Research Article

Canal Irrigation Water Distribution: Awareness of Water Use Rights and Farmer's Satisfaction in Central Khyber Pakhtunkhwa, Pakistan

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Abstract | In this research study, farmers' awareness of water uses rights and their satisfaction with irrigation water distribution were assessed. For this purpose, 466 farmers were randomly selected through a multi stage stratified random sampling technique from three irrigation sections in District Malakand, District Charsadda, and District Mardan, Khyber Pakhtunkhwa (KP). This study revealed that majority of the respondents did not attend formal school, cultivated 5–12.5 acres arable land (small farmers), and had moderate monthly family incomes (PRS 21000–50000). However, the respondents had the least information regarding revision of water distribution schedule, mutation of irrigation water, and share of irrigation water during stressful times, which decreased their satisfaction with irrigation water distribution. Findings and recommendations of this study will be helpful for the irrigation department (KP) to create awareness among the farmers regarding irrigation water rights at a satisfactory level.

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Introduction

Irrigation system is complex network that is run by public offices (formal institutions) and private people (informal institution). These systems are planned for allotting, conveying, implementing and releasing water to, through and from the fields of farmer. Productive working of an irrigation system ensures the supply of sufficient water to particular farmer's fields when required. Ideally, the irrigation system is supervised by public offices in consultation with community members (Sorensen *et al*., 2022). Currently the irrigated agriculture is governed by national water policy, 2018. Under this policy the concerned department is responsible for preparing strategies and plans for irrigated agriculture to ensure food security for the people of Pakistan. More crops per drop is the main theme of the policy that ensure implementation of improved agriculture methods and practices, legal reforms to control irrigation water wastes and extensive research in these issues (Nabi *et al*., 2019). The policy urges for modernization of irrigation system, and introduction of participatory irrigation practices for satisfactory and effective

implementation of irrigation water plans. Furthermore, the policy reiterates equitable water distribution without any discrimination among all stakeholders besides protection of water from contamination and pollution. Increases in water charges for continued supply of irrigation water is advised by the policy for sustainable water supply (Nabi *et al*., 2019; Sumra *et al*., 2020).

A riparian water right is a system of water allocation under which a farmer has the right to use water from a water source where the land touches the bank of that source. A riparian beneficiary has the right to use the water at any time as required. This principle is applicable in those regions where there is abundant water for users (King *et al*., 2021). On the other hand, appropriation principle refers to the allocation of water rights from watersheds that are not riparian. Because of water scarcity in Pakistan, the appropriation rules regulation has been devised instead of riparian rights. Under this principle, only a justifiable amount of water can be used by sharing water and applying beneficial use. Furthermore, the acquisition of water right refers to right to all of the common watersheds and waterways that have been declared open property and dedicated to all users (Zareie *et al*., 2021). The right of way to proceed through for movement is pertinent to each individual claiming a water right or contingent water right, with the goal that effective use of water can be expanded by expanding the irrigated command area of denied water assets. Public authorities can, likewise, take land for the purpose of passing on water without paying for it. Utilization of this philosophy is seen regularly in many activities, as in the planning of water system projects in the un-measured basins or in the improvement of new project watercourses in the places where there is hardship on these watercourses. This equally applies to the main streams at the watercourse command where the stream is a property shared by the investors of the command (Zareie *et al*., 2021). In summary, water is assigned to the ranchers as indicated by the harvest water needs. This rule has worked on the technique of appropriating water right (King *et al*., 2021).

The current irrigation system of warabandi was introduced during British rule (Hayat, 2007). The irrigation department is responsible to administer water supply and resolve water use disputes. However, the irrigation department frequently fails to resolve the issue among farm landowners because the system is quite old and water distribution is becoming more complex as the population grows. In sufficient water supply to farms on tail of a water channel is a major drawback of the warabandi system that spark some serious conflicts. When resource users are dissatisfied with the allocation of access rights and obligations (for example, when they view it to be unfair or unpredictable), their desire to spend on providing activities (for example, maintenance) may suffer (Van Koppen *et al*., 2007).

Canal water usage rights in Pakistan are usually linked to land rights i.e., land proprietors have the right to extract water via wells on their or collect rain water from their land; therefore, understanding water management activities at the watercourse level requires knowledge of land rights (Dhawan, 2017). Typically, a large watercourse covers a relatively larger command area (794 acres) than the average in Pakistan, and the amount of water received by different water users may be affected by their location in the command area, implying that the amount of water received by different water users along the watercourse varies as a function of the quality of maintenance and generally decreases as the distance from mogha (outlet) increases (Bowers, 1977).

The government has devised the water law and policy for effective and efficient use of water resources for enhance agriculture production on one side and to curtail and reduce the water resources related conflicts among farmers to the satisfaction of their personal needs and increase agriculture production.

Farmer's satisfaction is a function of timely availability of water, fertilizers, sufficient landholding, farmer's participation in irrigation activates and distance from irrigation canals (Maskey and Weber, 1996). In most cases, the satisfaction of farmers from irrigation water distribution is linked to the availability to irrigation water in sufficient quantity and required quality through sound water distribution system without any discrimination. A satisfied farmer, in this regard, is willing to pay their due share of water charges in time alongside contributing their due share in maintenance and repair of water distribution system (Aydogdu *et al*., 2015).

Materials and Methods

This research study was conducted on the canal water

irrigation system in central Khyber Pakhtunkhwa, Pakistan, i.e., District Malakand, District Charsadda, and District Mardan. The irrigation system of central Khyber Pakhtunkhwa is administered through upper Swat canal which subdivides into two branches i.e., Abazai and Machi branch. The branches are further divided in to three irrigation sections (Dargai, Harichand and Hatyan) 27 minors and 508 outlets (mogas). A total of 27830 farmers are benefitted from these three irrigation sections. A multi stage stratified random sampling technique was adopted for sample selection. At first stage both Machi and Abazai canals were selected. At second stage all the three irrigation sections (Dargai, Harichand and Hatyan) were selected. At third stage five (5) out of nine (9) minors were randomly selected from Dargai irrigation section, five (5) out of ten (10) minors were randomly selected from Harichand irrigation section and four (4) out of eight (8) minors were randomly selected from Hatyan irrigation section. At fourth stage 87 out of all 262 outlets (33%) were selected through systematic sampling with a skip interval of 03. At fifth stage the farmers using irrigation water from systematically selected 87 outlets were listed, which amounted to 15242 farmers. These lists were obtained from the irrigation department. Thus, the population frame for the current study was 15242 farmers for which the sample size was calculated, (n = 466) using Equation 1 (Chaudhry, 2009) and proportionately allocated to each outlet and randomly selected by using Bowley (1926) Equation 2.

$$n = \frac{N\hat{p}\hat{q}Z^2}{\hat{p}\hat{q}Z^2 + Ne^2 - e^2} \quad \ldots(1)$$

If, N = total respondents = 15242, p = population proportion=0.50, q = opposite proportion q= (1-p) =0.50, z = confidence level = 1.96, e = margin of error = 0.045

Bowley (1926) formula for proportional allocation of sample size is as under.

$$nh = \frac{Nh}{N} \times n \quad \ldots(2)$$

Where; n_h = sample size required for each irrigation outlets, N_h = total population of farmers at each irrigation outlets, N= total population of the farmers, n = required sample size.

Table 1: *Allocation of required sample to selected irrigation section and minors.*

S/No	Selected minors	Total number of moga on each minor	Selected moga from each minor	Total number of farmers on each minor	Sample size from each minor
Selected minors and farmers from Dargai irrigation section					
1	PC Minor	31	10	1448	44
2	Abazai Branch	28	10	935	29
3	Jalala Minor	21	7	1191	36
4	Shengari Minor	13	4	896	27
5	Pirsado Minor	15	5	608	19
6	Sub Total	108	36	5078	155
Harichand irrigation section					
1	Sharif Dheri Minor	10	3	234	8
2	Bariband Minor	39	13	2753	68
3	Amirabad Minor	24	8	1244	30
4	Behram Dheri Minor	16	5	489	12
5	Nusrat Zai Minor	14	5	512	20
6	Sub Total	103	34	5532	138
Hatyan irrigation section					
1	Shergarh Minor	13	4	1443	54
2	Kalo Minor	21	7	1413	53
3	Sapokanda Minor	11	4	241	9
4	Hatyan Minor	6	2	1535	57
5	Sub Total	51	17	4632	173
Grand total for all selected irrigation sections		262	87	15242	466

Conceptual framework

The conceptual framework of the study comprised on two independent variables (awareness of water use rights and socio-economic status of the respondents) and one dependent variable (farmer's satisfaction with irrigation water distribution) as given in Table 2. Furthermore, the integrated water resource management model was used as a theoretical framework in this research study, which encompasses coordinated efforts for resource management for efficient, equitable, and sustainable economic and social development at regional, national, and global levels.

Table 2: *Conceptual framework of the study.*

Independent variable	Dependent variable
Awareness of water use rights	Farmer's satisfaction with irrigation water distribution
socio-economic status of the respondents	

Measurement of variables

For measuring awareness of water use rights, a scale was developed with some slight modifications according to local requirements, as suggested by panel of experts (supervisory committee). Respondents having average score of 1.25 and below, 1.26 to 1.5 and 1.51 and above on awareness of water use rights and the devised scale comprised of 8 items, categorized as well aware of water use rights, somewhat aware of water use rights and low aware of water use rights and coded as 2, 1 and 0, respectively.

The socio-economic status of the respondents was divided into three categories as low socio-economic status coded "0", moderate socio-economic status coded "1" and high socio-economic status coded "2".

Data analysis

For the analysis of data, the chi-square test and Kendall's Tau-C test were used at bi-Variate and multi-Variate level to measure the association and direction of the independent and dependent variables. At bi-Variate level the association between awareness of water use rights and farmer's satisfaction with irrigation water distribution and at multi-Variate level socio-economic status of the respondents was used as control variable to find the association. The Mathematical form of chi-square test (Tai, 1978, Equation 4) and Kendall's Tau-C test (Nachmias, 1992, Equation 5) were given below:

$$x^2 = \sum_{i=1}^{r}\sum_{j=1}^{c}\frac{(O_{ij} - e_{ij})^2}{e_{ij}} \quad \ldots(4)$$

$$Tc = \frac{2(nc - nd)}{n2\frac{(m-1)}{m}} \quad \ldots(5)$$

Results and Discussion

Association between awareness of water right and farmers' satisfaction with irrigation water distribution Water right refers to the right to use some specific water in a predetermined quantity from a known source for a specific use. Conventionally, water use rights are established under four principles (Oregon water law) i.e., first in time, first in right concept, water right is attached to the land, and redistribution of water every five years. Under these principles the water use rights are determined which are transmitted with land ownerships from owner to owner. To test the association between awareness of water use rights and farmer's satisfaction with irrigation water distribution, the perception of water use rights limited to few statements is given in Table 3 and explained below.

Results in Table 3 show that the knowledge of the specific date and time to irrigate a piece of land was found significant and weak positive with farmer's satisfaction with irrigation water distribution ($P = 0.007$; $T^c = 0.133$). Similarly, a significant ($P = 0.001$) and weak positive ($T^c = 0.151$) association was found between the knowledge of quantity of water to irrigate agricultural land with farmer's satisfaction with irrigation water distribution. Moreover, farmer's satisfaction with irrigation water distribution had highly significant ($P = 0.000$) and positive ($T^c = 0.224$) association with knowledge of time duration to irrigate agricultural land. Awareness of water use rights is the first step to claim one's right of water use. The water distribution system catered for individual farmer's water rights in three important aspects i.e., quantity of water, duration of irrigation and timing of irrigation. For this purpose, predetermined rotation water distribution schedule was chalked out and the relevant farmers are informed accordingly. Generally, each farmer has the knowledge of timing, duration and quantity of irrigation water for their irrigation turn. Transparency and clarity in water distribution schedule reduces the chances of misappropriation, discrimination and theft in irrigation water and enhances farmer's satisfaction with irrigation water distribution as evident from the above mentioned

Table 3: *Association between awareness of water right and farmers satisfaction with irrigation water distribution.*

Independent variable (Awareness of water use rights)	Dependent variable	Statistics-χ2, (P= Value) and T^c
You know that which piece of land to irrigate on a specific date and time.	Farmer's satisfaction with irrigation water distribution	χ2= 10.071 (0.007) T^c = 0.133
You know how much water you are entitled to for irrigating your land	Farmer's satisfaction with irrigation water distribution	χ2=13.058 (0.001) T^c = 0.151
You know the period of time to irrigate your land.	Farmer's satisfaction with irrigation water distribution	χ2=38.176 (0.000) T^c = 0.224
You can claim for redistribution of water	Farmer's satisfaction with irrigation water distribution	χ2= 2.311 (0.315) T^c = 0.026
If a portion of agricultural land is sold you know how to redistribute the irrigation water	Farmer's satisfaction with irrigation water distribution	χ2= 45.451 (0.000) T^c = 0.310
The water right stays with the land not with the owner.	Farmer's satisfaction with irrigation water distribution	2= 36.311 (0.000) T^c = 0.197
You know that you are entitled to at least one third of irrigation water required for irrigating land.	Farmer's satisfaction with irrigation water distribution	χ2= 39.783 (0.000) T^c = 0.304
You cannot use your irrigation water for purposes other than irrigating agricultural land.	Farmer's satisfaction with irrigation water distribution	χ2= 4.542 (0.103) T^c = 0.023

Table 4: *Association between awareness of water use rights and farmers satisfaction with irrigation water distribution (controlling socio-economic status of the respondents).*

Socio-economic status of the respondents	Independent variable	Dependent variable	Statistics χ2, Chi-square (P=Value) and T^c	Statistics, χ2, Chi-Square (P=Value) and T^c for overall table
Low socio-economic status	Awareness of water use right	Farmer's satisfaction with irrigation water distribution	χ2 =27.095 (0.000) T^c = 0.259	χ2 = 54.436 (0.000) T^c = 0.259
Middle socio-economic status	Awareness of water use right	Farmer's satisfaction with irrigation water distribution	χ2 = 18.861 (0.001) T^c = 0.176	
High socio-economic status	Awareness of water use right	Farmer's satisfaction with irrigation water distribution	χ2 =18.384 (0.001) T^c = 0.289	

Source: *Survey 2022.*

significant and positive association results. A knowledgeable farmer of their irrigation water right is in better position to persuade the authorities and acquired their due share in term of quantity, duration and timing (Rustinsyah, 2019). Timely distribution of irrigation water in required quantity and quality is indicative of the efficient performance of irrigation department that may lead to a greater satisfaction of the farmers with water distribution. However, in most cases, despite of the timeliness of the water distribution, the water is not provided in the required quality which may reduce the overall satisfaction of the farmers. Narayanan (2014) explained that farmer's education and their control for irrigation water management has apparent positive influence on their satisfaction level which gradually decreases with decrease in their awareness of water use rights (Cornia, 1985; Joshi and Hooja, 2000) pointed out that equity and transparency in irrigation water rights related information dissemination among farmers of awareness inside the community reduces the information gap, enhances water use efficiency and ensure successful working of the community level organizations (Bhuyan, 2007). Conversely, insufficient awareness of water use rights promotes lack of trust in farm managers and government organizations that subsequently lead to farmer's dissatisfaction (Omid *et al.*, 2012).

The results further show that the farmer's satisfaction with irrigation water distribution exhibited highly significant and positive association with knowledge

of irrigation water redistribution when a piece of agricultural land is sold (P= 0.000; T^c = 0.310), the water right stay with the land not with owner (P= 0.000; T^c = 0.197) and knowledge of entitlement to at least one third of irrigation water required for irrigated land (P= 0.000; T^c = 0.304). According to the irrigation law, the irrigation water rights stay with the land and not with the owner. Thus, when a piece of agricultural land is sold the irrigation water right is transferred automatically to new owner, if the land is used for agriculture purposes, under the law. In such situation, the new owner will make a claim for revision of redistribution of water (rewarbandi) and his name along with water right will be entered in the register of record. In another scenario, if the land is sold for the purposes other than agricultural use, the water distribution will be revised and the irrigation timing will be reallocated proportionately among farmers according to their landholding size. However, ignorance to these important aspects may render the purchaser of agricultural land or the rest of the farmers deprived of their due irrigation water share. It is noticed that some farmer, in connivance with irrigation department exploited and deprived the ignorant farmers of their due share in irrigation water. Such water is then using illegally for irrigation and non irrigation purposes by the exploiter group. The farmers ignorant to their water use rights, therefore, are easy to deceive in the name of water shortage and scarcity as these farmers don't know that they are entitle to at least one third of irrigation water. The farmers that were well informed of their water use right with respect to the agricultural land owned or purchased by them and were informed of the minimum quantity of their water share were more likely to be satisfied with irrigation water distribution as clear from the above results. Agriculture crops production require prior planning in term of inputs, management, farming operations and marketing etc. Irrigation planning and management is the backbone of any agriculture system. For efficient the effective irrigation planning and implementation, farmers need to be aware of their irrigation turn and redistribution of irrigation water. Minch (2019) noticed that due to population growth much of the arable lands are brought under the residential areas. The irrigation shares of these lands are illegally allocated to few farmers by depriving the majority of the illiterate, poor and unaware famers. Moreover, increase in competition over the water use among industries, agriculture and other competing sectors affect water supply for irrigation purposes, especially during water stress time. In such stress time, the rich, powerful and well aware farmers trick the illiterate poor farmers and divert their share of water to the farms of rich farmers. The inequality in water distribution so created is, among other factor, due to unawareness of the water use rights by the deprived segment (Johnson, 1995; Vermillion, 1997; Prefol *et al*., 2006). The water use associations based on participatory approaches are established to overcome water distribution inequality through awareness raising, participatory water distribution planning and implementation. A series of study found that lack of clear water right and supportive irrigation water management training enhances the likelihood of inequality of irrigation water distribution that rise the chances of water-based disputes and farmer's dissatisfaction with irrigation water distribution (K'akumu *et al*., 2016; Johnson, 1995; Koppa, 2008). In some extreme cases, the power elite farmers are so influential that they illegally monopolized the water rights of the poor farmers and trade it to the needy ones through selling and lending to them. In this way, the deprived farmers, mostly unaware of their rights remain dissatisfied with existing irrigation water management (Rustinsyah, 2019; Wu *et al*., 2017; Brend' Amour *et al*., 2017). The role of irrigation department is in creating water use right awareness is quite passive and unsatisfactory. It is the proactive farmers that approach the irrigation department to get awareness of their water share and timing or to claim for redistribution of water schedule. The irrigation department seldom intervenes in such cases unless the complaint is lodged (Nazir, 2001; Malhotra, 1982; Maskey and Weber, 1996; Mettepenningen *et al*., 2013).

Conversely, farmer's satisfaction with irrigation water distribution was found non-significant with farmers can claim redistribution of water (P= 0.315; T^c = 0.026) and unawareness of not to use irrigation water for purposes other than irrigation (P= 0.103; T^c = 0.023). Making a claim for redistribution of water is quite complex and cumbersome process. Generally, the farmers are unaware of their rights or they want to avoid the complex process of claiming water redistribution. In addition, violation of rules in irrigation water use is so common that the people don't hesitate to use irrigation water for other than irrigation purposes without any complaint from other farmers. The same is the probable reason for the above non-significant results. Karami *et al*. (2018) reported

that regular revision of water distribution schedule is an important factor in farmer's satisfaction with irrigation water distribution. However, the role of irrigation department in this regard is quite passive. Moreover, claiming for rescheduling water distribution is so complex and cumbersome that the poor illiterate farmers prefer to avoid falling into its complexity (Barau *et al.*, 2021; Medelln-Azuara *et al.*, 2015).

Association between awareness of water use rights and farmers' satisfaction with irrigation water distribution (controlling socio-economic status of the respondents)

Results in Table 4 unveil that the association of awareness of water use rights on farmer's satisfaction with irrigation water distribution in the context of respondents socio economic status show positive (T^c = 0.259) and highly significant association (P= 0.000) in above mentioned variables for respondents from low socioeconomic status. The association of the above said variables was also positive (T^c = 0.176) and significant (P= 0.001) for respondents from middle socio economic status. Similarly, the association for the said variables were also positive (T^c= 0.289) and significant (P= 0.001) for high socio economic status respondents. The value of the level of significance and T^c for the entire table show a highly significant and positive association (P = 0.000 and T^c = 0.259) between awareness of water use rights and farmer's satisfaction with irrigation water distribution from low, middle and high socioeconomic status of the respondents. Similar chi-square and T^c value indicated that the effects of awareness of water use rights on farmer's satisfaction with irrigation water distribution were similar for respondents for all socio-economic status groups. Thus, awareness of water use rights is of universal importance in influencing farmer's satisfaction with irrigation water distribution irrespective of their socio-economic statuses. Socio-economic status is an important social divide that segregate society into low, middle and high classes (groups). The high socio-economic status farmer, because of their better economic standing and literacy level, are in better position to connect to and communicate with important information sources. Thus, farmers from upper and middle classes are more likely have better knowledge of their irrigation water use rights (Khan *et al.*, 2021). Moreover, a well-informed farmer is in better position to make prior arrangement for efficient utilization of available water resources, and get prepared for any future water shortage (Darkwah *et al.*, 2019). Adoption of innovative technologies is also linked, somewhat, to the socio-economic status of the farmers (Nkegbe and Shankar, 2014). Slowly and gradually, the awareness of water use rights are communicated to middle and low socio-economic status groups till equilibrium of information exchange is achieved (Khan *et al.*, 2021). In the canal irrigation system, the water rights are documented and recorded in the register of record. Moreover, rotational changes in timing of irrigation water are advertised a prior to its implementation to all farmers. Similarly, seasonal variations in irrigation water supply are planned and publicized among farmers for making irrigation water arrangement and crops management at their own level. Thus, due to high significant of irrigation water for farming system and decades old system of rotational irrigation water distribution, the farmers from all socio-economic groups are well aware of their water use rights and in better position to make arrangement in case of water shortage. Such adoptive strategies on part of farmers from different socio economic groups, based on their awareness water right lead to their satisfaction with irrigation water distribution (Darkwah *et al.*, 2019; Qureshi and Perry, 2021). Generally, similar level of awareness of rights among different socio-economic groups at the early stage of admission of rights to any facility is rare as people from high socio-economic status and educational level are better informed in these rights then low socio-economic groups. However, with passage of time, level of awareness of all socio-economic status groups reach to a common level due to maturity of information and its wide spread communication (Darkwah *et al.*, 2019; Khan *et al.*, 2021; Qureshi and Perry, 2021).

Conclusions and Recommendations

The study findings helped to depict that awareness of water use rights play important role in developing a satisfaction or dissatisfaction of farmers with irrigation water distribution. For all those farmers who have greater knowledge about their water rights in term of awareness, background and procedure of availing and making changes in water right were more likely to be satisfied with irrigation water distribution. Unawareness or insufficient awareness of the farmers regarding irrigation water use rights was the important factor causing farmers dissatisfaction with reference to irrigation water management. The farmers were only aware of timing and duration

of their irrigation turns with least information of revision of water distribution schedule, mutation of irrigation water and share of water during stress time. By creating awareness of water use rights, the legal and administrative procedures for revision and mutation of irrigation rights and linkages development with progressive farmers and NGOs will help understanding and attaining irrigation water use rights in a satisfactory manner. Social, electronic and print media can significantly contribute to create awareness among farmers with respect these rights. In addition, awareness and training session at village level by involving progressive farmers can help farmers link to opinion leaders at their vicinity for immediate guidance and support provision.

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Novelty Statement

This research study was conducted to determine farmers' awareness of water use rights and their satisfaction with irrigation water distribution in central Khyber Pakhtunkhwa-Pakistan. No such research was conducted before in the study area.

Author's Contribution

Abdul Zahir: Conducted the research.
Asad Ullah: Supervised the whole study.
Muhammad Jawad: Proofread the manuscript.
Syed Attaullah Shah: Analyzed the data.

Conflict of interest
The authors have declared no conflict of interest.

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