Smallholder Farmers' Willingness to Pay for Improved Access to Irrigation Water Supply in Egypt: A Contingent Valuation Approach

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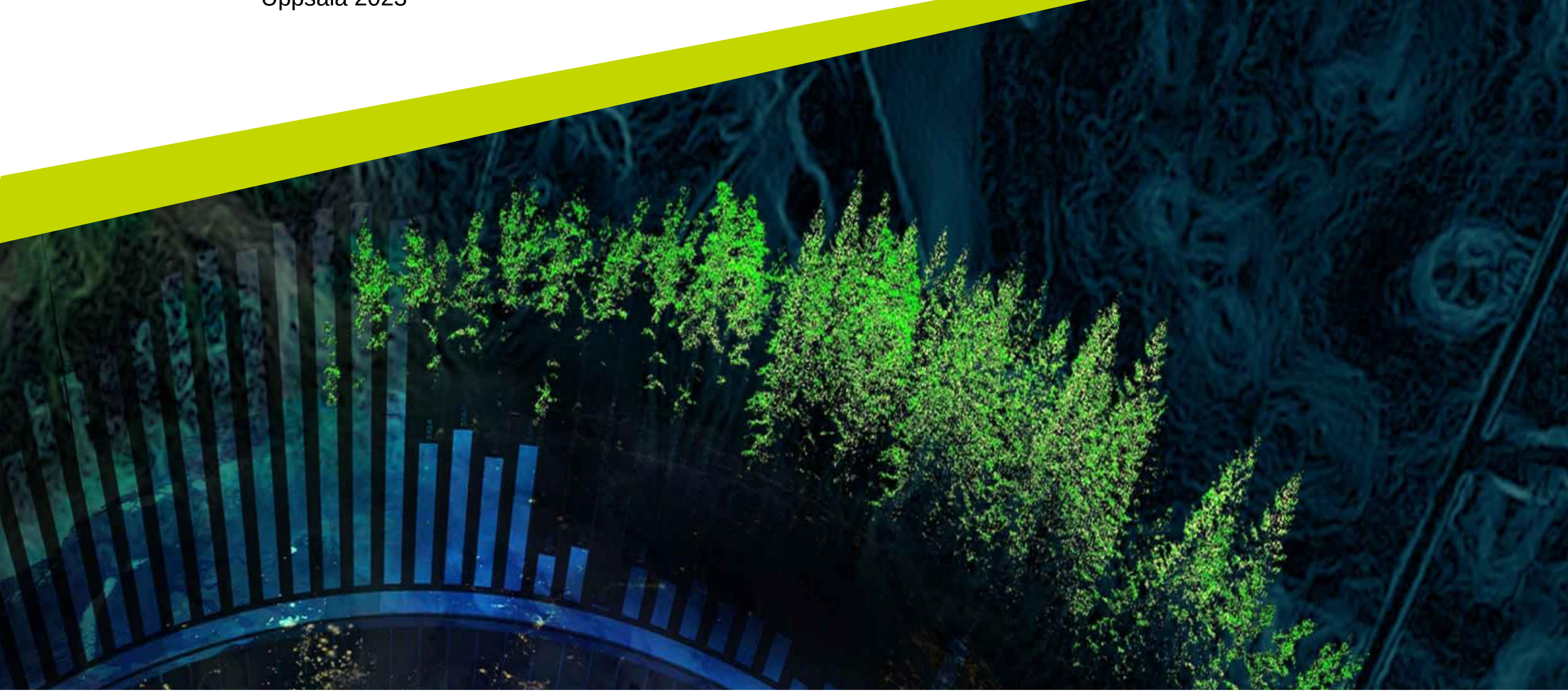

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Abstract

The agriculture sector in Egypt is heavily dependent on the River Nile's water. However, the country is facing a severe water scarcity problem, affecting crop yields, farmers' income, food security, and the environment. To address this issue, recent irrigation projects require farmers to contribute financially to enhance the financial sustainability of the projects, improve water management practices, distribute the benefits more equitably, and increase the efficiency of water use. This study examined smallholder farmers' willingness to pay (WTP) for improved access to irrigation water supply, which has not been studied before in Egypt. A survey of 313 smallholder farmers was conducted using a double-bounded dichotomous choice contingent valuation method in the Nile Delta region's Fayoum province. The interval regression model was used to estimate the determinants of farmers' WTP and their mean WTP. The results indicated that farmers are willing to pay a significant amount of around 1230 Egyptian pounds (409 SEK) per feddan (roughly 0.42 hectares) per year for improved irrigation water supply. Factors such as attitudes towards improved irrigation supply, efficient irrigation practices and adoption of new technologies, and average income from agriculture have a significant positive influence on WTP. On the other hand, access to loans has a significant negative impact on WTP. The results have substantial implications for policymakers and other stakeholders as they provide a better understanding of the smallholder farmers' behavior, who play an important role in water use and agriculture production in Egypt. Furthermore, it offers realistic estimates to design and implement well-structured water pricing in the country.

Keywords: contingent valuation, double-bounded, interval model, willingness to pay, irrigation water supply, attitude, agriculture income, access to loans

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Abbreviations

CVM	Contingent Valuation Method
DBDC	Double-Bounded Dichotomous Choice
EGP	Egyptian Pound
EFA	Exploratory Factor Analysis
FAO	Food and Agriculture Organization
KMO	Kaiser-Meyer-Olkin
NAI	Nordic Africa Institute
WTP	Willingness to Pay

1. Introduction

The study addresses a significant economic problem arising from the prevailing water scarcity, with a particular focus on irrigation water resources. Consequently, it recognizes the crucial role played by farmers in the irrigation water projects and the importance of their active participation in addressing this issue. In developing countries, growing water scarcity is increasingly becoming one of the prominent challenges for achieving sustainable development goals (FAO 2018). Around four billion people - or two-thirds of the global population - face water scarcity for at least one month per year, while half a billion-face severe water scarcity throughout the year (Mekonnen & Hoekstra 2016; Thomas et al. 2023). This challenge is expected to become even more urgent as the global population continues to grow, living standards improve, dietary patterns shift, and the impacts of climate change intensify (Wang et al. 2017).

Agriculture, being the largest consumer of water (approximately 80% of water consumption globally), is heavily impacted by water scarcity (Halli et al. 2022). With limited access to freshwater resources and growing demand for food due to population growth, developing countries face a delicate balancing act. Insufficient water availability hampers irrigation systems, resulting in crop failures, reduced crop yields, livestock productivity, limited diversification of agricultural practices, and increased vulnerability to droughts and other climate-related risks (FAO 2017a). The consequences are dire, as many communities in developing countries rely on agriculture for their livelihoods and sustenance (Dethier & Effenberger 2012). Therefore, growing water scarcity threatens to exacerbate food insecurity, as inadequate access to water for irrigation and farming activities disrupts food production and availability, driving up food prices and limiting access to nutritious food for vulnerable populations (Tilleard et al. 2023). Addressing water scarcity in developing countries is crucial for safeguarding agricultural production, enhancing food security, and supporting the overall well-being of communities in these regions.

Over the past few decades, most water-stressed developing countries have undertaken significant efforts to implement irrigation water projects to modernize irrigation systems and improve farmers' access to reliable and improved irrigation water supply (FAO 2017b). Recognizing the vital role of irrigation in enhancing agricultural productivity and addressing the challenges of food production and food security, these countries have invested in infrastructure development, such as the construction of irrigation canals, reservoirs, pumping systems, and water-saving technologies. These projects have sought to mitigate the adverse effects of water scarcity and erratic rainfall patterns, providing farmers with a more dependable water source for irrigation. By expanding access to irrigation water, these initiatives have facilitated increased agricultural production, improved crop yields, and enhanced the overall food security of these nations. Moreover, such projects have helped to stabilize and diversify agricultural activities, reducing farmers' vulnerability to climate-related risks and promoting sustainable agricultural practices.

Nevertheless, the implementation of irrigation water projects by developing countries' governments and their development partners has had mixed success in addressing the challenges of water scarcity and improving agricultural productivity (Rosegrant et al. 2021; Merrey et al. 2020; Merrey & Lefore 2018). One of the key reasons for this limited success has been the historical lack of participatory approaches in designing and implementing these projects. In many cases, the beneficiaries of these projects, mainly farmers, were not adequately involved in decision-making processes, resulting in a lack of ownership and commitment from the farming communities (Bathla et al. 2021). Consequently, the sustainability and successful operation of these irrigation systems became a challenge, as maintenance and proper operation often required active engagement and cooperation from the farmers. However, in recent years, there has been a growing recognition among governments and development partners of the need to involve farmers in the design and implementation of irrigation water projects (Muiruri 2017; Swamy 2019; Cech 2018). This shift in approach emphasizes the importance of participatory decision-making, where farmers are actively engaged in the planning, implementation, and management of these projects (Toan 2016; Upadhyaya et al. 2022; Hagos et al. 2022). By involving farmers from the outset, their knowledge and expertise can be tapped into, ensuring that the irrigation systems are designed to meet their specific needs and challenges. Furthermore, there is an increasing understanding that financial contributions from farmers toward the implementation and maintenance of these projects are crucial. By sharing the costs, farmers have a vested interest in the long-term success of the irrigation systems and are more likely to participate actively in their upkeep (Al-Rubaye 2019). This approach not only ensures the sustainability of the projects but also promotes a sense of ownership and responsibility among the farming communities (Lika et al. 2017; Dhakal et al. 2018).

From a literature perspective, the issue of cost recovery for irrigation water projects in developing countries poses a significant challenge, as farmers often show reluctance to pay for these services. Several reasons may contribute to farmers' resistance to financial contributions. First, the majority of developing countries' farmers are small-scale and resource-constrained, struggling to make ends meet with limited incomes. As a result, they may perceive additional financial burdens as unaffordable and burdensome, particularly when their immediate needs for inputs like seeds, fertilizers, and equipment remain unmet. Second, there is a lack of trust and transparency in the management and governance of irrigation water projects. Farmers may have concerns about the misuse or misallocation of funds, corruption, or inadequate service delivery. The absence of mechanisms for farmers to provide input or oversight in project planning and decision-making further exacerbates these concerns and hampers their willingness to contribute financially. Moreover, the perceived inequity in cost sharing can also discourage farmers from participating in cost recovery efforts. Farmers with small landholdings may feel that their financial contributions would disproportionately burden them compared to larger landholders who may benefit more from the irrigation infrastructure. This perception of unfairness undermines the sense of collective responsibility and cooperation necessary for successful cost recovery. Additionally, farmers may question the effectiveness and sustainability of the irrigation water projects. If they have experienced previous instances of project failure or lack of maintenance, they may be skeptical about the long-term benefits and hesitate to invest their limited resources. Therefore, addressing these concerns is crucial for creating an enabling environment that addresses farmers' financial constraints, ensures equity in cost-sharing, and demonstrates the tangible and sustainable benefits of the projects is critical in gaining farmers' trust and cooperation in cost recovery efforts.

The above-highlighted water scarcity issues and their consequences on agriculture are particularly pertinent to developing countries confronted with severe water scarcity due to inadequate water resource management and sustainable irrigation systems, such as Egypt (Myers 1989; Abdelhafez et al. 2020). The primary water source for Egypt is the River Nile, which supplies approximately 97% of the freshwater. This vital resource is primarily allocated to irrigated soils in the Nile Valley and Nile Delta (Osman et al. 2016), where agriculture consumes around 81.6% of the water resources. Unfortunately, a significant amount of water (50%-70%) is wasted through transportation, evaporation, and conventional irrigation (Moursy et al. 2023). Despite the challenges, Egypt continues prioritizing agriculture by allocating massive withdrawals to irrigation (Khadra & Sagardoy 2019). In the coming years, water scarcity is expected to intensify due to a projected increase in future demand, combined with the absence of alternative water resources in the country (Abdelhafez et al. 2020).

Moreover, since the late seventies, Egypt has recognized the significance of farmers' role in water resource management, promoting the designing of policies prioritizing their active participation (Allam 2004). Likewise, it has been extensively acknowledged that the participation of water users could play a significant role in the success of any project targeting water resource management (Abou-Hadid 2006). As discussed above, the farmers are found to be more willing to pay if they get involved in the project's decision-making, operation, and maintenance processes (Easter & Liu 2005; Abu-Zeid 2001;Tarimo et al. 1998). In essence, farmers' participation, demonstrated through their willingness to pay (WTP), provides both the financial stability and sustainability of irrigation projects. In literature, several empirical studies investigated WTP for irrigation water and its determinants in various countries. In the African context, extensive research has been done in Ethiopia (Getnet et al. 2022; Mekonnen et al. 2020; Alemayehu 2014), Kenya (Omondi et al. 2014), Uganda (Angella et al. 2014), and a few others. It is surprising that, uptill now, no research has been conducted in Egypt despite the water scarcity challenges and the urgent requirement for farmers' active participation in addressing them. To address this research gap, the present study aims to estimate the farmers' WTP and investigate the factors that influence farmers' WTP for improved access to irrigation water supply in Egypt. The research findings will be helpful for the policymakers and other relevant stakeholders in the region, facilitating a better understanding of the farmers' behavior and their decision-making processes and supporting the implementation of water pricing to improve water resource management.

The remaining sections of the paper are organized as follows. Section two provides a comprehensive literature review on the valuation of non-market goods and irrigation. Section three introduces the conceptual framework for determining the factors influencing farmers' WTP for irrigation water supply. Section four provides the details of the methodology, including information on the study area, data design, data collection method, variable descriptions, and theoretical and empirical models. Section five presents the results of the analysis. Section six further discusses the results and concludes the study. Finally, the last section offers policy implications derived from the research.

2. Literature Review and Conceptual Framework

The development of water pricing has been given the highest priority as an efficient instrument for water management (Bjornlund & McKay 1998), and its implementation is reflected as an encouraging tool not only for the efficient use of water resources but also for cost recovery (Gebretsadik & Romstad 2020). Pricing also helps correct maladministration and inefficient irrigation resource allocation (Tiwari 1998). Despite efforts to do so, it is still challenging to determine the correct price of the water. Because farmers often perceive water as a public good, they tend to reject the idea of treating water as a commodity. As water is supplied from public irrigation systems, common-pool resources generate non-marketed use value for all users. Another underlying assumption by Biswas & Venkatachalam (2015) is that the limited historical payment by farmers in the past implies their reluctance to pay for water in the future. However, the concept of treating water as an economic good stems from the fundamental principles of Economics, which involve making decisions on how to allocate scarce resources to meet present and future needs (Samuelson & Nordhaus 1985). In recent decades, there has been a growing recognition in the literature that water should be treated as an economic good. This notion was further solidified by the International Conference on Water and Environment in Dublin, Ireland (ICWE 1992), which emphasized the economic value of water in all its uses and called for its recognition as an economic good "Water has an economic value in all its uses and should be recognized as an economic good."

The recognition that irrigation water is considered an economic good, yet lacks a market price, poses challenges, particularly in developing countries, where setting water prices in the absence of water markets is complex. Consequently, non-market valuation techniques can be employed to assess the value of water in such cases (Young 2005). One widely used non-market valuation method is the contingent valuation method (CVM), which has been employed for over three decades for estimating cost recovery, enhancing the efficient allocation of resources, and determining the economic value of a resource (Hanemann 2006; Young & Loomis 2014; Mitchell & Carson 1989). In the CVM, a direct survey is conducted using structured questions to ask participants, such as farmers, to assign a value to a hypothetical good or service, such as irrigation water. The respondents consider their related assumptions and report the economic value of the specific good, which represents and reflects their WTP (Carson 2012). As such, the WTP represents the maximum amount of income a person would pay in exchange for access to a specific good (Haab and McConnell 2002).

Within CVM, several methods exist to elicit WTP, including iterative bidding, payment cards, open-ended, and dichotomous choice. Among all these forms, the dichotomous choice elicitation format is becoming more popular due to its proximity to reality, like our day-to-day market decisions where people usually buy or reject to buy based on the proposed price (Merino-Castello 2003; Hoehn 1987). Due to its straightforward yes or no format, the respondents are not required to think much before answering, and they can elicit the actual value of the good more accurately. The dichotomous CVM has two variations: single-bounded, with only one question, and double-bounded, with an initial question followed by a subsequent one. Hanemann et al. (1991) developed the double-bounded CVM, which is more efficient in improving the accuracy of WTP estimates.

Building upon the existing literature, Figure 1 presents the conceptual framework that guides the economic valuation of irrigation water. This framework specifically aims to investigate the factors that influence farmers' WTP for irrigation water, thereby providing a comprehensive understanding for the analysis.

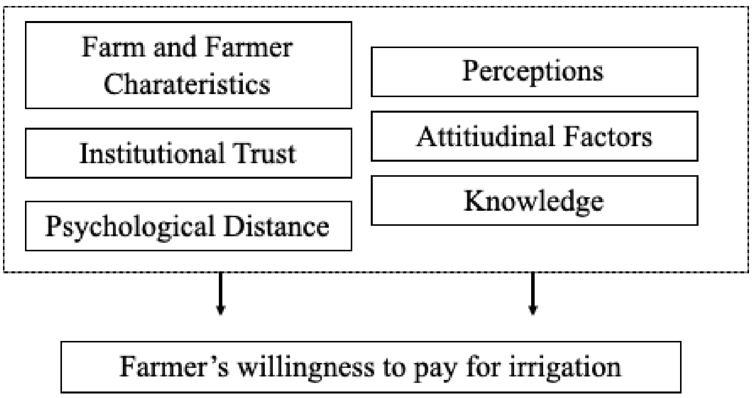

Figure 1. Conceptual framework

2.1 Farmer and farm characteristics

Studies have explored many farmers' characteristics that significantly influence their WTP for irrigation water, including farmers' age, household size, education, and farming experience. Regarding farmers' age, it has been observed to negatively influence their WTP, indicating that as farmers grow older, their WTP tends to decline. A study conducted by Mesa-Jurado et al. (2012) reported similar results, demonstrating that younger people are more concerned about the future availability of agricultural resources such as water, and display a higher WTP than older people. Conversely, the farmer's education level has been found to influence their WTP positively. Mesa-Jurado et al. (2012) and Mu et al. (2019) indicated that the higher-education respondents are more willing to pay. Theoretically, people with higher levels of education are expected to understand better than those with lower education (Halkos & Matsiori 2012), such as understanding irrigation water scarcity issues and the long-term benefits of improved irrigation water supply. On the other hand, the farming experience of the farmers has been observed to influence their WTP negatively. Existing literature supports the notion that as farmers gain more experience, they tend to approach retirement and exhibit a reduced WTP. Additionally, long-standing entitlement to irrigation water led to a reluctance to purchase water, causing WTP to decline over years of farming experience (Knapp et al. 2018). Regarding household size, Tang et al. (2013) found that household size negatively influences farmers' WTP, indicating that larger families are willing to pay less for irrigation water. One possible explanation for this finding is that larger families may tend to be more involved in non-agricultural activities, which could reduce their dependency on agriculture and the need for irrigation water. Contrary to this, a few studies have found a positive impact of household size on WTP. This perspective suggests that larger families anticipate that outcome (income or production) obtained from irrigated agriculture can support their large family (Alemayehu 2014; Mesa-Jurado et al. 2012).

Moreover, farmers' total income, share of agriculture income, and access to loans have also emerged as determinants of their WTP. Income, in particular, has been found to positively influence farmers' WTP, aligning with basic economic theory (Tang et al. 2013; Arouna et al. 2012). In addition, the share of agriculture income is an essential determinant of WTP. A study by Toshisuke & Hiroshi (2008) compared the WTP for rural and urban users in Japan and found that rural consumers are more willing to pay as they rely on water for their agricultural income. Another study from the semi-arid region of India provides evidence that farmers acknowledge the agricultural benefits of an improved irrigation water supply; therefore, they are willing to pay higher (Biswas & Venkatachalam 2015). This suggests that people with a higher dependency on income from agriculture are willing to pay more (Bakopoulou et al. 2010). Lastly, farmers' access to loans also positively influences their WTP (Omondi et al. 2014). Angella et al. (2014) reported similar findings, suggesting that loans enable farmers to generate higher income (from investing in different businesses), thereby enhancing their capacity to pay for irrigation water. Also, sometimes they can allocate their loan to agriculture (by eliciting higher WTP), expecting higher returns.

When considering farm characteristics, several factors significantly impact farmers' WTP, including farm size, type of irrigation water, and distance to the main irrigation channel. When examining the impact of farm size on WTP, the existing literature provides evidence for both negative and positive relationships. Angella et al. (2014) reported a positive impact, suggesting that larger farm size depicts greater overall financial capacity, leading to a positive WTP. Tey & Brindal (2012) also wrote that larger farms have more capacity to absorb costs and risks. In contrast with these results, Alemayehu (2014) provided a negative impact of farm size on WTP, suggesting that larger farms generate sufficient output from multiple crops, which reduces the importance of irrigation water for them. The type of irrigation water is another important determinant and has been found to impact WTP positively. For instance, when farmers heavily rely on groundwater, they show a positive willingness to pay to improve groundwater resources. Knapp et al. (2018) analyzed the farmers' WTP for off-farm surface water under decreasing groundwater resources in the Mississippi Delta region of the United States. They found that the farmers in this region have the highest WTP. These findings suggest farmers' dependency on surface water leads to higher WTP. Lastly, the distance from the irrigation channel has been found to influence farmers' WTP negatively (Kiprop et al. 2017).

2.2 Behavioral and psychological characteristics

In terms of behavioral characteristics, the literature provides evidence for the multiple factors that influence farmers' WTP. One particular focus is how farmers' knowledge and perceptions shape their WTP. For instance, Aydogdu & Bilgic (2016) conducted a study in GAP-Harran Plain, Turkey, investigating farmers' WTP for efficient irrigation and improved water productivity. They developed an index to measure farmers' knowledge and perceptions regarding natural resources and their future availability. Unexpectedly, they found a significant negative correlation between farmers' WTP and their knowledge and perceptions. This result is primarily attributed to the lower levels of education among farmers. Additionally, the farmers tended to only consider the upcoming year for planning purposes, hindering their ability to anticipate future needs adequately. Moreover, in that particular region, perceptions about the source of irrigation water were another reason. As they relied on the Ataturk dam (the 6th largest dam in the world) for their irrigation needs, they perceived it as a stable and reliable water source despite ongoing water challenges. Contrary to that, few studies complemented the literature with the positive influence of knowledge and perceptions on WTP. A study by Khan & Damalas (2015), who studied WTP for less health risk by pesticide use in agriculture, found that farmers with the highest risk perceptions have the highest WTP, which is again linked to their level of education. With respect to knowledge, a study by Mu et al. (2019) estimated farmers' WTP for irrigation water under water price reforms and concluded that the farmers with more knowledge and awareness of the water price reforms depicted a higher WTP. Another study supported this notion, focusing on the WTP for treating wastewater in irrigation (Deh-Haghi et al. 2020). Providing knowledge in an appropriate manner has the potential to influence the farmers' WTP positively (Aydogdu 2016).

Another aspect of interest is the influence of farmers' attitudes on their WTP, considering that attitude plays a crucial role in shaping human behavior (Gorton et al. 2008). A study conducted by Whittington et al. (1990) focused on estimating the WTP for water services in developing countries, specifically in Southern Haiti. It demonstrated the attitude of the respondents toward improved rural water supply is positively related with their WTP. Generally, the farmers are greatly affected by the unequal distribution of water supply and exhibit a positive attitude (Lasram et al. 2018). Another study focused on farmers' attitudes towards water user associates and found that it is positively and significantly related to WTP (Aydogdu 2016). Additionally, institutional trust is an important factor in analyzing WTP. Institutional trust refers to the degree of confidence that communities place in institutions responsible for governing natural resources (Beierle & Cayford 2002). In theory, institutional trust is expected to have a substantial impact on WTP (Jones et al. 2015). As farmers' trust increases in an institution, their WTP also tends to increase. A study by (Speelman et al. 2010) analyzed the WTP of smallholder irrigators in relation to changes in water rights systems. They found that lower institutional trust is associated with lower WTP. These findings hold significant value in guiding policymakers.

Furthermore, psychological distance was introduced to the conceptual framework as it is an influencing factor in environmental behaviors (Cheng et al. 2022). According to Trope and Liberman (2010), psychological distance refers to the actual distance (social, temporal, geographical, spatial) between an individual and an object or can be explained by how likely an event /object is likely to exist. When people think that the object is psychologically distant from an individual, they think more abstractly – looking at the bigger picture – and if they think the object is psychologically closer than they are thinking concretely – focus on the specific details. Moreover, Cheng et al. (2022) found that a shorter psychological distance was found to be associated with higher WTP.

3. Data and Methods

3.1 Study area

The Fayoum Governorate is located in the lower region of the Western Desert in Egypt, with a population of around 3.6 million (CAPMAS 2017). Fayoum governate is famous for growing fruits such as grapes, figs, and mangoes. Traditional crops, including wheat, cotton, rice, corn, sugarbeet, and sunflower, are also grown there. With a total irrigated area of 178,500 hectares, only about 10% of the land in Fayoum is owned by the government, while the remaining 90% is owned by farmers (CAPMAS 2019). The governate's agriculture and irrigation system heavily depends on the River Nile's surface water (Zaky et al. 2022). The governorate faces many water management challenges arising from increased demand for water and competition between agriculture, municipal, and industrial sectors over declining water resources. These factors, combined with illegal practices by farmers and inadequate infrastructure, contribute to the deterioration of water resource management (Abdelhaleem et al. 2021). At the same time, some areas suffer from extreme water shortages, especially at the ends of the canals (Ahmed 2023).

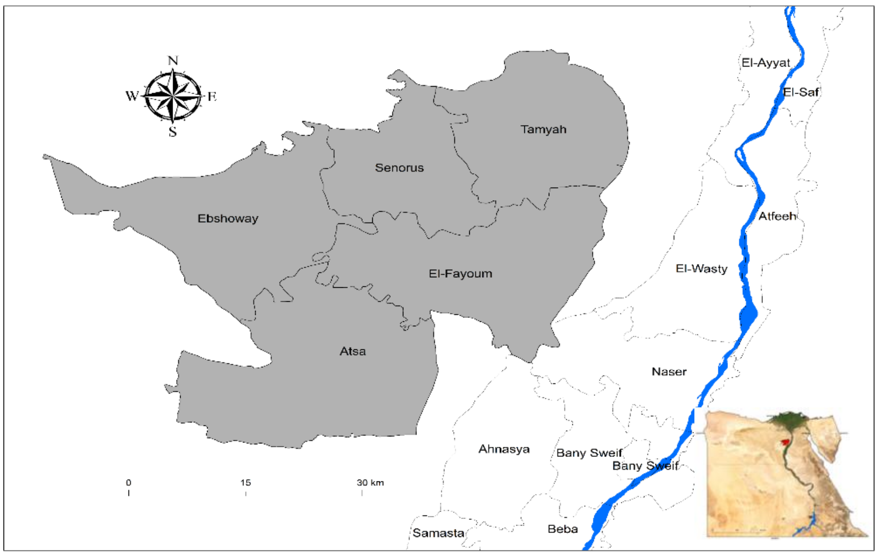

Figure 2. El-Fayoum Governate map

3.2 Survey design and data collection

This study interviewed a representative sample of 313 farmers in El-Fayoum Governate, Egypt. The survey was conducted in November-December 2022. Face-to-face interviews were conducted during data collection using a structured questionnaire with open and closed-ended questions. The questionnaire comprehensively captured all the essential information about farmers and their farm and irrigation system, including behavioral and psychological characteristics such as farmers' attitudes, perceptions, knowledge, institutional trust, and psychological distance. Finally, the farmers' WTP was assessed using the CVM.

3.2.1 The Contingent valuation method

The survey employed the double-bounded dichotomous choice (DBDC) elicitation format to estimate WTP, with an initial question followed by a subsequent one (Hanemann et al. 1991). Although widely applied, CVM encounters several biases. The four potential biases are hypothetical bias, starting point bias, strategic bias, and information bias (Tietenberg & Lewis 2018). A well-designed survey was implemented to minimize these biases (Tentes & Damigos 2012). Since the nature of the improvement being studied is hypothetical, it can attract a hypothetical bias (Venkatachalam 2004). To address this 'familiarity issue' approach was used (Mitchell & Carson 1989), suggesting that respondents who are more familiar with the good or service are likely to exhibit less hypothetical bias. All the participants in this study are farmers who are familiar with the presented scenario. Starting point bias occurs when the respondents' WTP amount is influenced by the initial bid value given in the scenario, leading them to accept or reject it without much thought. In order to minimize the starting point bias, the survey was created in four different versions, each with a distinct starting bid value (Whittington et al. 1990). These bid values were also assigned randomly among the respondents (Mitchell & Carson 1989). In brief, strategic bias may occur when the respondents attempt to free-ride, and information bias may arise when respondents lack experience with the scenario presented (Tietenberg & Lewis 2018). To overcome strategic bias, the elicitation format proved advantageous by stimulating day-to-day market decisions and requiring respondents to answer only yes and no (Loomis 1987). Lastly, to minimize information bias, the survey was carefully designed to provide information about the study before the actual data was collected. Moreover, there was active supervision during data collection. (Gunatilake et al. 2007). Hence, using a structured questionnaire, randomly assigned initial bid values, selecting respondents with prior knowledge about the hypothetical scenario, and encouraging respondents to express their true WTP can avoid most of the biases (Bateman et al. 2008). Overall, this dichotomous CVM format effectively minimizes many of the biases encountered in the survey (Cameron & Quiggin 1994). Hanemann (1994) further emphasized that the dichotomous format can eliminate certain biases that appear in the open format as it offers a logical structure for estimating the WTP.

The hypothetical scenario

Using up-to-date contingent valuation methodology, the farmers were offered a hypothetical scenario of improved access to irrigation water supply with the budget remainder (Ghosh et al. 2017).

The scenario in the survey is summarized as follows:

"In Fayoum, the regional government plans to construct a new irrigation scheme that would benefit the village by improving their access to irrigation water. The irrigation scheme would provide all the farmers with equal rights to use irrigation water regardless of the location of the farmland. This project has the capacity to benefit more than 66,000 households/irrigate about 400,000 feddans (168,000 hectares) of agricultural land, and the irrigation water would be available for around 30 years. The financial capacity of the regional government is limited; therefore, every farmer should share the cost of this project considering their landholdings, which will subsequently increase the irrigation water bill. It would be obligatory for the farmers to pay the water bill annually. Considering the governorate's situation, this is the only project that would provide the village with enough irrigation water; otherwise, they would experience severe water scarcity for irrigation.

Therefore, the government is considering a set surcharge for all farmers in the village.

1. If implemented, these extra funds will exclusively finance the construction of this irrigation water project in the village.
2. The government has full authority to revise the contribution of farmers to implement this irrigation water project in the village.

When you decide the amount, it is crucial to consider your income limit.

1. Sometimes people say they are willing to pay a different amount than they actually would pay because they miscalculate the real impact on their household budget.
2. Consider that your contribution may reduce your available income to buy farm inputs or to spend on your household.
3. You may also wish to adjust your budget based on what you expect your economic situation to be after COVID-19."

Bid design

Since the bid is designed using a DBDC elicitation format, which involves a 'follow-up bid' to the 'initial bid' whose value depends on the response of the initial bid (Hanemann, 1984). Six bid levels (500, 800, 1200, 1500, 1750, 2000) in EGP (Egyptian Pound) were used in four different questionnaire versions.

As an example, the initial bid question in the study is phrased as:

Are you willing to pay if the surcharge is 800 EGP per annum?

Yes ( ) No ( )

Depending on the response to an initial bid, the farmer was asked for a follow-up bid that was either lower or higher than the initial bid (Haab & McConnell, 2002).

If the answer to the initial bid is yes, the follow-up question was phrased as:

Are you willing to pay 1200 EGP per annum?

Yes ( ) No ( )

Initially, if the farmer answered yes to the initial bid of 800 EGP, the follow-up bid was higher, i.e., 1200.

If the response to the initial bid is no, the follow-up question was phrased as:

Are you willing to pay 500 EGP per annum?

Yes ( ) No ( )

Similarly, if the farmer answered no to the initial bid of 800 EGP, the follow-up bid was lower, i.e., 500.

Table 1 summarizes the bid design with an initial bid and a follow-up bid for the four questionnaire versions.

Table 1. Bid design

Bid Sets	Initial Bid ($\boldsymbol{V^i}$)	Lower follow-up bid ($\boldsymbol{V^l}$)	Higher follow-up bid ($\boldsymbol{V^h}$)
S1	800	500	1200
S2	1200	800	1500
S3	1500	1200	1750
S4	1750	1500	2000

Bid values in EGP (Egyptian Pound)
During the survey period EGP 3.00 ≈ 1 Swedish SEK

During the survey, it was made clear to the farmers that after their response to the initial bid, the follow-up bid replaces the initial bid, just in case to make clear that the amount of the follow-up bid would not add to the amount of the initial bid. They were also informed that no further alternatives would be provided after the follow-up question.

3.2.2 Description of the variables

Table 2 presents the description of the variables collected during the survey. The dependent variables include the initial bid value and follow-up bid value. The independent variables include farmer and farm characteristics, information regarding irrigation systems, and other behavioral and psychological attributes of the farmers.

Table 2. Description of the variables

Variable	Description	Type
Dependent Variables		
BID1	Initial bid value	Continuous, (800 - 1750)
BID2	Follow-up bid value, continuous	Continuous - (500 - 2000)
Independent Variables		
AGE	Age of the farmer (years)	Continuous
HSIZE	Household size (members)	Continuous
FS	Farm Size (kirats)*	Continuous
DIS	Distance from the main irrigation channel (meters)	Continuous
OFF	Off-farm job	Binary (1=yes - 0=No)
LOAN	Access to loan	Binary (1=yes - 0=No)
EDU	Education of the farmer	Categorical (1=No formal schooling - 6 =MS/PhD)
EXP	Farming experience	Categorical (1=less than 5 years - 4=more than 15 years)
HINC	Total household income	Categorical (1=less than 1200 EGP/month - 7=greater than 6000)
AGRI_INC	Agriculture income	Categorical (1=just a small part - 5=all)
TYP	Type of irrigation water	Categorical (1=surface water - 4=other)
WILL	I am willing to make changes to the way I irrigate my farm to reduce pressure on water resources	Categorical (1=strongly disagree - 5=strongly agree)
TECH	I am interested in trying different technologies and/or systems to reduce my farm's water-use emissions	Categorical (1=strongly disagree - 5=strongly agree)
OBLI	As a farmer, I have an obligation to maintain or improve the water resources for future generations	Categorical (1=strongly disagree - 5=strongly agree)
ISSU	How do you feel about water shortage issues in the village	Categorical (1=not at all informed - 5=well informed)
DISS	How often do you discuss water issues with others	Categorical (1=never -4=a lot)
INFO	How often do you seek information on irrigation water	Categorical (1=never -4=a lot)

YIEL	Shortage of irrigation water decreases the agricultural yields of my farm	Categorical (1=strongly disagree - 5=strongly agree)
COST	Shortage of irrigation water increases the overall cost of production of my farm	Categorical (1=strongly disagree - 5=strongly agree)
PROF	Shortage of irrigation water reduces the net profits of my farm	Categorical (1=strongly disagree - 5=strongly agree)
VILL	How much trustful do you perceive the Village Office of Water Resource when it comes to constructing irrigation schemes	Categorical (1 highly untrustworthy - 5= moderately trustworthy)
MINI	How much trustful do you perceive the Ministry of Agriculture and Land Reclamation when it comes to constructing irrigation schemes	Categorical (1=highly untrustworthy - 5= moderately trustworthy)
HARM	Water scarcity is harming farmers right now all over the country	Categorical (1=strongly disagree - 5=strongly agree)
THRE	Water scarcity is an immediate threat affecting farming activities right now	Categorical (1=strongly disagree - 5=strongly agree)
EFFE	Future generations of farmers more likely to feel the effects of irrigation water scarcity	Categorical (1=strongly disagree - 5=strongly agree)
UNLI	Irrigation water scarcity is likely to harm farmers in my country in the next 20 years	Categorical (1=strongly disagree - 5=strongly agree)
IMPA	I think IWS will significantly impact farmers I know	Categorical (1=strongly disagree - 5=strongly agree)

* 1 Feddan (roughly 0.42 hectare) = 24 kirats

3.3 Theoretical underpinnings

3.3.1 Random utility model

Hanemann (1984) constructed the fundamental model for analyzing the dichotomous contingent valuation scenario based on the random utility model developed by McFadden (1974). The utility model assumes that the individuals choose a consumption bundle that maximizes their utility, considering their income constraint. Hanemann (1984) proposed driving WTP from the indirect utility function.

The indirect utility function for the respondent k is formulated as follows:

$$U = u_k \ (y, \text{q}, \text{N}) + \varepsilon_{ik} \tag{1}$$

Where, U(.) is the indirect utility function, y is the income of the individual k, q is the provision of non-marketable goods which is improved access to irrigation water supply in this case, and N is the vector of household characteristics, and other determinants.

Under the status quo, with no improvement in the irrigation water supply (q^0), the indirect utility function would be formulated as:

$$U = u_{0k} \ (y_k \ , q^0, N_k) \ + \varepsilon_{0k} \qquad (2)$$

where, q^0 express the status quo. Now, if the farmer is willing to pay the bid value c (c_k > 0) for the improved access to irrigation water supply, q^1 would represent the improved state ($q^1 > q^0$). The indirect utility function would be formulated as follows:

$$U = u_{1k} \ (y_k - c_k \ , q^1, N_k) \ + \varepsilon_{1k} \qquad (3)$$

The amount of income (y_k - c_k), that a farmer gives up to be better off from the status quo to an improved situation is named WTP (Haab and McConnell, 2002).

The individual k answers 'yes' to the required bid value when:

$$u_{1k} \ (y_k - c_k \ , q^1, N_k) + \varepsilon_{1k} \ > \ u_{0k} \ (y_k \ , q^0, N_k) + \varepsilon_{0k} \qquad (4)$$

where u_{1k} (.) is the indirect utility function after a change, u_{0k} (.) is indirect utility at status quo. c_k is the bid value, and ε_{ik} (i = 1,0) is the error component at the two conditions.

3.3.2 Double-bounded CVM

In double-bounded CVM, the respondents answered 'yes' and 'no' in response to two sequential bid values. Four responses are found, which are yes-yes, yes-no, no-yes, and no-no. Based on these responses, the double-bounded format has four possible interval bounds for WTP (figure 2).

These are as follows:

(Yes-Yes) indicating, WTP ≥ V^h, WTP ⊂ [V^h, ∞]

(Yes-No) indicating, V^i ≤ WTP < V^h, WTP ⊂ [V^i ,V^h]

(No-Yes) indicating, V^l ≤ WTP < V^i, WTP ⊂ [V^l, V^i]

(No-No) indicating, WTP < V^l, WTP ⊂ [0, V^l]

The sequential two bid values offer censored or interval data for the WTP responses. When the response to both bids is yes-yes, the data is considered right-censored. Conversely, the data is left censored when the response to both bids is a no-no. However, responses such as yes-no and no-yes indicate that data is interval in nature.

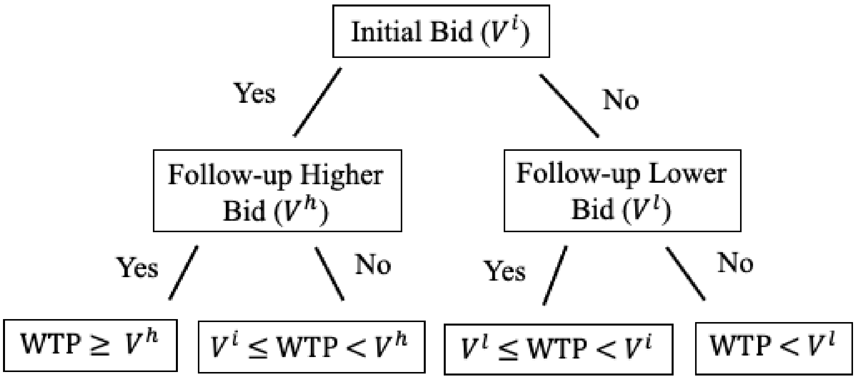

Figure 3. Interval bounds for WTP

3.4 Empirical strategy for the WTP estimation

Exploratory Factor Analysis

The survey collected information on farmers' attitudes, perceptions, knowledge, institutional trust, and psychological distance. Considering the similarities and correlations among these variables, exploratory factor analysis (EFA) was employed. EFA studies the correlation between a large set of variables (Bollen 1989) and attempts to uncover complex patterns (Child 2006). The literature provides support that the use of EFA is two-fold, firstly it identifies the logical combinations of the variables for a better understanding of relationship and correlation among them; secondly, it helps in reducing the data and brings forth the appropriate variables to be used in the analysis (Fabrigar et al. 1999; Gorsuch 2013).

In EFA, variables measuring farmers' attitudes, perceptions, knowledge, institutional trust, and psychological distance are grouped together into distinct factors. EFA simplifies the analysis by allowing to focus on key factors instead of multiple variables, thus facilitating the categorization of variables into functional latent constructs (Rummel 1988). Variables belonging to a similar latent construct are highly correlated while weakly correlated with variables from other constructs. EFA provides factor scores (i.e., eigenvalue) to these latent constructs. The factors with an eigenvalue greater than one are retained based on established criteria (Kaiser 1960). Additionally, the reliability of the factors is assessed using Cronbach's alpha, which measures the internal reliability and consistency of the factor (Verbeke et al. 2013). The latent constructs produced by factor analysis would then be used as aggregated independent variables for further analysis

(Hooper 2012). The interpretation of each factor is based on the type of variables included within it (Yong & Pearce 2013).

Interval Regression

Since the two dependent variables, initial bids and following bids, are interval and censored data, this study used an interval regression model to analyze the determinants of the WTP. Interval regression is a truncated regression model widely used when the dependent variable consists of an interval rather than a single value for each observation (Cameron 1988).

In this study, the farmers express their WTP for improved access to irrigation water supply. Using their responses to DBDC questions, we can conclude their true WTP lies within the above four possible ranges (Figure 2).

To motivate this model, the farmers' WTP is assumed to take a linear function as given below:

$$WTP_k = \alpha + X_k \beta + \varepsilon_k \qquad \varepsilon_k \sim (0, \sigma^2) \tag{5}$$

where, WTP_k is a dependent variable, representing WTP for improved irrigation water supply of the farmer k, α is a constant term, X_k is a set of independent variables/vector of explanatory variables that influence farmers' WTP, β is a coefficient andε_k is the error term representing other unobserved factors.

If a farmer has a yes-yes response, the probability of his true WTP is $\subset [V^h, \ \infty]$ is:

$$\begin{aligned} &\Pr(V^h \leq \text{WTP}) = Pr\ (V^h \leq \ \beta X_k + \ \varepsilon_k\ ) \\ &= \Pr\ (V^h - \beta X_k \leq \ \varepsilon_k\ ) \quad = 1 - \phi\ [\frac{V^h - \beta X_k}{\sigma}] \end{aligned} \tag{6}$$

Where, $\phi(.)$ is the standard normal cumulative distribution function.

If the farmer has a yes-no response, the probability of his true WTP $\subset [V^i, V^h]$ is:

$$\begin{aligned} &\Pr\ (V^i \leq \text{WTP} < V^h) = \Pr\ (V^i \leq \beta X_k + \ \varepsilon_k \ < V^h) \\ &= \Pr\ (\ V^i \leq \beta X_k \leq \ \varepsilon_k \ < V^h - \beta X_k\ ) \\ &= [\phi\ [\ \frac{V^h - \beta X_k}{\sigma}\ ] - [\ \frac{V^i - \beta X_k}{\sigma}]\ ] \end{aligned} \tag{7}$$

Probabilities for the other two responses (no-yes and no-no) are calculated in the same way.

Maximum Likelihood estimation is used to estimate β and σ. The log-likelihood for this model is:

$$\mathrm{LnL} = \sum \{ w^{yy} \ln (1 - \phi\, [\frac{V^h - \beta X_k}{\sigma}]) + w^{yn} \ln (\phi\, [\frac{V^h - \beta X_k}{\sigma}] - [\frac{V^i - \beta X_k}{\sigma}]) + w^{ny} \ln (\phi\, [\frac{V^i - \beta X_k}{\sigma}] - [\frac{V^l - \beta X_k}{\sigma}]) + w^{nn} \ln (\phi\, [\frac{V^l - \beta X_k}{\sigma}] - [\frac{-\beta X_k}{\sigma}])\} \quad (8)$$

And the mean WTP is estimated by the user-written command 'doubleb' in Stata (Lopez-Feldman 2012). The 'doubleb' command includes the initial bid, follow-up bid, response to the initial bid, and response to the follow-up bid to estimate the WTP as a dependent variable in the model. Two models are estimated for farmers' WTP, the first without control variables(explanatory) and the second with control variables. In the first model, the command directly estimates the α and σ in the equation [5] and WTP is the α, the constant. In the second model, the mean WTP would be calculated using 'nlcom' command while including all the explanatory variables (Haab & McConnell 2002).

4. Empirical Results

4.1 Descriptive statistics

Table 3 summarizes the main characteristics of the surveyed farmers (n = 313). The age distribution of the farmers in the study area ranges from 20 years to 85 years, with the majority population (39.9%) aged ≥ 55 years. Most farmers (64.53%) have household sizes ranging between 5 and 10 members, with a mean household size of 5. Regarding education, 49.84% of the farmers had no formal education, whereas 26.2 % had a technical education, and only 1.28% had a higher degree (MS/PhD). Moreover, most farmers (59.74%) have more than 15 years of hands-on experience in farming. The household income distribution shows that most farmers earn between 2000 to 4000 EGP/month. A large proportion of farmers (62.3%) reported that they have an off-farm income, suggesting a diversified income base. On the contrary, 29.39% of the farmers said that most/all of their income comes from agriculture, indicating their dependence on irrigation water for their livelihoods. Surprisingly, only 2.55% of the farmers reported having access to loans.

Regarding farm size, a majority of farmers (83.07%) own small-sized farms ranging from 1 to 50 kirats, with an average farm size of 41.5 kirats. Now the distribution for the type of irrigation water suggests that most farmers (63.9%) rely on surface water, while 22.04% use both surface and groundwater, supporting their dependence on the River Nile water (Nikiel et al. 2021). The information about distance from the main irrigation channel suggests that most farmers (34.50%) are more than 600 meters away from the main irrigation channel. Only 21.73% of the farmers reported that their farms are located within a radius of 150 meters from the main irrigation channel.

Table 3. Descriptive statistics

Characteristics	Frequency	Percent of the sample	Mean (SD)
Age			50 (12.18)
< 35	32	10.22	
35 to < 45	67	21.41	
45 to < 55	89	28.43	
≥ 55	125	39.94	
Household Size			5.5 (2.42)
< 5	103	32.90	
5 to 10	202	64.53	
> 10	8	2.55	
Education			2.4 (1.58)
No formal schooling	156	49.84	
Completed primary school	35	11.18	
Completed secondary school	5	1.6	
Technical qualification	82	26.2	
University degree	31	9.9	
Higher degree, MSc/PhD	4	1.28	
Farming experience (Years)			3.5 (0.72)
< 5	5	1.6	
5-10	26	8.31	
10-15	95	30.35	
> 15	187	59.74	
Total household income (EGP/month)			3.5 (1.59)
< 1200	37	11.82	
1200-2000	45	14.38	
2000-3000	81	25.88	
3000-4000	85	27.16	
4000-5000	32	10.22	
5000-6000	10	3.19	
> 6000	23	7.35	
Off-farm income			0.38 (0.48)
Yes	195	62.3	
No	118	37.7	
Share of agriculture income			2.6 (1.48)
Just a small part	101	32.27	
Less than a half	75	23.96	
Half	45	14.38	
Most/All	92	29.39	
Access to loan			0.03 (0.18)
Yes	8	2.55	
No	305	97.44	
Farm Size (Kirats)			41.5 (54.27)
1 - 50	260	83.07	
51 -100	29	9.26	
101-150	13	4.16	
> 150	11	3.51	
Type of irrigation water			1.8 (1.17)
Surface water	200	63.9	
Groundwater	2	0.64	
Surface and Groundwater	69	22.04	
Other	42	13.42	
Distance from the main irrigation channel (Meters)			865 (1029)
1-150	68	21.73	
151-300	56	17.89	

301-450	25	7.98
451-600	56	17.90
> 600	108	34.50

4.2 Farmer's WTP responses and mean WTP

Table 4 provides an overview of farmers' responses at different bid levels. It presents four response categories: yes-yes, yes-no, no-yes, and no-no. The percentage of yes-yes responses declines as the initial bid value increases. The distribution of no-no responses shows that 58% of the farmers who received the highest randomly assigned initial bid value and a lower follow-up bid value constitute the most significant proportion in this category.

Table 4. Farmers' responses by bid level

Initial Bid ($\boldsymbol{V^i}$)	Higher follow-up Bid ($\boldsymbol{V^h}$	Lower follow-up Bid ($\boldsymbol{V^l}$)	Yes-Yes	Yes-No	No-Yes	No-No
800	1200	500	17%	58%	19%	6%
1200	1500	800	8%	45%	40%	8%
1500	1750	1200	8%	27%	44%	22%
1750	2000	1500	5%	15%	22%	58%

The mean WTP for improved access to the irrigation water supply is 1228.401 EGP/feddan per year, as estimated by the bid-only model. After including explanatory variables and utilizing their average values, the WTP increased slightly to 1229.527 EGP/feddan per year. The significance level was set at a 95% confidence interval and p-value < 0.05.

Table 5. Mean WTP

	Mean WTP	SD	p-value	[95% conf. interval]	
WTP (bids only)	1228.401	23.39	0.000	1182.543	1274.259
WTP (explanatory variables)	1229.527	22.28	0.000	1185.844	1273.21

4.3 Exploratory factor analysis

Before conducting EFA, the standard tests to check the suitability of the data for factor analysis were undertaken: the Kaiser-Meyer-Olkin (KMO) test for sampling adequacy and Bartlett's test of sphericity. The KMO score was 0.761, which exceeds Kaiser's recommended minimum value of 0.60 by Kaiser (1974). Furthermore, Bartlett's test of sphericity generated X^2 (120) = 2538 with statistical significance $p < 0.000$, indicating that the correlation between variables is sufficiently significant for EFA (Bartlett 1954). Additionally, the sample size of 313 was found adequate to run EFA, as supported by previous literature (Hair et al. 2010). These tests support the suitability of EFA for analyzing the given data.

Two criteria were considered to determine the appropriate number of factors to retain in the analysis. Firstly, the rule of eigenvalue greater than 1.0 (Kaiser 1960). Secondly, the cumulative percentage of variance is explained by all factors greater than 60% (Hair et al. 1998). A varimax rotation technique, with a threshold of > 0.40, was applied to simplify the factor loadings and facilitate interpretation. This technique aims to maximize high-item loadings and minimize low-item loadings. As a result, six factors comprising 16 items/variables were identified. These factors were determined on items that exhibited high loadings, as presented in Table 6. Collectively, these six factors account for 79.28 % of the total variance observed in the data. The factors were subsequently labeled according to the nature of the variables included within each factor. Then, the means of the variables within each factor were calculated and used as independent variables in the regression model.

Additionally, to check the reliability of the factors obtained from EFA and evaluate how well the variables within each factor measure the underlying construct, Cronbach's alpha was used. Alpha takes the value from 0 to 1.0 , and the value close to 1.0 indicate greater scale reliability. Cronbach's alpha produced an overall reliability of all the items scale of 0.801. For each of the six factors individually, the reliability of the item scale ranged from 0.63 to 0.88. The test indicated that the factors exhibited an alpha-coefficient above the acceptance threshold of 0.60 (Hair et al. 2010).

Table 6. Factors with rotated loadings and Cronbach's alpha

Factor	Loading	Item/Variable
Psychological distance now	0.8644	HARM
(Cronbach’s alpha = 0.88)	0.9168	THRE
	0.9120	EFFE
Perceptions	0.9078	COST
(Cronbach’s alpha = 0.80)	0.7626	YIEL
	0.8173	PROF
Knowledge	0.8973	ISSU
(Cronbach’s alpha = 0.85)	0.8775	DISS
	0.8205	INFO
Institutional trust	0.8815	VILL
(Cronbach’s alpha = 0.87)	0.9275	MINI
Attitude	0.8898	WILL
(Cronbach's alpha 0.76)	0.8717	TECH
	0.6669	OBLI
Psychological distance future	0.7479	UNLI
(Cronbach’s alpha = 0.63)	0.9117	IMPA

4.4 Determinants of farmers' WTP

The results of the interval regression model are presented in Table 7. The model consists of thirteen variables, with seven directly obtained from the collected survey data and the remaining six variables imported from the EFA (Table 6). Under interval regression estimation, the sample has a mean WTP of 658.05 EGP/feddan per year with a 95% confidence interval [187.74; 1128.372].

Each coefficient in the model represents a marginal WTP associated with a specific variable holding all others constant. Household income, share of agriculture income, education, and farm size positively influence the WTP. Out of these variables, the share of agriculture income is statistically significant at a 5 % level. On the other hand, farming experience, loan, and distance from the irrigation channel negatively influence the WTP. And the negative impact of the loan on WTP is statistically significant at a 10 % level. The empirical finding regarding the impact of behavioral variables is mixed. Farmers' attitude is found to be significant at a 1% level and positively related with WTP. Moreover farmers' perceptions, institutional trust, and psychological distance are all positively associated with the WTP but not significant. In this category, the effect of knowledge on WTP is found to be negative and insignificant.

Table 7. Interval regression estimation results

Variables	Coefficients	Std. Error	p-value
Constant	658.05	239.96	0.006
EDU	0.162	15.571	0.992
EXP	-16.64	34.01	0.625
HINC	11.16	15.15	0.461
AGRI_INC	38.94**	15.29	0.011
FS	0.397	0.398	0.319
LOAN	-181.26*	108.27	0.094
DIS	-0.006	0.024	0.796
Attitude	86.32***	27.33	0.002
Perceptions	8.83	38.99	0.821
Knowledge	-17.88	29.98	0.551
Institutional Trust	23.85	18.45	0.196
Psy-dis now	2.87	30.90	0.926
Psy-dis future	20.10	23.47	0.392
LR chi2 (13)	23.76		
Log-likelihood	-387.94		
Prob> chi2	0.03		

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

5. Discussion

The empirical results presented in the preceding section confirm that the WTP for improved access to irrigation water is a decision shaped by factors, including agricultural income, farmers' attitudes, and their access to loans. These factors come into play when considering the willingness and the perceived value a farmer attaches to accessing an enhanced irrigation water supply.

Agricultural income

The agricultural income is found statistically significant at a 5% level, indicating that individuals with higher dependency on income from agriculture are willing to pay more. This implies that individuals who rely more heavily on income derived from agriculture are inclined to exhibit a higher WTP (Bakopoulou et al. 2010). Moreover, this finding aligns with the farmers' recognition of the agricultural benefits of improved irrigation water supply (Toshisuke & Hiroshi 2008; Biswas & Venkatachalam 2015). A study by Kidane et al. (2019) in Eritrea further strengthens this argument, highlighting the positive impact of agricultural income on WTP, particularly for farmers experiencing higher marginal products of water.

Farmers' Attitude

The farmers' attitude towards improved irrigation water supply, technology adoption, and efficient irrigation practices positively influence WTP and is statistically significant at a 1% level. This finding aligns with previous studies that have recognized attitude as a substantial factor influencing WTP (Deh-Haghi et al. 2020). Moreover, this finding is consistent with the Theory of Planned Behaviour, which proposes that a positive attitude toward a specific behavior increases the likelihood of adopting that behavior (Ajzen 1991). This observation is further supported by a study conducted in Southern Haiti, which highlights the positive relationship between respondents' attitudes towards improved rural water supply and their WTP (Whittington et al. 1990). In line with this, a study by Aydogdu & Bilgic (2016) explored farmers' WTP for irrigation water and found that farmers who utilize modern irrigation technology exhibit a positive and significant WTP. This finding contributes to our understanding of the positive impact that technology adoption and efficient irrigation practices can have on farmers' WTP. Overall, respondents' attitude toward paying for water resources is acknowledged as a critical factor in determining the success or failure of water supply projects (Devi et al. 2009).

Access to Loans

Farmers' access to loans is found statistically significant at a 10% level and negatively influences WTP. This outcome can be attributed to the burden of loan obligations that farmers already bear, making them less inclined towards taking responsibility for further expenses (Kiprop 2015). This finding is supported by a study that assessed farmers' WTP for the privatization of agricultural extension services in Ethiopia. They found a negative relationship between WTP and access to loans and reason the finding by reporting that farmers allocate the loan amount towards alternative livelihoods, focusing on non-farm activities rather than investing in agriculture (Gebretsadik & Romstad 2020). Contrary to that, few studies support the positive influence of access to loans on WTP (Omondi et al. 2014; Angella et al. 2014). This indicates the need for further exploration into the impact of loan access in the context of WTP for improved irrigation services (Kiprop 2015).

While other behavioral and psychological factors didn't show a significant relationship with WTP. Considering the negative impact of knowledge on WTP, a previous study conducted by Adomi et al. (2003) discovered a negative influence of knowledge on WTP, and suggested that several factors could contribute to this, such as an inadequate number of extension services, the educational level of farmers, and the lack of infrastructure. While it is essential to recognize the significance of appropriate information dissemination and effective knowledge sharing has the potential to positively influence farmers' WTP (Aydogdu 2016). Furthermore, the literature supports a positive relationship between institutional trust, perceptions, and WTP (Speelman et al. 2010; Khan & Damalas 2015), but these factors didn't demonstrate statistical significance in this study. Lastly, psychological distance is also found insignificant and I suggest that the lower educational level of the surveyed farmers may contribute to their reduced ability to comprehend these issues and respond accurately.

Regarding farmer characteristics, education positively influences farmers' WTP, but it is found to be statistically insignificant. A study by Ibrahim & Robert (2010) to estimate WTP for improved domestic water supply found a positive and insignificant relationship between education and WTP. Additionally, I propose two possible reasons for this observation. Firstly, the proportion of farmers with a high level of education may not be prominent in the collected data, resulting in limited impact. Secondly, the higher education sector is often neglected in developing countries (Nasim et al. 2020), which could result in the insignificance of the relationship. Furthermore, experience is negatively related with WTP (Knapp et al.,

2018) but not found to be significant. Lastly, household income is found to be insignificant and positively associated with WTP. The positive impact of household income is consistent with the basic economic theory (Arouna et al. 2012). Regarding farm characteristics, the farm size and the distance to the main irrigation channel are statistically insignificant, but their positive relationship is consistent with the previous literature (Angella et al. 2014; Kiprop et al. 2017).

Moreover, the results in Table 5 suggest that the estimated mean WTP for improved access to irrigation water supply is around 1230 EGP/feddan (roughly 0.42 hectare) per year, corresponding to approximately 4% of farmers' annual income (MALR 2020). Farmers' responses to the bid values demonstrated that a majority (86%) of farmers are willing to pay for irrigation, although the amount varied. The primary reason behind farmers' WTP is that they recognize that the current situation of irrigation water supply is highly crucial and requires timely action. In contrast, a small proportion of farmers (14%) stated their unwillingness to pay, citing financial constraints as the main factor. Some also believe that the problem is not a priority and that the proposed change is insignificant. Providentially, only one farmer objected to paying for irrigation water. Their responses indicate a major shift in the mindset of farmers in the region, suggesting an increasing acknowledgment of water as an economic good and a growing appreciation for the value of this resource (Kidane et al. 2019).

6. Policy Implications

By understanding these diverse factors, policymakers and stakeholders can develop more effective strategies and interventions to support irrigation water management and enhance productivity in farming communities. The results provide better insight into the factors influencing farmers' behavior, leading to several important policy implications. Firstly, the estimated mean WTP provides a realistic estimate to design and implement well-structured irrigation water pricing in the region that inculcates the adoption of efficient water use practices and a sense of responsibility among the water users. At the same time, it would serve as an effective means for the government to generate revenue (Gebretsadik & Romstad 2020) while setting a precedent for initiating similar projects, thus contributing to the country's overall development. Secondly, raising awareness among farmers about the benefits of improved irrigation water supply is important. Furthermore, educational activities should be emphasized in the region. Thirdly, considering that farmers' WTP is closely tied to their income from agriculture, the government should explore the feasibility of implementing a differential pricing approach, despite its challenges (Dinar & Mody 2004). Fourthly, policies should focus on enhancing farmers' access to modern irrigation technologies and iriigation systems. This should be complemented by capacity building and training programs to ensure farmers effectively utilize these technologies. Fifthly, policies should be designed to improve access to financial support mechanisms and introduce insurance schemes to mitigate the risks associated with agricultural investments. Lastly, it is essential to develop and implement comprehensive strategies for information dissemination, empowering farmers to make informed decisions regarding their water usage and agricultural practices.

7. Conclusion

This thesis aims to investigate the smallholder farmers' WTP for improved access to irrigation water supply in Egypt using contingent valuation. The findings indicate that a majority of farmers are willing to pay for irrigation, with the mean WTP estimated at 1230 EGP per year, approximately 4% of their annual income. This demonstrates a growing recognition among farmers regarding the economic significance of irrigation water and the need to address the current challenges in irrigation water supply.

The results from the interval regression model reveal that agricultural income significantly influences farmers' WTP, suggesting farmers who rely on income from agriculture demonstrate higher WTP. Furthermore, farmers' attitudes towards improved irrigation, technology adoption, and efficient irrigation practices have a significant positive impact on their WTP. This finding aligns with the theory of planned behavior, which suggests a positive attitude toward a specific behavior increases the likelihood of adopting that behavior. However, farmers' access to loans is found to have a significant negative impact on farmers' WTP. This can be attributed to the burden of existing loan obligations, which makes farmers less inclined to take on additional expenses.

Overall, the findings of this study have important policy implications for improving irrigation water supply. By understanding the factors influencing farmers' WTP, policymakers can design more effective and tailored policy interventions to support sustainable water resource management and agricultural development. Also, the estimated mean WTP serves as a practical benchmark to design and implement irrigation water pricing in the region.

8. Limitations and Future Research

In a surprising turn, the analysis revealed that several variables that were previously identified as influential factors in determining the WTP were found to be insignificant in our study. Despite their reported significance in previous research, these variables did not demonstrate a significant impact on WTP in our analysis. This discrepancy suggests that the dynamics of WTP may vary across different contexts and populations. Our findings highlight the importance of conducting context-specific studies to gain a deeper understanding of the factors that drive WTP in specific situations. Further research is warranted to explore alternative variables and factors that may have a more pronounced influence on WTP in this particular study setting.

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