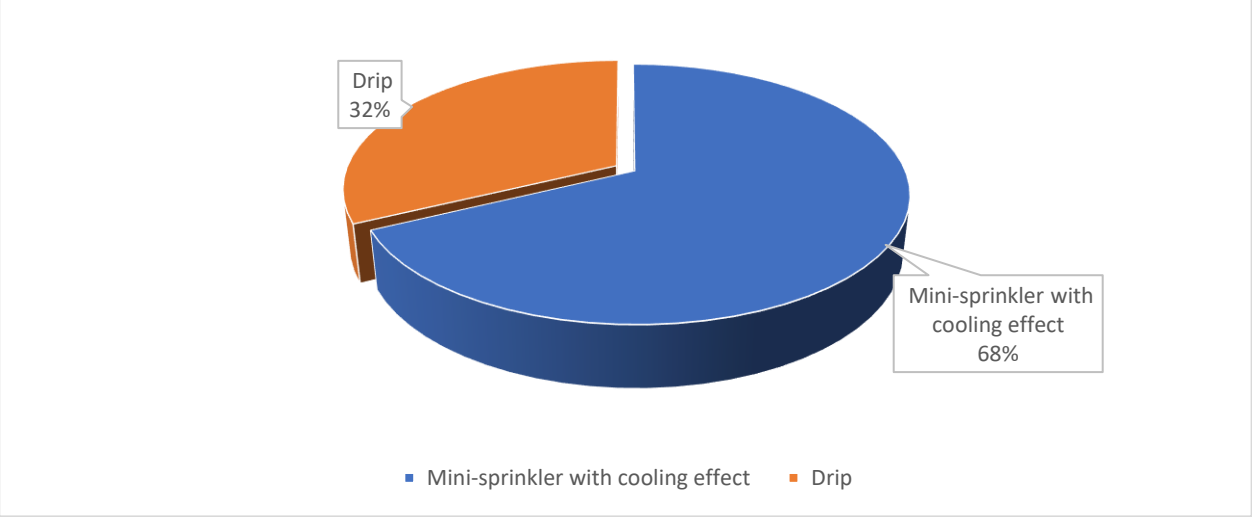


Figure 26 The Choice to be adopted (Mini-sprinkler with cooling effect or Drip)

2.6. Discussion

2.6.1. The Direct Determinants

As initially mentioned, the purpose of this study was to get a deeper understanding of the influential determinants for potato farmers' adoption of micro-irrigation technology on their lands in the Bekaa region in Lebanon.

This research further examined which factors seem to influence the farmers and their willingness to use a micro-irrigation system. Additionally, the analysis findings will be linked back to the findings of other studies. Following Hess (2004), the fundamental aim was to examine the similarities and differences among the results of previous findings and those of this study with the intent of clarifying, confirming and concluding which factors will affect the behaviour of farmers in adopting a new method of irrigation. Structure-wise, this chapter has discussed, according with the UTAUT model, what appears to be the main determinants as the performance expectancy, effort expectancy, social influence and facilitating conditions. Then, it was discussed the impact of moderator variables ad age, experience and voluntariness of use on the four previous direct determinants.

The Performance Expectancy was defined as the degree of farmers' expectations that using the micro-irrigation system will help them to attain profits in potato farming performance in terms of

benefits. The benefits were identified as saving water, reducing labor effort and time, saving energy, increasing yield, improving crop quality and improving the agricultural operations. The results seem to support the research question which stated that performance expectancy had a positive influence on behavioural intention to use micro-irrigation on potatoes. The effect of performance expectancy on behavioural intention was found to be relevant for many participants, which reflects the perceived benefits obtained using micro-irrigation system. The farmers' performance expectancy might increase by focusing on the usefulness of micro-irrigation systems. That means if the advantages of micro-irrigations systems were presented in meetings, for example, made by specialists this probably would increase the acceptance and adoption for people who were against this method, and who preferred the ordinary sprinklers. These farmers prefer to use ordinary sprinklers, which they already have, and do not want to spend high capitals to change the whole irrigation system. Almost, all participants declared that generation of good results and water economy were the top advantages of micro-irrigation system. However, they were hindered by the financial capacities, and the lack of knowledge about the system usage.

Regarding this, it is essential to establish an agricultural guidance, in order to promote the advantages of micro-irrigation system and its usage. The farmers seemed very enthusiastic for the micro-irrigation implementation, and at the same time, they were very anxious about losing the financial investments in case they would not be able to apply this method without professional guidance. This result was found to be consistent with previous research findings (Bahramzadeh & Shokati Mogharab, 2010; Im et al., 2011; Louho et al., 2006; Nejadrezaei et al., 2015; Sa'ari et al., 2017; Yu, 2012) that have found a positive relationship between performance expectancy and behavioural intention to use technology.

The effort expectancy construct was defined as the degree of ease of use associated with the adoption of a micro-irrigation system on potato cultivation. It was measured by the perception of ease of learning and using the system, as well as how much effort should be spent to use the micro-irrigation system whether drip or mini-sprinklers on potatoes. From the focus group analysis seems to emerge that farmers preferred to adopt an easy way to use system which required less effort and time than ordinary sprinklers on potato crops. This was confirmed by the majority of participants who consider the effort to extend the micro-irrigation system and how to integrate it into their potato cultivation. Within that context, the micro-irrigation technology can be implemented once per season, and then removed at the end of season, in order to reduce the labor effort and to save time. Furthermore, almost all participants, including a part of those who showed a high effort and attention concerns in extending the micro-irrigation system on their potato lands, showed their

willingness to learn about the micro-irrigation functions. They stated that becoming skillful in using the system will help to generate more yield, good quality and thus more profits. However, this contradicted with the need for agricultural trainings. Also, these trainings were required for the groups of farmers that find a difficulty in using this system, with extra effort and time. As well, the trainings help in raising awareness on the system advantages in order to remove the pre-judgement and reduce the water scarcity.

Sääksjärvi and Morel (2010) said that high effort expectancy could be seen as high level of doubt. That is, behaviour intention to use a new technology decreases with the increased effort expectancy level. That was consistent with our study where farmers who perceived low effort expectancy were those who had a high level of intention to use the micro-irrigation system. Despite the fact that micro-irrigation system was new to potato farming, this system was introduced to other cultivations in the region and farmers already had some knowledge about it. However, not knowing enough about the technology created a rising consumer doubt which could hinder the technology's acceptance. Moreover, this significant influence of effort expectancy on behavioural intention can be supported by providing agricultural and irrigation extension services among the potato farmers who discovered that it was difficult to improve their knowledge about the micro-irrigation systems, how they function, and the adequate way of its installation over the potato fields. Consequently, this finding was consistent with the results of other studies which underlined as the effort expectancy has an effect on behavioural and use intention (Birch & Irvine, 2009; Im et al., 2011; Louho et al., 2006; Venkatesh et al., 2003). Nevertheless, other studies as Nejadrezaei et al. (2015) and Yu (2012) had claimed that there was no relationship between effort expectancy and behavioural intention to use.

The third determinant, the social influence variable, was defined as the extent to which the farmer perceives others' opinions are important in one's decision to use micro-irrigation system. Additionally, this construct was related to the effect of personal moral obligation norms to adopt a micro-irrigation system for the sake of protecting the environment by preserving water resources. The study revealed an insignificant impact of social influence on behavioural intention to use micro-irrigation. This result was not consistent with Sa'ari et al. (2017), Yu (2012), Im et al. (2011) and Wang and Shih (2009) that have found a positive relationship between social influence and behavioural intention to use a technology. However, the findings of this study were consistent with Venkatesh et al. (2003) and Rosen (2005). Venkatesh et al. (2003) had found that the adoption of a new system depends on the user's beliefs and not others opinion. Social influence does not affect potato farmers to adopt a micro-irrigation system since the vast majority does not care about the

opinion of nearby farmers, family members, NGOs, engineers, agricultural associations and organizations. Moreover, due to the absence of agricultural extension, farmers rely only on each other's experience. This is why only few participants had seen that the barrier toward the implementation of micro-irrigation was the need for the spirit among farmers, in order to develop the self-confidence and the cooperation between them. Furthermore, the moral obligations that incite them to adopt a water-saving irrigation system showed that the majority of them were incited by these moral norms to implement the micro-irrigation system, in order to save the water for next generations and to have better quantity and quality of crops. In participants' opinion, the climate change and water scarcity put the continuity of their agricultural practices at risk and reduces the yield production and profits. However, some participants, a minority of them, stated that they do not take into consideration the suggestions of others. Rather, they depend on their confidence, self-esteem, ability, and conviction to use or not the technological system.

Lastly, the facilitating conditions determinant refers to the farmers' perceptions of the resources that support the use of micro-irrigation among potato farmers. It was measured by evaluating the demanded resources, knowledge and support to use micro-irrigation systems. The study results clearly depicted the direct and significant effect of facilitating conditions on use behaviour of using micro-irrigation systems. Facilitating conditions should include guidance departments at the Ministry of Agriculture, NGOs working in agricultural extensions especially during climate change, advertising on social media in order to raise awareness on new ways of saving water, in addition to any other available services to assist individuals to adopt and use micro-irrigation systems. Nevertheless, all farmers confirmed that these conditions are unavailable in Lebanon, and there is no guidance on agricultural features in whole country, which means that they cannot know about the benefits of micro-irrigation, or its right usage. This means that the agriculture is marginalized in Lebanon. Therefore, it is necessary to improve facilitating conditions in order to increase the adoption of micro-irrigation systems. This result was consistent with other empirical studies which found the same results (Hung et al., 2006; Im et al., 2011; Venkatesh et al., 2003; Wang & Shih, 2009). Meanwhile, Nejadrezaei et al. (2015), (Yu, 2012) Bahramzadeh and Shokati Mogharab (2010) concluded that there is no significant relationship between facilitating condition and technology use behaviour.

2.6.2. Key Moderators

With respect to the moderating effect of age, it emerged that age moderated the direct determinants (performance expectancy, effort expectancy, social influence and facilitating conditions). So according to the findings of this study, age was an important moderator in the context of adopting a micro-irrigation system among potato farmers. The younger group affirmed that it would be more difficult to persuade the older generation who doesn't have initiative to try new technologies, contrary to what the elderly said. In fact, the moderation by the age impact was reported in several studies (Morris et al., 2005; Venkatesh & Morris, 2000; Venkatesh et al., 2003).

Secondly, the second moderator, the experience, was considered by Venkatesh et al. (2003) as one of the important factors that affect behaviour intention. In this study, it was shown that the effect of effort expectancy on behaviour intention was in fact moderated by experience. It was measured in terms of usage history of micro-irrigation technology, such as the passage of time since first use or observation. The findings of this study revealed that, in terms of micro-irrigation usage, experienced farmers were more likely to accept and use micro-irrigation than inexperienced farmers. These results supported the popular belief that the experienced users' adoption tendency is always higher than those inexperienced. Additionally, it was confirmed that the effect of effort expectancy is stronger for inexperienced farmers. That is, if the level of the effect of effort expectancy decreases, the level of adoption of micro-irrigation technology increases. This result corresponds to Ventkatesh and Bala (2008). However, it appeared that experience was not a moderator of the effect of the facilitating conditions construct on use behaviour because farmers of different levels of experience have almost the same perceptions towards the resources supporting the use of micro-irrigation. This result is not consistent with the study of Alshehri et al. (2013) who claimed that experience moderates the effect of facilitating conditions on use behaviour.

At the last, voluntariness of use had moderated the effect of social influence on behaviour intention. It was measured on the basis of not using external obligations or incentives in order to implement the new irrigation system. The results confirmed that the case of subsidies, trainings and guidance, the level of adoption will increase and farmers will definitively implement the system. That is, if the micro-irrigation system was financially subsidized, almost all farmers in Lebanon will adopt it. Furthermore, the study findings showed that almost half of the participants had not the tendency to adopt a micro-irrigation if there is no external obligation which is consistent with what Venkatesh et al. (2003) had reported. One of the reasons behind their discouragement was that it seemed perceived as having no benefits on potato cultivation, needing a lot of effort, time and attention. In

this case, if the government grants subsidies to support the implementation of a micro-irrigation system, the vast majority will adopt it gradually or immediately.

2.6.3. Behavioural intention

The farmers' highest concern was the technology high cost and their belief that this system needs a lot of effort, labor and maintenance, and allows the emergence of diseases. At the same time, the majority of farmers considered micro-irrigation an important opportunity to develop their yields, yet they were very concerned of implementing this technique. They acknowledged the importance of this technology although they were very anxious due to the lack of funding, the high cost of the irrigation system, and the current inconvenient economic situation in the country. That is why most of them stated that they would not risk in adopting the new technique in the current situation of the country, at least not in these two years. Unless they obtain subsidies from the government, the majority had no intention to use the micro-irrigation system, whereas very few participants intended to adopt the system without any condition. Those latter are called the early adopters. These findings highlighted the fact that all farmers are ready for adoption of micro-irrigation system, whatever their age is, because they are aware that water scarcity has negative consequences on the quality of yields, and it puts the continuity of agricultural practices at risk. Additionally, they are aware of the advantages of micro-irrigation technique, if applied concisely after professional guidance. This adoption might be affordable, if during current situation in the country, subsidies and support will be provided. As well, the need for agricultural guidance is important to reduce pre-judgment of all unconvinced farmers. In fact, subsidies will grant farmers a primary experience at least on small areas to compare between actual and old results. In sum, the majority of farmers had chosen the mini-sprinklers system with cooling effect, because it provides better quality of yield, and reduces the waste of water.

As a closure, in Figure 27 above, we illustrate the weight flowchart resulting from the findings of the current study. It incorporates the four direct determinants that influence the behavioural intention and use behaviour to adopt a new technological system. It clearly represents the importance of the influence of each determinant on behavioural intention and use behaviour. That is, the shape of the arrow symbol directed from each determinant characterizes the importance of the impact of that specific determinant on the adoption of a new system. According to the results of the study, it appeared that among the first three determinants, the influence of Performance Expectancy on behavioural intention can be considered the stronger. Additionally, the influence of Effort Expectancy and social influence on behavioural intention is less than that of Performance

Expectancy. Nevertheless, it appeared that Social Influence or the third determinant has the weakest detected influence on behavioural intention, consequently on use behaviour. Finally, the Facilitating Conditions seemed to have the major weight to influence use behaviour directly. It should be noted that this flowchart was based on the findings of the study previously discussed.

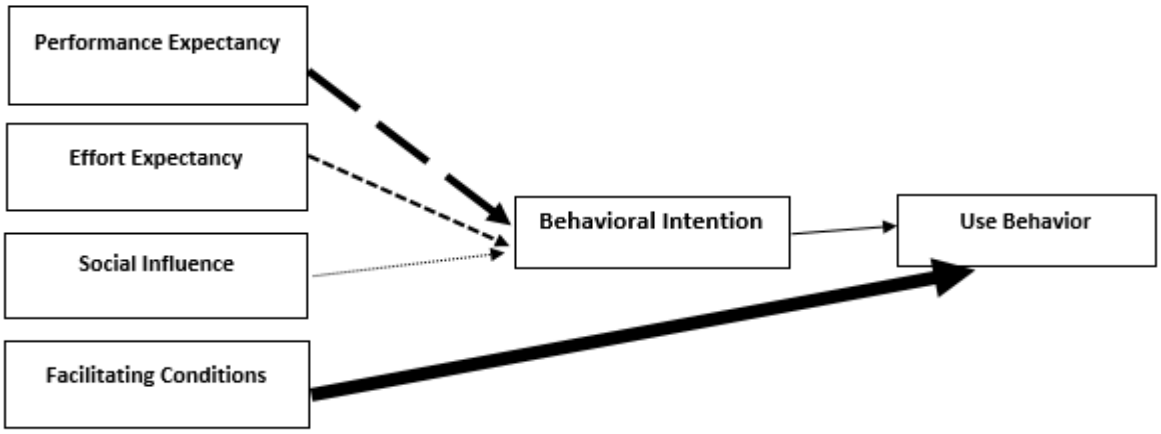


Figure 27 Weight flow chart of the four determinants

2.7. Conclusions and Recommendations

The FGD study was conducted to identify the influence of four factors and three key moderators on the acceptance factor of micro-irrigation systems (drip and mini-sprinklers) among potato farmers in the Bekaa Valley in Lebanon using the UTAUT model. Previous studies found that performance expectancy, effort expectancy, social influence and facilitating conditions can influence the intention to use a new technology as in this research refers to micro-irrigation technology. Based on the focus group analyses performed, performance expectancy, effort expectancy and facilitating conditions played a significant effect on the acceptance of micro-irrigation technology while the social influence did not.

Farmers are willing to accept micro-irrigation technology when they can make gain and reduce task uncertainty on their farming activities. They will also accept it when the technology can increase their work performance. As well, the government plays a part in developing micro-irrigation systems. It should encourage farmers to adopt this irrigation system on their potato cultivation through promotional programs. Thereby, campaigns can be launched to create awareness and increase farmers' knowledge on micro-irrigation benefits as well as efficient ways of

implementation. Additionally, the government should highlight the increasing of work performance to farmers thus will encourage them to accept micro-irrigation technology. It is also relevant to encourage farmers to adopt it through financial aids or subsidies which provide opportunities for farmers to decrease the financial burdens on them. Besides, the opinion of other farmers, family members and agricultural organizations as well as NGOs in the community may also influence them to accept the micro-irrigation technology on potato farming. Furthermore, once adopted, the micro-irrigation system requires monitoring in order to ensure the safety and quality of this technology.

Lastly, this qualitative part is the door for quantitative research regarding the adoption of a micro-irrigation system on potato farming which will be discussed in the next chapter.

Chapter 3

A Structural Equation Model

3.1. Introduction

After gaining insights from the focus group study, we present, in this chapter, a quantitative study. The latter generates logic and objective results communicated through statistics and numbers. It is an essential step to explore and analyze the factors affecting the adoption of a micro-irrigation system among the potato farmers in the Bekaa valley of Lebanon.

To achieve the research objective, we modified the original UTAUT model used in the qualitative chapter, to consider factors related to farmers' risk perception (FRP) associated with the adoption of micro-irrigation systems.

Risk perception is defined as the combination of uncertainty and the seriousness of the outcome (Bauer, 1960, 1967) as well as the expected losses associated with a specific purchase acting though as an inhibitor of the purchase behaviour (Peter & Ryan, 1976). So that risk perception is thought as an uncertainty regarding possible negative consequences of using a certain product or service.

In the e-commerce field, risk perception was found as an important barrier of the consumer acceptance of e-services. Jarvenpaa et al. (1999) and Pavlou (2001)showed that due to risk concerns consumers had a reluctance to finish online transactions (Hoffman et al., 1999). In this regard, we decided to engage in this quantitative research the risk perception variable to study the farmers' adoption of a micro-irrigation system.

We use a simplified version of the model proposed by Featherman and Pavlou (2003) in which the perceived risk is theorised to affect the adoption of a new technology (the original model of Featherman and Pavlou (2003) was related to the consumer acceptance of e-services). Various authors (Cocosila et al., 2009; Featherman & Pavlou, 2003; Im et al., 2008; Martins et al., 2014; Sitkin & Pablo, 1992) have addressed the importance of risk as a predictor of technology acceptance. According to Featherman and Pavlou (2003), risk perception should be linked to the UTAUT model through two links: (i) on the one hand, the perceived ease of use of the new technology may significantly diminish the perceived risk associated with its adoption; (ii) on the other hand, the new technology perceived as risky may reduce its perceived PE and likelihood of adoption. In this work, FRP was evaluated by two sub-facets: (i) overall and financial risk, which are supposed to consider the level of farmers' risk aversion; (ii) micro-irrigation implementation risk, which accounts for the perceived risk of adopting a micro-irrigation technology. In summary,

through this model, we introduce the hypothesis that the higher the farmers' risk aversion (i.e., the values of the three risk items), the lower their intention to invest in new micro-irrigation systems will be. Moreover, we hypothesised that FRP can be moderated by education levels since these may reduce a farmer's risk aversion (Knight et al., 2003). In Figure 28, we present the final research model.

Overall, the present study analysed several hypotheses that can drive the adoption of a new micro-irrigation system in the Bekaa Valley. Specifically, we tested the following hypotheses:

H1: PE has a positive and significant impact on the BI to adopt a new micro-irrigation system.

H1a: Age moderates the relationship between PE and BI.

H2: EE has a positive significant influence on the BI to introduce a new micro-irrigation system.

H2a: Age moderates the relationship between EE and BI.

H2b: Experience mediates the relationship between EE and BI.

H3: SI has a positive and significant relationship with the BI to adopt a new micro-irrigation system.

H3a: Age moderates the relationship between SI and BI.

H3b: Experience mediates the relationship between SI and BI.

H3c: Voluntariness of use mediates the relationship between SI and BI.

H4: FCs have a positive significant impact on the UB of a new micro-irrigation system.

H4a: Age moderates the relationship between FC and UB.

H4b: Experience mediates the relationship between FC and UB.

H4c: Voluntariness of use mediates the relationship between FC and UB.

H4d: Gross unit margin mediates the relationship between FC and UB.

H5: BI has a positive and significant impact on the UB of a new micro-irrigation system.

H6: FRP can negatively and significantly affect the BI to adopt a new micro-irrigation system.

H7: FRP negatively and significantly affects the PE of micro-irrigation systems.

H7a: Educational level mediates the relationship between FRP and PE.

H8: EE can negatively influence the FRP.

H8a: Educational level mediates the relationship between EE and FRP.

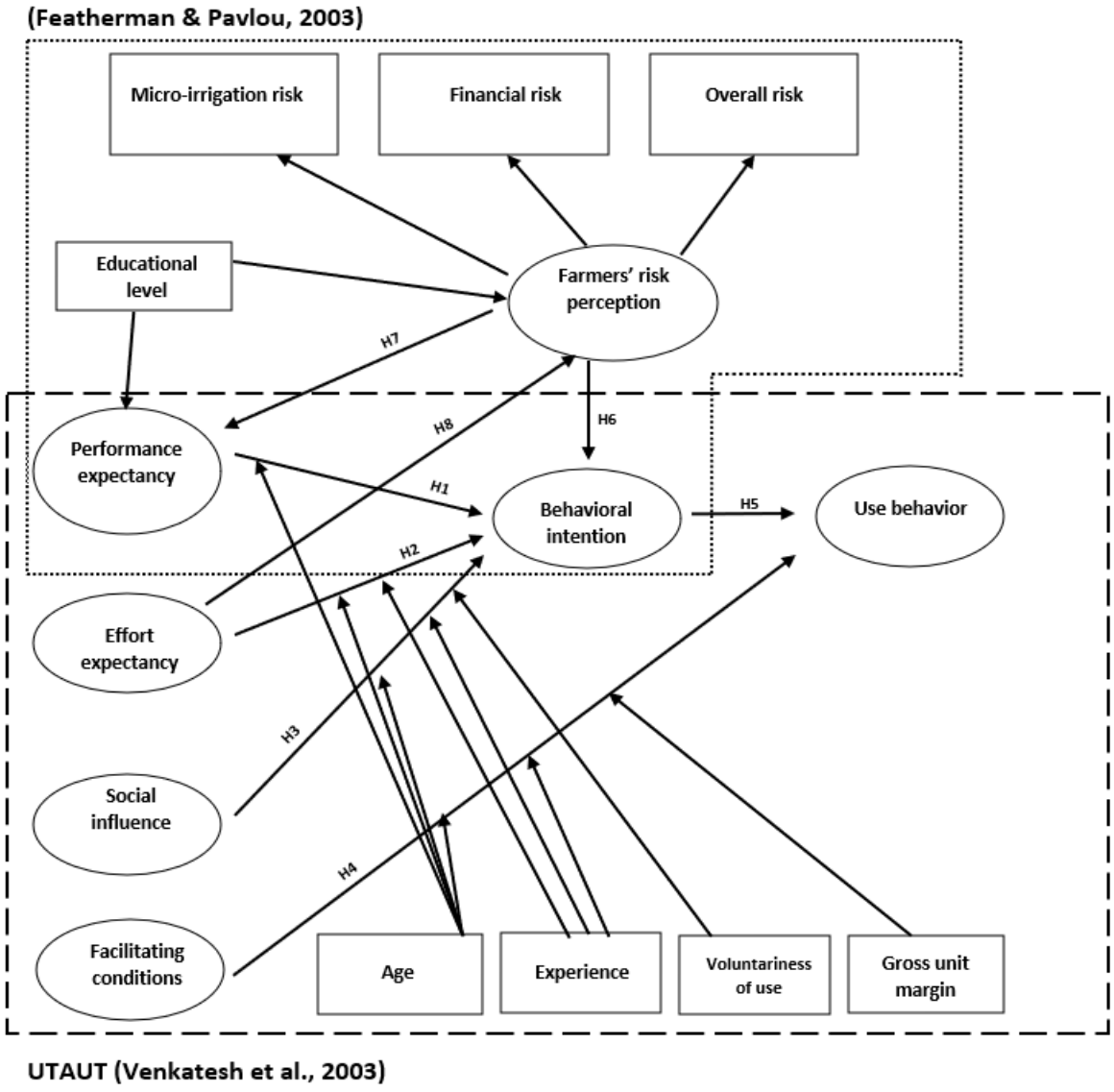


Figure 28 Research model

3.2. Materials and methods

3.2.1. Sampling and data collection

A quantitative study was conducted in the Bekaa Valley of Lebanon by targeting farmers located in its three main districts (North, Central, and West Bekaa). A random sample of potato farmers using the ordinary sprinkler irrigation system in the three main districts of the Bekaa Valley was selected for the study. The total number of potato growers in the area is approximately 500 (identified while interviewing the president of the syndicate of potato growers in the Bekaa Valley), of which 35, 20 and 45% are located in North Bekaa, Central Bekaa and West Bekaa, respectively. The survey was conducted using a Google Forms questionnaire administered face to face by a team of three

agricultural engineers who received 3 days of training in techniques and ethical features of questionnaires taught by one of the authors (who was also part of the team). A pilot test that involved 40 farmers was conducted in December 2020 to evaluate the reliability and validity of the questionnaire's items and scales. The main survey was conducted between January and March 2021.

The study's purpose was explained to all participants via previous phone calls and before the surveys. The significance of confidentiality and the privacy of all participants was reasserted at the beginning of the interviews, which lasted between 12 and 15 minutes.

3.2.2. Survey design

The survey was developed based on insights obtained from six previous focus groups conducted in the same area from April to March 2020. The quantitative questionnaire was divided into two sections. The first section included questions related to the farmers' socio-economic characteristics and the moderating variables proposed in the conceptual framework (i.e., gender, age, educational level, household assets, farming practices, percentage of share of potato land, gross margin, type of distribution channel, potato production quantity, micro-irrigation experience and voluntariness of use). This survey section featured the use of nominal and ordinal scales.

The second section contained questions about the FRP, anxiety and the major constructs included in the UTAUT model. Specifically, PE was measured using seven items concerning different perceptions of farmers regarding the micro-irrigation system, including its potential benefits linked to improved water management, increases in potato yield and quality, the possible reduction of energy costs, and improved plant disease management and control through greater pesticide and fertiliser efficiency. EE was evaluated using five items related to micro-irrigation system use on potatoes: perceived ease of use, the volume of effort required, specialised workforce requirements (or lack thereof), time savings and the likelihood of participants' skilful utilization. SI was measured using six items reflecting the perceptions of how people whose opinions are important to the farmers influence the adoption of micro-irrigation systems, the degree to which peers could affect the use of this new system and the effect of farmers' moral obligation norms on adopting a micro-irrigation system to preserve water resources for the sake of protecting the environment while avoiding the alteration of growing potatoes by rain-fed agriculture. Furthermore, the FC construct was assessed with four items related to disclosing the ability to access required resources or the necessity to obtain advanced training and the support necessary for using the micro-irrigation system. Since risk behaviour can affect the adoption of new technologies (Marra et al., 2003),

farmers' risk latent variable was measured by three types of risks (i.e., overall, financial, micro-irrigation implementation) to reveal the presence of risk-averse or risk-taking farmers.

Attitudes, intentions and preferences cannot be quantified directly (Straub et al., 2004). However, they can be indirectly quantified through observed and measurable indicators using scaling approaches (Gefen et al., 2000). To this end, a five-point Likert-type scale ranging from strongly disagree (-2) to strongly agree (2) was used to measure the participants' beliefs and opinions towards the acceptance of a micro-irrigation system. Risk perception items (i.e., overall risk, financial risk and micro-irrigation risk) ranged from 'extremely risky' (-2) to 'not at all risky' (2).

3.2.3. Statistical and econometric analysis

Structural equation modelling (SEM) was employed to analyse the relationships among the aforementioned variables. Notably, the SEM technique has been applied to the UTAUT model by various authors (Guggemos et al., 2020; Kim et al., 2015; Lakhal et al., 2021; Tsourela & Roumeliotis, 2015). SEM is a multivariate analysis that integrates factor and path analysis (Garson, 2015) and allows researchers to test and estimate a set of hypothesised relationships between numerous independent and dependent variables, each of which can be assessed by a set of indicators based on a theoretical model (Gefen et al., 2000; Vinzi et al., 2010). There are two types of SEM: (i) covariance-based SEM, which is generally used to test theories; (ii) PLS-SEM, which is used generally to broaden theories in exploratory research (Hair et al., 2016). Since PLS-SEM is geared towards theory development and prediction, this study shall refer to the latter type of SEM.

The specification of a PLS-SEM requires two steps. In the first step, a measurement model is specified that defines the latent variables in terms of the indicators that outline them. In this way, principal component analysis is usually performed by computing the factor loadings to assess the relative importance of explaining the variance of the latent variable. Factor loadings greater than 0.70 reflect that an indicator loads significantly on a construct providing acceptable indicator reliability (Chin, 1998; Garson, 2013; Hair et al., 2019). However, a factor loading greater than 0.50 is also a widely accepted threshold for significance (Hair et al., 2013). Moreover, the variance inflation factor (VIF) is often used to evaluate the presence of collinearity among indicators. VIF values should be lower than or equal to 3 to exclude collinearity issues (Hair et al., 2019). The internal consistency and reliability of different items as a group are usually evaluated according to Cronbach's alpha, with values ranging from 0.70 to 0.95 being considered acceptable (Bland & Altman, 1997; Hair et al., 2019; Nunnally, 1994a, 1994b). Next, the convergent validity of each construct is measured using the average variance extracted (AVE). The AVE is a measure of the

amount of variance that is seized by each construct in relation to the amount of variance due to measurement error. Values greater than 0.50 reveal that the construct explains at least 50% of the variance of its items (Hair et al., 2010; Henseler et al., 2009). AVE statistics are also useful in testing the discriminant validity of each construct. In this case, the Fornell and Larcker (1981) criterion suggests that the square root of each construct's AVE should be compared to the squared inter-construct correlation. A further analysis of the discriminant validity of each construct can be assessed using the heterotrait-monotrait ratio (HTMT) (Henseler et al., 2015). The HTMT reflects the mean of the item correlations across all constructs relative to the geometric mean of the average correlations for the items measuring the same construct. Values lower that the threshold of 0.90 are usually accepted (Hair et al., 2016; Hair et al., 2019; Henseler et al., 2015).

The second step of PLS-SEM analysis requires the estimation and testing of the structural model. The major purposes of this step are to analyse the links between the variables included in the model and to evaluate the hypothesised theoretical relationships (Hair et al., 2013). The general assessment criteria are the coefficient of determination (R^2) and the statistical significance and relevance of the path coefficients (Hair et al., 2011).

3.3. Results

3.3.1. Socio-demographic and economic characteristics of respondents

The survey was completed by a total of 220 randomly selected farmers. Overall, 20 questionnaires were eliminated due to being incomplete or containing compilation errors. Therefore, the analysis was conducted using a total sample size of 200 respondents. In the absence of official statistics, we interviewed the president of the syndicate of potato growers in the Bekaa Valley to obtain information on the total number of potato growers in this area. He reported that a total of approximately 500 potato growers were working in the area. Thus, the sample size of 200 farmers included in the analysis is statistically appropriate for representing the potato grower population located in the Bekaa Valley, permitting a ± 5% margin of error.

In Table 2, we present the demographic and socio-economic characteristics of the participants. Out of the 200 respondents, 69, 36 and 95 participants were from North, Central and West Bekaa, respectively. This composition broadly reflects the distribution of potato farmers in the Valley that was indicated by the president of the potato growers' syndicate. All participants were males since no women were running farms in the area. Farmer age was measured following three categories:

less than 45 years, 45–60 years and more than 60 years old. In the overall Bekaa region, the farmers were mostly aged from 45 to 60 years. They had an average family size of five people (s=0.14) and, on average, only one member of the household worked on the farm (overall Bekaa: $\bar{x}$ =1.29, s=0.04), while some households had a member involved in off-farm work (overall Bekaa: $\bar{x}$ =0.71, s=0.07). Moreover, approximately 44% (s=0.04) of farmers declared that their income depends also on external activities. The educational level of the participants was evaluated based on the following scale: farmers who did not attend school; those who attended primary school; those who earned a secondary or university diploma. The results presented in Table 2 indicate that in the three studied regions, the majority of participants possessed a secondary education and nearly all farmers had between 10 and 30 years of farming experience.

Previous micro-irrigation experience was assessed by a dichotomic variable where 0 was associated with 'don't have any micro-irrigation experience' and 1 was associated with 'I have experience with micro-irrigation'. Most farmers declared not having any experience with micro-irrigation (overall Bekaa $\bar{x}$ =0.12, s=0.02). Moreover, the majority of farmers stated not having social participation as being a member of an agricultural organisation or association (overall Bekaa $\bar{x}$ =0.35, s=0.03). Furthermore, the share of potato land against the total cultivated land showed an average value of 82.9% (s=2.83) in the three main districts, thereby confirming that potato cultivation is the main crop produced in the area. The average farmer cultivated 75 hectares of potato land ($\bar{x}$ =75.2, s=27.8) with private management. Moreover, there were three main potato distribution channels: wholesale, agents and/or export channels. On average, each potato grower in the region used approximately two channels ($\bar{x}$ =1.42, s=0.04). The gross margin for potato sales over the last 3 years was similar in the three main districts, with a mean value of 10.15% (s=1.10) for the Bekaa Valley. Finally, all previous results did not seem affected by geographical differences between the three regions since mean pairwise test statistics did not reveal a rejection of the null hypothesis of equal means (for brevity, we do not report these values; however, they are available upon request).

Table 2 Summary statistics of the socio-economic variables

Socio-economic variables	Response scale	North Bekaa *(N=69)*		Central Bekaa *(N=36)*		West Bekaa *(N=95)*		Overall Bekaa *(N=200)*	
		Mean	*Std.Dev*	Mean	Std.Dev	*Mean*	*Std.Dev*	*Mean*	*Std.Dev*
Age	0: Less than 45 years 1: 45-60 years 2: More than 60 years	0.99	0.10	1.22	0.14	1.14	0.06	1.14	0.06
Educational level	0: Not attended the school 1: Primary 2: Secondary 3: University	1.93	0.11	1.94	0.14	1.82	0.10	1.88	0.06
Number of family members	Number	4.51	0.25	4.72	0.24	4.71	0.21	4.64	0.14
Number of Household members on-farm work	Number	1.29	0.07	1.44	0.12	1.23	0.06	1.29	0.04
Number of household members in off-farm sector	Number	0.58	0.11	0.80	0.17	0.77	0.10	0.71	0.07
Farming Experience	0: Less than 10 years 1: 10 - 30 years 2: More than 30 years	1.07	0.10	1.27	0.13	1.18	0.07	1.16	0.05
Other financial income	0: No 1: Yes	0.32	0.06	0.58	0.08	0.44	0.05	0.43	0.04
Total land area	Hectares	125	72.8	248.4	148.7	58.7	14.7	158	37.4
Potato cultivation area (ha)	Hectares	45.4	15.7	222	147.7	41.2	11.1	75.2	27.8
Share of potato land	Percent	80.30	3.48	78.00	5.42	86.61	5.00	82.88	2.83
Land Management	0: Rented land 1: Private land 2: Both private and rented	1.03	0.10	1.11	0.14	0.93	0.08	0.99	0.06
Wholesale channel	0: No 1: Yes	0.45	0.06	0.47	0.08	0.45	0.05	0.46	0.04
Intermediaries/Agents channel	0: No 1: Yes	0.68	0.05	0.86	0.06	0.72	0.05	0.73	0.03
Export channel	0: No 1: Yes	0.25	0.05	0.11	0.05	0.26	0.05	0.23	0.03
The overall number of channels per farmer	Numbers	1.39	0.07	1.44	0.09	1.42	0.06	1.42	0.04
Gross Margin (%)	Percent	12.15	2.14	10.00	2.09	8.74	1.52	10.15	1.10
Social Participation	0: No 1: Yes	0.30	0.06	0.58	0.08	0.29	0.05	0.35	0.03
Micro irrigation experience	0: I don't have experience 1: I have experience	0.07	0.03	0.19	0.07	0.12	0.03	0.12	0.02

3.3.2. Results for UTAUT behavioural variables

3.3.2.1. Measurement model

The measurement model was assessed for indicator reliability, internal consistency and convergent validity using confirmatory factor analysis. Table 3 summarises the descriptive statistics of the UTAUT's model components and the differences between the constructs. All items were evaluated using a five-point scale ranging from -2 to 2. Differences were tested by performing pairwise t-tests (not reported for the sake of space) on the average summation scores for items obtained after having assessed reliability using Cronbach's α for each construct. The reliability of each indicator was assessed by examining the loadings and the VIF. Factor loading values greater than or equal to the threshold level of 0.70 and VIF values lower than or equal to 3 were treated as significant, as recommended by (Hair et al., 2019).

The PE scores indicate that farmers agreed that the micro-irrigation system provides benefits. The results highlight that farmers have a high PE of micro-irrigation systems, especially concerning the yield increase and better quality of potato production. They also believe that a micro-irrigation system will help them reduce energy costs and potato disease incidence while improving the efficient use of pesticides and fertilisers. No differences were noted among the three zones when applying pairwise *t*-tests.

Concerning EE, participants perceived the implementation of a micro-irrigation system as a strategy to reduce efforts related to the actual time spent on irrigation management.

Concerning the SI construct, the findings showed that farmers perceived the new system as a way to avoid moving to rain-fed irrigation and as a moral obligation to preserve water.

Concerning the FC construct, potato farmers reported that it is important to receive effective training to raise their awareness about the use of micro-irrigation systems. Moreover, they believe that certain types of subsidies could help them to facilitate the introduction of micro-irrigation systems in their land. No significant differences were observed between the three main districts since pairwise tests did not reject the null hypothesis of equal means among the different areas of the Bekaa Valley.

The FRP construct showed that farmers in Bekaa Valley generally show risk-averse attitudes not only towards general decisions but also concerning the implementation of micro-irrigation

systems in their fields. Risk-taking decisions only seemed to emerge from the analysis with respect to financial risk.

Regarding the behavioural intention to invest in micro-irrigation systems, participants in Central Bekaa were pessimistic ($\bar{x}$ = -0.22, s=0.24) about the possible implementation of this technology. This result could be partly related to the economic and social instability of the country initiated with the economic setback of October 2019, which was aggravated by the COVID-19 pandemic and peaked with the destructive Beirut port explosion in August 2020. Concerning the use behaviour construct, farmers showed a neutral position regarding the desire to implement micro-irrigation. In the case of a possible adoption, most of them would begin to implement it on an average of 30% of their land.

Table 3 Summary statistics of the micro irrigation related items and latent components

Micro Irrigation (MI) items and latent components	Loading	North Bekaa*(N=69)*		Central Bekaa*(N=36)*		West Bekaa*(N=95)*		Overall Bekaa *(N=200)*	
		Mean	***Std.Dev***	***Mean***	***Std.Dev***	***Mean***	***Std.Dev***	***Mean***	***Std.Dev***
Performance Expectancy		0.52	0.13	0.35	0.22	0.43	0.11	0.45	0.08
I think MI would increase my yield	0.89	0.43	0.16	0.22	0.27	0.33	0.14	0.35	0.10
I think MI enhances the potato quality	0.88	0.33	0.17	0.11	0.26	0.30	0.14	0.28	0.10
I find MI would reduce energy costs	0.76	0.90	0.13	1.11	0.16	0.87	0.09	0.93	0.07
I find MI allows efficiency in fertilizers' and pesticides' use	0.85	0.65	0.16	0.39	0.25	0.40	0.13	0.49	0.09
I think MI reduces disease incidence	0.86	0.28	0.17	-0.08	0.27	0.25	0.14	0.20	0.10
Effort Expectancy		0.70	0.15	0.22	0.27	0.43	0.14	0.49	0.10
I find MI does not need a lot of effort	0.94	0.70	0.17	0.11	0.28	0.29	0.15	0.40	0.11
I think MI would save time in respect to my actual irrigation system	0.94	0.71	0.16	0.33	0.28	0.56	0.14	0.57	0.10
Social Influence		0.90	0.12	0.85	0.16	0.86	0.08	0.87	0.06
I feel a moral obligation to modify my current irrigation system in order to save water to face the impact of climate change	0.96	0.91	0.13	0.89	0.16	0.88	0.09	0.90	0.07
I feel a moral obligation to use MI in order not to be forced to move from growing potatoes to a rain-fed agriculture	0.97	0.88	0.12	0.81	0.17	0.83	0.09	0.85	0.06
Facilitating Conditions		1.38	0.08	1.13	0.16	1.19	0.08	1.25	0.05
I need subsidies to be able to implement the MI system	0.75	1.59	0.08	1.11	0.20	1.32	0.10	1.38	0.07
I need trainings to raise my awareness about the benefits of the MI and to technically know how use it in a proper way	0.89	1.17	0.10	1.14	0.17	1.07	0.09	1.12	0.06
Farmers' Risk Perception		0.01	0.12	0.56	0.16	0.07	0.10	0.14	0.07
In general, how much risky I would say are my behaviour and the decisions I take?	0.92	0.07	0.14	0.83	0.17	0.19	0.11	0.27	0.08
For the implementation of a micro-irrigation system in my farm, how much risky I would say are my behaviour and the decisions I take?	0.95	0.16	0.12	0.78	0.16	0.21	0.10	0.30	0.07
With regards to finance, how much risky I would say are my behaviour and the decisions I take?	0.91	-0.20	0.13	0.08	0.19	-0.18	0.11	-0.14	0.08
Behavioural Intention									
I am very likely to adopt the MI system on potato cultivation in the next 12-24 months		-0.04	0.14	-0.22	0.24	0.24	0.15	0.06	0.10
Use Behaviour		17.28	1.70	14.08	2.33	15.09	1.34	15.67	0.96
Percentage of my land on which I will adopt MI	0.92	34.06	3.26	27.78	4.43	29.74	2.57	30.88	1.84
I really want to use micro-irrigation to improve my potato cultivation	0.94	0.51	0.18	0.39	0.29	0.45	0.15	0.46	0.11

The construct reliability was assessed by evaluating the composite reliability (CR) and Cronbach's alpha (CA). The results presented in Table 4 suggest that the CR and CA results for each variable are above the accepted threshold levels, which demonstrates the presence of internal consistency. The convergent validity was assessed using the AVE. Table 4 also shows that the AVE results for each construct are higher than the threshold of 0.5, which determines

convergent validity. To assess discriminant validity, both the Fornell-Larcker criterion and the HTMT were adapted. Table 4 presents the Fornell-Larcker results. The square roots of the AVE for each construct (PE (0.84), EE (0.94), SI (0.95), FC (0.82), FRP (0.93)) were all higher than the correlations of these constructs with other latent variables. This reveals that all constructs are valid measures of unique concepts. The HTMT values are presented in Table 5. Notably, all HTMT values were equal to or lower than the threshold level of 0.90. Therefore, we conclude that all the constructs show evidence of discrimination.

Table 4 Reliability and validity measures: CR, CA, and AVE of latent variables

	CR	CA	AVE	PE	EE	SI	FC	FRP	BI	UB	AGE	ExpMI	VoUS	UNMARG
PE	0.92	0.90	0.71	**0.84**										
EE	0.94	0.87	0.88	0.00	**0.94**									
SI	0.95	0.92	0.93	0.61	0.61	**0.95**								
FC	0.81	0.54	0.68	0.00	0.47	0.00	**0.82**							
FRP	0.95	0.92	0.86	-0.19	-0.03	0.00	0.08	**0.93**						
BI	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	**1.00**					
UB	0.92	0.84	0.86	0.71	0.74	0.61	0.42	-0.26	0.83	**0.93**				
AGE	NA	NA	NA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.00**			
ExpMI	NA	NA	NA	0.00	-0.06	0.00	0.00	0.00	-0.11	0.00	0.02	**1.00**		
VoUS	NA	NA	NA	0.45	0.60	0.45	0.55	-0.07	0.68	0.72	-0.14	-0.20	**1.00**	
UNMARG	NA	NA	NA	0.04	0.08	0.07	0.05	-0.02	0.04	0.00	-0.05	-0.03	0.00	**1.00**
EDUC	NA	NA	NA	0.00	0.00	0.00	0.00	0.00	0.06	0.00	-0.62	0.00	0.00	0.00

Note: Diagonal elements are the square root of the Average Variance Extracted (AVE).
NA: not applicable

Table 5 The Heterotrait-Monotrait Ratio (HTMT) values

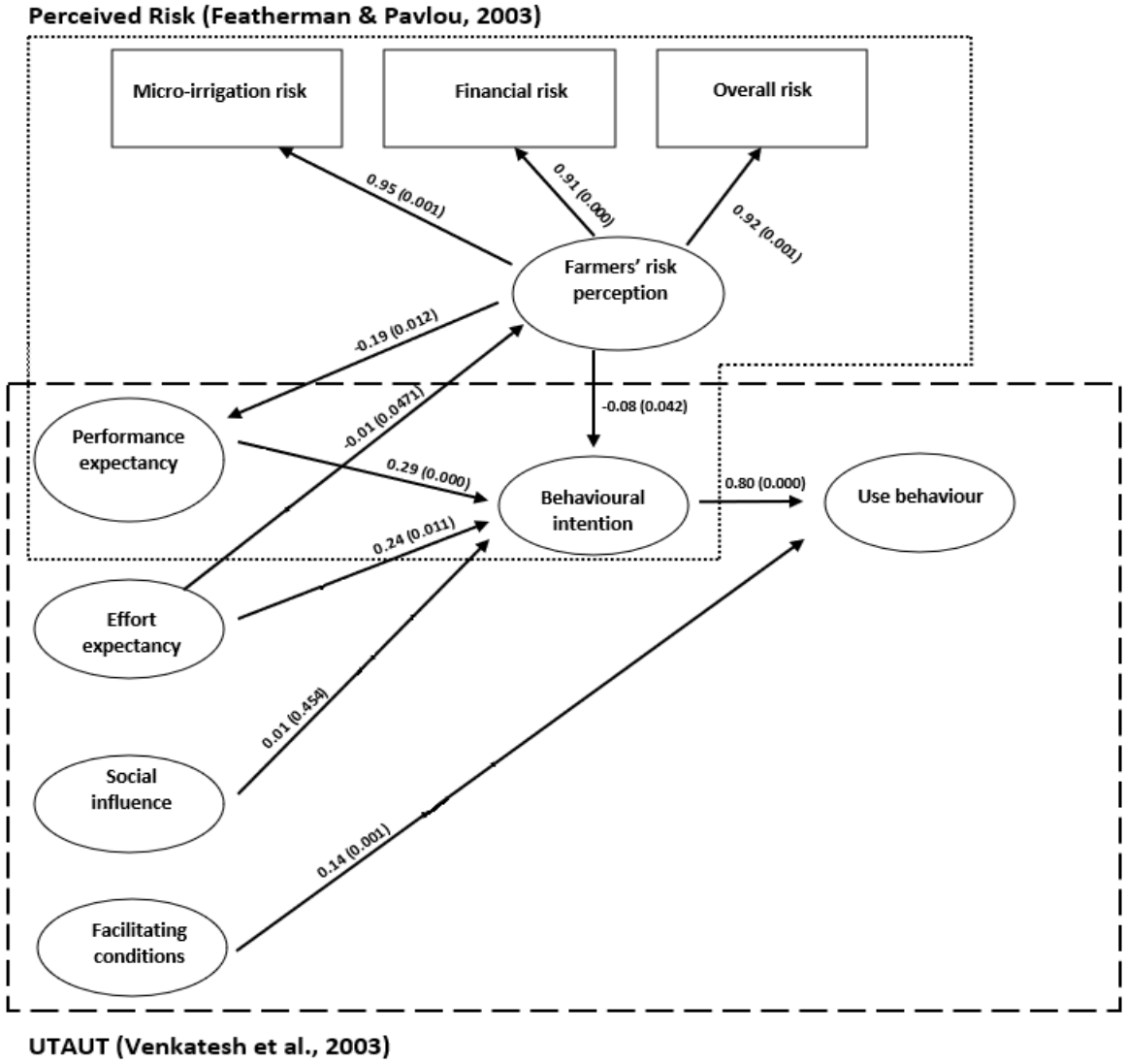
	PE	EE	SI	FC	FRP	BI	UB	AGE	ExpMI	VoUS	UNMARG
EE	0.00										
SI	0.67	0.69									
FC	0.00	0.70	0.00								
FRP	0.22	0.04	0.00	0.13							
BI	0.00	0.00	0.00	0.00	0.00						
UB	0.81	0.86	0.69	0.60	0.30	0.90					
AGE	0.00	0.00	0.00	0.00	0.00	0.00	0.00				
ExpMI	0.00	0.06	0.00	0.00	0.00	0.11	0.00	0.02			
VoUS	0.46	0.65	0.47	0.74	0.07	0.68	0.78	0.14	0.20		
UNMARG	0.05	0.09	0.07	0.07	0.02	0.04	0.00	0.05	0.03	0.00	
EDUC	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.62	0.00	0.00	0.00

3.3.2.2. Estimation results – Structural model

In Figure 29 and Table 6, we present the estimation results of the PLS-SEM. As shown in Table 6, several models were tested. The UTAUT and FRP (UTAUT + FRP), which is the research model with interaction effects (D + I) and without them (D) to evaluate whether the moderator's age, prior micro-irrigation experience, voluntariness of use, gross unit margin and educational level influenced the behavioural intention and use behaviour. The UTAUT without FRP was also tested with interaction effects (D + I) and without them (D). In all of the tested models, the adjusted R^2 values for both behavioural intention and use behaviour were higher than 0.25, thereby excluding weak model power (Hair et al., 2016). Upon comparing the estimated models, it was shown that the inclusion of moderators increased the adjusted R^2 for both behavioural intention (0.55 vs. 0.65 for UTAUT and UTAUT + FRP, respectively) and use behaviour (0.71 vs. 0.74 for UTAUT and UTAUT + FRP, respectively). Moreover, upon adding the FRP variable and moderating effects, the adjusted R^2 for use behaviour increased from 0.71 (UTAUT (D+I)) to 0.74 (UTAUT+FRP (D+I)). Thus, adding the FRP to the UTAUT model with its moderating effects helps to explain variance in the use behaviour construct better than all other models. Therefore, we focused on the analysis of the main research model (UTAUT + FRP (D+I)). Figure 29 presents the path coefficients of the research model. The bootstrapping technique involving 5000 iterations (Hair et al., 2017) was used. The results show that PE ($\beta = 0.29$, $p = 0.00$) was the most predictive factor of potato farmers' behavioural intention to invest in micro-irrigation systems, followed by EE ($\beta = 0.24$, $p = 0.01$). These two latent variables positively and significantly impacted the behavioural intention variable. Interestingly, the results indicated that the SI has no significant impact on their behavioural intention to adopt micro-irrigation systems ($\beta = 0.01$, $p= 0.45$). Furthermore, the results revealed that the FCs had a significant impact on the potato farmers' behaviour regarding the use of micro-irrigation systems on their lands ($\beta = 0.14$, $p= 0.00$). The FRP constructs had a significant and negative effect on PE ($\beta = -0.14$, $p = 0.03$) and behavioural intention among potato farmers ($\beta = -0.08$, $p = 0.04$), revealing the importance of risk aversion in influencing the adoption of micro-irrigation systems. On the contrary, EE had no significant effect on risk perception ($\beta = -0.01$; $p = 0.47$). As expected, the potato farmers' behavioural intention had a strong and significant impact on the use of micro-irrigation ($\beta = 0.80$, $p = 0.00$). Regarding the moderating effects presented in Table 6, only the direct effect of voluntariness of use on behavioural intention was statistically significant ($\beta = 0.44$; $p = 0.00$). The direct effect of prior experience in micro-irrigation ($\beta = 0.11$; $p = 0.00$) and the gross unit margin ($\beta = 0.11$; $p = 0.00$) were statistically significant in terms of use behaviour. Furthermore, educational level was negatively and significantly related to PE ($\beta = -0.08$,

p = 0.04) and FRP (β = -0.14, p = 0.03). Regarding the product-indicator results, age moderated the effect of EE on behavioural intention (β = 0.11, p = 0.05), while voluntariness of use moderated the effect of SI on behavioural intention (β = 0.10, p = 0.03) and gross unit margin moderated the effect of FCs on use behaviour (β = 0.11, p = 0.00). Moreover, educational level moderated the effect of EE on FRP (β = -0.16, p = 0.02) and the effect of FRP on PE (β = -0.16, p = 0.00). The other interaction effects were not significant (see Table 6).

In summary, the results of the PLS-SEM strongly support the use of the extended UTAUT+FRP model to predict potato farmers' behavioural intention and use behaviour in micro-irrigation adoption. The research model was able to explain 65% of the variance in their behavioural intention and 74% of the variance in their use behaviour related to adopting micro-irrigation systems.



Note: For the outer model, the loadings and their p-values (in parentheses) are reported. For the inner model, the path coefficients and their p-values (in parentheses) are reported.

Figure 29 The estimated structural equation model

Table 6 Structural model with path coefficients and R-squares for models with UTAUT and UTAUT and Perceived Risk, with direct (D) effects only, and with direct and interaction effects (D + I)

	UTAUT		UTAUT + Farmers' Risk Perception	
	D	D+I	D	D+I
Behavioural intention				
R^2 Adj.	0.55**	0.65**	0.55**	0.65**
Performance expectancy (PE)	0.32**	0.31**	0.31**	0.29**
Effort expectancy (EE)	0.42**	0.21*	0.45**	0.24**
Social influence (SI)	0.08	0.04	0.05	0.01
Farmers' Risk perception (FRP)			0.06	-0.08*
Age		0.07		0.05
Experience in micro-irrigation (ExpMI)		-0.01		-0.04
Voluntariness of use (VoUS)		0.45**		0.44**
PE x Age		-0.08		-0.09
EE x Age		0.09		0.11*
EE x ExpMI		0.05		0.05
SI x Age		0.03		0.02
SI x ExpMI		-0.07		-0.07
SI x VoUS		0.10*		0.10*
Use Behaviour				
R^2 Adj.	0.71**	0.74**	0.71**	0.74**
Facilitating conditions (FC)	0.13**	0.14**	0.13**	0.14**
Behavioural intention (BI)	0.79**	0.80**	0.79**	0.80**
Age		-0.06		-0.06
Experience in micro-irrigation (ExpMI)		0.11*		0.11**
Gross unit margin (UNMARG)		0.11*		0.11**
FC x Age		-0.03		-0.03
FC x ExpMI		0.02		0.02
FC x UNMARG		0.10*		0.10*
Risk Perception				
Educational level (Educ)				-0.28**
Effort expectancy (EE)				-0.01
EE x Educ				-0.16*
Performance expectancy				
Educational level (Educ)				0.13*
Farmers' Risk Perception (FRP)				-0.14*
FRP x Educ				-0.16**

Note: * p-values < 0.05, ** p-values < 0.01; all other path coefficients are not significant

3.4. Discussion and conclusions

Climate change and extreme weather events, such as prolonged droughts combined with repeated heatwaves, are projected to become more frequent in Lebanon and affect specialised areas of agricultural production such as the Bekaa Valley (UNDP, 2021). Notably, a growing interest in the need to put water mitigation strategies in place has emerged (MoE, 2016; MoE, 2011). Water demand in the Bekaa Valley is often greater than water supply, which is primarily obtained from groundwater sources that are being depleted (Karam & Karaa, 2000) due to the semi-arid environment (UNDP, 2021). Water management in agriculture requires technological interventions such as micro-irrigation. Notably, the implementation of micro-irrigation may induce significant benefits. In arid and semi-arid regions such as the Bekaa Valley, micro-irrigation may ensure water saving in crop production. Benefits have also been noted in terms of crop yield and quality, reduced energy consumption, decreased labour inputs and the more efficient use of fertilisers and pesticides (Kumar et al., 2016). Thus, improving water use efficiency through micro-irrigation in potato cultivation is a strategic approach to addressing the Bekaa region's water scarcity.

Table 7 presents the outcomes of the tested hypotheses. According to the results of the PLS-SEM model, PE, EE and FRP significantly impacted the potato farmers' behavioural intention while SI did not show a significant relationship with their behavioural intentions. Notably, the FC variable positively influenced the use behaviour.

Following the path coefficients' rankings, PE plays a central role in affecting farmers' behavioural intention to adopt micro-irrigation. Thus, the farmers were driven to accept the micro-irrigation system based on their confidence in its usefulness. This implies that farmers would accept micro-irrigation based on their expectation that using this system for potato production would help them gain benefits in potato farming, which is consistent with results obtained in previous studies (Alshehri et al., 2019; Im et al., 2011; Ronaghi & Forouharfar, 2020; Yu, 2012). Based on our analysis, it emerged that farmers were convinced that micro-irrigation reduces energy costs. However, they showed hesitancy regarding the achievement of increased potato yield, the generation of better potato quality, the reduction of disease incidence and the efficient use of fertilisers and pesticides following the adoption of a micro-irrigation system. The prior focus group analysis showed that farmers were hesitant to adopt micro-irrigation due to the lack of information they had about the system's usage. This means that having specialists run workshops and seminars to improve farmers' knowledge of how micro-irrigation works and the advantages related to introducing this system would likely increase the levels of acceptance and adoption. Furthermore, agricultural extensions were found to reduce these technical gaps (Lampach & Phu, 2021), resulting

in the more widespread adoption of this new technology. Similarly, Namara et al. (2005) reported the need to augment extension services to enhance the technical knowledge and the ease of using micro-irrigation technology.

Notably, EE is the second most influential construct affecting behavioural intention. Our results highlighted that potato farmers preferred to adopt systems that require less effort and time than ordinary sprinklers on potato crops. Similar results were obtained in different fields by Im et al. (2011), Wang and Shih (2009) and Venkatesh et al. (2003), who found that EE had a positive and significant relationship with behavioural intention. Thus, to enhance the use of micro-irrigation systems, the challenge facing local non-governmental organisations, agricultural associations and the Ministry of Agriculture is jointly coordinating the development of initiatives for planning site training. Through such initiatives, pilot area studies and field training can be launched to create awareness and increase farmers' knowledge on micro-irrigation benefits as well as efficient methods of implementation (USAID-LRBMS, 2012(a)). Additionally, our study revealed that SI did not have a significant impact on behavioural intention, which is similar to the results of previous works (Chismar & Wiley-Patton, 2002; Phichitchaisopa & Naenna, 2013). This suggests that farmers' moral obligation related to water conservation does not seem to influence their adoption of micro-irrigation. In contrast, we observed a significant impact of FCs on farmers' use behaviour. This result is not new since (Kijsanayotin et al., 2009; Zhou et al., 2010) reported the same finding. This suggests that our respondents were concerned about their surrounding environments and that appropriate training and subsidies could influence their use of micro-irrigation. Notably, factors such as a lack of training, awareness, resources and incentives could be preventing farmers from accepting and adopting micro-irrigation systems in the Bekaa region. The UTAUT model was extended to include the FRP. The results showed that micro-irrigation, financial and overall risks are salient concerns related to risk perception. Similar to Martins et al. (2014), our results reveal that risk perception is an important factor that negatively affects farmers' PE and their intention to use micro-irrigation systems. This reflects that the higher the risk aversion, the lower the investment in micro-irrigation would be. As result, policymakers and farmers associations must guarantee that micro-irrigation systems are technically feasible and improve yield and quality in potato crop production.

Furthermore, moderator age exhibited a significant impact on EE in terms of behavioural intention, which suggests that older farmers perceived the micro-irrigation as easy to use. Additionally, our study shows a significant and positive impact of previous experience on use behaviour, revealing that farmers who had prior experience with micro-irrigation were more likely to accept and use these systems than inexperienced farmers. Thus, previous experience affected the adoption of new

investments. This is unsurprising since the results of De Amicis et al. (2020) indicated that experts are more likely than non-experts to choose non-traditional investments. Similarly, the education moderator showed that less-educated farmers would have less confidence in using the micro-irrigation system Agarwal and Prasad (1999); Claar et al. (2014). Thus, the national government, donors and local authorities' interventions should target farmers in the Bekaa Valley based on their education level, especially among the younger generations. This strategy is expected to positively impact the introduction of new technologies (e.g., micro-irrigation systems) in the area.

Table 7 Hypotheses testing

Hypotheses	Relationship	Result
H1	PE has a positive and significant impact on the BI to adopt a new micro-irrigation system.	Supported
H1a	Age moderates the relationship between PE and BI.	Not supported
H2	EE has a positive significant influence on the BI to introduce a new micro-irrigation system.	Supported
H2a	Age moderates the relationship between EE and BI.	Supported
H2b	Experience mediates the relationship between EE and BI.	Not supported
H3	SI has a positive and significant relationship with the BI to adopt a new micro-irrigation system.	Not supported
H3a	Age moderates the relationship between SI and BI.	Not supported
H3b	Experience mediates the relationship between SI and BI.	Not supported
H3c	Voluntariness of use mediates the relationship between SI and BI.	Supported
H4	FCs have a positive significant impact on the UB of a new micro-irrigation system.	Supported
H4a	Age moderates the relationship between FC and UB.	Not supported
H4b	Experience mediates the relationship between FC and UB.	Not supported
H4c	Voluntariness of use mediates the relationship between FC and UB.	Not supported
H4d	Gross unit margin mediates the relationship between FC and UB.	Supported
H5	BI has a positive and significant impact on the UB of a new micro-irrigation system.	Supported
H6	FRP can negatively and significantly affect the BI to adopt a new micro-irrigation system.	Supported
H7	FRP negatively and significantly affects the PE of micro-irrigation systems.	Supported
H7a	Educational level mediates the relationship between FRP and PE.	Supported
H8	EE can negatively influence the FRP.	Supported
H8a	Educational level mediates the relationship between EE and FRP.	Supported

Conclusion

In the context of climate change and water scarcity affecting the Mediterranean region, especially in arid and semi-arid areas of Lebanon, the need for new water management policies is becoming urgent. Potato cultivation in the Bekaa valley of Lebanon can be devastatingly affected by the diminution of groundwater as well as the expected decrease in precipitation. Thus, various conditions threatening water balance make adaptation to climate change more difficult in Lebanon. So, adopting micro-irrigation on such type of crops can induce lots of benefits.

Given the importance of mitigation and adaptation policies devoted to a better management of water resources, a study of the farmers' perceptions and socio-economic factors in affecting the adoption of a new micro-irrigation system on potato crops was done using the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Venkatesh et al., 2003).

Two tools of analysis were provided. One utilizes the Focus Group Discussion and the second is related to a quantitative survey using the structural equation model approach (PLS-SEM). Both analyses identified that performance expectancy, effort expectancy and facilitating conditions strongly impact the potato farmers' behavioural intentions and use behaviour related to the new technology. In addition, the risk perception which was added to the UTAUT model in the quantitative survey part, influenced the adoption of a micro-irrigation system among potato farmers.

Performance expectancy was measured by the perceptions of using a micro-irrigation system in terms of providing benefits. Effort Expectancy was measured by the perceptions of ease of use of a micro-irrigation system. Further, social influence construct was measured by the perception of how people, whose opinion is important to the farmers, influence the adoption of micro-irrigation systems, the degree to which peers could affect the use of this new system, and the effect of personal moral obligation norms to adopt a micro-irrigation system for the sake of protecting the environment by preserving water resources. Facilitating conditions was measured by the perception of being able to access required resources, as well as to obtain knowledge, trainings and the necessary support needed to use micro-irrigation systems. And the risk perception construct, added in the quantitative part, was measured based on three types of risks (i.e., overall, financial, micro-irrigation implementation) in order to reveal the presence of risk-averse or risk-taking farmers.

The focus group discussion results revealed that micro-irrigation adoption has several advantages on potato cultivation such as saving water, labor, pesticides and fertilizers' use as well as increasing profits, reflecting the performance expectancy construct. Regarding effort expectancy, the majority of participants showed their agreement that micro-irrigation reduces time and effort. Moreover, participants did not seem to agree that other farmers', family members opinion or peers would influence their choice to adopt a micro-irrigation system. The analysis of the facilitating conditions showed that the presence of barriers such as the lack of trainings and subsidies influence the possibility to adopt a micro-irrigation system.

In regard with the quantitative part, the performance expectancy scores designated that farmers agreed that the micro-irrigation system provides benefits. Farmers have an elevated performance expectancy of micro-irrigation systems when concerning the yield increase and better quality of potato production. Farmers also perceive that a micro-irrigation system will help them reduce energy costs and potato disease incidence while improving the efficient use of pesticides and fertilisers. Concerning the effort expectancy construct, potato farmers perceived micro-irrigation as a system designated to reduce effort and time spent on irrigation management. The analysis of the social influence variable revealed that farmers perceive the micro-irrigation system as a way to avoid moving to rain-fed irrigation and as a moral obligation to preserve water. Finally, participants believe that effective training raise their awareness about the use of micro-irrigation systems. They also expose that subsidy could help them to facilitate the introduction of micro-irrigation systems in their land. Already knowing that farmers' risk perception variable was added to the UTAUT model in this research part, the results showed that micro-irrigation, financial and overall risks act as relevant concerns related to risk perception. That is risk perception is an important factor negatively affecting farmers' performance expectancy and their intention to use micro-irrigation systems.

In both qualitative and quantitative studies, age was an important moderator in adopting a micro-irrigation system among potato farmers. Further, experience was tested by the familiarity of the farmers of the functioning of the micro-irrigation system either by their own trial on other type of crops or by observing others using it on potatoes or on other crops. It was revealed that experienced farmers were more likely to accept and use micro-irrigation than inexperienced farmers. Voluntariness of use which was measured on the basis of not using external obligations or incentives in order to implement the new irrigation system, had moderated the effect of social influence on behavioural intention only in the qualitative study. The education moderator

implemented only in the quantitative survey showed that less-educated farmers would have less confidence in using the micro-irrigation system. However, the gross unit margin moderator, added exclusively in the quantitative research, did not have any effect.

It was concluded that farmers are willing to adopt micro-irrigation technology if they can engender gain for their potato cultivation and reduce time and effort of their farming activities. Moreover, farmers were concerned about receiving the appropriate training, incentives and subsidies that could motivate them to adopt and use micro-irrigation. It was also determined that risk perception impacts the use of micro-irrigation system. However, most of the farmers were found to be risk averse inducing a lower investment in micro-irrigation.

Political Recommendation

Our outcomes offer visions for the policymaking process, and they bring up insights that can grow up this field of research.

Firstly, farmers are willing to adopt a micro-irrigation system if they have an extended knowledge about the system along with technical assistance. Factors such as a lack of training, awareness, resources and incentives could be preventing farmers from accepting and adopting micro-irrigation systems in the Bekaa region. This means that having specialists run workshops and seminars to improve farmers' knowledge of how micro-irrigation works and the advantages related to introducing this system would likely increase the levels of acceptance and adoption. Furthermore, agricultural extensions were found to reduce these technical gaps, resulting in the more widespread adoption of this new technology. Namara et al. (2005) reported the need to augment extension services to enhance the technical knowledge, self-confidence and the ease of using micro-irrigation technology.

Secondly, farmers were found keen to invest in if they can engender more gains by reducing also time and effort of their farming activities. To enhance the use of micro-irrigation systems, the challenge facing local non-governmental organisations, agricultural associations and the Ministry of Agriculture is jointly coordinating the development of initiatives for planning site training. Through such initiatives, pilot area studies and field training can be launched to create awareness and increase farmers' knowledge on micro-irrigation benefits as well as efficient methods of implementation.

For a risk-averse farmers' population, the investment in micro-irrigation would be lower. As a result, policymakers and farmers associations must guarantee that micro-irrigation systems are technically feasible and improve yield and quality in potato crop production.

The education moderator showed that less-educated farmers would have less confidence in using the micro-irrigation system (Agarwal and Prasad, 1999; Claar et al., 2014). Thus, the national government, donors and local authorities' interventions should target farmers in the Bekaa Valley based on their education level, especially among the younger generations. This strategy is expected to positively impact the introduction of new technologies (e.g., micro-irrigation systems) in the area.

The government should encourage farmers to adopt micro-irrigation through financial aids and subsidies. Farmers are showed to be hindered by financial capacities especially after the economic setback in Lebanon initiated in October 2019.

In the context of studying farmers' perceptions on the adoption of a new agricultural technology, further research may considerate the creation of enabling conditions for the development of agricultural insurance. The latter may include long-term agricultural loans with low interest, enhanced access to credit for investment in innovative technologies, the support of local agricultural activities and production by limiting the illegal imports on the Lebanese borders. Another point of research interest could be studying the impact of identifying more export markets and enhancing the coordination with exporters and farmers. As well, exploring the effect of promoting and organizing cooperative work and farmers' associations on the adoption of a new technology could engender important insights.

Although it presents useful data and recommendations, this study is not without certain limitations. Legal restrictions and safety measures linked to the COVID-19 pandemic sometimes kept us from certain physical spaces and face-to-face interviews. Notably, several farmers rejected face-to-face participation in the questionnaires due to the pandemic. Also, the sample only included males since no females ran farms in the study area. Thus, it would be useful to repeat the same analysis and extend the study to other countries and incorporate female participation.

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Annexes

Annexe 1 Focus Group Protocol

Participants' demographics: (to be distributed at the beginning of the focus group discussion)

Full Name	Age	Education level	Type of land management	Farm size(ha)	Potato cultivated in 2019 (ha)	Other crops cultivated in 2019 (crops and ha)	System of irrigation used	Annual irrigation water used (m^3/ha)
		[_] Primary [_] Secondary [_] University	[_] Private land [_] Rented land				[_] Sprinkler [_] Mini-sprinkler [_] Drip Other……	

Department of Agricultural Sciences

University of Sassari

THESIS TOPIC

Dear Respondents, I am a Ph.D student working on **"Impact and adaptation policies in irrigation practices in the Mediterranean area under climate change"** at the University of Sassari, Italy. I am presently conducting a research on the factors affecting the adoption of new irrigation systems as a mean to save water in irrigated agriculture and avert the water scarcity crises among designated potato farmers. Recent climatic changes, drought conditions and water scarcity, characteristics of arid and semi-arid regions such as the case of some agricultural regions in Lebanon, make a new model necessary for managing agriculture irrigated land. A solution maybe the adoption of new irrigation technologies and strategies to achieve the following objectives: sustainable use of water and energy resources; reduction of the amount of fertilizers; and reduction of labor dependency and costs; reduction of soil moisture (less disease pressure from fungi and less mobility for insects, thus fewer pesticide applications), improvement of tuber quality and yield increase; reduction of fuel usage and thus production costs. Micro-irrigation technologies such as minisprinkler or drip systems are believed to be one of such innovative intervention approaches.

The purpose of this discussion is to kindly request you to answer the proposed questions. Note that the information you provide will be treated with highest confidence and at no time will your name and/or that of your organization be referred directly. This information will be used for academic purposes only. Thank you.

Focus Group research protocol on the topic:

IMPACT AND ADAPTATION POLICIES IN IRRIGATION PRACTICES IN THE MEDITERRANEAN AREA UNDER CLIMATE CHANGE:

The case of potato crops in Bekaa Valley-Lebanon

Researcher:

- Maria Sabbagh (UNISS)

Participants *:

• 6 Farmer Focus groups: 2 focus groups in each of the 3 main districts of the Bekaa whose farmers are adopting the ordinary sprinkler irrigation system

• Each Focus Group will be made up of 5/6 farmers

• Interviews should be conducted in areas where potato cultivation has been present.

Q1: *Are you involved in the decisions regarding the planning of crops and irrigation strategies to be implemented in your farm?*

YES	1	CONTINUE
NO	2	END*

Q2: *Are you adopting the ordinary sprinkler irrigation system on potato crop in your farm?*

YES	1	CONTINUE
NO	2	END*

Q3: *Are you willing to participate in a discussion group on the cultivation of potatoes and the irrigation techniques (adopted and not adopted)? Your opinions will be recorded and used only for research purposes and anonymously.*

YES	1	CONTINUE
NO	2	END*

The group should be balanced in terms of age, geographical location and farm size.

*** Thank the participants for their willingness to participate in the study.**

General instructions

a) The focus group should last about 80/90 minutes. The time spent on each section can be modified.

b) Due to COVID-19, “Zoom platform” should be used in some focus groups asking farmers to close their microphones when they are not speaking and if they want to add something they should send a message in the chat and the moderator will authorize them to speak. During the session, the screen must be shared highlighting each question.

c) The progressive numbers refer to the inquiries to be addressed. The questions can be slightly adapted based on the context in which are operated.

d) The italicized text contains indications for the facilitator.

In no case the points should be interpreted as questions to be asked the same way as they are. They should be used as a reminder for the facilitators to keep the discussion within the research objectives.

1. Introduction of the moderator (5 minutes)

The moderator must introduce himself. Present the topic of the project and research (see below). Explain the role of facilitators. Explain what the use of audio recordings will be: the recordings will be used only by researchers and the identity of the participants will not be revealed. The group will discuss the behavioural aspects related to the possible shifting from an irrigation technique (ordinary sprinkler) to another (drip or minisprinkler) that saves more water, induces higher production and better quality on the cultivation of potato crops. Explain that participants are free to express their opinions, that their opinions matter, and that there are no right or wrong answers. The context of the discussion is convivial.

Warm-Up

Presentation of the moderator and the participants (name and some questions to break the ice and create a friendly environment for discussion). Moderator reminder: keep in mind that information on age, level of education, farm size should have already been recorded before the interview. Since the interviews are recorded, it is necessary that during the participant is well identified, by name, who is speaking among the interviewees. See the Focus Group recruiting instructions.

2. Information about potato crop and irrigation

Potato is largely consumed by the local population and is essential in the Mediterranean diet. It is geographically centralized in two main areas, Akkar and Bekaa valley, which represent about 80% of the total national production.

In the Bekaa, farmers have the opportunity to grow for 120 to 150 day potato crop by choosing one or two of the three following seasons:

- *the earliest is planted starting mid-February till first of March and harvested from mid-June,*
- *mid-season which is usually planted between April and June and harvested from mid-September,*
- *the late season is often planted between July and mid-August and harvested from mid-November.*

Water resources and irrigation

Due to climate change causing water scarcity, a higher water resource is needed and since farmers are using huge amounts of water, groundwater resources could be reduced at higher speed. The irrigation trends in the Bekaa Valley have shown a 20 percent increase in the irrigated area over the last 10 years, with a corresponding decline in the availability of groundwater of 40 percent.

Depending on the region, the groundwater in Lebanon had a depth of 20 m, 150 m or 200 m. In drought years, the farmers usually start settling the water pumps deep in the ground (up to 100 m instead of 70 m), which has drastically reduced the groundwater resources and increased the risk of current and future droughts. In the case of consecutive drought years, there is a high probability that water shortages will occur not only for irrigation but also for domestic uses.

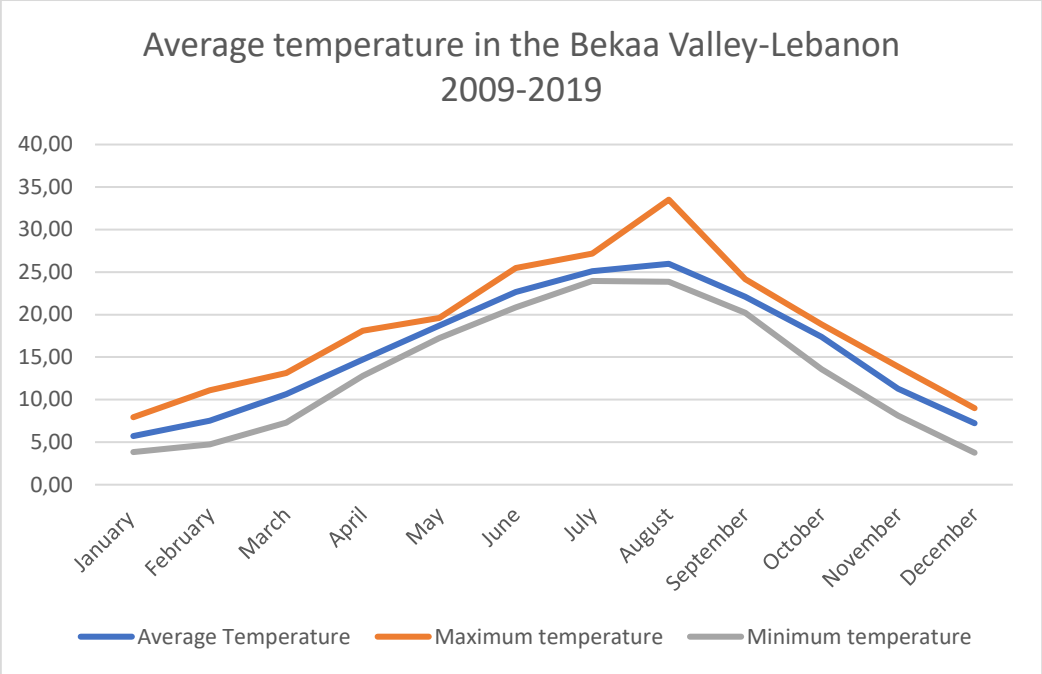

Figure A. 1 Temperature in the Bekaa Valley – 2009 - 2019

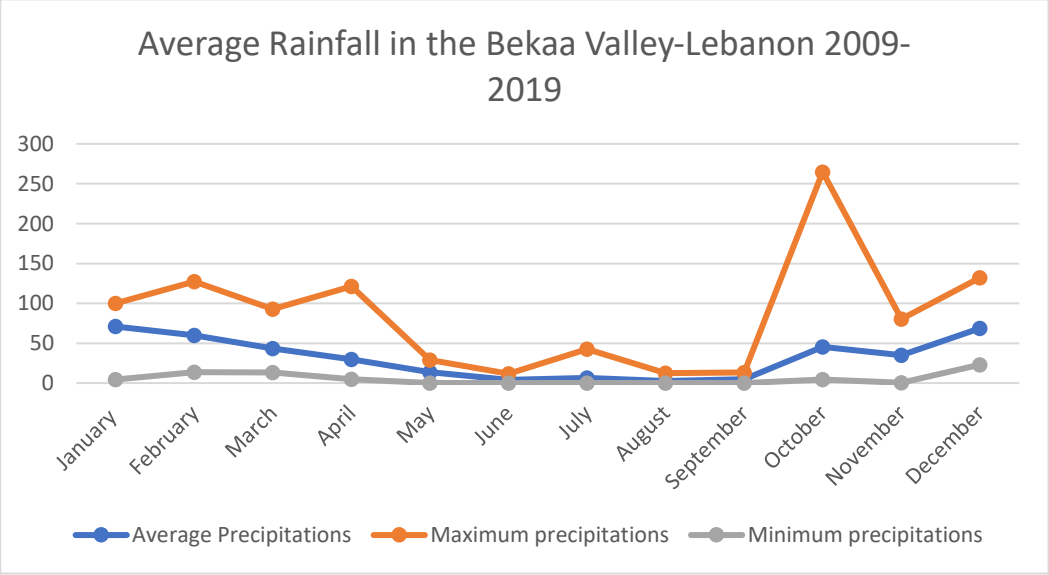

Figure A. 2 Precipitations in the Bekaa Valley – 2009 – 2019

In Figure A.1 and Figure A.2 we present the average, maximum and minimum for temperature and precipitations, respectively, at monthly frequency in the Bekaa Valley. The statistics were computed using the data for the years 2009 - 2019, last data period available. From figure A.1 it appears that temperature presents a noticeable variability especially during the month of August in which the

potato crop is in high need of irrigation (min 24°C; max 34°C). From the figure A.2 it emerges that precipitations show a high variability (especially during the month of October with min 4.5 mm; max 256 mm during the period). This pattern testifies as in the area an efficient water saving management plan is essential.

***In the area of our research, the irrigation systems used to cultivate potato crop are**:*

• *The ordinary sprinklers (approximately used by 90% of farmers in the Bekaa Valley).* Please look at the picture below. Are you familiar with ordinary sprinklers? What do you think about their use? (Investigate ...)

Figure A. 3 Ordinary Sprinkler irrigation system used on potato crop in the Bekaa Valley

Now we would like to show you other irrigation systems newly introduced to the potato crop in Lebanon and used by a small number of farmers.

• *Localized (= micro-irrigation) at low volume:*

- *Drip (used by approximately 1% of farmers in the Bekaa)*
- *Static or dynamic sprayers (eg minisprinklers)(used by approximately 5% of Bekaa farmers)*

Figure A. 4 Drip irrigation system used on potato crop in the Bekaa Valley

Figure A. 5 Minisprinkler irrigation system used on potato crop in the Bekaa Valley

The benefits from micro irrigation are that water is applied to the root zone of the plant directly and at frequent intervals in controlled quantities and thus reduces the consumption of water by 30-70%. This will lead to an increase in crop yield and quality allowing a uniform yield reducing also the development of insects and diseases by increasing the efficiency of spraying. Micro irrigation controls erosion can reduce labor operations since there is less growth of weeds.

Recent studies showed that in order to counteract high summer temperatures, only minisprinklers have all the suitable characteristics for cooling. Cooling effect leads to significant improvements to

the crop in terms of decreasing the leaf temperature, increasing photosynthesis which will improve the productivity, physiological status, quality, and earliness of harvest. Cooling can occur after a month of planting, managed during the maximum heat hours with very short and close irrigation shifts consisted of low flow and small size drops.

3. ***Questions:***

Direct determinants

Perceived usefulness

Q-1: I would like each of you to introduce himself, what do you know about micro irrigation and what are the main reasons for using the current potato irrigation system? Let's think about the following sentence "adopting micro irrigation can be useful in your farm in terms of increasing potato yield, saving energy, labor, and pesticides quantities and increasing your benefits", what is your opinion?

Q-2: What are your perceptions about the possible advantages and disadvantages deriving from the adoption of micro irrigation systems? Please, start with the advantages and after we would like to know opinion about possible disadvantages
In summary, these are therefore the advantages and disadvantages that have emerged. Did we forget any of them?

Perceived ease of use

Q-3: How do you perceive the implementation and operation of the micro irrigation system in terms of difficulties or easiness of the tasks? Do you find the related technical operations are time consuming and exhausting?

Q-4: Now let's think again about the possibility of implementing a micro irrigation system. Overall, do you think that you will become skillful in using it in potato crop? If yes why. If not why.

Norms

Q-5: Now let's change our point of view. I would ask you to list 2 or 3 people (family members, friends, other farmers, organizations and associations of farmers, etc.) whose judgment you think is important to you that they would APPROVE and DISAPPROVE your adoption of a micro-irrigation system?

Q-6: As a farmer in the area, do you think is it important for you to collect information from other farmers regarding new agricultural practices and also to observe their possible successes before adopting new irrigation system? If yes, kindly explain/if no, kindly explain?

Q-7_1: Now I would like to learn from each of you, what means for you the term "climate change and water "scarcity"?

Q-7_2: What do you think about personal moral obligation norms as adopting a micro irrigation system for the potato cultivation in order to protect the environment and to save water for your children and the future generation?

Facilitating conditions

Q-8: Tell me how do you consider the guidance role of the agricultural/irrigation extension services in your area? For instance, do they provide the adequate knowledge and assistance regarding the agricultural practices or do you prefer relying on your personal experience and why?

Q-9: If you were convinced that you could successfully implement a micro irrigation system, what barriers do you think can prevent this execution?

- *I find that the initial expenses are high for installing the system*
- *I have a lack of capital for covering the entire area*
- *I need credit facilities as a farmer*
- *I need subsidies*
- *I don't have the technical know-how*
- *I need more trainings and awareness about the benefits of the system*
- *I find it technologically complicated*
- *I think it is not feasible in a large field*
- *I admit that the system requires time to time attention for minor repairs*
- *I perceive the system as an effort consuming*
- *I need motivation and family/friends/farmers support*
- *I want the spirit among farmers*
- *My land is very scattered*

<u>Indirect determinant</u>

Anxiety

Q-10: When you think about the possibility of implementing water saving irrigation system, what sensations do you feel?

1. Scepticism

2. Concern

3. Indifference

4. It is an opportunity

5. Enthusiasm (positive)

6. Nervousness

7. Anxiety

Are there other types of emotions that we could add? ----------

Q-11: When you think about the possibility of implementing specifically minisprinkler or drip irrigation, what feelings do you feel?

1. Concern

2. Indifference

3. Scepticism

4. Nervousness

5. It is an opportunity

6. Enthusiasm (positive)

7. Anxiety

Are there other types of emotions that we could add? ----------

Key moderators

Age and Experience

Q-12: In your opinion, the age of farmers in this area reduces the incentive to adopt new irrigation practices because for example older farmers do not expect that those practices will pay off in their life

Voluntariness of use

Q-13_1: I want you to imagine a situation where there are not external obligations to adopt a new irrigation system. Will you move from the ordinary sprinklers to the micro irrigation? Yes, or not? Please, explain.

Q-13_2: What about if the government decide to subsidize the use of water-saving irrigation systems? Would you agree or not? Please, explain

Behavioural intention

Q-14: Do you have a plan to adopt a micro irrigation system in the next 12-24 months? If yes why, if not why.

Q-15: We have reached the end of our meeting. We still have few minutes and I would like to have some final comments from you regarding the previous discussion of your views and, also, your concerns related to the micro irrigation systems. Do you have any further comments that you think could be important for this study?

******

The focus group is over. Thanks for collaboration. It has been very valuable and will allow me to progress in my research. In particular, today's work will allow me to build a more detailed questionnaire.

To be distributed. The indication is anonymous, there is no need to enter data that identifies the interviewee.

The data presented in the table below are recorded based on preliminary studies on farmers' irrigation systems, key experts' information and own calculations. Thus, I will introduce some economic and technical information that I consider important for the potato cultivation and the different irrigation systems.

Status Quo **Sprinkler**	**Option A:** **Mini-Sprinkler with cooling process**	**Option B:** **Drip**

INITIAL EQUIPMENT COSTS (US$)	450	3500 (↑↑)	1500 (↑)
ANNUAL USE OF WATER (mm^3/ha)	5500	5500 (=)	5500 (=)
ENERGY COSTS (US$)	2000	1300 (↓)	850(↓↓)
YIELD (tons/ha)	35	46 (↑↑)	41(↑)
WATER WASTE (mm^3/ha)	1920	1100 (↓)	275(↓↓)
FERTILIZERS COSTS (US$)	1100	700(↓↓)	700(↓↓)
PESTICIDES COSTS (US$)	300	200(↓)	200(↓)
INCREASING PHOTOSYNTHESIS	=	(↑↑)	=
PHYSIOLOGICAL STATUS	=	(↑↑)	=
BETTER QUALITY	=	(↑)	=
EARLINESS OF HARVEST	=	(↑↑)	=

Table 1:Labels representation : " = " the same effect as the status quo; "(↑)" a stronger increasing effect than the status quo; "(↑↑)" a highly stronger increasing effect than the status quo; "(↓)" a stronger decreasing effect than the status quo, " (↓↓)" a highly stronger decreasing effect than the status quo

Considering the technical, economic aspects and critical issues presented in the table above, are you willing to adopt a new micro irrigation system, or would you prefer remaining on using the current one?

[ ]	Yes
[ ]	NO

If not, Why?..... .....

If Yes, which option would you be willing to implement?

[ ]	A
[ ]	B

Please provide the three main features in the table that convinced you to opt for your option

INITIAL EQUIPMENT COSTS (US$)	[ ]
ANNUAL USE OF WATER (mm^3/ha)	[ ]
ENERGY COSTS (US$)	[ ]
YIELD (tons/ha)	[ ]
WATER WASTE (mm^3/ha)	[ ]
FERTILIZERS COSTS (US$)	[ ]
PESTICIDES COSTS (US$)	[ ]
INCREASING PHOTOSYNTHESIS	[ ]
PHYSIOLOGICAL STATUS	[ ]
BETTER QUALITY	[ ]
EARLINESS OF HARVEST	[ ]

In your opinion, are there further important characteristics that would have conditioned your choice and we have forgotten? Could you suggest us?

_____

_____

Annexe 2 Quantitative Survey

Dear Respondent,

This survey is a part of my PhD research entitled **"Impact and adaptation policies in irrigation practices in the Mediterranean area under climate change"** at the University of Sassari, Italy. The purpose of this research is to explore the factors that may facilitate or hinder the adoption of micro-irrigation systems as a mean to save water in irrigated agriculture and avert the water scarcity crises among designated potato farmers. In Lebanon, potato is largely consumed by the local population and is geographically centralized in two main areas, Akkar and Bekaa valley, which represent about 80% of the total national production. Recent climatic changes, drought conditions and water scarcity, characteristics of arid and semi-arid regions in Lebanon such as the Bekaa area, make a new model necessary for managing agriculture irrigated land. Micro-irrigation technologies such as mini-sprinkler or drip systems are believed to be one of such innovative intervention approaches.

In the Bekaa, the irrigation systems used to cultivate potato crop are:

• the ordinary sprinklers (approximately used by 90% of farmers in the Bekaa Valley),

• the localized irrigation systems (= micro-irrigation) that are newly introduced to the potato crop in Lebanon and used by a small number of farmers:

 Drip (used by approximately 1% of farmers in the Bekaa)

 Static or dynamic sprayers (eg minisprinklers)(used by approximately 5% of Bekaa farmers).

It would be greatly appreciated if you would take about 12 minutes of your time to complete the questionnaire. Note that the information you provide will be treated with highest confidence and at no time will your name and/or that of your organization be referred directly. This information will be used for academic purposes only. Thank you.

Do you cultivate potatoes?

a. Yes
b. No

If the response is “yes”, we go ahead to the following questions and if the response is “no” we will thank the participant for his participation and interest in our questionnaire that will be directly ended because these questions are intended only to potato farmers.

Socio-economic questions

1. Name: What is your full name?

   _____

2. Gender: What is your gender?
   a. Male
   b. Female

3. Age: How old are you?
   a. Less than 45 years
   b. 45-60
   c. Above 60

4. Marital status: What is your marital status?
   a. Single
   b. Married
   c. Divorced
   d. Widowed

5. Of how many members is your household composed (including you)?

   _____

6. A. Any of the households’ members are involved in the farm’s work?
   a. Yes
   b. No

   B. If yes, how many household members are involved farm’s work (including you)?

   _____

7. A. Is any member of the household working in a sector different from the farm?
   a. Yes
   b. No

   B. If yes, in which sector?

   a. Public administration
   b. Human health
   c. Agriculture, forestry and fishing
   d. Financial and insurance activities
   e. Research activities
   f. Education

g. Manufacturing
h. Construction
i. Wholesale and retail trade
j. Accommodation and food service activities
k. Real estate, business and administrative activities
l. Arts, entertainment and recreation activities
m. Transport
n. Mining and quarrying

C. How many of the household's members are working in each sector?

a. Public administration _____
b. Human health _____
c. Agriculture, forestry and fishing _____
d. Financial and insurance activities _____
e. Research activities _____
f. Education _____
g. Manufacturing _____
h. Construction _____
i. Wholesale and retail trade _____
j. Accommodation and food service activities _____
k. Real estate, business, and administrative activities _____
l. Arts, entertainment, and recreation activities _____
m. Transport _____
n. Mining and quarrying _____

D. Are they working as a part-time or full-time job in the related sector?

a. Part-time

b. Full-time

8. Does household own other real estate /properties? (other than house and land)

a. Yes
b. No

9. Does the household have an income from renting out a land, a building, an apartment, or any other real estate?
c. Yes
d. No

10. Education: What is your highest educational level?
a. Not attended the school
b. Primary
c. Secondary

d. University

11. Farming experience: How long have you been working in the agricultural sector?
    a. Less than 10 years
    b. 10 - 30 years
    c. More than 30 years

12. Total land size: What is your total land area (Dunums)?

_____

13. What is your potato cultivation area (in Dunums)?

_____

14. Region: In what geographical region do you cultivate potatoes?
    a. North Bekaa
    b. Central Bekaa
    c. West Bekaa

15. Do you own or do you rent the farm's equipment and machineries?
    a. I own it.
    b. I rent it.
    c. Both own and rent

16. A. Land management: What is the type of your land's management?
    a. Private land
    b. Rented land
    c. Both private and rented land

B. If is it a private (own?) land, how did you acquire it?

    a. Inherited
    b. Purchased
    c. Inherited + Purchased

17. Do you raise livestock?
    a. Yes
    b. No

18. Farm's workers:
    A. How many permanent workers do you have in your farm? (not including you)

    _____

    B. How many seasonal workers do you hire?

    _____

19. What is the average cost to cultivate 1 dunum of potato?

_____

20. Quantity of production: What is your total annual quantity of potato production? (Tons)

_____

21. Was the last production higher, lower or the same as the average productions of the last three years?
    a. Higher
    b. Lower
    c. Same

22. A. Is COVID-19 affecting your potato production?
    a. Yes
    b. No

B. If yes, can you relate the percentage (%) of the affected production?

_____

23. What is your type of potato channel distribution?
    a. Direct distribution to the internal wholesaler
    b. Direct distribution to the internal retailer
    c. Intermediaries/Agents
    d. Exports

24. What is the percentage (%) of potato sales for each channel?
    a. Direct distribution to the internal wholesaler _____
    b. Direct distribution to the internal retailer _____
    c. Intermediaries/Agents _____
    d. Exports _____

25. What is the average unit price in each channel in the last 3 years (LBP/Kg)?
    a. Direct distribution to the internal wholesaler _____
    b. Direct distribution to the internal retailer _____
    c. Intermediaries/Agents _____
    d. Exportation _____

26. In this year, what is the price of a kilogram of potato (LBP/Kg)?
    a. Direct distribution to the internal wholesaler _____
    b. Direct distribution to the internal retailer _____
    c. Intermediaries/Agents _____
    d. Exports _____

27. A. Do you have a second income source?
    a. Yes

b. No

B. If yes, from which activity the second income source is coming?

a. Private income: rental properties/ share of enterprise/ bond/ investment interest and dividends
b. Business income (shops, salaries from another employment, etc.)

28. Major source of income:
a. Farm income less than off-farm income,
b. Farm income equal to or greater than off-farm income

29. A. Financial services: Do you have access to bank loans?
a. Yes
b. No

B. If yes, why did you take the loans?

a. To buy new agricultural equipment/systems

b. To cover land costs

c. To make land repairs

d. To purchase supplies (fertilizers, pesticides, seeds, etc.)

30. Social participation: Are you a member of an agricultural organization/association?
a. Yes
b. No

31. Extension services: Do you have access to guidance and extension services?
a. Yes
b. No

32. A. Funds: Have you received any funds or subsidies from government or other donors?
a. Yes
b. No

B. If yes, from which entity?
a. Non-governmental Organization (NGO)
b. Ministry of Agriculture
c. Agricultural association/organization
d. Others, Please write who provided the funds_____

33. Irrigation source: What is your main irrigation source?
a. Surface water

b. Groundwater

34. Irrigation system: which irrigation system do you use?
    a. Ordinary sprinklers
    b. Micro-irrigation
    c. Others, please write which irrigation systems_____

35. What policies or incentives would you propose to stir up micro-irrigation systems investments?
    a. Subsidies and aids
    b. Guidance and extension services
    c. Protection of local production

36. Micro-irrigation experience:
    a. My peers already use a micro-irrigation system so that I'm familiar with that technology
    b. I use micro-irrigation on other types of crop
    c. I don't have any experience with micro-irrigation

37. Voluntariness of use: If micro-irrigation system will be subsidized, would you implement it?
    a. Yes
    b. No

Attitude towards risk questions

The following questions will allow us to evaluate your attitude to various types of risks (ethical, financial, health, social) qualitatively.

1. **In general**, would you say that your behaviour and the decisions you take are:

Not at all risky	Not risky	Moderately risky	Extremely risky	More than extremely risky

2. **For the implementation of agricultural activities in your farm**, would you say that your behaviour and the decisions you take are:

Not at all risky	Not risky	Moderately risky	Extremely risky	More than extremely risky

3. With regards to **finance**, would you say that your behaviour and the decisions you take are:

Not at all risky	Not risky	Moderately risky	Extremely risky	More than extremely risky

4. With regards to **health**, would you say that your behaviour and the decisions you take are:

Not at all risky	Not risky	Moderately risky	Extremely risky	More than extremely risky

UTAUT questions

Performance Expectancy

Question 1**.** I think micro-irrigation would help to save water, helping cope climate change.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 2**.** I think micro-irrigation evenly distributes water in the field crop.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 3. I think using micro-irrigation would not increase my yield.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 4. I think using micro-irrigation would not enhance the potato crop quality.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 5. I find micro-irrigation would reduce energy costs.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 6. I find the use of micro-irrigation allows efficiency in fertilizers' and pesticides' use.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 7. I think micro-irrigation would not reduce disease incidence.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Effort Expectancy

Question 1**.** I would find that micro-irrigation is easy to be used on the potato cultivation's field.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 2. Micro-irrigation does not need a lot of effort.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 3. Micro-irrigation dispenses me from the need of a specialized work force.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 4. I think using micro-irrigation would not save time in respect to my actual irrigation system.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 5. It would be easy for me to become skillful at using micro-irrigation on potatoes.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Social Influence

Question 1**.** I will take into consideration the opinion of other/nearby farmers or family members regarding the use of micro-irrigation.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 2. I would use micro-irrigation if nearby farmers will use it.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 3. Others farmers whose opinions I value are typically using micro-irrigation.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 4. In general, NGO's and agricultural associations would support the use of micro-irrigation.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 5. I don't feel a moral obligation to modify my current irrigation system in order to save water to face the impact of climate change.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 6. I feel a moral obligation to use micro-irrigation in order not to be forced to move from growing potatoes to a rain-fed agriculture.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Facilitating conditions

Question 1**.** I am having ease of obtaining agricultural information, guidance, and extension or training courses from local agricultural authorities.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 2. I don't need subsidies to be able to implement the micro-irrigation system.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 3. I currently don't have the knowledge necessary to use micro-irrigation on my field.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 4. I need trainings to raise my awareness about the benefits of the micro-irrigation and to technically know how use it in a proper way.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Anxiety

Question 1. I am worried to adopt a micro-irrigation system because of its high initial cost.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 2. I find micro-irrigation as an opportunity to be implemented in my field.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Behavioural intention

Question 1. All things considered; I would be very likely to adopt the micro-irrigation system on potato cultivation in the next 12-24 months.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Use Behaviour

Question 1. I really want to use micro-irrigation to improve my potato cultivation.

Strongly Disagree	Disagree	Neutral	Agree	Strongly agree

Question 2. I will adopt micro-irrigation on ..... % of my land.

0%	25%	50%	75%	100%