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Cropping Scenario in Water User Associations (WUAs) Managed Groundwater Irrigation System's Command Area in West Bengal

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ABSTRACT

The groundwater irrigation, catering to more than 60 per cent of total irrigation in India, has significantly contributed to food grains production. Participatory irrigation management programme has been implemented transferring irrigation management to WUAs. Present study was undertaken during 2019 to explore cropping scenario in groundwater irrigation command under jurisdiction of WUAs in Burdwan district of West Bengal covering a random sample of 120 farmers. It is revealed that paddy was the major crop in both kharif and summer season. During rabi season, potato was grown in larger areas followed by mustard. While all 120 farmers had grown paddy as single crop in kharif season, 100 and 82 farmers have cultivated potato and mustard in rabi season and 75 farmers have grown boro rice during summer season. Cultivated land utilization index value was more than 50 per cent. Crop diversity index (CDI) value of 36 per cent showed lack of crop diversification in groundwater irrigation command areas that warrants need of bringing more areas under different crops. Multiple cropping index of 176 per cent showed a higher cropping intensity in groundwater irrigation command. Thus, Extension advisory services need to promote crop diversification in groundwater irrigation command areas through proper crop planning and capacity building of WUAs.

INTRODUCTION

Irrigated agriculture is the dominant user of water consuming bulk of a developing country's total water consumption. The contribution of groundwater irrigation to achieve self-sufficiency in food grains production is phenomenal. In recent years, groundwater has quickly risen to take centre stage in India's agriculture and food security. Over the past three decades, it has emerged as the primary driver of irrigated area growth, and it now makes up more than 60 per cent of the nation's irrigated area. According to estimates, irrigated agriculture today provides more than 70 per cent of India's food grain production, with groundwater playing a significant role in this process (Ghosh et al., 2019). This revolution has largely gone unrecognized since the expansion of groundwater irrigation has not primarily been driven by government or policy but rather gradually through highly decentralized private activity (Madramootoo & Fyles, 2010). The poor performance of publicly supplied irrigation system is often debated and the participatory irrigation management (PIM) has been suggested as a solution. Irrigation management transfer (IMT) to WUAs has been implemented in various states and a total of 84,779 WUAs have been formed covering a command area of 17.8 M ha under various irrigation systems (Gany et al., 2019).

Although the groundwater is annual replenishable resource, its availability is non-uniform with space and time. Eastern region of India has rich water resources with an average annual rainfall of more than 1000 mm; however, irrigation scenario has been lagging behind as compared to other regions in the country

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(Srivastava et al., 2014). In all the eastern Indian states, groundwater development is less than that in country (62%); it is 28, 32, 35, 40 and 44 per cent in Odisha, Jharkhand, Chhattisgarh, West Bengal and Bihar, respectively (Central Ground Water Board, GOI, 2014).

West Bengal has a considerably better irrigation status as compared to the other eastern Indian states (Ghosh et al., 2014). Among the eastern Indian states, West Bengal has 7.5 per cent of the nation's water resources, making it comparatively water resource rich. Rainfall serves as West Bengal's primary water source with an average annual rainfall of roughly 1700 mm, 76 per cent of rainfall occurs in four monsoon months (July to October), with the remaining falling in non-monsoon months. The state now uses roughly 40 per cent of its 27.4 billion cubic meters (BCM) of assessed annual renewable groundwater resources, leaving a significant untapped potential (Ghosh et al., 2017). According to the National Water Policy of 2002, which supported PIM to put into practice in many Indian states, a paradigm shift from an agency-managed to farmer-managed irrigation system is felt inevitable. West Bengal government has been implementing PIM since 2012 under the Accelerated Development of Minor Irrigation Project to improve the irrigation and agricultural situation in the state's minor irrigation commands through the formation of 848 WUAs, which up until July 2015 covered 25,499 ha of command area and 50,265 farmers (Mukherjee et al., 2022). The current study was conducted to examine the cropping scenario in the command areas of the WUAs regulated groundwater irrigation system in West Bengal.

METHODOLOGY

The Burdwan (East) district of West Bengal was locale of the current study. Two blocks, Ausgram I and Ausgram II, were chosen following simple random sampling out of the blocks having groundwater irrigation command area. Two groundwater irrigation systems being managed by the WUAs were randomly chosen from each block thus covering a total of four groundwater irrigation systems' command areas. From each groundwater lift irrigation command area, random samples of 30 farmers were selected. In total, 120 farmers were chosen as the respondents for present study. On the basis area, production and productivity of various crops grown in the kharif, rabi, and summer seasons, irrigation intensity, cropping intensity, and crop diversification, the cropping scenario in groundwater irrigation command regions was investigated. A structured interview schedule was used to elicit responses from the sampled farmers about the aforementioned factors. The following indices were calculated to realize the cropping scenario in groundwater irrigated area.

Cultivated land utilization index (CLUI) was derived by summing the products of land area planted to each crop, multiplied by the actual duration of that crop divided by the total cultivated land area, times 365 days.

$$\mathrm{CLUI} = \frac{\sum_{i=1}^{n} (a_i d_i)}{A \times 365} \times 100$$

where, i = 1, 2, 3….. n

n = total number of crops

a_i = area occupied by the i^{th} crop;

d_i = days that the i^{th} crop occupies

A = total cultivated land area available for 365 days.

Crop diversity index (CDI) was calculated by using the following equation:

$$\mathrm{CDI} = 1 - \sum_{j=1}^{n} \left(\frac{a_{ij}}{A_i}\right)^2$$

where, a_{ij} = area planted to the j^{th} crop in the i^{th} location;

A_i = total area planted under all crops.

The CDI is zero for a land area growing only one crop and approaches unity as the level of diversity increases. This has been estimated for both kharif and rabi seasons.

Multiple Cropping Index (MCI) was formulated as the sum of the areas planted to different crops harvested during the year, divided by the total cultivated area.

$$\mathrm{MCI} = \frac{\sum_{i=1}^{n} a_i}{A} \times 100$$

where, i=1, 2, 3…….. n

a_i = area planted under i^{th} crop

A = Total cultivated area

Respondents were classified in three categories based on mean and standard deviation values with respect to cultivated land, CLUI, CDI and MCI.

RESULTS AND DISCUSSION

Farmers in the specified groundwater irrigation command area in the Burdwan district of West Bengal cultivate various crops in rice-based cropping systems. Table 1 indicates that groundwater irrigation command areas had more diverse agriculture, particularly during the rabi season. However, during both the kharif and summer seasons, paddy was the major crop occupying an average area of 2.69 and 1.49 acres, respectively. The productivity of paddy was higher in summer season (6.02 t/ha) as compared to kharif season (5.47 t/ha). It is evident that while all 120 farmers had cultivated paddy during kharif season, 75 farmers cultivated paddy crop during summer season indicating dominancy of paddy based cropping systems. Mean cultivated area was less in boro (summer) rice as irrigation was totally dependent on groundwater lift that having restricted command areas. During rabi season, potato was mostly preferred by the farmers and cultivated in a mean area of 0.69 acre with productivity of 28.07 t/ha. Wheat was grown in mean area of 0.61 acre with average productivity of 2.58 t/ha. Among the oilseeds, mustard was cultivated in an average area of 0.60 acre with productivity of 1.02 t/ha. Out of total 120 farmers sampled in present study, a total of 100 farmers preferred the cultivation of potato crop in rabi season while 82 farmers cultivated mustard crops that indicates the diversified cropping where many farmers had cultivated both the crops. Few farmers had also cultivated vegetables like onion (0.05 acre), chili (0.23 acre) in a very less area with average productivity of 4.41 t/ha and 4.14 t/ha, respectively in rabi season. During summer season, although boro rice was mostly grown crop, few farmers had also grown pulse crop and sesame crop. Only two farmers had grown sesame

Table 1. Cropping scenario in groundwater irrigation command areas of Burdwan district in West Bengal

Crops	Kharif season			Rabi season			Summer season		
	No. of farmers	Mean (SD)		No. of farmers	Mean (SD)		No. of farmers	Mean (SD)	
		Area (acre)	Productivity (t/ha)		Area (acre)	Productivity (t/ha)		Area (acre)	Productivity (t/ha)
Paddy	120	2.69(2.24)	5.47(1.64)				75	1.32(1.31)	6.02(0.88)
Potato				100	0.69(0.66)	28.07(7.43)			
Mustard				82	0.60(0.41)	1.02(0.3)			
Pulse							7	0.26(0.34)	1.46(1.69)
Onion				8	0.05(0.05)	4.41(1.67)			
Chilli				7	0.23(0.28)	4.14(1.88)			
Wheat				3	0.61(0.48)	2.58(0.49)			
Sesame							2	0.66(0)	1.31(0.26)

Table 2. Analysis of cropping scenario in groundwater irrigation command areas of Burdwan district in West Bengal

Particulars	Mean (SD)	Percentage of farmers		
		Low <μ-σ	Medium μ-ó<>μ+σ	High >μ+σ
Cultivable Land	2.73 (2.27)	3.33	80.00	16.67
Cultivated Land Utilisation Index (CLUI)	52.45 (12.46)	15.83	70.00	14.17
Crop Diversity Index (CDI)	0.36 (0.14)	14.16	69.17	16.67
Multiple Cropping Index (MCI)	175.57 (43.3)	15.00	72.50	12.50

crop in summer season with mean area of 0.66 acre and productivity of 1.31 t/ha. Pulses were also grown in summer season in mean area of 0.26 acre with productivity of 1.46 t/ha. The farmer's involvement in groundwater irrigation management under the auspices of WUA must have been managed irrigation in a better way, leading to a better crop production situation. Nevertheless, there is still a chance to cultivate more land with better irrigation scheduling and crop planning.

During both the kharif and summer seasons, paddy is the main crop in the command areas of groundwater irrigation systems, with larger acreage in the former than the latter. Potato and mustard are mostly grown during the rabi season with few farmers preferred also wheat and vegetables. In addition to boro rice, lentils and sesame were also cultivated under groundwater irrigation command, increasing agricultural diversification. During kharif season, mean area under cultivation was 2.69 acre while that in rabi and summer season was 2.18 acre and 2.24 acre, respectively, in the selected groundwater irrigation systems' command areas.

Table 2 presents the cropping scenario in selected groundwater irrigation systems' command based on Cultivated Land Utilisation Index (CLUI), Crop Diversity Index (CDI) and Multiple Cropping Index (MCI). As these irrigation systems were managed by the WUAs, a better irrigation service was expected resulting in better cropping scenario. The CLUI of 52.45 per cent indicates an above average utilization of the cultivable land in the selected groundwater irrigation area. The crop planning of the farmers was mainly restricted to four major crops viz. rice in kharif season, potato and mustard in rabi season and boro rice in summer season. Therefore, cultivated land utilization was quite good in the command of groundwater irrigation systems in Burdwan district of West Bengal. The CDI value of 36 per cent shows the crop diversification in the groundwater irrigation command areas; however, more areas need to bring under different crops. The CDI is zero for a land area growing only one crop and approaches unity as the level of diversity increases. The area was mainly occupied with paddy crop in both kharif and summer season, potato and mustard crops in rabi season. Multiple cropping index (MCI) indicated the sum of the areas planted to different crops harvested during the year, divided by the total cultivated area. The MCI of 176 per cent shows the intensified cropping in the groundwater irrigation command. The crops were grown by the farmers in all three seasons; however, while all 120 farmers had grown paddy as single crop in kharif season, 100 and 82 farmers had cultivated potato and mustard in rabi season and 75 farmers had grown boro rice during summer season. Thus, multiple cropping was visible in groundwater irrigation command.

Similar as well as contrast to the findings of present study, past researchers have reported the impact of groundwater irrigation on crop performance. The efficiency of groundwater irrigation systems in term of cropping scenario is important in the context of achieving more crop per drop. The irrigation systems in West Bengal have positively impacted on cropping intensity and crop yields. Irrigation acts as a catalyst in the introduction and spread of HYV seeds and fertilizers. Paddy is a major crop in irrigated area in West Bengal. Farmers are forced to grow paddy in medium and low land ecosystem in kharif season as most of the annual rainfall occur during July to November and water stagnates in the field which can only be sustained by paddy crop. According to the impact assessment of PIM and IMT on crop performance, which covered 18 systems in 11 countries, irrigation systems that don't produce rice can be 100 to 200 percent more productive than irrigation systems that do (Restrepo, 2004). A better cropping scenario is witnessed in groundwater irrigation command. According to Srivastava et al. (2009), the farmers who buys groundwater for irrigation in central Uttar Pradesh utilize it in more efficiently to obtain better water productivity in wheat, sugarcane and potato crops as they apply water more judiciously as compared to other categories of farmers in groundwater irrigation command. The better water productivity in case of buyers cultivating wheat, sugarcane and potato is due to the fact that they are predominantly small and marginal farmers with small landholdings and thus, they engage in intensive cultivation with proper utilization of resources. Mishra et al. (2011) reported that the impact of PIM is found positive with respect to cultivated area, cropping intensity, irrigated area, irrigation intensity, crop diversification and crop productivity in three minor irrigation systems in Odisha rehabilitated with aid from the European Commission and turned over to WUAs. During dry season, pulses, oilseeds and vegetables are grown by the farmers with a reduction in fallow area by 50 per cent. On an average, yield is increased by 45 per cent in rice, 57 per cent in pulses, 80 per cent in oilseeds, 40 per cent in sugarcane and 43 per cent in vegetables. Thus, it may be concluded that post-PIM has witnessed remarkable increase in yield in almost all the crops due to better irrigation performance. Through a rise in irrigation intensity, cropping intensity, and yield with regional and temporal fluctuations, PIM's impact on agricultural performance is accomplished (Ghosh & Kumar, 2012). There is room for improvement by learning from the experiences in the states like Maharashtra, where cropping patterns indicate a trend away from food grain crops and toward high value crops; instead of growing grains, farmers prefer to produce cash crops like sugarcane, turmeric, wheat, soyabeans, and vegetables, in irrigation command areas under jurisdiction of WUAs (Pharande, 2015). The variation of impact in a given irrigation system often warrants attention in irrigation management by WUAs. It is seen in agricultural performance evaluation in the WUAs jurisdiction command area in minor and medium irrigation projects in Nayagarh district of Odisha that WUAs at the tail reach record cultivated land utilisation indices lower than 50 per cent; the crop diversity indices and multiple cropping indices are found to be low as the farmers have not grown any crops during rabi season due to a lack of irrigation water at the tail end. It is debated whether the switch from government-managed to farmer-managed irrigation systems is the only, or even the main cause of improved agricultural production. The impact of PIM and IMT is found to be diverse across the irrigation sources as well as command areas of different irrigation systems in different regions of the world. In India, the impact of PIM in states like Andhra Pradesh, Karnataka, Tamil Nadu, Madhya Pradesh, Odisha, and Rajasthan indicates an increase in share of net irrigated area in net sown area (3–12%), which is primarily due to increased groundwater irrigated area. PIM has also resulted an improvement in productivity of major crops (11–20%), food grain productivity (8–39%), area under high yielding varieties (13–54%), cropping intensity (3–12%) and fertilizer consumption (21–80%). Relatively more increase in groundwater irrigated area (16–63%) has resulted in increase of net irrigated area from 6 to 38 per cent (Ghosh et al., 2019). Therefore, groundwater irrigation systems under aegis of WUAs have the potential to improve the irrigation efficiency and cropping scenario. In India, groundwater irrigation is predominant in Indo-Gangetic plains, where rice and wheat crops use bulk of irrigation that has led to unsustainability of groundwater resource (Gautam et al., 2021; Kaur & Sharma, 2022); therefore, WUAs need to give attention for proper crop planning and management of irrigation to ensure efficient use of groundwater under PIM.

CONCLUSION

Cropping scenario in WUAs managed groundwater irrigation systems' command areas is assessed with the help of three indices like CLUI, CDI and MCI. Paddy based cropping system is predominant in groundwater irrigation command area where paddy is the major crop both in kharif and summer season. The crop diversification has been witnessed in the rabi season with major crops grown like potato, wheat and mustard. The efficiency of WUAs in crop planning and diversification is visible in rabi season and same is also required in summer season when farmers prefer to grow paddy inspite of higher water requirements due to better productivity of paddy in summer season as compared to kharif season. Extension advisory services to WUAs for proper crop planning to grow less irrigation requiring high value crops and capacity building of member-farmers will further improve the cropping scenario and irrigation efficiency in groundwater irrigation command areas.

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