# Farmers' Acceptance of a Micro-irrigation System: A Focus Group Study

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**Abstract**

Despite water scarcity and lots of benefits, implementation of micro-irrigation systems on potato crops in the Bekaa Valley of Lebanon is notably low. This could be related to farmers' acceptance to use this technique. The objective of this study is to investigate the factors that can affect or not the adoption and the investment in a new micro-irrigation system. For this aim, the unified theory of acceptance and use of technology (UTAUT) served as the conceptual framework. A qualitative approach using focus group discussion was applied. A total of 34 farmers in six focus groups were conducted in the three main districts of the Bekaa Valley. From the analysis, performance expectancy, effort expectancy and facilitating conditions emerged as the three most prominent factors to understand farmers' acceptance and adoption of micro-irrigation systems. The focus

group findings indicated that potato farmers are willing to adopt a new micro-irrigation system if they ensure its provision in gains, its reduction of time and effort correlated with the farming activities. Barriers included lack of knowledge about the system, financial capabilities and extension services. Generally speaking, participants were enthusiastic about the idea to adopt a micro-irrigation system, but they are hindered by the unstable socio-economic conditions in Lebanon and the financial abilities. It was concluded that age, experience and voluntariness of use exert an effect on the related major determinants. This study will provide recommendations that can be considered while drafting agricultural policies.

**Keywords:** UTAUT model, Focus group, climate change, Micro-irrigation, Technology acceptance

## 1. Introduction

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

Lebanon is a small mountainous country on the Mediterranean Sea's eastern coast, covering a total area of 10,452 Km². From a climatic point, Lebanon is dominated by a Mediterranean climate with a cold rainy winter and a semi-hot dry summer. 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. In Lebanon, groundwater sources are increasingly stressed by climate change as well by the increased demand from agriculture, the inadequate utilization of underground water, the population growth and the industrial development (UNDP & UNHCR, 2021). Further, recent results (Halwani & Halwani, 2022) showed that from 1930 to 2019, the average temperature in Lebanon has increased between 1 to 3 ºC and a recent report from USAID (USAID, 2018) expected a 4–11% decrease in precipitation by 2100. Thus, various conditions threatening water balance make adaptation to climate change more difficult in Lebanon. In this situation, the

enhancement of irrigation water usage efficiency and the conservation of water resources are turning into strategic priority.

The Bekaa valley of Lebanon, which represents 42% of Lebanon's area, is a very fertile valley in which 60% of Lebanon's agricultural production is concentrated including cereals, potatoes, vegetables and grapevine (MoE & UNDP, 2011; MoE et al., 2015). 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 (MoA & LARI, 2008). The Bekaa valley is divided into three main zones: North Bekaa, Central Bekaa and West Bekaa. The valley is confronting the consequences of drought and reduced water availability that menace the yield and quality of irrigated crops (Karam & Karaa, 2000; MoE et al., 2015; Jaafar et al., 2016) . This is the case of potato crops which is one of the most sensitive crops to soil moisture stress and requires a systematic irrigation schedule (Ayas, 2013).

Since potato crops are sensitive to water stress , water use efficiency such as water-saving technologies are becoming of high importance. Until now, in the Bekaa region, the high majority of potato farmers are still using the ordinary sprinkler irrigation (MoA & LARI, 2008). Micro-irrigation, particularly mini-sprinklers, could be a solution to the above-mentioned climate-change related problems (Houston et al., 2018). Mini-sprinklers are small sized static sprinklers with a flow varying between 150 and 300 L per hour and a pressure of 1.5 bars inducing a water cooling canopy (Deligios et al., 2019). Micro-irrigation can induce an even application of water resulting in an improved crop quality and yields, in water savings leading as well to energy and fertilizer savings compared with other irrigation methods (Varma & Namara, 2006; Shah, 2011). Further, micro-irrigation systems allow for a high level of control of chemical applications and weed and disease reduction due to limited wetted area. Previous researches executed in the

Middle East and North Africa (MENA) region, in Lebanon and beyond indicated that the use of micro-irrigation in potato cultivation could have promoting results in terms of water savings of up to 40% (Darwish et al., 2003; Darwish et al., 2006), and allowing for energy savings associated with higher crop quality and yields (Karam & Karaa, 2000; Varma & Namara, 2006; Shah, 2011(Rouzaneh et al., 2021).

Given the lack of information available on the performances of innovative technologies, farmers may evaluate these new systems through their experience and knowledge. This study aimed to analyze the indirect non observed factors such as farmers' motivations, attitudes and socioeconomic factors which may influence theirs' perceptions and behaviours in affecting their investment in and adoption of a new micro-irrigation system. By disentangling these factors, effective strategies, and support systems for promoting the use of micro-irrigation systems in the area could be designed. To this end, the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Venkatesh et al., 2003) was adopted. The UTAUT model (Venkatesh et al., 2003) is a tool that is used to analyse the individual acceptance and the use of new technology by evaluating the influencing factors. Previous studies utilized the UTAUT model to investigate factors affecting the adoption of pressurized irrigation technology among olive farmer (Nejadrezaei et al., 2018), the acceptance of e-agriculture (Eweoya et al., 2021), farmers' use of communication technologies (Mahamood et al., 2016) as well the acceptance of water saving technologies (Sabbagh & Gutierrez, 2022).

A qualitative study that utilized focus group discussion (FGD) approach was employed. In this study, FGD could be an appropriate tool because it can allow for drawing upon the respondent's knowledge, views, and experiences about the specific topic of introducing micro-irrigation systems. To the best of our knowledge, this is the first study to use the UTAUT model combined with a Focus Group Discussion approach to shed light on the impact and importance of behavioural factors in

influencing the adoption and use of a micro-irrigation system. Hence, the research question is: "what behavioural factors could affect the intention to adopt and invest in a micro-irrigation system by the potato farmers in the Bekaa Valley of Lebanon?

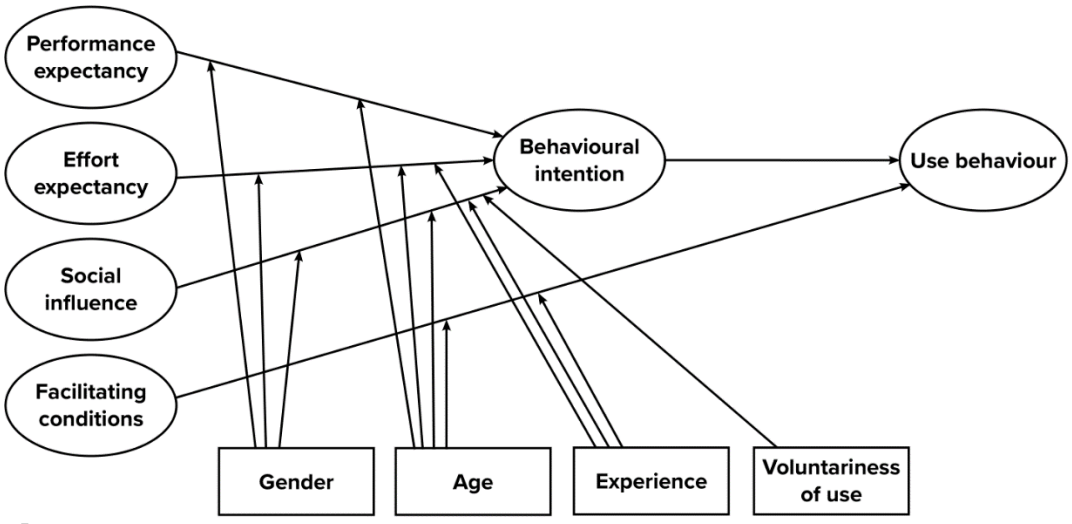
The remainder of this paper is organised as follows. Section two briefly analyses the UTAUT model. Section three explains the methodological approach employed in this study to explore the acceptance of a new micro-irrigation system. Section four presents the results of focus groups conducted with potato farmers in three main districts of the Bekaa valley. Section five discusses the main findings providing insights about policies that government could implement to encourage potato farmers in adopting a micro-irrigation system. In section 6, the main conclusions are presented, and section 7 is related to the study's limitations.

## 2. **Research behavioural model and Research's questions**

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) which 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) (Fishbein & Ajzen, 1975); ii) the Theory of Planned Behaviour (TPB) (Ajzen, 1985); iii) the Technology Acceptance Model (TAM) (Venkatesh & Davis, 2000); iv) the Combined TAM and TPB (C-TAM-TPB) (S. Taylor & P. A. Todd, 1995); v) the Innovation Diffusion Theory (IDT) (Moore & Benbasat, 1991); vi) the Motivation Model (MM) (Davis et al., 1992); vii) the Social Cognitive Theory (SCT) (Bandura, 1994; Compeau et al., 1999;

Compeau & Higgins, 1995) and finally viii) the Model of PC Utilization (MPCU) (Thompson et al., 1991). According to UTAUT, an individual's perspectives about the technology impact his or her behavioural intent to use and actual use of the technology. Based on the integration of the eight models, UTAUT suggested four major determinants that have an effect on a person's "use behaviour" to adopt a technology: performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FC). The first three constructs influence use behaviour through a behavioural intention variable, while the fourth construct directly impacts the use behaviour. These constructs can be affected by four moderators a) age, b) gender, c) experience with similar technology, and d) voluntariness of use. Fig.1 presents the model.

**Figure 1.** Unified theory of acceptance and use of technology model (UTAUT) (Venkatesh et al., 2003); Adapted with permission from Viswanath Venkatesh, *MIS Quarterly*, 2003.[1]




[1] Note: The diagram applies nomenclature, using ovals to identify latent variables and rectangles for moderator variables.

The Performance Expectancy (PE) represents the user's level of belief in how much advantageous a system usage will be and how it will help out to attain benefits (Venkatesh et al., 2003). PE aggregated all job performance related aspects, like usefulness (adapted from TAM/TAM2 and C-TAM-TBP) (S. Taylor & P. Todd, 1995; Venkatesh & Davis, 2000), job fit (from MPCU) (Thompson et al., 1991), relative advantage (from IDT) (Moore & Benbasat, 1991), extrinsic motivation (from MM) (Davis et al., 1992) and outcome expectations which are related to the consequences of the behaviour (from SCT) (Bandura, 1994; Compeau et al., 1999; Compeau & Higgins, 1995). 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). Persons with high PE had high intentions to use a new technology (AbuShanab & Pearson, 2007). 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 Effort Expectancy (EE) construct suggests that the level of ease of use affiliated with the user's adoption of a system is an important component 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) (Venkatesh & Davis, 2000), complexity (MPCU) (Thompson et al., 1991) and ease of use (IDT) (Moore & Benbasat, 1991). Previous research concluded that EE is a positive predictor of behavioural intention so that the higher the perceived ease of use of a new technology, the higher the intention to adopt it (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.

The social influence determinant (SI) refers to the magnitude to which individuals perceive they should adopt a technology based on inputs from persons who carry significant positions in their life (Venkatesh et al., 2003). It also consists of "the degree to which peers influence use of the system"

(Slade et al., 2015; Šumak & Šorgo, 2016; Venkatesh et al., 2003). Social influence (SI) consists of three variables: a) subjective norms which relate to the person's perception that people who are important to her or him think that they should or should not execute the particular behaviour (Ajzen, 1991; Davis, 1989; Fishbein & Ajzen, 1975; S. Taylor & P. Todd, 1995), b) social factors which connects to the interpersonal arrangements that the individual has made with others as with co-workers (Thompson et al., 1991) and c) image which is the extent to which the use of a new technology is seen to enhance one's image or status in one's social system (Moore & Benbasat, 1991). Based on the review of the literature, it is expected that social influence positively influences the behavioural intention to use 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 or infrastructure that the individual believes would encourage the use of the system and make it simpler for him to use it (Venkatesh et al., 2003). The facilitating conditions determinant consists of three distinct constructs: a) perceived behavioural control (Ajzen, 1991; S. Taylor & P. Todd, 1995) which are the possible internal and external limitations on behaviour related to resources, b) facilitating conditions adapted from (Thompson et al., 1991) which relate to objective factors that persons agree make an act easy to realize, and c) compatibility from (Moore & Benbasat, 1991) which indicates the extent to which a new technology is perceived as being consistent with the current needs and capabilities of potential adopters. Each one of these constructs is operationalized to incorporate technological and/or organizational aspects that are intended to eliminate obstacles to use. Facilitating conditions are found to positively influence use behaviour (de Veer et al.,

2011)[19]. According to [19], 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 the 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).

Overall, the present study proposed several research questions to discover how the adoption of a new micro-irrigation system on potatoes in the Bekaa Valley could be accepted and introduced. Specifically, the research questions are the following: What are the reasons behind using the use of current sprinkler irrigation on potato fields? How do potato farmers perceive a micro-irrigation system and its implementation on their field? How do they observe the opinion of persons holding important positions in their lives and other farmers' successes? What are the difficulties and barriers that they face that prohibit them from adopting a micro-irrigation system? What strategies or policies could be used to encourage potato farmers towards using micro-irrigation?

## 3. Materials and Methods

The objective of this study was to explore via focus group discussion how socioeconomic and psychological factors influence the adoption of a micro-irrigation system as a mean to save water and avert the water scarcity crises among potato farmers in the Bekaa Valley of Lebanon. The focus groups 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.

### *3.1. The focus group protocol*

The focus group research protocol was divided into three sections. The first section had the scope of warming up the discussion introducing the research theme and to collect information about gender, age, education, type of land management, farm size and the annual irrigation water used. Participants also received explanations of the role undertaken by the facilitator and that audio recordings would have only been used for the purpose of this study reasserting the significance of privacy of all participants. It was explained that all participants were free to reveal their opinions related to the discussion and that all answers were to be accepted.

Section two aimed at providing information regarding the potato cultivation, the status of underground water in the Bekaa region as well as the differences between the sprinkler irrigation system and the micro- irrigation system delivering by that the advantages that could be obtained implementing a micro-irrigation system.

Section three contained open ended questions related to the UTAUT model that the moderator asked to participants of the three main districts of the Bekaa Valley. To trigger the discussion around the behavioural elements of the UTAUT model, section three was opened asking participants about their knowledge of the micro-irrigation system and the reasons behind using the ordinary sprinklers. This allowed the moderator to explore the degree to which each farmer believes that using the micro-irrigation system will help him or her to attain gains exposing by that the performance expectancy determinant. The moderator then 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. This permitted the moderator to explore their effort expectancy towards micro-irrigation systems. Further, participants were asked to list people whose judgment is important to them that they would approve or disapprove their adoption of a micro-irrigation 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. This revealed the

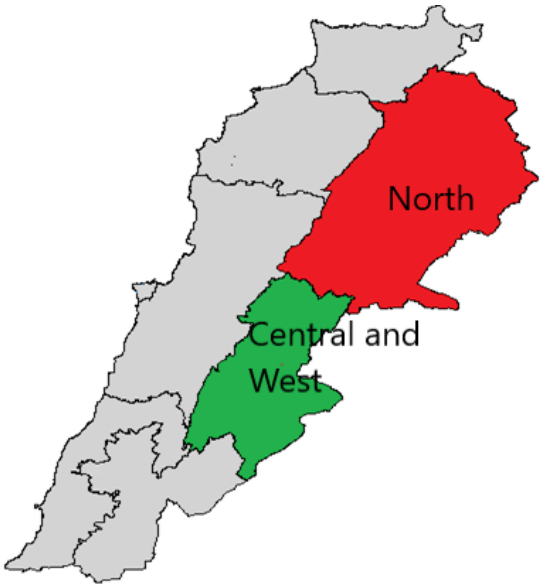
social influence construct. To measure the facilitating conditions, the moderator explored their opinion of being able or not to access required resources, as well as to obtain trainings and the necessary support needed to use micro-irrigation systems. Following the UTAUT model variables, questions related to the moderating variables were raised in the focus groups. The moderator asked participants if they believed that the age of the farmers affect their incentive to adopt new irrigation practices. Experience was tested 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. For the voluntariness of use, farmers were asked about their tendency to adopt a micro-irrigation system in the case of the presence of external obligations as well as in the case of subsidies offered by the government.

### 3.2. *Sampling and data analysis*

Fig. 2 shows the geographical area in which focus groups were 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). 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. Random sample selection is particularly appropriate when inferences are made to a large population because of the assumption that opinions, attitudes or whatever is being studied will be normally distributed within that population. And since the goal is to select a sample that will yield rich data to understand the phenomenon studied (Hennink et al., 2019), data were randomly collected from a total of 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.

**Figure 2** Lebanon's map showing the Bekaa Valley focus group discussions' districts




Due to the COVID-19 restrictions and safety limitations, three focus group meetings were conducted via a virtual meeting "Zoom" platform 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.

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.; 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 since potato cultivation fields are largely male owned while female participation is more significant across industries in the region (Konishi, 2017)

**4.** All focus groups were audio-recorded and then manually transcribed and analysed qualitatively using NVivo12 software.

## 5. Results

### *5.1. Participants characteristics*

In Table 1 the demographic characteristics are presented. The focus groups were held among a total of 34 farmers from which 11 participants from the West Bekaa, 11 others from the North of the Bekaa and 12 farmers from the Central Bekaa. Unfortunately, all 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 regard 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 the West Bekaa the average farm was 146 hectares (SD=208), whereas in the North Bekaa, the mean farm size was 590 hectares (SD=1,55). In the region of Central Bekaa was 663 hectares (SD=1,55).

Unfortunately, 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** ***S***ample mean and standard deviation demographic data

| **Characteristics** | **West Bekaa** ***(N=11)*** | **North Bekaa** ***(N=11)*** | **Central Bekaa** ***(N=12)*** |
|---|---|---|---|

| | *Mean (SD)* | | |
|---|---|---|---|
| **Age** (years) | 55 (11) | 46 (13) | 52 (16) |
| **Farm Size** (hectares) | 146 (208) | 590 (1,555) | 663 (1,556) |
| **Age Ranges** *N (%)* | | | |
| **<= 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** *N (%)* | | | |
| **Primary** | 3 (28%) | 1 (9%) | 3 (25%) |
| **Secondary** | 4 (36%) | 3 (27%) | 5 (42%) |
| **University** | 4 (36%) | 7 (64%) | 4 (33%) |

*4.2. Results of the focus groups*

*4.2.1.* This section has as aim to present the findings from the six conducted focus groups. After being transcribed from Arabic language to English, text files were imported into Nvivo12 to first begin with the codings and finding core themes that reflect what participants were discussing indicating the frequency of each core theme (Allsop et al., 2022). The results are categorized into the investigated determinants affecting the acceptance of the micro-irrigation system in potato farming and three key moderators. 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.

*Major Determinants*

*4.2.1.1. Performance Expectancy*

Performance expectancy was measured by the perceptions of using a micro-irrigation system in terms of providing benefits. 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 participant 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.*

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 for example 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 the respondents 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 deriving from the adoption of micro irrigation systems. Based on the content analysis, the most important benefit mentioned by the respondents was water saving. This pattern is evident from the word cloud in Fig. 3 which depicts the most frequently occurring words emerging from focus group discussions.

In Fig. 3, central words with larger font are the most frequent, while distant words with smaller fonts are the less frequent. Thus, the most recurrent words (water, distribution, saving, control, etc.) are important advantages in the opinion of the farmers. Participants highlighted that micro-irrigation is a water saving technique since it supplies water directly to the soil surface close to the plant roots, rather than the land around. As well, they believe that micro-irrigation ensures uniform distribution of water by delivering water only wherever necessary and evenly over the whole land despite the presence of wind. Moreover, farmers consider that micro-irrigation enhances the financial benefits by increasing yield, productivity, and therefore, farm profits. They suppose, as well, that the micro-irrigation is a way to reduce operational costs in terms of reducing energy (less energy for water supply/ low pumping needs) and saving pesticides and fertilizers.

**Figure 3** Word cloud of the perceived advantages of micro-irrigation


Overall, it was shown that farmers perceived the micro-irrigation as a system having 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.

#### *4.2.1.2. Effort Expectancy*

Regarding participants perception of the easiness of use of a micro-irrigation system, and if they will be skillful in using it, 62% of them 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.*

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 can'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. 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.*

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.

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 would 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 ‘‘effort expectancy” plays a positive role in user’s intention to use micro-irrigation technology.

*4.2.1.3. Social Influence*

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,etc.) 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.*

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, 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. Nearly all participants, 94%, were very interested to have access to the experiences and suggestions of other farmers. Inside this group, 50% of them voted for the collective benefit, and 44% 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.*

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.*

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.

They stated that

> It is *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.*

Overall, it seemed that social influence may not influence on the farmers' intention to use a micro-irrigation system.

#### *4.2.1.4. Facilitating Conditions*

This construct is relevant to the question about the guidance role of the agricultural/irrigation extension services in the area. 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.*

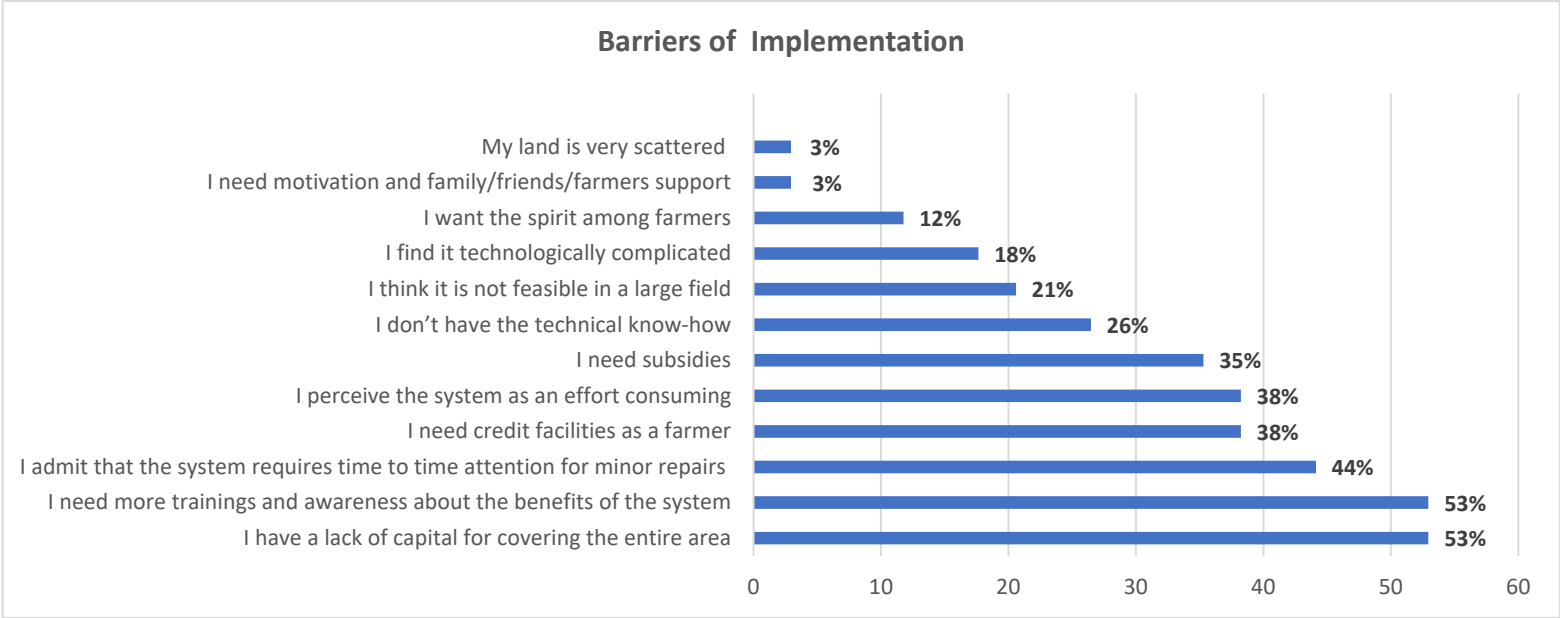
*We have some agricultural guidance from some agricultural associations and institutions*; *they are doing all they can for agricultural extension. I take into account the information they provide, because agricultural guidance is necessary and sometimes it is a memory refresh for things I know, but 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. Participants had the possibility of multiple choices. Several barriers were mentioned by each participant and results are illustrated in Fig.4. 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, facilitating conditions could improve a farmer's use behaviour of a micro-irrigation system.

**Figure 41** Barriers of implementation of a micro-irrigation system




### *4.2.2. 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 only included exploration of the possible effects of the age, experience and voluntariness of use as moderating factors on the four main constructs.

#### *4.2.2.1. Age*

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.

It was indicated that 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.*

However, 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. 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.*

4.2.2.2. Experience

Experience was tested by the familiarity of the farmers in 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.*

#### 4.2.2.3. 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. 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.*

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. 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.*

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. It was stated from 85% of the participants 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.*

#### *4.2.3. The Direct 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.

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.*

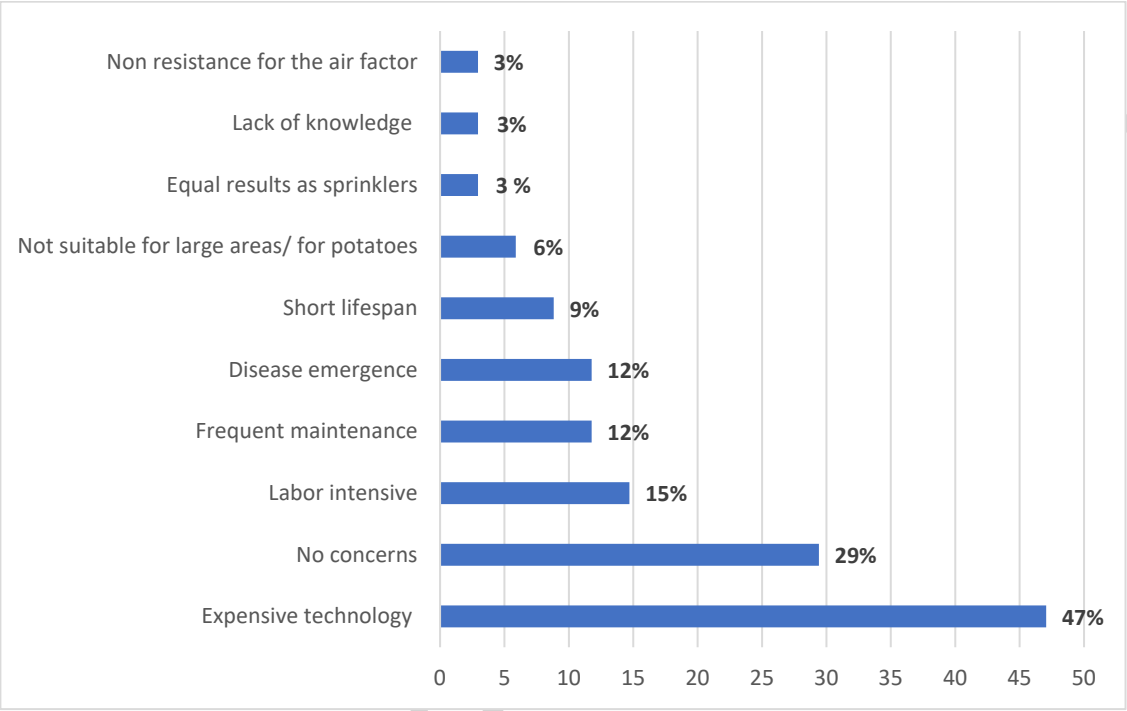
*Yes, if the country's situation stabilizes, I have an intention to adopt a micro-irrigation system soon;*

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

Fig.5 below shows the different answers obtained when investigating the concerns of the participants over the micro-irrigation systems. Each participant had the possibility to mention multiple concerns. 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.

**Figure 5** The concerns related to the micro-irrigation system




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.

At the end, in order to recapitulate the main results of each construct, the following table summarize the findings:

**Table 2. Main findings emerged from the focus group discussions**

| Construct or Moderator | Questions | Findings |
|---|---|---|
| **Performance Expectancy** | A. Knowledge of the micro-irrigation system. | Basic technological knowledge of the micro-irrigation system stating that it incorporates drip irrigation and mini-sprinklers irrigation. |
| | B. The reasons behind using the ordinary sprinklers. | Sprinklers are less expensive. |
| | C. Possible advantages deriving from the adoption of micro irrigation systems. | Water saving, uniform distribution, yield increase, farm profits, energy cost reduction, pesticides and fertilizers reduction. |

| | | |
|---|---|---|
| **Effort Expectancy** | A. Perception of the easiness of use of a micro-irrigation system. | Easy extension over the field, labor and effort saving, time saving. |
| | B. Skillfulness in using micro-irrigation. | 88% of farmers claimed that they will be skillful in using micro-irrigation. |
| **Social Influence** | A. List people whose judgment is important to farmers and that they would approve and disapprove their adoption of a micro-irrigation system. | 47% stated that they don't care to others' opinions.<br>21% considered the opinion of "other farmers" or "nearby farmers" important.<br>20% highlighted the importance of their family members' opinion such as fathers, sons and/or cousins.<br>12% of the farmers were interested in NGO's judgment and advice, as well as agricultural association, organizations and engineers. |
| | B. The importance of collecting information from other farmers and observing their possible successes before adopting a new irrigation system. | 94% of farmers were very interested to have access to the experiences and suggestions of other farmers. |
| **Facilitating Conditions** | A. The guidance role of the agricultural/irrigation extension services in the area. | 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. |
| | B. Barriers that farmers thought might prevent them from implementing a micro-irrigation system. | The most important barrier was the high initial expenses for installing the system. |
| **Age** | A. The age of the farmers affects their incentive to adopt new irrigation practices. | 62% of the participants considered that age had no influence on the intention of use of a new agricultural technology because no matter his age, a farmer remains enthusiastic and encouraged to adopt new technologies, thus developing himself and his land. |
| **Experience** | A. The familiarity of the farmers in micro-irrigation system either by their own trial on their crops or by observing others using it on potatoes or on other crops | 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. |
| | B. The tendency to adopt a micro-irrigation system in a situation where there is no external obligation to adopt the technology. | 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. |

| | | |
|---|---|---|
| **Voluntariness of use** | A. The possibility of adopting micro-irrigation if the government decides to subsidize the use of water-saving irrigation systems. | 85% of the participants 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. |
| **Behavioural Intention** | A. A 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. | 59% of the participants said that they do not have any plan for the adoption of micro-irrigation in the next 12-24 months due to the unstable economic conditions in Lebanon that does not encourage farmers to invest high capitals; the lack of micro-irrigation usefulness in terms of profits and feasibility and the lack of financial means.<br>41% of the participants stated that a plan to adopt the micro-irrigation system is possible in the near future if there is the presence of subsidies by the government. |
| | B. Concerns regarding the micro-irrigation system. | the top concern was the high cost of initial equipment and the possibility of financial losses (47%).<br>15% confirmed that micro-irrigation is labor intensive technique that requires a lot of effort, time and attention.<br>29% have no concerns at all.<br>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. |



## 6. Discussion

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.

Based on the focus group analyses performed, performance expectancy, effort expectancy and facilitating conditions could play a significant effect on the acceptance of micro-irrigation technology while the social influence could not.

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 benefits were identified as saving water, reducing labor effort and time, saving energy, increasing yield, improving crop quality and improving the agricultural operations. The farmers' performance expectancy might increase by focusing on the usefulness of micro-irrigation systems. That means if the advantages of micro-irrigation systems were presented in meetings made by specialists, this probably would increase the acceptance and adoption for people who were against this method, and who preferred the ordinary sprinklers. Almost all participants declared that generation of good results and water saving were the top advantages of micro-irrigation system. However, they were very anxious about losing the financial investments in case they would not be able to apply this method without professional guidance. This asserts the idea of the essentiality to establish an agricultural guidance, in order to promote the advantages of micro-irrigation system and its usage. 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(Ronaghi & Forouharfar, 2020) that have found a positive relationship between performance expectancy and behavioural intention to use technology.

The effort expectancy 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 on potatoes. From the focus group analysis, it seemed that farmers preferred to adopt an easy way to use system which

required less effort and time than ordinary sprinklers on potato crops. 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, demonstrated their willingness to learn about the micro-irrigation functions. By that, organizing trainings and pilot studies could be a way for farmers to decrease their level of doubt. During on-field trainings, farmers discover how micro-irrigation functions, and the adequate way of its installation over the potato fields. Similar with other research (Birch & Irvine, 2009; Im et al., 2011; Louho et al., 2006; Venkatesh et al., 2003(Nkandu & Phiri, 2022)), effort expectancy could have an effect on behavioural intention.

The third determinant, the social influence, seemed to have an insignificant impact on behavioural intention to use micro-irrigation. This result was consistent with (Venkatesh et al., 2003) and (Rosen, 2005(Yang et al., 2020)). In his research, (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 was found not affecting 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. This is why promoting the importance of agricultural associations and farmers' gatherings, will revitalize the spirit among farmers and the cooperation between them.

Lastly, the facilitating conditions determinant was measured by evaluating the available resources and support to use micro-irrigation systems. The study results clearly depicted the direct effect of facilitating conditions on use behaviour of using micro-irrigation systems consistently with (Hung et al., 2006; Im et al., 2011; Venkatesh et al., 2003; Wang & Shih, 2009). Guidance departments at the Ministry of Agriculture, NGOs working in agricultural extensions especially on the climate change subject, advertising on social media raising awareness on new ways of saving water, in addition to any other available services to assist individuals to adopt and use micro-irrigation systems could be an essential way to enhance the adoption of a micro-irrigation system.

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.

With respect to the moderating effect of age, it emerged that it 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, 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. 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.

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 in the case of subsidies, 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. 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.

## 7. Conclusions

The aim of this study was to investigate the potato farmers' behaviour in adopting a micro-irrigation system. To achieve this objective, we adapted the unified theory of acceptance and use of technology (UTAUT) model.

The outcomes offer visions for the policymakers to encourage potato farmers' in adopting a new micro-irrigation system. Firstly, farmers are willing to accept micro-irrigation technology when they can make gain and reduce task uncertainty on their farming activities. Secondly, they are keen to adopt a micro-irrigation system if they find that it reduces effort and time of their farming activities. Finally, it is relevant to encourage farmers to adopt it through financial aids or subsidies which provide opportunities for farmers to decrease the financial burdens on them. As well agricultural extensions, field trainings, pilot area studies are also important in increasing the farmers' intention to adopt a micro-irrigation system.

## 7. Limitations

Legal restrictions and safety measures linked to the COVID19 pandemic were a reason of the limited sample size. Also, the sample used lacked gender differentiation since no females operated farms in the study area. Thus, it would be useful to repeat the analysis with a larger sample for focus group discussions incorporating female participation and extending the study to other countries.

## References


AbuShanab, E., & Pearson, J. M. (2007). Internet banking in Jordan: The unified theory of acceptance and use of technology (UTAUT) perspective. *Journal of Systems and information Technology*.

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, *50*(2), 179-211. https://doi.org/https://doi.org/10.1016/0749-5978(91)90020-T

Al-Gahtani, S. S. (2004). Computer technology acceptance success factors in Saudi Arabia: an exploratory study. *Journal of Global Information Technology Management*, *7*(1), 5-29.

Allsop, D. B., Chelladurai, J. M., Kimball, E. R., Marks, L. D., & Hendricks, J. J. (2022). Qualitative methods with Nvivo software: A practical guide for analyzing qualitative data. *Psych*, *4*(2), 142-159.

Alshehri, M., Drew, S., & AlGhamdi, R. (2013). Analysis of citizens acceptance for e-government services: applying the UTAUT model. *arXiv preprint arXiv:1304.3157*.

Arbuckle, J. G., Prokopy, L. S., Haigh, T., Hobbs, J., Knoot, T., Knutson, C., Loy, A., Mase, A. S., McGuire, J., & Morton, L. W. (2013). Climate change beliefs, concerns, and attitudes toward adaptation and mitigation among farmers in the Midwestern United States. *Climatic change*, *117*(4), 943-950.

Ayas, S. (2013). The effects of different regimes on potato (Solanum tuberosum L. Hermes) yield and quality characteristics under unheated greenhouse conditions. *Bulgarian Journal of Agricultural Science*, *19*(1), 87-95.

Bahramzadeh, M., & Shokati Mogharab, S. (2010). Cultural approach to IT: compliance evaluation based on UTAUT. 8th international conference on management. http://www. civil ica. com/Pape r-IRIMC

Bandura, A. (1994). Social cognitive theory and exercise of control over HIV infection. In (pp. 25-59). Springer.

Bandyopadhyay, K., & Fraccastoro, K. A. (2007). The effect of culture on user acceptance of information technology. *Communications of the association for information systems*, *19*(1), 23.

Bank. (2014). Turn down the heat: confronting the new climate normal. *World Bank Publications*.

Birch, A., & Irvine, V. (2009). Preservice teachers' acceptance of ICT integration in the classroom: applying the UTAUT model. *Educational media international*, *46*(4), 295-315.

Compeau, D., Higgins, C. A., & Huff, S. (1999). Social cognitive theory and individual reactions to computing technology: A longitudinal study. *MIS quarterly*, 145-158. https://doi.org/10.2307/249749

Compeau, D. R., & Higgins, C. A. (1995). Application of social cognitive theory to training for computer skills. *Information systems research*, *6*(2), 118-143. https://doi.org/10.1287/isre.6.2.118

Darwish, T., Atallah, T., Hajhasan, S., & Chranek, A. (2003). Management of nitrogen by fertigation of potato in Lebanon. *Nutrient Cycling in Agroecosystems*, *67*(1), 1-11.

Darwish, T., Atallah, T., Hajhasan, S., & Haidar, A. (2006). Nitrogen and water use efficiency of fertigated processing potato. *Agricultural water management*, *85*(1-2), 95-104.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, 319-340. https://doi.org/10.2307/249008

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1992). Extrinsic and intrinsic motivation to use computers in the workplace 1. *Journal of applied social psychology*, *22*(14), 1111-1132.

de Veer, A. J. E., Fleuren, M. A. H., Bekkema, N., & Francke, A. L. (2011). Successful implementation of new technologies in nursing care: a questionnaire survey of nurse-users. *BMC Medical Informatics and Decision Making*, *11*(1), 1-12. https://doi.org/10.1186/1472-6947-11-67

Deligios, P. A., Chergia, A. P., Sanna, G., Solinas, S., Todde, G., Narvarte, L., & Ledda, L. (2019). Climate change adaptation and water saving by innovative irrigation management applied on open field globe artichoke. *Science of the Total Environment*, *649*, 461-472.

Eweoya, I., Okuboyejo, S. R., Odetunmibi, O. A., & Odusote, B. O. (2021). An empirical investigation of acceptance, adoption and the use of E-agriculture in Nigeria. *Heliyon*, *7*(7), e07588.

FAOSTAT. (2017). *FAOSTAT statistical database*.

Field, C. B. and V. R. Barros (2014). *Climate change – Impacts, adaptation and vulnerability: Regional aspects*. Cambridge University Press: New York, NY, USA, 2014; ISBN 1107058163.

Fishbein, M., & Ajzen, I. (1975). *Intention and behavior: An introduction to theory and research*. Addison-Wesley.

Halwani, J., & Halwani, B. (2022). Climate Change in Lebanon and the Impact to Water Resources. In *Climate Change in the Mediterranean and Middle Eastern Region* (pp. 395-412). Springer.

Hennink, M. M., Kaiser, B. N., & Weber, M. B. (2019). What influences saturation? Estimating sample sizes in focus group research. *Qualitative health research*, *29*(10), 1483-1496.

Houston, L., Capalbo, S., Seavert, C., Dalton, M., Bryla, D., & Sagili, R. (2018). Specialty fruit production in the Pacific Northwest: adaptation strategies for a changing climate. *Climatic change*, *146*, 159-171.

Hung, S.-Y., Chang, C.-M., & Yu, T.-J. (2006). Determinants of user acceptance of the e-Government services: The case of online tax filing and payment system. *Government information quarterly*, *23*(1), 97-122.

Im, I., Hong, S., & Kang, M. S. (2011). An international comparison of technology adoption: Testing the UTAUT model. *Information & management*, *48*(1), 1-8.

Jaafar, H.; King-Okumu, C.; Haj-Hassan, M.; Abdallah, C.; El-Korek, N.; Ahmad, F (2016). Water Resources within the Upper Orontes and Litani Basins—A Balance, Demand and Supply Analysis amid the Syrian Refugees Crisis; IIED Working Paper; International Institute for Environment and Development: Beirut, Lebanon.

Kallaya, J., Prasong, P., & Kittima, M. (2009). An acceptance of mobile learning for higher education students in Thailand.

Karam, F., & Karaa, K. (2000). Recent trends towards developing a sustainable irrigated agriculture in the Bekaa Valley of Lebanon. *Option Méditerranéennes B series*, *31*, 65-86.

Konishi, T. F. Y. (2017). JOBS IN NORTH LEBANON: ASSESSMENT OF THE POTATO VALUE CHAIN . *Jobs Working Paper*, *Issue 9.*

LARI. (2019). Temperature and Precipitation data in the Bekaa in the last 10 years, The World Bank Group: Beirut, Lebanon.

Louho, R., Kallioja, M., & Oittinen, P. (2006). Factors affecting the use of hybrid media applications. *Graphic arts in Finland*, *35*(3), 11-21.

Mahamood, A. F., Mohammed, R., Ahmad, M. K., Ridzuan, A. H., Hamzah, M. R., Abdullah, S., & Shaffril, H. A. (2016). Applying diffusion of innovation theory and unified theory of acceptance and use of technology (UTAUT) on farmers' use of communication technology. *Journal of Human Development and Communication (JoHDEC)*, *5*, 27-40.

MoA. (2003). National Action Plan to Combat Desertification: The World Bank Group: Beirut, Lebanon .

MoA, & LARI. (2008). A technical package of booklets for the following selected crops: apple, cherry, grapevine, tomato, potato, EU Agriculture Development Project *MED/2003/5715/ADP;* The World Bank Group: Beirut, Lebanon .

MoE, & UNDP. (2011). Lebanon's Second National Communication to the United Nations Framework Convention on Climate Change. In Climate Change Vulnerability and Adaptation: Human Settlements and Infrastructure; The Ministry of Environment—United Nations Development Programme: Beirut, Lebanon.

MoE, UNDP, & GEF. (2015). Economic costs to Lebanon from climate change: A first look. Ministry of Environment—United Nations Development Programme: Beirut, Lebanon.

Moore, G. C., & Benbasat, I. (1991). Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information systems research*, *2*(3), 192-222. https://doi.org/10.1287/isre.2.3.192

Morris, M. G., Venkatesh, V., & Ackerman, P. L. (2005). Gender and age differences in employee decisions about new technology: An extension to the theory of planned behavior. *IEEE Transactions on engineering management*, *52*(1), 69-84.

Nassuora, A. B. (2012). Students acceptance of mobile learning for higher education in Saudi Arabia. *American Academic & Scholarly Research Journal*, *4*(2), 24-30.

Nejadrezaei, N., Allahyari, M. S., Sadeghzadeh, M., Michailidis, A., & El Bilali, H. (2018). Factors affecting adoption of pressurized irrigation technology among olive farmers in Northern Iran. *Applied Water Science*, *8*(6), 1-9.

Nejadrezaei, N., Khara, H., Allahyari, M. S., Sadeghzadeh, M., & Gharra, K. (2015). Effective factors on adoption technology among trout fish farms in Guilan Province.

Nkandu, P., & Phiri, J. (2022). Assessing the Effect of ICTs on Agriculture Productivity Based on the UTAUT Model in Developing Countries. Case Study of Southern Province in Zambia. *Open Journal of Business and Management*, *10*(6), 3436-3454.

Niles, M. T., & Mueller, N. D. (2016). Farmer perceptions of climate change: Associations with observed temperature and precipitation trends, irrigation, and climate beliefs. *Global Environmental Change*, *39*, 133-142. https://doi.org/10.1016/j.gloenvcha.2016.05.002

Pearson, F. S., Lipton, D. S., Cleland, C. M., & Yee, D. S. (2002). The effects of behavioral/cognitive-behavioral programs on recidivism. *Crime & Delinquency*, *48*(3), 476-496.

Ronaghi, M. H., & Forouharfar, A. (2020). A contextualized study of the usage of the Internet of things (IoTs) in smart farming in a typical Middle Eastern country within the context of Unified Theory of Acceptance and Use of Technology model (UTAUT). *Technology in Society*, *63*, 101415.

Rosen, P. A. (2005). *The effect of personal innovativeness on technology acceptance and use*. Oklahoma State University.

Rouzaneh, D., Yazdanpanah, M., & Jahromi, A. B. (2021). Evaluating micro-irrigation system performance through assessment of farmers' satisfaction: implications for adoption, longevity, and water use efficiency. *Agricultural water management*, *246*, 106655.

Sa'ari, J. R., Jabar, J., Tahir, M. N. H., & Mahpoth, M. H. (2017). Farmer's acceptance towards sustainable farming technology. *International Journal of Advanced and Applied Sciences*, *4*(12), 220-225.

Sabbagh, M., & Gutierrez, L. (2022). Micro-Irrigation Technology Adoption in the Bekaa Valley of Lebanon: A Behavioural Model. *Sustainability*, *14*(13), 7685. https://www.mdpi.com/2071-1050/14/13/7685

Scoville-Simonds, M., Jamali, H., & Hufty, M. (2020). The hazards of mainstreaming: Climate change adaptation politics in three dimensions. *World Development*, *125*, 104683.

Shah, S. (2011). Towards Adopting Nanotechnology in Irrigation: Micro Irrigation Systems. *India Water Portal: Karnataka, India*.

Slade, E. L., Dwivedi, Y. K., Piercy, N. C., & Williams, M. D. (2015). Modeling consumers' adoption intentions of remote mobile payments in the United Kingdom: extending UTAUT with innovativeness, risk, and trust. *Psychology & Marketing*, *32*(8), 860-873.

Šumak, B., & Šorgo, A. (2016). The acceptance and use of interactive whiteboards among teachers: Differences in UTAUT determinants between pre-and post-adopters. *Computers in Human Behavior*, *64*, 602-620. https://doi.org/doi.org/10.1016/j.chb.2016.07.037

Taylor, S., & Todd, P. (1995). Assessing IT usage: The role of prior experience. *MIS quarterly*, 561-570. https://doi.org/10.1287/isre.6.2.144

Taylor, S., & Todd, P. A. (1995). Understanding information technology usage: A test of competing models. *Information systems research*, *6*(2), 144-176.

Thompson, R. L., Higgins, C. A., & Howell, J. M. (1991). Personal computing: Toward a conceptual model of utilization. *MIS quarterly*, 125-143. https://doi.org/10.2307/249443

UNDP; UNHCR. (2021). *Lebanon Crisis Response Plan 2017–2021*; The UN Refugee Agency: Beirut, Lebanon.

USAID. (2018). Climate Risk Profile - Lebanon. Adaptation Thought Leadership and Assessments (ATLAS), USAID Agency: Beirut, Lebanon.

Varma, S., & Namara, R. (2006). Promoting micro irrigation technologies that reduce poverty. *Water Policy Briefing*, *23*.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management science*, *46*(2), 186-204. https://doi.org/10.1287/mnsc.46.2.186.11926

Venkatesh, V., & Morris, M. G. (2000). Why don't men ever stop to ask for directions? Gender, social influence, and their role in technology acceptance and usage behavior. *MIS quarterly*, 115-139.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS quarterly*, 425-478.

Wang, Y.-S., & Shih, Y.-W. (2009). Why do people use information kiosks? A validation of the Unified Theory of Acceptance and Use of Technology. *Government information quarterly*, *26*(1), 158-165. https://doi.org/10.1016/j.giq.2008.07.001

Yang, X., Chen, L., Wei, L., & Su, Q. (2020). Personal and media factors related to citizens' pro-environmental behavioral intention against haze in China: A moderating analysis of TPB. *International Journal of Environmental Research and Public Health*, *17*(7), 2314.

Yu, C.-S. (2012). Factors affecting individuals to adopt mobile banking: Empirical evidence from the UTAUT model. *Journal of electronic commerce research*, *13*(2), 104.