Research Article

Influence of Formal Mechanisms on Irrigation Water Distribution: A Farmer Centric Analysis in Pakistan

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Abstract | This study investigates the formal influences on irrigation water distribution practices in central Khyber Pakhtunkhwa (KP), Pakistan, and its impacts on farmer satisfaction. A multistage stratified random sampling technique was used for interview schedule, and data collected from 466 farmers of districts i.e. (Malakand, Charsadda and Mardan). Chi-square and Kendall's T^c tests were applied to analyze the relationship between the formal influences and farmer's satisfaction with irrigation water distribution. Results showed significant positive associations between farmer's satisfaction and other factors e.g. adherence to prescribed water shares ($P = 0.000, T^c = 0.294$), strict irrigation schedules ($P = 0.000, T^c = 0.206$), predetermined time schedules ($P = 0.000, T^c = 0.347$), lack of influence by large landlords ($P = 0.020, T^c = 0.318$), fair water redistribution during stress periods ($P = 0.000, T^c = 0.511$), the ability to lodge complaints ($P = 0.000, T^c = 0.172$), and prompt resolution of these complaints ($P = 0.000, T^c = 0.112$). Conversely, political influence over irrigation schedules had a negative impact on satisfaction ($P = 0.012, T^c = -0.118$). The study further revealed that the irrigation department of KP province emphasized on the technical distribution, however, it fails to address socio-economic and political inequities in the study districts of KP province. This research further recommended that policymakers may enhance the equality and fairness in irrigation water distribution, strengthen the complaint mechanism by making it more transparent and time-bound. It may also involve the farmers in the water distribution system to reduce the chance of inequality in irrigation water distribution.

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Introduction

The historical evidence of irrigation water management was derived from Egypt and Mesopotamia during 6000 B.C., when the river Nile water was channelized for irrigation purposes. Later on, the Egyptians learned to create and construct large Dams for irrigation water storage during 3100 B.C.

In addition, water reservoirs and irrigation channels of ruined system was also discovered in 300 B.C. in Sari Lanka (Wambua, 2019).

The establishment of modern flood irrigation systems comprising huge water reservoirs and canal irrigation systems started in the USA, China, Turkey, and India (Wambua, 2019). Irrigation water management on modern grounds was introduced for the first time in the 19th century in America to overcome the problems of water shortage, due to lacking of irregularity in rain/precipitation for irrigation purposes and food production. For this purpose, the Water User Associations (WUAs) was established to regulate irrigation water (Aydogdu, 2009). In Turkey, WUAs was formed by the district government to overcome water conflicts among cultivators in 1942 (Aydogdu, 2009). The learning from such participatory irrigation water management practices was later on diffused to different countries of the world including Chile, Peru, Mexico, Brazil, Senegal, Sudan, Somalia, India, Turkey, and Pakistan in the 1980s (Kıral, 1995; Erdogan, 2000).

In light of the above water management practices, Pakistan brought the 18th amendment into the constitution, through which the provincial government is responsible to manage the irrigation water under the Provincial Irrigation and Drainage Act. The concerned irrigation department was referred the control for the management and distribution of irrigation water in a sustainable manner in the PK province. Preliminary, the irrigation department collaborates with the local communities during the course of planning and implementation phase. However, the functions and implementation of these formal organizations are not ideally smooth. Inequality in the distribution of water is common throughout the region due to political, administrative, and powerful elite interferences. The corruption in the administration further aggrieved the problems of unfair water distribution (Thomas and Grindle, 1990; Mohmand, 2019). Integrated water resource management system emphasizes strengthening the irrigation department through legal and institutional reforms alongside empowering the farming community to actively participate in all aspects of irrigation water management (Cheema *et al*., 2006; Tummers and Bekkers, 2014; Ali, 2015, 2018; Beg, 2018).

Similarly, the structure of the irrigation department is based on three pillars i.e. irrigation laws and policies, irrigation infrastructures, and irrigation administration. The irrigation administration includes all the technical and administrative staff that implements the laws and policies in the fields for irrigation water supply through established agriculture infrastructure up to the satisfaction of farmers (Wang and Wu, 2018; Alaerts, 2020). The technical staff of the irrigation department is responsible for the structural design of the water reservoirs, irrigation canal outlets, etc. to ensure fair and timely distribution of sufficient irrigation water to all user groups without any deprivation. On the other side, the executive staff is responsible for controlling the flow of water from various inlets and outlets and ensuring the prevention of any illegal activities alongside resolving irrigation base conflicts and efficient fee recovery (Wegerich and Hussain, 2016; Ali, 2020).

The irrigation administration plays an active role in resolving water distribution-related disputes among farmers. The irrigation department has implied canal inspectors, gauge readers, and Beldars that regularly inspect the canals and outlets of their jurisdiction area to apprehend any illegal activities and resolve any disputes on the spot. Such events are brought to the notice of the high-up for appropriate legal actions. Moreover, the farmer can approach the irrigation department staff to inform them about any illegalities and inappropriate actions that may cause unrest among farmers (Wahaj, 2001; Alaerts, 2020; Muhammad *et al*., 2023).

Furthermore, the demand and supply of irrigation water face multiple socio-political interferences during water distribution. Size of landholding, political power, economic viability, and family size are the important determinants of social stratification in rural Pakistan (Abbas *et al*., 2020). The powerful elites are characterized by large landholding political affiliation with powerful groups and a huge baraderi system which is used to monopolize major input resources for agriculture including irrigation water. These elite groups manage to influence the irrigation department in their favor to get an undue share of irrigation water for themselves. They have a high influence on small-holding farmers to stop them from making any complaints to the irrigation department. The political pressure on the irrigation department is so excessive and considerable, due to which SOP's are being set aside to benefit the elite class of the farmer community (Rinaudo, 2002).

In the developing countries, political interferences are being used in irrigation departments as usual practices from top to bottom levels to get political benefits. As a matter of fact, the ruling political power always instructs the irrigation department to make adjustments in water distribution for their favor (Pasquini *et al*., 2018; Ricks and Doner, 2021). Similarly, the political favors and changes in irrigation policies/regulations are remained as question mark. Deprivation of the majority of small-holding farmers through dysfunctional formal institutions is an immoral issue as well (Pasquini *et al*., 2018; Ali, 2020; Jacoby and Kohat, 2021).

Materials and Methods

This research study was conducted on the canal water irrigation system to exhibit formal influences in irrigation water distribution and their subsequent effects on farmer satisfaction in Central Khyber Pakhtunkhwa, Pakistan, i.e., District Malakand, District Charsadda, and District Mardan. The irrigation system of central Khyber Pakhtunkhwa is administered through the upper Swat canal which is subdivided into two branches i.e. Abazai and Machi branch. The branches are further divided into 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. In a very first stage, both Machi and Abazai canals was undertaken. Referring second stage, all three irrigation sections (Dargai, Harichand and Hatyan) was selected. In the third stage, five (5) out of nine (9) minors were randomly chosen from the Dargai irrigation section, five (5) out of ten (10) minors were randomly taken from the Harich and irrigation section and four (4) out of eight (8) minors were randomly selected from Hatyan irrigation section. In the fourth stage, 87 out of all 262 outlets (33%) were selected through systematic sampling with a skip interval of 03. In the fifth stage, the farmers using irrigation water from systematically selected 87 outlets were listed, which amounted to 15242 farmers, and data (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 shown in Table 1 by using Bowley (1926) Equation 2.

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 the 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
Selected minors and farmers from the 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
Selected minors and farmers from the 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

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

Where; N= total number of farmers of 87 systematically selected irrigation outlets = 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.

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

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.

Conceptual framework

The integrated water resource management model constituted the theoretical model that further developed the conceptual framework of the current study. The conceptual model of the study included two independent variables (formal influences in irrigation water distribution and the socio-economic status of the respondents) and one dependent variable (farmer's satisfaction with irrigation water distribution), as shown in Table 2.

Table 2: *Conceptual framework of the study.*

Independent variable	Dependent variable
Formal influences in irrigation water distribution	Farmer's satisfaction with irrigation water distribution
Socio-economic status of the respondents	

Measurement of variables

For measuring formal influences in irrigation water management, a scale was developed with some slight modifications according to local requirements, as suggested by a panel of experts (supervisory committee). For this purpose, formal influences in irrigation water management were indexed into three categories i.e. low control of formal institutions in water distribution (average score 1.76 and above), moderate control of formal institutions in water distribution (1.51 to 1.75) and high control of formal institutions in water distribution (1.5 and below) these categories are coded as 0, 1 and 2, respectively. Furthermore, the socioeconomic status of the farmers was measured through Udai Pareek revised scale and Kuppuswamy modified socio-economic (SES) scale which is based on the composite of three important variables i.e. farmers education, farmers monthly income and land holding (Wani, 2019). For this purpose, socio-economic status of the respondents was divided into three categories low socio-economic status coded "0", moderate socio-economic status coded "1" and high socio-economic status coded "2".

Data analysis

In this research study, the data was analyzed at Univariate, the Bi-Variate and Multivariate level by using SPSS software. Univariate analysis included frequency counting and %age calculation. The Chaudhry and Kamal (1996) equation was used for calculation of percentages for the background, explanatory, and outcome variables as mentioned in Equation 3.

$$\text{\%age of data class} = \frac{f}{N} \times 100 \quad \dots(3)$$

Where, f = frequency of data class, and N = number of observations in the data set.

Similarly, the Bi-Variate level, the chi-square test (Tai, 1978) was used to test the association between formal influences in irrigation water management and farmer's satisfaction with irrigation water distribution. The mathematical form of the chi-square test as below.

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

Where; χ^2 = chi square; O_{ij} = Observed frequencies in i^{th} row and j^{th} column; e_{ij} = Expected frequencies regarding i^{th} row and j^{th} column; r = Number of rows; c =Number of columns; Df = (r-1) (c-1).

Moreover, for Multivariate analysis, Kendall's Tau-C test was applied to find out the strength and direction of the relationship of the said variables by using the socio-economic status of the respondents as a background variable. Kendall's Tau-c is expressed through the Equation 5 (Nachmias and Chava, 1992).

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

Where; nc= Number of concordant pairs, nd= Number of discordant pairs, r= Number of the row, c= Number of columns and m= min (r,).

Table 3: *Frequency distribution and proportion of farmers regarding formal influences in irrigation water management.*

Statements	Yes	No	Uncertain	Total
Water is distributed among farmers/ agricultural lands according to prescribe share	185 (39.5)	281 (60.0)	2 (0.4)	468 (100)
The irrigation schedule is strictly followed.	317 (67.7)	151 (32.3)	00	468 (100)
Farmers are provided irrigation water according to predetermined time schedule.	312 (66.7)	156 (33.3)	00	468 (100)
Political elites influence the set irrigation schedule	294 (62.8)	174 (37.2)	00	468 (100)
The big land lards can influence the set irrigation schedule.	234 (50.0)	234 (50.0)	00	468 (100)
During water stress situation the water is redistributed fairly.	148 (31.6)	320 (84.4)	00	468 (100)
The aggrieved farmers can easily launch a complaint to authorities for unfair water distribution	132 (28.2)	330 (70.5)	6 (1.3)	468 (100)
The authorities resolve the farmer's complaints promptly.	41 (8.8)	421 (90)	6 (1.3)	468 (100)

Results and Discussion

Frequency distribution and proportion of farmers regarding formal influences in irrigation water management

The irrigation system was established during British rules with some precise calculation and procedure for determining the quantity of water supplied to each land parcel and the way in which the smooth water supply will be ensured. In this way the rights of each farmer for irrigation water during its abundance and scarcity is properly documented. Moreover, the role of irrigation department in water distribution and management is sufficiently elaborated to formalize irrigation water management. The formal influences in irrigation water management, in this study, are measured through perceptional statements as given in Table 3.

The result show that 60 % of respondents stated that the water was not distributed among farmers/ agricultural land according to prescribed share, while 39.5 % respondents agreed to this view. On the other hand, 67.7 % and 66.7 % respondents agreed that irrigation schedule was strictly followed and irrigation water was provided to farmers according to prescribed time schedule, respectively. On the other hand, 32.3 % and 33.3 % respondents disagreed to these statements, respectively. The irrigation department follows a fix schedule for irrigation water distribution. Under the rule, the irrigation administration fixes a specific quantum of irrigation water for land parcel according to the season and availability of water and its rotational distribution, termed as "Warabandi". The schedule is made public for the awareness of relevant farmers. Thus, each farmer is generally aware of the timing for irrigating their fields. Majority of the farmers are satisfied with timing of irrigation schedule, however, they are unsatisfied of the quantum of water they receive. The difference is due to ignoring the ground reality while calculating the irrigation water share for each land parcel. Consequently, the farms at long distance from main canals or at tail end of irrigation channels receive disproportionate low among of irrigation water than farms located on head, despite of equal amount of time allocation. Poor engineering structure silting of irrigation channels, water loss due to seepage, evapotranspiration, obstruction in water channels and theft are the main reasons for insufficient irrigation water supply to farmers at tail. Rinaudo *et al*. (2000) explained that farmers received canal water on the basis of a weekly roaster of water termed as warabandi. The supply of water from watercourses is utilized by one farmer at a time. Theoretically, the water is allocated under the concept of equity i.e. each hectare of arable land received equal amount of water. Thus, each hydraulic unit is authorizing for water distribution to its specific command area. The irrigation staff regulate water supply by opening and shutting the water gates at each outlet. The quantum of water discharge is calculated from the dimensions of the outlet. At farm level the principle of equity is governed by length of time of water turn of each individual farmer according to size of their landholding. Lenton (1986) found that time table for water distribution is based on three important components i.e. frequency of delivery to the fields, duration of delivery and delivering flow rate to the field. The author further added that despite of the fixed frequency and duration of irrigation water delivery the farmers receive different amount of irrigation water due to decline in delivery flow rate to the field. Thus, the farmers at tail end are less satisfied with irrigation water supply than farmers at head. Gill and Sampath (1992) reported that water supply through irrigation canal system is limited while the arable land are expending due to conversion of waste land to agricultural land. Moreover, the high yielding genetically modified varieties of crops require excessive inputs including increased amount of water. Diffusion of these new varieties exerted excessive pressure on irrigation water supply (Armah *et al*., 2010; Habtamu, 2011).

The results further show that 62.8 % respondents were of the view that political elites influenced irrigation schedule while 37.2 % respondents disagreed to it. Moreover, an even proportion of 50% respondents both agreed and disagreed that big landlords could influence the set irrigation schedule. Moreover, 74.4 % respondents disagreed to the statements that during water stress situation water was fairly distributed and 31.6 % respondents agreed to it. The rural society is under the strong hold of social stratification system. The rural society is clearly divided into have and haven't. Income, size of landholding and political affiliation are the foundation stone of rural stratification system in study area. The privileged group like rich and politically strong farmers with large landholding manages to monopolize better share in irrigation water than the poor farmers, especially, during stress season. Use of personal influence, political influence and paying bribe to officials are the main tools to influence the predetermined irrigation schedule in their favor. Consequently, the poor farmers that constitute the majority of farming community are not satisfied with irrigation water distribution reschedule during stress season and describe it unfair (Armah *et al*., 2010). Nakashima (2005) mentioned that politicians and elected representatives influence the irrigation department to their advantage. These politicians and big landlords are so influential that they control the posting and transfers of irrigation department staff according to their will. The participatory approach encourages participation of farmers from all segment of society in integrated water resource management. However, the problems of elite capture prevail that deprive the poor segment of farmers from their due share of water (Habtamu, 2011).

Furthermore, 70.5% of respondents stated that aggrieved farmers could not easily launch a complaint to authority for unfair water distribution and 28.2 % respondents stated that launching of such complaints was easy. Moreover, majority of 90 % respondents reported that the authority didn't resolve farmer's complaints promptly, while 8.8 % respondents were satisfied in this aspect. The working of formal institutions is a combination of power and responsibilities. The irrigation department is responsible for fair distribution of irrigation water to all farmers without any discrimination. Moreover, in unsatisfactory state of affair the department is responsible for taking notice of such issue and immediate resolution of problems. The officials of irrigation department are also responsible to listen to the grievances of farmers and take prompt remedial action. However, these responsibilities of irrigation department are far from achievement. In some instances the staff of irrigation department is blame for favoritism, nepotism and corruption in irrigation water distribution. The farmers in this situation are disappointed to the extent that they don't launch complaints to authority for illegality out of disappointment of no action from irrigation department. However, there is an irrigation department version of explanation to this problem according to which insufficient number of irrigation staff, insufficient economic allocation, low availability of mobility and other facilities alongside political interference limit the working of irrigation department for fair distribution of irrigation water (Nisar *et al*., 2022). Freeman and Lowdermilk (1985) reported that the political elites, irrigation department officials and influential farmers enjoying the major benefits from irrigation water distribution despite of their violation of laws. This violator group is united and strong to such a level that the poor farmers cannot lodge/ file a complaint against them. If someone lodge such complaint is not entertained by irrigation department. The authors further added that there is a wide gap between farmers and irrigation department bureaucracy. Consequently, the farmers cannot approach appropriate office to resolve their problems. On the other side, the irrigation department bureaucracy maintains status quo that benefit them and minority elite class (Nakashima, 2005; Habtamu, 2011; Nisar *et al*., 2021).

Association between formal influences in irrigation water management and farmers' satisfaction with irrigation water distribution

Institutions are meant to meet the basic human need in an organized and systematic manner. The formal institutions work under the bureaucratic setup to bring clarity and certainty to the working of an organization. In the same way, the irrigation department has its own bureaucratic setup and system of working which brings certainty to water distribution and water use right.

Table 4: *Association between formal influences in irrigation water management and farmers' satisfaction with irrigation water distribution.*

Independent variable (Formal influences in irrigation water management)	Dependent variable	Statistics-χ2, (P= Value) and T^c
Water is distributed among farmers/ agricultural lands according to the prescribed share.	Farmer's satisfaction with irrigation water distribution	$\chi2$= 80.038 (0.000) T^c = 0.294
The irrigation schedule is strictly followed.	Farmer's satisfaction with irrigation water distribution	$\chi2$= 59.622 (0.000) T^c = 0.340
Farmers are provided irrigation water according to a predetermined time schedule.	Farmer's satisfaction with irrigation water distribution	$\chi2$=60.159 (0.000) T^c = 0.347
Political elites influence the set irrigation schedule.	Farmer's satisfaction with irrigation water distribution	$\chi2$=8.840 (0.012) T^c = -0.118
The big landlords cannot influence the set of irrigation schedules.	Farmer's satisfaction with irrigation water distribution	$\chi2$= 48.351 (0.000) T^c = 0.318
During a water stress situation, the water is redistributed fairly.	Farmer's satisfaction with irrigation water distribution	$\chi2$= 147.476 (0.000) T^c = 0.511
The aggrieved farmers can easily launch a complaint to authorities for unfair water distribution.	Farmer's satisfaction with irrigation water distribution	$\chi2$= 97.677 (0.000) T^c = 0.172
The authorities resolve the farmer's complaints promptly.	Farmer's satisfaction with irrigation water distribution	$\chi2$= 91.482 (0.000) T^c = 0.112

To assess the association between formal influences in irrigation water management and farmer's satisfaction with irrigation water distribution, the perception of formal influences in irrigation water management was limited to a few perceptional statements given in Table 4.

The results in Table 4 revealed that water distribution to agricultural land according to prescribed share and farmer's satisfaction with irrigation water distribution was found highly significant (P = 0.000) and positively (T^c = 0.294) associated. Similarly, a highly significant (P = 0.000) and positive (T^c = 0.206) association was found between strictly following the irrigation schedule and farmer's satisfaction with irrigation water distribution. The quantity of irrigation water supply to each farm is governed by a schedule of water distribution termed warabandi. According to this schedule, the irrigation water is proportionately allocated to each farm in the command area according to the size of the farm. The quantity of water distribution is determined by the duration of flow. Thus, big farms receive longer duration of water flow than small farms. Under the prevailing water distribution system, the irrigation turns are rotated among farmers annually. Such a system sounds fair in water distribution, under which the irrigation turns are shifted between day and night for all farmers. Such a formal system of irrigation water distribution ensures a scheduled supply of irrigation water to each farmer if implemented in its true spirit and raises farmers satisfaction with irrigation water distribution as evidenced by the above positive results. Alam *et al.* (2012) explained that the irrigation outlet has a specific dimension to allow a specific quantity of water inflow from the main canal. The main gate at the head of the water channels controls the volume of water inflow from the canal to the irrigation channels. The irrigation channels are supposed to irrigate a specific area, which is determined by the quantity of inflow, termed as command area. Each farmer receives his water share according to the size of arable land on a weekly basis on a specific day, time, and duration (warabandi). Given the significant differences in the length of watercourses and volume of water channels, the farmers at the tail end of irrigation channels are somewhat unsatisfied with irrigation water distribution, especially during water stress and drought time. However, most of the farmers are satisfied with the irrigation schedule (Sekiya *et al.*, 2017; Manero *et al.*, 2019). The type of crops and the timing of irrigation directly affect farmer's satisfaction with irrigation water distribution. Water-demanding crops at lean times are brought under water stress due to an insufficient supply of irrigation water. However, at the time of affluence, there is plenty of water for all farmers who receive their water share according to a predetermined schedule (Sekiya *et al.*, 2017; Stirzaker *et al.*, 2017). Stirzaker *et al.* (2017) further added that during water stress time the scheduled water is insufficient to sustain crops for good yield. In such situations, the farmers opt for alternate irrigation strategies like tube-well, groundwater, etc. are involved in water theft (Sekiya *et al*., 2017; Stirzaker *et al*., 2017).

Similarly, the association of provision of irrigation water distribution to farmers according to a predetermined time schedule was found highly significant (P = 0.000) and positive (T^c = 0.347) with farmer's satisfaction with irrigation water distribution. On the other hand, political elites influencing irrigation schedules exhibited significant and negative associations with farmer's satisfaction with irrigation water distribution (P = 0.012; T^c = -0.118). Moreover, the inability of big landlords to influence the irrigation schedule was found significant and positive in association with farmer's satisfaction with irrigation water distribution (P = 0.020; T^c = 0.318). Ideally, a rotational water distribution system is a balanced procedure to care for the irrigation water needs of all farmers satisfactorily. It is like persons standing in a queue and receiving their needful items according to need. The end result of a fair formal system is expected to be similar. However, there are extraneous and intervening factors that affect fairness in the water distribution. These factors include the prevailing power balance in society due to socio-economic and political reasons, corrupt administration water stress, etc. For instance, due to the political power imbalances, the existing water equilibrium is in favor of a few politically powerful persons to which excessive irrigation water is supplied at the cost of depriving poor farmers, hence leading to their dissatisfaction. Several forms of corruption and corrupt practices like bribery, nepotism, favoritism, etc. disrupt water distribution equilibrium in favor of powerful groups, leading to dissatisfaction among powerless farmers. However, the deprived segment of farmers may regain power through their unity to establish equality and ensure their due share in irrigation water. Gomo (2020) also mentioned that there are imbalances created in irrigation water distribution due to natural and anthropogenic reasons. Natural imbalances include seasonal variation, water availability, demand for different crops, and distance of the field from the main source of irrigation. Social inequality due to the socio-economic and political background of farmers and corruption at the institutional level adversely affect the system of fair water distribution. In such a situation, the politically powerful, rich, and big landlords receive a greater share of water than poor small-holding farmers, especially those located at the end of irrigation channels. The illiterate and poor farmers are tricked and deprived of their share of irrigation water by confusing them with the complexity of the irrigation water schedule or by controlling the water flow by reducing the water supply from the inlet (Joshi and Hooja, 2000). Kimmich and Tomas (2019) further added that the design of the irrigation infrastructure is another reason for the unequal irrigation water supply between rich and poor farmers. The rich farmers invest in their irrigation system by cementing the irrigation lines to reduce water losses on the way. Moreover, they regularly clean their irrigation channels to ensure a smooth flow of water to their fields. On the other hand, the socially disorganized and poor farmers neither have resources nor are united to reduce water losses and ensure better irrigation water supply to their fields (Joshi and Hooja, 2000; Omid *et al*., 2012).

Furthermore, fair water redistribution during stress time shows a highly significant and moderate positive association with farmer's satisfaction with irrigation water distribution (P= 0.000; T^c = 0.511). In addition, the launching of complaints to authorities by aggrieved farmers for unfair water distribution had a highly significant and positive association with farmers' satisfaction with irrigation water distribution (P = 0.000; T^c = 0.172). Likewise, prompt resolution of farmer's complaints by the authorities was significantly and positively associated with farmer's satisfaction with irrigation water distribution (P= 0.000; T^c = 0.112). All the norms, values, rules, and laws have evolved to strengthen the balanced functioning of various components of society. The same is true for formal administration in irrigation water management. The formal rules and procedures are changed and amended according to situational requirements, thus when the equilibrium of the water distribution schedule is disturbed by natural factors like water stress, a new equilibrium is achieved by redistributing the available water proportionately among the farmers. If the water distribution is transparent and fair, it is more acceptable to all dependent farmers. In case of dissatisfaction, the aggrieved party is provided the opportunity to lodge a complaint to the authority and raise their concerns over water distributions or water redistributions. The authorities are bound to respond to such complaints and redress the farmer's grievances. In this, way fair and transparent formal institution enhances fair water distributions to the satisfaction of farmers from all socio-economic backgrounds as evidenced by highly significant and positive results. On the other side, the power elite groups may influence and disrupt the impartiality of irrigation authorities and water distributions through their formal and informal influences. Thus, water redistribution in an unfair and corrupt system is more beneficial to powerful group than non-cohesive and deprived poor group of farmers. The partiality of administration and water redistribution creates distrust among farmers against these authorities. On the other side, the social cohesion of deprived farmers provides the required strength to compel the authorities to assist the deprived group and take prompt action in the redistribution of water (Koc *et al*., 2006). The powerful group of farmers, in such a situation, has its own strategies for power retention. They use their resources to keep poor farmers disorganized and less motivated for participatory irrigation management or lead the poor farmers and shield them from accessing the required information. Their informal influence on poor farmers at the village level is, sometimes, so strong that the marginalized group of farmers does not dare to claim the irrigation water distribution or lodge a complaint in this respect (Omid *et al*., 2012). In developing nations, the response of irrigation authorities toward farmer's complaints is lost in the offices (Koc *et al*., 2006). However, a fair officer in irrigation authorities is more likely to redress farmers' graveness timely and fairly and ensure their share in irrigation water distribution (Omid *et al*., 2012; Naz, 2018; Kimmich and Tomas, 2019).

Association between formal influences in irrigation water management and farmers' satisfaction with irrigation water distribution (controlling socio- economic status of the respondents)

Results in Table 5 revealed that the association of formal influences in irrigation water management and farmers' satisfaction with irrigation water distribution in the context of low socioeconomic status farmers showed positive (T^c = 0.291) and highly significant association (P=0.000). The association of the above-mentioned variables was positive (T^c= 0.272) and highly significant (P=0.000) for respondents from middle socioeconomic status and the association of the same variables was also positive (T^c = 0.385) and significant (P=0.002) for farmers from high socio-economic status. The value of the level of significance and T^c value for the entire table show a highly significant and positive association (P=0.000 and T^c = 0.310) between formal influences in irrigation water management and farmer's satisfaction with irrigation water distribution for all three categories i.e. low, middle and high socioeconomic status farmers. Variation in T^c and chi-square values for respondents from all three categories i.e. low, middle, and high socioeconomic statuses indicated that the association of formal influences in irrigation water management and farmer's satisfaction with irrigation water distribution is explained on the basis of farmer's socioeconomic status. The results of T^c showed that formal influences in irrigation water management enhanced farmers' satisfaction from water distribution of the farmers of high socio-economic status at a greater level than that of low and middle socio-economic status farmers. The formal rules, regulations, and procedures are instrumental in ensuring fair water distribution through integrated water resource management. The formal rules rest authority in irrigation administrations to manage and control the irrigation infrastructure and irrigation water for perennial and sustainable irrigation water supply to all farmers' groups in a satisfactory and fair manner. The economic benefits of agricultural organizations vary from farmer to farmer depending on the size of agricultural land, their innovativeness, and connectivity with the mark*et al*ongside expertise in growing crops that are in high demand. It is evident that farmers

Table 5: *Association between formal influences in irrigation water management and farmer's satisfaction with irrigation water distribution (controlling the socio-economic status of the respondents).*

Socio-economic status of the respondents	Independent variable	Dependent variable	Statistics $\chi2$, Chi-Square (P=Value) and T^c	Statistics, $\chi2$, chi-square (P=value) and T^c for the overall table
Low socio-economic status	Formal influences in irrigation water management	Farmer's satisfaction with irrigation water distribution	$\chi2$ =43.892 (0.000) T^c = 0.291	$\chi2$ = 78.223 (0.000) T^c = 0.310
Middle socio-economic status	Formal influences in irrigation water management	Farmer's satisfaction with irrigation water distribution	$\chi2$ =22.717 (0.000) T^c = 0.272	
High socio-economic status	Formal influences in irrigation water management	Farmer's satisfaction with irrigation water distribution	$\chi2$ =17.179 (0.002) T^c = 0.385	

with huge irrigation land demanded for higher supply of irrigation water for their agricultural production. A fair mechanism of a formal water distribution system takes care of protecting their irrigation share in water and its timely supply. Consequently, farmers from high socio-economic status groups are better rewarded for formal arrangements from irrigation water distribution as compared to those from middle and low socio-economic status groups as evidenced by the high T^c value. Several studies also reported that a formal system of irrigation water distribution and its fair implementation increase farmer's satisfaction with irrigation water distribution (Chambers, 1988; Qureshi *et al*., 2008; Gebrehiwot, 2018; Manero and Wheeler, 2022). However, the big farmers naturally favor inefficient utilization of irrigation water due to their big agricultural land (Hu *et al*., 2013), which leads to their greater satisfaction compared to farmers from other socio-economic status groups (Chambers, 1988; Hu *et al*., 2013). However, the formal administration has not always been smooth and fair in the distribution of irrigation water (Chambers, 1988; Hu *et al*., 2013). The big landlords exert excessive influence over over-irrigation administration to get a larger share of irrigation water they authorize to them at the cost of depriving the small and middle farmers. This factor of unfairness in irrigation water distribution favors farmers from high socio-economic status due to the partiality of formal authorities and leads to greater satisfaction of high socio-economic status farmers in the utilization of more water than other farmers (Mangan *et al*., 2021; Manero and Wheeler, 2022).

Conclusions and Recommendations

It is concluded that formal authority like an irrigation department is more focused on the procedures and mechanisms related to the technicality of water distribution in a calculated manner. These technical formulations bring clarity and certainty to irrigation water distribution during normal and slag seasons. However, there are insufficient provisions in the formal system to overcome the socio-economic and political basis of inequality in water distribution and redistribution.

The study recommended that policymakers enhance equality and fairness in irrigation water distribution and strengthen the complaint mechanism by making it transparent and time-bound, while also involving farmers in the water distribution system to reduce the chance of inequality in irrigation water distribution and improve farmers' satisfaction with irrigation water distribution. The establishment of a one-window operation that includes accepting irrigation complaints and its time-bound resolution with intimation to aggrieved farmers can enhance the administrative function of the irrigation department and reduce farmers' worries about discrimination over irrigation water supply.

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Novelty Statement

This research study comprehensively analyzed the irrigation water distribution fairness/ equality in the KP province, and practical implementation of the framed policies by the concerned departments.

Author's Contribution

Abdul Zahir: Research, analysis and original draft preparation.
Asad Ullah and Yonis Gulzar: Helped in analysis and relevant literature
Mohammad Shuaib Mir , Abdus Salaam and Arjumand Bano Soomro: Helped in editing and format setting.

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

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