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# Sustainable Water Conservation and Management Practices: A Perception Survey of the Farmers of Haryana, India

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## ABSTRACT

In order to ensure water sustainability, alarming levels of water scarcity across the globe is a critical issue warranting urgent address. The present study aims to bring to light the perception of farmers regarding water conservation and management practices from the selected five districts of the Haryana region of India. By analyzing the responses of 125 farmers, collected through a self-administered questionnaire, the impact of socio-demographic factors, current irrigation system, and cost-benefit perception of the farmers was studied on water conservation and management practices. Using ordinal regression analysis, the study revealed that the cost-benefit perception of the farmers, viz. willingness to pay an additional price for canal water and an increase in the availability of water due to canal lining, are the major factors responsible for undertaking conservation and sustainability measures. Further, socio-demographic variables such as age and education also influence water conservation behavior. The study recommends vital policy reforms and initiatives for efficient water use and management to resolve the grave concern of scarcity of usable water. The present study is unique in its suggestion of a comprehensive water conservation and management framework.

## INTRODUCTION

Water is the elixir of life for all beings, may it be flora, fauna, or humans (Ravish et al. 2018). Freshwater is a natural resource that is indispensable for the life and well-being of humans and the ecosystem. Yet, the future availability of this valuable resource is less than certain. As reported by the United States Geological Survey, around 97 percent of water is present in the oceans, which is not potable (Water Science School 2018). Only the remaining 3 percent of water is fresh. Freshwater is distributed among icecaps and glaciers (68.7 percent), surface water (0.3 percent), and groundwater (30.1 percent). Out of the surface water, 87 percent is in the lakes, and the rest in rivers and swamps. This means that a mere one percent of the total water on earth is usable by human beings. In practice, only 0.007 percent of the water on earth is available to serve its 7.8 billion people (United States Census Bureau 2021).

With the growing population and economic activities, the need for this prime natural resource is also surging (Garg & Hassan 2007, Brown 2017, Ghosh 2021). The wasteful expense of this valuable natural resource often undermines the significance of water. The growing urbanization and industrial activity coupled with climate change have resulted in an alarming level of water shortage globally. Nearly one-fifth of the world's population lives in areas of physical water scarcity (Xiao-Jun et al. 2014, Manju & Sagar 2017). Among the 17 countries facing extreme water stress, the emerging economy of India ranks 13$^{th}$ in number (Hofste et al. 2019). In addition to the surface water resources (rivers, lakes, and streams), even the groundwater resources of the country have been severely overdrawn, mainly for providing water for irrigation. According to World Resources Institute, groundwater stress is more pronounced in the northern part of India, where the groundwater tables have experienced an annual decline at an alarming rate of more than 8 centimeters from 1990-2014 (Hofste et al. 2019). Thus, India is facing worrisome groundwater stress. Despite the depleting water resources of the country, with increasing population water demand is on a constant upsurge (Gupta et al. 2016). India has more than 18 percent of the world's population but only 4 percent of the world's renewable water resources (National Water Mission 2021). Keeping in view the ferocity of the situation, the Haryana region of India, which falls in the north-western part of the country (between 27 degrees 37' to 30 degrees 35' latitude and between 74 degrees 28' to 77 degrees 36' longitude and with an altitude of 700-3600 ft above sea level) has been selected for the present study (Haryana Tourism Corporation Limited 2020). Further, this area is characterized by low and erratic rainfall, which makes it a perfect milieu to carry out this research.

Given the erratic rainfall and water scarcity in Haryana, the building of canals has been a popular way of irrigating the agricultural fields in this region (Yadav 1987). Through irrigation, canal water is supplied to the fields. The performance of irrigation systems is thus of vital importance to the farmers for better crop yield and earning a decent livelihood (O'Keeffe et al. 2018). Haryana, often called the 'agricultural hub of India,' contributes 6.9 percent of India's food grain production (Tripathi & Gupta 2021). Thus, efforts to strengthen the irrigation infrastructure are of utmost significance, as water stress in Haryana poses a nationwide food security threat (Grewal et al. 2021). In view of the significance of agricultural activities, irrigation channels hold the utmost significance in this region, given the scant rainfall. These channels, however, are in a dismal state and call for rehabilitation/repair. To add, there is huge water loss due to mismanagement and the poor state of the canals. Considerable seepage loss is a major factor contributing to low water-use efficiency when water is conveyed to the fields by an irrigation system. This seepage loss not only reduces the water efficiency of the canal system but also reduces the quality of groundwater through soil salinization and waterlogging (Han et al. 2020).

Urgent remedial measures are, therefore, imperative in the direction of conservation to desist from the current situation of extreme water stress in the country. The suggestion of sustainable water conservation and management practices is thus a major concern that the present study aims to address. From this, the following secondary objectives have further been framed. First, to assess the impact of socio-demographic factors on water conservation and management practices. Second, to discern the impact of the current irrigation system on water conservation and management practices. Third, to study the impact of cost-benefit perception on the adoption of water conservation measures. Fourth, to suggest likely sustainable initiatives for water conservation and management.

Given the deficient water supply in the southwestern region of Haryana, canal irrigation is a preferred medium for agricultural activities. Therefore, the present study has been undertaken to study the perception of the farmers and suggest improvement measures in the overall irrigation system to ensure judicious use and conservation of water. This study contributes to the literature in several ways. First, there is a dearth of empirical evidence suggesting a holistic framework for designing efficient water conservation and management practices in irrigation. The present study aims to fill this gap in the literature. Second, first-hand responses from farmers of Haryana obtained for the present study provide a unique data set for the implementation of technology-based reform in the agriculture and irrigation sector. Third, the study provides rare evidence of the impact of socio-demographic variables, current irrigation system, and cost-benefit perception of the farmers on water conservation and management through robust statistical analysis. Overall, the present research will be of vital significance for the practitioners, policy-makers, and the public at large.

## Literature Review and Hypothesis Development

Keeping in view the objectives of the study, relevant literature has been classified into the following three sub-strands: impact of socio-demographic factors on water conservation and management practices, impact of current irrigation system on water conservation and management practices, and impact of cost-benefit perception of farmers on water conservation and management practices.

**Impact of socio-demographic factors on water conservation and management practices:** In designing efficient water conservation policies, many studies have explored the role of the socio-demographic profile of the respondents. For instance, Verdugo et al. (2006) established that age and gender significantly impact the water conservation viewpoints of the respondents by studying the responses of 300 individuals (140 males and 160 females) from randomly selected 100 Mexican households. Accordingly, older people and females were found to be more inclined towards conserving water. Similarly, Fan et al. (2014), taking a sample of 776 households across 16 villages in the rural Wei River Basin, found that gender and education determine the perception of water consumption by individuals. In this study, males/younger population underestimated their water consumption, whereas women and the elderly could accurately estimate this pattern.

Recently, Jaafar & Kharroubi (2021), in a study of 678 farmers in Lebanon, established that a significant role is played by socio-demographic factors, like age, nationality, and geographical area, in determining the use of smart irrigation mobile applications. Accordingly, young farmers, as compared to the older ones, were more likely to adopt smart irrigation technology. The level of education, however, exerted no influence on the adoption of smart irrigation technology in this study. Contrary to these findings, Garcia et al. (2014), through a face-to-face survey of 234 Spanish households, established that water conservation campaigns should be targeted towards more educated groups by the authorities to increase the level of awareness of water scarcity. The majority of the related literature, thus, reiterated the general theoretical supposition regarding the impact of socio-demographic factors on water conservation and management (e.g., Verdugo et al. 2006, Jaafar & Kharroubi 2021). From this, the following may be hypothesized:

H1: There is a significant impact of socio-demographic factors on water conservation and management practices

**Impact of current irrigation system on water conservation and management practices:** The impact of the current irrigation system on water conservation and management efficiency has often been deliberated on in literature (Lecina et al. 2010, Ahmadzadeh et al. 2016). In India, the current canal irrigation system needs a major overhaul (Afroz & Singh 2007, Shah 2011). In a survey of 10 major canal command areas in India, Singh et al. (2004) found that an alarming proportion of respondents (44 percent) had unfavorable attitudes toward canal irrigation. Various reasons were stated for this dissatisfaction, like the faulty alignment of canals resulting in water scarcity during crucial periods of the year, water logging during the rainy season, poor maintenance and upkeep of the canal water distribution system, lack of proper monitoring by the officer concerned, and the like. These reasons were attributed to the inefficient performance of irrigation administration, low orientation towards operations and maintenance, and the institutional gap with respect to the maintenance of minor canals. Amarsinghe et al. (2021) further emphasized that low water-use efficiency and productivity, as well as the expanding gap between irrigation potential used and irrigation potential created, are important challenges in canal irrigation performance in India.

One of the most critical repercussions of this deterioration in the canal irrigation system is the establishment of a pump irrigation economy, which has caused damage to groundwater resources (Shah 2011). Furthermore, the replenishment rate of groundwater is not in sync with its depletion rate (Jakeman et al. 2016). In this context, Johansson et al. (2002) pointed out that while it is difficult to apportion surface water to competing consumers, draining groundwater has an impact on resource accessibility for future generations. Declining quality is another stark feature, making groundwater unfit for agricultural use (Bhala 2007). Gebremeskel et al. (2018), in a study conducted in the semi-arid Tigray region in Northern Ethiopia, further exclaimed that using more and more groundwater for irrigation increases the salinity of the soil, thereby reducing agricultural productivity. Therefore, increasing the use of groundwater may be expensive. In addition, Barmakova et al. (2022) conducted a study in the Karatal district of the Republic of Kazakhstan. They established that well-managed irrigation practices like monitoring water quality are vital for maintaining groundwater quality.

Jaafar & Kharroubi (2021) furthermore established that while the majority of participants (about 69 percent) preferred groundwater for irrigation, others showed a preference for canal water (around 12 percent); a faint minority (nearly 7 percent) preferred a combination of both or other irrigation sources. The study highlighted that one of the most important factors that can help farmers optimize their water use is irrigation timing (Jaafar & Kharroubi 2021). It is thus essential to understand the current availability of water in the canal irrigation system and study its impact on conservation practices (e.g., Lecina et al. 2010, Hrozencik et al. 2022). A variety of opinions of the theorists about different sources require an assessment of the current pattern of irrigation in the region of the study to suggest an optimal channel for irrigation. Therefore, the following may be hypothesized:

H2: There is a significant impact of the current irrigation system on water conservation and management practices

**Impact of cost-benefit perception of farmers on water conservation and management practices:** Among others, farmers' perceptual stance has a major implication on their water conservation and management initiatives (Singh et al. 2004). Knox, Kay & Weatherhead (2011), in a perception study of farmers from the temperate region of England, asserted that efficient use of water resources not only enhances farmers' value (financial benefits) but also helps build sustainable rural communities. The authors suggested the use of this pathway for efficient water use to achieve better irrigation management. A recent example has, further been presented by Han et al. (2020) in their study of the arid region of the Renmin branch canal irrigation district. The study clearly shows that building and regular service of canal lining is vital for reducing seepage loss. As compared to no lining, an interesting finding of the study was that building canal lining using concrete and geomembrane results in a considerable (86 percent) reduction in water loss due to seepage.

Furthermore, the need for smooth delivery of canal water to the fields cannot be overemphasized (Flynn & Marino 1987, Tyagi 2019). Delivery structures, thus, play a vital role in improving water conveyance efficiency. According to the study conducted by Singh et al. (2006) in Hisar (district of Haryana), 34-43 percent of the canal water is lost due to seepage from the conveyance system. In conjunction, Sultan et al. (2014), in a comparative analysis of developing nations, found the water conveyance loss in lined water courses to be lesser than that in unlined ones. Thus, the type of canal lining is a crucial factor for ensuring better water use efficiency. Accordingly, rehabilitation and development of the canals and water courses are required to ensure sustainable water use.

Expressing a corollary view, Singh et al. (2004), through a perception survey of 100 farmers (selected through stratified random sampling) of the command area of Odisha, found that the majority of the respondents (56 percent) had a favorable outlook towards the role of canal irrigation in cultivation. A major portion (70 percent) of the 50 farmers selected from the non-command areas also reiterated the need for canal irrigation for better yield and income. Further, according to Morita (2021), the quantity and quality of water distributed to farmers should be optimally managed by means of effective irrigation scheduling and implementation of appropriate irrigation technologies on suitable soils. However, the high cost of infrastructure changes, a lack of storage dams, and the unjust water distribution system in irrigation schemes restrain farmers from being more efficient (De Clercq et al. 2021). Water utilization for agricultural output in water-scarce regions, thus, necessitates innovative and long-term research as well as suitable technology transfer (Jaafar & Kharroubi 2021, Lecina et al. 2010). From the above, we hypothesize:

H3: There is a significant impact of the cost-benefit perception of farmers on water conservation and management practices

## MATERIALS AND METHODS

### Data Collection

The data for the present study has been collected through a survey of the farmers of the Haryana region of India from October 2021 to February 2022. The southwestern region of the Haryana state faced severe droughts/famines during 1966, 1968, and 1987. The solution to counter water scarcity in the region was addressed by the construction of the Jawahar Lal Nehru (JLN) Feeder. JLN Feeder is currently the main channel stretching over 104 kilometres (RD 0 to 343100), which off-takes from Khubru Head at RD 145250/R of Delhi Parallel Branch. JLN Feeder is the lifeline of Southern Haryana, catering to the irrigation and drinking water needs of Rohtak, Jhajjar, Rewari, Narnaul, and Bhiwani districts, having a discharge capacity of 3541 Cs. at the head. The five districts (Rohtak, Jhajjar, Rewari, Narnaul, and Bhiwani) to which the JLN Feeder caters have been identified as five distinct strata, and respondents fulfilling the pre-specified criteria have been randomly selected from each stratum. The Ethical Clearance Certificate before conducting the survey was obtained from the Institutional Ethics Committee of the affiliated institution of the authors.

For the present study, the perception of the farmers has been studied using two potent techniques: focused group discussions and self-administration of questionnaires. One-to-one interaction enabled the observation of the perception of the farmers on canal lining as a water conservation and management measure. Focused group discussions, moreover, enabled the identification of certain latent constructs that are of significance from a water conservation point of view. To investigate the perceived and expected impact of lining by the population, focus group discussions were conducted. Focus group research involves formal discussions with a selected group of people to address a specific issue. To facilitate the exchange of opinions, the groups should be as homogeneous as possible. These discussions are considered a suitable method to investigate various perceptions and values of groups of people about a certain topic. A trained local facilitator, along with the first author, conducted ten focus group discussions with 5–10 participants each, men and women separately. Discussions were held across 5 different district locations within the state of Haryana served by the JLN Feeder. The topics of discussion were current water availability, expected or actual consequences of irrigation canal lining, and perception and valuing of possible changes and training for the conservation of water.

A structured questionnaire was self-administered to 200 respondents, out of which 125 usable responses could be obtained. The sample was drawn equally from each district. The respondents selected for the present study either owned their farms or worked on rented farms on a sharing basis. For participating in the survey, the following riders were used to select the respondents (farmers) for the present study. First, the farmers below 18 years of age were excluded from the purview of the study. Second, given their small landholding, farmers who reported owning land less than 1 hectare were excluded from the study. Third, only farmers capable of reading, understanding, and interpreting the survey instrument were included in the study. Those with any mental disability were excluded from the study. Fourth, for inclusion in the survey, the respondent must be familiar with either English or Hindi language. Consent of the farmers, who met the premeditated research criteria, was obtained after explaining to them all relevant information (study objectives, potential risks, and benefits of participation in the survey) regarding the survey. The willing and informed participation of the sample respondents was, thus, obtained to depict a true and fair view of the farmers' perception of water conservation and management practices. Farmers meeting the above-specified criteria were thereafter randomly selected for the present study.

### Survey Instrument

Data for the present study was collected by the first author, accompanied by field investigators in a private setting. Two field investigators, well-versed in the local language/dialect of the inhabitants of the region, were appointed to facilitate data collection. This ensured effective communication and better observation of various latent constructs. Selected farmers filled out a multi-dimensional questionnaire during a personal interview session of 10-30 minutes. Initially, the questionnaire was developed in English. Subsequently, it was translated into Hindi (since the majority of the respondents were well-conversed in the Hindi language). Thereafter, to check whether the questionnaire qualified for parallel-form reliability, it was re-translated into English. Disagreement, if any, in the re-translated version was corrected to enhance the efficiency of the instrument in capturing the views of the respondents. At the time of the interview, both Hindi as well as English versions were used depending upon the preference of the respondents.

The survey instrument was bifurcated into various sections. Section 1 on the demographic profile of the respondents included questions such as age, gender, district, education, etc. Section 2 aimed to evaluate the current irrigation system. Questions like the type of canal lining in the area, major crops sown by them, and their current use of groundwater were delved into in this section of the questionnaire. Section 3 gauged the cost-benefit perception of the respondents. Response to questions like willingness to pay the additional amount for better access to canal water throughout the year and impact on the availability of water and area under irrigation after building concrete lining of the canal was obtained.

Further, questions on perceived change in water use efficiency and conveyance efficiency were also asked. The last section studied the water conservation measures and management practices preferred by the respondents. In the majority of the questions, a five-point Likert scale was used to obtain the degree of agreement and disagreement where 1, strongly disagree and 5, strongly agree. A pilot study was conducted on a sample of 15 farmers to test the consistency and clarity of the survey instrument. The value of Cronbach's Alpha was further examined to assess the internal consistency of the instrument. The coefficient alpha estimates were found to be within the high-reliability category (i.e., greater than 0.70). The scale was thus considered appropriate to be used for the study.

### Conceptual Model and Framework for Analysis

The conceptual framework to study the impact of socio-demographic variables, the current irrigation system in the region, and the cost-benefit perception of farmers on water conservation and management practices has been demonstrated in Fig 1. Socio-demographic variables (gender, education, district, and age), current irrigation system (current use of groundwater, preference of canal water over groundwater), and cost-benefit perception of farmers (willingness to pay additional charges, increase in availability of water, benefit crop yield, improvement in economic status, and increase in water conveyance and water

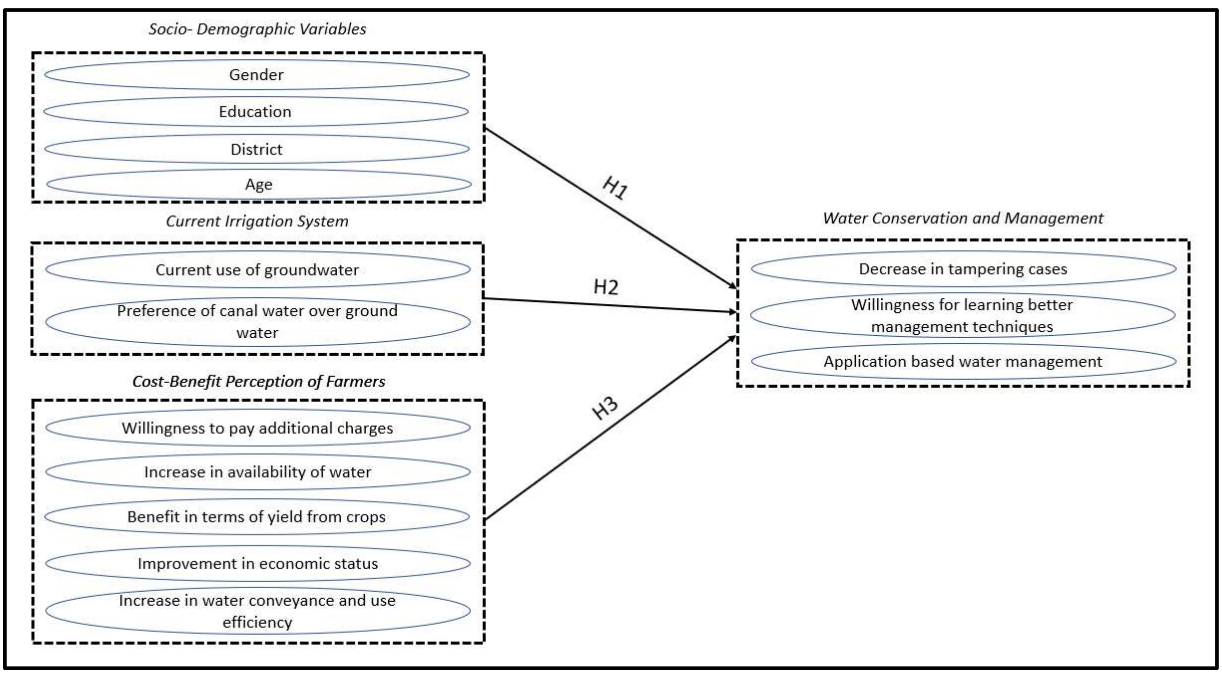


Fig. 1: Conceptual Framework and Hypotheses.

Table 1: Description of Variables.

| Measure | Variable | Symbol | Description |
|---|---|---|---|
| Panel A: Dependent Variables | | | |
| Water Conservation and Management | Decrease in tampering cases | *DTAMP* | Impact on tampering cases with regards to the canal irrigation water |
| | Willingness to learn better management techniques | *WLT* | Evaluation of willingness of respondents to learn (e.g., undertaking training) better water management techniques for sustainable water use |
| | Application-based water management | *ABWM* | The willingness of respondents to use application-based water management techniques |
| Panel B: Independent Variables | | | |
| Socio-Demographic Variable | Age | *AGE* | Age of the respondents in years |
| | Gender | *GENDER* | The gender of the respondents |
| | Education | *EDU* | The level of education of the respondents |
| | District | *DIST* | Districts of respondents in which the survey was administered |
| Current Situation of Irrigation System | Groundwater Use | *GWU* | Current usage level of groundwater in the region of respondent |
| | Preference of Canal Water over Groundwater | *PCW* | The preference of respondents for canal water over groundwater for irrigation |
| Cost-Benefit Perception of Farmers | Willingness to pay additional charges | *WPAC* | Willingness to pay for additional charges for canal irrigation |
| | Increase in the availability of water. | *IAW* | Perception of availability of water in the respondent's region due to canal lining |
| | Benefit crop yield | *BCY* | The benefit of the lining of canal/water courses on yield from crops |
| | Improvement in economic status | *ECOSTAT* | Whether there has been an improvement in economic status due to canal lining |
| | Increase in water conveyance efficiency and water use efficiency | *IWCUE* | Perception of water use efficiency in the region due to canal lining |

use efficiency) have been taken as independent variables. Three separate models with dependent variables: willingness to learn better management techniques, decrease in tampering cases, and application-based water management denoting water conservation and management practices have been formulated. The variables have been defined in Table 1. After establishing a basic association between the variables through correlation analysis, the hypothesized relationship will be ascertained through ordinal regression analysis. The respondents (farmers) did not influence the design, conduct, or reporting of the survey.

## RESULTS AND DISCUSSION

### Focused Group Discussions

The discussions with the farmers helped analyze the cropping pattern followed in the region. The following findings have been derived:

- The current use of groundwater was discussed, and it was concluded that the groundwater in the region is saline, leading to irrigation-related issues for the farmers. The CC irrigation system is likely to bring better water conveyance efficiency and ultimately help in water conservation.
- Farmers demonstrated interest in receiving training in modern agriculture technology and an app-based system for monitoring irrigation in the fields, which is also a stepping stone for sustainable agriculture.

It was, therefore, apparent that farmers are willing to seek assistance from agricultural officers and extension workers on the employment of better irrigation technologies. Through water users' associations and regular meetings on the use of modern technologies and water-saving methods to combat the problems of waterlogging and salinity in the command area, better irrigation systems can thus be put in place.

Table 2 presents the descriptive statistics of the variables under consideration for the present study. The table provides the mean and standard deviation of the key variables. As reported, the average decrease in tampering cases (*DTAMP*) has been observed to be 4.52, which denotes that the water conservation and management measures are in place. The mean value of other dependent variables (*WLT and ABWM*) also portrays the willingness of the farmers to undertake water conservation and management practices. Amongst the independent variables, *GWU* having a mean value of 4.59 signifies a high use of groundwater in the region of the study. While there is high current usage of groundwater, preference for canal water is yet clearly highlighted by the

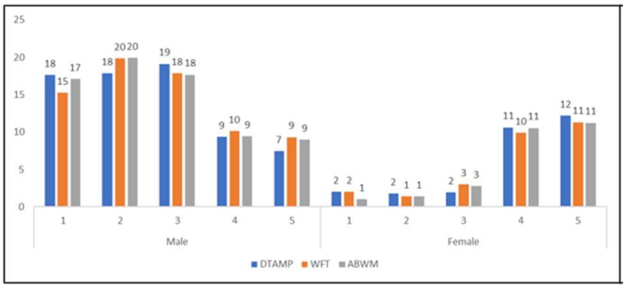

Fig. 2a: District-wise perception of farmers on water conservation and management on the basis of the gender (in %)

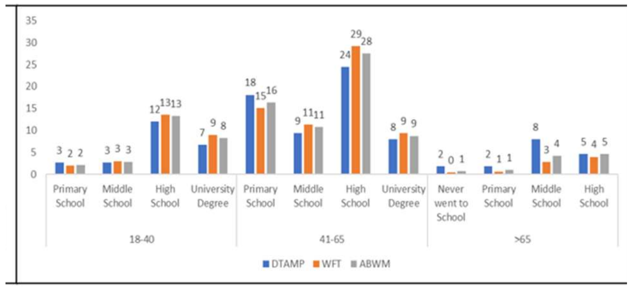

Fig. 2b: Perception of farmers on water conservation practices on the basis of the age and education (in %)

Table 2: Descriptive Statistics

| Variables | Mean | Stdeviation |
|---|---|---|
| DTAMP | 4.520 | 0.947 |
| WLT | 4.030 | 1.492 |
| ABWM | 3.490 | 0.989 |
| DIST | 3.000 | 1.420 |
| GENDER | 1.270 | 0.447 |
| AGE | 1.930 | 0.624 |
| EDU | 2.460 | 1.051 |
| GWU | 4.590 | 0.742 |
| PCW | 4.110 | 1.259 |
| WPAC | 4.030 | 1.170 |
| IAW | 4.280 | 1.209 |
| BCY | 4.230 | 1.033 |
| ECOSTAT | 2.740 | 0.556 |
| IWCUE | 4.500 | 0.997 |

Source: Author's analysis.

Note: Data of 125 respondents' has been presented in the table.

mean value of 4.11 for *PCW*. Additionally, the mean results demonstrate the expectation of an increase in the availability of water (*IAW*= 4.28) and increased crop yield (*BCY*= 4.23). Similarly, the average value of *IWCUE* observed to be 4.50 indicates a perception of farmers on improvement in water conveyance and use efficiency as a result of the rehabilitation of canal lining.

As shown in Fig. 2a, the male population from the 1$^{st}$, 2$^{nd}$, and 3$^{rd}$ districts demonstrated greater vigor for the adoption of water conservation and management practices compared to their female counterparts in other districts. Further, as shown in Fig. 2b, farmers who went to high school and are in the age group of 41-65 years showed higher interest in undertaking water conservation and management measures.

Bivariate correlation coefficients of Spearman's rho and Kendall's tau-b have been reported in Table 3. These correlation coefficients establish the strength of the relationship between variables with rank orders. Statistically significant correlations with a very high correlation coefficient have been observed between *ECOSTAT* and *DTAMP*, as well as between *IWCUE* and *DTAMP*. Furthermore, statistically significant associations with high correlation coefficients have been observed between variables *IAW* and *BCY*, *ECOSTAT* and *IAW*, *ECOSTAT* and *BCY*, *IWCUE* and *IAW*, and *IWCUE* and *BCY.*

Further, significant correlations have been observed between *IWCUE* and *ECOSTAT*. This is a cause of concern for the computation of the regression models as the correlation coefficient is higher than the acceptable limit (as per the rule of thumb) of 0.50. The problem of multicollinearity arises due to such high correlations. Variance inflation factors (VIFs) have been further utilized as a formal measure of multicollinearity. The VIFs were found to be within the limit of 10 (Mansfield & Helms 1982). Nonetheless, the variables *IWCUE* and *ECOSTAT* were included one at a time in the regression models to obtain robust results.

The results have been obtained through ordinal regression analysis. Variables with a ratio or ordinal scale are used as covariates, while variables with categorical responses are taken as factor variables. The impact of socio-demographic factors, current irrigation system, and cost-benefit perception has been regressed on water conservation and management practices. This impact has been analyzed using ordinal regression coefficients by formulating Model 1, Model 2, and Model 3.

The results obtained from the model fitting information of regression analysis, as reported in Table 4, show significant chi-square statistics in all the models. This implies that all models are a significant improvement over the intercept-only model. Thus, the model has better prediction power than a mere guess.

## Analysis of the Impact of Socio-Demographic Factors on Water Conservation and Management Practices

Table 5 presents the results of the regression analysis.

Table 3: Non-Parametric Correlations.

| | | DTAMP | WLT | ABWM | DIST | GENDER | AGE | *EDU* | *GWU* | *PCW* | *WPAC* | *IAW* | *BCY* | *ECOSTAT* | *IWCUE* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kendall's tau_b | DTAMP | 1.000 | -0.025 | -0.016 | 0.078 | -0.028 | -0.079 | -0.046 | 0.016 | 0.532** | 0.612** | 0.641** | 0.689** | 0.920** | 0.921** |
| | WLT | -0.025 | 1.000 | 0.812** | 0.080 | -0.109 | -0.477** | 0.405** | -0.064 | -0.043 | 0.067 | -0.120 | -0.102 | -0.091 | -0.088 |
| | ABWM | -0.016 | 0.812** | 1.000 | 0.070 | -0.086 | -0.441** | 0.371** | -0.005 | -0.090 | 0.051 | -0.092 | -0.085 | -0.060 | -0.073 |
| | DIST | 0.078 | 0.080 | 0.070 | 1.000 | 0.478** | -0.040 | -0.002 | -0.075 | -0.152* | -0.058 | -0.004 | 0.133 | 0.038 | 0.064 |
| | GENDER | -0.028 | -0.109 | -0.086 | 0.478** | 1.000 | 0.043 | -0.094 | 0.008 | -0.139 | -0.115 | -0.101 | 0.038 | -0.048 | -0.029 |
| | AGE | -0.079 | -0.477** | -0.441** | -0.040 | 0.043 | 1.000 | -0.274** | -0.038 | -0.043 | -0.215** | -0.011 | -0.014 | -0.052 | -0.055 |
| | EDU | -0.046 | 0.405** | 0.371** | -0.002 | -0.094 | -0.274** | 1.000 | 0.007 | -0.068 | 0.010 | -0.019 | -0.083 | -0.067 | -0.081 |
| | GWU | 0.016 | -0.064 | -0.005 | -0.075 | 0.008 | -0.038 | 0.007 | 1.000 | -0.026 | -0.082 | 0.020 | 0.015 | -0.002 | 0.046 |
| | PCW | 0.532** | -0.043 | -0.090 | -0.152* | -0.139 | -0.043 | -0.068 | -0.026 | 1.000 | 0.627** | 0.617** | 0.454** | 0.584** | 0.568** |
| | WPAC | 0.612** | 0.067 | 0.051 | -0.058 | -0.115 | -0.215** | 0.010 | -0.082 | 0.627** | 1.000 | 0.641** | 0.528** | 0.601** | 0.617** |
| | IAW | 0.641** | -0.120 | -0.092 | -0.004 | -0.101 | -0.011 | -0.019 | 0.020 | 0.617** | 0.641** | 1.000 | 0.688** | 0.714** | 0.705** |
| | BCY | 0.689** | -0.102 | -0.085 | 0.133 | 0.038 | -0.014 | -0.083 | 0.015 | 0.454** | 0.528** | 0.688** | 1.000 | 0.733** | 0.750** |
| | ECOSTAT | 0.920** | -0.091 | -0.060 | 0.038 | -0.048 | -0.052 | -0.067 | -0.002 | 0.584** | 0.601** | 0.714** | 0.733** | 1.000 | 0.964** |
| | IWCUE | 0.921** | -0.088 | -0.073 | 0.064 | -0.029 | -0.055 | -0.081 | 0.046 | 0.568** | 0.617** | 0.705** | 0.750** | 0.964** | 1.000 |
| Spearman's rho | DTAMP | 1.000 | -0.026 | -0.017 | 0.088 | -0.029 | -0.085 | -0.052 | 0.018 | 0.594** | 0.673** | 0.699** | 0.750** | 0.950** | 0.951** |
| | WLT | -0.026 | 1.000 | 0.863** | 0.094 | -0.116 | -0.525** | 0.466** | -0.069 | -0.048 | 0.080 | -0.133 | -0.116 | -0.098 | -0.095 |
| | ABWM | -0.017 | 0.863** | 1.000 | 0.080 | -0.089 | -0.478** | 0.426** | -0.005 | -0.102 | 0.061 | -0.102 | -0.093 | -0.064 | -0.078 |
| | DIST | 0.088 | 0.094 | 0.080 | 1.000 | 0.534** | -0.046 | -0.001 | -0.087 | -0.187* | -0.078 | -0.007 | 0.152 | 0.044 | 0.074 |
| | GENDER | -0.029 | -0.116 | -0.089 | 0.534** | 1.000 | 0.045 | -0.103 | 0.008 | -0.149 | -0.124 | -0.107 | 0.041 | -0.049 | -0.030 |
| | AGE | -0.085 | -0.525** | -0.478** | -0.046 | 0.045 | 1.000 | -0.315** | -0.040 | -0.049 | -0.243** | -0.013 | -0.015 | -0.056 | -0.060 |
| | EDU | -0.052 | 0.466** | 0.426** | -0.001 | -0.103 | -0.315** | 1.000 | 0.008 | -0.078 | 0.010 | -0.023 | -0.095 | -0.074 | -0.089 |
| | GWU | 0.018 | -0.069 | -0.005 | -0.087 | 0.008 | -0.040 | 0.008 | 1.000 | -0.030 | -0.091 | 0.021 | 0.019 | -0.002 | 0.048 |
| | PCW | 0.594** | -0.048 | -0.102 | -0.187* | -0.149 | -0.049 | -0.078 | -0.030 | 1.000 | 0.690** | 0.676** | 0.528** | 0.632** | 0.620** |
| | WPAC | 0.673** | 0.080 | 0.061 | -0.078 | -0.124 | -0.243** | 0.010 | -0.091 | 0.690** | 1.000 | 0.708** | 0.599** | 0.655** | 0.675** |
| | IAW | 0.699** | -0.133 | -0.102 | -0.007 | -0.107 | -0.013 | -0.023 | 0.021 | 0.676** | 0.708** | 1.000 | 0.733** | 0.753** | 0.747** |
| | BCY | 0.750** | -0.116 | -0.093 | 0.152 | 0.041 | -0.015 | -0.095 | 0.019 | 0.528** | 0.599** | 0.733** | 1.000 | 0.769** | 0.795** |
| | ECOSTAT | 0.950** | -0.098 | -0.064 | 0.044 | -0.049 | -0.056 | -0.074 | -0.002 | 0.632** | 0.655** | 0.753** | 0.769** | 1.000 | 0.972** |
| | IWCUE | 0.951** | -0.095 | -0.078 | 0.074 | -0.030 | -0.060 | -0.089 | 0.048 | 0.620** | 0.675** | 0.747** | 0.795** | 0.972** | 1.000 |

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed)

Table 4: Model Fitting Information.

| Dependent Variable | Model | Model | -2 Log Likelihood | Chi-Square | d.f. | Sig. |
|---|---|---|---|---|---|---|
| *DTAMP* | *(a) DTAMP= f(AGE, GENDER, EDU, DIST, GWU, PCW, WPAC, IAW, BCY, ECOSTAT)* | Intercept Only | 193.376 | | | |
| | | Final | 122.673 | 70.703 | 13.000 | 0.000 |
| | *(b) DTAMP= f(AGE, GENDER, EDU, DIST, GWU, PCW, WPAC, IAW, BCY, IWCUE)* | Intercept Only | 193.376 | | | |
| | | Final | 54.510 | 138.866 | 13.000 | 0.000 |
| *WLT* | *(a) WLT= f(AGE, GENDER, EDU, DIST, GWU, PCW, WPAC, IAW, BCY, ECOSTAT)* | Intercept Only | 253.725 | | | |
| | | Final | 159.319 | 94.406 | 13.000 | 0.000 |
| | *(b) WLT= f(AGE, GENDER, EDU, DIST, GWU, PCW, WPAC, IAW, BCY, IWCUE)* | Intercept Only | 253.725 | | | |
| | | Final | 160.119 | 93.606 | 13.000 | 0.000 |
| *ABWM* | *(a) ABWM= f(AGE, GENDER, EDU, DIST, GWU, PCW, WPAC, IAW, BCY, ECOSTAT)* | Intercept Only | 230.927 | | | |
| | | Final | 174.946 | 55.981 | 13.000 | 0.000 |
| | *(b) ABWM= f(AGE, GENDER, EDU, DIST, GWU, PCW, WPAC, IAW, BCY, IWCUE)* | Intercept Only | 230.927 | | | |
| | | Final | 174.887 | 56.040 | 13.000 | 0.000 |

Link function: Logit

In Model 1, the results obtained by regressing socio-demographic variables (*AGE* and *EDU*) on *DTAMP* exhibited a negative impact. However, the insignificance of these results precludes reliance, and thus, *H1* is rejected in the case of Model 1 (A) and (B). The results highlight that *AGE* and *EDU* variables have no bearing on the decrease in the number of tampering cases in the region. In the case of Model 2, *AGE*, however, has a highly significant negative impact in both the models *(Model 2(A): Coeff. = -1.880, p<0.01; Model 2(B): Coeff. = -1.859, p<0.01)*. This negative impact implies that with an increase in age, farmers' willingness to undertake training decreases. Additionally, *EDU* has a highly significant positive impact in the case of Model 2 *(Model 2(A): Coeff. = 1.283, p<0.01; Model 2(B): Coeff. = 1.234, p<0.01)*. So, with an increase in the level of education, the farmers demonstrated a higher willingness to undertake training. Overall, from the results of Model 2, *H1* stands accepted, implying thereby that both *AGE* and *EDU* play a vital role in determining farmers' willingness to undertake training for water conservation and management. Similar results have been obtained by testing the impact of socio-demographic variables *AGE (Coeff.= -1.135, p<0.01)* and *EDU (Coeff.= 0.868, p<0.01)* on ABWM through Model 3 (B). *H1* is thus accepted in the given case. On the contrary, Model 3 (A) demonstrated insignificant estimates, and thus, *H1* is rejected for this model. In sum, the results demonstrate that with increasing levels of education, farmers' willingness to adopt water conservation and management measures improved. However, with an increase in age, the resistance to adopting water conservation and management practices also saw a surge in the present study. These results are in consonance with that of Jaafar & Kharroubi (2021).

## Analysis of the Impact of Current Irrigation System on Water Conservation and Management Practices

From the results of Model 1 and Model 2, the impact of the current irrigation system in use on water conservation and management practices is statistically insignificant, thus leading to the rejection of *H2* in the case of both these models. This implies that the current usage of the irrigation system in the region does not influence the adoption of water conservation and management practices (*DTAMP* and *WLT*). On the contrary, a significant negative influence of *GWU (Coeff.= -0.006, p<0.01)* and *PCW (Coeff.= -0.031, p<0.01)* on *ABWM* has been observed under Model 3 (A). *H2* thus stands accepted in the case of Model 3. It can be inferred that the current pattern of groundwater usage for irrigation and preference for canal water over groundwater demonstrate a negative impact on the application-based water management methods for water conservation.

Further, it signifies that the farmers currently rely highly on groundwater for irrigation, and those who prefer canal water over groundwater demonstrated a negative interest in application-based water management. Likewise, Jaafar & Kharroubi (2021), in their study on smart irrigation apps, demonstrated that the majority of the participants in their study used groundwater for irrigation, followed by canal water and a combination of groundwater and canal water. They emphasized that one of the critical factors for farmers to optimize water use was irrigation scheduling. Further, in a study on the adoption of modern irrigation methods by Gebremeskel et al. (2018), it was found that earlier experience with the use of irrigation systems is a critical factor for the adoption of new systems in the region of the study.

Table 5: Regression Results of the Impact of Socio-Demographic Characteristics, Current Irrigation System and Cost-Benefit Perception of Farmers on Water Conservation and Management Practices.

| Independent variables | Model 1 | | | | Model 2 | | | | Model 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DTAMP | | | | WLT | | | | ABWM | | | |
| | A | | B | | A | | B | | A | | B | |
| | Coefficient | Std. error | Coefficient | Std. error | Coefficient | Std. error | Coefficient | Std. error | Coefficient | Std. error | Coefficient | Std. error |
| Dependent Variable | | | | | | | | | | | | |
| 1 | -3.938*** | 0.881 | -11.728*** | 2.275 | -3.460*** | 0.742 | -3.454*** | 0.738 | -3.994*** | 0.747 | -3.985*** | 0.747 |
| 2 | -2.997*** | 0.822 | -8.626*** | 1.782 | -1.355** | 0.626 | -1.347** | 0.621 | -1.248** | 0.548 | -1.235** | 0.549 |
| 3 | -1.256* | 0.749 | -3.205** | 1.427 | -1.003 | 0.619 | -0.997 | 0.614 | -0.963* | 0.542 | -0.95* | 0.543 |
| 4 | -1.016 | 0.744 | -0.725 | 1.237 | -0.440 | 0.614 | -0.444 | 0.608 | 5.065*** | 0.831 | 5.075*** | 0.831 |
| Covariate Variables | | | | | | | | | | | | |
| AGE | -0.039 | 0.291 | -0.253 | 0.495 | -1.880*** | 0.350 | -1.859*** | 0.349 | -1.131 | 0.271 | -1.135*** | 0.271 |
| EDU | -0.050 | 0.274 | 0.063 | 0.435 | 1.283*** | 0.282 | 1.234*** | 0.277 | 0.876 | 0.241 | 0.868*** | 0.242 |
| GWU | 0.057 | 0.273 | -0.114 | 0.407 | -0.561 | 0.360 | -0.482 | 0.350 | -0.006*** | 0.244 | 0.000 | 0.242 |
| PCW | -0.032 | 0.551 | 0.395 | 0.877 | 0.472 | 0.500 | 0.426 | 0.500 | -0.031*** | 0.471 | -0.038 | 0.468 |
| WPAC | 0.707 | 0.490 | 0.675 | 0.725 | 1.104** | 0.537 | 1.268** | 0.538 | 0.649 | 0.474 | 0.681 | 0.478 |
| IAW | -0.476 | 0.561 | -0.435 | 0.800 | -1.027* | 0.596 | -1.197** | 0.593 | -0.198 | 0.524 | -0.217 | 0.515 |
| BCY | 0.604 | 0.571 | 1.329 | 0.857 | 0.132 | 0.588 | 0.161 | 0.619 | -0.338 | 0.507 | -0.298 | 0.531 |
| ECOSTAT | 1.514*** | 0.570 | - | - | -1.127* | 0.604 | - | - | -0.195 | 0.500 | - | - |
| IWCUE | | | 2.878*** | 0.873 | | | -1.066* | 0.624 | | | -0.241 | 0.534 |
| Factor Variables | | | | | | | | | | | | |
| District | | | | | | | | | | | | |
| District=1 | -0.399 | 0.899 | -0.258 | 1.414 | -2.268** | 1.040 | -2.266** | 1.035 | -0.912 | 0.816 | -0.908 | 0.816 |
| District=2 | 0.357 | 1.021 | 3.337* | 1.903 | -1.002 | 1.065 | -1.085 | 1.053 | -0.269 | 0.829 | -0.249 | 0.833 |
| District=3 | 0.504 | 0.908 | 1.298 | 1.540 | -0.102 | 1.065 | -0.022 | 1.070 | -0.045** | 0.812 | -0.010 | 0.822 |
| District=4 | 0.648 | 1.014 | 3.308* | 1.958 | 1.498* | 0.880 | 1.537* | 0.881 | 0.616 | 0.742 | 0.645 | 0.747 |
| District=5 | 0.000 | . | 0.000 | . | 0.000 | . | 0.000 | . | 0.000 | . | 0.000 | . |
| Gender | | | | | | | | | | | | |
| Gender=1 | -0.057 | 0.744 | 0.179 | 1.241 | 2.104** | 0.833 | 2.028** | 0.823 | 0.897 | 0.623 | 0.890 | 0.622 |
| Gender=2 | 0.000 | . | 0.000 | | 0.000 | | 0.000 | | 0.000 | . | | |
| Negelkerke Pseudo R-squared (%) | 54.900 | | 85.200 | | 60.300 | | 59.900 | | 42.500 | | 42.500 | |
| Test of Parallel Lines | | | | | | | | | | | | |
| Chi square | 67.494*** | | 54.510* | | 35.841 | | 48.888 | | 107.686*** | | 108.289*** | |
| Pearson's Goodness of Fit | | | | | | | | | | | | |
| Chi square | 901.810*** | | 237.139 | | 512.077*** | | 479.139* | | 748.385*** | | 744.651*** | |

Note: (1) Regression estimates have been computed for a sample of 125 respondents.

(2) *, **, ***, respectively, indicates significant at the 10 percent, 5 percent, and 1 percent levels.

Source: Author's analysis.

### Analysis of the Impact of Cost-Benefit Perception of Farmers on Water Conservation and Management Practices

In the case of Model 1 (A), the results of the impact of cost-benefit perception of farmers on water conservation and management practices depicted that *ECOSTAT* exerted a highly significant positive impact *(Coeff.= 1.514, p<0.01)* on *DTAMP*. Similarly, in Model 1 (B), *IWCUE* exerted a highly significant positive impact *(Coeff.= 2.878, p<0.01)* on *DTAMP*. On the contrary, the variables *ECOSTAT (Coeff.= -1.127, p<0.1)* and *IWCUE (Coeff.= -1.066, p<0.1)* have a negative impact on *WLT* as reflected by the results of Model 2 (A) and (B). This implies that as the perception of economic status improves and the water conveyance and use efficiency increases, the willingness to undertake training takes a toll. Furthermore, *WPAC* exerted a significantly high positive impact on *WLT (Model 2(A): Coeff.= 1.104, p<0.05; Model 2(B): Coeff.= 1.268, p<0.05)*. This demonstrates that the farmers who are willing to pay additional charges are also supportive of undertaking training to learn modern technology in irrigation. Contrarily, a significant negative influence of *IAW* has been observed on *WLT* as reported in Model 2 *(Model 2(A): Coeff.= -1.027, p<0.10; Model 2(B): Coeff.= -1.197, p<0.05)*. This reflects that with an increase in the availability of water in the region, the farmers' willingness to undertake training for better management techniques decreases. Nevertheless, *H3* stands accepted for both Model 1 and Model 2 due to the significance of the present results. On the other hand, none of the variables has shown a significant impact in the case of Model 3, implying thereby that the cost-benefit perception of farmers has no impact on *ABWM*. This leads us to reject *H3* in this case. Overall, *H3* is accepted in the case of *DTAMP* and *WLT,* which signals that farmers believe that there has been a decline in tampering cases post-canal construction and are willing to undertake training for better conservation and management. Like the present study, Burt & Styles (1999), in a study of modern water control and management practices, also recommended that there exists greater potential to improve water management through increased conveyance and use efficiency as well as by undertaking optimized delivery measures.

In total, *H1* postulating a significant impact of socio-demographic variables on water conservation and management practices has been accepted as per the results of *Models 2 (A), 2 (B),* and *3 (B)*. This, therefore, signifies the direct influence of *AGE* and *EDU* on the willingness to undertake training and adoption of application-based water management techniques by the farmers. Further, *H2* has been accepted only in the case of *Model 3 (A)*, thereby implying that the current irrigation system exerts a major impact only on the perceptual use of application-based water management techniques. Finally, *H3* stands accepted in a majority of the models under investigation, viz., *Model 1 (A), 1 (B), 2(A),* and *2 (B)*. Thus, the high influence of the cost-benefit perception of farmers can be established in the decrease in tampering cases and farmers' willingness to undertake training. The overall results of the study have been summarized in Table 6.

### Robustness Tests

Several measures to establish the robustness of the results have been undertaken. First, Cox & Snell (in the range of 36.1-67.1%) and McFadden (in the range of 23.6-71.8%) pseudo R squares were computed in addition to Nagelkerke R square for the likelihood estimation measures in ordinal regression. Comparable results have been deduced using these alternative R square measures. Secondly, multiple linear regression with bootstrapped standard errors has been computed as an alternative measure of analysis. Broadly similar inferences have been derived using this alternate specification. For the sake of brevity, the results obtained have not been elaborated here.

## CONCLUSION

The present study highlights the importance of steps required in the direction of sustainable water conservation and

Table 6: Overall results.

| Hypotheses | Description | Results | | | | | |
|---|---|---|---|---|---|---|---|
| | | Model 1 DTAMP | | Model 2 WLT | | Model 3 ABWM | |
| | | A | B | A | B | A | B |
| H1 | There is a significant impact of socio-demographic factors on water conservation and management practices. | Reject | Reject | Accept | Accept | Reject | Accept |
| H2 | There is a significant impact of the current irrigation system on water conservation and management practices. | Reject | Reject | Reject | Reject | Accept | Reject |
| H3 | There is a significant impact of the cost-benefit perception of farmers on water conservation and management practices. | Accept | Accept | Accept | Accept | Reject | Reject |

management practices. Concrete canal lining is deemed an appropriate measure for sustainable irrigation along with other modern technology-driven practices, such as app-based monitoring and irrigation control, that help in efficient water management. The results of the study demonstrated that socio-demographic variables play a key role in the acceptance of modern irrigation practices and willingness to adopt water conservation practices. Further, the farmers also demonstrated a willingness to pay additional charges for canal water. The respondents also believed that by undertaking training there is a likelihood of an increase in the availability of water in the region by efficient management of irrigation practices. The results further point out that there is an expectation of a decrease in the number of tampering cases in the region. Additionally, an increase in the economic status and an increase in water conveyance and use efficiency are envisaged, which will ultimately lead to water conservation.

With the increasing problem of depleting water tables on account of excessive usage and changing properties due to groundwater irrigation in the Haryana region, it is important to spread awareness amongst the farmers about water conservation practices. The findings of the study, thus, have recommendations for the academicians, government, non-profit institutions, society at large, and the environment in general. First, the research provides a backdrop for the evaluation of the current irrigation practices in the selected region. It suggests designing appropriate strategies for increasing water conveyance efficiency and thereby ensuring sustainable water use. Second, keeping sustainable development in perspective, non-governmental agencies can collaborate with governmental institutions to initiate training and education programs for the farmers for better management of irrigation sources. Third, corporate/industrial participants can step in to develop modern technologies, such as the use of app-based water management, which is essential in today's world to enhance farm productivity and conserve water. Fourth, industry participants/engineers can aid in the development of materials and construction technologies for canal lining so as to improve water use efficiency. Finally, the increased awareness about the pertinence of environmental conservation is gaining traction among international agencies (e.g., United Nations Sustainable Development Goal 13- Climate Action). Economies are thus required to take immediate remedial actions for the preservation of the environment for future generations, with water being one of its most essential components.

Given the prominence of water in both farm and non-farm activities, the study carries important implications for determining practical ways and means of efficient water management. The study ignites a sense of realization that this extremely valuable resource must be utilized judiciously with the intent to save it for future generations. India has been grappling with water scarcity, which calls for investment in efficient water management technologies such as micro-irrigation. There is also a need for private sector participation in resource augmentation and efficiency. This strongly calls for strict implementation of remedial measures for the steady wherewithal of the irrigation system. For instance, maintenance works and rehabilitation of the canal lining are some such imperative measures.

The present study has the following contributions to the implementation of efficient water conservation and management practices. First, to create awareness about the benefits of sustainable use of water and its impact on the environment. The study suggests undertaking large-scale public awareness programs so as to improve water conservation consciousness among the masses in general and the farmers in particular. Secondly, the study emphasizes the role of policy-makers in bringing change in irrigation practices through the training of farmers and propagating technology-based irrigation management. Thirdly, the study is expected to offer insights to industrial corporations about the willingness of farmers to undertake training and adoption of modern technology for irrigation. This will help them to develop modern application-based systems of irrigation and appropriately assist the farmers.

The study is, however, limited in scope on account of the study of perception in restricted geographical areas in the state of Haryana, India. On account of the same, the views of the present sample of farmers cannot be generalized for all regions across the world as this might vary based on the conditions of the area. Further, the water conservation attitudes presented by the farmers cannot be used for actual behaviors. Though the questionnaire was iterated in the regional language and utmost care has been taken while translation of the same, yet gap in understanding and interpretation may have resulted in some distortion in the results. The study mainly focuses on practices farmers can adopt for water conservation and sustainability; however, technical parameters for the efficiency of transportation of the irrigation water and canal lining cannot be commented upon.

Future research endeavors can attempt to explore the technicalities of the shape and materials of canal lining. The present study restricts socio-demographics, current irrigation systems, and cost-benefit perceptions of farmers; however, factors such as the conjunction of various water conservation techniques applied together in different proportions along with the lining of the water courses can provide interesting insights. Furthermore, the study may be replicated in another geographical jurisdiction to establish the region-specific perceptual differences.

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