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Can Participatory Irrigation Management be an answer to Sustainable Irrigation Water Management? A case study from India

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Abstract

Participation of the communities at various tiers of irrigation management has gained popularity over the years. A parallel urge has been the promotion of sustainable practices that can provide high resource efficiency and greater returns with smaller resource outlay. Though studies have focused on both the issues, few have tried to link both. This study attempts to add to the existing knowledge by exploring whether sustainable management of irrigation can be achieved with the inclusion of farmers themselves in the operation and management of irrigation. For these 250 farmers who are members of Water Users Associations (WUAs) and 120 farmers who have never been a part of any WUA have been interviewed using Focus Group Discussion. Relative Irrigation Supply (RIS) and Irrigation Water Productivity (IWP) calculated using the CROPWAT 8.0 software of FAO, have been selected as the indicators of sustainability. Results show that the RIS among the participant farmers is lower than the non-participant farmers. The variability in RIS between the groups is statistically significant at p<0.05. The IWP is higher among the participant farmers and lower among the non-participants. The variance in IWP between the groups is not significant statistically. The strict adherence to water fees payment and training on rationed water use has imbibed water saving practices among the participant farmers. Thus, the study indicates that Participatory Irrigation Management can sustainability of irrigation practices among users and hence establishes a link between sustainable irrigation practice and community participation.

Keywords: CROPWAT, Irrigation Water Productivity, Participatory Irrigation Management, Relative Irrigation Supply, Sustainable Irrigation, Water Users Association

1. Introduction

Sustainability in terms of resource utilization in a way such that it provides for the present needs without compromising with the ability of the future generations to meet their resource needs was introduced by the Brundtland Commission (Bruntland, 1987). The Agenda 21 is the 'blueprint' of the practices and measures that are to be taken up globally across all scales to achieve sustainable development (UN-DESA 2012; Bryner 1999). In providing the world with sustainable policy practices, the Agenda in its 28th chapter recognizes the importance of communities and their participation in realizing the goal of sustainable development (Eckerberg & Forsberg, 1998; Meadowcroft, 2004; Coenen, 2009). UNDP (2012) has hinted that water governance in terms of political, social, economic and administrative systems is crucial for the attainment of sustainable water management (Sinclair et al., 2013). This is what connects PIM and sustainable irrigation management, although both differ in their reasons for emergence.

While the concept of sustainable development emerged to provide for a long lasting and efficient utilization of resources and the entire ecosystem in general, PIM emerged to address the glitches of traditional irrigation system. The PIM practice started gaining momentum in the decade of the 1970s when universally it was felt that the traditional, bureaucratic and centralized nature of the irrigation system was to be blamed for the inefficiency of the irrigation sector (Cremers et al., 2005; Gandhi & Namboodiri, 2008).

PIM as the name suggests is the practice of involving farmers and users themselves in the management of the irrigation systems. According to Gandhi and Namboodiri (2012), PIM involves the water users for the management of water at various tiers. Under this process, groups of farmers are organized into "formal bodies" which are variously referred to as Water Users Associations (WUAs), irrigation cooperatives or partnerships (Pg.7, ibid). Another parallel practice, Irrigation Management Transfer (IMT) also involves the users for operation and management of irrigation, but it differs a little from PIM. While IMT intends to replace the role of government in irrigation management, PIM aims at strengthening the links between the users and government by allowing farmers/ beneficiary's participation (Restrepo et al., 2007; Hamada & Samad, 2011). Chattopadhyay et al. (2022) in their study point out that participation of the communities leads to modification of the collective rules to promote proper implementation of such rules, which in turn leads to sustainable management of water resources. Similar claims have been made by Rao et al. (2021) in their study on China where PIM promoted the adoption of the sustainable techniques like Mulched drip irrigation techniques among the participant farmers.

Thus, the importance of community involvement in providing for sustainable and eco-friendly resource use has been felt globally and the water resource, especially irrigation resources, has been no exception. The rising crisis of global freshwater resources stands in crossroads with the rising global population that requires food security for its sustenance. The World Bank (May 2020) states that about 20% of the total cultivated area of the world is irrigated and it produces 40% of the world's food. This hints at the rising demand for irrigation water to feed the increasing world population. In the light of present-day climate change and scarcity of water resources, efficient use of water for irrigation becomes crucial (Calzadilla et al., 2011; Mancosu et al., 2015). This efficiency is often hindered by the absence of proper institutions for sustainable water resource management (Sudgen et al., 2020; Chattopadhyay et al., 2022).

Taking cue from the global attempts, India introduced the Command Area Development (CAD) Program way back in 1974 which recommended the involvement of farmers and water users in the management of irrigation. Though the program could not achieve much, it did set the ground for PIM. The National Water Policy of 1987 led to formal introduction of PIM in India and participation of the stakeholders was seen as an instrument for better irrigation management (Nayak & Manasi, 2016). The National Water policy of 2002 further emphasized on the involvement of users, especially the women users and gave impetus to necessary legal and institutional changes for the devolution of irrigation management rights to local bodies like WUAs (Devi, 2018). Similar attempts were made in the subsequent Water Policy of 2012 that recommended the involvement of WUAs at the planning and decision-making stages of irrigation management. Policies like Per Drop More Crop, Pradhan Mantri Krishi Sinchai Yojana, Har Khet Ko Pani etc., have emphasized the adoption of PIM. Since then, the farmers have been an integral part of irrigation management in India but there is no unified PIM law in the country and each state has adopted the practice flexibly. For instance, states like Andhra Pradesh, Gujarat, Tamil Nadu and Odisha have enacted legislations for the adoption of PIM while the state of West Bengal has refrained from legalizing PIM. Apart from the government initiatives, various non-government actors have also enabled the introduction of PIM in India. This list may include Non-Government Organizations like Society for Promoting Participative Ecosystem Management (SOPECOM) of Pune and Development Support Centre (DSC) of Gujarat and funding agencies like World Bank, the State Water and Land Management Institutes (WALMI).

PIM has been in practice across the globe for over four decades now and its impact analysis is becoming crucial. Majority of the works that have been taken up previously have either portrayed the practice of PIM in the light of institutional and bureaucratic changes in the irrigation management or have assessed it based on the improvements in water fees collection, conflict resolution, irrigated area or area under crops (Jadeja & Parmar, 2017; Pèk et al., 2019; Husain et al., 2021). These works have highlighted the chequered nature of PIM's outcome, and the factors have been promoting or obstructing the successful implementation of PIM (Cambaza et al., 2020; Senanayake et al., 2015). Though Chattopadhyay et al. (2022) have emphasized on the importance of the WUAs in devising irrigation management plans that are locally sustainable, they have not devised quantitative measures to approve of the sustainability that is claimed to have been achieved with the introduction of PIM. Thus, few papers have gone beyond the institutional and participatory features in understanding the sustainable resource management introduced by PIM. Moreover, a comparative analysis of such outcomes in the presence and absence of PIM is lacking in most of the literatures. This paper tries to bridge this gap by including the measures on irrigation supply and the per unit productivity of irrigation water supplied by comparing the participant and non-participant farmers.

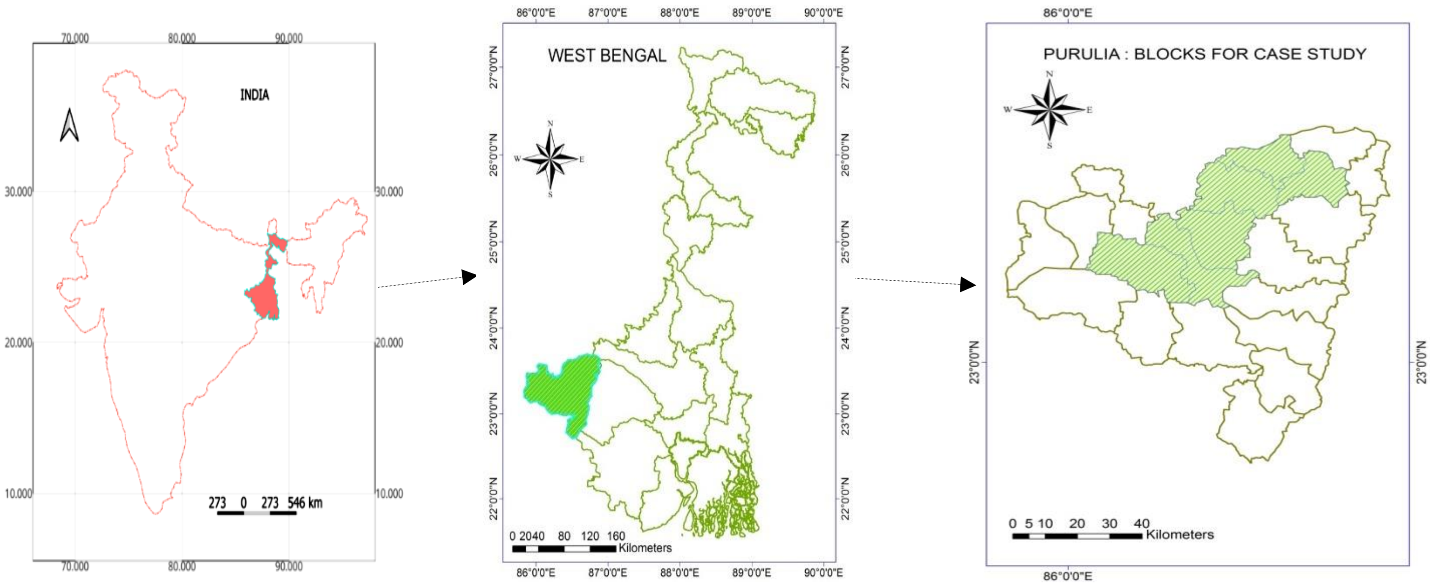
This paper thus attempts to understand the practice of sustainable resource management through the prism of Participatory Irrigation Management (PIM). Though a lot of work has been taken up individually on the concepts, few works have reflected on whether the involvement of the communities and stakeholders leads to sustainable irrigation management. The PIM here has been considered as the means to attain the end that is sustainability. It attempts to bring out the implication of the participation of the users on the efficiency of water use. For this, firsthand information has been collected across two groups that are similar in their socio-cultural, economic and demographic characteristics, but are different in terms of a 'treatment' or 'placebo'. The treatment here is PIM, where the treatment group has been a part of the PIM bodies like Water Users Association while the control group has never participated in any such PIM body. Overall, the study aims to highlight whether sustainable management of irrigation water can be brought about by PIM by measuring the RIS and IWP between the two groups of farmers.

2. Materials and Methods

2.1 Study area and Sampling

The study is based on the Indian District of Purulia in the state of West Bengal (Map 1). The district is in the undulating red and lateritic agroclimatic zone and is characterized by low rainfall and poor soils with low fertility. The district experiences dry tropical climate with very high evapotranspiration rates (Ezung et al., 2022). The district has a high preponderance of small and marginal farmers with 79% of the farmers with a land holding size of less than or equal to 1 hectare (NABARD Report, 2022). Thus, irrigation and its sustainable utilization have become crucial for the district. The study is based on six Community Development Blocks drained by three major rivers from the district, namely Kangsabati, Damodar and Kumari. The blocks chosen for the study lie within these three river basins. The selection of the Blocks has been further done based on two factors a) the post monsoon water level b) presence/absence of the PIM bodies. From each river basin, one block with participant farmers and one non-participant farmer has been selected, thus adding up to six blocks. Moreover, each block selected recorded the lowest post monsoon water level within the river basin with or without PIM bodies.

A total of 250 Farmers who have participated in PIM have been chosen from 25 WUAs across three blocks from each river basin and 120 non-participant farmers have been chosen for the study from each. The participant farmers were chosen using Purposive Sampling Technique and the non-participants were chosen using random sampling technique. Purposive sampling has been utilized to intentionally focus on the participants and their experiences, while random sampling was done in case of non-participants to avoid biases. Both the farmer groups have been selected from similar demographic and socio-economic profiles so that near similar characteristics of the respondents can be maintained. This has been done cautiously to avoid any bias in estimating the 'treatment' effect. Thus, the farmers chosen for the study are mainly small and marginal ones for both the groups. While the former farmers own 1-2 hectares of land, the latter own land below 1 hectare. Respondents also come from two broad demographic categories, tribal and non-tribal. While among the participant 120 farmers (48% of the total participant farmers) belong to the tribal category, 59 non-participant farmers are tribal (49.16% of the non-participant farmers).



Map 1. The hierarchical selection of Study area

2.2 Data Collection

Both primary and secondary data have been utilized for the study. The primary data has been collected firsthand from both the participants and the non-participants using face to face interviews conducted between 2021 to 2023. The data mainly relates to inputs on the duration of water supply, power of the pump, distance of water source from the farm. Secondary data has been collected from various Government reports on input related to weather.

2.3 Indicators and Techniques Used

The study is based on two water related indicators – a) Irrigation Water Productivity (IWP) b) Relative Irrigation Supply. These two indicators have been used to identify whether PIM could attain sustainable management of irrigation.

Irrigation Water Productivity is a measure output produced with per unit water supplied in m3. It is the per unit productivity of water. Thus, it requires data both on the production of crops and the amount of water supply. It is the ratio of the input in terms of water supply while output in terms of crop production. The measure of IWP as a measure for sustainability has been common across literatures (Li et al., 2024; Mali et al., 2016; Kassam, 2007; Zhang, 2013). Similar implications have been noted in the Economic Survey of India (2018-19), where the suggestion has been to shift the focus from 'land productivity' to 'irrigation water productivity' with a view to improve the water efficiency (PIB, Government of India, Ministry of Finance 4th July 2019). Thus, this factor has been used as an indicator of water use efficiency as it is backed both by the research fraternity as well as the Government.

It includes the surface water diverted to the fields through pumps. The IWP has been considered as an effective tool in assessing the sustainability of irrigation management. This is the volume of the water applied and includes all kinds of water losses from evaporation and run off.

The data on the production of crops includes the average production of the major crops grown by the respondents from 2021 to 2023. The crops include paddy and horticultural crops. The data has been collected both from the participants and from the project reports. The value of the production of the crops is in kg. The data on the volume of water used has been calculated from the data on flow rate (gallons per million or gpm) of the pumping system, the area irrigated and the time for which the pumping system has been used. It has been calculated in two steps. The volume of irrigation water supplied is given by,

$V = Q * t$ *(Equation1)*

Where, *V is the volume of water in m3, Q is the flow of Water in gpm, and t is the time of the pump's operation.*

Since the flow of water needs to be measured, this was calculated by,

$Q = HP * 3690 / TDH * SG$ *…… (Equation 2)*

Where, *Q is the flow rate of water in gpm, HP is the Horsepower of the pump, SG is the Specific gravity = 1, TDH is the Total Dynamic Head = Vertical height travelled + friction loss in the pipe.*

The efficiency of the pumping system has been taken as 55% according to FAO guidelines (pumping efficiency for surface water ranges between 50%-60%).The Calculations have been computed from the website of *Irrigated Agriculture and Extension Centre (IAREC)* of the *USDA* www.irigation.wsu.edu

The Relative Irrigation Supply is the ratio of the total supply of irrigation water to the total demand of the same by the crops (Benavides et al., 2021; Chandran & Ambili, 2016). It is thus the total amount of water that a crop needs from irrigation and doesn't include the part of crop water demand that is met by precipitation. For this, data on two variables were taken: a) crop water demand b) water supplied.

The Crop Water Need is given by,

$Et_{(c)} = \text{Water supply (mm)} - Et_{(0)}\ \text{(mm)}$ ………… (Equation1)

Where, $ET_{(c)}$ is the total crop water demand and $Et_{(0)}$ is the potential evapotranspiration (PET).

Again, *Irrigation water need (IN) =* $ET_{(c)}$ *(mm) - Pe (mm)*………. (Equation2)

Where, $ET_{(c)}$ *is the Crop water demand and Pe is the effective rainfall in mm.*

But IN is the depth of water needed by the crops in mm, but RIS requires volumetric data.

Thus, *Volume of Irrigation Water needed by the crop (INc) = IN (From Equation2) * Area to be irrigated.*

For estimating the Potential Evapotranspiration (PET) data and effective rainfall (Pe) the FAO Penman-Monteith method has been utilized using the CROPWAT 8.0 software to calculate the PET.

Once both the IWP and RIS have been calculated for the participants and non-participants, the data was put to statistical test to understand whether there exists any significant difference between the two sets of samples used for the study. For this, the data was checked for homogeneity using Levene's method and for normality of the distribution using the Shapiro-Wilk measure. Depending on these, the data fulfilling the assumptions of Parametric test was put to Independent T test while the failing the assumptions was put to the non-parametric Man-Whitney U test. While RIS qualified for parametric test, IWP was non- parametrically tested.

2.4 Limitations of the Study

The study did face constraints and limitations in terms of sampling, time and money. The use of purposive sampling for the participant farmers was relevant for the FGD and in-depth study of the participants' experiences but the sampling bias could not be dealt with altogether. There were constraints on time and money and hence the study could not be conducted over a larger geographical area. This could not lead to the study of the spatial variations in the nature and working of PIM.

3. Result

3.1 Irrigation Water Productivity

This indicator gives an overview of the productivity of crops in terms of the irrigation water applied and measures the per unit output of crop that can be procured from each unit of irrigation water applied. Table 1 shows that participant farmers who belong to some PIM group have scored a higher IWP than the non-participants. While the participants have an IWP of 1.54kg of crops per m^3 of irrigation water application, the non-participants can grow 1.33kg of crops with $1m^3$ of irrigation water (Fig.1). This may be attributed to the higher levels of both the production of crops as well as higher irrigation water supply among the participant farmers.

Table 1: The Irrigation Water Productivity indicating the per unit crop production of Irrigation Water among the Participants and Non-participants.

Group	Production (kg)	Supply (m3)	IWP (kg/m3)
Participants	54463.7	35366	1.54
Non-Participants	29706.09	22335.41	1.33

Source: Computed by authors from field data

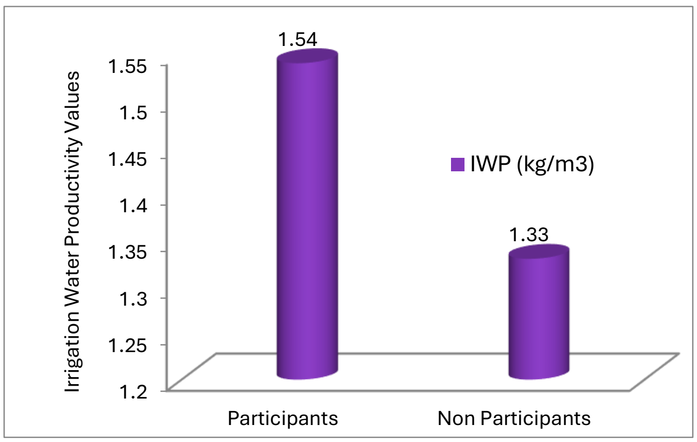


Fig.1The Irrigation Water Productivity indicating the per unit output from irrigation water

3.2 Relative Irrigation Supply

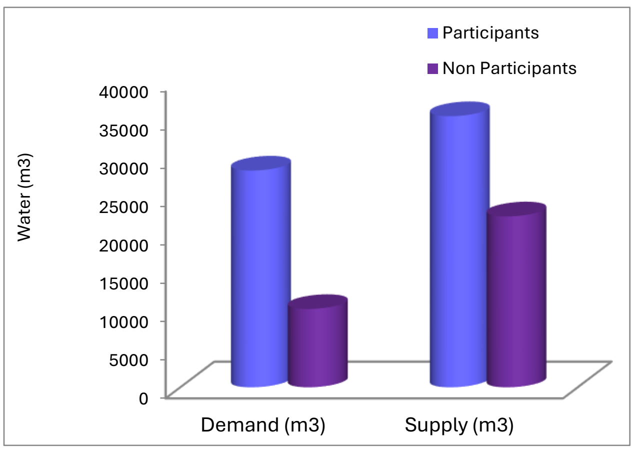
This section brings out the ratio between the crop water demand in terms of irrigation water needed and the water that is supplied to the crops. It is an indicator of the demand supply gap of irrigation water. An RIS of 1 indicates a perfect balance between the demand and supply; a value of less than 1 indicates a deficit while a value of more than 1 indicates excess water supply.

Table 2 shows that both the participants and the non-participants have recorded a surplus supply of irrigation water. But the non-participants showed a greater RIS value than the participants. While the demand for irrigation water has been higher for the participant farmers (28292.81 m^3), the non-participants have a lower demand (10245.6 m^3) (Fig.2). But in terms of supply, the participants have shown a lower value (35366.01m^3) as compared to the non-participants (22335.41 m^3). Thus, the non-participants tend to supply more than what is demanded by the crops. This has been highlighted by the RIS figures, where the RIS value for the participants is 1.25 but for the non-participants it is almost double at 2.18 (Fig.3)

Table 2: The demand-supply gap and Relative irrigation Supply among the participants and non-participants.

Group	Demand (m3)	Supply (m3)	RIS
Participants	28292.81	35366.01	1.25
Non-Participants	10245.6	22335.41	2.18

Source: Computed by authors from field data



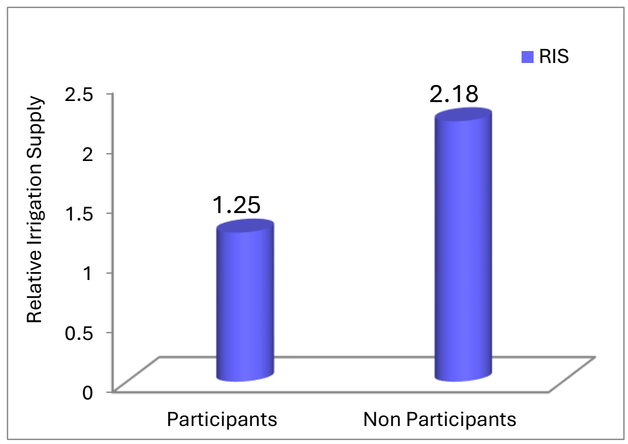


Fig.2 The demand supply situation of irrigation water participants and non-participants

Fig.3 The Relative irrigation supply between the between the participants and non-participants

3.3 Significance testing of the Variance between the Groups

The previous section hinted at the variation in the values of PIS and IWP across the two groups. Thus, it becomes crucial to identify whether such values and their variation is statistically significant. To analyze the statistical significance of the variance in terms of the IWP and RIS among the groups, a variability test must be conducted. For conducting the parametric test, the data needs to meet the assumptions of a) homogeneity of data b) normal distribution of the data. For check if the data is normal, the *Shapiro-Wilk's* measure of normality has been tested. A value of more than 0.05 or a significance value below 95% indicates the data is distributed normally. For the homogeneity of variance*, Levene's Test* for Equality of Variances has been utilized. A value with 95 % significance or one with a p value of less than 0.05 indicates that there is homogeneity of variance.

a) Homogeneity of data: To assess the homogeneity of data, Levene's Test has been conducted with the help of SPSS (Table 3). While the significance level for RIS is 0.008 the significance of IWP is 0.003. Thus, the data for both the indicator is statistically significant ($p<0.05$). This shows that the data is homogenous and hence confirms with the requirement for conducting the parametric test

Table 3: Levene's Test for checking the homogeneity of the data

		Levene Statistic	df1	df2	Sig.
RIS	Based on Mean	7.913	1	368	.008
IWP (kg/m3)	Based on Mean	10.016	1	368	.003

Source: Computed by authors using SPSS

b) Normality of the distribution: The Shapiro –Wilk's measure has been used to test whether the data is distributed normally (Table 4). The participants have been denoted by '0' while the non-participants have been denoted by '1'. For RIS, both the groups have a significant value above 0.05 and hence show a normal distribution. While for IWP, while non-participants show a normal distribution ($p>0.05$), the participants don't show a normally distributed data ($p<0.05$). Hence it violates the assumption of parametric test.

Table 4: Shapiro-Wilk's Test for testing the normality of the data

	GROUPS	Shapiro-Wilk		
		Statistic	Df	Sig.
RIS	0	.954	120	.468
	1.0	.915	250	.079
IWP (kg/m3)	0	.777	120	.001
	1.0	.980	250	.933

Source: Computed by authors using SPSS

The preceding tests thus imply that parametric independent t test may be conducted for RIS as it fulfills the assumptions for both homogeneity and normality of data. While IWP failed the assumption of the normality of distribution and hence the non-parametric Mann Whitney U test has been conducted for it.

a) RIS: The parametric t test was employed to check the variance in RIS between the groups (Table 5). The test assumes two conditions- a) that there are equal variances between the two groups and b) that the variances are not equal. The significance table indicates that there lies significant variation between the two groups in terms of irrigation supply for both the assumptions as indicated by the p value ($p<0.05$). A negative mean difference indicates that the first group represented by the participants has recorded a lower supply as compared to the non-participants. The mean relative irrigation supply of the participant farmers is about 0.9 times lower than the non-participant farmers as is evident from the mean difference column.

Table 5: Independent t test for checking the significance of variance in RIS between the groups

		T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
RIS	Equal variances assumed	-3.253	370	.002	-.933879	.28706	-1.51552	-.35223
	Equal variances not assumed	-3.311	260.624	.003	-.933879	.282079	-1.51304	-.35471

Source: Computed by authors using SPSS

b) IWP: Table 6 indicates the results for the variance in Irrigation Water Productivity between the groups calculated by the non-parametric Mann Whitney U test. The significance table implies that there is no significant variation in the water productivity between the two groups ($p>0.05$). Thus, significant variation between the groups could not be achieved when it comes to per unit productivity of the irrigation water.

Table 6: Mann-Whitney U test indicating the variance between the groups in terms of IWP

	IWP (kg/m3)
Mann-Whitney U	168.000
Wilcoxon W	358.000
Z	-.618
Asymp. Sig. (2-tailed)	.536
Exact Sig. [2*(1-tailed Sig.)]	.550

Source: Computed by authors using SPSS

4. Discussion

The study hinted at the variations in irrigation water management between the participants and non-participants in the wake of a better and sustainable irrigation supply. The RIS and IWP were utilized as indicators for measuring this sustainability. While the RIS is an indicator of the balance between the demand and supply of irrigation water, the IWP is a measure of the productivity of the irrigation water. Thus, while RIS is a direct measure of sustainable water utilization, IWP is a latent indicator and has economic implications of sustainability. This is because under ideal conditions, a sustainable IWP will lead to greater production with lesser water (Playάn & Mateos, 2006; Ali & Talukder, 2008).

The study finds that both the participants and the non-participants have a surplus supply of irrigation water. This hints at the improvement in the irrigation situation in both the traditional and participatory irrigation systems. But the non-participants recorded a higher supply of irrigation water as compared to the participants. Thus, while the RIS for the non-participants is 2.18, it is 1.25 for the participants. A supply twice the demand as indicated by the RIS values of the non-participants is indicative of a wasteful use of water by the non-participant farmers. This may be explained by the lack of awareness and training about efficient utilization of irrigation water among the non-participants. That lack of training on the techniques that lead to improved irrigation conditions as a factor affecting irrigation performance has been highlighted by many scholars in their study (Batt & Merkley, 2010; Samian et al., 2015; Serote et al., 2021). Wang et al. (2013) in their study on northern China found that the amount of water diverted for irrigation tends to be lower when the water charges are levied as per duration of irrigation instead of the area to be irrigated. This indicates that a strict levy of water charges among the participant farmers in terms of the time length of water supply, as part of the WUA norm is yet another reason for the near balanced supply of irrigation by the participants. As noted by Walker (1989) in the FAO irrigation and Drainage Paper 45, more than 40% of the total water diverted for irrigation is wasted at the farm level. Thus, a switchover to water saving techniques like drip irrigation and sprinkler irrigation can reduce the water consumption among the non-participant farmers.

The IWP values are higher among the participant farmers than the non-participant farmers, although the difference is a small one. Thus, while the IWP for the participants is 1.54, it is 1.33 for the non-participants. A better IWP indicates that the per unit productivity of water is greater for the participants than the non-participants. This indicates a greater utilization of irrigation water by the participants as compared to the non-participants. But the difference being negligible, there is still scope for the participants to improve their IWP. Similar results where the difference in the Irrigation Water Use Efficiency between the participants and the non-participant farmers was negligible, was found by Zhou et al. (2017) and Zema et al. (2018).

The test for variance in the IWP and the RIS between the two groups indicated by both nonparametric and parametric tests show variable results. For IWP, the groups don't show any significant variation. Thus, in terms of the per unit productivity of irrigation water, the groups don't show much variance. This can also be sensed from the negligible difference in the values of the IWP of the two groups. The IWP in this case doesn't clearly imply sustainable management of irrigation water under PIM. Again, in terms of the RIS, the groups show significant statistical difference as evident from the independent t test ($p<0.05$). This holds importance, as the RIS is an important measure of sustainable water use. The significance in variation hints at the stark difference in the pattern of irrigation supply between the two groups and a higher value for the non-participants indicates wasteful use.

Although variability in test results couldn't be established between the participants and non-participant farmers in terms of IWP, RIS varied significantly. The presence of sustainable practices among the participant farmers like the timely payment of water fees, lesser conflicts in water distribution, adherence to water sharing norms during the dry periods are indeed indicators of sustainability. As noted by Chai, Gan, Turner, Zhang, Yang, Niu and Siddique (2014) in their study on Chinese agriculture, that involvement of the stakeholders improves the water saving technologies where farmers were found to move from being passive to active in water-saving actions. Higher water use efficiency and better utilization of water with improved participation conditions and greater involvement of communities in the operation and management of irrigation systems has been confirmed by Chaudhry (2018), in her study on Pakistan. The water pricing can thus be used as a measure to introduce water-conserving technologies even among the non-participant farmers (Schoengold & Zilberman, 2007).

5. Conclusion

Overall, the study tried to analyze the sustainable use of irrigation water in the light of participatory irrigation management. The indicators utilized in the study are representative of sustainable irrigation management as with proper demand supply balance and efficient utilization of each water unit, the wasteful usage of irrigation water can be lowered. This in turn will reduce the demand for water as a part of the "waste not want not" strategy. The study incorporates the treatment-control mechanism for understanding the practice of sustainability among the users. It finds that with participation, efficient utilization of irrigation can be achieved. This is partly because of the training and awareness generation among the participants and partly because of the stringent water pricing policy among the participants.

The constraint of time and money didn't allow the study to be conducted in a varied spatial unit with a different geographical setting. This could have further enabled a comparative and comprehensive understanding of sustainable PIM practices in varied physical settings. This gap can be bridged by future research endeavors to understand how physio-climatic conditions shape as well as modify the urge to participate and in turn affect the sustainable resource utilization. Moreover, whether PIM emerges as the future of sustainable irrigation management in the light of the present-day environmental crisis needs deeper understanding. As noted by Shah et al. (2002), there can be no blueprint for the success of PIM as each case is peculiar and is guided by the local opportunities and constraints ranging from physical to institutional and socio-economic factors. The disappointing outcomes of applying the WUAs model to various regions of South Africa, Sub Saharan Africa, Central Asia etc. are classic examples of how the mere imitation of irrigation models from developed nations cannot benefit the developing ones (ibid). Thus, each institution formed under PIM should be seen as unique and its success mantra should be based on its local determinants.

The study also promotes greater inclusion of the stakeholders themselves at various tiers of irrigation management to ensure greater proficiency of the irrigation systems. It suggests that the IWP among the participant farmers needs to be improved and one way of doing it could be switching over to the modern irrigation techniques like sprinkler and drip irrigation which can ensure lesser wastage and greater outputs. Similarly, among the non-participant farmers the introduction of volumetric water charges can be a way towards prudent and economical water utilization. Moreover, the Government policies should be designed to mandate the inclusion of communities at the decision making and planning stages of irrigation management. More sensitization among the non-participants about the benefits of PIM can organize more and more water users under an institutional umbrella like the WUA. Above everything, the study testifies that greater inclusion of communities as managers and operators of irrigation can be regarded as a sustainable practice and thus more communities should be transformed from mere water users to water managers.

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