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Araştırma Makalesi

Halep'teki Tarım İşletmelerinin Modern Sulama Sistemleri Kullanımını Etkileyen Faktörler

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ÖZ

Bu çalışma, Suriye'nin Halep kentindeki çiftçilerin modern sulama sistemlerini benimsemelerini etkileyen; coğrafi, sosyo-ekonomik ve demografik faktörleri incelemektedir. Halep'te modern sulama sistemlerinden sıklıkla yağmurlama ve damla sulama sistemleri kullanıldığından çalışma ağırlıklı olarak bu iki sistem üzerinden açıklanmaktadır. Çalışmanın verileri, Oransal Örnekleme Yöntemiyle seçilen 210 çiftçiden oluşan bir örneklem aracılığıyla yüz yüze yapılan anketler ile elde edilmiştir. Modern sulama sistemlerini kullanan ve kullanmayan çiftçilerin bazı özellikler açısından karşılaştırılmasında Ki-kare bağımsızlık testi kullanılmıştır. Bulgular, bölgede çiftçilerin modern sulama yöntemlerinin kullanımının "eğitim düzeyi, tarımdaki deneyim yılı, aile genişliği, arazinin eğimi, arazinin su kaynaklarına uzaklığı, işletme büyüklüğü, traktör sahipliği ve tarımsal girdi fiyatları" gibi değişkenlerden etkilendiğini ortaya koymaktadır. Bu bilgiler ışığında, bölgede modern sulama yöntemlerini teşvik etmek için eğitimli ve deneyimli çiftçiler ile yerel yönetimlerin ve tarımsal yayım kuruluşlarının işbirliği içinde hareket etmesi önerilmektedir. Ayrıca modern sulamanın gerekliliğine ve her geçen yıl etkisini daha da çok hissettiren "su krizi" konusunda çiftçilerin bilinçlendirilmesine öncelik verilmelidir.

Anahtar kelimeler: Modern sulama sistemleri, Tarımsal yenilik, Kuzey Halep, Suriye, Sosyoekonomik faktörler

Factors Affecting the Farmer's Use of Modern Irrigation Systems in Aleppo

ABSTRACT

This study analyses the geographical, socio-economic and demographic factors affecting the adoption of modern irrigation systems by farmers in Aleppo, Syria. Since sprinkler and drip irrigation systems are frequently used among modern irrigation systems in Aleppo, the study is mainly explained through these two systems. The data of the study were obtained through face-to-face surveys with a sample of 210 farmers selected by proportional sampling method. Chi-square test of independence was used to compare farmers who use modern irrigation systems and those who do not use modern irrigation systems in terms of some characteristics. The findings reveal that the use of modern irrigation methods by farmers in the region is affected by variables such as education level, years of experience in agriculture, family size, slope of the land, distance of the land to water resources, farm size, tractor ownership, and agricultural input prices. In the light of this information, it is recommended that trained and experienced farmers, local administrations and agricultural extension organisations should act in cooperation to encourage modern irrigation methods in the region. In addition, priority should be given to the necessity of modern irrigation and raising awareness of farmers about the "water crisis", which makes its effect felt more and more every year.

Key words: Modern irrigation systems, Agricultural innovation, Northern Aleppo, Syria, Socioeconomic factors

INTRODUCTION

The most important factors affecting agricultural activities in the world can be listed as climate change, decrease in water resources and increase in global water demand, demand for safe food, fluctuations in food prices, population mobility due to internal/external migration, condition of agricultural lands and natural disasters (FAO, 2018). Each of these is important for agricultural efficiency and productivity. Among these, water resources emerge as another critical determinant of agricultural viability with sustainable water management practices necessary to ensure food security in an environment of increasing competition and scarcity. The demand for water, one of the world's most important assets, is increasing continuously. For this reason, the effective use of water with existing water resources is gaining an increasingly important and strategic dimension (Aydın Eryılmaz et al., 2022; Gençoğlan et al., 2005 and 2006). Irrigation systems are innovations and practices that control water use and conserve water and soil resources to reduce water losses and increase agricultural productivity (Levidow, 2014). The unconscious use of irrigation water worldwide leads to a number of serious problems. These include soil salinization, soil erosion, lowering of ground water levels, water pollution, competition for water resources, and damage to ecosystems (Foley et al., 2005). In plants, in general, the lack of water prevents the development of the plant, while the excess causes the death of the plant.

Syria was considered one of the few countries that achieved self-sufficiency in many agricultural products, especially the main agricultural crops such as wheat, barley and cotton (Carnegie, 2015). Benefiting from a Mediterranean climate, ample water sources, and fertile lands, the nation has historically cultivated a robust agricultural sector. However, climate change and recurrent droughts, compounded by technical delays, had already posed considerable challenges to Syrian agriculture even prior to the onset of the war. This drought had strong effects on the agricultural sector through the great shortage of irrigation water sources and resulted in social and economic problems (FAO, 2023). Syria has suffered from three droughts since 1980 where the most influential was between 2006 and 2010 and was considered the worst ever in 100 years (Harmoon Center, 2017). The situation has only worsened with the decade-long conflict, resulting in widespread destruction of agricultural infrastructure and exacerbating food insecurity across the nation. Agriculture, being the largest consumer of water resources in Syria, has significantly exacerbated the country's water deficit. With approximately 87% of total water consumption attributed to agriculture, addressing inefficiencies in this sector becomes paramount to mitigating water scarcity and enhancing food security (OCHA, 2021).

Efforts to increase agricultural productivity through the adoption of modern irrigation techniques have shown promise, with studies indicating a potential doubling of productivity compared to traditional methods (Letey et al., 1990). Despite the availability of modern irrigation techniques that reduce 30% to 60% of water compared to traditional methods that have been in service for more than three decades, traditional irrigation methods are still widely used in Syria. Because of the war that began in 2011 and has not ended until now, it was difficult to conduct studies covering the entire Syrian geography. Therefore, the northern Aleppo region was chosen because of its security stability, especially with the Turkish support for the region from all sides, which had a great impact on the return of economic activities in general, especially agricultural, since the area is mainly an agricultural area. The region, known as the Euphrates Shield area, has witnessed a revitalization of agricultural activities following the 2016 military operation, facilitating the return of displaced populations and the reopening of trade routes with Türkiye. This area is considered one of the important agricultural areas in Syria, and it is socially and economically like the rest of the country. Therefore, the results of any study can be generalized to other regions. The most important factor in restoring economic activity in general and agricultural activity is the opening of the border gates with Türkiye and the return of commercial traffic in both directions, where there are three gates: Jarablus, Azaz and Al-Rai and thus the possibility of entering all agricultural inputs from Türkiye. Türkiye also allowed farmers in the Euphrates Shield area to export their products to Türkiye such as olive oil, cotton and potatoes. The task of disseminating innovations belongs primarily to the Agricultural Extension Agency, which is considered the link between research centers and farmers. However, according to the current Syrian situation, with the weakness of this agency, there are many agencies that work to disseminate innovations without coordination, in addition to the lack of studies and research that study the extent of farmers' acceptance or rejection for these innovations. The results of research conducted in the field of adopting innovative agricultural ideas and methods indicate that the farmer does not accept any new idea or innovative agricultural method as soon as he hears about it, as usually a period passes before, farmers try the new idea or method or accepts it, despite the economic benefits that will accrue to him of using it (Robertson, 2012). The theory of innovations by Rogers (1983) is considered one of the important theories for studying the causes of acceptance or rejection of new innovations by farmers. He also divided the stages of adoption into five stages: knowledge, persuasion, decision, implementation, and confirmation.

To increase farm productivity and profitability, grant support for the establishment of modern irrigation systems should be increased in a short term and all farmers should be informed about this support (Aydın

Eryılmaz et al., 2022). Abaci and Boz (2022) suggested that government incentives should be encouraged the use of the drip irrigation method by farmers due to the profitability returned from it. For this research, modern irrigation methods are considered one of the innovations that many studies have dealt with. Surya et al (2021) suggested that problems such as difficulty in maintaining, uneven terrain, and a lack of trust in micro irrigation system are the significant determinants of micro irrigation system adoption. Bijay et al (2018) investigated factors affect the intensity of the irrigation technologies which is the number of irrigation technologies adopted in cotton production, and found the irrigated cotton yield realized, land holding (total land owned), education and computer use were significant factors. Bayramoğlu and Ağızan (2018) used sequential probit regression analysis and found the land, the record net income, the agricultural income, the financial profitability, the education and the gross product were positive, the age of the manufacturer and the mark of the male labor unit (EIB) were negative in the process of adopting new irrigation methods. Wang et al (2016) found that obtaining information on irrigation technologies from individual farmers or farmers' associations, and extension agencies significantly influenced farmers' decisions to adopt improved irrigation technologies. Dinar and Yaron (1990) examined the effect of the quality and scarcity of inputs and found that the citrus growers who were quickest to adopt modern irrigation technologies were those with lower land quality and the highest rate of evaporation. Salazarand Rand (2016) studied the effect of production risks on the choice of type of irrigation technology among small farmers in Chile. They found that the higher the educational level of the farmers, with the ability to obtain credit, the presence of agricultural extension services, and living in an area where there are more adopters of modern irrigation techniques increases the likelihood of farmers adopting modern irrigation. Saeed et al. (2014) found that social factors, support provided to farmers, personal characteristics of farmers, as well as the influence of environmental factors were responsible for 55% of the total variance in the use of modern irrigation systems. However, there remains a dearth of research comprehensively analyzing these factors in the context of northern Aleppo.

Raising the efficiency of using the already scarce water resources is very important in order to increase the irrigated area, increase the productivity of crops and not deplete groundwater that will be through the application of modern irrigation methods and urging farmers to adopt them. Against this backdrop, this paper aims to investigate the socio-demographic and socio-economic characteristics of farmers in northern Aleppo and identify the determinants influencing their adoption of modern irrigation techniques. By addressing these objectives, the study seeks to inform policy interventions and agricultural extension efforts aimed at enhancing water efficiency and agricultural productivity in conflict-affected regions like northern Aleppo.

MATERIALS AND METHODS

Data collection for this study involved conducting personal interviews with farmers using a structured questionnaire designed to align with the research objectives. Three primary administrative areas were identified: Jarablus, Azaz, and Al-Ba. Villages where farmers relied solely on rainwater for irrigation were excluded. The estimated number of farmers in the selected eighteen villages was approximately 25,000. Utilizing the Krejci and Mörgan (1970) equation to determine the sample size with a confidence level of 5%, the calculated sample size was 210.

$$s = \frac{x^2 np(1-p)}{d^2(n-1) + x^2 p(1-p)}$$

Where s: Sample size; x^2: chi- square for the specified confidence level at 1 degree of freedom estimated (3.841); n: population size estimated; p: population proportion; d: The degree of accuracy is a fixed value that is estimated at (0.05). But in the period in which the data collected between the first of February to the third of March 2021 and because of the military actions in some villages facing combat fronts, 5 villages were excluded with the forms that some of them gathered, and the final number of villages settled on 13 villages and 210 surveys.

The sampling process aimed to ensure geographic diversity within the study area while capturing a representative sample of farmers engaged in irrigated agriculture. Face-to-face personal interviews conducted with the selected farmers provided valuable insights into their socio-demographic characteristics and factors influencing their adoption of modern irrigation techniques.

By employing rigorous sampling techniques and structured data collection methods, this study sought to generate robust findings reflective of the agricultural landscape in northern Aleppo. The resulting dataset served as a foundation for analyzing the determinants driving farmers' decisions regarding modern irrigation methods, thus contributing to the broader understanding of agricultural dynamics in conflict-affected regions.

This factor examines the irrigation methods employed by the sample population for crop irrigation, distinguishing between traditional methods such as floods and furrowing, and modern methods like sprinklers and drip irrigation. Analysis of the research questionnaire revealed that 42.85% of sampled individuals utilize at least one

modern irrigation method (either sprinklers or drip), while 57.14% do not employ any modern techniques. Data analysis for this study involved employing a combination of methods including frequency tables and descriptive statistics. Furthermore, the Chi-Square Test was applied to examine the relationships between categorical variables and determine whether observed frequencies significantly deviate from expected frequencies. This statistical test enabled the assessment of associations between variables such as irrigation methods and socio-demographic characteristics among the sampled farmers. This test will help in understanding the factors influencing farmers' adoption of modern irrigation techniques in the northern Aleppo region. The statistical software SPSS was utilized to conduct the analysis.

RESULTS AND DISCUSSIONS

Characteristics of farmers

According to the survey results, all members of the sample were male, with 91.42% of them being married. The average age of farmers was 46.75 years, with the largest percentage (48.1%) falling within the middle-aged group. Concerning family size, the average number of members per family was 6.42, with 44.8% of farmers belonging to the category of large families (more than 6 members). Regarding educational level, the average years of schooling for sample members was7.83. The majority of respondents (44.8%) had a pre-high school education, while 35% had completed high school, and 19.5% had pursued post-high school education. In terms of agricultural experience, the average years of experience among sample members was 19.6 years. Notably, 41.4% had over 20 years of experience, 38.1% had 11-20 years, and only 20.5% had less than 10 years of experience. Additionally, 43% of sample members had resided outside their area for more than a year, excluding the period of military service, which typically lasted two years, with much of it occurring away from the farm area.

Table 1. Main characteristics of farmers and farms

Demographic Features	**Frequency**	**%**	**Demographic Features**	**Frequency**	**%**
Gender			**Marital status**		
			Single	18	8.6
Male	210	100.0	Married	192	91.4
Age (Mean: 46.76; Std. Dev.: 10.67)			**Experience** (Mean:19.63; Std. Dev.: 9.42)		
≤ 40 years	68	32.4	≤10 years	43	20.5
41-55 years	101	48.1	11-20 years	80	38.1
>55 years	41	19.5	>20 years	87	41.4
Education			**Family size** (Mean:6.49; Std. Dev.: 1.79)		
Less than High school	94	44.8	<4	29	13.8
High school	75	35.7	4-6	87	41.4
University	41	19.5	>6	94	44.8
Land Ownership			**Residence outside the region**		
Owned by him	100	47.6	No	91	43.3
Not owned by him	110	52.4	Yes	119	56.7
Farm income groups			**Farm Size**		
Low income	143	68.1	<26 decares	64	30.5
Medium income	50	23.8	26-50 decares	78	37.1
High income	17	8.1	>50 decares	68	32.4
Non-farm income			**Source of Labor**		
No	130	61.9	Mostly family labor	62	29.5
Yes	80	38.1	Foreign wage labor	100	47.6
			Both of them	48	22.9
Price of inputs			**Getting loans**		
Cheap	35	16.7	Borrow	86	41.0
Expensive	175	83.3	Doesn't borrow	124	59.0
Total	210	100.0	Total	210	100.0

The average monthly income of farmers was $124.36 and the farmers were distributed into three categories according to income level as follows: 68.1% classified as low-income, 23.8% as middle-income, and 8.1% as high-income earners. Notably, only 38.9% of the sample reported having non-farm income from jobs, commerce, or service activities, while the majority (69.1%) relied solely on farm income. In the questionnaire, income and input and output prices were assessed in dollars due to the rapid depreciation of the Syrian currency, as farmers and business owners commonly evaluate goods and services based on the dollar. A significant proportion (83.3%) of respondents considered prices to be high and inappropriate, while 16.7% deemed them cheap and appropriate.

Regarding farm size, the average area of agricultural land for farmers was 48.58 decares and the largest percentage (37.1%) owned medium-sized farms ranging from 26 to 50 decares. Additionally, 47.6% of farmers owned their lands, while the remaining 52.4% did not own the lands they cultivated.

The research findings revealed that 47.6% of farmers primarily rely on external wage labor as their main source of workforce, whereas 29.5% predominantly depend on family members for farm work, surpassing the reliance on external wage labor. Additionally, 22.9% of farmers reported an equal distribution of labor between family members and external sources. Regarding financial support, regarding financial support, the study indicated that 41% of farmers acquire credit to finance their agricultural activities, while 59% do not obtain any type of credit at all.

Socio-demographic factors effects on the use of modern irrigation method

The researchers found that the process of technology transfer requires raising the ability of farmers to respond to these developments with the presence of the risk factor and these capabilities are related to his personal and social characteristics. Welch (1978) argues that the contribution of human capital to returns from agriculture could be attributed to allocative and worker ability. Table 2 shows the results of the Pearson chi-square test between the social characteristics of the sample members and the adoption of modern irrigation. For the age, $\chi^2 = 2.556$ and p= 0.633 which does not indicate to any significant relationship with the adoption of modern irrigation methods and it is the same result of Wang et al (2016) in Canada who found that age has no effects in the decision of using modern irrigation methods. Conversely, Bayramoglu and Ağızan (2018) found a negative correlation between farmers' age and the adoption of new irrigation techniques.

Table 2. Distribution of farmers who use and do not use modern irrigation methods according to their socio-demographic characteristics

Variable	Not use		Used		Chi-square (P-value)[+]
	Frequency	%	Frequency	%	
Age of farmers					
≤ 40 (young farmers)	40	58.8	28	41.2	2.556 (0,633)
41-55 (middle-aged)	54	53.5	47	46.5	
>55 (old farmers)	26	63.4	15	36.6	
Education level of farmers					
Less than High school	75	79.8	19	20.2	48.089*** (0,000)
High school	37	49.3	38	50.7	
University	8	19.5	33	80.5	
Experience of farmers					
< 11 years	17	39.5	26	60.5	1.283** (0,024)
11-20 years	52	65.0	28	35.0	
>20 years	51	58.6	36	41.4	
Family size					
<4	12	41.4	17	58.6	25.025*** (0,000)
4-6	37	42.5	50	57.5	
>6	71	75.5	23	24.5	
The residency outside the region					
No	70	58.8	49	41.2	1.629 (0,443)
Yes	50	54.9	41	45.1	

+: *,,*** :** Statistical significance at the 0.10, 0.05, and 0.01 levels of probability.

Educational attainment exhibited a noteworthy relationship with farmers' adoption of modern irrigation methods (χ^2 = 48.089, p = 0.000). This concurs with research by Salazar and Rand (2016) and Rossi et al. (2015), who found that higher levels of education increase the propensity for adopting modern irrigation practices.

The number of years practicing farming has significant association with the adoption of modern irrigation methods (χ^2 = 11.283, p = 0.024). Carrer (2015) found that the experience in citrus production increases the adoption of modern irrigation. Similarly, Alcon et al. (2011) identified years of experience as a crucial determinant in adoption decisions. Family size exhibited a significant relationship with the adoption of modern irrigation methods (χ^2 = 25.025, p = 0.000). Ogunniyi et al. (2018) found that family was one of the factors influencing the decision to use modern irrigation and the relationship between family size and adoption was inverse. The residence of the farmer out his area for a time more than one year and the adoption of modern irrigation methods have no significant relationship (χ^2 = 1.629, p = 0.443). Contrastingly, Salazar1 and Rand (2016) noted that living in an area where there are more adopters of modern irrigation techniques increases the likelihood of farmers adopting modern irrigation.

These insights underscore the multifaceted interplay between farmers' socio-demographic characteristics and their adoption of modern irrigation techniques, shedding light on avenues for targeted interventions and policy interventions to enhance technology adoption in agriculture.

Geographic factors effects on the use of modern irrigation method

Table 3 presents geographic factors effects on the adoption of modern irrigation method. The analysis revealed no significant relationship between the distance of the farm from the farmer's residence and the adoption of modern irrigation (χ^2 = 6.165; p = 0.187). However, for the land slope, the results showed a significant association between the land slope and the adoption of modern irrigation (χ^2 = 21.470; p= 0.000). This aligns with findings by Wang et al. (2016), who observed that the slope of the agricultural land hinders irrigation using traditional methods and pushes farmers to increase the efficiency of irrigation using modern methods. Cox et al (2018) further emphasized that soil erosion is impossible to avoid as the slope of the land exceeds 8%, it becomes difficult to irrigate by traditional methods.

Table 3. The effects of geographic factors on using modern irrigation method

Variable	Not use		Used		Chi-square (P-value) [+]
	Frequency	%	Frequency	%	
Distance from farmers' residence (km)					
≤ 2 (close)	86	60.6	56	39.4	6.165 (0,187)
3-4 (little farther)	28	51.9	26	48.1	
>4 (far)	6	42.9	8	57.1	
Land slope					
Fully flat	93	68.4	43	31.6	21.470*** (0,000)
Sloping	27	36.5	47	63.5	
Rain					
Little rain	47	62.7	28	37.3	1.646 (0,439)
Good rain	73	54.1	62	45.9	
Wind					
Weak	23	52.3	21	47.7	2.320 (0,313)
Strong	97	58.4	69	41.6	
Soil fertility					
Low	9	75.0	3	25.0	1.661 (0,436)
Good	111	56.1	87	43.9	
Distance from river or water bodies (Km)					
< 4 (close)	43	69.4	19	30.6	9.229** (0,056)
4-10 (little farther)	14	40.0	21	60.0	
>10 (far)	63	55.8	50	44.2	

+: *,,*** :** Statistical significance at the 0.10, 0.05, and 0.01 levels of probability.

Contrarily, Chi-square analysis showed no significant relationship between the rate of the rainfall and the adoption of modern irrigation (χ^2 = 1.646; p= 0.439). Nonetheless, Dessalegn (2005) highlighted rainfall as a critical factor in determining land irrigation decisions, while Daqduqa et al. (2013) noted that high rainfall rates, particularly on extensive holdings, can favor rainfed agriculture over irrigation. Although wind adversely affects

certain crops and undermines the efficacy of modern irrigation methods like sprinkler irrigation, our analysis found no significant relationship between wind and the adoption of modern irrigation (χ^2 = 2.320; p = 0.313). This contradicts Dhawan's (2002) assertion that wind significantly influences irrigation method selection (Table 3). Similarly, no significant association emerged between soil fertility and the adoption of modern irrigation (χ^2= 1.661; p = 0.436). However, Caswell et al. (1985) contended that modern technology tends to be adopted on lands with deeper wells and lower soil qualities compared to traditional technology.

Rivers, canals, and water bodies are easy, available, and low-cost sources, which are of great benefit to the agricultural lands nearby. Interestingly, a significant relationship surfaced between proximity to rivers or water bodies and the adoption of modern irrigation (χ^2 = 9.229; p = 0.056). This aligns with Badr's (2010) findings, suggesting that farmers who depend on rivers and irrigation canals to irrigate their crops are the least likely to adopt modern irrigation methods.

Socio-economic factors effects on the use of modern irrigation method

Table 4 presents the association between the socio-economic characteristics of farmers and the adoption of modern irrigation. The results indicate no significant association between the farm income and the adoption of modern irrigation (χ^2 = 3.821, p = 0.431). However, Bayramoglu and Ağızan (2018) and Rossi et al (2015) found that farmer income positively influences the decision to adopt modern irrigation methods. A significant relationship was observed between farm size and the adoption of modern irrigation (χ^2 = 24.752, p = 0.000). This aligns with findings from Van den Berg (2013), Panahi (2013), and Amankwah (2013), who concluded that larger farms are more inclined to adopt modern irrigation methods, with irrigated area being a significant factor in adoption decisions. Regarding land ownership, no significant association was found between land ownership type and the adoption of modern irrigation methods (χ^2 = 0.753, p = 0.686). However, Bijay et al. (2018) found that holding land effects positively the intensity of the irrigation technology adoption. It was found a significant association between the source of labor and the adoption of modern irrigation (χ^2 = 86.177, p = 0.000). Similar results were found by Amankwah (2013), indicating that farmers who pay higher labor costs tend to adopt formal (recommended) irrigation methods. Non-farm income did not show a significant relationship with the adoption of modern irrigation methods (χ^2 = 3.522, p = 0.172). Chi-square analysis revealed a significant relationship between attitudes towards the prices of modern irrigation equipment and adoption (χ^2 = 6.871, p = 0.032). Mahammad (1978) also found that the price of input was one of the most important factors affecting the adoption of innovations by farmers. Owning a tractor showed significant relationship with the adoption of modern irrigation (χ^2 = 4.735, p = 0.094). Binswanger (1978) reviewed several studies about the adoption of tractors in Asian countries and concluded that farm size and the adoption of tractors were always related positively and significantly.

Analysis showed no significant relationship between owning animals and the adoption of modern irrigation (χ^2 = 2.143, p = 0.343). Similarly, no significant relationship was found between accessing loans and adoption (χ^2 = 4.185, p = 0.123), although Ogunniyi et al. (2018) identified access to credit as a factor influencing modern irrigation adoption. Salazar and Rand (2016) also emphasized the positive impact of credit availability on farmers' likelihood to adopt modern irrigation methods.

CONCLUSSION AND RECOMENDATIONS

The objective of this study was to examine the effects of various demographic, geographic, and economic factors on farmers' use of modern irrigation methods in the northern Aleppo region. To determine if there were significant differences between farmers who used modern irrigation methods and those who did not, a chi-square test of independence was conducted. The results indicated that a higher level of education, more years of experience in agriculture, and a smaller number of family members were associated with a greater likelihood of using modern irrigation methods. In order to promote the adoption of modern irrigation techniques, it is crucial for authorities to raise awareness among farmers about the importance and benefits of these methods through various agricultural extension approaches. Additionally, farmers with higher levels of education and more experience in agriculture can serve as role models and positively influence their peers. The findings related to geographical characteristics revealed a significant correlation between the use of modern irrigation methods and both the slope of the land and its proximity to surface water sources. It can be inferred that these factors themselves motivate farmers to adopt modern irrigation methods, due to the challenges posed by traditional irrigation on sloping land and the limited availability of water sources. Furthermore, our study identified several socio-economic factors that significantly influenced farmers' increased utilization of modern irrigation methods, including larger farm size, reliance on external labor, ownership of agricultural tractors, and the perception of affordable prices for agricultural inputs. Considering high input prices as a factor influencing

the use of modern irrigation was met with a lack of impact on financing due to the weakness of this sector. Encouraging farmers to adopt modern irrigation techniques necessitates ensuring the availability of modern irrigation supplies and components in the market at reasonable prices and with good quality. Additionally, facilitating access to loans specifically for modern irrigation purposes, with simplified requirements, can greatly contribute to increasing the adoption of modern irrigation practices.

Table 4. The effects of Socio-Economic factors on using modern irrigation method

Variable	Not use		Used		Chi-square (P-value) [+]
	Frequency	%	Frequency	%	
Farm income group					
Low income	80	55.9	63	44.1	3.821 (0,431)
Medium income	33	66.0	17	34.0	
High income	7	41.2	10	58.8	
Farm size group					
<26 decares	42	65.6	22	34.4	24.752*** (0,000)
26-50 decares	51	65.4	27	34.6	
>50 decares	27	39.7	41	60.3	
Landownership					
Not owned (rent or public land)	59	59.0	41	41.0	0.753 (0,686)
Property land	61	55.5	49	44.5	
Source of labor					
Mostly family labor	56	90.3	6	9.7	86.187*** (0,000)
Mostly waged labor	24	24.0	76	76.0	
Both family and waged labor	40	83.3	8	16.7	
Nonfarm income					
No	79	60.8	51	39.2	3.522 (0.172)
Yes	41	51.2	39	48.8	
The attitude on the prices of modern irrigation equipment					
Cheap	13	37.1	22	62.9	6.871*** (0,032)
Expensive	107	61.1	68	38.9	
Tractor ownership					
No	68	64.2	38	35.8	4.735** (0,094)
Yes	52	50.0	52	50.0	
Having animals					
No	43	52.4	39	47.6	1.143 (0,343)
Yes	77	60.2	51	39.8	
Getting loans					
No	66	53.2	58	46.8	4.185 (0,123)
Yes	54	62.8	32	37.2	

+: *,,*** :** Statistical significance at the 0.10, 0.05, and 0.01 levels of probability.

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