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Precision Agriculture Technologies; The Socioeconomic Determinants Of The Canal Lining Adoption

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Abstract

Pakistan being an agricultural-based economy, needs to pull-out of the problems related to the agriculture sector. Irrigation system of Pakistan has leads to various seepage losses from the canals. The canal seepage leads to various problems including salinity and the waterlogging, ultimately devastate the land and its agriculture use. This study explores the causes of the water loss before the canal lining and its impact on the agriculture productivity, along with the[1] socioeconomic impact of the canal lining on the farmers and relevant respondents. The targeted area of the study was the agricultural zone of Faisalabad region of Punjab, Pakistan. Simple random sampling technique were utilized to collect the sample of 140 respondents. An amalgam of quantitative and qualitative sampling is adopted by relaying on surveys, interviews, observations and analysis of data. A descriptive analysis is conducted to analyze the data by using percentage and frequency method.

The results indicate that the 46.4% respondents have 17-25 minutes per Acer of time allocated for canal water turn followed by 32.9% with 16 minutes allocated for canal water turn. Majority of respondents (47.1%) reported that water quality is improved after lining. Sixty-five percent view that the lining has reduce water logging to some extent, only 13.6% reported it ineffective. The 50.7% of total are concerned to some extent for water resources depletion while 31% to great extent. Majority (45% of respondents) report that canal lining is useless in preventing crops from the pest attack. 50.7% report that any industry exploits the canal while 49.3% said no industry use it. Majority reported that government policies are available for farmers (65.7%). It is indicated that there is significant relation between the farmer's age & education and the assessment of the socio-economic impact of canal lining. Higher income also leads to higher assessment of the socioeconomic impact of lining. Thus, most of the farmers support the canal lining except few favoring the Kacha Warabandi system. Findings favor the socioeconomic factor and their role in defining the farmers' behavior. Yet the effective planning, reducing conflicts, improving allocation and distribution can be helpful increasing capacity of the croplands and the sustain the agriculture sector equitably.

Keyword: *socioeconomic impact, canal lining, water seepage, waterlogging, salinity.*

Introduction

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The Punjab Irrigation Department is implementing the Punjab Irrigation System Improvement Project (PISIP), funded by the Japan International Cooperation Agency (JICA). This project includes the "Rehabilitation of Khadir Feeder, Khadir District, and Chenab Escape" and a study on the impact of canal lining in Punjab (PISIP, 2016). Canal lining involves protecting the canal prism with impervious material to improve its longevity and discharge capacity (Saad, 2016).

Socio-economic impact assessments (SEIA) evaluate the range of impacts from planned changes, like canal lining, and design strategies to minimize negative effects while maximizing positive outcomes. Canal lining can create job opportunities, improve living standards, and address waterlogging issues by reducing seepage losses (Mackenzie, 2007).

Environmental impact assessments (EIA) aim to support sustainable development by extending valuable environmental properties and avoiding negative effects. Effective EIAs help design long-term feasible projects that balance irrigation and drainage impacts (Wallingford et al., 2012).

Water is crucial for economic development, especially in agricultural countries like Pakistan. In areas like Sindh and Khairpur, agriculture relies heavily on water supply. However, water shortages due to issues like India's occupation of Pakistani rivers can have significant socio-economic consequences. Canal lining reduces seepage, controls waterlogging, and increases canal capacity, although it may also reduce groundwater recharge and impact biodiversity (Asim et al., 2012).

Poor water and sanitation can lead to serious public health risks. Properly managed canal lining can improve water quality, reduce waterborne diseases, and enhance overall health (UNESCO, 2007; Dennis et al., 2013). Canal lining in Pakistan needs more research on material suitability and economic viability (Riaz et al., 2005).

Economic evaluation is crucial for planning future strategies. Proper assessment helps enhance project benefits, increase production, and ensure food security (Munir et al., 2015). Lining canals improves landscape aesthetics, reduces maintenance costs, and minimizes breach risks (Zuberi, 1999).

Reservoirs and canals are vital for water storage and frequency distribution in agriculture. Lined canals prevent seepage and waterlogging, although unlined canals help recharge groundwater (Mirudhula, 2014). Canal maintenance is necessary to sustain irrigation systems, but it can disturb sediments and impact water quality downstream (Victoria, 2015).

Waterlogging from canal seepage can harm crop production, and excessive irrigation by farmers exacerbates this issue (Kharag, 1998). Providing safe drinking water and sanitation is essential for health and economic benefits (UN Millennium Project, 2005). Household water treatment can improve water quality for those in need but requires behavior change (Maria et al., 2010).

Studies provide with that lined watercourses significantly reduce water losses compared to unlined ones. For example, lined watercourses in the Indus Basin reduce water loss by 22.5% (Arshad et al., 2009). Seepage losses can be drastically reduced through lining, which saves water for irrigation and household use (Uchdadiya, 2014).

Lining canals also prevents soil salinity and waterlogging, improving soil productivity and crop yields (Waltina et al., 2003). However, lining is expensive and requires maintenance, but its benefits outweigh the costs (Munir et al., 2015).

Different methods and materials are used for canal lining, each with varying efficacy, life expectancy, and cost (Khyati et al., 2016). The irrigation system in Pakistan, especially in Sindh, faces significant water losses due to seepage, which affects agricultural land. Canal lining is a solution, though it can be challenging due to crop cycle disruptions (Ashfaques et al., 2013).

Pakistan's irrigation system is extensive, but seepage losses are a serious problem. Lining canals reduces these losses, enhances bank stability, and decreases maintenance costs (Rabeia et al., 2003). Various lining methods, including concrete and chemical treatments, improve irrigation efficiency but require regular maintenance (Tahir et al., 2009).

Seepage losses can be measured using methods like ponding tests, which are considered precise. Factors influencing seepage include canal linings, soil properties, and groundwater table location (Liqiang et al., 2012). Lining targeted areas with high seepage losses can save significant water for agricultural use (Martin, 2015).

Underdeveloped countries often face water scarcity due to unlined canals. Quantifying and addressing seepage losses can significantly improve irrigation systems and crop yields (Sultan et al., 2014). Conveyance losses from seepage significantly impact agricultural productivity, but canal lining can mitigate these losses (Tariq et al., 2014).

Canal lining plays a crucial role in reducing water losses, increasing irrigation efficiency, and supporting sustainable agriculture. Proper maintenance is essential to ensure the long-term benefits of canal lining (Yaragatti, 1982; Maghrebi et al., 2011). Operational and seepage losses are the most significant issues in water conveyance, and effective management is necessary to minimize these losses (Saeed et al., 2014).

The aim of study is to estimate the losses and establish the effective ways to overcome those losses and to ensure maximum efficiency. We analyze the socioeconomic nature of the farmers, study the pros and cons of lining and the socioeconomic influence of canal lining in Faisalabad region. Assuming that the canal lining too has some demerits we provide with the ways to reduce the potential negative impacts of canal lining.

Literature review

Irrigation system play an important role in fostering agricultural productivity and socio-economic development, can be done only through water management. Yet the threats including the declining water table and the inefficient frequency distribution system are significant challenges to the farming community of Pakistan. Various researches highlight the importance of the water management in improving the crop yield and income level of the farmers. Zaidi (1993) conclude that the reduced irrigation facilities and irrigation supply result in lower produce, reduce the income and strengthen poverty among farmers. Conversely, efficient water supply through canal lining significantly boosts farmers' economies and agricultural productivity.

IDWR (2005) highlighted the substantial water wastage due to low conveyance efficiency in Pakistan's Indus Basin canal system. This inefficiency restricts water deliveries to agricultural areas, impacting crop cultivation. Addressing these losses through canal lining can enhance water frequency distribution and supplement irrigation supplies at a lower cost.

Ahmad and Butt (1993) identified seepage as a major cause of water conveyance losses in irrigation systems, leading to significant water wastage before reaching farms. They stressed the importance of reducing conveyance losses to maximize water-saving potential.

Chancellor (1993) concluded that canal lining offers a substantial return on investment, with a 30% increase in efficiency observed in main canals and major distributaries.

Zeb et al (2000) highlighted various factors contributing to conveyance losses in watercourses, including seepage from turnouts, sedimentation, weed growth, and unlined canal banks. These losses underscore the need for effective water management strategies.

Skogerboe (1999) demonstrated that lined watercourses significantly reduce water losses compared to unlined ones, with potential savings of up to 22.5%. However, challenges such as poor maintenance and structural failures can affect the effectiveness of canal lining projects.

Copland (1987) reported conveyance losses ranging from 38% to 62% in watercourses in Khushab district, prompting the implementation of projects like On-Farm Water Management (OFWM) to address these issues.

IWASRI (2004) concluded that lined watercourses exhibit higher conveyance efficiency compared to unlined ones, with a 12% to 14% increase observed in efficiency.

Zafar (2004) emphasized the importance of canal lining in improving agricultural productivity, enhancing rural infrastructure, and boosting economic conditions in rural areas.

Pardhan et al (1999) highlighted the link between agricultural efficiency, poverty alleviation, and migration patterns. They emphasize on the role of irrigation projects in preventing land abandonment and migration to urban centers. 80% concluded that abandonment of the land leads to the migration toward cities.

Asim et al (2012) identified factors contributing to water shortages in Pakistan, including inadequate planning for new dams, climatic variations, and population growth. They stressed the need for sustainable water management practices to address these challenges.

Sharif (2010) centered upon that the cost of the farmers in Punjab has increased because of the dependence of the tube wells for irrigation, resulted from the lack of canal water supply. Addressing water crises requires a balance between agricultural needs and energy considerations.

Usman (2014) emphasized the importance of addressing functional and conveyance losses in irrigation systems to maximize agricultural production. Water frequency distribution can be optimized by adopting water management strategies and maintaining of irrigation infrastructure.

Afzal (1996) highlighted water scarcity problems can be resolved by water conservation practices and employing sustainable resource management. Artificial rainwater harvesting and canal lining can play a significant role in improving irrigation efficiency.

Haq & Khan (2002) also study the impact of the water losses on the agriculture productivity and provides with the measures to combat the impact by ensuring water management practices implementation and overcoming the water scarcity challenges.

The seepage losses can be minimized by using the canal water lining in irrigation system. Studies have indicated that lined watercourses can proved to be helpful in reducing seepage losses by 8% to 19.8% (Irrigation research institute, 1992).

Burt et al (2010) conducted studies on soil compaction to minimize seepage rates in irrigation canals. Compacting canal banks and bottoms can reduce seepage rates by up to 90%, improving water conservation.

Tanji et al (2002) highlighted the significant seepage losses from unlined canals, ranging from 20% to 30% of total water volume. Canal lining is essential for reducing these losses and improving water efficiency.

Chang et al (2001) emphasized the role of vegetation in soil and water conservation. The problem of soil erosion and water seepage can be reduced by plantation of grasses and clovers on the canal channel edges. Office of the Operation and Maintenance of Dams (2013) focus on minimizing the water losses by employing effective management operations. Employing measures that can be useful in reducing the water loss in form of evaporation from reservoirs, as is significant cause of water scarcity resulted from loss.

Hassani (2013) conducted experimental demonstration to estimate the rate of evaporation in dams by using empirical study and the budget approach. Understanding evaporation rates is crucial for water resource management and preventing water loss.

Armstrong et al (2008) evaluated different methods for estimating evaporation rates from water bodies. They concluded that longer-term methods are suitable for accurate evaporation rate calculations.

Schertzer (1978) compared evaporation rates by using energy budget method and mass transfer method and found that former one was more reliable than later method.

Mostafa et al (2009) discussed the impact of climate change, in term of increasing temperature resulting in reduction of water resources and agriculture. They emphasized the need for physical methods in comparison to chemical methods (reduce evaporation only by 20-40%) to reduce evaporation rates and combat the effects of global warming.

Arnell (1999) highlighted the complex interplay between climatic and non-climatic factors that influence the water availability of future. Managing the population growth, technological advancement, water management practices is essential for sustainable water use and economics of agricultural development.

Moghazi (1997) emphasized the importance of appropriate canal lining methods to minimize seepage losses effectively. Cost-effective lining solutions can optimize water conservation efforts.

Choudhary et al (2007) developed analytical methods for measuring seepage and recharge rates in irrigation canals. These methods provide accurate assessments of water losses and aid in developing targeted solutions for water management.

Kahlown et al (2004) deduce that the hydraulic properties (arrangement of canal bank etc.) and character of soil have strong impact on the water losses from the canal. Thus known behavior and features of the soil is important for crafting effective water management strategies.

Cevik et al (2000) highlighted the challenges of managing conveyance losses in irrigation systems. Efficient water management practices are essential for reducing losses and optimizing water frequency distribution.

Plusquellec (2006) provides that the long-term potential of canal lining is reduced when is constructed by using sub standards goods and wrong procedures. An alternative solution is to use the geosynthetic materials that can act as a sustainable option in preventing the water seepage.

WAPDA PC-1 (2000) underline aim was to ensure the equitable water frequency distribution in all areas and it is evident across different regions of world that canal lining improves water frequency distribution efficiency and ensures equitable access to water resources.

Kavita et al (2014) emphasized the significance of addressing seepage losses in irrigation systems. Identifying and recovering these losses can enhance water conservation efforts and improve agricultural productivity.

BIPINCHANDR et al (2016) advocated for reservoir-based irrigation systems to address farmers' water needs. Equitable water frequency distribution and increased water storage capacity can benefit agricultural communities.

Agriculture plays a crucial role in economic growth and food security globally, especially in developing regions. According to Ararso et al. (2009), agriculture is responsible for 80% of food production in Pakistan and 50% in India, underscoring its importance in these countries. However, in sub-Saharan Africa, only 9% of food is produced through agriculture, despite the availability of sufficient water resources and land. The challenge lies in the underutilization of these resources, with only 16.8% of potentially arable land being developed for irrigation.

Effective water management is essential for improving agricultural productivity. Gal et al. (2009) argue that current administrative systems are inadequate in ensuring food safety and suggest that improving organizational frameworks and involving stakeholders can enhance the situation. They highlight the importance of better water management practices and the integration of farms and agro-food processors to boost productivity.

Water loss through inefficient irrigation practices is a significant issue. Burt (2008) demonstrated that compacting the sides and bottoms of irrigation canals can substantially reduce seepage, thus conserving water. Rashid et al. (2005) highlighted the critical role of irrigation water in crop success, noting that significant water losses result in less irrigated area than potential.

In Bangladesh, Sattar et al. (2009) pointed out that a large amount of water is wasted in rice plots due to continuous ponding. Sayed (2010) emphasized the importance of command area development to improve irrigation efficiency, noting substantial transportation losses in earthen canals. Rashid (1991) discussed the uneven frequency distribution of water resources in Bangladesh and the growing significance of groundwater exploitation.

Conflicts over water frequency distribution can be mitigated through structured systems like the pacca warabandi in Punjab, which ensures fair water allocation among farmers, as highlighted by Chaudhry (1996). Conversely, the kacha warabandi system often leads to disputes during periods of scarcity.

Water quality is another concern. Kijne et al. (1991) found that groundwater quality deteriorates towards the tail ends of distributary command areas, affecting crop yields. Mercer and Morgan (1986) discussed the challenges water suppliers face in pricing water to recover costs while maintaining political and administrative feasibility.

Improving irrigation systems can alleviate poverty, as evidenced by NDA (1996) in South Africa. Revamping irrigation systems can increase yields and incomes, thereby reducing poverty. However, outdated water planning approaches have led to unforeseen ecological impacts, as Covich (1993) observed.

In conclusion, as agriculture determines the food security and economic stability in developing countries and is susceptible to various challenges including inefficient water management, water frequency distribution conflicts, and environmental impacts. Improving governance, adopting participatory approaches, and employing sustainable practices are essential for boosting agricultural productivity and ensuring food security.

Methodology

Research design: The research involves studying the impact of the socioeconomic determinants on the canal lining in the region of Faisalabad, disadvantages of canal lining and the measure suggested to ensure the reduction of the potential negative impacts of the canal lining. The study is based on the following conceptual framework developed for the empirical conduct.

Table 1: conceptual framework:

Independent Variables/ Background variables	Dependent Variables
• Canal lining • Seepage looses • Salinity • Irrigation	• Social and economic problems • Living standard • Poor health • Fertile land • Income • Safe drinking water • Maintenance of canals • Water saving • Progressive rural areas

Table 2: Socioeconomic factors analysis:

Factor	Rationale	Source
Age	Plays an important role in determining the behavioral outcome, difference in age leads to different responses	Gould and William,1980
Education	Is an important determinant of individual response	Gould and Kalbe, 1995
Occupation	Activity to earn livelihood and to work	Seligman, 2002

Data collection: An organized interview schedule is developed for the collection of the data from the relevant farmers. Simple random sampling technique is used for the collection of the data. The sample size is 140 observations.
Two stage data collection procedure is employed to overcome the challenges associated with data collection. Pre-testing the interview schedule on 15 farmers helps in identifying and rectifying any issues in the questionnaire. This step ensures the validity and reliability of the data collection tool, leading to better responses and more accurate data.
Then an interview schedule, consisting of structured questions, is used to gather data. This tool, as described by Goode and Hatt (1992), enables precise data collection through face-to-face interactions with farmers. The questions are designed to cover various aspects of the research, such as socioeconomic characteristics, disadvantages of canal lining, and its socioeconomic impacts.
Data collected through interviews are then analyzed by using the SPSS (statistical package for the social science) which is further analyze to made discussion and deduce possible recommendation and the practical implications.

Sampling: It is comfortable to study sample rather than whole population. Sample is proportion of the population that truly represent the population, having all the characteristics of population (Houghton, 2000).

Data analysis: Data collected through interviews are then analyzed by using the SPSS (statistical package for the social science) which is further analyze to made discussion and deduce possible recommendation and the practical implications.
The technique of frequency frequency distribution is utilized to analyze each of the variable, the descriptive analysis of the variables are provided in the result section.

Results & discussions:

Results of socioeconomic determinants:

Table 3: age group

Age groups (in years)	Frequency	Percentage
Up to 25	31	22.1
26-35	77	55.0
Above 35	32	22.9
Total	140	100.0

Table no. 3 provides that the farmers with the age up to 25 are the 22.1% of total respondents. 55.0% of respondents have age between 26 to 35 years and 22.9% of farmers have age above 35 years (frequency= 32 out of 140). So, most the farmers belonged to middle age group.

Table 4: Frequency distribution of farmers regarding their educational level.

Education	**Frequency**	**Percentage**
Up to middle	23	16.4
Matric	37	26.4
Above Matric	80	57.1
Total	140	100.0

Table no. 4 reflects that the farmers regarding their education where up to middle are 16.4%, matric are 26.4% and above matric are 57.1%. So, most of the farmers are above matric.

According to Gould, et al. 1998. "Education is the source of influencing human behavior. It is a mental influencing human behavior, so that it fits into the prevailing patterns of social interaction and organization".

Table 5: Frequency distribution of the farmers regarding their family structure.

Family structure	Frequency	Percentage
Nuclear	37	26.4
Joint	103	73.6
Total	140	100.0

Table no. 5 given that, most of the farmers belong to joint family structure. While only 26.4% of the respondent farmers are living in the nuclear family system.

Table 6: Frequency distribution of farmers regarding family size.

Family Size (Nos.)	**Frequency**	**Percentage**
Up to 5	36	25.7
6-10	65	46.4
Above 10	39	27.9
Total	140	100.0

Table no. 6 provide with the information that majority of the families vary in size from 6-10 members (=46.4%). 46.4%. 27.9% have family members more than 10 while only 25.7% are farmers residing in the family of the members up to 5. So, most of the farmers have 6-10 family members.

Table 7: Frequency distribution of the farmers regarding their profession.

Profession	**Frequency**	**Percentage**
Govt. employee	33	23.6
Farmer	83	59.3
Self employed	20	14.3
Unemployed	4	2.9
Total	140	100.0

Table no. 7 convey that 23.6% of farmers also are employed in the government sector, 59.3% are entirely engaged in farming, 14.3% are self-employed, & 2.9% are unemployed. Therefore, major portion of the respondents are solely or merely farmer. According to Seligman (2002), a profession is any activity that is conducted steadily to make source of income and ensure a living standard.

Table 8: Frequency distribution of the farmers & their monthly household income.

Income (Rs.)	**Frequency**	**Percentage**
Up to 25000	42	30.0
25001-40000	72	51.4
Above 40000	26	18.6
Total	140	100.0

Table no. 8 give us the results of the farmers in relation with the monthly household income they earned, where 30.0% among them belongs to the lower income group, 51.4% have the income in between 25001-40000 and 18.67% have the income above 40000. So, majority of the farmers belong to middle income group.

Table 9: Frequency distribution of farmers regarding tenancy status.

Tenancy status	Frequency	Percentage
Owner	114	81.4
Tenant	11	7.9
Owner-cum tenant	15	10.7
Total	140	100.0

Table no. 9 manifest that 81.4%, majority of farmers have tenancy status of ownership, only few 7.9% are tenant, while some 10.7% have tenancy status of owner-cum tenant. So, majority of the farmers have their own house.

Table 10: Frequency distribution of farmers regarding their land size (Acer).

Size of land holding	Frequency	Percentage
Up to 10	39	27.9
11-20	52	37.1
Above 20	49	35.0
Total	140	100.0

Table no. 10 reflects that 27.9% farmers use the land up to 10 Acer, 37.1% farmers own land of 11 to 20 Acers, while Above 2 Acer of land is owned by the 35% of respondent farmers. So, mostly farmers have 11 to 20 Acer land.

Table 11: Frequency distribution of the farmers according to approximate electricity bill.

Electricity per month bill	Frequency	Percentage
Up to 5000	69	49.3
5001-7500	28	20.0
Above 7500	43	30.7
Total	140	100.0

Table no. 11 provide with that 49.3% of the farmers have up to 5000Rs. Electricity bill per month, 20.0% farmers 5001 to 7500Rs. Electricity bill, while 30.7% farmers above 7500Rs. Electricity bill.

Table 12: Frequency distribution of the farmers suffering from water born disease.

Response	Frequency	Percentage
Yes	43	30.7
No	97	69.3
Total	140	100.0
If yes		
Diarrhea	13	9.3
Cholera	3	2.1
Malaria	2	1.4
Other	25	17.9
NA	97	69.3
Total	140	100.0

Table 12 shows that 30.7% of farmers are afflicted by the water-borne diseases, while the remaining 69.3% remains unaffected. Among those who are troubled, diarrhea suffer the 9.3% of farmer’s child, cholera suffer the 2.1% of child, 1.4% suffer from malaria, and 17.9% from various other waterborne diseases.

Table 13: Frequency distribution of the farmers & when there child incurred diarrhea, how much and what is drink availability to them.

Response	Frequency	Percentage
Milk	20	14.3
ORS	40	28.6
No response	80	57.1
Total	140	100.0

Table no. 13 reflects that 14.3% farmers said that when a child has diarrhea thy give him milk, 28.6% said that they give ORS to that patient while 57.1% farmers give no response.

Table 14: Frequency distribution of farmers according to visit of health center.

Response	Frequency	Percentage
Govt. hospital	46	32.9
Private hospital	59	42.1
Dispensary	20	14.3
Other	15	10.7
Total	140	100.0

Table no. 14 reflects that 32.9% farmers visit to Govt. hospital when they have a health problem, 42.1% farmers visit to Private hospital in case of health problem, 14.3% of framers visit to dispensary in case of emergency , while other 10.7% farmers visit any other health center.

Table 15: Frequency distribution of the farmer's satisfaction to health facilities.

Response	**Frequency**	**Percentage**
Yes	66	47.1
No	74	52.9
Total	140	100.0

Table no. 15 convey that in the targeted region the health facilities are sufficient for the 47.1% of the farmers, ensuring there level of satisfaction with the available infrastructure, while remaining 52.9% are dissatisfied with facilities available to them.

Table 16: Frequency distribution of the farmers according to growing crops and production.

Crop	Frequency	Percentage	Avg. yield	Std. Dev.
Wheat	84	60.0	36.69	7.68
Rice	63	45.0	40.16	10.57
Sugarcane	80	57.1	972.16	417.14
Cotton	30	21.4	37.28	7.90

Maize	10	7.1	58.00	20.47

Table 16 shows that 60.0% of farmers cultivate wheat with an average yield of 36.69 monds. Additionally, 45.0% of farmers grow rice, achieving an average yield of 40.16 monds. Sugarcane is grown by 57.1% of farmers, with an average yield of 972.16 monds. Cotton is cultivated by 21.4% of farmers, yielding an average of 37.28 monds. Finally, 7.1% of farmers grow maize, with an average yield of 58.00 monds.

Table 17: Frequency distribution of farmers regarding to allocated time of canal water turn.

Total allocated time of their canal water turn (warabandi) per acre	Frequency	Percentage
Up to 16 minutes	46	32.9
17-25 minutes	65	46.4
Above 25 minutes	29	20.7
Total	140	100.0

Table no. 17 provide with s that 32.9% of the farmers said that total allocated time of their canal water turn is up to 16 minutes per Acer, 46.4% farmers have 17 to 25 minutes per Acer, and other 20.7% farmers have above 25 minutes per Acer.

Table 18: Frequency distribution of the farmers according to tube well facility.

Tube well facility	Frequency	Percentage
Yes	100	71.4
No	40	28.6
Total	140	100.0

Table no. 18 manifest that majority of the farmers take the help of the tube wells among the irrigation facilities, as reported by them (=71.4%). While some still are unable to take assistance from the tube well may be due to installation and operational cost associated with it. So majority is getting advantages from the tube well.

Table 19: Frequency distribution of the farmers regarding water saved from lining has increased irrigation.

Response	Frequency	Percentage
To a great extent	109	77.9
To some extent	23	16.4
Not at all	8	5.7
Total	140	100.0

Table no. 19 reveals that 77.9% respondent reported that water saved from canal lining has increased irrigation to great extent, while 16.4% farmers agreed to some extent with this benefit of canal lining and remaining only 8 farmers(5.7%) not agreed with this benefit of canal lining.

Table 20: Frequency distribution of farmers regarding improvement in water quality after lining.

Response	Frequency	Percentage
To a great extent	25	17.9
To some extent	66	47.1
Not at all	49	35.0
Total	140	100.0

Table no. 20 provide with that 17.9% farmers, reported that canal lining is effective in improving the water quality to greater extent, 47.1% reported that water quality improved to some extent as an outcome of lining and remaining 35.0% farmers are diverge from this statement.

Table 21: Frequency distribution of the farmers regarding canal lining is a good thing.

Response	**Frequency**	**Percentage**
To a great extent	59	42.1
To some extent	69	49.3
Not at all	12	8.6
Total	140	100.0

Table no. 21 reveals that canal lining is effective to great extent as reported by 42.1% farmers, whereas 49.3% agree to some extent that it is effective. Only a few of 8.6% farmers do not align with the concept of importance of canal lining and its benefits.

Table 22: Frequency distribution of farmers regarding canal lining increased productivity of crops.

Response	**Frequency**	**Percentage**
To a great extent	57	40.7
To some extent	35	25.0
Not at all	48	34.3
Total	140	100.0

Table no. 22 reflects that 40.7% farmers reported that canal lining increased the productivity of crop to great extent, 25% respond that productivity is increased after canal ling but to some extent, while 34.3% farmers totally disagree with this.

Table 23: Frequency distribution of farmers regarding water demand of animals affected by canal lining.

Response	Frequency	Percentage
To a great extent	42	30.0
To some extent	70	50.0
Not at all	28	20.0
Total	140	100.0

Table no. 23 reveals that 30.0% of the farmers said that water demand of animals affected by lining to great extent, 5% farmers reported that it affected to some extent, while 20% farmers think that water demand of animals do not affected by lining the canals.

Table 24: Frequency distribution of the farmers regarding lining has reduced water logging.

Response	Frequency	Percentage
To a great extent	30	21.4
To some extent	91	65.0
Not at all	19	13.6
Total	140	100.0

Table no. 24, indicate that the issue of water logging can be overcome by canal lining to great extent, 65% farmers think that water logging is reduced only to some extent while 13.6% farmers think that there exists no significant relation between water logging and lining of the canals.

Table 25: Frequency distribution of the farmers regarding ground water depletion overtime.

Response	Frequency	Percentage
To a great extent	44	31.4
To some extent	71	50.7
Not at all	25	17.9
Total	140	100.0

Table no. 25 indicate that the ground water is depleting overtime to great extent as reported by 31.4% farmers. The major portion of farmers about 50.7% view that there is ground water depletion only to some level. While 17.9% farmers think that there is no ground water depletion.

Table 26: Frequency distribution of the farmers regarding, unlined canals were reason of bad environment due to unbalance flow of water in canals before lining.

Response	Frequency	Percentage
To a great extent	27	19.3
To some extent	44	31.4
Not at all	69	49.3
Total	140	100.0

Table no. 26 provide with that only 19.3% of the farmers are of the view the unlined canals as a reason behind bad environment, 31.4% said that unlined canals were reason of bad environment to some extent while majority think that they had no linkage at all (=49.3%) .

Table 27: Frequency distribution of the farmers according to problem with water supply.

Response	Frequency	Percentage
To a great extent	51	36.4
To some extent	46	32.9
Not at all	43	30.7
Total	140	100.0

Table no. 27 provide with that majority farmers having problem with water supply (=36.4), 32.9% farmers having issue with the water supply to some extent while other 30.7% farmers have no problem with water supply.

Table 28: Frequency distribution of farmers regarding canal lining saves crops from pest attacks.

Response	Frequency	Percentage
To a great extent	44	31.4
To some extent	33	23.6
Not at all	63	45.0
Total	140	100.0

Table no. 28 disclose that the majority of farmers (= 45%) think that the canal lining cannot play any role in defining the attack or disease caused by the pest to the crops. Only 31.4% of the farmers think that this measure may be proved effective to great extent in preventing the crops from the invaders. 23% of farmers view it to be proved effective to only few extent.

Table 29: Frequency distribution of the farmers regarding water theft.

Condition of water theft	Frequency	Percentage
Frequently	69	49.3
Never	17	12.1
Rarely	54	38.6
Total	140	100.0

Table no. 29 reflects that majority 49.3% farmers said that water theft is frequent , 12.1% farmers there is no water theft, while 38.6% farmers said that there is water theft but rarely.

Table 30: Frequency distribution of the farmers regarding water quality.

Water quality	**Frequency**	**Percentage**
Very poor	40	28.6
Acceptable	91	65.0
Very good	9	6.4
Total	140	100.0

Table no. 30 given that the farmers with the frequency of 40 out of 140 consider the water has a poor quality (=28.6%), major part of farmers (65% farmers) said that water has acceptable quality, while only 6.4% said that water quality is very good.

Table 31: Frequency distribution of the farmers regarding water dispute.

Status of water dispute	**Frequency**	**Percentage**
Frequently	72	51.4
Never	41	29.3
Rarely	27	19.3
Total	140	100.0

Table no. 31 reflects that major part of community view the water disputes as frequent occurring event (51.4%), 29.3% of the respondents disclose that there is never any conflict on water in the village while 19.3% confirmed that it may takes place seldom in the village.

Table 32: Frequency distribution of the farmers regarding inter village communication facility.

Response	**Frequency**	**Percentage**
Good	45	32.1
Normal	64	45.7

Poor	31	22.1
Total	140	100.0

Table no. 32 give the information that the intercommunication infrastructure is available and useful in villages (it is good= 32.1%), major portion of farmers (45.7% farmers) view that inter village communication facilities are average, while inter-village communication is very poor as perceived by (frequency= 31) 22.1% of farmers.

Table 33: Frequency distribution of the farmers regarding incentive provided to shopkeepers near canal.

Response	Frequency	Percentage
Yes	27	19.3
No	113	80.7
Total	140	100.0

Table no. 33 provides with the information that shopkeepers are given with the incentive as reported by the 19.3% of the farmer respondents, whereas major portion of farmers (80.7% farmers) said that no incentive given to shopkeepers.

Table 34: Frequency distribution of the farmers & improvement in their incomes.

Response	Frequency	Percentage
Yes	109	77.9
No	31	22.1
Total	140	100.0

Table no. 34 reveals that majority of farmers reported that their incomes are increased as a result of canal lining (=77.9%), while 22.1% respondents view that there is no significant relation between the income and the canal lining adoption.

Table 35: Frequency distribution of farmers regarding, any industry which uses water of canal.

Response	**Frequency**	**Percentage**
Yes	71	50.7
No	69	49.3
Total	140	100.0

Table no. 35 reflects that majority 50.7% farmers said that there is industry which uses the water of canal, while 49.3% farmers that there is no industry nearby.

Table 36: Frequency distribution of the farmers regarding to equality of water for all the farmers.

Response	**Frequency**	**Percentage**
Yes	50	35.7
No	90	64.3
Total	140	100.0

Table no. 36 provide with s that only 35.7% farmers reported that frequency distribution of ater is equal for all the farmers, while majority 64.3% farmers reported that frequency distribution of water is not equal for all farmers.

Table 37: Frequency distribution of the farmers regarding government policy provided benefits to farmers.

Response	Frequency	Percentage
Yes	92	65.7
No	48	34.3
Total	140	100.0

Table no. 37 disclose that major portion of respondents (65.7% farmers) view that governments make effort to craft the policies for the sustainability of the agriculture sector and stability of the farmer lives, whereas 34.3% farmers reported that there is no government policy available to them for the improvement of lives.

HYPOTHESES formulation and testing:

Hypothesis 1: Higher age of farmers leads to higher assessment of socio-economic impact of canal lining.

Table 38: Relationship between age of the selected farmers and their assessment of socio-economic impact of canal lining

Age (in years)	**Socio-economic impact**			Total
	Low	Medium	High	
Up to 25	15	8	8	31
	48.4%	25.8%	25.8%	100.0%
26-35	36	30	11	77
	46.8%	39.0%	14.3%	100.0%
Above 35	5	14	13	32
	15.6%	43.8%	40.6%	100.0%
Total	56	52	32	140
	40.0%	37.1%	22.9%	100.0%

Chi-square = 9.83 d.f. = 4 P-value = .043* Gamma = .183
** = Highly significant

Table 38 provide with the relation between age of farmers and their assessment of socio-economic impact of canal lining. Chi-square value (9.83) reflects a significant association between age of the farmers and their assessment of socio-economic impact of canal lining. Gamma value also reflects a positive relationship between the variables. It means, old age farmers had more assessment of socio-environmental impact of canal lining as compared to lower age farmers. So, the hypothesis "more age a farmer has the greater the probability of more assessment of socio-economic impact of canal lining" is proved.

Hypothesis 2: Higher level of education possessed by farmers leads to higher assessment of socio-economic impact of canal lining.

Table 39: Relationship between education of the selected farmers and their assessment of socio-economic impact of canal lining

Education	**Socio-economic impact**			Total
	Low	Medium	High	
Up to middle	11	7	5	23
	47.8%	30.4%	21.7%	100.0%
Matric	23	9	5	37

	62.2%	24.3%	13.5%	100.0%
Above Matric	22	36	22	80
	27.5%	45.0%	27.5%	100.0%
Total	56	52	32	140
	40.0%	37.1%	22.9%	100.0%

Chi-square = 30.15 d.f. = 4 P-value = .000** Gamma = .268
** = Highly significant

Table 39 provide with the relation between education of the farmers and their assessment of socio-economic impact of canal lining. Chi-square value (30.15) reflects a highly significant linkage between education of the farmers and their assessment of socio-economic impact of canal lining. Gamma value also reflects a positive relationship between the variables. It reflects that farmers with education matric and above have more assessment of socio-environmental impact of canal lining as compared to lower level educated farmers. So, the hypothesis "more the education a farmer has the greater the probability of assessment of socio-economic impact of canal lining" is proved.

Hypothesis 3: Higher the income of the farmer leads to higher assessment of socio-economic impact of canal lining

Table 40: Relationship between income of the selected farmers and their assessment of socio-economic impact of canal lining

Income	**Socio-economic impact**			Total
	Low	Medium	High	
Up to 25000	26	8	8	42
	62.0%	19.0%	19.0%	100.0%
25001-40000	25	34	13	72
	34.7%	47.2%	18.1%	100.0%
Above 40000	5	10	11	26
	19.2%	38.5%	42.3%	100.0%
Total	56	52	32	140
	40.0%	37.1%	22.9%	100.0%

Chi-square = 18.48 d.f. = 4 P-value = .001** Gamma = .318
** = Highly significant

Table 40 illustrates the relationship between farmers' income and their evaluation of the socio-economic impact of canal lining. The chi-square value (18.48) indicates a highly significant association between these variables. The gamma value also reveals a positive correlation. This implies that higher-income farmers had a greater assessment of the socio-environmental impact of canal lining compared to lower-income farmers. Therefore, the hypothesis "Higher the income of the farmers, higher will be the assessment of socio-economic impact of canal lining" is confirmed.

Recommendations:

1. The government should advocate for lining all watercourses and channels.
2. Implement concrete lining for canals and watercourses to conserve water and boost agricultural productivity.
3. Recommend lining the sides of canals, rather than the beds, to protect the underground water table.
4. Canal lining should be promoted to enhance water quality and prevent waterborne diseases.

5. Lined canals reduce water disputes among farmers.
6. Canal lining helps prevent waterlogging and flooding.
7. Ensure equitable frequency distribution of water to all agricultural areas through canal lining.
8. Minimize water conveyance losses by lining canals.
9. Improve the financial stability of farmers by adopting canal lining.
10. Increase the capacity of canals by lining them.
11. Recommend using materials for lining that have low maintenance costs.

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