A Comparative Analysis of Economic Performance of Farmers under Participatory Irrigation Management vs Non-Participatory Irrigation Management

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Abstract

This paper examines the economic performance of the farmers under two water governance models i.e participatory and non-participatory irrigation management system. We developed economic indicators of crop cultivation practices, marketing and profitability and labor demand. Subsequently, variables for each indicator were also developed. We used multistage cluster and quota-based sampling techniques. Primary data was collected from 140 farmers. Four distributaries were selected. A 5-scale Likert survey questionnaire was used to collect primary data on economic performance. Kruskal-Wallis-H-Test and Post-Hoc-Mann-Whitney-U-Test were used for analyzing the data. We conclude that crop cultivation practices at the tail end have improved. There has also been a paradigm shift recorded among farmers. from cultivating number of acres to number crops per acre with respect to water availability. Under marketing indicator, we found that all farmers selling their products individually reduces the bargaining power of the farming community. Labor demand has increased due to labor migration from tail-end areas.

Keywords: Participatory Irrigation Management, Economic Performance, Reforms

Introduction

Human knowledge and understanding dictate water to be the central pillar to life essentially evolves. Being a finite common pool resource, in economic terms, it can be categorized as an absolute scarce good. The availability of water is subject to geographical locations. Some regions have enough water supply not only to meet current but all future demand as well. In other regions, however, water demand exceeds its supply and threatens the environment, the human living in it and their economic development. Arguably, the greatest challenge to humankind is creating a mechanism which ensures the effective and efficient utilization of water. The per capita availability of water is drastically reducing and will reach critical levels in future, owing to the ever-increasing population. Some regions already face acute water shortages. Therefore, water management and governance has become a global issue. According to UN water scarcity is mainly an issue of governance.

Many countries are reforming their water governance models under integrated water resources management (IWRM) principles. The International Conference on Water and Environment (1992) commonly known as Dublin principles, declares that:

- Fresh water is a finite, vulnerable and essential resource, which should be managed in an integrated manner.
- Water development and management should be based on a participatory approach, involving users, planners and policy makers at all levels.
- Women play a central role in the provision, management and safeguarding of water.
- Water has an economic value and should be recognized as an economic good, taking into account affordability and equity criteria.

As per Memon and Mustafa (2012) inequitable water distribution for agriculture, irrigation subsidies, cost recovery, operational management, and corruption are the main water sector challenges in Pakistan. Some experts suggest that non-inclusion or non-involvement of final consumers in water management decision-making is main problem within the water sector (Bandaragoda, 2006). Therefore, Participatory Irrigation Management (PIM) was introduced as a magic bullet for the solution of these problems. It was assumed that the involvement of stakeholders through decentralization will become the new normal, allowing them to reap social, economic and environmental benefits on their own. Consequently, in the late 1990s Pakistan also introduced irrigation sector reform, infused with the spirit of PIM. Resultantly Punjab and Sindh provinces established their own irrigation and drainage authorities in 1997, with the vision to contribute to the sustainable development of the country.

Another assumption of the reforms was that once farmers form and managed their own organizations, they would potentially take common actions to manage the system and secure economic benefits, all the while selling agriculture and livestock products, and purchasing economic inputs as well. Once the farmers became economically well off, they would pay the cost of the water and irrigation system as well. This research study focuses on whether or not farmers under the PIM are earning economic benefits, compared to their non-PIM counterparts.

Objective

The main objective of the study is to investigate the comparative performances of farmers of PIM and non-PIM in reaping economic benefits from the agriculture sector.

Research Question

Are farmers under PIM seen improved crop cultivation, marketing & profitability, increased labor demand, and abiana payment as compared to non-PIM farmers?

Hypotheses

H01 Farmers under PIM have improved crop cultivation practices as compared to non-PIM farmers

H02 Farmers under PIM are performing better in marketing and profitability of their crops as compared to non-PIM farmers

H03 Areas under PIM have increased labor demand due to increased agricultural activities as compared to non-PIM areas

Literature Review

Irrigation Sector Challenges

The irrigation sector faces numerous challenges in Pakistan. The challenges include governance and policy issues, operation and maintenance of old infrastructure, a subsidized irrigation sector, inequitable irrigation water distribution and corruption in the water sector, (Memon and Mustafa, 2012) over-exploitation of groundwater, increasing water logging and salinity, (Faruqee & Carry, 2007, Nakashima 1999) and diminishing water tax collection (Hussain et al., 2021). As of today, the irrigation sector is heavily subsidized. But this was not always the case. In Punjab, the recovery from the irrigation sector significantly contributed to the national income till 1970s. Now, however, withdrawing subsidies does not differ in other three provinces (Planning Commission of Pakistan, 2012). Now, the system is collecting 62% of O&M cost (Bandragoda, 1999). Resultantly, budget allocations by governments were not enough to maintain the system properly, hence its deteriorating state.

Water as an Economic Good

The declaration of International Conference on Water and Environment (ICWE) in 1992 in Dublin explicitly defined water as an economic good. The Conference defines states, "Water has an economic value in all its competing uses and should be recognized as an economic good". The fourth principle of Dublin principles (1992) says, "Water has an economic value and should be recognized as an economic good, taking into account affordability and equity criteria."

Here, an economic good means anything which has an economic value.

Conditions of availability, regarding relative or absolute scarcity, helps markets define or assign something as an economic good. As per Malthus (1970), scarcity, "implies a strong and constantly operating check on population from the difficulty of subsistence". In terms of water, the term is defined as, "A good is scarce in relation to other scarce goods". In terms of water, absolute scarcity in economics is something that carries opportunity costs (Zisopoulou et.al. 2022). So, in order to define something as an economic good, it must meet two characteristics i.e scarcity and opportunity cost or other potential uses. Water has both characteristics. In the Dublin Water Principles (1992), the first principle state that "Water is a finite, vulnerable and essential resource which should be managed in an integrated manner".

Since the year this has been the dominant approach, globally supported by the development community, it has been named as the Integrated Water Resources Management (IWRM) approach. Resultantly, IWRM has become the dominant global approach. The IWRM approach aims to, "ensure a process that promotes and coordinates development and management of water, land, and related resources in drainage basins to maximize economic and social welfare equitably, without compromising the sustainability of vital ecosystems" (Katusiime & Schütt, 2020).

Performance on Equity

Equity has many dimensions, but in terms of irrigation water, it disregards size. With landholding, equity becomes the protection of rights, fairness and transparency of users in procedures (Mustafa D., 2002). In theory, PIM promotes equity in water distribution, as it ensures farmers' participation in water management. Resultantly, it improves the equitable distribution of water.

Water allocation in Pakistan is based on land holding area in acres. In surface irrigation areas, water is distributed on *warabandi,* which can be defined as a system where allotted irrigation time is proportional to landholding size (Anwar & Haq, 2013). Usually, it is based on weekly rotation, where farmers receive water for certain number of minutes per acre. It varies with crop type, season and location of land on canal. Warabandi systems ensure the number of minutes but not quantity of water. Warabandi system changes rotation timing with every new crop, meaning two times in a year (Bandragoda & Rehman, 1995). The system itself has equitable water distribution. But due to political influences and corruption of officials more water is distributed at heads and less water is available for tail-end landowners. At governmental levels, equitable water distribution is measured by canal depth at the tail with "tail-gauge". If water is flowing at a certain gauge level, it means equitable water distribution has been reached by a water agency (Anwar & Haq, 2013).

Performance of FOs in promotion of equity depends on various factors like maturity level of FOs, capacity of managing day to day issues, participation by FO members in various activities. Memon and Mari (2014) conducted a study on "Factors influencing equity in farmer-managed irrigation distribution in Sindh, Pakistan". The study concludes that equitable water distribution is directly linked with maturity, continuous institutional capacity building and participation. Furthermore, they have identified a "mass effect" on increase in equity, concluding that with an increase of 10 members, a FO would probably increase five percent in equity. 75% members of FOs show their satisfaction of the water distribution mechanism (Memon and Mari 2014). Farmers are satisfied with warabandi mechanism of water distribution, but studies have increasingly shown they do not explain why the remaining 25% remained unsatisfied. Regardless of the majority of the farmers being satisfied with the water distribution, this satisfaction is not reflected in WTP.

The many research studies have focused on performance evaluation of water governance systems, whether it be comparative analyses of the two approaches of water governance or measurement performance with past and present. Some other aspects are its financial performance, service delivery, increases in productivity and so on. But these studies have not focussed on the economic performance of the farmers of both water management systems.

Conceptual Framework

The following conceptual framework explains how better economic output and performance can be achieved under PIM and non-PIM:

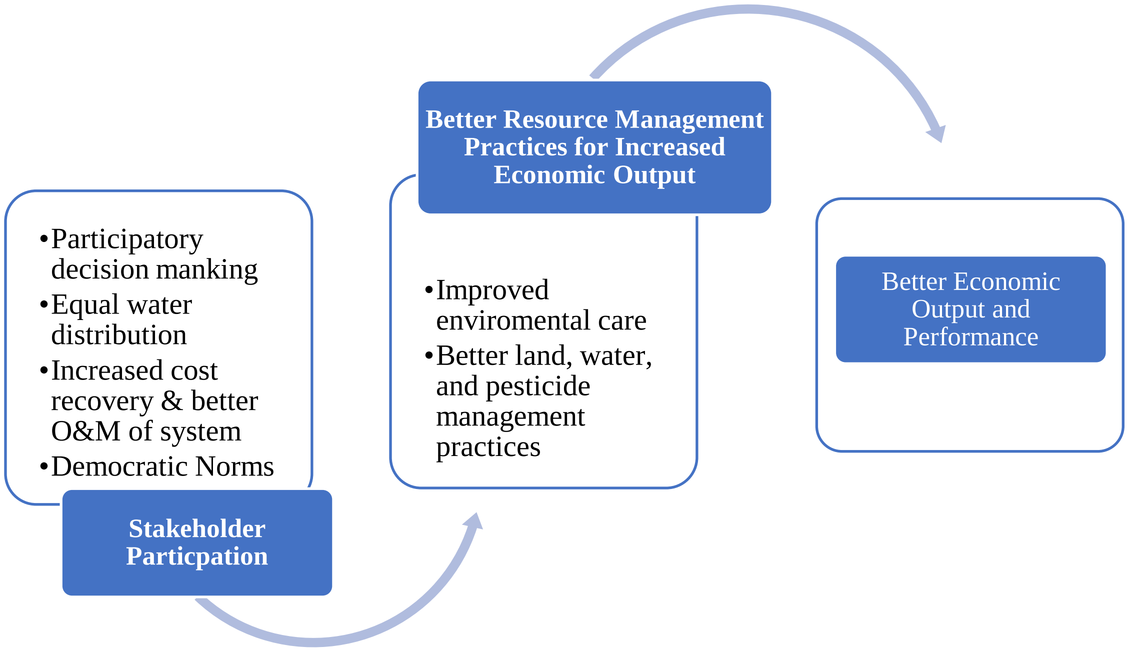

Figure **Error! No text of specified style in document.**-1 Conceptual Framework

Methodological Framework

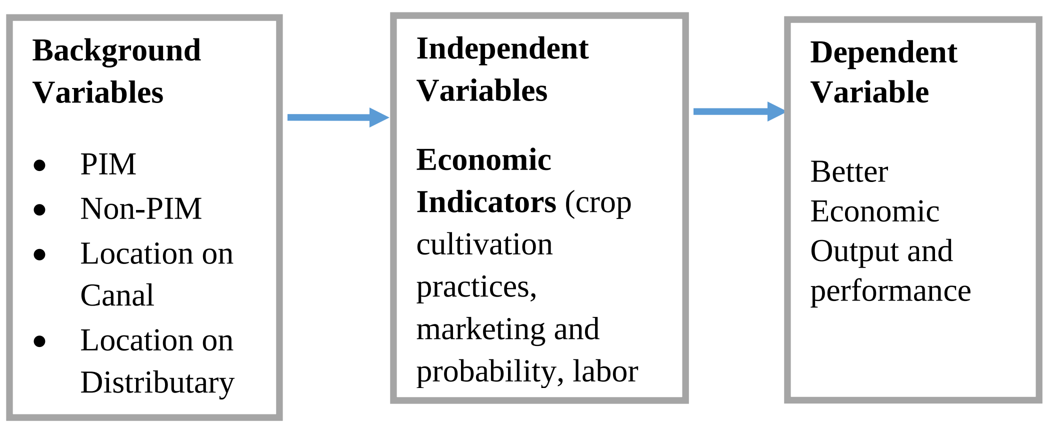

Figure II Methodological Framework

Methodology

In order to achieve the laid down objectives and answer the research question, this study observes four distributaries at Nara Canal. The Canal is being governed by Sindh Irrigation and Drainage Authority (SIDA). To compare performance, four distributaries were selected with the attributes of Farmers Organization as PIM representative and Non-Farmers Organization as non-PIM representative. The location attribute was head PIM and non-PIM and tail PIM and non-PIM. The performance comparison has been carried out by comparing head with head and tail with tail distributaries.

Sample Size

The sample was selected through a multistage sampling technique. In multistage sampling, two or more than two levels of components are connected together (Acharya, A. S. et al, 2013). It encompasses the recurrence of two fundamental steps: listing and sampling (Daniel, J. 2011). Typically, the cluster sampling reduces in size and number with each stage, with the final sampling being carried out at the last stage (Acharya, A. S. et al, 2013). Cluster sampling is a type of probability sampling in which population elements are selected randomly in naturally occurring groupings (Daniel, J. 2011). In the case of this study, the canal system is considered as cluster.

In this research study, the first stage Area Water Board (the canal being managed by SIDA under PIM system) was selected. In the second stage, the canal was selected. In the third, distributaries and in the fourth stage, water courses were selected. Finally, at the fifth stage, Khatedaars were selected randomly.

Overall, four distributaries were selected at Nara Canal: two from each participatory and non-participatory irrigation management system. The selected distributaries were Daulatpur as a PIM head and Khatian as a PIM tail, Belharo as a non-PIM head and Mureed as a non-PIM tail. At each distributary 35 respondents were randomly interviewed.

Data Collection Tool

A structured questionnaire was developed to assess the economic performance of the users of both systems to collect primary data. A 5-point Likert scale used in the questionnaire. It went from strongly disagree to strongly agree.

The questionnaire consisted of a respondent profile, variables with regard to economic indicators were crop cultivation practices that took place, marketing and profitability of crops and labor demand as key indicators (Table I). These indicators and their variables were helpful in analyzing how a changing water governance paradigm has impacted economics of the farmers through crop cultivation practices, cropping intensity, crop diversification, and collective action for getting the right market prices for the produce and buying of inputs.

Table I: Economic Indicators and Variables

S. No	Indicators	Variables
1	Crop Cultivation Practices	Cropping intensity, crop rotation, increase in land under cultivation, and crop diversification.
2	Marketing and Profitability	Right prices of production, sell product jointly, increase in production due to improved water management, and availability of adequate infrastructure and marketing to give good prices.
3	Labor Demand	Increased demand of labor in agriculture, and migration of agricultural labor due to non-availability of water.

Pilot testing of the tool was carried out prior the collection of primary data. The pilot testing was designed to identify missing items, assess content validity, and ensure these questionnaire items were clear and understandable. The ambiguities were removed from the tools after pilot testing.

Data Analysis Technique

Due to the non-parametric nature of the collected primary data, non-parametric tests such as Kruskal-Wallis H Test and Post Hoc Mann Whitney U Test are used to analyze the economic indicators. Kruskal-Wallis H test is applied when there are three or more independent groups (Nussbaum, 2014). Mann Whitney U test is applied when there are two independent groups (Nussbaum, 2014). This has been applied as a Post Hoc test. While the crop production section was analyzed by using the parametric methods i.e. One-way ANOVA test and post hoc Tukey's HSD test. Further, this study applied descriptive statistics (frequency analysis) on some indicators related to water problems.

Kruskal-Wallis H Test

Kruskal-Wallis H test is a non-parametric test. It was carried out to analyze the difference between farmers of FO and Non-FO in head and tail distributaries at Nara canal giving preference to indicators.

$$H = \left[\frac{12}{n(n+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i}\right] - 3(n+1) \qquad (1)$$

Where k is the number of populations, n_i is the number of observations in sample i, n is the total number of all the samples, and R_i is the sum of the ranks for sample i.

Mann-Whitney U Test

Post Hoc test (i.e., Mann-Whitney U test) was performed to those statistically significant indicators in the Kruskal-Wallis H test to analyze the difference between selected farmers groups.

$$U = R - \frac{n(n-1)}{2} \qquad (2)$$

Where R is the sum of ranks in the sample, and n is the number of items in the sample.

One-Way ANOVA Test

One-Way ANOVA test was carried out to determine the significance in crop yield between farmer groups.

$$F = \frac{MST}{MSE} \qquad (3)$$

$$MST = \frac{\sum_{i=1}^{k}(T_i^2/n_i) - G^2/n}{k-1} \qquad (4)$$

$$MSE = \frac{\sum_{i=1}^{k}\sum_{j=1}^{n_i} Y_{ij}^2 - \sum_{i=1}^{k}(T_i^2/n_i)}{n-k} \qquad (5)$$

Where F is the variance ratio for the overall test. MST is the mean square due groups (between groups, MSE is the mean square due to error (within groups, residual mean square), Y_{ij} is an observation, T_i is a group total, G is the grand total of all observations, n_i is the number in group i and n is the total number of observations.

Tukey's Test

Post hoc Tukey's test was carried out to the difference in farmer groups that were statistically significant in One-Way ANOVA test.

$$HSD = q\sqrt{\frac{MSE}{n}} \qquad (6)$$

Where q is constant, MSE mean square within (from ANOVA output), and n is number of items in one sample.

A Kruskal-Wallis H test was carried out to analyze the difference between farmers of the PIM head (Daulatpur), PIM tail (Khatian), non-PIM head (Belharo) and non-PIM tail (Mureed) distributaries at Nara canal giving preference to governance indicators. And a Post Hoc test (i.e., Mann-Whitney U test) was performed to analyze the difference between farmers of the FO head (Daulatpur), FO tail (Khatian), non-FO head (Belharo), and non-FO tail (Mureed) distributaries at Nara canal, giving preference to those governance indicators that were statistically significant in the Kruskal-Wallis H test. In the Post Hoc test each statistically significant variable was pairwise compared between different farmers groups (i.e., FO head with FO tail, FO head with non-FO head, FO head with non-FO tail, FO tail with non-FO head, FO tail with non-FO tail, and non-FO head with non-FO tail).

Results and Discussions

This section presents the results and discussion on the set indicators to compare the economic performance of both PIM and non-PIM systems.

Crop Cultivation Practices

The crop cultivation changing in other distributaries specially at tail may be the cause of shortage of water. This result is aligned with result of earlier section of water and land management practices where farmers shared that they cultivate crops and land as per the expected water availability.

The other variable under cultivation practices was increase in the cropping intensity. A Kruskal-Wallis H test shows the significant difference of p=0.006 among the different farmer groups. Interestingly cropping intensity has increased in the tail areas, the result suggests that due to shortage of water now farmers in tail are having multiple crops at the same time and in same area of land to get the maximum economic benefit of limited water. On the other hand, the situation is different in head distributaries, where the cropping intensity has not increased. Within tail distributaries the mean rank of non-PIM tail is higher as compared to even PIM tail suggesting that the cropping intensity has increased over the years at non-PIM tail.

A Kruskal-Wallis H test revealed a statistically significant difference in the land under cultivation, which has increased between the different farmer groups. The mean rank of 55.75 for PIM tail, and 66.92 for non-PIM tail are much higher as compared to head distributaries. This result was quite interesting. Farmers at tail distributaries shared that their land under cultivation has increased. It ran slightly counter to earlier results, as they already described that due to water shortages, they cultivate limited land. They explained that from last year, Chief Engineer of Nara Canal has taken serious actions on water theft. As a result, they were able to receive more water and cultivate more lands. Within tail distributaries the mean rank of PIM tail is higher than non-PIM tail suggesting that the land under cultivation has increased at PIM tail as compared to farmers at non-PIM tail.

Improved water management leads to crop diversification and adoption of more profitable crops. Variables have insignificant differences between the different farmer groups. PIM tail has the highest mean rank, as compared to other distributaries. This is indicative that PIM tail farmers have not only improved water management practices but are also acquiring economic benefits through crop diversification as well.

Table 2 Crop Cultivation Practices

Variables	Mean Rank				Chi-Square	p-value	Post hoc
	PIM Head	PIM Tail	Non-PIM Head	Non-PIM Tail			
The cropping intensity has increased over the years	39	54.89	42.04	61.02	12.436	0.006	a*, b$^{n.s}$, c**, d$^{n.s}$, e$^{n.s}$, f**
The land under cultivation in your area has increased	34.72	55.75	39.83	66.92	25.229	0.000	a**, b$^{n.s}$, c**, d*, e*, f**
Improved water management leads to crop diversification and adoption of more profitable crops	41.54	60.48	47.7	48.16	6.239	0.101	

a = Difference between PIM Head and PIM Tail; b = Difference between PIM Head and Non-PIM Head; c = Difference between PIM Head and Non-PIM Tail; d = Difference between PIM Tail and Non-PIM Head; e = Difference between PIM Tail and Non-PIM Tail; f = Difference between Non-PIM Head and Non-PIM Tail.
*significant at 0.05; **significant at 0.01; n.s = Not significant

Marketing and Probability

Marketing of agriculture products and earning profitability from crops are key economic indicators for farmers' wellbeing. Therefore, this study asked several questions and statements on how farmers are marketing their products and profiting from them.

There is statistically insignificant difference between the different farmer groups. The majority, irrespective of PIM or non-PIM farmers, disagreed that they are getting the right prices for their crops. Only at Mureed distributary, non-PIM tail 28% farmers shared that they are getting right prices.

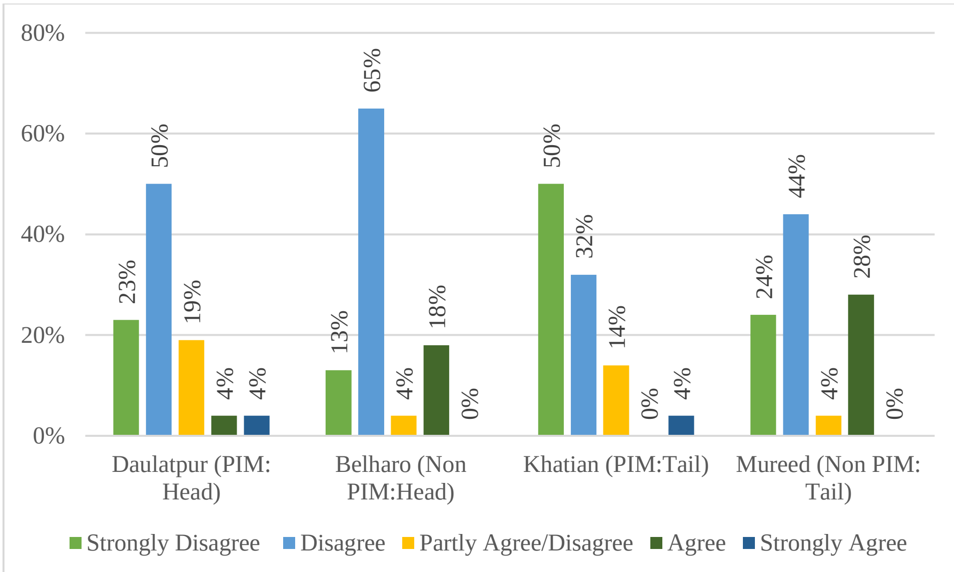

Figure 1: We are Getting Right Price for our Production

The PIM system encourages the joint actions by farmers in their farming activity. To assess the joint action in selling their crops, this study asked whether they sell their product jointly or separately. The joint selling of the product often increases the bargain position of farmers and acquires maximum economic benefit. Despite acknowledging not getting fair prices, the farmers are not able to sell their crops jointly. The Kruskal-Wallis H test revealed a statistically insignificant difference in joint selling of production between the different farmer groups. Furthermore, the majority of the farmers agreed that better water management practices increase production, resultantly allowing them to acquire more profits as well.

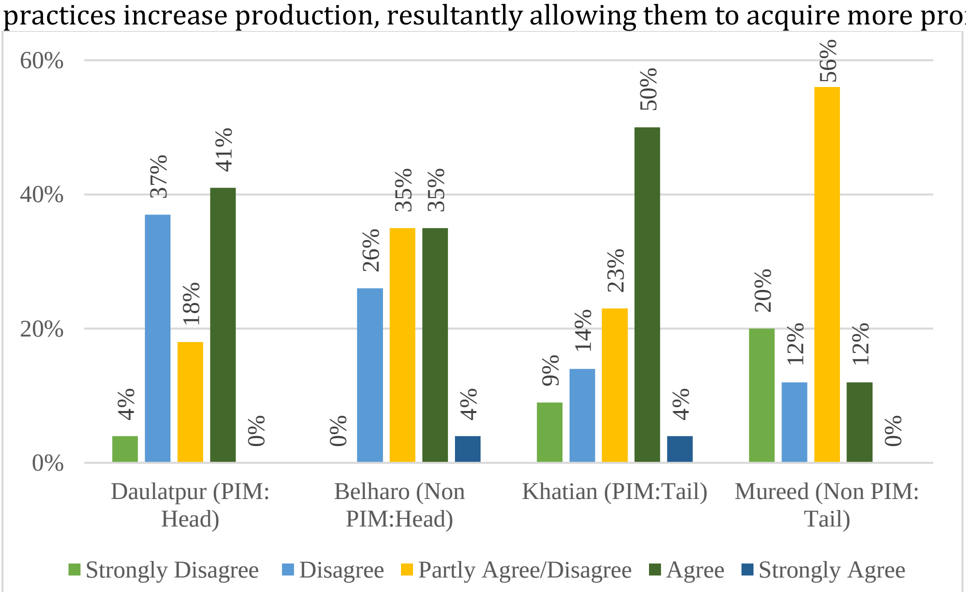

Figure 2: Improved Water Management gives Substantial Increase in Production and

Marketed Surplus from the Farming Activity

As most of the agriculture products have little perishable life, it is necessary to have adequate infrastructure and processing facilities available, so that the product can easily travel from farm to market to gain maximum economic benefits. In this regard, this study inquired about the adequate availability of these facilities. The test results revealed a statistically significant difference in adequate infrastructure, marketing and processing arrangements are available to give good prices between the different farmer groups. Further, the results show that the non-PIM head has location advantage, as it is in proximity to the main road of Mirpurkhas and Digri. Therefore, their farmers have a comparative advantage of access to market as compared to other distributaries.

A Kruskal-Wallis H test revealed a statistically insignificant difference in improved water availability and management leading to good profitability between the different farmer groups. $\chi2(2) = 3.725$, $p = 0.293$, with a mean rank of 46.11 for PIM head, 58.23 for PIM tail, 48.63 for non-PIM head and 44.34 for non-PIM tail.

Table 3: Marketing and Profitability

Variables	Mean Rank				Chi-Square	p-value	Post hoc
	PIM Head	PIM Tail	Non-PIM Head	Non-PIM Tail			
We are getting the right price for our production	49.85	37.41	52.8	52.9	5.444	0.142	
We sell our production jointly	46.2	40.98	50.26	57.92	6.048	0.109	
Improved water management gives substantial increase in production and marketed surplus from the farming activity	48.19	57.52	52.93	38.76	6.354	0.096	
Adequate infrastructure, marketing/processing arrangements are available to give good prices	42.67	33.84	64.93	54.52	17.307	0.001	$a^{n.s}$, b**, $c^{n.s}$, d**, e**, $f^{n.s}$
Improved water availability & management lead to good profitability to the farmers	46.11	58.23	48.63	44.34	3.725	0.293	

a = Difference between PIM Head and PIM Tail; b = Difference between PIM Head and Non-PIM Head; c = Difference between PIM Head and Non-PIM Tail; d = Difference between PIM Tail and Non-PIM Head; e = Difference between PIM Tail and Non-PIM Tail; f = Difference between Non-PIM Head and Non-PIM Tail.

*significant at 0.05; **significant at 0.01; n.s = Not significant

Labor Demand

Increase in the agriculture labor demand is another significant indicator for economic activity in the agriculture sector. A Kruskal-Wallis H test revealed a statistically insignificant difference in increased demand of labor in the agriculture sector between the different farmer groups. $\chi2(2) = 5.462$, $p = 0.141$, with a mean rank of 49.07 for PIM head, 57.73 for PIM tail, 39.95 for non-PIM head and 47.28 for non-PIM tail. The descriptive analysis shows that only PIM-tail agreed with the statement and shared that there is an increased agriculture labor demand in their area.

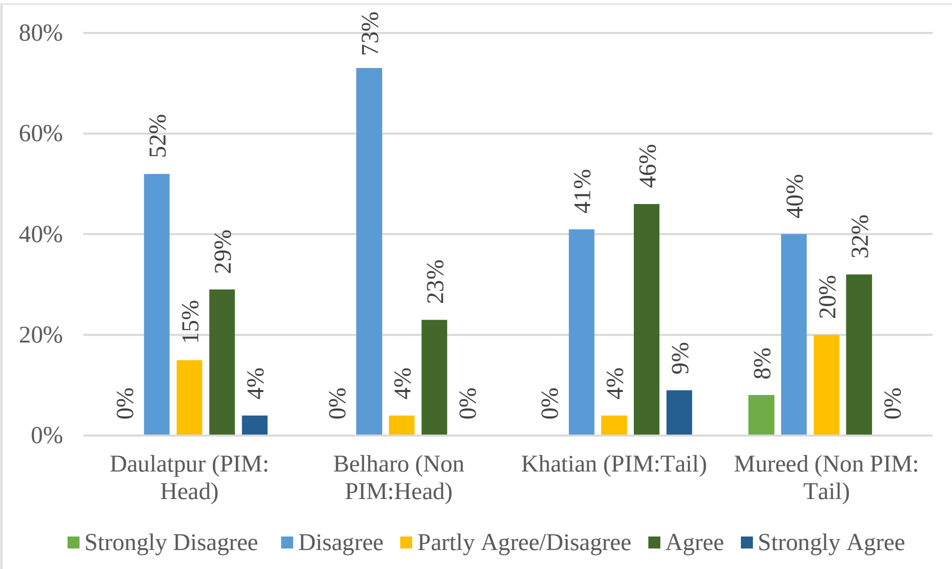

Figure 3: There is the Increased Demand of Labor in Agriculture Sector

The next question was about migration of agriculture labor from the area. The test results revealed a statistically significant difference in agriculture labor migration rates due to non-availability of water between the different farmer groups. The analysis further discloses that labor migration is taking place in tail distributaries. That is obvious, as reduced water availability has forced farmers to cultivate their land as per water availability. Thus, there is reduction in land. Under-cultivation has forced labor to move in the areas where they can find their livelihoods.

Table 4: Difference between PIM and Non-PIM Farmers Giving Preference to Labor Demand

Variables	Mean Rank				Chi-Square	p-value	Post hoc
	PIM Head	PIM Tail	Non-PIM Head	Non-PIM Tail			
There is an increased labor demand in agriculture sector	49.07	57.73	39.95	47.28	5.462	0.141	
Agriculture labor is migrating due to non-	47.44	50.16	38.26	59.54	8.667	0.034	a[n.s], b[n.s], c[n.s], d[n.s],

availability of water							$e^{n.s}$, f^{**}

a = Difference between PIM Head and PIM Tail; b = Difference between PIM Head and Non-PIM Head; c = Difference between PIM Head and Non-PIM Tail; d = Difference between PIM Tail and Non-PIM Head; e = Difference between PIM Tail and Non-PIM Tail; f = Difference between Non-PIM Head and Non-PIM Tail.
*significant at 0.05; **significant at 0.01; n.s = Not significant

Agriculture Practices, Cost and Product Pricing
Majority of farmers at PIM and non-PIM systems have agreed or strongly agreed that they face the problem of using poor agricultural technology. This indicates that farmers of PIM and non-PIM systems, regardless in which water management system they lie, poor agricultural technology is a concern for them.

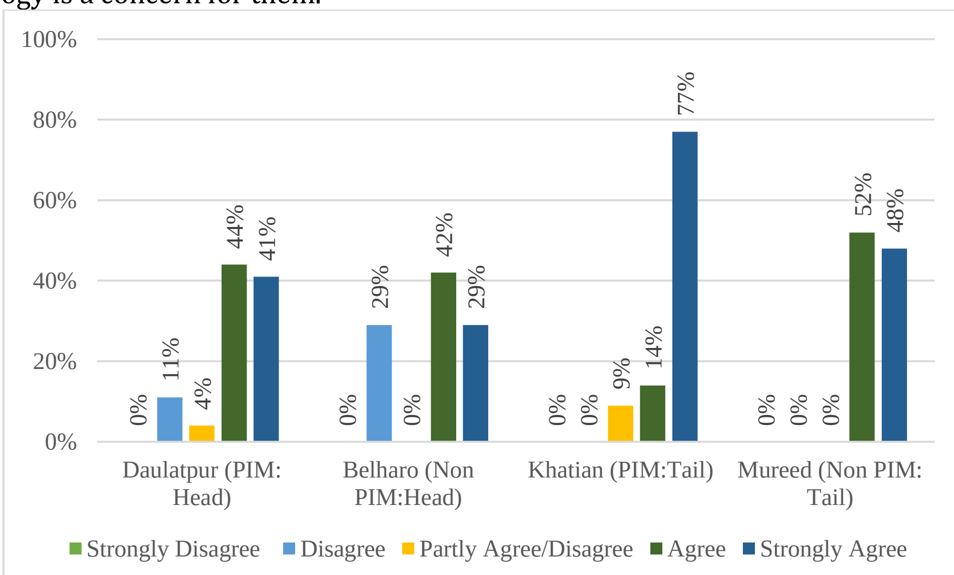

Figure 4: Poor Agricultural Technology

Majority of farmers in PIM and non-PIM systems have agreed or strongly agreed that they face the problem of poor crop yields. This indicates that farmers at PIM and non-PIM systems regardless of which water management system they lie in, are affected by poor agricultural yields.

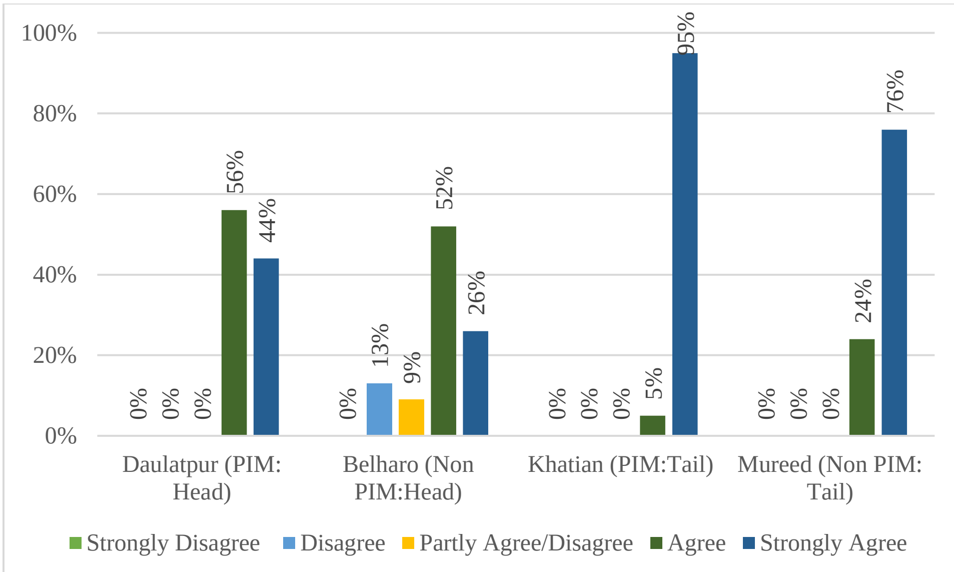

Figure 5: Poor Agricultural Yields

Majority of farmers in PIM and non-PIM systems have agreed or strongly agreed that they receive poor prices for their agricultural yields. This indicates that farmers at PIM and non-PIM systems regardless of which water management system they lie in, are affected by poor output prices.

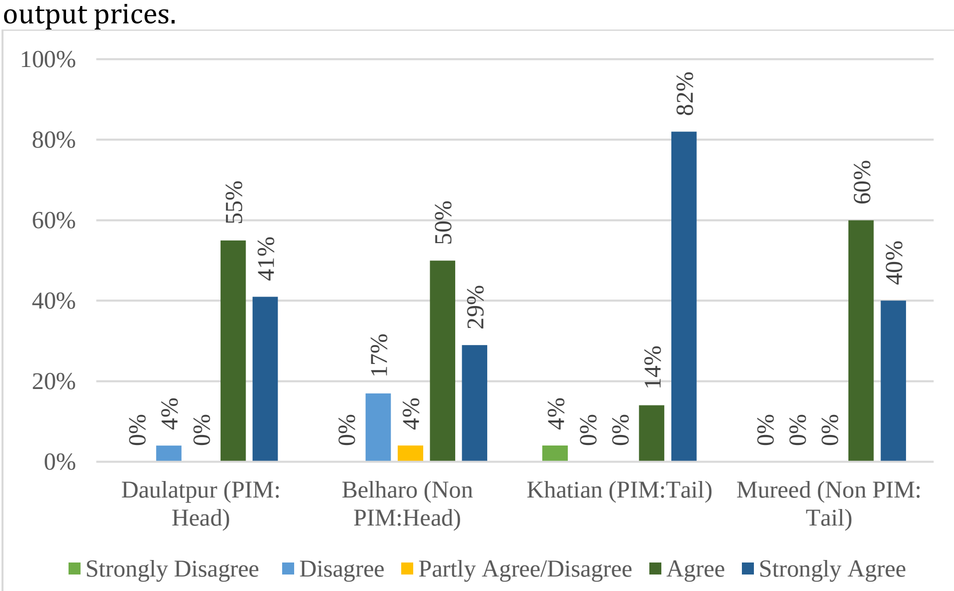

Figure 6: Poor Output Prices

Majority of farmers in PIM and non-PIM systems have agreed or strongly agreed that they face the problem of poor marketing access. This indicates that farmers at PIM and non-PIM systems, regardless of which water management system they lie in, are affected by poor marketing access.

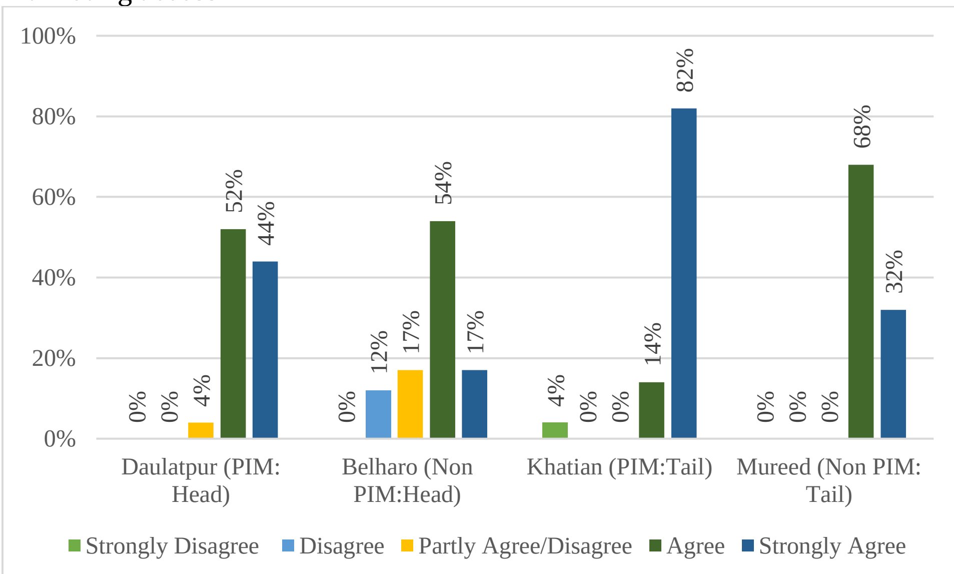

Figure 7: Poor Marketing Arrangements/Access

Majority of farmers at PIM and non-PIM systems have agreed or strongly agreed that face the problem of poor credit availability. This indicates that farmers in PIM and non-PIM systems, regardless of which water management system they lie in, are affected by poor credit availability.

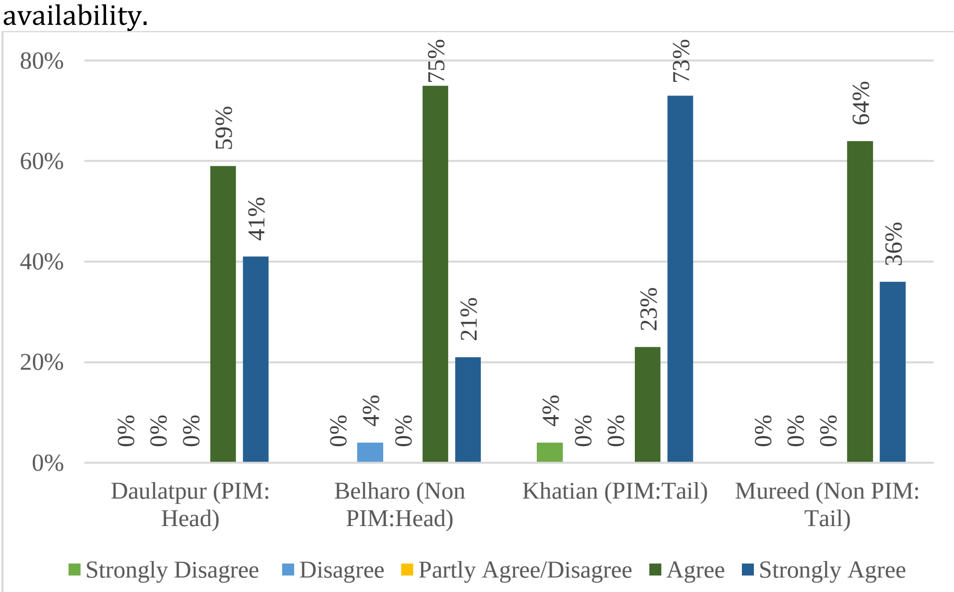

Figure 8: Poor Credit Availability with Farmers

Majority of farmers in PIM and non-PIM systems have agreed or strongly agreed that they get poor market prices for their farm product. This indicates that farmers at PIM and non-PIM systems, regardless of which water management system they lie in, are affected by receiving low product prices.

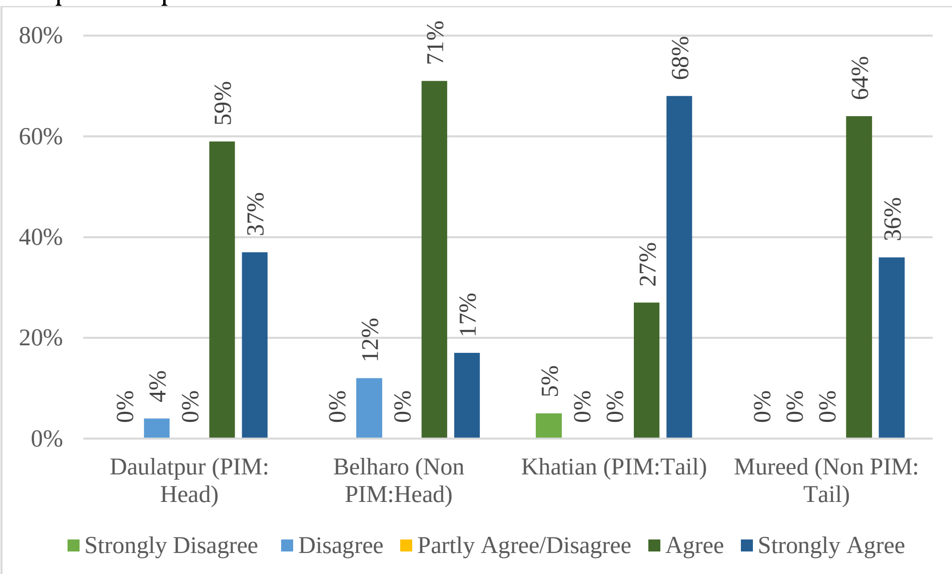

Figure 9: Poor Price of Product

Crop Production Analysis

As the study area lies in the wheat-cotton belt, this section will analyze the two major rabi and kharif season crops (i.e., wheat and cotton respectively).

Wheat Crop Cultivation

Wheat Crop Yield

The average wheat yield was high at the non-PIM head (1395 Kg/Acre). The wheat yield was higher at non-PIM head than PIM head and at the PIM tail than non-PIM tail.

Table 5: Average Wheat Crop Yield

Name of Distributary	Yield (Kg/Acre)	
	Mean	Standard Deviation
Daulatpur (PIM: Head)	1175	226.794
Belharo (Non-PIM: Head)	1395	255.53
Khatian (PIM: Tail)	1225	185.799
Mureed (Non-PIM: Tail)	1139	196

The one-way ANOVA has determined a statistically significant difference between the farmer groups ($F(3,86) = 6.608$, p-value = 0.000). A Tukey post hoc test revealed that the wheat yield is statistically significantly higher at non-PIM head as compared to PIM head (p-value = 0.004) and non-PIM tail (p-value = 0.000). There is no statistically significant difference in wheat yield between PIM head and PIM tail, PIM head and non-PIM tail, PIM tail and non-PIM head, and PIM tail and non-PIM tail.

Table 6: One-Way ANOVA Test

ANOVA Wheat Crop Yield					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	962788.806	3	320929.602	6.608	.000
Within Groups	4176571.194	86	48564.781		
Total	5139360.000	89			

Table 7: Tukey HSD Test

Multiple Comparisons Dependent Variable: Wheat Crop Yield Tukey HSD						
(I) Groups PIM and non-PIM	(J) Groups PIM and non-PIM	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
PIM Head	Non-PIM Head	-228.933*	65.719	.004	-401.12	-56.75
	PIM Tail	-57.455	68.086	.833	-235.84	120.93
	Non-PIM Tail	35.345	64.421	.947	-133.44	204.13
Non-PIM Head	PIM Head	228.933*	65.719	.004	56.75	401.12
	PIM Tail	171.478	67.378	.060	-5.05	348.01
	Non-PIM Tail	264.278*	63.672	.000	97.46	431.10
PIM Tail	PIM Head	57.455	68.086	.833	-120.93	235.84
	Non-PIM Head	-171.478	67.378	.060	-348.01	5.05
	Non-PIM Tail	92.800	66.112	.501	-80.41	266.01
Non-PIM Tail	PIM Head	-35.345	64.421	.947	-204.13	133.44
	Non-PIM Head	-264.278*	63.672	.000	-431.10	-97.46
	PIM Tail	-92.800	66.112	.501	-266.01	80.41

*. The mean difference is significant at the 0.05 level.

Wheat Crop Input Practices and Cost

Majority of farmers (i.e., 75%) at all distributaries were using the TD-1 seed variety, while the remaining were using Galaxy, Bakhtawar, Sehar, TJ-83, Inqulab and Ayoub seed varieties. According to farmers, they did not observe any variation in wheat yield due to seed variety. Farmers at the PIM head, non-PIM head and non-PIM tail were using around 60 Kilograms (Kg) of seed per acre but the farmers at PIM tail were sowing 70 Kg seed per acre. Farmers at PIM head were using on average 1 bag of DAP, 2 bags of Urea and 1.25 bags of 23-23 fertilizers per acre. Farmers at non-PIM head were using on average 1 bag of DAP, 3 bags of Urea 1.25 bags of NP and 1 bag of 23-23 fertilizers per acre. Farmers at PIM tail were using on average 1 bag of DAP, 3 bags of Urea and 1 bag of 23-23 fertilizers per acre. On average, farmers at the non-PIM tail were using 1 bag of DAP and 2 bags of Urea fertilizers per acre. Famers at PIM head and non-PIM head were applying on average 1 litre of pesticide per acre, whereas farmers at PIM tail and non-PIM tail were not applying any pesticides. Logran, Atlantis and

Bromo were the pesticides applied by farmers on wheat crop.

Table 8: Wheat Crop Input Practices and Cost

Name of Distributary	Seed (Kg/Acre)	Abiana (PKR/Acre)	Fertilizer				Pesticides (L/Acre)	Input Cost (PKR/Acre)	
			DAP	Urea	NP	23-23			
			Bags	Bags	Bags	Bags		Mean	Standard Deviation
Daulatpur (PIM: Head)	62	200	1.25	2	0	1.25	1	25103	8388.345
Belharo (Non-PIM: Head)	60	220	1	3	1.25	1	1	26986	6756.749
Khatian (PIM: Tail)	70	60	1	3	0	1	0	21974	3924.032
Mureed (Non-PIM: Tail)	59	100	1	2	0	0	0	24337	3268.285

Wheat Crop Income and Net Revenue

The wheat crop average net revenue was more at the PIM tail (15378 PKR/Acre). The wheat crop net revenue was higher at non-PIM head than PIM head and at PIM tail than non-PIM tail. The average income at non-PIM head was higher than other distributaries but due to high input cost the average net revenue at non-PIM head was lower than PIM tail.

Table 9: Wheat Crop Income and Net Revenue

Name of Distributary	Income (PKR/Acre)		Net Revenue (PKR/Acre)	
	Mean	Standard Deviation	Mean	Standard Deviation
Daulatpur (PIM: Head)	34475	7438.755	9372	12086.826
Belharo (Non-PIM: Head)	39871	7923.567	12885	11717.749
Khatian (PIM: Tail)	37352	5770.124	15378	7310.484
Mureed (Non-PIM: Tail)	32730	6395.041	8393	6425.037

Cotton Crop Production

Cotton Crop Yield

The average cotton yield was higher at the non-PIM head (1116 Kg/Acre). The cotton yield was higher at non-PIM head than PIM head and at non-PIM tail than PIM tail.

Table 9: Average Cotton Crop Yield

Name of Distributary	Yield (Kg/Acre)	
	Mean	Standard Deviation
Daulatpur (PIM: Head)	880	295.387
Belharo (Non-PIM: Head)	1116	329.134
Khatian (PIM: Tail)	898	148.104
Mureed (Non-PIM: Tail)	980	168.104

The one-way ANOVA has determined a statistically significant difference between the farmer groups ($F(3,70) = 3.495$, p-value = 0.020). A Tukey post hoc test revealed that the cotton yield is statistically significantly higher at non-PIM head as compared to PIM head (p-value = 0.029). There is no statistically significant difference in cotton yield between PIM head and PIM tail, PIM head and non-PIM tail, PIM tail and non-PIM head, PIM tail and non-PIM tail, and non-PIM head and non-PIM tail.

Table 10: One -Way ANOVA Test

ANOVA Cotton Yield					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	667796.083	3	222598.694	3.495	.020
Within Groups	4458863.377	70	63698.048		
Total	5126659.459	73			

Table 11: Tukey HSD Test

Multiple Comparisons Dependent Variable: Cotton Yield Tukey HSD						
(I) PIM and Non-PIM Groups Cotton	(J) PIM and Non-PIM Groups Cotton	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
PIM Head	Non-PIM Head	236.364*	82.925	.029	18.12	454.61
	PIM Tail	217.697	84.510	.057	-4.72	440.11
	Non-PIM Tail	135.411	76.997	.302	-67.23	338.06
Non-PIM Head	PIM Head	-236.364*	82.925	.029	-454.61	-18.12
	PIM Tail	-18.667	90.706	.997	-257.39	220.06
	Non-PIM Tail	-100.952	83.752	.626	-321.37	119.47
PIM Tail	PIM Head	-217.697	84.510	.057	-440.11	4.72
	Non-PIM Head	18.667	90.706	.997	-220.06	257.39
	Non-PIM Tail	-82.286	85.322	.770	-306.84	142.27
Non-PIM Tail	PIM Head	-135.411	76.997	.302	-338.06	67.23
	Non-PIM Head	100.952	83.752	.626	-119.47	321.37

	PIM Tail	82.286	85.322	.770	-142.27	306.84

*. The mean difference is significant at the 0.05 level.

Cotton Crop Input Practices and Cost

Majority of farmers (i.e., 70%) at all distributaries were sowing Tasco-901 and Lalazar seed varieties, while others were sowing MNH-886, BT-147 and Nayab-78 seed varieties. According to farmers, they have not observed variations in cotton yield due to seed variety. Farmers at the PIM head and PIM tail were sowing around 4.5 Kg of seed per acre but the farmers at non-PIM head and non-PIM tail were sowing 6 and 5 Kg seed per acre respectively. Farmers at PIM head were using on average 1.5 bags of DAP, 3 bags of Urea, 1.25 bags of NP and 1.75 bags of 23-23 fertilizers per acre. Farmers at non-PIM head were using on average 1 bag of DAP, 3.5 bags of Urea, 1.5 bags of NP and 1.5 bags of 23-23 fertilizers per acre. Farmers at PIM tail were using on average 1.25 bags of DAP, 3.5 bags of Urea and 1 bag of 23-23 fertilizers per acre. Farmers at non-PIM tail were using on average 1.25 bags of DAP and 3 bags of Urea, 2 bags of NP and 1.25 bags of 23-23 fertilizers per acre. Famers at PIM head and non-PIM head were applying on average 4.5 litres of pesticide per acre, whereas farmers at PIM tail and non-PIM tail were applying 3.5 and 3.75 litres of pesticides per acre. Curacron, Polo, Amida, Bifenthrin, Lembda, Fighter, Deltamethrin, Karaty and Puma pesticides were applied by farmers on wheat crop.

Table 12: Cotton Crop Input Practices and Cost

Name of Distributary	Seed (Kg/ Acre)	Abiana (PKR/ Acre)	Fertilizer				Pesticides (L/Acre)	Input Cost (PKR/Acre)	
			DAP	Urea	NP	23-23			
			Bags	Bags	Bags	Bags		Mean	Standard Deviation
Daulatpur (PIM: Head)	4.5	200	1.5	3	1.25	1.75	4.5	36555	14663.955
Belharo (Non-PIM: Head)	6	100	1	3.5	1.5	1.5	4.5	37626	8762.914
Khatian (PIM: Tail)	4.5	150	1.25	3.5	0	1	3.5	30456	3760.55
Mureed (Non-PIM: Tail)	5	100	1.25	3	2	1.25	3.75	31601	3049.54

Cotton Crop Income and Net Revenue

The cotton crop average net revenue was higher at the PIM tail (43950 PKR/Acre). The cotton crop net revenue was higher at non-PIM head than PIM head and at PIM tail than non-PIM tail. The average income at non-PIM head was higher than other distributaries but due to high input cost the average net revenue at non-PIM head was lower than PIM tail.

Table 13: Cotton Crop Income and Net Revenue

Name of Distributary	Income (PKR/Acre)		Net Revenue (PKR/Acre)	
	Mean	Standard Deviation	Mean	Standard Deviation
Daulatpur (PIM: Head)	63752	19188.972	27197	22026.286
Belharo (Non-PIM: Head)	74590	21840.131	36964	21907.717
Khatian (PIM: Tail)	74406	16120.948	43950	15957.388
Mureed (Non-PIM: Tail)	65904	9304.057	34303	9385.701

Conclusion

The economic indicators such as crop cultivation practices in tail areas are changing, with farmers adopting new crops as well. Another trend of multi cropping was visible in tail end areas, especially in the PIM farmers. Both trends emerged due to shortage of water as farmers wanted to get the maximum economic benefit from the available water. As farmers have already started a paradigm shift from cultivating more and more land to cultivating crops as per water availability, maximizing their benefits from available water. Therefore, this study suggests the introduction of new crops and capacity building of farmers to help them in adoption of this change. On the marketing front, farmers across the board sell their products or purchase inputs individually rather than collectively, which reduces the bargaining power of the farmers. This study suggests that awareness be given to farmers through social mobilization, helping them in exploring new markets and getting the maximum economic benefit of their produce. Only those farmers who are nearby the main market takes advantage of competitive market prices. On the agriculture labor demand side, the data shows that labor has migrated from tail end areas due to water shortages. However, on the other side, shortage of labor has also increased the demand of labor as well.

The study revealed that the existing market structure, with a dominant role of middleman and the absence of local and cooperative markets has impacted the bargaining power of farmers, along with the purchasing of inputs and selling of outputs. Therefore, it is recommended that farmers may sell their output and purchase agriculture input together to improve their bargaining power and maximize their economic benefit of their produce, saving time and other associated resources.

References

1. Acharya, A. S., Prakash, A., Saxena, P., & Nigam, A. (2013). Sampling: Why and how of it. Indian Journal of Medical Specialties, 4(2), 330-333.
2. Bandaragoda, D. J. (1999). Institutional change and shared management of water resources in large canal systems: Results of an action research program in Pakistan (Vol. 36). IWMI.
3. Bandaragoda, D. J. (2006). Limits to donor-driven water sector reforms: Insight and evidence from Pakistan and Sri Lanka. Water policy, 8(1), 51-67.
4. Cornish, G., & Perry, C. (2003). Water charging in irrigated agricutlure-lessons from the field (OD150).
5. Daniel, J. (2011). Sampling essentials: Practical guidelines for making sampling choices. Sage Publications. Accessed from https://www.sagepub.com/sites/default/files/upm-binaries/40803_5.pdf.
6. Faruqee, R., & Carey, K. (1997). Research on land markets in South Asia: what have we learned? (No. 1754). World Bank Publications.
7. Hussain, S., Khan, M. M., Shoaib, M., Raza, A., Shah, S. A. R., Khan, T. A., & Khan, S. (2021). Performance evaluation of participatory irrigation management as an alternative to a state-managed irrigation system. Irrigation and Drainage, 70(1), 150-168.
8. Katusiime, J., & Schütt, B. (2020). Integrated water resources management approaches to improve water resources governance. Water, 12(12), 3424.
9. Khan, M. S., Rahpoto, M. S., & Mangnejo, G. M. (2020). The Effect of the Financial Crisis on Corporal Well-Being: Apparent Impact Matters: Assessment of Contagion to Developing Economies. Research Journal of Social Sciences and Economics Review, 1(3), 232-238.
10. Khan, M. S., Rahpoto, M. S., & Talpur, U. (2021). The Effect of the Financial Crisis on Corporal Wellbeing: Apparent Impact Matters. In Internet of Everything and Big Data (pp. 25-34). CRC Press.
11. Khoso, A. A. K., Pathan, M. S. K., & Ahmed, M. (2022). Exploring The Impacts and Aftershocks of Covid-19 on Islamic Banking and Conventional Banking in Pakistan. International Research Journal of Management and Social Sciences, 3(1), 179-192.
12. Khowaja, I. A., Talpur, U., Soomro, S. H., & Khan, M. S. (2021). The non-banking financial institutions in perspective of economic growth of Pakistan. Applied Economics Letters, 28(8), 701-706.
13. Malik, R. P. S.; Prathapar, S. A.; Marwah, M. (2014). Revitalizing canal irrigation: towards improving cost recovery. Colombo, Sri Lanka: International Water Management Institute (IWMI). 52p. (IWMI Working Paper 160). [doi: 10.5337/2014.211]
14. Malthus T R (1970). An essay on the principle of population (1798) and A Summary view of the principle of population (1830). Flew A, ed. (Penguin Books, London).
15. Memon, J. A., & Mustafa, U. (2012). Emerging Issues in the Implementation of Irrigation and Drainage Sector Reforms in Sindh, Pakistan. The Pakistan Development Review, 51(4-II), pp-289.
16. Muhammad, S. K. P. (2023). THE INFLUENCE OF ORGANIZATIONAL CULTURE ON EMPLOYEE COMMITMENT AND TURNOVER INTENTIONS: A STUDY OF THE IMPORTANCE OF POSITIVE CULTURE FOR RETAINING EMPLOYEES. Global Research Journal of Management and Social Sciences (GRJMSS), 1(1), 85-94.
17. Nakashima, M. (1999). Pakistan's Institutional Reform of Irrigation Management: Initial Conditions and Issues for the Reform. 広島国際研究, (5), 121-135.
18. Nussbaum, E. M. (2014). Categorical and nonparametric data analysis: choosing the best statistical technique. Routledge.
19. Pathan, M. S. K. (2022). The Impact of Emotional Intelligence on Leadership Effectiveness. International Research Journal of Management and Social Sciences, 3(3), 1-7.

20. Pathan, M. S. K. (2023). Assessing the mediating role of job satisfaction in the relationship between organizational culture and employee commitment. International Research Journal of Education and Innovation, 4(1), 1-11.
21. Planning Commission (2012). Annual Plan 2011-2012. https://www.pc.gov.pk/uploads/annualplan/2011-2012.pdf
22. Sindh Water Management Ordinance, (2002). https://www.google.com/search?client=firefox-b-d&q=Sindh+Water+Management+Ordinance%2C+2002
23. United Nations Environment Programme, & World Meteorological Organization (1992). International Conference on Water and the Environment: Development Issues for the 2lst century. https://wedocs.unep.org/20.500.11822/30961.
24. Zisopoulou, K., Zisopoulos, D., & Panagoulia, D. (2022). Water Economics: An In-Depth Analysis of the Connection of Blue Water with Some Primary Level Aspects of Economic Theory I. Water, 14(1), 103.