Farmer's Satisfaction with Irrigation Water Distribution and Pollution in Canal Water in Central Khyber Pakhtunkhwa-Pakistan

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Abstract

The aim of this study was to highlight irrigation water pollution effects on farmer's satisfaction in central Khyber Pakhtunkhwa, Pakistan. A sample size of 466 farmers was selected through a multistage stratified random sampling technique, and an interview schedule was used as a tool to ascertain farmers' satisfaction with irrigation water distribution. To determine outcomes, both univariate and bivariate analysis were used. The dependent variable (farmer's satisfaction with irrigation water distribution) effects were assessed on the independent variable (pollution in irrigation water) by using the Chi-square test, and Kendall's T^c was used as a directional test. The study revealed significant and negative association with farmer's satisfaction with opening of sewerage lines into irrigation water channels (P = 0.000; T^c = -0.222), opening drainage lines into irrigation water channels (P = 0.000; T^c = -0.206), dumping of household solid wastes on the bank of irrigation water channels (P = 0.000; T^c = -0.206), regular choking of irrigation channels with household solid wastes (P = 0.000 ; T^c = -0.185) and negative effects of polluted irrigation water on crops yield (P = 0.000 ; T^c = -0.145). On the other hand, a significant (P = 0.000) and weak positive (T^c = 0.078) association was found between farmer's satisfaction with irrigation water distribution and personnel of irrigation department informing the farmers about water pollution and its effects on agriculture production. The study recommended three prong approaches of creating awareness related to adversities of irrigation water pollution among masses, strengthening moral basis of controlling water pollution and strict implementation of law to apprehend and punish the criminals of water pollution can improve the state of irrigation water pollution and subsequently farmer's satisfaction with irrigation water distribution.

Key words: Pollution in irrigation water, Satisfaction, Canal Water distribution, Pakistan

INTRODUCTION

In Indo-Pak subcontinent, the irrigation system was initiated during 1850 under British administration. For this purpose, the old canal system in Punjab and Sindh provinces were revived while some new and large canal system were constructed to establish the greatest canal irrigation system of the world. After partition in 1947, the water supply to Pakistan was disrupted that led to water dispute between India and Pakistan. The matter was resolved through World Bank intervention in 1960s and inking of Indus water treaty, under which the river of Indus basin i.e. Indus, Jhelum and Chenab were assigned for use to Pakistan. Pakistan took advantage of this treaty by establishing Pakistan Water and Power Development Authority (WAPDA) to construct barrages, link canals and dams for storage, diverging and channelizing irrigation water to agriculture fields in the plains of Pakistan (Britannica, 2021). One empirical study by Hussain *et al.,* (2011) suggested that in Pakistan 274 billion cubic meter water is available for agriculture, household and industrial uses, out of which 130 billion cubic meters is consumed in these sectors while 62 billion cubic meters is lost to the sea. Furthermore, for the 210 billion cubic meter water demanded for agriculture, only 190 billion cubic meters is available with shortfall of 20 billion cubic meters. The study further estimated an increase in agriculture water supply and demand gap to quantum of 27 billion cubic meters within a decade. Furthermore, the consumptive requirements of the crops is only 68 billion cubic meter while the rest of irrigation water is lost in the system due to poor water use efficiency, technical and social reasons (Ijaz *et al.,* 2017; Britannica, 2021 Munir *et al*, 2021).

Irrigation water pollution is the contamination of irrigation water in rivers, lakes, canals, water channels and ground water with residential, industrial and agricultural effluents. Most of the these effluents are harmful chemical and micro organisms that pollute the fresh water sources, reduce water quality and in some extreme cases made its toxic for humans and agricultural uses and degrade the overall quality of the water (Kahlown, 2004; Shukla *et al.,* 2022).

Naturally, water is easily polluted due its ability to dissolve majority of organic and inorganic compounds. The toxic and non toxic wastes from industries, residencies and farms easily mix or dissolve in water to make it toxic and reduce its quality. Contamination of irrigation water, therefore, can be from point source (industrial effluents), non point source (agricultural water runoff) and transboundary (one country spilling wastes to another country waters). Use of polluted water is harmful for human, health, ecosystem health and agricultural production (Bwire *et al.,* 2020). Municipal sewage in a form of human excreta and solid waste is a major source of irrigation water contamination in Pakistan. Million of moist tonnes excreta loaded with bacterial contamination is produced in urban and rural areas of the country. Only few of the metropolitans have sewage treatment plants to treat household sewage. Therefore, most of the household and industrial wastes are discharged directly into rivers and canals system which are the main source of irrigation water for agriculture (Rafiq, 1999; Qutub, 2004; Kahlown, 2004). The adverse effects of municipal sewage and industrial waste are multi dimensional ranging from reduction in water quality making at unsuitable for irrigation, chocking the irrigation channels and source of water borne disease in human and animals (Khan, 2002). Therefore, legal and institutional reforms proposed under integrated water resource management emphasizes on the involvement of local communities and strengthening the legal institutional systems to control water pollution (Shukla *et al.,* 2022).

MATERIALS AND METHODS

This research study was carried out in three districts i.e. Malakand, Charsadda and Mardan. The central Khyber Pakhtunkhwa is irrigated through upper Swat canal which further divided into two sub canals (Abazai and Machi) and three administrative irrigation sections i.e. Dargai, Harichand & Hatyan. A multi stage stratified random sampling technique was adopted for sample selection shown in Table-1. The lists of 15242 farmers were obtained from the irrigation department. Thus the population frame for the current study was 15242 farmers and sample size for current study was (n = 466) by using Chaudhry (2009) and for proportion allocation using Bowley (1926) equation-2

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

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

$$n_h = \frac{Nh}{N} \times n \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(Equation-2)}$$

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 & minors

Selected minors and farmers from Dargai Irrigation Section					
S/No	**Selected minors**	**Total number of outlets on each minor**	**Selected outlets from each minor**	**Total number of farmers on each minor**	**Sample size from each minor**
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 Harichand Irrigation Section					
S/No	**Selected minors**	**Total number of outlets on**	**Selected outlets from each minor**	**Total number of farmers on each minor**	**Sample size from each minor**

		each minor			
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 Hatyan Irrigation Section					
S/No	**Selected minors**	**Total number of outlets on each minor**	**Selected outlets from each minor**	**Total number of farmers on each minor**	**Sample size from each minor**
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

Measurement of variables

The domain pollution in irrigation water was measured on scales adopted from Jitarwal and Sharam (2007), Manero (2018) and Habtamu (2011) with some slight modifications according to local requirements, as suggested by panel of experts (supervisory committee). Thus, pollution in irrigation water variables were measured on 8 items scales. The variable pollution in irrigation water was indexed into three categories and the respondents having an average score of 1.25 and below, 1.26 to 1.75 and above 1.75 on the pollution in irrigation water scale were categorized as high level of irrigation water contamination, moderate level of irrigation water contamination & low level of irrigation water contamination and coded as 0, 1 and 2 respectively

Data Analysis

Statistical package for the social sciences (SPSS) version 20 was used for analysis of data. Univariate analysis included frequency counting and percentage by using Chaudhry and Kamal (1996) equation. While at Bi-Variate analysis, chi-square test (Tai 1978) was used to find out the association between dependent (farmer's satisfaction with irrigation water distribution) and independent (pollution in irrigation water) variables and Kendall's Tau-C test was used to find out the strength and direction of the relationship between these variables (Nachmias and Chava, 1992).

RESULTS AND DISCUSSION

Perception of farmers regarding Pollution in irrigation water

Fresh water is now considered as limited natural resource that should be cautiously used for its sustainability. Due to growing population and global climatic changes there is abrupt decline in per capita water availability and quality of fresh water. The irrigation water pollution is on rise due to direct opening of household and commercial waste lines into water canals and other reservoirs. Water pollution is prohibited by law, however, implementation of such laws that prevent water pollution remain unachieved. The perception and experiences of respondents regarding irrigation water pollution are given in Table-2 and explained as below,

Majority of 85.9 percent and 86.5 percent respondents agreed that the sewerage and drainage lines opened into irrigation water channels respectively, while only 14.1 percent and 13.5 percent respondents negated it, respectively. Moreover, 86.7 percent respondents affirmed that they dumped their household wastes on the bank of irrigation channels while 13.5 percent respondents negated this view. Household wastes management is an emerging environmental problem for developing countries. According to law it is illegal to drain household wastes into water bodies or throw solid wastes into irrigation canals and channels. However, the municipalities' services and implementation of environmental laws in rural Pakistan are almost none existing. Neither the government has any plan for management of household wastes nor there any community efforts to manage the household wastes. Consequently,

the household waste is directly drained into irrigation canals and water channels or the solid waste is dumped on the bank of irrigation canals of directly thrown into it. The water contaminated through household wastes swarm with fetal micro-organisms and unhealthy chemicals that directly or indirectly enter to food chain through its human, animals or irrigation use. Moreover, the organic and inorganic solid thrown into irrigation system reduces the water carrying capacity of canals and chock the irrigation outlets that hinder the flow and supply of irrigation water to farmers. The government has to spend millions of rupees on cleaning and desilting of water canals and its associate tributaries. The farmers further informed during FGDs that polluted irrigation water is the source of diverse water born fetal diseases for them and their animals. Moreover, the sharp edge solid wastes caused physical injury to them during irrigation. It was also reported by the farmers due to huge quantum of polythene bags and pampers thrown into irrigation water it is literary impossible for farmers to remove all these wastes personally and dump it into some suitable place. Dumping household and industrials wastes into water bodies and irrigation channels is an emerging national problem that may cause some serious tragedy (Rafiq, 1999), as the water of these water bodies is directly or indirectly consumed by human population (Kahlown, 2004). Majority of population is constrained to throw their household wastes into water bodies due to non availability of appropriate drainage and waste management system (Sayal, 2015). The hazardous water is used for watering cattle and irrigated fields. Moreover, this water seeps down to contaminate ground water, making it unsuitable for human use. Detection of heavy metals, metals salts, acids, oil, hazardous compounds and bacteria is not unusual in the irrigation and the river water of the country (Sayal, 2015).

Furthermore, 82.9 percent respondents informed that irrigation water was regularly chocked with household solid wastes that were dumped into irrigation canals/channels, and 18.7 percent respondents negated this view. Moreover, 69.2 percent respondents stated that polluted irrigation water negatively affected their crops yield, while 24.4 percent respondents were against this view. In addition, 79.1 percent respondents negated that irrigation department personnel informed them about water pollution and its effects on agriculture production, while 20.5 percent respondents were informed by irrigation department personnel about this problem. With growing population and increase in desire for luxurious life has exerted tremendous pressure on exhaustible and non exhaustible natural resources on one side, and have added environmental pollution on the other side. Human desire for better standard life is compelling for lavish resource use without compromising their comfort. On the other hand, the capitalistic production system is developing and promoting disposable resources uses that can be used once and then thrown away. Consequently, the human society is becoming a disposable society. Short term human comforts through use of disposable products create tons and tons of solid wastes that are front line threat to natural environment. The solid wastes thrown into water channels stuck into the narrow lines. Moreover, some of the hygroscopic wastes like drapers swell up by absorbing water and chock the irrigation channels. The impermeable products like polythene bags, dam the water flow. In addition, the huge deed animals like cow, goat, and sheep etc. can completely stop the flow of water into irrigation outlets. Moreover, the organic and inorganic chemicals deplete the water quality. Consequently, farmers receive insufficient quantity of water due to obstruction posed by solid wastes and low quality of water due to chemical and microbial admixture into it. The polluted water is both insufficient and inappropriate for agriculture use and reduces the agriculture production. Irrigation department is responsible for implementing relevant law and awareness among masses to control water pollution and its adverse effects on the crops and human. However, the department has been unsuccessful in performing this aspect of their duty, as evident from the above results. Khan (2002) also reported that use of foul water is negatively affecting crops production. In some extreme cases the water pollution is so grave that irrigation water become unavailable to the farmers and they are constrained to quit the farming profession. Amir (2012) further added that municipality services like garbage collection don't exist in rural areas and the people throw their household wastes directly into irrigation canals/ channels as an easy way out. These canals are found chocked due to solid wastes almost a week after a cleaning drive. The officials have completely failed to punish the offenders and control water pollution. Hayat (2007) added that the household chemical wastes like detergents and other organic and inorganic compounds that are added into canals, reduces the dissolved oxygen concentration in water with profound environmental effects. Scheierling *et al.,* (2012) suggested treatment of waste water before its use for agriculture purposes. However, these suggestion remain unimplemented that promote water born disease in human and their cattle, alongside decreasing agriculture crops yield (Khwaja, 2003).

The result further show that 84.2 percent respondents negated launching of any complaint by them or their community against violators to authority, while 14.9 percent launched such complaints. Furthermore, 95.5 percent respondents stated that persons polluting irrigation water channels were not punished by authorities and only 3 percent respondent's witnessed punishment of persons polluting irrigation water by authorities. The rural community system is based on cast and baraderi system where people from common decent live together. These communities are strongly integrated due to high mutual interdependence and daily face o face interaction. They exhibit common behavioral

characteristics and share common language, norms and values. The non-existence of municipality services compelled some people to become deviant and throw solid wastes in irrigation system. The convenience of getting rid of household wastes in an easy manner motivated the rest of the people to get rid of their household wastes in the same manners. Thus, a deviant behaviour with passage of time and greater social acceptability became a social norm, which majority of people doesn't complaint of. However, some sensitive farmers have experienced the negative effect of such pollution and have started efforts to control this menace by sensitizing community or initiating legal suits. However, the response from irrigation department and judiciary to punish the culprits is highly discouraging. Consequently, the morale of reform leaders in controlling water pollution is at stack. Amir (2012) further added that the people in forefront of irrigation water reforms faced threats from violators to stop their campaign. Moreover, existence of punitive law for pollution control is insufficient until its fair and forceful implementation by executive authority. The officials of irrigation department are found complaining of non cooperation from police and judiciary to apprehend the culprits and punish them. Moreover, the development authority in rural and urban areas is found criminally involved in diverting household waste lines into canals and rivers (Khattak, 2016; Donnell and Talbot-Jones, 2018). Despite of several court verdicts the administration has failed to apprehend pollution mafia. The powerful industrialists, developers and builders have become mafia in grabbing productive agriculture land and contaminated fresh water source (Ahmed, 2018; Yasif, 2018).

Table-2: Frequency distribution and proportion of farmers regarding Pollution in irrigation water

Statements	Yes	No	Uncertain	Total
Your sewerage line ends/opens into irrigation water channels.	402 (85.9)	66 (14.1)	00	468 (100)
Your drainage line ends/opens into irrigation water channels.	405 (86.5)	63 (13.5)	00	468 (100)
You dump/ throw your solid/household waste on the bank/ into irrigation water channels.	405 (86.5)	63 (13.5)	00	468 (100)
The irrigation water are regularly choked with solid waste producing at household level	388 (82.9)	78 (16.7)	2 (0.4)	468 (100)
The personnel of irrigation department inform you about water pollution and its effects on agricultural production.	96 (20.5)	370 (79.1)	2 (0.4)	468 (100)
Crop yield is negatively affected due to polluted irrigation water	324 (69.2)	114 (24.4)	30 (6.4)	468 (100)
You and your community launch complaint against violators to the authorities.	69 (14.9)	394 (84.2)	5 (1.1)	468 (100)
Persons polluting irrigation water channels are punished by authorities.	14 (3.0)	447 (95.5)	7 (1.5)	468 (100)

Source: Survey 2022

Association between pollution in irrigation water and farmers' satisfaction with irrigation water distribution

Irrigation water is the most important input component of irrigated agriculture. Quantity and quality of irrigation water is determinist to the overall farm productivity. Growing water pollution due to anthropogenic interventions is the major concern for environmental scientists, agronomist and social scientists. To understand farmer's satisfaction with irrigation water distribution, it is important to identify an understand causes and consequences of irrigation water pollution. Association of irrigation water pollution and farmer's satisfaction with irrigation water distribution is given in Table-3 and explained below.

Results in Table-3 show that opening of sewerage lines into irrigation water channels had a highly significant but negative association ($P = 0.000$; $T^c = -0.222$) with farmer's satisfaction with irrigation water distribution. Similarly, the result of opening drainage lines into irrigation water channels and farmer's satisfaction with irrigation water distribution was found highly significant and negative ($P = 0.000$; $T^c = -0.206$). Moreover, dumping of household solid wastes on the bank of irrigation water channels exhibited a highly significant and negative association with farmer's satisfaction with irrigation water distribution ($P = 0.000$; $T^c = -0.206$). With increase in population, there are rising concern over water pollution due to anthropogenic causes. The solid and liquid pollutants generated due to human activities, generally, end up into water (both in marine and fresh water). A major chunk of such pollutants are produced at household level in shape of human excreta and household wastes. Ideally, the household wastes should be managed properly by municipality to avoid environmental hazard and pollution. However, in rural areas of Pakistan such

municipality services and drainage lines are unavailable, due to which the household wastes is directly drained into irrigation channels or dumped on its banks. Due to disproportionate population growth and desire for lavish life style, the amount of household wastes is increasing in an unprecedented rate which ends up into water channels, hence downgrading the quality of irrigation water and enhancing farmer's dissatisfaction with irrigation water distribution. The same is the reason of the above mentioned negative association. Baig *et al.,* (2019) reported that there is rapid increase in water pollution due to household wastes drained into water bodies causing complex environmental, social and health related problems. The water pollution is putting several plants and animal species at risk. Moreover, it lower the water quality and make it unsuitable for agricultural purposes, resulting into low agriculture yield and wastage of farmers efforts (Buechler *et al.,* 2002; Taylor *et al.,* 2005; Baig *et al.,* 2019). Comparative studies unveiled substantial decreases in yield due to irrigation with contaminated water as compared to clean water. Furthermore, contaminated water created salinity, nutrition deficiency and social structure related problems that adversely affected the crops root system and lowered agriculture productivity (Ongley, 1999). The household pollutants seep down the soil and contaminate ground water. Such water is unsuitable for human and agriculture use. Due to irrigation water contamination, the agriculture is becoming economically non feasible. In the highly polluted areas, farmers have already changed their farming profession or ready to change it (Scheierling, 1996; Gaballah *et al.,* 2005). Mere education and awareness raising efforts are insufficient to control water pollution until some strong population control laws are not implemented in its true spirit (Sulaeman *et al.,* 2018).

Furthermore, highly significant (P = 0.000) and negative (T^c = -0.185) association was found between regular choking of irrigation channels with household solid wastes and farmer's satisfaction with irrigation water distribution. With the technical advancement the human life style has tremendously changed. In pursuit of better life style and luxury, the industrial production system is exerting tremendous pressure on natural resources. Moreover, the industrial and household solid waste mostly ends up into water bodies. Furthermore, wasteful use of resources and promotion of disposable products have multiplied the household waste production to such an extent that some of the societies are now termed as disposable society. The huge amount of solid waste produced has excessive environmental costs. The solid waste dumped into irrigation channels is mostly impermeable and hygroscopic in nature. Such waste swells up and chock the narrow water passages. In addition, the big watercourses like canals and minors located near habitation also need regular and frequent cleaning operation. Due to choking of watercourses and dumping solid wastes into canals, the water flow is interrupted and reduced in terms of speed and volume of water flow. Irrigation channels cleaning operation requires high financial and human input and wastes lot of time as well. Regular interruption in flow of water due to solid wastes decreases irrigation water supply and adversely affected farmer's satisfaction with irrigation water distribution. The government has devised the policies and laws to control water pollution, yet, there are problems in its implementation. Consequently, the problems of irrigation water pollution remain uncontrolled and increases with each passing day (Olabode and Lawrence, 2014; Suleiman *et al.,* 2018). Municipality services in rural areas are either non-existing or passive in waste collection and management. On the other side, irrigation department pay little heals to irrigation water pollution. Consequently, irrigation water pollution and frequency of obstruction of watercourses due to solid waste is on rise (GOP, 2015). The government spent millions of rupees on cleaning the irrigation channels but failed to stop dumping of waste into water channels. As a result, the farmers receive irrigation water in low quantity and poor quality (Suleiman *et al.,* 2018).

Similarly, a significant (P = 0.000) and weak positive (T^c = 0.078) association was found between farmer's satisfaction with irrigation water distribution and personnel of irrigation department informing the farmers about water pollution and its effects on agriculture production. Moreover, negative effects of polluted irrigation water on crops yield exhibited highly significant (P = 0.000) and negative (T^c = -0.145) association with farmer's satisfaction with irrigation water distribution. The personnel of irrigation department has multiple responsibilities to perform including planning and management in irrigation water distribution and infrastructure and, awareness raising among farmers with respect to various dimensions of efficient water use. Therefore, it is expected that irrigation staff will organize such awareness raising events and campaigns to create awareness among farmers regarding effects of polluted water on crops yield. In reality, the over burdened irrigation department staff are unable to perform the irrigation extension related responsibilities up to the satisfaction of the farmers. However, they manage to give authentic knowledge of the negative influence of polluted water on crops yield which is responsible for somewhat satisfaction of farmers with irrigation water distribution as evident from the above results. The irrigation department and its associated non-governmental organizations are striving for controlling water pollution. However, they alone, without active involvement of community, cannot control water pollution. Therefore, they are mandated with arranging awareness raising campaigns to appraise farmers about negative effects of polluted water on their farms, its soil structure and overall agricultural productivity (Withanachchi, 2018). The purpose of such awareness campaign is to mobilize the farmers and other

community members to take active part in controlling water pollution. Moreover, a farmer informed of the negative effect of polluted water on their crops is vigilant in controlling water pollution on one side and taking appropriate measures to apply safe irrigation water to their field on the other side, resulting in to their greater satisfaction (Sidawi,2016 ; Seebach, 2016). With the passage of time the consumers of agriculture products are getting aware of health precautions of food grown with contaminated water. Consequently, they preferred to purchase better quality of food on high prices. In this way, the consumers demand for quality food grown with clean irrigation water is transmitted through agriculture market to the farmers. The additional income opportunities so created are compelling the farmers to use clean irrigation water for growing high yield crops with better financial return (Misawa and Kondoh, 1992). During high water stress time the farmers are trained in diluting the reuse water to reduce its contamination level to a desirable level and applied it for irrigation purposes in the field. Awareness rising of farmers helps them to understand treatment of domestic water for reducing its contamination level and its reuse for irrigation purposes. Literate and well aware farmers can easily understand and apply water reuse regulation to satisfy their irrigation water need (Abdel-Shafy and Aly, 2002).

Conversely, farmer's satisfaction with irrigation water distribution showed a non-significant and very weak positive association with launching complaint against violators to the authorities (P = 0.215; T^c = 0.042) and punishment of polluters by the authorities (P = 0.183; T^c = 0.003). The rural communities have strong sense of cohesion characterized with intimate and face to face interaction. Water pollution has not yet been considered as a major problem by the farmers or they don't want to affect their relation with other fellow farmers on the basis of pollution in irrigation water. Moreover, irrigation water pollution problem has been diffused to each nook and corner of rural communities due to non availability of municipality services in the study area. Additionally, the law has never been implemented to punish water polluters. Therefore, the farmers don't complaint instances of water pollution to the authorities as evident from the non-significant results. The irrigation department and other responsible authorities play a passive role in controlling water pollution in developing countries. The community members seldom complaint about water pollution as these complaints are rarely admitted and occasionally resolved (Rustinsyah, 2019). Moreover, such complaints lodged by individuals and groups to control water pollution become a source of disagreement, disputes and even violent conflict among farmers. In such situation, greater attention is paid to resolving conflicts, and not to controlling water pollution (Misaghi *et al.,* 2017; Withanachchi, 2018; Sulaeman *et al.,* 2018).

Table-3: Association between pollution in irrigation water and farmers' satisfaction with irrigation water distribution

Independent variable (Pollution in irrigation water)	Dependent variable	Statistics-$\chi 2$, (P=Value) & T^c
Your sewerage line ends/opens into irrigation water channels.	Farmer's satisfaction with irrigation water distribution	$\chi 2$=58.115 (0.000) T^c = -0.222
Your drainage line ends/opens into irrigation water channels.	Farmer's satisfaction with irrigation water distribution	$\chi 2$= 60.687 (0.000) T^c = -0.206
You dump/ throw your solid/household waste on the bank/ into irrigation water channels.	Farmer's satisfaction with irrigation water distribution	$\chi 2$= 60.687 (0.000) T^c = -0.206
The irrigation water channels are regularly choked with solid waste producing at household level	Farmer's satisfaction with irrigation water distribution	$\chi 2$= 61.421 (0.000) T^c = -0.185
The personnel of irrigation department inform you about water pollution and its effects on agricultural production.	Farmer's satisfaction with irrigation water distribution	$\chi 2$= 17.405 (0.002) T^c = 0.078
Crop yield is negatively affected due to polluted irrigation water	Farmer's satisfaction with irrigation water distribution	$\chi 2$= 30.212 (0.000) T^c = -0.145
You and your community launch complaint against violators to the authorities.	Farmer's satisfaction with irrigation water distribution	$\chi 2$= 5.790 (0.215) T^c = 0.042
Persons polluting irrigation water channels are	Farmer's satisfaction with irrigation	$\chi 2$= 6.220 (0.183)

punished by authorities.	water distribution	$T^c = 0.003$

Source: Survey 2022

CONCLUSIONS AND RECOMMENDATIONS

Pollution in irrigation water in terms of sewerage and drainage lines ending up into irrigation system and dumping of solid wastes into it caused chocking of irrigation outlets/ passages due to solid wastes and affected crops yield which negatively influenced farmer's satisfaction with irrigation water distribution. Pollution free irrigation water is mandatory for growing healthy and nutritious crop sustainably. Controlling water pollution through provision of municipality services for solid waste collection and prevention of sewerage lines ending up into irrigation system can positively influence quality supply of irrigation water to the farmers. Moreover, awareness rising of farmers and their mobilization for controlling irrigation water pollution with active support from irrigation department and other relevant authorities and strict implementation of law by penalizing the culprits can help reduction in irrigation water pollution and supply of clean water to farmers for the irrigation purposes.

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