REPUBLIC OF TURKEY
ERCIYES UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
DEPARTMENT OF AGRICULTURAL SCIENCE AND TECHNOLOGIES

FARMER'S ADAPTATION OF MODERN IRRIGATION TECHNIQUES IN IRAQ

Prepared By
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Supervisor
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Ph. D. Thesis

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KAYSERİ

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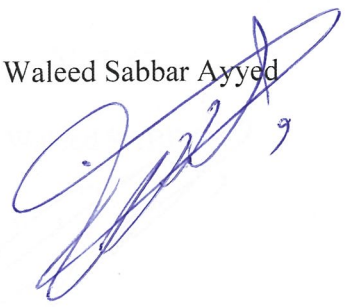
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SCIENTIFIC ETHICS SUITABILITY

I declare all information in this work was obtained in accordance with academic and ethical rules. All results and material that not been at the essence of this work are also transferred and expressed by giving reference as required by these rules and behavior.

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SUITABILITY FOR GUIDE

The Ph.D. dissertation entitled **"Farmer's Adaptation of Modern Irrigation Techniques in Iraq"** has been prepared in accordance with Erciyes University Graduate Education and Teaching Institute Thesis Preparation and Writing Guide.

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ABSTRACT

The research aims to identify the farmers' adoption of modern irrigation techniques in Salahaddin and Kirkuk provinces of Iraq. Following a general assessment, the barriers that prevent farmers from adopting modern irrigation techniques and the factors that encourage the farmers in adopting modern irrigation technologies were tried to be identified. The farmers registered in Agricultural Directorates of Salahaddin and Kirkuk municipalities (21 and 16 directorates) constituted the research. Face-to-face questionnaires were applied to farmers randomly selected from the farmers of two municipalities. From two provinces, 338 farmers voluntarily participated into the survey. In data analyses, range, frequency distribution and percentages, standard deviation, t-test, arithmetic mean, weighted average, simple correlation equation (Pearson), Spearman's correlation coefficient(r), validity coefficient, significance test and Cronbach's Alpha were used as statistical parameters. According to present findings, farmer's adoption of modern irrigation techniques was found to be "average" in both provinces. From this information, it can be deduced that there is a weakness in the expertise and knowledge about these modern irrigation techniques. This indicates the need for programs, activities and guidance to train them. There is a need for Agricultural Extension services of the Ministry of Agriculture to implement educational and training programs to assist farmers with understanding the modern irrigation technologies. The governing bodies must explain that these technologies had a positive impact on water consumption, as well as quantity and quality of their production.

Key Words: Modern irrigation technologies, Salahaddin, Kirkuk, Agricultural extension, adoption.

IRAK ÇİFTÇİLERİN MODERN SULAMA TEKNİKLERİNİ BENİMSEMESİ

Waleed SABBAR

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ÖZET

Bu tez çalışmasında Irak'ın Salahaddin ve Kerkük şehirlerinde çiftçilerin modern sulama teknolojilerini benimse düzeyleri belirlenmeye çalışılmıştır. Bu amaçla genel bir değerlendirmenin ardından çiftçileri modern sulama teknolojilerini benimsemeden alıkoyan ve teşvik eden faktörler belirlenmeye çalışılmıştır. Salahaddin ve Kerkük şehirlerinde Tarım İlçe Müdürlüklerinde (21 ve 16 adet) kayıtlı çiftçiler çalışma evrenini oluşturmuştur. Çalışma evrenini temsil edecek şekilde her iki şehirde de tesadüfi örnekleme ile seçilen çiftçilere yüz-yüze anket çalışması uygulanmıştır. Her iki şehirden toplam 338 çiftçi bu çalışmada ankete katılmaya gönüllü olmuşlardır. Veri analizlerinde aralık, frekans dağılımı ve yüzdeler, standart sapma, t-testi, aritmetik ortalama, ağırlıklı ortalama, basit korelasyon eşitliği (Pearson), Spearman's korelasyon katsayısı (r), geçerlilik katsayısı, önemlilik testi ve Cronbach's Alfa katsayısı gibi parametreler kullanılmıştır. Araştırma sonuçlarına göre her iki şehirde de modern sulama teknolojilerinin çiftçiler tarafından benimsenme düzeyi "orta" düzeyde bulunmuştur. Bu bilgiden hareketle modern sulama teknolojileri hakkında bir bilgi ve deneyim eksikliğinden bahsedilebilir. Buda çiftçilerin bu yönde eğitimine dönük faaliyetlerin gerekliliğini ortaya koymaktadır. Bu amaçla Tarım Bakanlığına bağlı Tarımsal Yayım birimlerinin çiftçilerinin modern sulama teknolojilerine yönelik bilgi ve becerilerini arttıracak yayım çalışmalarına hız vermesi gerektiği kanaatine varılmıştır. Yönetici pozisyonundaki kurum ve kuruluşlar bu teknolojilerin su kullanımının yanı sıra ürün miktar ve kalitesine de olumlu etkileri hakkında çiftçileri bilinçlendirmesi gerekmektedir.

Anahtar Kelimeler: Modern sulama teknolojileri, Salahaddin, Kerkük, Tarımsal yayım, adaptasyon.

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ABBREVIATIONS

**	:	Significant at the probability level 0.01
CIMMYT	:	The International Maize and Wheat Improvement Center
IWMI	:	International Water Management Institute
n.s	:	Non-significant
NGOs	:	Non-Governmental Organizations
P-value	:	Probability value
R S- Value	:	The Spearman Range correlation coefficient
R -value	:	Means the Pearson correlation coefficient
S.D	:	Standard Deviation is a measure that is used to quantify the amount of variation or dispersion of a set of data values.
WSF	:	Its mean a water-soluble fertilizers

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INTRODUCTION

Water is an essential and indispensable component of human life. A major global crisis has resulted in absolute limitation of water as a renewable resource and excessive consumption due to population growth (Nejat Pour, 2008). Recent technological developments in agriculture and resultant farmers' adoption have brought far-reaching changes to agriculture over the past half century (Berardi and Geisler, 1984; Dillman and Hobbs, 1982; Hawley and Mazie, 1981; Cochrane, 1979).

Decades ago, especially towards the end of the 20^{th} century, water management became an international concern. Society health promotion, water resource sustainability, environmental conservation, economic growth (especially in the agricultural sector) and meeting basic needs of people are believed to be more than ever dependent on proper management and use of water resources (Aghapour Sabbaghi., 2009).

Davivongs *et. al*. (2012) indicated water as the most significant asset and reported that water played great roles in productivity of farmlands. Furthermore, potential access to this vital source has great contributions to welfare of small farmers (Kitchaicharoen, 2008). As stated by Namara *et. al*. (2006), water supply, diversion and conservation are all designated by water needs. Such needs also designate measures to be taken for ecological and environmental sustainability. The artificial channeling of water to and from the growing fields is what is known in modern terms as irrigation.

Irrigation is then defined as application of water to crops in a desired quantity at needed periods of time. It helps in growing farm crops, preserving environment and revegetating degraded soils during the dry periods with inadequate rainfalls (De Vries., 2012). It enables water to meet different needs of agriculture, industry and households (Lenton and Muller., 2012; Grigg., 2008). Modern technologies generally improve water use efficiency, thus allow farmers to irrigate larger lands with the same quantity

of irrigation water. Such efficient uses are especially crucial in countries like Iraq with quite hot and dry seasons and insufficient water resources (Genius *et. al.,* 2013). Recorded history shows that Iraq had always embark on traditional irrigation methods to enhance agricultural production as the annual rainfall is nothing to depend on. However, a geometric increase in population since the 1950s put so much pressure on the traditional irrigation capabilities and consequently hampered adequate yield levels. The adverse impacts of internal wars in Iraq have faced irrigation activities of the country with extinction. Therefore, modern irrigation technologies are still new to many parts (if not all) of the country with majority of the farmers in rural areas sticking to traditional irrigation systems due to very little agricultural extension services coupled with poor economic conditions and high illiteracy level of the farmers.

Technology is the most important driving force for the long-term growth of agricultural productivity but must be adopted efficiently and productively. The adoption of new and improved technologies (such as modern irrigation technologies) by farmers has always been a problem from generation to generation. It has been established that, all members of the population of potential adopters do not adopt a new technology at the same time; and some never adopt at all. Despite the theoretical and practical justification for the practices, the economic rationality for adoption and the diligence with which information is disseminated, this incomplete level of adoption prevails. Socioeconomic characteristics, on-going policies, potential risks and economic power of the farmers designate farmers' adoption of new technologies (Shideed and Mohammed, 2005). New technology adoption in various production systems is an important source of productivity. New technologies bring about various benefits to farmers. They may reduce cost of production, improve yields, thus increase outputs and revenues.

Although efforts have been spent to improve farmer's adoption level of new technologies, studies have shown that inadequate agricultural research and extension greatly influenced the spread and adoption of modern techniques/technologies to and among farmers. Agricultural production can be increased (about 50%) from the current production levels if the available agricultural techniques and technologies are put into practice (Arab Organization for Agricultural Development, 2001). Unfortunately, due to the many difficulties encountered in the transfer process putting the available techniques into use, such new technologies have become a nightmare. In fact, there is a huge gap

between what researchers do as well as the results they get in the test station and the production level of the farmers in their fields. This clearly shows that either the technology was not well-transferred to the user or the user has failed to put into use what they have received from the researchers which could be due to many other issues such as social and economic factors. Various parameters could influence farmers' attitudes towards approval of new technologies such as modern technologies for irrigation.

Rogers (1995) stated that there were close relations among the farmers of the same or different societies and thus they learn a lot from each other. Farmers also tend to imitate the practices and implementations of successful growers. They generally try to do what these farmers are doing in their agricultural operations.

Several factors influence farmer' decision on adoption of new irrigation technologies. Extension services raise a consciousness about new irrigation techniques. Then service-provided farmers judge these techniques whether to accept or refuse based on their land sizes, crops grown, education, experience, availability of labor or demand, expected fertility improvements, the availability of input costs for credit facilities and other factors (Rogers, 1983).

Farmers may either instantaneously accept a new technology or it may take a long time to decide about a technology. Farmers' decisions depend largely on their level of education, age and income levels. Therefore, previous studies on adoption of new technologies basically focused on the relationships between demographic characteristics of the farmers and their attitudes towards a new technology.

In their exclusive works, (Oka, 2000; Everitt and Dunn, 1991) reported that farmers' decision on new technologies mostly depend on their income levels. The empirical studies of (Genius *et. al.*, 2013; Dridi and Khanna, 2005) indicated demographic attributes and income levels of the farmers as the most important factors influencing their decisions on new technologies and farmer's adaptation of new irrigation technologies.

Irrigation technology can dramatically increase water use efficiency. There is a growing awareness about potential benefits of high water use efficiencies especially in dry lands

of Iraq. Farmers' selection of a new irrigation technologies may not be the best one in all cases based solely on economic viability. Better than relying on a single criterion, various other parameters should also be taken into consideration while selecting a new technology. Irrigation methods or technologies all have different attributes and all such different attributes should be taken into consideration. It should also be kept in mind that only the methods well-designed, constructed and operated could yield targeted outcomes. Cornish and Cornish (1998) indicated water supply, agricultural practices and economic factors as the most significant parameters to be considered while selecting or adopting a new irrigation technology.

The objectives

The expected information from the survey will go a long way in assisting agricultural extension services and the ministry of agriculture in Iraq in aspects of irrigation management to design, plan, organize, evaluate and implement programs that will enhance information dissemination to farmers with regard to modern irrigation technologies. To sustain the management of irrigation system, all stakeholders must be aware of forces that helps in developing the system and those that hinder them. With the present survey, most of these problems can be prevented. The outcome of this survey will be beneficial to farmers, agricultural extension workers of the state. Findings of this research can also be useful in promoting the management of decentralized small-scale resources and help in reaching out to grass-root level farmers in areas of resource allocation and sustainability. Although the findings will be specifically obtained from Mosul region, it can also be applicable to other regions of northern/southern Iraq.

The objectives are:

1. To identify the demographic, economic and social characteristics of the participants of Salahaddin and Kirkuk provinces, Iraq.

A: Quantitative Characteristics

B: Qualitative Characteristics

2. To identify the farmers' adoption of modern irrigation techniques in Salahaddin and Kirkuk provinces in general.

3. To recognize the farmers' adoption of modern irrigation techniques in each province separately.

A: Farmers' adoption of modern irrigation techniques in Salahaddin province.

B: Farmers' adoption of modern irrigation techniques in Kirkuk province.

4. To identify the difference between the average adoption of respondents in the provinces of Salahaddin and Kirkuk.

5. To identify the size of the barriers that prevent farmers from adopting modern irrigation techniques in general.

A. Identify the size of the barriers that prevent farmers from adopting modern irrigation techniques in Salahaddin provinces.

B. Identify the size of the barriers that prevent farmers from adopting modern irrigation techniques in Kirkuk provinces.

6. To identify the factors that encourage the farmers in adopting modern irrigation technology in general:

A. To identify the factors that encourage the farmers in adopting modern irrigation technology in Salahaddin provinces.

B. To identify the factors that encourage the farmers in adopting modern irrigation technology in Kirkuk provinces.

7. To identify the correlations between the respondents' adoption of modern irrigation techniques in the provinces of Salahaddin and Kirkuk in general and some independent variables related to the respondents**.**

Research Questions

The researcher tries to find answers to some of the following questions;

1. What are the demographic, economic and social characteristics of the respondents in the provinces of Salahaddin and Kirkuk?

A: Quantitative Characteristics.

B: Qualitative Characteristics.

2. What is the farmers' adoption of modern irrigation techniques in Salahaddin and Kirkuk provinces in general?

3. What is the farmers' adoption of modern irrigation techniques in each province separately?

A: What is the farmers' adoption of modern irrigation techniques in Salahaddin province?

B: What is the farmers' adoption of modern irrigation techniques in Kirkuk province?

4. What is the difference between the average adoption of respondents in the provinces of Salahaddin and Kirkuk?

5. What is the size of the barriers that prevent farmers from adopting modern irrigation techniques in general?

A: What is the size of the barriers that prevent farmers from adopting modern irrigation techniques in Salahaddin provinces?

B: What is the size of the barriers that prevent farmers from adopting modern irrigation techniques in Kirkuk provinces?

6. What are the factors that encourage the farmers in adopting modern irrigation technology in general?

A: What are the factors that encourage the farmers in adopting modern irrigation technology in Salahaddin provinces?

B: What are the factors that encourage the farmers in adopting modern irrigation technology in Kirkuk provinces?

7. What is the correlation between the respondents' adoption of modern irrigation techniques in the provinces of Salahaddin and Kirkuk in general and some independent variables related to the respondents?

Research Hypotheses

A. Null hypotheses

1. There is no relationship between farmers’ adoption of modern irrigation technology and age.

2. There is no relationship between farmers' adoption of modern irrigation technology and farm size.

3. There is no relationship between farmers' adoption of modern irrigation technology and number of years of experience in farming.

4. There is no relationship between farmers' adoption of modern irrigation technology and size of household.

5. There is no relationship between farmers' adoption of modern irrigation technology and access to sources of information.

6. There is no relationship between farmers' adoption of modern irrigation technology and extension efforts.

7. There is no relationship between farmers' adoption of modern irrigation technology and farm ownership.

8. There is no relationship between farmers' adoption of modern irrigation technology and marital status.

9. There is no relationship between farmers' adoption of modern irrigation technology and farm labor.

10. There is no relationship between farmers' adoption of modern irrigation technology and the family rank.

11. There is no relationship between farmers' adoption of modern irrigation technology and educational level.

12. There is no relationship between farmers' adoption of modern irrigation technology and government supports.

B. Alternative hypotheses

1. There is a relationship between farmers' adoption of modern irrigation technology and age.

2. There is a relationship between farmers' adoption of modern irrigation technology and farm size.

3. There is a relationship between farmers' adoption of modern irrigation technology and number of years of experience in farming.

4. There is a relationship between farmers' adoption of modern irrigation technology and size of household.

5. There is a relationship between farmers' adoption of modern irrigation technology and access to sources of information.

6. There is a relationship between farmers' adoption of modern irrigation technology and extension efforts.

7. There is a relationship between farmers' adoption of modern irrigation technology and farm ownership.

8. There is a relationship between farmers' adoption of modern irrigation technology and marital status.

9. There is a relationship between farmers' adoption of modern irrigation technology and farm labor.

10. There is a relationship between farmers' adoption of modern irrigation technology and the family rank.

11. There is a relationship between farmers' adoption of modern irrigation technology and educational level

12. There is a relationship between farmers' adoption of modern irrigation technology and government supports.

CHAPTER 1

GENERAL INFORMATION

1.1. Irrigation Technologies

Irrigation is generally defined as application of water to land or plants in a controlled fashion at needed periods or specific intervals. According to Cantor (1967), irrigation is defined as application of water, required for plant growth but not sufficiently met by natural precipitations, to plant root zones. Irrigation is among the most significant inputs in agricultural production activities.

In Ancient Egypt, Mesopotamia, and Ancient Persia, archaeological evidence of irrigation to support crops where natural rainfall was insufficient could be traced back to 6000 BC. In the alluvial plains of the Indus valley, civilizations (present Pakistan and Northern India) practiced irrigations at around 4500 BC as a means of water manipulation aimed at drastically increasing their agriculture-based settlements (Kang, 1972).

During these ancient times and even till this date, water is conveyed to the field through dug-out furrows or ditches and released along the upper end of the field. This old method of watering a field, otherwise termed as “Traditional Irrigation” or “Surface Irrigation” method relies on gravity to deliver water down or across a field. Although it may be less costly to construct and operate than the modern irrigation methods, traditional irrigation methods are not quite efficient. And coupled with the ever increasing world population, low rainfall patterns, it is important to device or adopt more efficient methods of irrigation such that water usage will be minimized while maintaining optimum crop yields.

Negri and Brooks (1990) indicated that pressurized irrigation technologies, especially sprinkler and drip irrigation, can provide significant water savings as compared to the surface , in other words, gravity irrigation systems since these methods provide more uniform water distribution over the field surface, reduce runoffs and deep percolation. Sprinkler irrigation also does not require land leveling in undulated topographies. The system can provide greater water use and irrigation water use efficiencies than the conventional surface irrigation methods (Sloggett, 1985). While the water application efficiency generally varies between 40-65% in surface irrigation methods, the value can reach up to 85-90% in pressurized irrigation systems (Aillery and Gollehon, 2003). Evaporative losses are the only disadvantage of sprinkler systems (Olen *et. al.*, 2016) and such losses even get bigger under windy conditions (Negri and Hanchar, 1989). Just because of greater water application and use efficiencies, pressurized irrigation systems (sprinkler and drip) can achieve 10-35% water savings as compared to conventional surface irrigation systems without any pressures (Caswell and Zilberman., 1985; Sloggett., 1985).

1.2. Importance of modern irrigation technologies

It has been reported by several researchers that the adoption of new irrigation technologies may necessitate adoption to global warming and climate change (Jackson *et al.*, 2009; Joyce *et al.*, 2009; Cavagnaro *et al.*, 2006; Kurukulasuriya and Rosenthal, 2003; Smit and Skinner, 2002 and Burton, 2000).

In modern day agriculture, modern irrigation technologies play a great role in increasing yields and ultimately well-fare of farmers and alleviating poverty. According to Nin *et al.* (2003), new and modern technologies (especially modern irrigation methods like sprinkler and drip) had significant effects on agricultural activities especially of developing countries. In affirmation to this, Mapila (2011), also stated that new technologies should be disseminated to new generations through extension activities of the responsible authorities and such activities will in turn boost the productions of developing countries. However, it is not just the availability of modern agricultural technologies, but the capability of farmers (the end users) to adopt and make a profitable use of these technologies is also crucial (Akudugu *et. al.*, 2012).

As compared to traditional irrigation, modern irrigation methods could give a more reliable management for timing and quantity of water to be applied in each irrigation, could allow users to monitor water supply to plant requirements and would aid in protecting plants against extreme weather conditions like droughts and frosts (Frisvold and Bai, 2016).

Although modern irrigation technologies (drip irrigation, sprinklers and micro-sprinklers) have become widespread, literature on their adoption is quite limited (Dinar and Yaron, 1990).

1.3. Factors Influencing Adoption of Modern Agricultural Technologies

Several parameters designate farmers' adoption of modern technologies, especially of modern irrigation technologies. Literature about farmers' adoption of modern irrigation methods have generally employ numerous key variables such as output-input prices, field sizes and human capitals to describe levels of adoption (Dinar and Yaron, 1990). Growers more likely to adopt if: (a) input-output prices are increasing (Caswell and Zilberman, 1985); (b) farm sizes are greater and (c) there is a variability in experiences, educational levels and ages of human capital (Putler and Zilberman, 1988). Most of the first-hand literature on adoption focused on land sizes as the most important determinant (Harper *et al.,* 1990; Green and Ng'ong'ola, 1993; Adesiina and Baidu-Forson, 1995; Nkonya *et al.,* 1997; Fernandez-Cornejo, 1998; Baidu-Forson, 1999; Boahene *et al.,* 1999; and Daku, 2002). Farm size could affect the parameters effecting adoption of modern technologies. Farm size could affect adoption positively, negatively or neutrally. Many researchers for instance, (McNamara *et al.,* 1991; Abara and Singh, 1993; Feder *et al*., 1985; Fernandez-Cornejo, 1996; and Kasenge 1998) indicated that land size had a positive relation with adoption. Yaron *et al.* (1992) and Harper *et al.* (1990) have however reported negative correlations of land size with farmers' adoption of new technologies, while Mugisa-Mutetikka *et al.* (2000) indicated a neutral correlation between two parameters. Abara and Singh (1993) have opined that with small farms, the huge installation and maintenance expenses limit the adoption of such technologies. Therefore, Feder *et. al.* (1985) indicated greater adoption capacities for the farmers with larger fields. Adoption of new technologies are somehow different in small and large-scale farmers, thus responsible authorities should take this issue into

consideration while offering new technologies (Akudugu *et al.,* 2012). It was reported in a previous study carried out Kenya that large-size specialized farmers adopted new technologies faster than small holdings (Gabre-Madhin and Haggblade, 2001).

Age is another designating parameter for farmers' adoption of new technologies. It is a significant factor affecting farmers' decision whether or not to adopt a new technology. However, different opinions or findings were reported in previous studies about the effects of age on farmers' decisions. McNamara *et. al.* (1991) conducted a study in Georgia and reported significant positive effects of age on farmers' decisions about pest management practices for peanuts. Adesiina and Baidu-Forson (1995) also reported positive correlations between farmers' age and their adoption of new sorghum varieties in Burkina Faso. In contrast however, age was found not significantly or negatively correlated with farmers' adoption decisions (Harper *et. al.,* 1990; Green and Ngongola, 1993; Adesiina and Baidu-Forson, 1995 and Baidu-Forson, 1999).

Level of education was indicated as another significant factor influencing farmers' adoption of new technologies (Feder and Slade, 1984 and Tjornhom, 1995). In general, education is expected to have positive impacts on farmers' decisions and attitudes towards to modern technologies (Waller *et. al,* 1998; Caswell *et. al,* 2001). It has been pointed out by Rogers (1983) and Ehler and Bottrell (2000) that technologically complex nature of modern technologies negatively affected adoption and such negative issues could only be solved thorough education.

1.4. Irrigation Systems

Different irrigation methods have been introduced for irrigation of different crops and plants under different conditions. Surface, sprinkler and drip / micro are the three main irrigation methods. In surface irrigation methods without any pressures, water flow over the field surface is achieved through gravity. In sprinkler irrigation, water is sprayed over the plants similar to rain fall under pressure. Micro-irrigation applies frequent and small quantities through dripping, bubbling. In such methods, only certain portion of the lands is wetted rather than wetting the entire field like in surface irrigation methods. Sub-surface irrigation practiced through raised water table or sub-surface drip lines is also getting widespread around the world.

1.4.1. Surface/Gravitational Irrigation Systems

In conventional surface irrigation methods, water flows over the field to be irrigated through gravitational forces. Water infiltrates into the soil profile while moving over the field and stored within the root zone of the plants. Rill, furrow, border and border strips are the common surface irrigation methods. In surface irrigation methods, a flow is introduced at one edge of the field and gradually covers the field (Jamal, 2017).

Surface irrigation has been practiced since the ancient times. Today, surface irrigation methods are practiced over 95% of irrigated lands worldwide. In ancient times, check-dams or canals were used to divert water from a source. These canals were all earthen canals composed mostly of clay and silty soils. Invention of new equipment and technologies, surface irrigation methods have started to be applied in further places from the water sources.

Conventional surface irrigation still has some advantages over the modern pressurized irrigation methods. A highly flexible, relatively easy to manage irrigation method is the gravity flow system (Jamal, 2017). The advantages of surface irrigation over the modern ones can be summarized as follows:

1. It is easy to operate and maintain the surface irrigation methods with a minimal knowledge and understanding.
2. Surface irrigation methods are preferred in places with sufficient water resources since it is easier to refill the plant zone.
3. Initial system installation costs are quite low since there is no need for special equipment, pipe, and etc.
4. Since the structural elements are mostly placed along the field edges, entire land is used for cultivation.
5. Since there is no need for energy since water flow is achieved through gravity, the system becomes more economical.
6. They are less affected by the characteristics of climate and water quality. Like sediments and other debris, trickle system efficiency is reduced, and wind affects the sprinkler systems

7. Under surface irrigation, salinity is less of an issue.

8. Available water resources can be used in a less-planned fashion without any specific design requirements.

Surface irrigation methods have also numerous disadvantages. The soils to be irrigated with surface irrigation methods should have medium or high water holding capacity, in other words, soils texture should be clay or loamy. These methods cannot be used in sandy soils with quite low water holding capacity since the water applied to sandy soils will directly percolate beneath the root zone. The lands to be irrigated with surface irrigation methods should have almost flat terrain, otherwise they should be leveled accordingly before to practice these methods, otherwise, an even water distribution will not be achieved, some parts of the field will get more and some parts will get less water than the required quantity. Leveling will also bring an extra cost to farmers (Jamal, 2017).

Water application efficiency of surface irrigation methods are quite lower than the pressurized irrigation systems like sprinkler or drip irrigation. While water application efficiency varies between 55-60% in surface irrigation methods, the value may reach up to 90% in sprinkler and to 95% in drip irrigation. Such high efficiencies will bring about great savings in irrigation water and allow farmers to irrigate greater lands with the same quantity of water (Jamal, 2017).

Surface irrigation methods are usually labor-intensive methods (Figure 1.1). Though one doesn’t need to be overly skilled in this labor, irrigations are still to be done carefully in order to achieve high efficiencies. Appropriate monitoring and assessment practices may improve efficiencies (Jamal, 2017).



Figure 1.1. General images for surface irrigation systems

1.4.2. Sprinkler irrigation systems

Sprinkler irrigation is a method of applying irrigation water which is similar to natural rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground. The water supplied through sprinklers then infiltrates into the soil profile and stored within the root zone. The pump supply system, sprinklers and operating conditions must be designed to enable a uniform application of water. For water to be applied with a pressure, water is delivered from the source to sprinklers under pressure. Water is distributed under pressure. A pump unit is used to supply pressure. Advantages of sprinkler irrigation systems can be summarized as follows:

- There is no need for land leveling,
- The method can be applied in every kinds of soil texture with high infiltration rates.
- The method can be applied to shallow soils with close impervious barrier or groundwater table to surface.
- An even (uniform) water distribution is achieved over every part of the irrigated land, there is no runoff, therefore high water application efficiencies are achieved in this method. In this case, larger areas can be irrigated with limited water resources.
- With a proper design and construction, soil erosion is prevented.
- When the pipelines are buried, or installed over the land surface, they occupy less area than open canals in surface irrigation methods. So, larger area is cultivated and machinery applications can easily be applied.
- Irrigations are easily performed with less labor cost.
- Pesticides and fertilizers can be applied through the irrigation system (fertigation).
- Frost damage can be prevented in valuable crops and fruits

The factors restricting the use of sprinkler irrigation or disadvantages of the system can be summarized as follows:

- Initial investment costs are higher as compared to surface irrigation methods. So, system design and construction should comply with the technical specification to minimize the costs.
- There is a continuous need for pressure to operate the system. That will increase operational costs.
- High wind speeds or windy periods may negatively influence water distribution. Therefore, irrigations should be performed on non-windy days, or lateral pipelines should be installed perpendicular to prevailing wind directions to prevent such uneven water distribution.
- High temperatures increase evaporation, thus reduce water application efficiencies. Irrigation should be performed in evenings in places with high day temperatures. However, since it is hard to do irrigations in evenings, they should be performed early in the morning or late in the evening. Irrigation should be avoided at noon hours with the greatest temperature of the day.
- Irrigation performed at pollination periods reduce fruit set ratios and decrease yields. Therefore, irrigations should be so scheduled as not to cover pollination periods.
- Since plant leaves are also wetted in this method, some diseases may spread faster. Therefore, sprinkler irrigation should be avoided in plants sensitive to diseases resulted from wetting of the leaves.
- When the irrigations are terminated at day hours, water droplets left over the leaves may result in leaf burns. Therefore, irrigations should be terminated at dark.
- In case of using saline irrigation waters, water droplets left over the leaves evaporate and leave the salt over the leaf surfaces. This salt may then again result in leaf burns. Therefore, saline waters should be avoided in sprinkler irrigation.

Sprinkler irrigation can be applied in every soil texture ranging from light textured ones (sandy soils) with high infiltration rates to heavy textured ones (clay soils) with high water holding capacity and low infiltration rates. The method can be applied both shallow and deep soils. The method can reliably be applied at high slopes or undulated

topographies. However, the system design should comply with prevailing topography. Sprinkler irrigation can also be used for reclamation of saline lands through applying a leaching fraction in each irrigation. Sprinkler irrigation should be avoided in irrigation of plants sensitive to diseases resulting from wetting of leaves and fruits. The method can be used in irrigation of field crops. Tomato, pepper, beans, strawberry should not be irrigated with sprinkler irrigation. It should be used also in vineyards and banana irrigation. Fruit trees can be irrigated with micro-sprinklers beneath the tree canopy. Every kind of water resources can be used in sprinkler irrigation. In case of surface waters, sediment and floating substances should be filtered through before to take water into pipelines. Usually waters with low salinity levels are preferred in sprinkler irrigation (Figure 1.2 and 1.3).

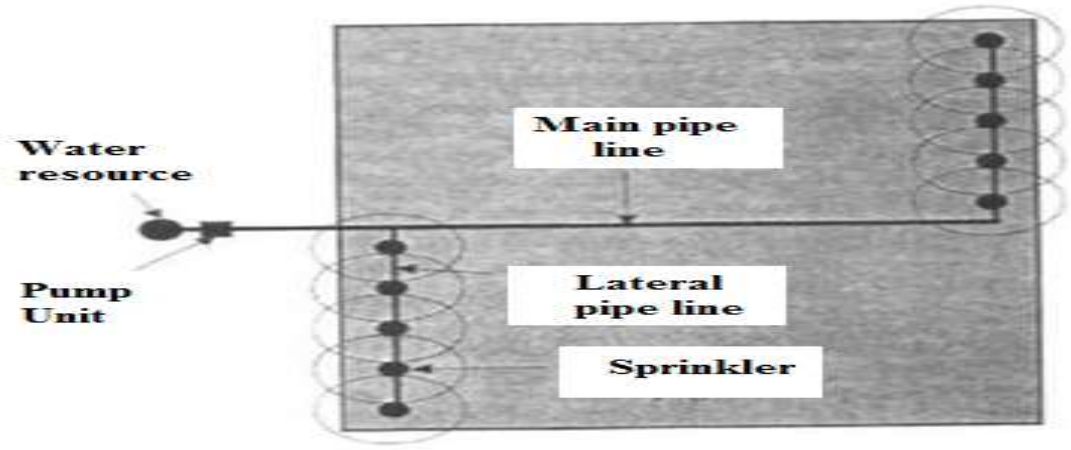


Figure 1.2. General lay out of a sprinkler irrigation system



Figure 1.3. General images of sprinkler irrigation in practice

1.4.3. Drip irrigation systems

The basic principle in drip irrigation is to apply less water in more frequent intervals. Daily or couple-days water requirement of the plants are supplied. Water initially is passed through a control unit to filter sand, sediment and floating items. Plant nutrients and fertilizers can also be incorporated into the system. Water is delivered to plants through pipelines and drippers. Water is applied in drops from the drippers. Applied water infiltrates into soil profile and stored within the root zone of plants. A wetted line is achieved in this method along the plant rows. There are dry sections between plant rows. Entire field is not wetted. Therefore, more land can be irrigated with limited water resources. Advantages of drip irrigation can be summarized as follows:

- Fertilizer and nutrient loss is minimized due to localized application and reduced leaching.
- Water application efficiency is high if managed correctly.
- Field levelling is not necessary.
- Fields with irregular shapes are easily accommodated.
- Recycled non-potable water can be safely used.
- Moisture within the root zone can be maintained at field capacity.
- Soil type plays less important role in frequency of irrigation.
- Soil erosion is lessened.
- Weed growth is lessened.
- Water distribution is highly uniform, controlled by output of each nozzle.
- Labour cost is less than other irrigation methods.
- Variation in supply can be regulated by regulating the valves and drippers.
- Fertigation can easily be included with minimal waste of fertilizers.
- Foliage remains dry, reducing the risk of disease.

- Since salts are moved toward to boundaries of wetted section, plant root zone can be clarified from the salts. Plants sensitive to saline soils can be grown with drip irrigation.
- Usually operated at lower pressure than other types of pressurized irrigation, reducing energy costs.
- Dry sections over the field surface can be used to operate machinery.
- Saline waters can also be used in irrigations.

Beside all these advantages, drip irrigation systems have also some constraints or disadvantages as summarized below:

- Initial cost can be more than overhead systems.
- The sun can affect the tubes used for drip irrigation, shortening their usable life.
- If the water is not properly filtered and the equipment not properly maintained, it can result in clogging.
- Drip irrigation might be unsatisfactory if herbicides or top-dressed fertilizers need sprinkler irrigation for activation.
- Drip tape causes extra cleanup costs after harvest. Users need to plan for drip tape winding, disposal, recycling or reuse.
- Waste of water, time and harvest, if not installed properly. These systems require careful study of all the relevant factors like land topography, soil, water, crop and agro-climatic conditions, and suitability of drip irrigation system and its components.
- Most drip systems are designed for high efficiency, meaning little or no leaching fraction. Without sufficient leaching, salts applied with the irrigation water may build up in the root zone, usually at the edge of the wetting pattern. On the other hand, drip irrigation avoids the high capillary potential of traditional surface-applied irrigation, which can draw salt deposits up from deposits below.
- The PVC pipes often suffer from rodent damage, requiring replacement of the entire tube and increasing expenses.

- Drip irrigation systems cannot be used for damage control by night frosts (like in the case of sprinkler irrigation systems)

Drip irrigation can be applied in every soil texture ranging from light textured ones (sandy soils) with high infiltration rates to heavy textured ones (clay soils) with high water holding capacity and low infiltration rates. The method can be applied both shallow and deep soils. The method can reliably be applied at high slopes or undulated topographies. However, the system design should comply with prevailing topography. The method can also be applied in saline soils.

Drip irrigation can be used for field crops (except for cereals, pastures, some forage crops), vegetables, orchards and vineyards. The method is especially used in irrigation of high-market value plants and the plants sensitive to water deficit.

In drip irrigation, every kind of surface and groundwater can be used, low capacity water resources can be used. Saline waters can be used. When the surface waters are used, water should be settled in a basin and filtered before to supply to the system (Figure 1.4 and 1.5).

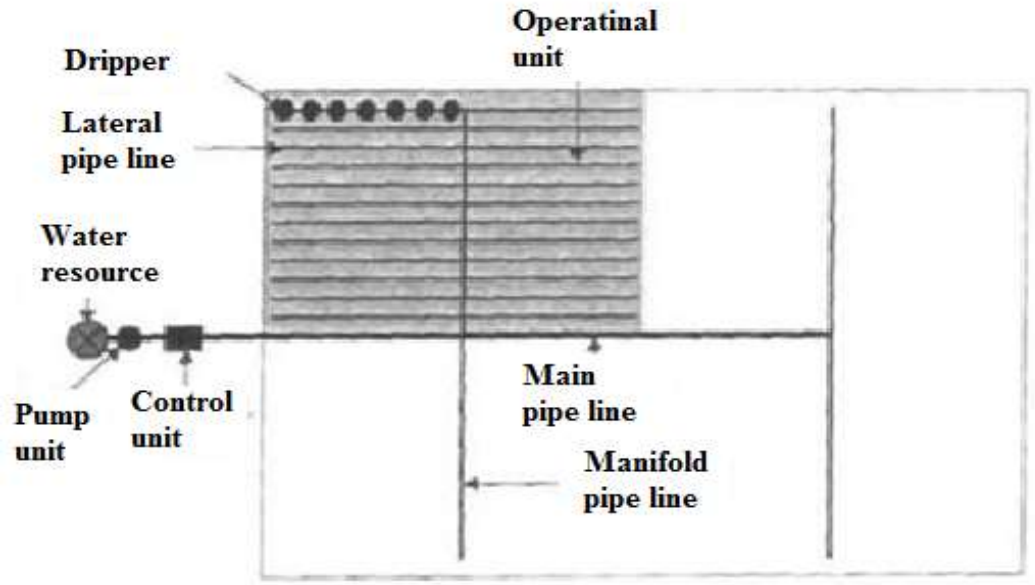


Figure 1.4. General lay out of drip irrigation system




Figure 1.5. General images from drip irrigation systems in practice

1.5. Selection and Installation of Irrigation Technologies

With all the numerous benefits arising from the use of modern irrigation technologies, there are some key principles and practices to take into account before one decides to venture into its installation. In order to make a selection of an irrigation technology for field implementation, one should find answers to the following questions.

1. Are the water resources available for irrigation? Assessing the availability of water resources is the first and the foremost thing to do before to decide on any methods. For this purpose, general information about surrounding water resources should be gathered including climate, annual precipitations, potential surface and groundwater resources, their distance the fields and seasonal variations in these resources. The size of land to be irrigated with the available water resources should also be taken into consideration in this heading.

2. Which method is to be used? Assessing the kind of irrigation technologies that can be successfully implemented under the said environmental conditions and agricultural context while taking into consideration the; water resources (access and distance), initial investment costs, operational costs.

3. The crops to be irrigated? It is vital to assess the potential, the traditional knowledge and the markets for crops to be irrigated. It is also vital to assess the crops are traditionally cultivated by the farmers in the area, its irrigation practices in the and in

which season they cultivated. Answers to other questions such as; can irrigation be readily introduced (in the dry wet season), what is the intended use of the irrigated crops (self-sufficiency or to be sold) and if to be sold, is there a market for irrigated crops?... are necessary to consider.

4. What is the social and economic context? Assess the motivation, interest and capacity of farmers to adopt modern irrigation technologies, from which an implementation plan could be prepared together with the farmers before the proposal and introduction of any irrigation technologies. While doing this, it is necessary to take into account the farmer's familiarity with irrigation, the irrigation techniques currently being used, the capacity of local farmers to successfully adopt the new technologies, and the materials and inputs required to install and operate the new technologies. With the answers to these questions, programs for training and capacity-building and an action plan for installation and operation of the irrigation techniques can be formulated together with the farmers; stating clearly the responsibilities of community, aid and government organizations.

5. Available support services! The private and public organizations able to assist farmers in the introduction, implementation and maintenance of the new technologies should be assessed.

1.6. Factors to Consider

There are several factors to consider while introducing a new technology or modern irrigation systems. Agricultural, technical and socioeconomic factors are the leading ones to consider. Besides, climate and environmental factors should also be taken into consideration while making decisions on agricultural technologies. A feasibility process should be conducted to decide whether or not a new technology is feasible. Such a process should include especially the cost items and a cost-benefit analysis.

1.6.1. Agricultural considerations

For successful production of good crops and optimal crop yield, adequate attention must be paid to: crop selection, appropriate varieties, crop rotation, cultural practices and

growing conditions. Following criteria should be taken into consideration while selecting crops or plants to be grown and irrigated:

- Crop rations plans for wet and dry seasons,
- Potential new plants with high yields and income-generation potential under irrigated conditions,
- Crops to be selected for food security,
- Crops to be selected for the markets,
- Farmers' experience and motivation about the potential crops,
- Proper cultural practices and inputs for the crops to be selected.

1.6.2. Economic considerations

Proper economic bases should be taken into consideration for sustainability of modern irrigation technologies. Such economic criteria should include initial investment costs, operation and maintenance costs. Small holdings generally try to bear such costs with own capital assets coming from sale of their produce, while large-scale farms are generally able to acquire credits or grants for their expenditures on operation and maintenance. The following economic aspects should be given due consideration in the introduction of irrigation technologies.

1.6.3. Operation and maintenance costs

Energy is operational cost for the operation of pump systems related to fuel or electricity and requires cash payments. Labor costs are operational expenses relating to equipment handling such as treadle pump or watering can, but also the cost of reservoir filling or moving sprinkler lines from one position to another. Small-holdings are generally dependent on their own or family labor. However, large-scale farms generally hire paid-labor for such operations. Maintenance costs includes the costs of canal cleaning, system repairs, repair and maintenance of tools and equipment. Overall, annual maintenance costs account for about 15% of investment costs.

1.6.4. Access to credit

Farmers need easy access to credit in order to be able to purchase irrigation equipment and to finance their operational costs. Although initial subsidies can be considered in post-emergency situations, micro-credit institutions should also be involved in setting up a sound rural credit system for economically viable irrigated agriculture.

1.6.5. Social and cultural considerations

Adoption of a new technology is a complex issue for small holdings. Thus, farmers should initially get used to installation and operation of these new technologies. In this sense, social factors should be taken into consideration and participatory approach should be established during the selection, installation, operation and maintenance of modern irrigation technologies. Follow-up programs or visits should be made to check the proper installation and operation of the new systems. Social norms, local practices and customs should also be taken into consideration while selecting proper practices and implementations. Gender plays a significant role in irrigation practices of farmers. Therefore, gender also should be taken into consideration while selecting an irrigation system or a new technology.

1.6.6. Climate and environmental considerations

Crop production and food security in Iraq is largely designated by climate and extreme weather events and is significantly affected by natural and biological hazards such as drought, cyclones, pests and diseases. Rain-fed production in particular, may vary significantly from year to year depending on fluctuations in precipitation where dry years may follow years of heavy rainfall. Climate change and increasing frequency and severity of extreme weather events have affected the farming sector, which is highly sensitive to extreme weather events and will raise the risk faced by rural people, most of whom depend on agriculture for their livelihoods and food security. Local environmental aspects should be given due consideration and carefully monitored in relation to the repercussions of increased irrigation water use and more intensive agriculture.

Just because of the following profits, modern pressurized irrigation systems are largely supported:

1. Means of water conservation in irrigated farming and the prevention of impending water crises (Shah and Keller, 2002; Polak *et al.*, 1997),

2. Increasing income and reducing poverty among rural poor; enhancing rural household food and nutrition security (Bilgi, 1999),

3. As a means of extending the limited water available over a large crop area (Palanisami *et al.*, 2011).

In many studies, financial paybacks have been proven. Puran *et. al.* (2010) indicated a threefold increase for irrigated lands and a 78% decline in the use of labor per hectare. There are also substantial economic returns on investments by farmers in micro-irrigation technologies (Dhawan, 2002). The incentives for the adoption of drip irrigation are financial resources and crop suitability. Mamara *et al*. (2005) indicated that social status of a farmer had significant impacts on their adoption of new technologies. Extension specialists and policy makers also play a great role in introduction of new or modern irrigation technologies (Palanisami *et al.*, 2011).

The loss of irrigation water used by crops in the agricultural sector has two major components in one part, known as Evapotranspiration (ET), and is spent as soil and crop evaporation losses. The second component includes all the losses caused by water distribution to the land (Fereres and Soriano, 2006). Efficiency is defined as the ratio of benefit from the supplied water. For instance, water supply efficiency is defined as the ratio of water required by the plants to the water diverted from the supply. In India for instance, overall irrigation efficiency in commonly used conventional flood irrigation technique was 38% because of significant losses during water conveyance and distribution (Narayanamoorthy, 2003). However, such efficiency values reach up to 90 % in sprinkler and to 95% in drip irrigation systems (Sivanappan, 1994). The advantages of modern irrigation technologies are not solely limited to water saving. Different studies identified the other technological advantages as listed below:

1. Weed and soil erosion problems are minimized since water is applied in very small quantities directly to the root zone. The technique also reduces humidity in the atmosphere, which can reduce pests.

2. It also significantly reduces water logging problems, salinity and pollution of groundwater.

3. It reduces farming costs mainly due to labor cost savings and energy savings (Raman, 2009).

4. Better quality of crop output. Continuous and consistent field-wide application of water will improve product quality.

5. Efficiency is also achieved in nutrient and fertilizer use. With drip irrigation systems, the use of water-soluble fertilizers (WSF) is recommended. These fertilizers are highly suitable for fertilization that ensures the root zones are supplied with nutrients, resulting in marginal or no nutrient loss. Using this system, fertilizer efficiency can be increased up to 95% as compared to conventional water application methods.

6. They can be applied in all soil textures and surface terrains.

7. Especially for women in villages, it can lead to social empowerment.

Despite several advantages, various researchers have documented several factors restricting the use and spread of modern irrigation technologies. These factors include:

1. For small and marginal farmers, high initial costs make the technology unfeasible.

2. These systems require appropriate filtration to prevent the small emitter holes from being blocked by dust and other particles.

3. Professionals are needed for system installation and maintenance. Failure by government, private companies and NGOs to provide technical support and follow-up may be a barrier to adoption.

4. Mechanical damages resulting from equipment, birds, farm labor and animals.

5. Easy access to irrigation water, free electricity for farmers, unrestricted use of groundwater, particularly in rural parts of the country.

These factors are major obstacles for widespread of this technology. In addition to these, lack of demonstrability of the benefits at field level may also be one of the reasons for the slow spread. Energy savings can be particularly hard to prove (Palanisami *et al.,* 2011). Initiatives and incentives promoting micro irrigation in Iraq have at best been a lukewarm response for many years. There are currently many pockets in potential areas that, despite several targeted programs and initiatives, have not adopted the technology. Several causes have been attributed to the lukewarm response, including lack of groundwater access, lack of cash, crop specificities and lack of know-how, poor product quality, and lack of credit facilities.

Research has shown that yield improvements and water savings from micro-irrigation technologies are highly variable because they depend on the crops grown and the type of irrigation system used (Sakthivadivel and Bhamoriya, 2004). It has often been found that the magnitude of land productivity advantage is lower than that of water productivity, but farmers rarely have to pay market rates for water or electricity used to pump water from the source or irrigate the fields, so there is a little incentive to improve water productivity.

Cheap labor availability and disguised unemployment also work to dampen the drip irrigation technology adoption incentive. At the same time, government extension systems were not of great help for this technology. Without the attendant measures, the shift to micro-irrigation is expected to compound the over-exploitation of the aquifer. The policy of granting subsidies may have only jeopardized the willingness to pay once many farmers have the ability to pay. Therefore, many researchers find that the spread is driven by subsidies, but there are many areas where the technology could not even be spread by subsidies.

The scientific community has widely discussed global climate change and its consequences. Then, researches have tried to come up with future scenarios about climate change and global warming. It was envisaged that agriculture was the most vulnerable sector and will be influenced by climate change at upper most level (Deschênes and Greenstone, 2007). Climate plays a dominant role in plant growth and

development and shapes various practices like tillage, sowing and harvest dates. The relationship between plants and pathogens can also be affected by climate conditions. Additionally, climate change-induced adverse weather conditions (frost, drought, hail, flood) may pose serious risks on agricultural production activities. According to Seo and Mendelsohn (2008), adaptation strategies need to be taken into account to effectively assess the effects of climate change and global warming on agriculture.

Pidgeon and Fischoff (2011) indicated that climate adaptation plans should consider the advantage/disadvantages of each system. Irrigation was indicated as the primary adaptation strategy to climate change (Seo, 2011). According to Christofidis (2006), about 30 million hectares are suitable for sustainable development of irrigated farming in Brazil. In addition, Brazil has plenty of water resources (the country holds about 12% of the freshwater reserves of the planet). Margulis and Dubeux (2010) indicated that climate change reduced surface water sources of Brazil, but increased ground water resources. In precipitation variables, the difference between rain fed and irrigated production can be observed. Seo (2011) studies about the irrigation practices of Latin America and reported similar findings. Mendelsohn and Seo (2007) and Seo (2011) concluded based of their findings that adoption of irrigation was sensitive to temperature as well as precipitation, validating it as an adaptive strategy.

Furthermore, the volume of water input in a farming system is dependent on plant species, land size, soil texture, plant growth stages, planting and harvest dates (Bernardo, 1997; Negri *et al.,* 2005). In addition, irrigation is considered as a crucial strategy to supply crop water needs. The likelihood of irrigation decreases as rainfall increases. Irrigation is a response to water shortages and is essential to increase yields (Coelho *et al.,* 2006). However, as Mendelsohn and Seo (2007) noted, as rainfall increases, the marginal contribution of irrigation to producers' profitability decreases. This is reasonable because producers do not need to use irrigation techniques intensively in areas where the volume of rainfall is high. The positive sign may indicate risk-averse producers in the case of rainfall variance. According to Rolim *et. al.,* (2012), it was necessary to consider climate data in relation to climate change scenarios. According to Cline (2007), irrigation is needed as the weather becomes drier. Just because of differences between ET and precipitation, there is a need for increased irrigation. In addition, plants have limited heat tolerance. Wahid *et al.,* (2007) pointed

out that multiple genetic approaches can mitigate the adverse effects of heat stress on plants. Although the likelihood of irrigation will decline, irrigation investment must continue to represent a significant share of agricultural investment. However, according to Faurès (2007), the investment pattern will significantly change from those observed in previous decades. Modern irrigation technologies will need to be adapted to serve ever more productive farming.

CHAPTER 2

MATERIALS AND METHODS

This chapter presents information related to methods and procedures that was used in the course of the study. The research design of this study is clearly described as well as how issues of validity and reliability were handled during this study. Methods of data collection have been covered under this section. This chapter also addressed issues of how data were analyzed, and limitations of this study.

2.1. Research Methodology

This study used a direct research by developed administered questionnaire to collect data so as to obtain a high response rate (Ary, Jacob and Razavieh, 2002). The researcher follows the descriptive approach to achieve research objectives because it is suitable for research procedures, which aims to describe the phenomenon or the existing situation and the use of multiple methods, including survey, questionnaires, interviews, and direct observation and the advantage that the monitoring of reality in the future helps to change the circumstances that govern this reality. The paragraphs were reviewed by a panel of experts in agricultural extension department and agricultural irrigation systems from different Universities (Appendix 1).

2.2. Research Area

The provinces of Salahaddin and Kirkuk of Iraq were selected as the research area of the present thesis because they include a large number of farmers adopting modern irrigation techniques of various kinds such as pivot irrigation system and permanent irrigation systems and drip irrigation (Figure 2.1). They belong to agricultural departments spread throughout the two provinces (Salahaddin and Kirkuk). Farmers in these provinces cultivate winter crops, including wheat, barley and summer crops such

as corn and fodder, as well as protected and exposed vegetable crops. Agriculture is the main source of income for farmers.



Figure 2.1. Research site

2.3. The Research Community and its Specifications

The research included all modern irrigation farmers belonging to the agricultural branches of the municipalities of Salahaddin and Kirkuk. The number of agricultural branches in the province of Salahaddin was 21. However, five of 21 were excluded

because there were no sprinkler irrigation in them, bringing the total number of agricultural branches in Salahaddin to 16. There are 16 agricultural branches in Kirkuk, with 3 being excluded, making the number 13 within the province. A random sample was taken from the agricultural branches in each province by 50%, which is why the branches including in the search reached 8 and 7 in the provinces Salahaddin and Kirkuk, respectively. The number of sprinkler irrigation farmers in the provinces totaled 2,537 and 838 in two provinces, respectively. A random sample was taken proportional to 10%, reaching a size of 254 and 84 farmers investigated in Salahaddin and Kirkuk, respectively. As such, the total number of respondents reached was 338 in two provinces, with the results of the sampling shown in following tables (Table 2.1, 2.2, 2.3 and 2.4, 2.5, 2.6).

Table 2.1. Distribution of irrigation systems and areas cultivated with modern irrigation systems in Salahaddin province

N	Agricultural Branches	Type of modern irrigation system					
		Pivot		Permanent		Drip	
		Frequency	Farm size	Frequency	Farm size	Frequency	Farm size
1	**Aleilm**	17	1360	15	600	17	340
2	**Shaykh ajmil**	1	80	6	240	843	8000
3	**Almuetasim**	2	160	-	-	-	-
4	**Alshurqat**	2	240	3	150	13	160
5	**Talwl albaj**	16	980	27	1115	-	-
6	**Dujail**	612	33350	6	240	4305	21525
7	**Samrraa**	183	16140	4	160	-	-
8	**Alaishaqy**	16	1400	-	-	650	4550
9	**Altuwz**	-	-	-	-	-	-
10	**Balad**	8	560	-	-	-	-
11	**Sahil al'aysar**	4	400	12	600	2	45
12	**Baiji**	-	-	-	-	-	-
13	**Aldhulueia**	4	328	3	190	108	298
14	**Tikrit**	302	44459	122	4505	80	700
15	**Dijla**	11	884	2	80	-	-
16	**Altharthar**	292	31080	166	9960	-	-
17	**Alzawia**	-	-	-	-	-	-
18	**Alsiynia**	-	-	-	-	-	-
19	**Amrili**	-	-	-	-	-	-
20	**Aldawr**	583	36028	75	1972	-	-
21	**Hamrin**	18	1660	23	1020	-	-
Total		2121	169109	464	20832	5118	31068

Table 2.2. Distribution of the number of farmers and agricultural areas of the selected agricultural branches in the province of Salahaddin.

N	Agricultural Branches	Type of modern irrigation system					
		Pivot		Permanent		Drip	
		Frequency	Farm size	Frequency	Farm size	Frequency	Farm size
1	**Aleilm**	17	1360	15	600	17	340
2	**Almuetasim**	2	160	-	-	-	-
3	**Samrraa**	183	16140	4	160	-	-
4	**Alaishaqy**	16	1400	-	-	650	4550
5	**Tikrit**	302	44459	122	4505	80	700
6	**Dijla**	11	884	2	80	-	-
7	**Altharthar**	292	31080	166	9960	-	-
8	**Aldawr**	583	36028	75	1972	-	-
Total		1406	131511	384	17277	747	5590

Table 2.3. Distribution of farmers and agricultural areas in the selected agricultural branches according to type of modern irrigation systems in the province of Salahaddin.

N	Type of irrigation technology	Cultivated areas	Number of farmers	The sample
1	**Pivot**	131511	1406	141
2	**Permanent**	17277	384	38
3	**Drip**	5590	747	75
Total		154378	2537	254

Table 2.4. Distribution of irrigation systems and agricultural areas in the province of Kirkuk

N	Agricultural Branches	Type of modern irrigation system					
		Pivot		Permanent		Drip	
		Frequency	Farm size	Frequency	Farm size	Frequency	Farm size
1	**Yaychi**	5	520	28	889	11	26
2	**Almultaqaa**	1	180	275	88389	22	115
3	**Aldubus**	3	280	84	3307	3	3
4	**Sarkran**	1	80	253	12878	9	35
5	**Altuwn kubri**	7	720	38	1292	22	110
6	**Shawan**	-	-	40	989	45	235
7	**Qurat hanjir**	-	-	-	-	23	149
8	**Laylan**	25	1924	30	1240	18	90
9	**Taza**	1	68	22	1568	41	288
10	**Daquq**	11	2193	14	571	9	45
11	**Alrashad**	-	-	-	-	22	130
12	**Wahdat bashir**	-	-	-	-	-	-
13	**Alriyad**	-	-	-	-	-	-
14	**AlAbbasi**	-	-	4	80	226	1695
15	**Hawijah**	5	200	19	399	-	-
16	**Zab**	-	-	-	-	-	-
Total		59	6155	919	33691	451	2931

Table 2.5. Distribution of modern irrigation techniques according to the selected agricultural branches in Kirkuk province

N	Agricultural Branches	Type of modern irrigation system					
		Pivot		Permanent		Drip	
		Frequency	Farm size	Frequency	Farm size	Frequency	Farm size
1	**Yaychi**	5	520	28	889	11	26
2	**Almultaqaa**	1	180	275	88389	22	115
3	**Sarkran**	1	80	253	12878	9	35
4	**Altuwn Kubri**	7	720	38	1292	22	110
5	**Laylan**	25	1924	30	1240	18	90
6	**Taza**	1	68	22	1568	41	288
7	**Daquq**	11	2193	14	571	9	45
	Total	51	5685	660	106827	132	709

Table 2.6. Distribution of farmers and agricultural areas in the selected agricultural branches according to type of modern irrigation systems in the province of Kirkuk

N	Type of irrigation technology	Cultivated areas	Number of farmers	The sample
1	**Pivot**	5685	51	5
2	**Permanent**	106827	660	66
3	**Drip**	709	132	13
Total		113221	843	84

2.4. Preparing the Data Collection Tool

A questionnaire was prepared, which consisted of two parts. The first part included paragraphs regarding the measurement of independent variables related to the respondents as follows:

1. Educational Level: Measurement of the variable through 7 levels (illiterate, reading and writing, elementary, Primary, middle school, high school, Bachelor, Master).
2. Age: The measurement was taken of years of ages of the respondents during data collection.
3. Number of years of practice: Measurement of the number of years of practicing agriculture with modern irrigation.
4. Farm size : Counted with the decare the farmers have.

5. Number of family members: Counted with the number of family members the farmer had at the time of data collection.
6. Access sources of information through a standard 12 paragraph form with a scale of (always, sometimes, rarely, does not reach). Values were given as (0, 1, 2, 3), respectively. Thus, the theoretical range reached (0-24).
7. Extension Efforts: Measurement of the variable using 8 standard paragraphs and a scale of (always, sometimes, rarely, never). Values were given as (0, 1, 2, 3), respectively, producing a theoretical range of (0-24).
8. Ownership of Land: Measured according to type of land ownership according to the following levels: (ownership, contract, rent, participation).
9. Marital Status: Measured according to the following levels: (married, unmarried, widowed, divorced), with values given as (1, 2, 3, 4), respectively.
10. Agricultural Employment: Measured according to the following levels: (based on family members, paid workers, both types of employment).
11. Family rank: Measured according to the following levels: (father, wife, son/daughter), with values of (1, 2, 3), respectively.
12. Government support: Measured according to the following levels: (No, Yes), with values of (0, 1), respectively.

The second part consisted of three sub-parts. These three parts of the scale were prepared after the researcher got

- Acquainted with the literature,
- Scientific sources,
- Previous studies, and scientific research.

The first of these parts consisted of 31 standard paragraphs to measure the adoption of modern irrigation technologies by farmers. A three-dimensional scale was listed on the top (verified, intermediate verification, weak verification), with the digital values given as (3, 2, 1), respectively. As such, the theoretical scope of the measurement reached (31-93).

The second sub-part consisted of 34 standard paragraphs to measure the determinants that prevent farmers from adopting modern irrigation techniques. At the top was a five-point scale (very large, large, medium, few, none), with the digital values given as (5, 4, 3, 2, 1), respectively. It was analyzed according to the weighted mean.

The third sub-part consisted of 10 standard paragraphs to measure the factors that encourage the adoption of modern irrigation techniques, and it was a three-point scale (big, medium, few), with the digital values given as (3, 2, 1), respectively. It was evaluated according to the weighted mean.

For the purpose of clarifying of data collection tool and included variables, the following flow chart was provided of Figure 2.2.

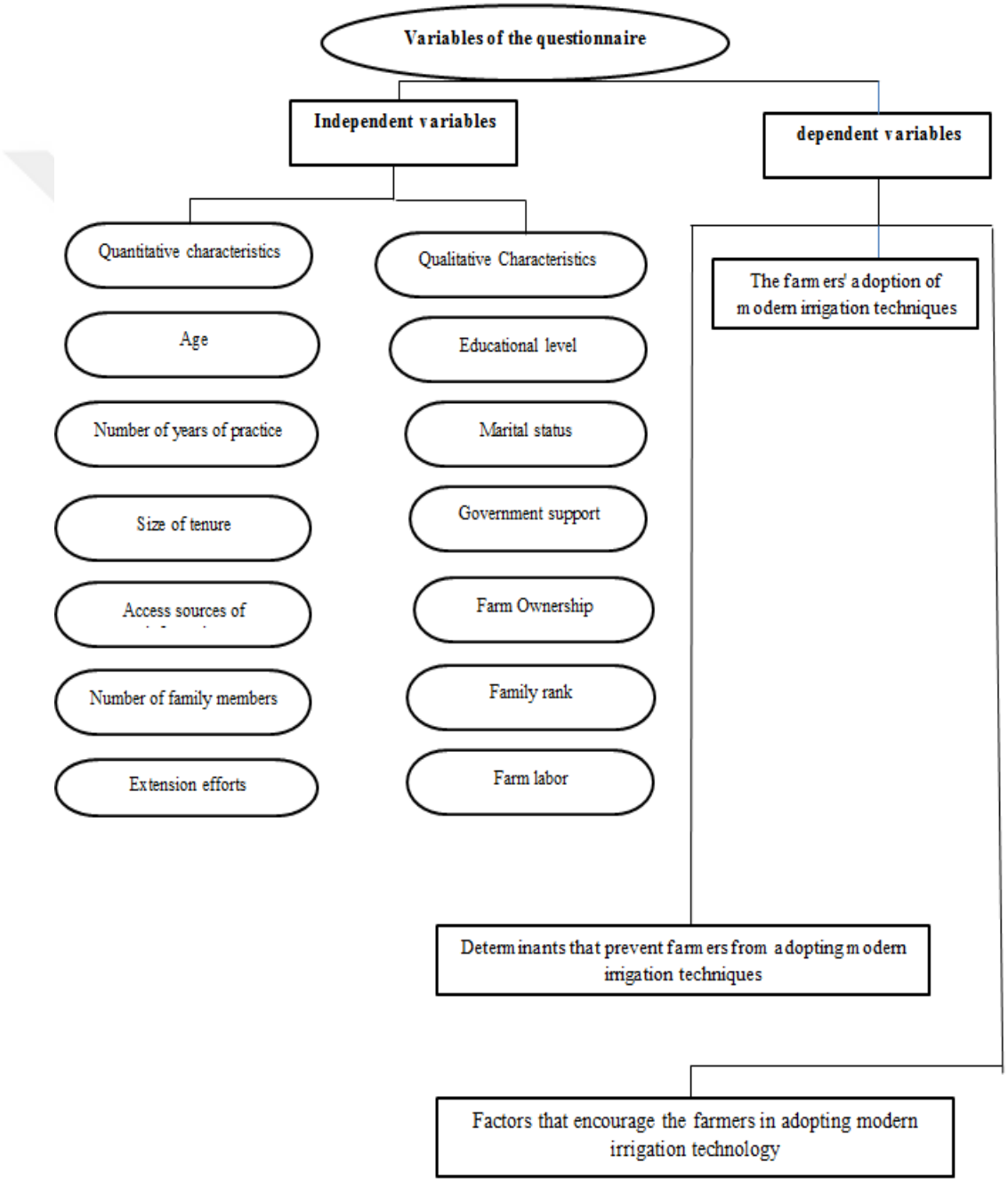


Figure 2.2. Flow chart for questionnaire processes

2.5. Validity of Scale

Virtual Honesty: Means the extent to which an instrument allows one to observe or measure what he or she intends to observe or measure (Gorden, 1975). The accuracy of the scale has been achieved with the quality of virtual honesty and honesty of content in order to identify the extent to which the questionnaire was completed for the objectives for which it was prepared. This included the clarity of the paragraphs and the accuracy of their formulation. Expert opinions were taken through addition, deletion, or modification. Various paragraphs have been amended: 12 on the adoption scale, 9 on the scale of determinants, and 2 on the encouraging factors. The total number of standard scales of the three parts did not change.

2.6. The First Test

Tests were made based on the questionnaire on a sample of 30 respondents, with 20 from modern irrigation farmers in Salahaddin and 10 in Kirkuk. They were randomly selected from outside the research sample.

2.7. Reliability of the Scale

Reliability is the stability of results if the scale is repeated on the same group of individuals. According to Bargh, J. A., and Chartrand, T. L. (2000), "A research study should be conducted using a random sample of participants from a broadly defined population in a random sampling setting".

After collecting survey data, the stability was calculated with the aid of Cronbach's alpha for three parts of the form. Cronbach's alpha gives the coefficient of minimum stability, the coefficient of stability, and validity of measurements, as shown in Table 2.7.

Table 2.7. Results of Cronbach's alpha values for reliability and validity of measurements

Measurement	Reliability	Validity
Agricultural adoption of modern irrigation techniques	0.76	0.871
A measure of the factors determining the farmer's adoption to the modern irrigation techniques	0.82	0.905
A measure of factors encouraging the farmer's adoption to the modern irrigation techniques	0.84	0.916

2.8. Statistical Methods

After completion of data collection and tabulation, experimental data were subjected to statistical analysis with the aid of SPSS (Statistical Package for Social Science) v23 statistical software. The following statistical methods were used:

1. **Range:** It is used to divide some independent variables into categories as :

Range = Highest Value - Lowest Value

$$\textbf{Length of category} = \frac{\textbf{Range}}{\textbf{Number of categories}}$$ **(Noting that the result is rounded to the nearest integer).**

2. **Frequency distribution and Percentages:** Used to distribute the subjects according to the variables studied.

3. **Standard deviation (SD) :** Use to describe deviations of numeric values per worker from the mean.

$$s.d = \frac{\sqrt{\sum X^2 i - \frac{(\sum Xi)^2}{n}}}{n-1}$$

s.d = standard deviation

$\sum \boldsymbol{x^2 i}$ = sum of square of the numeric values.

$\sum \boldsymbol{x^2}$ = sum of square of a value

n = Number of values or number of respondents

4. **t-test :** Used to test the difference between two independent samples:

$$t = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{Sp\sqrt{\frac{1}{n1} + \frac{1}{n2}}}$$

$$Sp = \sqrt{\frac{(n1-1)s_1^2 + (n2-1)s_2^2}{n1+n2-2}}$$

5. Arithmetic mean:

$$\overline{X} = \frac{\sum X}{n}$$

$\bar{x}$ = arithmetic mean

$\sum x$ = sum of numeric values

n = Number of values or number of respondents

6. Weighted average: Used to arrange the paragraphs according to their weighted average:

$$\bar{X} = \frac{\sum WiXi}{\sum Wi}$$

7. Simple correlation equation (Pearson): Use to find the correlation between farmer adoption and quantitative variables covered in the study

$$r = \frac{\sum XY - \frac{\sum X \sum Y}{n}}{\sqrt{(\sum X^2 - \frac{(\sum X)^2}{n})(\sum Y^2 - \frac{(\sum Y)^2}{n}}}$$

r = simple correlation coefficient

X = independent factor values

Y = values of the dependent variable

n = Number of respondents

8. Spearman's correlation coefficient (r) : Used to find the relationship between adoption of farmers and the descriptive variables included in the study

$$r = 1 - \frac{6 \sum d^2}{n (n^2 - 1)}$$

r = Correlation Coefficient

$\sum \mathbf{d}^2$ = sum of squares of differences

n = Number of respondents

9. Validity coefficient : Used to measure the validity of the test paragraphs for each field after performing the pre-test, which is: the square root of the stability coefficient

10. Used to significance test to determine the correlation between farmer adoption level and each of the independent factors and by comparing them with t-table by a degree of freedom of n-2.

$$t = r\sqrt{\frac{n-2}{1-r^2}}$$

t = value (t) calculated.

r = correlation coefficient value

n = Number of respondents

11. Cronbach's Alpha coefficient: Use to find reliability

$$\alpha = \frac{n}{(n-1)}\left(1 - \frac{\sum_{i-1}^{n} s_i^2}{s_{sum}^2}\right)$$

∝ = Cronbach's Alpha coefficient

N = Number of scale paragraphs

Si2= Variance of one paragraph

S2x= total of entirely variances

CHAPTER 3

RESULTS AND DISCUSSION

3.1. Personal, Economic and Social Characteristics of the Respondents in the Provinces of Salahaddin and Kirkuk.

3.1.1. Quantitative Characteristics

The results on quantitative characteristics revealed that 26.6% of the surveyed farmers were over 50 years of age and 37.3% of the respondents were young (between the ages of 23-36 years). This is the category in which the individual is more receptive to the techniques, experiences and agricultural developments, including the modern irrigation techniques of all kinds and the accompanying knowledge experiences. Related to the transfer of agricultural innovations suggest a relationship between adoption of the innovator and the age of the individual.

It is also clear that 26.6% of the respondents had years of practicing agriculture with modern irrigation systems within the low category (5 – 8 year) and 36.4% of them within the medium category (9 – 12 years). This indicates that not a small number of respondents have a period of practice, which is reflected in their adoption of modern irrigation techniques.

In addition, 45.8 % of the respondents had possession of land less than 150 decare and the result refers to the fragmentation of agricultural tenure, which is reflected in the adoption of modern agricultural techniques, including modern irrigation technology.

It is clear from the Table 3.8 of the size of the family that 55.1% had a family with less than 8 members. The literature relates the transfer of modern technologies to the size of the family as one of the factors affecting the adoption of modern technologies.

Table 3.1 shows that 50.6 % of the respondents had a low level of access to information sources, indicating poor information on modern irrigation techniques.

The table also shows that nearly half of the respondents had subjected to low level of extension efforts. This indicates a weakness in the outreach activities of the respondents.

Table 3.1. Distribution of respondents according to their quantitative characteristics.

N	Characteristics			N	Characteristics		
Age		**Frequency**	**Percentage**	**Access sources of information**		**Frequency**	**Percentage**
1	Low (23 - 36)	126	37.3	1	Low (13 – 20)	171	50.6
2	Medium (37 – 50)	122	36.1	2	Medium (21 - 28)	127	37.6
3	High (51 – 65)	90	26.6	3	High (29 – 37)	40	11.8
years of experience		**Frequency**	**Percentage**	**Number of family members**		**Frequency**	**Percentage**
1	Low (5 – 8)	90	26.6	1	Low (6 - 8)	186	55.1
2	Medium (9 – 12)	123	36.4	2	Medium (9 – 11)	87	25.7
3	High (13 - and below)	125	37	3	Large (12 – 15)	65	19.2
Farm size		**Frequency**	**Percentage**	**Extension efforts**		**Frequency**	**Percentage**
1	(Less than 150)	155	45.8	1	Low (7 – 10)	85	25.1
2	(151- 300)	101	29.9	2	Medium (11 – 14)	167	49.4
3	(301 - and more)	82	24.3	3	High (15 and below)	86	25.5

3.1.2. Qualitative characteristics

The results revealed that 52.6% of the respondents were in the category of primary and junior graduates, table 3.2 indicating the weakness of the educational level of nearly half of the respondents. This is an educational obstacle to the adoption of agricultural techniques. The results of the Table 3.2 showed that 36.1% of the surveyed farmers were the owners of contracts and not the owners of the agricultural land in their possession. This is an obstacle to the adoption of modern irrigation, and 31.1% of the respondents were owners of agricultural land.

The results of the table showed that 68.9% of the respondents were married and this is a strong motive for the farmers to adopt modern technologies in order to provide an economic resource to meet the requirements of married life. It is consistent with the literature of agricultural extension, indicating that increasing the number of family members is pushing farmers to adopt modern agricultural techniques.

Table 3.2 shows that 52.4% of the respondents occupy the rank of father in the family order and were responsible for the economic side of supporting their families, while 37% occupy the rank of the son in the family order. In terms of agricultural employment, it was found that 49.4% of the workers in agriculture were the families of the respondents. This indicates the dependence of the farmers concerned on their families in the management of the farm business, as well as the modern irrigation techniques.

And 74.9% of the respondents indicated that they received government support which may relate to seeds, fertilizers, pesticides or other agricultural equipment or any material that has been processed for agriculture through agricultural equipment related to the use of modern irrigation technology.

Table 3.2. Distribution of respondents according to their qualitative characteristics

N	Characteristics			N	Characteristics		
Educational level		**Frequency**	**%**	**Farm Ownership**		**Frequency**	**%**
1	Illiterate	40	11.8	1	Ownership	105	31.1
2	Reads and writes	90	26.6	2	Rent	73	21.6
3	Primary School	48	14.2	3	Contract	122	36.1
4	Middle school	74	21.9	4	Participation	38	11.2
5	High school	58	17.2	**Family rank**		**Frequency**	**%**
6	Bachelor	19	5.6	1	Father	177	52.4
7	Master	9	2.7	2	Wife	36	10.6
marital status		**Frequency**	**%**				
1	Single	78	23.1	3	Daughter, Son	125	37.0
2	Married	233	68.9	**Farm labor**		**Frequency**	**%**
3	Widowed	13	3.8	1	Family members	167	49.4
4	Divorced	14	4.2	2	Paid workers	89	26.3
Government support		**Frequency**	**%**	3	Both types	82	24.3
1	yes=1	253	74.9				
2	no = 0	85	25.1				

3.2. Farmers' Adoption of Modern Irrigation Techniques in Salahaddin and Kirkuk Provinces in General.

The results showed that the values of respondents for irrigation techniques ranged from (40-88) with an average of 59.93 and a standard deviation of 12.23 on a scale with a minimum value of 31 and an upper value of 93, divided the respondents into three categories using the law of range. The highest percentage of respondents was in the middle category as shown in Table 3.3.

Table 3.3. Distribution of respondents according to adoption categories in farmers' adoption of modern irrigation techniques in Salahaddin and Kirkuk provinces in general

Categories	Frequency	%	Average
Low (40 - 55)	137	40.5	48.14
Medium (56 - 71)	144	42.6	63.40
High (72 -88)	57	16.9	79.86
Total	338	100%	S.D=12.23

Table 3.3 shows that 42.6 % of the respondents were in the middle category, followed by the low category (40.5%). Therefore, the level of respondents' adoption was described as “low”. This may be due to the lack of knowledge of most subjects of modern irrigation techniques. Such a low value indicated the reason for the weakness of the extension activities or the lack of interest of the respondents in the extension activities and their absence.

3.3. Farmers' adoption of modern irrigation techniques in each province separately

3.3.1. Farmers adopt modern irrigation techniques in the province of Salahaddin:

The results showed that the values of respondents' adoption of irrigation techniques ranged from (40-88) with an average of 59.86 and a standard deviation of 12.26, divided the respondents into three categories using the range law. The highest percentage of respondents were in the middle category.

Table 3.4. Distribution of respondents according to adoption categories in Salahaddin province

Categories	Frequency	%	Average
Low (40- 55)	105	41.3	48.08
Medium (56 – 71)	106	41.7	63.47
High (72 – 88)	43	17	79.74
Total	254	100%	S.D=12.26

About 41.3% of the respondents were in the middle category, followed by the low category (41.7%). Thus, the level of respondents' adoption was considered to be in a tendency to decrease. This may be due to the ignorance of most subjects in the measurement of modern irrigation techniques not being subjected to counseling activities.

3.3.2. Farmers Adopt Modern Irrigation Techniques in Kirkuk province:

The results showed that the values of respondents' adoption of irrigation techniques ranged between 40-88 with an average of 60.14 and a standard deviation of 12.19. The respondents were divided into three categories using the law of range, which showed that the highest percentage of respondents within the middle category, as shown in Table 3.5.

Table 3.5. Distribution of respondents according to adoption categories in Kirkuk province

Categories	Frequency	%	Average
Low (40 – 55)	33	39.3	48.12
Medium (56 -71)	37	44.0	63.27
High (72 -88)	14	16.7	80.21
Total	84	100%	S.D=12.19

Table 3. 5 shows that 44 % of the respondents are in the middle category, followed by low category (39.3%). The level of respondents' adoption is therefore considered to be “low”. This may be due to the lack of knowledge of the importance of modern irrigation techniques in rationalizing water use or there may be a lack of guidance activities or lack of interest in the activities of the respondents and non-attendance.

3.4. Difference Between the Average Adoption of Respondents in the Provinces of Salahaddin and Kirkuk

The results of the t-test between two independent samples showed no significant difference between the respondents in Salahaddin and Kirkuk provinces as shown in Table 3.6.

Table 3.6. Test results for two independent samples

The province	Frequency	%	Average	Test – Two independent samples	P-value
Salahaddin	254	75.1	59.86	0.183	0.853
Kirkuk	84	24.9	60.14		
Total	338	100%	There is no significant difference		

Since the P value (0.853) was greater than 0.05, the null hypothesis "There is no correlation relationship between farmers' adoption of modern irrigation technology in Salahaddin and kirkuk provinces" was accepted. Therefore, it is possible to state that there was no significant difference between the averages of respondents' adoption in the provinces of Salahaddin and Kirkuk. The respondents in two provinces have information that is almost identical and similar to modern irrigation systems or that they rely on sources of information that are almost identical in experience and information about modern irrigation systems.

3.5. Size of the Barriers That Prevent Farmers From Adopting Modern Irrigation Techniques in General

The results showed a number of determinants that prevent farmers from adopting modern irrigation techniques. The determinants were arranged in descending order according to the weighted mean as shown in Table 3.7.

Table 3.7. The descending order of determinants that prevent farmers from adopting modern irrigation techniques in general

N	Difficulties / Challenges	Very large	Large	Medium	Few	None	Weighted average	The rank
1	Modern irrigation system has high cost in construction, operation and maintenance	115	73	64	52	34	3.54	1
2	Lack of attention to water resources and the organization of their exploitation	108	75	68	50	37	3.49	2
3	Many problems and maintenance difficulties	107	74	66	51	40	3.46	3
4	Lack of interest in giving priority to small farmers	104	77	65	52	40	3.45	5
5	Insufficient amount of water	101	72	77	55	33	3.45	5
6	Lack and inefficiency of training courses provided to farmers	101	83	62	52	40	3.45	5
7	Lack of interest in cleaning irrigation and water channels of harmful aquatic weeds	103	76	60	56	43	3.41	7
8	Lack of agricultural radio programs	100	74	66	57	41	3.39	8.5
9	Modern irrigation system needs a lot of effort during operation	102	71	63	61	41	3.39	8.5
10	Lack of agricultural extension staff who supervising modern irrigation systems	106	68	58	58	48	3.37	11.5
11	Poor effectiveness of agricultural extension in solving irrigation technology problems	96	78	62	60	42	3.37	11.5

N	Difficulties / Challenges	Very large	Large	Medium	Few	None	Weighted average	The rank
12	Lack of support for farmers adopting irrigation technologies with production requirements	93	75	77	53	40	3.37	11.5
13	Lack of interest in the maintenance of water resources	85	96	68	40	49	3.37	11.5
14	Difficulty of modern irrigation system requirements for operation and construction	101	72	64	50	51	3.36	14
15	The instability of the State's price policy with respect to agricultural products	100	69	67	51	51	3.34	15.5
16	Lack of timely availability of water	91	77	72	53	45	3.34	15.5
17	Weak knowledge of farmers about scientific recommendations related to modern irrigation systems	94	67	75	61	41	3.33	17.5
18	Poor extension services on modern irrigation systems techniques	98	70	64	58	48	3.33	17.5
19	Lack of agricultural television programs	95	72	65	59	47	3.32	19.5
20	Lack of interest in introducing farmers to the correct agricultural practices of irrigation technology	94	80	59	51	54	3.32	19.5
21	Weakness of agricultural extension activities in the dissemination of modern irrigation techniques	82	90	66	51	49	3.31	21
22	There is no good management for spreading modern irrigation techniques	96	65	72	52	53	3.29	22
23	Lack of incentives to adopt modern irrigation techniques	96	74	54	59	55	3.28	23.5
24	Farmers' distrust of irrigation and maintenance, irrigation system data	84	83	62	62	47	3.28	23.5
25	Weak agricultural extension activities related to modern irrigation	91	67	72	59	49	3.27	25.5
26	Weak training programs for farmers on the maintenance of modern irrigation techniques	85	84	61	54	54	3.27	25.5
27	Lack of interest in irrigation maintenance and repair of cracks, leading to an increase in the loss rate	88	68	72	64	46	3.26	27
28	Poor implementation of extension activities for farmers to illustrate the importance of using modern irrigation	94	70	59	58	57	3.25	28
29	Neglect of workers dedicated to the operation of modern irrigation systems	82	81	63	60	52	3.23	29
30	Climate change reduces the possibility of using modern irrigation techniques	81	72	69	67	49	3.20	30

N	Difficulties / Challenges	Very large	Large	Medium	Few	None	Weighted average	The rank
31	There are no workers trained enough to use modern irrigation techniques	82	70	63	79	44	3.19	31
32	There is no plan to deploy appropriate technologies to address the problem of water scarcity	74	78	67	59	60	3.13	32
33	Lack of visits and personal visits between extension workers and farmers	72	68	71	78	49	3.10	33
34	Farmers are not encouraged to use modern irrigation technology	73	66	67	81	51	3.08	34

It is clear from Table 3. 14 that the top constraint was the high cost of the modern irrigation system. This may be due to the high prices of irrigation systems that may not be commensurate with the economic potential of the farmers, the lack of attention to water resources and the organization of their exploitation. For the exploitation of water resources and the distribution process among farmers in proportion to the cultivated areas and type of irrigation system or the need for drilling for groundwater for exploitation of agriculture by farmers, and the many problems and maintenance difficulties. This may be due to the weakness of farmers' knowledge of some of the technical aspects of modern irrigation techniques, especially the central ones, and the lack of interest in giving priority to small farmers. This may be due to lack of interest in small farmers in terms of areas cultivated with modern irrigation systems at the time of fragmentation of agricultural holdings. And the last four were occupied by the following sections: There are no workers trained enough to use modern irrigation techniques, and may be due to the acquisition of some expertise by farmers due to the continuous practice of irrigation systems, there is no plan to deploy appropriate technologies to address the problem of water scarcity related to the irrigation system and for facilitating the task of obtaining it by farmers to address the problem of water scarcity, which has become one of the most important problems of the modern era. In the last penultimate section came the lack of visits and personal exchanges between the staff of agricultural extension and agriculture and may be caused by the difficulty of communication between agricultural extension workers and farmers because of the circumstances. The last section shows that farmers were not encouraged to use modern irrigation technology. This may be because farmers have a desire to use modern irrigation systems if these systems are available at subsidized prices.

3.5.1. Size of the barriers that prevent farmers from adopting modern irrigation techniques in Salahaddin province

The results of the study showed that there are a large number of factors that prevent the adoption of modern irrigation techniques by farmers in Saladin province, where the weighted mean values ranged from 3.54 to 3.16. The determinants were determined by the weighted mean, as shown in Table (3.15).

Table 3.8. The descending order of determinants that prevent farmers from adopting modern irrigation techniques in Salahaddin.

N	Difficulties / Challenges	Very large	Large	Medium	Few	None	weighted average	The rank
1	Modern irrigation system has high cost in construction, operation and maintenance	90	53	46	35	30	3.54	1
2	Lack of attention to water resources and the organization of their exploitation	84	55	51	33	31	3.50	2
3	Many problems and maintenance difficulties	83	59	42	41	29	3.49	3
4	Insufficient amount of water	84	54	46	40	30	3.48	4.5
5	Lack and inefficiency of training courses provided to farmers	88	50	45	38	33	3.48	4.5
6	Lack of interest in giving priority to small farmers	84	55	46	34	35	3.47	5
7	Lack of interest in cleaning irrigation and water channels of harmful aquatic weeds	82	50	56	39	27	3.47	5
8	Modern irrigation system needs a lot of effort during operation	79	63	43	37	32	3.47	5
9	Lack of agricultural radio programs	84	56	42	38	34	3.46	9
10	Lack of agricultural extension staff who supervising modern irrigation systems	82	53	45	44	30	3.44	7.5
11	Poor effectiveness of agricultural extension in solving irrigation technology problems	65	78	50	26	35	3.44	7.5
12	Lack of support for farmers adopting irrigation technologies with production requirements	74	57	57	39	27	3.44	7.5
13	Difficulty of modern irrigation system requirements for operation and construction	77	60	43	44	30	3.43	13
14	Lack of interest in the maintenance of water resources	82	55	46	31	40	3.42	14
15	The instability of the State's price policy with respect to agricultural products	80	57	41	38	38	3.40	16
16	Lack of timely availability of water	78	53	53	34	36	3.40	16
17	Weak knowledge of farmers about scientific recommendations related to modern irrigation systems	73	57	57	34	33	3.40	16
18	Poor extension services on modern irrigation systems techniques	76	50	54	46	28	3.39	18.5
19	Lack of agricultural television programs	80	50	47	44	33	3.39	18.5
20	Lack of interest in introducing farmers to the correct agricultural practices of irrigation technology	78	53	46	44	33	3.38	20

N	Difficulties / Challenges	Very large	Large	Medium	Few	None	weighted average	The rank
21	Weakness of agricultural extension activities in the dissemination of modern irrigation techniques	65	71	48	35	35	3.37	21
22	There is no good management for spreading modern irrigation techniques	79	46	56	35	38	3.36	22
23	Lack of incentives to adopt modern irrigation techniques	67	68	42	41	36	3.35	23
24	Farmers' distrust of irrigation and maintenance, irrigation system data	80	55	34	43	42	3.34	24
25	Weak agricultural extension activities related to modern irrigation	67	64	47	40	36	3.33	26
26	Weak training programs for farmers on the maintenance of modern irrigation techniques	74	52	49	43	36	3.33	26
27	Lack of interest in irrigation maintenance and repair of cracks, leading to an increase in the loss rate	77	53	42	41	41	3.33	26
28	Poor implementation of extension activities for farmers to illustrate the importance of using modern irrigation	72	53	49	45	35	3.32	28
29	Neglect of workers dedicated to the operation of modern irrigation systems	68	63	43	38	42	3.30	29
30	Climate change reduces the possibility of using modern irrigation techniques	66	54	53	43	38	3.26	30.5
31	There are no workers trained enough to use modern irrigation techniques	68	53	43	58	32	3.26	30.5
32	There is no plan to deploy appropriate technologies to address the problem of water scarcity	62	59	47	39	47	3.19	32
33	Lack of visits and personal visits between extension workers and farmers	60	50	52	58	34	3.17	33
34	Farmers are not encouraged to use modern irrigation technology	60	49	53	56	36	3.16	34

It is clear from Table 3.15 that the top four items were the cost. The reason for this is that the economic potential of the farmers is much less than the cost of purchasing modern irrigation systems. Second, there is a lack of attention to water resources and the organization of their exploitation. This may be due to the need for a cadre specialized in guiding and guiding farmers and providing them with assistance for optimal exploitation of water resources and organizing its distribution among farmers in proportion to the cultivated areas and type of irrigation system or provide assistance in the exploration of groundwater for the exploitation of agriculture by farmers. Ranked third was the many problems and maintenance difficulties. This may be due to the weakness of farmers' knowledge of some of the technical aspects of modern irrigation techniques, especially the central ones. The fourth place was the insufficient amount of water. This may be due to in some years, farmers face scarcity or scarcity of water due to the lack of rain and snow for the irrigation farmers or the need for a deeper depth for the aquifer farmers. The last four orders were occupied by the following sections: There

are no workers trained enough to use modern irrigation techniques. The reason may be the lack of extension activities that gain farmers experiences and information about the irrigation systems, there is no plan to deploy appropriate technologies to address the problem of water scarcity, which may be caused by the need to provide irrigation systems and facilitate the task of obtaining them by farmers to address the problem of water scarcity, lack of visits and personal exchanges between extension staff and farmers. The last rank item was a section that does not encourage the farmers to use modern irrigation technology may be the cause of this need. Giving farmers material support encourages the rapid adoption of modern irrigation technologies. Farmers are willing to use modern irrigation systems if they are available.

3.5.2. Size of the barriers that prevent farmers from adopting modern irrigation techniques in Kirkuk province

The results showed that there are a large number of factors that prevent the adoption of modern irrigation techniques in the province of Kirkuk, with a weighted average of between 3.53 and 2.85, the determinants were determined by the weighted mean as shown in Table 3.9.

Table 3.9. The descending order by the weighted average of determinants that prevent farmers from adopting irrigation techniques in Kirkuk

N	Difficulties / Challenges	Very large	Large	Medium	Few	None	weighted average	The rank
1	Modern irrigation system has high cost in construction, operation and maintenance	25	20	18	17	4	3.53	1
2	Lack of attention to water resources and the organization of their exploitation	24	20	17	17	6	3.46	2
3	Modern irrigation system needs a lot of effort during operation	22	21	16	18	7	3.39	3
4	Lack of interest in giving priority to small farmers	21	21	18	17	7	3.38	4.5
5	Insufficient amount of water	20	22	21	12	9	3.38	4.5
6	Lack of interest in cleaning irrigation and water channels of harmful aquatic weeds	22	19	18	16	9	3.34	6
7	Lack and inefficiency of training courses provided to farmers	19	21	21	15	8	3.33	7
8	Lack of agricultural radio programs	21	20	18	15	10	3.32	8
9	Many problems and maintenance difficulties	20	20	18	16	10	3.28	9
10	Lack of agricultural extension staff who supervising modern irrigation systems	20	18	18	17	11	3.22	10

N	Difficulties / Challenges	Very large	Large	Medium	Few	None	weighted average	The rank
11	Poor effectiveness of agricultural extension in solving irrigation technology problems	20	18	18	14	14	3.19	12
12	Lack of support for farmers adopting irrigation technologies with production requirements	19	18	20	14	13	3.19	12
13	Difficulty of modern irrigation system requirements for operation and construction	19	18	19	16	12	3.19	12
14	Lack of interest in the maintenance of water resources	19	17	18	19	11	3.16	14.5
15	The instability of the State's price policy with respect to agricultural products	18	19	18	17	12	3.16	14.5
16	Lack of timely availability of water	22	16	14	17	15	3.15	16.5
17	Weak knowledge of farmers about scientific recommendations related to modern irrigation systems	18	20	15	19	12	3.15	16.5
18	Poor extension services on modern irrigation systems techniques	18	17	21	15	13	3.14	18.5
19	Lack of agricultural television programs	18	20	17	14	15	3.14	18.5
20	Lack of interest in introducing farmers to the correct agricultural practices of irrigation technology	17	19	19	15	14	3.11	20
21	Weakness of agricultural extension activities in the dissemination of modern irrigation techniques	17	19	18	16	14	3.10	22
22	There is no good management for spreading modern irrigation techniques	16	19	20	16	13	3.10	22
23	Lack of incentives to adopt modern irrigation techniques	17	19	15	22	11	3.10	22
24	Farmers' distrust of irrigation and maintenance, irrigation system data	16	18	19	20	11	3.09	24
25	Weak agricultural extension activities related to modern irrigation	17	15	23	16	13	3.08	25
26	Weak training programs for farmers on the maintenance of modern irrigation techniques	17	19	16	17	15	3.07	26.5
27	Lack of interest in irrigation maintenance and repair of cracks, leading to an increase in the loss rate	16	15	23	19	11	3.07	26.5
28	Poor implementation of extension activities for farmers to illustrate the importance of using modern irrigation	14	18	20	22	10	3.04	28
29	Neglect of workers dedicated to the operation of modern irrigation systems	18	16	19	13	18	3.03	29
30	Climate change reduces the possibility of using modern irrigation techniques	15	18	16	24	11	3.02	30
31	There is no plan to deploy appropriate technologies to address the problem of water scarcity	14	17	20	21	12	3.00	31.5
32	There are no workers trained enough to use modern irrigation techniques	13	19	20	19	13	3.00	31.5
33	Farmers are not encouraged to use modern irrigation technology	12	18	19	20	15	2.90	33
34	Lack of visits and personal visits between extension workers and farmers	13	17	14	25	15	2.85	34

It is clear from Table 3.16 that the high cost of the modern irrigation system came in the first order. This may be due to the fact that the economic potential of the farmers may not be commensurate with the high costs of purchasing modern irrigation techniques. The second one is the lack of attention to water resources and the organization of their exploitation and the existence of an organization concerned with the exploitation of water resources and their distribution among farmers in proportion to the cultivated areas and type of irrigation system or the need to search for secondary sources of water. In the third place was the section about modern irrigation system needs a lot of effort during operation. This is related to the farmers' lack of knowledge of the correct methods of operation. Fourth place was the lack of interest in giving priority to small farmers and may be due to lack of interest in small agricultural areas used modern irrigation systems at the time of fragmentation possession. The last four rankings were occupied by the following paragraphs which are there is no plan to deploy appropriate technologies to address the problem of scarcity of water. It may be caused by the need to provide irrigation systems and facilitate the task of obtaining them by farmers to address the problem of water scarcity, which has become one of the most important problems of modern times. Second one there are no workers trained enough to use modern irrigation techniques, which shows farmers need to gain experience and information on modern irrigation systems. The third one does not encourage the farmers to use modern irrigation technology may be due to the need of farmers to support the government material and moral. The last section states lack of visits and personal exchanges between staff of agricultural extension and agriculture and may be caused by the difficulty of communication between agricultural extension workers and farmers because of security conditions.

3.6. Factors That Encourage the Farmers in Adopting Modern Irrigation Technology in General

The results showed that there were encouraging factors for farmers to adopt modern irrigation techniques. The factors were arranged according to the weighted mean as shown in Table 3.10.

Table 3.10. The descending order of factors encouraging the adoption of modern irrigation techniques in general

N	Paragraphs	Big	Medium	Few	Weighted mean	Ranking
1	Provide modern irrigation techniques supported by price	210	90	38	2.50	1
2	Support modern irrigation farmers with production inputs	198	86	57	2.43	2
3	Minimize the routine of promoting the treatment of access to modern irrigation technology	192	83	63	2.38	3
4	Attention to irrigation water sources	187	85	66	2.35	4
5	Granting loans to farmers for the purpose of purchasing modern irrigation systems	182	85	71	2.32	5
6	Distribution of leaflets for modern irrigation farmers	185	75	78	2.31	6
7	Provide subsidized spare parts supported by the price from the state	169	95	74	2.28	7
8	Increase the number of agricultural extension workers in the region	162	92	84	2.23	8
9	Implementing irrigation activities related to modern irrigation methods	157	89	92	2.19	9
10	Paying attention to technicians responsible for repairing irrigation technology failures	154	78	106	2.14	10

It is clear from Table 3. 17 that the provision of modern irrigation systems has been ranked. The first is among the factors that encourage the farmers to adopt modern irrigation techniques. This may be due to the need of farmers for these technologies to face the scarcity of water and to continue to grow agricultural crops in order to provide an adequate economic resource to meet many requirements of life. It may also be due to the need of farmers for material and moral support to motivate them to adopt modern irrigation techniques and to continue to use or use more than the technology and different types, whether irrigation spray or drip, and in the last order came the paragraph of interest in the technician specialists to reform the failures of modern irrigation technology.

3.6.1. Factors that encourage the farmers in adopting modern irrigation technology in Salahaddin province

The results showed that there were encouraging factors for adopting modern irrigation techniques. The factors were arranged according to the weighted mean as shown in Table 3.11.

Table 3.11. The descending order of factors encouraging the adoption of modern irrigation techniques in Salahaddin province

N	Paragraphs	Big	Medium	Few	Weighted mean	Ranking
1	Provide modern irrigation techniques supported by price	168	57	29	2.54	1
2	Support modern irrigation farmers with production inputs	159	54	44	2.47	2
3	Minimize the routine of promoting the treatment of access to modern irrigation technology	157	55	42	2.45	3
4	Granting loans to farmers for the purpose of purchasing modern irrigation systems	156	56	42	2.44	4.5
5	Attention to irrigation water sources	154	60	40	2.44	4.5
6	Distribution of leaflets for modern irrigation farmers	153	57	44	2.42	6.5
7	Provide subsidized spare parts supported by the price from the state	145	73	36	2.42	6.5
8	Increase the number of agricultural extension workers in the region	140	71	43	2.38	8
9	Implementing irrigation activities related to modern irrigation methods	137	70	47	2.35	9
10	Paying attention to technicians responsible for repairing irrigation technology failures	134	61	59	2.29	10

It is clear from the Table 3. 18 that the provision of modern irrigation systems has ranked first among the encouraging factors for the adoption of modern irrigation techniques. This may be due to the need of farmers to encourage and material and moral support in order to adopt the modern irrigation techniques to address the problem of water scarcity in the province. In the second place came the section to support farmers with production requirements, which may be due to the need of farmer respondents to support the necessary inputs. The last rank was the section concerned with the technicians repairing irrigation technology failures. This may be due to the need for technicians to repair the faults of irrigation technology.

3.6.2. Factors That Encourage the Farmers in Adopting Modern Irrigation Technology in Kirkuk Province

The results showed that there were encouraging factors for adopting modern irrigation techniques. The factors were arranged according to the weighted mean as shown in Table 3.12 in the province of Kirkuk.

Table 3.12. The descending order of factors encouraging the adoption of modern irrigation techniques in Kirkuk province

N	Paragraphs	Big	Medium	Few	weighted mean	Ranking
1	Provide modern irrigation techniques supported by price	42	33	9	2.39	1
2	Support modern irrigation farmers with production inputs	39	32	13	2.30	2
3	Minimize the routine of promoting the treatment of access to modern irrigation technology	35	30	19	2.19	3
4	Granting loans to farmers for the purpose of purchasing modern irrigation systems	31	29	24	2.08	4
5	Attention to irrigation water sources	28	25	31	1.96	5
6	Distribution of leaflets for modern irrigation farmers	28	23	33	1.94	6
7	Provide subsidized spare parts supported by the price from the state	24	22	38	1.83	7
8	Increase the number of agricultural extension workers in the region	22	21	41	1.77	8
9	Implementing irrigation activities related to modern irrigation methods	20	19	45	1.70	9
10	Paying attention to technicians responsible for repairing irrigation technology failures	20	17	47	167	10

It is clear from the Table 3. 19 that the provision of modern irrigation systems has ranked the first among the encouraging factors for the adoption of modern irrigation techniques in the province of Kirkuk. This may be due to the need for farmers to increase material and moral support in order to adopt modern irrigation techniques. Because of water shortage in the province, in the second place came the section about supporting farmers with the requirements of production. This is due to the need of farmer respondents to support the necessary requirements to raise the level of production in the province. The last place was the section of interest of technicians concerned with repairing irrigation technology failures. This may be due to the need for technical experts to deal with the technical faults facing modern irrigation systems.

3.7. Correlation Between the Respondents' Adoption of Modern Irrigation Techniques in the Provinces of Salahaddin and Kirkuk in General and Some Independent Variables Related to the Respondents

3.7.1. Quantitative variables

1- Age

The results of the analysis showed that the age of the respondents ranged from (23-65) with an average of (41.37) and a standard deviation (11.49). The subjects (respondents) were divided into three categories using the law of the range and the highest percentage within the low age group as shown in Table 3.13.

Table 3.13. Distribution of respondents according to age groups.

Categories	Frequency	%	Average	R -value	P-Value
Low (23-36)	126	37.3	64.30	- 0.225**	0.000
Medium (37-50)	122	36.1	58.77		
High (51-65)	90	26.6	56.10		
Total	338	100	S.D=11.49		

To find the correlation between the level of adoption of modern irrigation technologies and the variable age, the Pearson correlation coefficient (-0.225) was used to indicate a negative relationship between two variables. The accompanying P-Value value was 0.000, which is less than 0.05. The probability level was 0.01, so the null hypothesis "There is no relationship between farmers' adoption of modern irrigation technology and age." was rejected and the alternative hypothesis "There is relationship between farmers' adoption of modern irrigation technology and age." was accepted indicating that the young people were more receptive to modern agricultural techniques, including modern irrigation techniques. Present findings were consistent with the results of earlier studies (Adesina and Zinnah, 1993; Mauceri *et. al.*, 2005; Alexander and Van Mellor, 2005; Kalantari *et. al.*, 2010; Dhraief, M. Z., Bedhiaf-Romdhania, S., Dhehibib, B., Oueslati-Zlaouia, M., Jebali, O., and Ben Youssef, S. , 2018 Ibn Musah, A. A., Du, J., Bilaliib Udimal, T., and Abubakari Sadick, M., 2018;) indicating that older

generations were reluctant to adopt and younger generations typically embrace net technologies more quickly.

2- Number of years in practicing modern irrigation

The results of the analysis showed that the years of practicing modern irrigation ranged between (5-18) with an average of (11.20) and a standard deviation (3.38). The subjects were divided into three categories using the range law and the highest percentage was within the "high" category.

Table 3.14. Distribution of respondents according to categories of years of practice of agriculture in modern irrigation.

Categories	Frequency	%	Average	R -value	P-Value
Low (5-8)	90	26.6	50.81	0.553**	0.000
Medium (9-12)	123	36.4	59.14		
High (13 - and below)	125	37	67.28		
Total	338	%100	S.D= 3.38		

The relationship between the level of adoption of modern irrigation techniques by farmers and the variable number of years of agricultural practice using modern irrigation techniques yielded a Pearson correlation coefficient of (0.553) indicating a positive relationship between two variables, and the associated P-Value value was 0.000 less than 0.05 at the probability level of 0.01, so the null hypothesis "There is no relationship between farmers' adoption of modern irrigation technology and Number of years of practicing agriculture in modern irrigation " Was rejected and the alternative hypothesis "There is relationship between farmers' adoption of modern irrigation technology and Number of years of practicing agriculture in modern irrigation." was accepted. This may be due to the fact that the more years practiced by the farmer with the modern irrigation techniques, the more experienced the benefits, which is reflected at the level of the respondent to modern irrigation techniques. Present findings were again consistent with the results of previous studies (NCUBE, E. 1985; Hayati and Lari, 2000; Jahannama, 2001; Zebib Kassahun Weldegiorges, 2014; Audrey Amagove Kinyangi , 2014 And Uwandu, C. N., Thomas, K. A., and Okoro, C. M. , 2018). The

results illustrated that 26.2% of the respondents were working for less than 9 years, 36.4% were working for 9 -12 years and 37.0% were working for more than 13 years. This means that the years of respondent's practice of agriculture with modern irrigation techniques also increased their experience and benefits, which is reflected on adoption of respondents to modern irrigation techniques.

3- Farm size

The results of the analysis showed that the size of the agricultural holdings ranged from 50 to 550) decare with an average of 198.44 decare and a standard deviation of 125.47. The respondents were divided into three categories using the range law. The highest percentage was in the low category as shown in Table 3. 22.

Table 3.15. Distribution of respondents according to size of farm.

Categories	Frequency	%	Average	R -value	P-Value
Low (less than 150)	155	45.8	53.93	0.575 **	0.000
Medium (151-300)	101	29.9	60.74		
High (301 - and more)	82	24.3	70.25		
Total	338	100 %	S.D = 125.47		

To find the correlation between farmers' adoption of modern irrigation techniques and the variable size of farm holdings, Pearson correlation analysis was performed and a coefficient of 0.575 indicated a positive relation between two variables. Associated P-Value value was 0.000 less than 0.05 indicating that there was a significant correlation between them at the probability level 0.01. Therefore, the null hypothesis “There is no relationship between farmers’ adoption of modern irrigation technology and Farm size ” Was rejected and the alternative hypothesis “There is relationship between farmers’ adoption of modern irrigation technology and Farm size ” was accepted. These findings comply with the results of earlier studies (Lin, 1991; CIMMYT Economics Program , 1993 ; Stephenson, 2003; Bagheri, A., and Ghorbani, A. , 2011 ; Thomas Bilaliib Udimal and others, 2017) showing that farm size had a positive relation with the adoption of rice technology. Both models indicated increased adoption levels of paddy farmers with increasing firm sizes. This means (Nerica) rice technology should target

farmers with large rice farms since they have the potential of adopting the technology. Farmers with large farm size are likely to adopt a new technology as they can afford to devote part of their land to try new technology which when successful would cause them to adopt the technology fully, unlike those with less farm size. The result shows that a unit increases in farm size will result in about 17% and 20% chances of adopting the (Nerica) rice variety for logit and probit models respectively ($p<0.01$). It is therefore, argued that farmers with large farms are wealthier than small-scale farmers, and can afford inputs that go with the technology adoption. In addition, since (Nerica) rice technology comes as a package, they were able to adopt the package more than the smaller size farmers, especially fertilizer and other inputs requirement. Present findings confirmed by the study of Uaiene et al. (2009) indicating significant effects of farm size on farmers' adoption of new technologies.

4- Number of family members

The results of the analysis showed that the number of family members of the respondents ranged between (6 – 15) with an average of (8.51) and a standard deviation (2.14). The subjects were divided into three categories using the law of the range and the highest percentage was within the low category as shown in Table 3.16.

Table 3.16. Distribution of respondents according to number of family members.

Categories	Frequency	%	Average	R -value	P-Value
Low (6 – 8)	186	55.1	58.50	0.197**	0.001
Medium (9 – 11)	87	25.7	59.79		
Big (12 – 15)	65	19.2	64.22		
Total	338	100 %	S.D = 2.14		

To find a correlation between the farmers' level of adoption of modern irrigation techniques and variable number of individuals of the family, a correlation coefficient was used. Pearson correlation coefficient (0.179) indicated a positive correlation between two variables, and the associated P-Value value was 0.001 less than 0.05 indicating that the correlation was significant at the probability level of 0.01. Therefore, the null hypothesis "There is no relationship between farmers' adoption of modern

irrigation technology and the number of family members ” Was rejected and the alternative hypothesis “There is relationship between farmers’ adoption of modern irrigation technology and the number of family members ” was accepted indicating a significant correlation between two variants. Present findings on such correlations were consistent with the outcomes of the previous studies (Bonabana- Wabbi 2002; Mignouna et al, 2011; Kinyangi, A. A. , 2014 And Saeed, G., Sadegh, E. M., and Maryam, A. , 2014) reporting that a larger household had the capacity to relax the labor constraints required during the introduction of new technology.

5- Access sources of information

The results of the analysis showed that the respondents' knowledge of the sources of information ranged between (13 – 37) sources with an average of (21.48) and a standard deviation (5.83). The respondents were divided into three categories using the law of range and the highest percentage was within the low category as seen in Table 3.17.

Table 3.17. Distribution of respondents according to Sources of information

Categories	Frequency	%	Average	R -value	P-Value
Low (12 – 20)	171	50.59	56.37	0.393	0.000
Medium (21 - 28)	127	37.57	61.24		
Large (29 – 37)	40	11.84	71.00		
Total	338	100 %	S.D = 5.83		

Pearson correlation analysis was performed to find a correlation between farmers' adoption of modern irrigation techniques and variable of access sources of information. The correlation coefficient of 0.393 indicated a positive correlation between two variables. The associated P-Value value was 0.000 less than 0.05 indicating that the correlation was significant at the probability level of 0.01. Therefore, the null hypothesis “There is no relationship between farmers’ adoption of modern irrigation technology and the measurement of variable access to sources of information ” was rejected and the alternative hypothesis “There is relationship between farmers’ adoption of modern irrigation technology and the measurement of variable access to sources of information ” was accepted providing a significant correlation between two variants.

Present findings on such a correlation were consistent with the outcomes of previous researchers (Ariel Dinar and Dan Yaron , 1992; Michael Musyoki Muthui , 2006 and Asghar Bagheri and Ardavan Ghorbani , 2010) , reporting that source of information had a significant and positive relationship with the technology adoption. It implies that the higher the frequency of contact with extension service providers, the higher the intensity of adoption. These results were also similar to the findings of Obeta and Nwagbo (1991), which revealed that frequent contact with extension agent was likely to minimize doubts among farmers and increase innovation take up.

6- Extension efforts

The results of the analysis showed that the pilot efforts ranged from (7-20) with an average of (12.46) and a standard deviation (2.62). The respondents were divided into three categories using the law of range and the highest percentage was within the medium category as shown in Table 3,18.

Table 3.18. Distribution of respondents according to extension efforts.

Categories	Frequency	%	Average	R -value	P-Value
Low (7- 10)	85	25.1	53.79	0.353**	0.000
Medium (11 – 14)	167	49.4	60.42		
High (15 - and below)	86	25.5	65.06		
Total	338	100 %	S.D = 2.62		

To find the correlation between the farmers' adoption of modern irrigation techniques and the variable of extension efforts, Pearson correlation coefficient (0.353) was used. The associated P-Value value was 0.000 less than 0.05 indicating that the correlation was significant at the probability level of 0.01. Then, the null hypothesis “There is no relationship between farmers’ adoption of modern irrigation technology and extension efforts ” was rejected and the alternative hypothesis “There is relationship between farmers’ adoption of modern irrigation technology and extension efforts ” Was accepted providing a significant correlation between two variants. Present findings for correlations between two variables were consistent with the results of previous similar studies (Feder and Umali, 1993; Dong, 2008; Ommani et al.,2009; Thomas Bilaliib Udimal and others , 2017 ; Adetola I. Adeoti, 2009) reported that adopters had higher

number of extension visits per year (4.31) than non-adopters (2.07) and the difference between then was significant at 1%.

3.7.2. The qualitative variables

1- Educational level:

Based on educational levels, respondents were divided into seven categories and the highest percentage was within the category of "reads and writes", as shown in the Table 3.19.

Table 3.19. Distribution of respondents according to education level

Categories	Frequency	%	Average	R S- Value	P-Value
Illiterate	40	11.8	56.60	0.231	0.000
Reads and writes	90	26.6	56.03		
Primary	48	14.2	62.38		
Medium	74	21.9	62.56		
Middle school	58	17.2	63.52		
Bachelor	19	5.6	63.56		
Master	9	2.7	64.82		
Total	338	100%	** Significant at the probability level 0.01		

To find the correlation between the level of adoption of modern irrigation techniques and the variable of educational achievement, the Spearman Range correlation coefficient was used and a correlation coefficient of 0.231 indicated a positive relationship between two variables. The P - Value associated with the correlation coefficient value was 0.000 less than 0.05 indicating that the correlation was significant at probability of 0.01 level. Therefore, the null hypothesis "There is no relationship between farmers' adoption of modern irrigation technology and Educational level " was rejected and the alternative hypothesis "There is relationship between farmers' adoption of modern irrigation technology and Educational level " was accepted. Present findings comply with the results of Audrey Amagove Kinyangi (2014), which mentioned that there was a significant ($p<0.05$) difference in the levels of respondents' education, indicating respondents' different understanding of how the various factors affect the

adoption of agricultural technology among smallholder farmers. (Chitere and Dourer, 1985; feder, ibid, 1993; Michael Musyoki Muthui , 2006 ; Margaret Mwangi and Samuel Kariuki2, 2015) reported that educational level of a farmer increased his ability to obtain; process and use of information relevant to adoption of a new technology. Gem (2004) conducted a survey and indicated that education played a pivotal role in the survival of the organization and therefore employees should be exposed to various educational programs to enable them to acquire knowledge in their respective endeavors.

2. Farm Ownership

Based on farm ownership, respondents were divided into four categories and the highest proportion was within the agricultural contract, as shown in Table 3.20.

Table 3.20. Distribution of Respondents according to farm ownership

Categories	Frequency	%	Average	R S- Value	P-Value
Own	105	31.1	65.05	0.251 **	0.000
Rent	73	21.6	60.08		
Contract	122	36.1	59.15		
Share	38	11.2	52.37		
Total	338	100%	** Significant at the probability level 0.01		

Spearman Range correlation coefficient of (0.251) indicated that there was a significant correlation between the level of adoption by farmers of modern irrigation techniques and type of tenure for agricultural land. The P- Value associated with the correlation coefficient was 0.000 less than 0.05. Therefore, the null hypothesis “There is no relationship between farmers’ adoption of modern irrigation technology and Farm ownership ” was rejected and the alternative hypothesis “There is relationship between farmers’ adoption of modern irrigation technology and Farm ownership ” was accepted providing a significant correlation between two variables. This may be because the owners of the agricultural land of the respondents were more keen to adopt modern agricultural techniques. Present findings about such correlations do not comply with the findings of previous studies (Bhuiyan , 1987; Reyes, Y., 1996; Getacher, T., Mesfin, A., and Gebre-Egziabher, G., 2013 and Huang, Z., and Karimanzira, T. , 2018) reporting

insignificant effects of land ownership on soil testing and fertilizer recommendations ($p > 0.05$).

3- Marital status:

The number of respondents according to this variable was divided into four categories and the highest percentage was within married, as shown in Table 3.21.

Table 3. 21. Distribution of respondents according to marital status.

Categories	Frequency	%	Average	R S- Value	P-Value
Unmarried	78	23.1	56.06	0.179 **	0.001
Married	233	68.9	60.75		
Widowed	13	3.8	61.00		
Separated	14	4.2	68.21		
Total	338	100%	** Significant at the probability level 0.01		

To find the correlation between farmers' adoption of modern irrigation techniques and the marital status variable, Spearman correlation coefficient was used. Correlation coefficient of 0.179 indicated a positive relationship between two variables. The P-Value associated with the correlation coefficient was 0.001, which is less than 0.05. Therefore, the null hypothesis “There is no relationship between farmers’ adoption of modern irrigation technology and marital status ” was rejected and the alternative hypothesis “There is relationship between farmers’ adoption of modern irrigation technology and marital status ” was accepted providing a significant correlation between two variables. Married couples were keener to adopt modern agricultural techniques in order to provide an economic resource for them and their families to meet the requirements of modern life. Present findings were parallel to the outcomes of earlier studies (Adeoti et al., 2007; Opara, 2010; Msuya, 2016; Kumornu and Owusu, 2012) reporting significant correlations of marital status with the agricultural information use.

4- Family rank

Based on family rank variable, respondents were divided into three categories and the highest percentage was within the category of the father, as shown in the Table 3.22.

Table 3. 22. Distribution of respondents according to family rank

Categories	Frequency	%	Average	R S- Value	P-Value
Father	177	52.4	59.57	$0.036^{n.s}$	0.506
Wife	36	10.6	59.11		
Son	125	37.0	60.83		
Total	338	100%	n.s Non-significant (apparent relationship)		

To find the correlation between farmers' adoption of modern irrigation techniques and family rank variable, Spearman Range correlation coefficient was calculated. A coefficient of 0.036 indicated an insignificant relationship between two variables. The associated P-Value with the correlation coefficient was 0.506 which is greater than 0.05. Therefore, the null hypothesis "There is no relationship between farmers' adoption of modern irrigation technology and the family rank" was accepted. This may be due to the fact that the respondents in the various family orders were keen to achieve high production to fill the requirements of modern life and therefore there is no difference between them in terms of interest in agricultural work and the adoption of modern agricultural techniques. There is no similar study with this variable.

5- Farm labor:

The number of respondents according to this variable was divided into three categories and the highest percentage was within the category of family members, as shown in Table 3.23.

Table 3.23. Distribution of respondents according to farm labor

Categories	Frequency	%	Average	R S- Value	P-Value
Family members	167	49.4	66.91	0.447 **	0.000
Paid workers	89	26.3	49.82		
Both types of labor	82	24.3	56.93		
Total	338	100%	** Significant at the probability level 0.01		

To find the correlation between farmers' adoption of modern irrigation techniques and the variable of agricultural labor, Spearman Range correlation coefficient was calculated as 0.447 which indicated a positive relationship between two variables. The P- Value associated with the correlation coefficient was 0.000 less than 0.05. Therefore, the null hypothesis "There is no relationship between farmers' adoption of modern irrigation technology and Farm labor " was rejected and the alternative hypothesis "There is relationship between farmers' adoption of modern irrigation technology and Farm labor " was accepted. Present findigns comply with the results of earlier studies (Hayati and Lari, 2000; Karbasi, 2001; Bjornlund et al., 2008; Ratchaneewan Chuchird *et al*., 2017; Thomas Bilaliib Udimal and *et al.*, 2017) reported that the coefficient of family labor had a positive sign in relation to the adoption of (Nerica) rice. This implies that a farmer with family labor was more likely to adopt (Nerica) rice than those without family labor. The (Nerica) rice requires timely planting, prompt weeding and harvesting and all these activities are labor demanding, as a result, farmers who are assured of labor are more likely to adopt than those that are not sure of their chances of getting labor.

6- Government support:

According to the variable of government support, present respondents were divided into two categories and the highest percentage within the category of (yes - obtained government support), as shown in Table 3. 31.

Table 3.24. Distribution of respondents according to government support

Categories	Frequency	%	Average	R S- Value	P-Value
Yes	253	74.9	60.89	0.220 **	0.001
No	85	25.1	57.29		
Total	338	100%	** Significant at the probability level 0.01		

To find the correlation between the level of adoption of modern irrigation techniques and the variable of government support, Spearman Range correlation coefficient was calculated. A coefficient of 0.220 indicated a positive relationship between two variables. The P-Value value associated with the correlation coefficient was 0.001 and it was less than 0.05. Therefore, the null hypothesis "There is no relationship between

farmers' adoption of modern irrigation technology and governmental support " Was rejected and the alternative hypothesis "There is relationship between farmers' adoption of modern irrigation technology and governmental support" was accepted providing a significant correlation between two variables. Present findings well-comply with the results of Usman (2018) and consistent with the findings of the other studies. (Cremades *et al*., 2014) reported that if the subsidy was available, 73% of plots had household-based irrigation technology adopted; the adoption level was only 50% if the subsidy was not available. Similarly, if the farmers could obtain the subsidy when they invest in irrigation technology, the adoption level of plots for community-based irrigation technology (29 %) was also considerably higher than without the subsidy (11 %). (Ommani *et al.*, 2009; Dinar and Yaron, 1992) reporting possible posi relationship between the adoption of irrigation technology and policies encouraging

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions - Recommendations

Conclusions

Based on present findings, the following conclusions were drawn from this thesis:

1– The results demonstrated an average level adoption of modern irrigation techniques by the farmers. It can be deduced that there was a weakness in the expertise and knowledge of farmers about the modern irrigation techniques. This indicates the need for programs, activities and guidance of extension specialist to train them.

2– The farmers of Salahaddin and Kirkuk demonstrated an average level adoption of these modern irrigation techniques. This is a scientific indicator of how low the process of farmers adopting these modern technologies remains in Salahaddin and Kirkuk, which demonstrates the need of training activities and guidance in each of these provinces.

3– The results of the test analysis showed no significant difference between the respondents in the Salahaddin and Kirkuk provinces. Thus, it can be deduced that there was no difference in knowledge or experience of modern irrigation techniques between two provinces.

4– The results showed real determinants in the adoption of modern irrigation techniques: the major one was the cost of the irrigation system, a lack of interest in water resources, and poor organization in utilizing these resources. It can thus be deduced that there was a need to find solutions to these determinants to improve the adoption of these irrigation techniques by the farmers.

5– The results indicated several encouraging factors for farmers to adopt modern irrigation techniques. First of all, these techniques should be provided to them and then the production requirements must be outlined for plants to follow the techniques.

6– A reverse correlation was established between the farmers' adoption of modern irrigation techniques and the age of the farmers. From this, it can be deduced that older farmers were committed to the traditional irrigation methods while younger farmers were more receptive to new technologies and innovations.

7– A positive correlation was established between farmers' adoption of modern irrigation techniques and all the other variables except for family rank. There was no relationships between farmers' adoption of modern irrigation techniques and the family rank. Thus, it is possible to deduce that majority of investigated variables related to farmers' adoption of modern irrigation techniques.

Recommendations

The following recommendations were made based on conclusions drawn from the results of this thesis:

1– There is a need for the Central Agricultural Extension Authority, represented by the General Authority for Training and Agricultural Extension, to implement educational and training programs to assist farmers with understanding the modern irrigation technologies. The governing bodies must explain that these technologies have a positive impact on water consumption, as well as increase the quantity and quality of their production.

2– There is a need for the guidance and training activities in the provinces of Salahaddin and Kirkuk related to the importance of adopting modern irrigation techniques and ensuring their continued adoption.

3– Farmers must be encouraged and motivated towards using modern irrigation techniques through material and moral support.

4– The agricultural supervisors working in Salahaddin and Kirkuk provinces must undertake field visits to their local modern irrigation plants to observe the process. This provides moral encouragement to the farmers.

5– It is necessary to find solutions for the determinants preventing farmers from adopting modern irrigation techniques, especially related to providing these technologies easily and assisting with their costs.

6– Farmers in Salahaddin and Kirkuk must be supplied with information resources such as magazines and manuals regarding the operation and maintenance of modern irrigation systems.

7– It is important to consider the independent variables which showed significant correlation with the adoption of modern irrigation techniques by farmers in the preparation and implementation of extension activities for the farmers using these modern systems.

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APPENDIX

(APPENDIX 1)

Research of topic "Farmer's Adaptation of Modern Irrigation Techniques in Iraq"

FARMERS' QUESTIONNAIRE

Please go through this questionnaire and, if necessary, provide a response. Your answers will be treated in confidence. There will be no attempts to identify individual respondents. Your involvement is voluntary; you may choose not to take part. You may also refuse to participate or answer certain paragraphs in certain procedures. It is not necessary to put your name on the questionnaire.

The Researcher

Waleed Sabbar Ayyed

Independent variables

1. Age: [ ]

2. Educational level:

- **Illiterate [ ]**
- **Reads and write [ ]**
- **Primary [ ]**
- **Middle school [ ]**
- **High school [ ]**
- **Bachelor [ ]**
- **Master [ ]**

3. Farm size (in decare): [ ]

4. Farm ownership :

- **Own the farm [ ]**
- **Rent the farm [ ]**
- **Contract [ ]**
- **Participation [ ]**

5. What is your marital status:

[ ] Married [ ] Unmarried [ ] Widow [ ] Divorced

6. Number of family members [ ]

7. What is your relationship with the family? (Family rank)

[ ] Father [ ] Wife [ ] Daughter , Son

8. Number of years practicing modern irrigated agriculture [ ]

9. Farm labor:

Depend on family members [ ], Bring paid workers [ ], Both types of labor [ ]

10. What are the primary sources of agricultural information? (Access sources of information)

N	The sources	Always	Sometimes	Scarcely	No
1	Directorate of Agriculture in the province				
2	Agricultural advisor in the farming offices				
3	Agricultural Equipment Agents				
4	Agricultural offices				
5	Distinguished farmers				
6	Friends and neighbors				
7	Television programs about extension agriculture				
8	Radio programs about extension agriculture				
9	Books and publishing extension				
10	Agricultural Newspapers and Magazines				
11	Institutes and Colleges of Agriculture				
12	Personal Experiences				
13	Other :				

11. Have you received/accessed to governmental support (including financial and inputs in kind) in the last four years? 1. Yes [ ] 2. No [ ]

12. Extension efforts provided by agricultural extension agents in the field of modern irrigation

N	Extension efforts	Always	Sometimes	Scarcely	No
1	Visit the participant in the field				
2	Officers spend enough time when they visit your field				
3	They create training courses on modern irrigation systems				
4	They create seminars on modern irrigation systems				
5	They provide you with bulletins about the importance of using modern irrigation systems				
6	They work of advertising about the benefits of modern irrigation systems				
7	Create Explanatory fields in your area				
8	They create for a field day each year				

● Adoption levels of modern irrigation techniques

N	Adoption levels of modern irrigation techniques	verified	Intermediate verification	Weak verification
1	Use of the water balance to estimate the volume consumed by each crop in the farm			
2	Use of the lecemeter method to calculate water consumption			
3	Plastic pipes can be used when doing surface irrigation			
4	Use valves to control the amount of water to do irrigation in a given area			
5	Use the accurate measurement methods to determine the amount of water added and reduce the loss of water because of overflow			
6	Use of fixed sprinkler irrigation systems to ensure accurate distribution			
7	Use of moving sprinkler systems to ensure uniform irrigation of plants			
8	Use of semi-portable spray irrigation systems			
9	When using sprinkler irrigation, consider the size of the main line, the sub-lines and the distance between the sub-lines			
10	When using sprinkler irrigation, consider the distance between the sprinkler, the machine hole and the amount of the pressure			
11	Use the fixed nozzle spray at approximately 9° angle to adequately water the plants			
12	Use the perforated tube to distribute the water in a better way			
13	Use circular spray to ensure correct watering of plants in large areas			
14	Use the method of settling the surface of the farmland from surface irrigation			
15	Use of long lines and strips in surface irrigation			
16	Use alternating lines in surface irrigation			
17	Use of terraces when conducting surface irrigation			
18	Surface irrigation by using plastic pipes (siphons)			
19	Surface irrigation by slides			
20	Surface irrigation by flat basins			

21	Spray irrigation by using sprinklers			
22	Spray irrigation by using corrects pipes			
23	Control systems in sprinkler irrigation			
24	Lifting and pumping group in agricultural irrigation			
25	Using of localized irrigation which has single-nozzles in drip irrigation			
26	Using of localized irrigation which have multi-nozzles that are more accurate inside the line for drip irrigation			
27	Using of localized irrigation on line in drip irrigation			
28	Using of localized irrigation inside line in drip irrigation			
29	Use self-washing in drip irrigation			
30	Use of non-self-washing in drip irrigation			
31	Using of localized irrigation consisting of hoses for proper watering of the plants			

● Size of the obstacles that prevent farmers from adopting modern irrigation techniques

N	Difficulties / Challenges	Very large	Large	Medium	Few	None
1	Modern irrigation system has high cost in construction, operation and maintenance					
2	Lack of attention to water resources and the organization of their exploitation					
3	Lack and inefficiency of training courses provided to farmers					
4	Lack of interest in giving priority to small farmers					
5	Insufficient amount of water					
6	Lack of interest in cleaning irrigation and water channels of harmful aquatic weeds					
7	Modern irrigation system needs a lot of effort during operation					
8	Lack of agricultural radio programs					
9	Many problems and maintenance difficulties					
10	Lack of agricultural extension staff who supervising modern irrigation systems					
11	Poor effectiveness of agricultural extension in solving irrigation technology problems					
12	Lack of support for farmers adopting irrigation technologies with production requirements					
13	Difficulty of modern irrigation system requirements for operation and construction					
14	Lack of interest in the maintenance of water resources					
15	The instability of the State's price policy with respect to agricultural products					
16	Lack of timely availability of water					
17	Weak knowledge of farmers about scientific recommendations related to modern irrigation systems					
18	Poor extension services on modern irrigation systems techniques					
19	Lack of agricultural television programs					
20	Lack of interest in introducing farmers to the correct agricultural practices of irrigation technology					
21	Weakness of agricultural extension activities in the dissemination of modern irrigation techniques					

22	There is no good management for spreading modern irrigation techniques					
23	Lack of incentives to adopt modern irrigation techniques					
24	Farmers' distrust of irrigation and maintenance, irrigation system data					
25	Weak agricultural extension activities related to modern irrigation					
26	Weak training programs for farmers on the maintenance of modern irrigation techniques					
27	Lack of interest in irrigation maintenance and repair of cracks, leading to an increase in the loss rate					
28	Poor implementation of extension activities for farmers to illustrate the importance of using modern irrigation					
29	Neglect of workers dedicated to the operation of modern irrigation systems					
30	Climate change reduces the possibility of using modern irrigation techniques					
31	There are no workers trained enough to use modern irrigation techniques					
32	There is no plan to deploy appropriate technologies to address the problem of water scarcity					
33	Lack of visits and personal visits between extension workers and farmers					
34	farmers are not encouraged to use modern irrigation technology					

- **The factors that encourage farmers to adopt modern irrigation technology .**

N	Paragraphs	Big	Medium	Few
1	Provide modern irrigation techniques supported by price.			
2	Support modern irrigation farmers with production inputs			
3	Minimize the routine of promoting the treatment of access to modern irrigation technology.			
4	Attention to irrigation water sources.			
5	Granting loans to farmers for the purpose of purchasing modern irrigation systems.			
6	Distribution of leaflets for modern irrigation farmers			
7	Provide subsidized spare parts supported by the price from the state			
8	Increase the number of agricultural extension workers in the region.			
9	Implementing irrigation activities related to modern irrigation methods			
10	Paying attention to technicians responsible for repairing irrigation technology failures			

Thank you for your participation

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