2019

WBADMI PROJECT RAPID IMPACT ASSESSMENT REPORT

INTERNATIONAL WATER MANAGEMENT INSTITUTE

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Acronyms

ARYA	Attracting and Retaining Youth in Agriculture
CD	Check Dam
CDI	Crop Diversification Index
DC	Demonstration Centre
DPMU	District Project Management Unit
DWRID	Department of Water Resources Investigation and Development
ESA	Europe Space Agency
EWP	Economic Water Productivity
FFS	Farmer Field School
FGD	Focus Group Discussion
FIG	Fishery Interest Group
GEE	Google Earth Engine
Ha	Hectares
HYV	High Yielding Variety
IBRD	International Bank of Reconstruction and Development
ICAR	Indian Council of Agricultural Research
ICT	Information and Communications Technology
IDA	International Development Association
IWMI	International Water Management Institute
KII	Key Informant Interview
LDTW	Light Duty Tube Well
MDTW	Medium Duty Tube Well
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MI	Minor Irrigation
MP	Mass production
MWS	Micro-watershed
NDVI	Normalized Different Vegetation Index
NDWI	Normalized Different Water Index
O&M	Operations and maintenance
OBC	Other Backward Classes
PDO	Project Development Objective
PDW	Pump Dugwell
PDW (S)	Pump Dugwell (Solar)
PWP	Physical Water Productivity
RLI	River Lift Irrigation
RS	Remote Sensing
SAR	Synthetic Aperture Radar
SC	Scheduled Castes
SFMIS	Surface Water Minor Irrigation Scheme
SPMU	State Project Management Unit
SRI	System of Rice Intensification
ST	Scheduled Tribes
TW	Tubewell
USGS	United State Geological Survey
WBADMI	West Bengal Accelerated Development of Minor Irrigation
WDS	Water Detention Structures
WUA	Water User Association

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Executive Summary

This report presents the results from impact assessment of minor irrigation (both surface and groundwater) schemes newly constructed or rejuvenated under the WBADMI project in the western lateritic districts of West Bengal covering Paschim-Medinipur, Birbhum, Bankura and Purulia. The defining aspect of the WBADMI project was the creation of Water User Associations (WUAs) to look after the operation and management of these schemes. Along with it, agricultural support services were provided under the project to realise the full potential of additional irrigation capacity created through infrastructure. To assess the impact of these interventions through quantitative and qualitative methods, this study compared the before (2013-14) and post (2017-18) project implementation situation in project schemes. Comparison of WBADMI schemes with similar other minor irrigation schemes under different Government departments was also done. These non-project (non ADMI) schemes have similar structures/schemes implemented as part of other government programmes and are without the existence of Water User Associations. For the assessment, our study randomly sampled 42 schemes distributed across four districts and 10 non-Project schemes.

The primary impact of the project is observed in increased cultivated area with kharif and rabi cultivated area increasing by 23.1 % and 458.3 %, respectively post implementation. Cropping Intensity in project schemes increased from 113.8% (pre implementation) to 168.2% (post implementation). Along with increasing cultivated area, especially in rabi season, the project schemes were found to be crucial in securing the Kharif paddy production which in pre project implementation years had facedconsiderable risk and damage from unreliable and variable (both intra and inter annual variability) monsoonal rainfall. Availability of irrigation water has considerably reduced instances of crop failure during Kharif.

There is a significant increase in crop diversification in project schemes. Farmers in project scheme villages during Rabi season have started growing many vegetables like brinjal, cauliflower, leafy vegetables, onion, pumpkin, ridge-gourd, sesame etc. Along with it, area under mustard cultivation has increased 7.5 times post project implementation, while potato area increased by 4 times during the same period. Due to this, the dependence on paddy as the only source of income has decreased in project areas. Crop diversification index (measure of crop diversity with higher value representing higher crop diversification) increased from 0.29 to 0.87 in project schemes. The increase in cultivated area, cropping intensity and crop diversification is directly correlated with farmers receiving sufficient and reliable irrigation. Pre project implementation, only 21.5 % and 2.3 % sampled project schemes area received irrigation in kharif and rabi season, respectively which has increased significantly to 89.4 % and 53.6 % post project implementation.

Overall increase in agriculture and irrigation indicators for project schemes is found to be high, however there are differences in performances across different scheme types and districts. Across scheme types, performance of all scheme types is high and similar in kharif season with cultivated area receiving irrigation in range of 75-100%. However, large differences become evident in Rabi when performances across schemes varies a lot with values of cultivated area receiving irrigation ranging from low of 27% to high of 89%. TW, PDW and RLI tapping high sub-surface storage and flowing rivers with large catchment area, outperforms other surface water scheme (CD, WDS and SFMI) where limited storage is created by impoundment of water from small catchment area. This limited storage gets depleted due to use, evaporation and seepage. This difference in irrigation water availability is reflected in indicators of cultivated area and cropping intensity with highest performance observed in TW, PDW and RLI, whereas on average CD, SFMIS and WDS performance is relatively low. However, comparison between surface and groundwater schemes cannot be direct as it ignores local contextual situation limiting implementation of sub-surface schemes in every region due to bio-physical constraints.

We also find substantial difference in performance of irrigation and agricultural indicators across districts. For example, Birbhum has the highest cropping intensity and crop diversity while Bankura performs comparatively much lower on all these parameters. The difference in performance is a reflection of both the type of schemes operating within each district and also the quality of scheme management across districts. For example, performance of surface water schemes in Birbhum is almost two time better then performance of Bankura. Such a large difference reflects the much better operation and management of schemes in Birbhum. This could be result of local contextual differences including better design, training, better DPMU team, effective social outreach etc.

In spite of the substantial achievements in increasing total area cultivated under schemes, there is a substantial gap between average area actually cultivated under the schemes during Kharif and Rabi and the proposed command area. Overall, cultivated area during Kharif and Rabi comes to 67.5% and 47.6% of the proposed command area for the sampled project schemes. This gap between cultivated area and proposed command area for kharif is highest for Surface Flow Minor Irrigation scheme (SFMIS) (51.7%) followed by River Lift Irrigation (RLI) (36.9%), Water Detention structures (WDS) (34.2%), Check Dam (26.9% gap) and Tube well (TW) (26.4% gap) schemes. The larger gap in surface water schemes relative to ground-water schemes (PDW and TW) during Rabi season is a reflection of limited water storage that gets depleted quickly post-monsoon season.

There have been substantial yield gains in project schemes. Overall, paddy yield has increased significantly from 2.8 tonnes/hectare to 4.4 tonnes/ hectare post project scheme implementation. For mustard also, the average yield increased from 0.7 tonnes/hectare to 1 tonne/per hectare. Similarly, we find a significant increase in potato yield from 14.5 tonnes/hectare to 23.4 tonnes/hectare post implementation of scheme. The reasons for the increase in paddy yield are not just improved irrigation water availability but also effective adoption of new technologies and better agricultural practices such as adoption of line sowing of paddy, seed treatment, use of HYV seeds provided by project. Overall, 54.2% of households who are member of WUA reported to have received training/exposure visit/demonstration on improved agricultural practices other than fisheries/horticulture (like improved varieties, farm machineries, better water management, optimum fertilizer use etc.).

As noticed in agriculture and irrigation performance, there is a lot of variation in exposure to new technology under project scheme across districts. Birbhum (64.9%) and Paschim-Medinipur (69.0%) had the highest percentage of households receiving training exposure visit/demonstration on improved agricultural practices. In terms of reaching out to WUA farmers, the project has done moderately well with only 30.9% households in project villages receiving neither any input support nor exposed to new technology. Above average performance of Birbhum is mostly the result of better outreach and extension activities done through district project staff with support organization. Thus, more emphasis is needed in making these extension services available to all farmers.

The positive impacts of the WBADMIP schemes are to a great extent results of the Water User Associations that have been created under the project, along with the agricultural support services provided as part of the scheme. The added value of creating WUA and providing agricultural support services becomes apparent when we see that the performance of WBADMI schemes is significantly better compared to other non-project minor irrigation schemes under different government departments. For example, increase in cropping intensity between 2014 to 2018 for WBADMI schemes was much larger (113.8% to 168.2%) than for non-ADMI schemes where cropping intensity rose from 120.1% (2014) to only 145.1% (2018). Not just cropping intensity, but crop diversification was also much higher in WBADMI schemes. While the crop diversity index increased from 0.29 to 0.87 in WBADMI schemes, for non-ADMI schemes it has remained almost same (0.23 to 0.28). The additional benefits of WUA and agricultural support services are not only reflected in increased cropping intensity, higher crop diversification, higher yield and higher income, but also in agricultural labour demand in village and in women participation and decision making in agricultural activities.

It is of utmost importance that Water User Association continues to remain strong even in future after the project has ended. Judging the institutional and management aspects of the Water User Associations, we found the following strengths –

- WUAs as an institution are to a large extent democratic in nature. A huge majority of respondents (93%) felt that WUA's Executive committee was democratically elected.
- WUAs are preparing crop cycle plans to better coordinate amongst users in using the limited water resource. Annual general meeting is held once before start of each cropping season to do a crop planning for that season and decide on the water schedule, attended by WUA members.
- Majority of the WUA members feel positively about financial transparency of WUAs. Overall, 81.6 % of the respondents felt their WUA was financially transparent. One of the reasons might be that the WUA savings is kept in bank accounts and not as cash, ensuring financial transparency. Also keeping regular records in cash book, stock ledger, irrigation log book etc. help in making them transparent.

Despite these strengths there exists some institutional drawbacks that can pose serious challenge going forward –

- To ensure long term sustainability of WUAs, water fees and funds collected play a critical role generating funds for required maintenance and operations. On average across all schemes, WUA generated 2.6 % of capital costs with only 8 schemes generating more than 5 % and only 2 schemes over 10 % threshold of O&M. In centralized water distribution schemes (TW, RLI and PDW) high operating electricity charges makes it necessary to set higher water fee to cover expenses. In comparison, surface schemes of WDS, SFMIS, where centralized water distribution doesn't exist, have nominal charges. WUA water fees are not set according to any cost recovery principle but largely are collected (in case of schemes with centralized distribution system) to cover operational cost of electricity usage. This leaves a funding gap for maintenance activities.
- WUA institutional framework is bulky with lot of sub-committees which exist on paper, but controlled by the same group of people. Not enough people are trained in WUA management activities.
- The project has also actively endeavored to make these WUAs inclusive of marginalized sections like small farmers and tribal farmers. Despite effort from the project, it has been challenging to include women farmers as WUA members with some notable exceptions. More targeted efforts need to be made to increase effective representation of marginalized sections in the Executive committees of WUA. These committees have the highest decision making powers in the operation and management of the WUA.

Structural design, integrity and performance of the minor irrigation infrastructure is another important and critical criterion that controls the long term sustainability of project. Overall, current condition of infrastructure of the schemes was found be good or very good in 36 of 42 schemes sampled and also rated to be either good or very good by 85 % of the respondents. In line with irrigation performance, TW and PDW are rated the best with all schemes rated good and almost 95 % respondents rating infrastructure to be very good. Most of the moderate and bad ratings are concentrated across surface water schemes. When compared against similar non-project government irrigation (non-WBADMI) schemes, better infrastructure condition and design of project scheme becomes evident. In case of non-project scheme, only 38.8 % scheme infrastructure is rated to be good (against 84.6 % in project schemes) by respondents whereas almost 1/4th rate infrastructure as bad. This reflects the importance of WUA model with existing support from DPMU offices in project schemes where members operate and maintain schemes.

Design performance of SFMIS was moderate in many cases due to design deficits in the area of inlet design and high siltation as observed during field visits. It would be highly beneficial for WBADMI project schemes if technical design team can revisit these schemes and tweak the design. Pipe leaks and pump breakdowns were also observed. Many schemes have associated large underground water delivery pipe network. This is prone to leakage if not designed properly and leads to both wastage of water but also cutting water supply to a part of command area. It reiterates the fact that adequate O&M fund needs to be collected and training imparted locally.

Creation of infrastructure and water storage is critical but would be of little use if it is not properly managed. For fair, equitable and efficient use of available water, it is necessary to have operating water management and distribution plan agreed by WUA members and followed. Overall, out of 42 schemes sampled, 28 (or 66 %) have existing water distribution plans. When compared across scheme types, it becomes evident that most of the schemes with non-existing plans are concentrated in CD and WDS schemes. This lack of water schedules plan reflects the non-centralized operation of these surface water schemes where water from schemes is accessed via individual pumps, in contrast to PDW, RLI and TW where there is centralized pump house and associated distribution infrastructure to distribute water. The non-existence of centralized distribution infrastructure leads to little control over water use and management and is largely governed by individual capacity to pump and distance of farm fields from scheme infrastructure. There is a positive correlation among existence of water schedule and irrigation performance with scheme type with high percentage of existing water distribution schedule showing high performance in terms of providing irrigation water. This reflects the importance of developing water distribution plans and need to be taken up more efficiently in all project schemes.

The project has also actively promoted fishery and horticultural activities as alternative livelihood options for the farmers. This has resulted in increased practice of fishery and horticulture amongst our project farmers. About 14% of project farmers reported to be practicing fisheries in the current year. Only 4.3% among these farmers were practicing fisheries before the start of ADMI project. This increase in fishery practice can be observed across all 4 districts. However, the greatest increase was observed for Purulia and Bankura. In SFMIS & WDS schemes fisheries uptake is found to be more and consequently larger uptake was observed in Purulia and Bankura, which had more surface irrigation schemes. The WBADMIP scheme has encouraged farmers to cultivate more vegetables and fruits in their area through training and input support services which can lead to additional source of income and lessen their dependence on paddy and other food crops. Amongst our sample farmers in project schemes, 29.4% reported to have cultivated vegetables and fruits in 2018. This is much higher than before the start of ADMI project when only 5.3% were cultivating either fruits or vegetables. All these indicate that there was a marked increase in horticulture practice among project farmers. Project is demonstrating good examples of mixed horticulture with intercropping of field crops.

To understand the change in income of an average farmer family in project villages due to increase in net sown area, cropping intensity and crop choices under the scheme, incremental increase in family income was estimated. This incremental income captures the monetary value of increased area under cultivation and diversified crop choices for project schemes families. Incremental benefit (per hectare) is highest for TW (Rs. 61,146), followed by RLI (Rs. 48,337) and PDW (Rs. 46,512). Check Dam, SFMIS and WDS have relatively low values of incremental incomes as cropping intensity is low for these schemes. It also reflects the fact that often these schemes are not new but rejuvenated. As a result, even before scheme it acted as a source of limited irrigation and the impact of rejuvenation on income is comparatively less.

The increased family income is spent on health, education, savings etc. The project has provided quite strong agricultural support services to farmers to encourage them into adopting improved cropping practices and diversifying their income source through horticulture and aquaculture. This has not only increased their income, but also improved their domestic consumption of vegetables and fish. Overall 82.1% project farmers indicated increase in income after project implementation and 86.5% indicated increase in food availability. Increased agricultural activities across seasons within project village with the introduction of WBADMI scheme have generated increased demand for agricultural labor. In project villages, average number of man-days that farmers worked as agricultural laborers is 61.5 days and is much higher than 22.6 man-days that farmers work as agricultural laborers in a year in villages serviced by other non-project government minor irrigation schemes.

The key project development objective (PDO) of enhancing agricultural production of small and marginal farmers has been achieved reasonably well through development and management of community-based minor irrigation services in the project area. The element of community involvement in the form of WUAs and agricultural support services have definitely added critical value towards this endeavor of improving agricultural production and livelihood.

1. Background

The Government of West Bengal, through Government of India, has secured a loan and credit from the International Bank of Reconstruction and Development (IBRD) and the International Development Association (IDA) for implementation of West Bengal Accelerated Development of Minor Irrigation (WBADMI) project across the state of West Bengal. The Project is under the Department of Water Resources Investigation and Development (DWRID), Government of West Bengal. The project duration is from January 2012 to December 2019.

The project development objective (PDO) is to enhance agricultural production of small and marginal farmers in the project area. This is to be achieved through accelerated development of minor irrigation services to small and marginal farmers, strengthening community-based irrigation management, operation and maintenance, and support to agricultural development, including provision of agricultural services for encouraging crop diversification, use of improved technologies as well as creating income generation activities.

The project components include (i) strengthening community-based institutions (Water User Associations - WUAs), (ii) development of minor irrigation (MI) schemes (surface, groundwater and lift irrigation systems), (iii) provide agricultural support services to crops, horticulture and fishery, and (iv) project management. The project has completed 5 years with the said interventions and management options.

Initially, it was proposed that 2400 minor irrigation sub-projects of different types of schemes should be constructed with command area varying from 5 to 50 Ha to irrigate a total command area of about 32,000 ha, in all the districts (23) in the state (Figure 1). But after four years of the project period (up to 2016), it was felt that MI schemes (approx. 2879 nos.) should be executed through either micro-watershed (MWS) approach or isolated scheme approach for rapid development in the blocks of different backward districts in tribal / backward class dominated rain-fed/ single cropped area where cropping intensity is less than 100%.

2. Scope of assignment

The scope of work for this assignment was to conduct a rapid assessment to analyze the development outcomes of the WBADMI project to date in terms of enhancing agricultural production of small and marginal farmers through community managed minor irrigation infrastructures/schemes. This will provide opportunities to identify or revise project activities to incorporate emerging ideas/learning over the remaining project period and for such future irrigation development programs.

The key objective of the assessment study was to investigate the development outcomes of the ongoing WBADMI project in enhancing agriculture, horticulture and fishery production of small and marginal farmers through community managed minor irrigation schemes. The specific objectives were:

- Assess changes in agriculture, horticulture and fishery production, and cropping intensity resulting from investment in minor irrigation for the WBADMI Project.
- Assess changes in selected indicators of socio-economic, biophysical, institutional, livelihood and environmental status, and on the performance of WUAs including value addition to irrigation service delivery.
- Provide recommendations on emerging lessons and best practices to factor in the remaining project period and report to the state as well as central governments. Future policies may take into account the lessons learnt from the project and how the existing framework has helped in achieving the goals set out for this project.

In order to accomplish the above objectives, International Water Management Institute (IWMI) undertook the assessment study in the identified districts of Purulia, Bankura, Paschim Medinipur (including Jhargram) and Birbhum (Figure 1). The study assessed the project interventions across the technological, biophysical, socio-economic and institutional impact domain (Figure 2) in the handed-over minor irrigation schemes and compared their benefits/results with the selected nearby scheme implemented by the department and/or area not covered under the project in the five districts.

The assessment period was eight months from the date of commencement i.e. 30th July, 2018 to 31st March 2019.

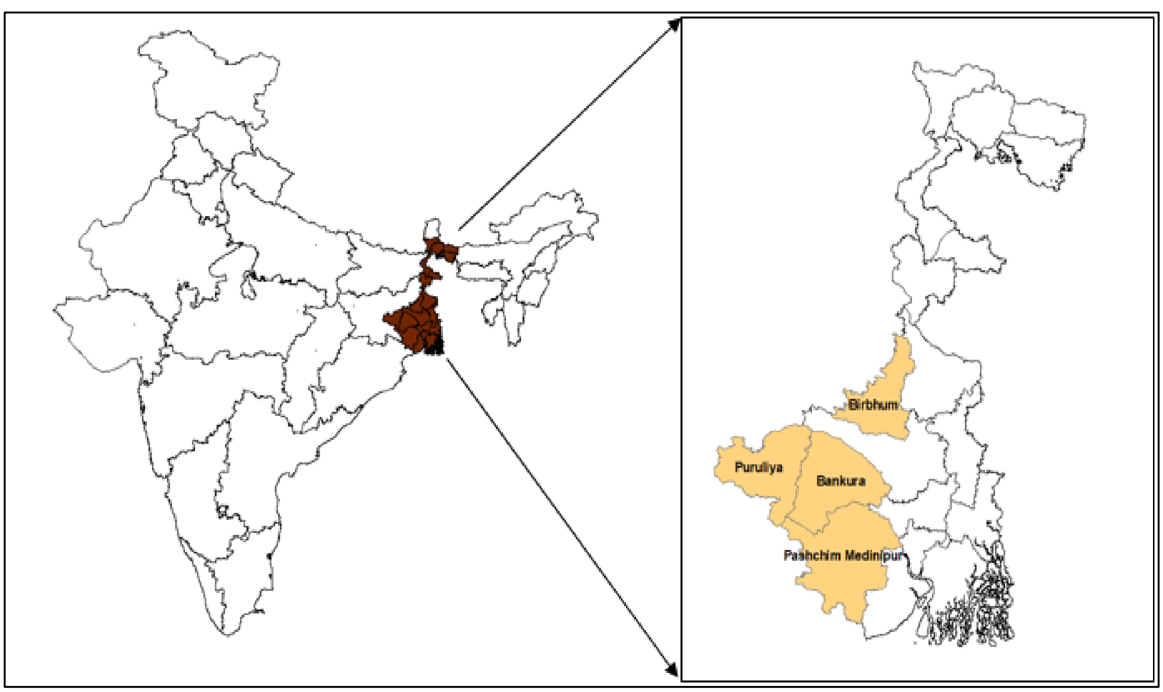


Figure 1 State of West Bengal and four study districts of assessment

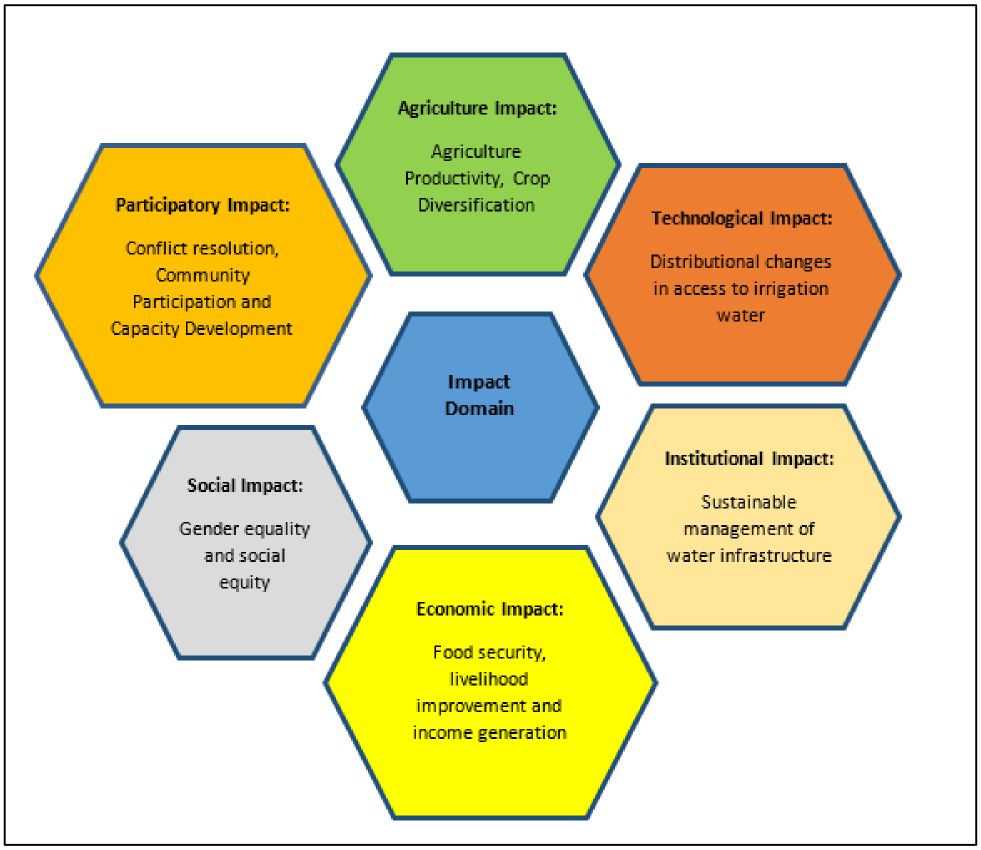


Figure 2 Overview of impact domain areas assessed in order to measure the outcomes/impacts.

3. Methodology

3.1 Inception Period

The contract between WBADMI project and International Water Management Institute (IWMI) came into effect from 30th July 2018. The first formal consultation meeting with the select members of the project team at the State Project Management Unit (SPMU) and Project Director (PD), WBADMI project was held on 6th August, 2018, followed by a field visit organized during the initial exploratory stage Mission from 7th -8th August, 2018.

The initial meetings were planned with the objective to discuss and clarify aspects relating to intervention approaches adopted for the types of schemes/data such as details of district wise handed over schemes, command area details, WUAs composition and guidelines, management structure of the project, identification and planning of schemes, operational details, etc. In the meeting with the project team and PD, proposed approach and broad sampling strategy/methodology were discussed for undertaking the impact assessment. Their feedback and suggestions were also sought in order to make it a consultative process. The approach was appreciated and suggestions with regard to documenting a few case studies including success stories were recommended by the project management team.

The first inception field visit by IWMI took place on 7th -8th August 2018 in Paschim Medinipur and Bankura along with project team from SPMU, Kolkata. During the Mission, field visits were made to the selected minor irrigation schemes and interactions were held with respective WUAs to get an overall understanding of how they were functioning. During the visit, interaction with members of the District Project Management Unit (DPMU) and Support Organization (SO) in the two districts were also held to generate an overall understanding of the project and to generate the available secondary data. The initial visit helped in getting a sense of the overall ground realities /situations along with a rough assessment of the functioning of WUAs in the districts and the benefits generated from the schemes.

Based on inception phase meeting and interactions, approach and methodology for undertaking impact assessment was discussed and finalized. Informal discussions with Dr. Anju Gaur (TL World Bank) were also held with regard to the proposed approach and methodology. Inception Report was submitted to the PD, WBADMI project at the scheduled time, which was also shared with the World Bank.

Figure 3 Pictures of the study area from IWMI field team visit

3.2 Methodological framework

Secondary reports and data were reviewed through literature survey, including government documents, reports provided by WBADMI project, material from the project website and as obtained from discussion with the project team. The conceptual framework of the project and implementation of WUAs was studied prior to the designing of the sampling strategy. Project profiles of similar interventions in irrigation and agricultural services were also examined. Preliminary stakeholder consultations and interviews were held with key stakeholders, including project officials and PD at SPMU level as well as district levels (DPMU), NGOs working as Support Organization with the DPMU and WUA members, to understand the project objectives, implementation strategies and benefits being realized by the farming community in the project villages.

Based on the preliminary discussion, assessment used three distinct approaches spread across four phases (Figure 4) to assess impact: Quantitative household survey, Qualitative assessment framework (including Focus group discussions (FGDs), Key informant Interviews (KII), Field visits) and remote sensing.

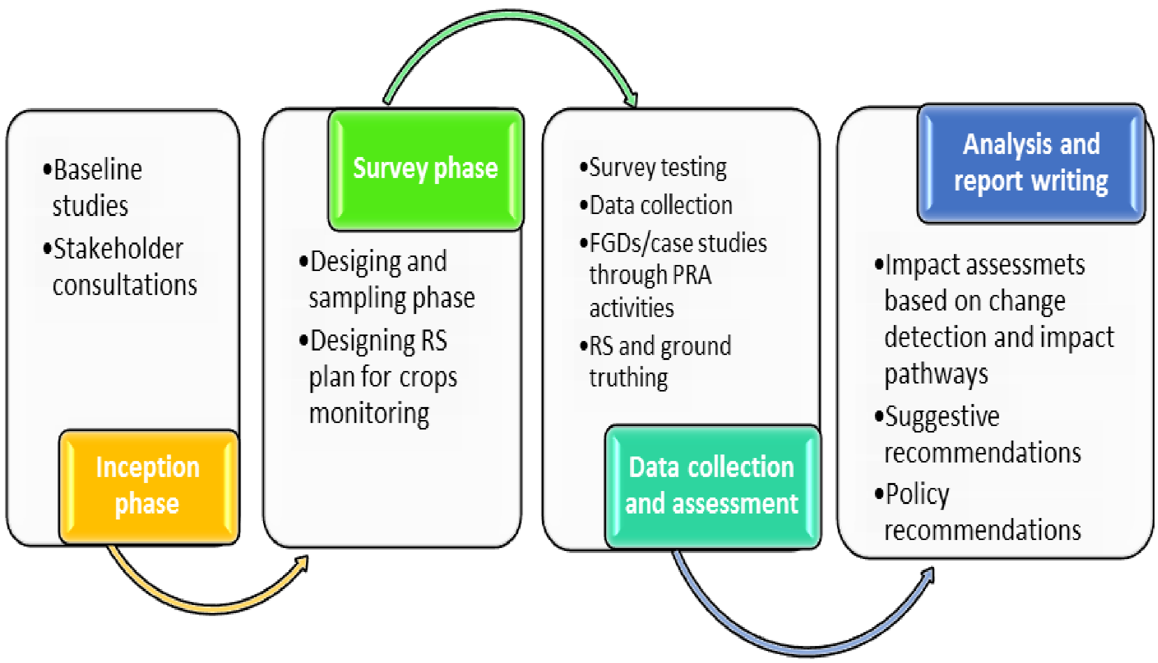


Figure 4 Four phases of the assessment cycle and their corresponding activities

The quantitative household survey was used to select a random sample of farmers from the Water User Associations and estimate the impact of the scheme on certain indicators. For the assessment, change in indicators (spread across impact domains given in Figure 2) was estimated in sample of farmers using before and after approach to analyze the impact of this scheme. Assessment also compared project scheme impacts against few non-project minor irrigation structures/schemes (where similar structures/schemes were implemented as part of other government programs) in the vicinity. The remote sensing component was used for corroborating and/or supplementing the results obtained from our household sample survey.

The qualitative component includes both pre- and post-assessment using participatory methods and field-level observations to capture the perception and awareness of communities along with other relevant stakeholders in the study area. Qualitative techniques including site visits, observations, focus group discussions and in-depth interviews with WUA members as well as local institutions representatives provided contextual insights into what did or did not work along with the reasons for its success or failure.

3.3 Sampling Methodology

The sampling plan was designed based on the information obtained from the qualitative exploratory study during inception period. Based on the available data on the project website and details provided by the project officials with regard to the types of various minor irrigation schemes (Figure 5), a total of 326 schemes were identified to have already been handed over to the community. The breakup of handed over schemes are highlighted in Table 1.

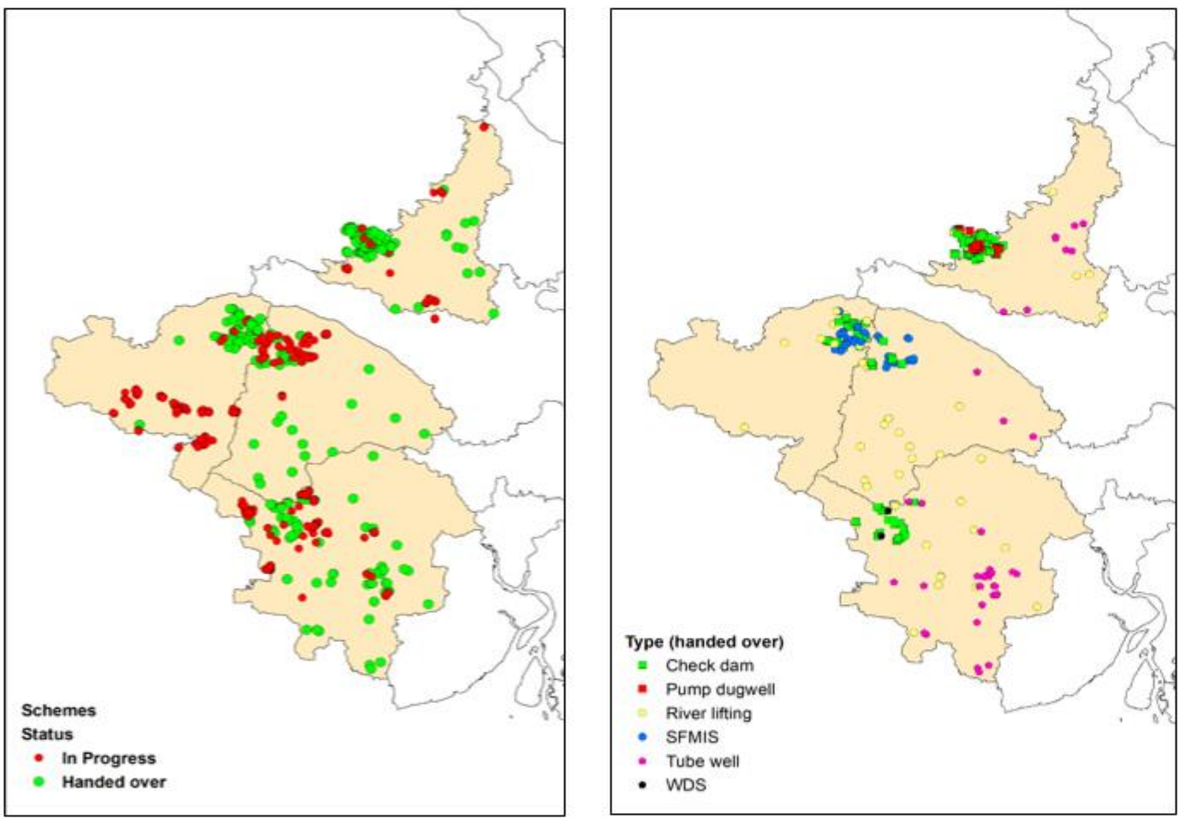


Figure 5. Spatial location of schemes in 4 assessment districts. Left: Handed over and in progress schemes. Right: Break up of types of handed over schemes

Table 1: Break up of handed over schemes for each type under different districts

		Scheme type					
District	**No. of Handed over schemes**	**CD [a]**	**TW [b]**	**RLI [c]**	**PDW [d]**	**SFMIS [e]**	**WDS [f]**
BANKURA	38	6	3	15	0	13	1
BIRBHUM	108	52	8	9	32	5	2
PASCHIM MEDINIPUR	106	21	37	13	23	0	12
PURULIA	74	28	0	12	0	33	1
Grand Total	**326**	**107**	**48**	**49**	**55**	**51**	**16**

[a] CD = Check dam
[b] TW = Tube wells includes LDTW and MDTW
[c] RLI= River lift irrigation includes LI, Midi(D) RLI, Midi(E) RLI and Mini(E) RLI
[d] PDW = Pumb dugwell includes PDW(Solar)
[e] SFMIS = Surface water minor irrigation schemes include SFIS, SFMIS(40ha), SFMIS(50ha) and SFMIS(60ha)
[f] WDS = Water detention structures

Since Jhargram has been recently carved out of district Medinipur, the details against Paschim Medinipur are inclusive of Jhargram as well. The command area of the schemes varies from 2 ha to over 80 ha. The schemes such as tube well (TW) and pump dug well (PDW), which have small individual command areas, operate on cluster basis. Each of these minor irrigation schemes have been handed over to a registered Water User Associations (WUA). All the landholders in the command area of the scheme as well as users of the scheme can be members of WUA. WUAs are formed during the pre-planning phase to take on responsibility for operation, maintenance and management of the minor irrigation scheme. Support Organization (SO) facilitates the process for formation of WUAs.

For the selection of our sample**,** we used a combination of stratified random sampling and purposive sampling, with a minimum of 10% of the handed over schemes spread in each of the study districts. The first stratification was based on the type of scheme and size, but we also considered the batch of a scheme based on when it was handed over and the grading received based on WBADMI project evaluation. The next level of sub-stratification for household sample survey within the command area of the sampled scheme was done based on small/marginal, women-headed and tribal farmers. Figure 6 gives a conceptual overview of sampling steps taken.

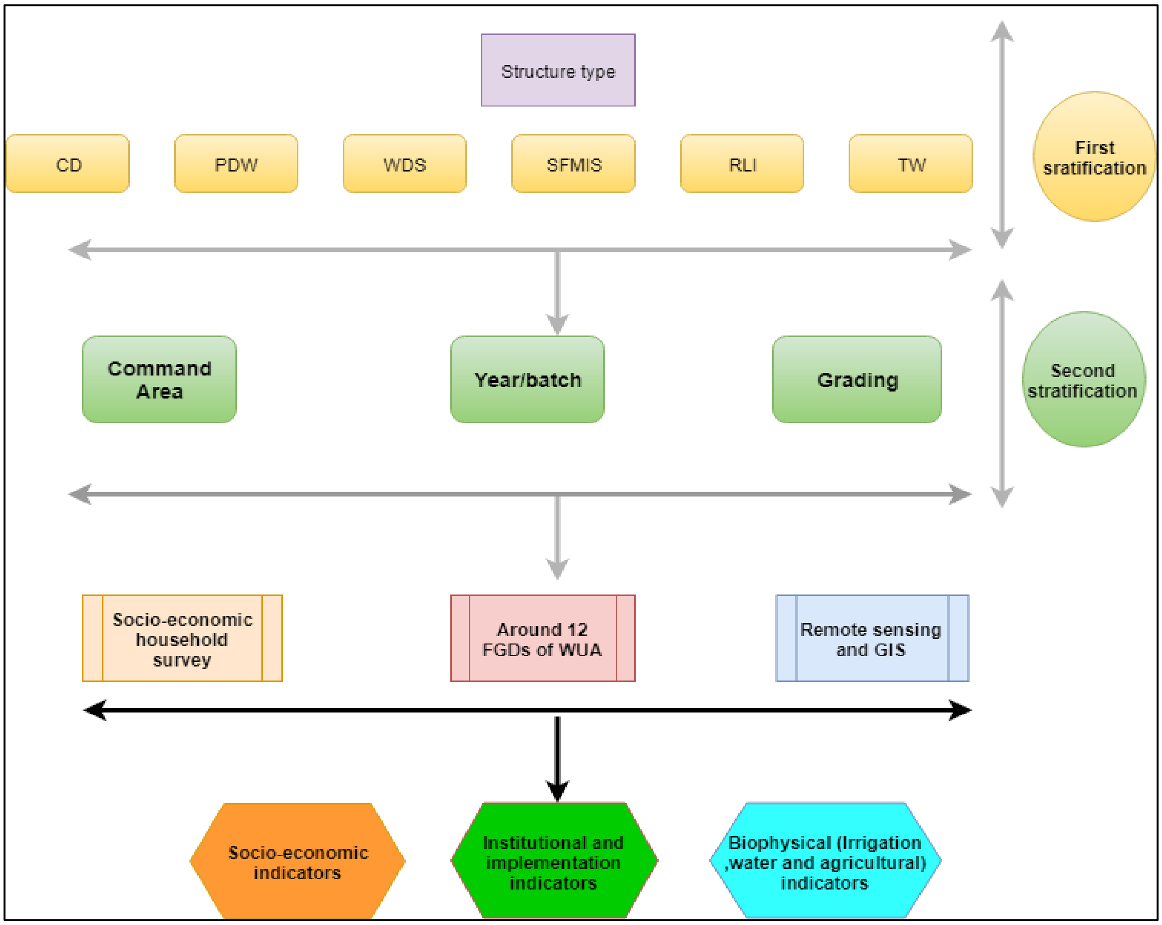


Figure 6 Conceptual overview of sampling steps taken for the study

For the first level stratification, type of minor irrigation schemes was categorized based on their nature and size into six strata, namely check dam (CD), water detention structure (WDS), surface flow minor irrigation scheme (SFMIS), lift irrigation (LI), tube well (TW), and pump dug well (PDW). The WBADMI project has also evolved a set of guidelines to grade the WUAs into A, B, C and D categories. While selecting schemes for sampling within a type of scheme, grading of respective WUAs were also considered to randomly pick based on best performing as well as poor performing schemes.

- For our sampling purpose, only schemes that had been handed over by the year 2017 are considered. This is done to ensure that at least one year of operations post handing over can be captured in our assessment. As we limited our selection criterion to schemes handed over by 2017, we were left with 260 schemes in four districts from a total of 326 handed over schemes. Their distribution across different districts and scheme type is given in Table 2.

- Out these 260 schemes, 42 schemes are selected using mixed sequential sampling method (random sampling followed by purposive sampling), considering various parameters like scheme type, size of command area, grading received in the project etc. Distribution of selected schemes is given in Table 2 and their spatial distribution in Figure 7.

- List of selected schemes is given in Annex 2.

Table 2: Distribution of handed over schemes (till 2017) across different districts and scheme type

District	CD	PDW	RLI	SFMIS	TW	WDS	Total
BANKURA	3	0	15	13	3	1	35
BIRBHUM	49	27	9	5	8	2	100
PASCHIM MEDINIPUR	14	0	13	0	32	0	59
PURULIA	21	0	12	32	0	1	66
Grand Total	87	27	49	50	43	4	260

Table 3: Distribution of selected schemes for sampling across different districts and according to scheme type (numbers in bracket indicate number of households sampled)

District	RLI	WDS	Check Dam	PDW	SFMIS	Tubewell	Total
Bankura	3 *(37)*	1 *(8)*	1 *(9)*	0	2 *(19)*	1 *(15)*	8 *(88)*
Birbhum	2 *(17)*	2 *(20)*	5 *(42)*	4 *(32)*	0	2 *(37)*	15 *(148)*
Paschim Medinipur	2 *(29)*	0	4 *(37)*	0	0	4 *(79)*	10 *(145)*
Purulia	1 *(12)*	1 *(8)*	3 *(27)*	0	4 *(41)*	0	9 *(88)*
Total	8 *(95)*	4 *(36)*	13 *(115)*	4 *(32)*	6 *(60)*	7 *(131)*	42 *(469)*

In the next step, study selected members of Water User Association in these 42 schemes for conducting the survey interviews. For selecting sample for the household level survey, a list of farmer-members of Water User Associations (WUAs) for these 42 schemes from the local Project Management units was obtained. From this list, farmer-members were selected using proportionate stratified random sampling. A minimum of 10% of the farmers using water for irrigation in the command area, who are also members of their respective WUA, were covered under household sample survey. Stratification was done based on land holding size, tribal/no-tribal status and gender. For selected farmer-members, survey team visited their house and conducted a household-level survey with the household-head. In our sample, we had 469 households who had membership in Water User Associations across four districts. The distribution of our sample across district and scheme-type is provided in Table 4.

Table 4: Summary of sample households selected for detailed household survey

	WBADMI Website record	DPMU sampling frame	Sample
Total	2814	2319	469
Female	686	304	72
Percentage	*24.4%*	*13.1%*	*15.4%*
ST	640	NA	171
Percentage	*22.7%*	*NA*	*36.5%*
Marginal	1811	NA	341
Percentage	*64.4%*	*NA*	*72.7%*

According to WBADMI project website records, there were 2814 WUA in these 42 schemes, but the list of members that we received from DPMU and used for sampling frame contained 2319 members. Study sample of 469 households represent a coverage at least 17% of total members. As described in Table 4 above, sample of farmers had 15.4% households with at least one female member in Water User Association. In the sampling frame (i.e., the total list of WUA members provided by DPMU), 13.1% were female members, which is less than 24.4% female members as recorded in WBADMI website. In study sample, 36.5% households belonged to scheduled tribe and 73% were marginal farmers. These numbers are slightly higher than what is recorded in WBADMI project website. But, since these records referred to initial member details, there could be some changes down the line. In any case, this illustrates that study sample had a good representation of marginal and tribal farmers from the Water User Associations.

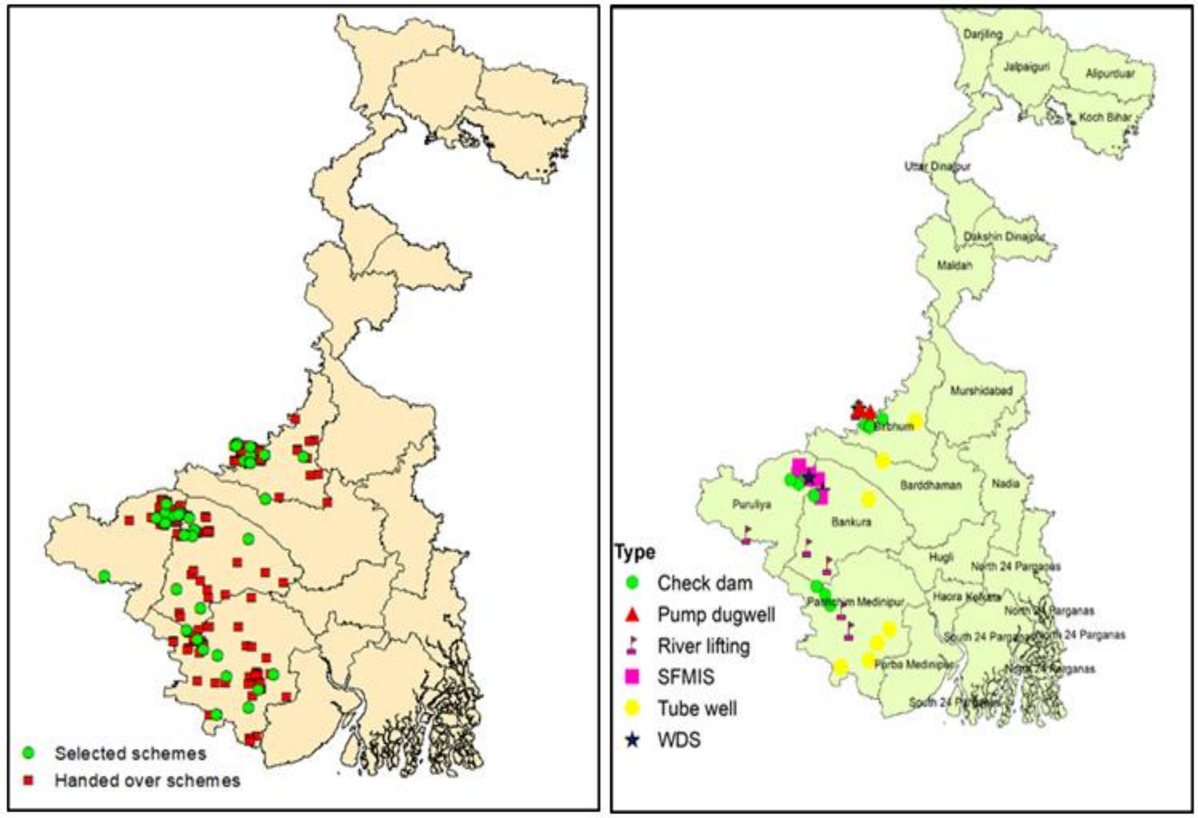


Figure 7: Spatial distribution of Selected and handed over schemes in assessment districts

Selection of other (non-WBADMI project) government minor irrigation schemes: The WBADMIP schemes are different from other similar minor irrigation schemes in West Bengal, because of the Water User Associations created to look after operation and maintenance and also the extensive agricultural support services provided by the project to enhance agricultural production and raise farmers' income. Consequently, in our analysis we have also compared performance of WBADMIP schemes with other similar non-project minor irrigation schemes of the government. These schemes were selected randomly from a list of comparable schemes provided by DPMU. This comparison of WBADMIP with similar other non-project minor-irrigation schemes of the government emphasizes the role of Water User Associations (WUA) and agricultural support services, i.e., non-project government schemes in minor irrigation without any role of WUA. For the assessment, 10 schemes were selected across four districts – 4 check dams, 2 RLI schemes, 2 WDS schemes and 2 SFMIS schemes. List of selected schemes is given in Annex 2. In all, assessment had a sample of 98 farmers from other non-project schemes.

3.4 Instruments for assessment study

3.4.1 Quantitative household survey

A quantitative socio-economic household survey was undertaken in sampled villages. For household survey, questionnaire was designed based on the list of identified biophysical and social indicators, tested and implemented in identified areas. Questionnaires were developed by the multi-disciplinary expert team of IWMI and digital forms for questionnaires were used for data collection. Pre-testing of questionnaires was done in the field by the IWMI team with the support of a local team and DPMU. The survey was conducted in October 2018. Since the harvesting season is late November/ early December, we collected data on the cropping pattern and yield of farmers in the MI command area focusing on summer 2018, rabi 2017/18 and kharif 2017. However, recall data on farming practices before start of project (i.e. 4 years ago) for the 12-month period (kharif 2014, pre-kharif (summer) 2014 & rabi 2013/14) were also collected. The years selected for assessment (2013-14 & 2017-18) received normal rainfall in the selected districts. Apart from eliciting information on farming practices, survey respondents were also asked to provide basic information on asset ownership, migration, fisheries and horticulture. In addition, there was a detailed section to gather information on WUA performance in terms of operation, maintenance, financial transparency, equitable participation etc. as perceived by the members. We also collected information on female household members' participation in agricultural activities and their ability to take part in economic decision making.

3.4.2 Qualitative survey (FGD and KII)

Sixteen focus group discussions (FGD) with WUA members and eight Key Informant Interviews (KII) across all four districts were conducted by the multi-disciplinary expert team of IWMI. Additionally, one horticulture expert and one fishery expert visited five schemes each, to separately assess the horticulture and fisheries component of the scheme. A participatory approach was exercised to conduct the FGDs with WUA members. List of selected schemes for FGD is given in Annex 3.

3.4.3 Remote sensing

Earth observation data is used specially to supplement household survey for assessment of biophysical indicators covering agriculture and irrigation by assessing changes in the cropped area and surface water spread. This was done for select project schemes to showcase the application of method and suitability as a way forward in future studies.

- Data Used

Satellite data from Landsat 8 provided freely by United State Geological Survey (USGS) (30m spatial resolution) with 16-day revisit time from March 2013, Sentinel-2 optical satellite data (10m spatial resolution) with 5-day revisit time, and Sentinel-1 (10-meter spatial resolution) at 12 to 4 days temporal resolution provided by Europe Space Agency (ESA) were used in this analysis. Around 300 images from both Landsat 8 and Sentinel -2 were used to generate map for the crop dynamics in minor-irrigation schemes in selected districts. Table 5 gives brief of RS data sources used.

Table 5: RS data sources used in the geospatial analysis

Image Type	No. of Scenes	Resolution (m)	Year
Landsat – 8	84	30	2013-2018
Sentinel – 1	100	10	2015-2018
Sentinel – 2	206	10	2014-2018

To process large amount of satellite data, Google Earth Engine (GEE) environment was used which has very high processing capabilities. Google Earth Engine is a cloud-based platform for planetary-scale geospatial analysis that uses Google's massive computational capabilities.

- Method

Geospatial analysis focused on assessing two biophysical indicators: Crop area mapping and surface water spread. Figure 8 gives the workflow used to arrive at both indicators.

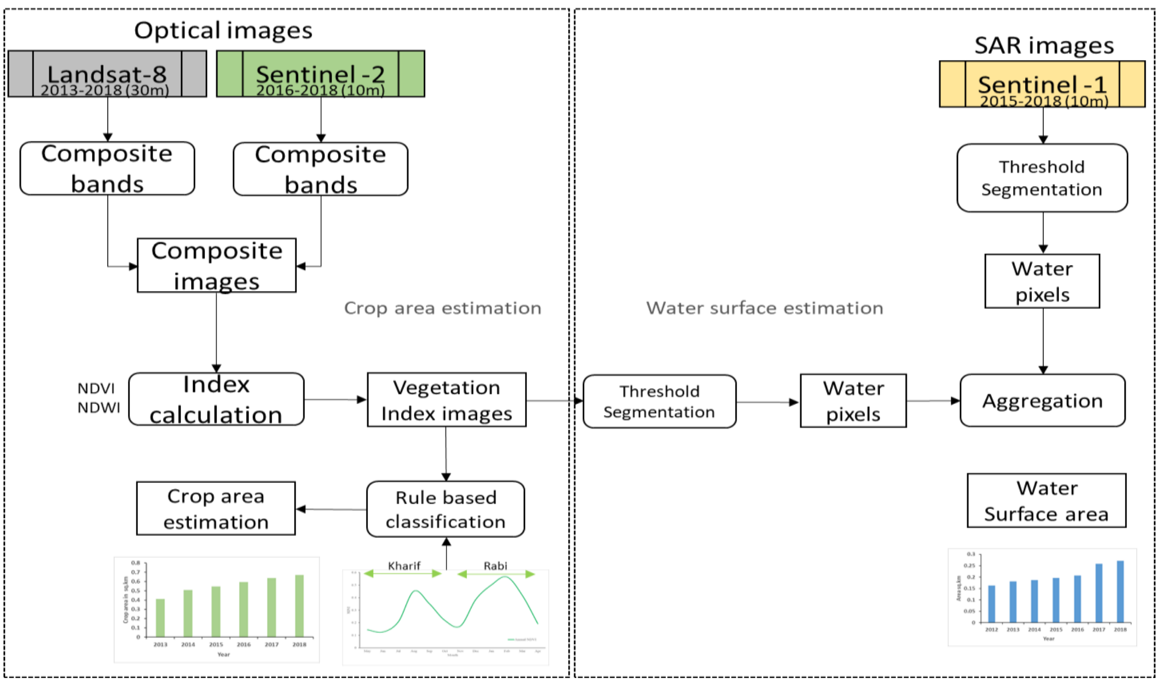


Figure 8: Data processing approach used in geospatial analysis for the crop and surface water area extraction

3.4.4 Case studies

Case studies of few key selected interventions and different approaches of development from 11 schemes were undertaken for an in-depth analysis. The case studies were identified in consultation with the project implementation team. This focused on the methods and practices that led to the outcomes. These stories were picked up during the field visits and interaction with stakeholders including project authorities.

4. Results and Discussion

In the following sections, we discuss impact of this project on key agricultural, irrigation, institutional, social and economic indicators based on the study of sampled schemes in the project area of the four identified districts.

4.1 Agricultural Indicators

4.1.1 Cultivated area

The primary impacts of the WBADMI project scheme can be observed in terms of bringing more area under agriculture and increasing cropping intensity. As can be seen from Figure 9 below, cultivated area under kharif and rabi crops shows significant increase in project schemes. While kharif area increased from 147.0 hectares in kharif 2014 to 181.1 hectares in kharif 2017 i.e. by 23.1%, rabi area saw a substantial jump from 18.7 hectares in rabi 2013/14 to 104.4 hectares in rabi 2017/18 (percentage wise 458.3% jump in rabi area, but this is mostly because of low base). For pre-kharif season also, study found that cultivated area increased from just 2.5 hectares in pre-kharif 2014 to 19.5 hectares in pre-kharif 2018.

Average area cultivated during kharif is highest in tubewell schemes (23.2 hectares), followed by RLI (17.4 hectares), check dams (12.8 hectares), SFMIS (12.3 hectares), WDS (8.2 hectares) and

PDW (6.9 hectares). In rabi season, total area serviced by schemes is relative much lower than kharif except for tubewell schemes.

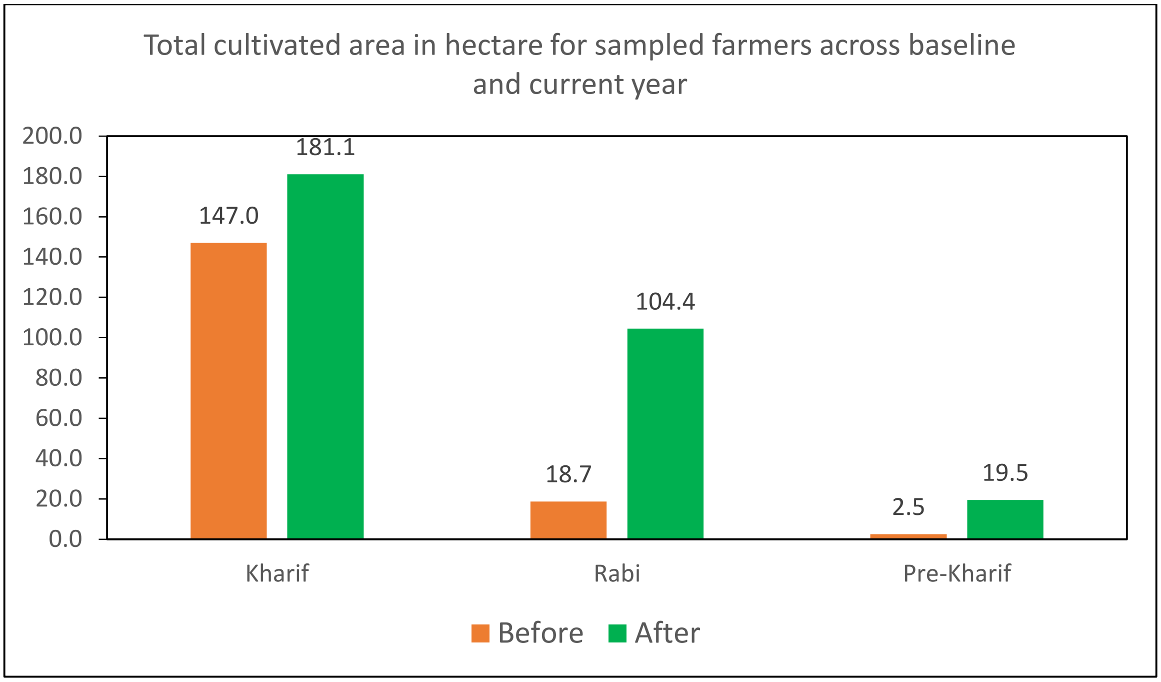


Figure 9: Total cultivated area (ha) of sampled farmers before and after project implementation

Cultivated area under schemes was also mapped using remote sensing data to complement results from household survey data. For this, optical data from Landsat – 8 and Sentinel-2 data were used to generate the time series of crop area. At first, composite images were created and from them, Normalized Different Vegetation Index (NDVI) was calculated. More than 186 Landsat images for each 16-day composite from 2011-2018 and more than 200 composite images from Sentinel – 2 data were used to generate time series of crop area using GEE platform.

To extract the seasonal crop area extent from Landsat and Sentinel-2 images, the rule-based threshold segmentation method was applied by contrasting behavior of crop and non-non pixels in the acquired images. By evaluating extracted NDVI pixel values profile for different cropping season (kharif, rabi and pre-kharif), NDVI were defined for peak growth and harvest separately. The crop pixels were then extracted with rule-based segmentation in pixels.

Cultivated area mapping is done for command area map as shared by project team and in order to make it more robust, a buffer around the command is taken to include any spill over impact or change in command area from the one provided by project team.

Example of cultivated area mapping as done for Gadhadhpur check dam located in Birbhum district is shown in Figure 10. Scheme was handed over in July 2016. Figure 10 gives the time series of images (False composite), calculated NDVI and crop area estimation for rabi season for pre-implementation year (2016) and post implementation years (2017, 18 and 19). It also gives the trend of command area value in overall NDVI and cultivated area from 2016 to 2019.

From images in Figure 10, it is evident that crop area has increased from 2016 to 2019 rabi season in Gadadhapur Check Dam. It clearly represents that the average NDVI value has intensified over the time along with increase the cropping area. As seen in Figure 10 (i to l part), overall cultivated area (in green) has expanded considerably after 2016 (image i), however still showing year to year variability. Pre project implementation (year 2016) had only very small area cultivated which is evident in RS imagery. Geospatial analysis corroborate the data assessed from household survey data which shows that cultivated area has shown a significant increase after the implementation of project with 87.5 % of command area is cultivated in rabi in comparison to only ~ 12.5 % pre-project implementation period.

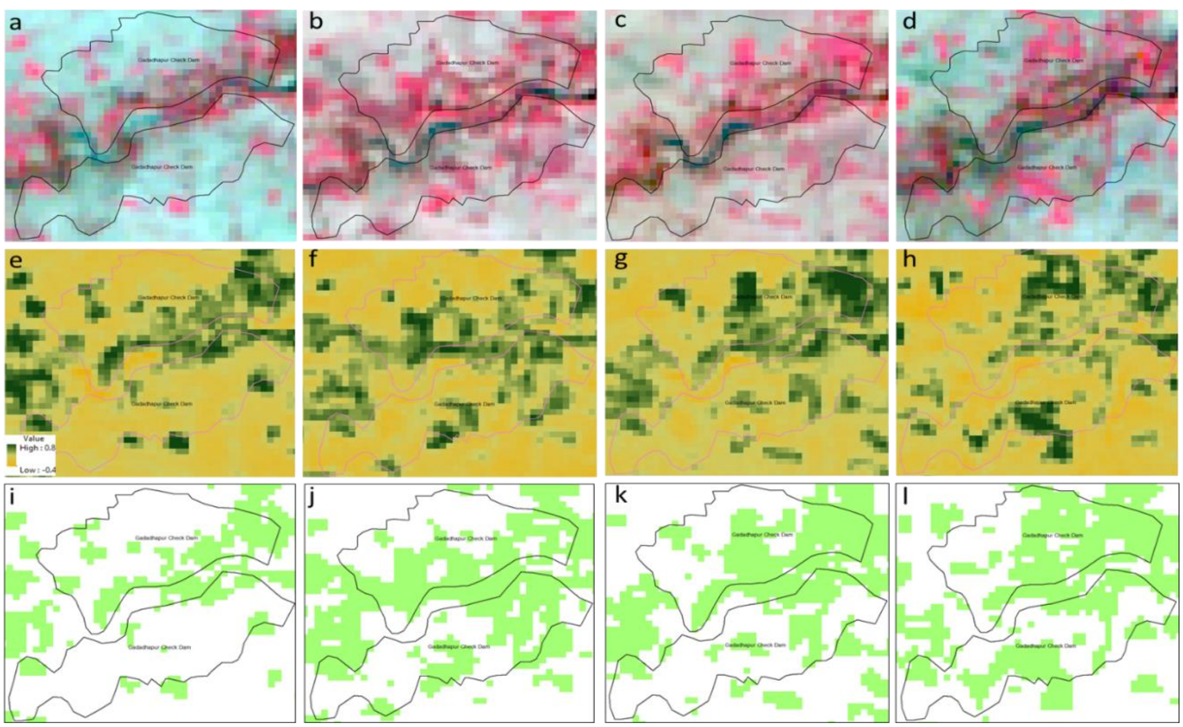


Figure 10: Crop area changes over the time in Gadadhapur Check Dam, (a-d) false color composite of 2016 Jan 31, 2017 Feb 04, 2018 Jan 25 and 2019 Jan 25, (e-h) NDVI changes of the corresponding date and (i-l) crop area for corresponding dates

Detailed field data collection was done for 2019 rabi season for validating RS analysis using which cultivated area is mapped for 2019. RS mapped cultivated area is compared against collected household data of rabi season to corroborate the increase that was observed in household data analysis. Table 6 compares the percent of RS mapped area (command area + buffer area) cultivated to percent of command area cultivated, as assessed from household data, in rabi season for 14 schemes. Overall, a very good match between the two results is seen with cultivated area mapped from RS corroborating the household collected data.

One key difference is that the RS mapped area in surface scheme shows lower value compared to household survey data. This is because 2018-19 monsoon season was below normal so surface water schemes area in rabi season is lesser than 2017-18 rabi area (normal rainfall year) to which household data corresponds to. This mismatch is not observed in TW schemes which are not impacted by low monsoon rains.

Table 6: Percent of command area cultivated in rabi season as assessed from RS data and household survey data

Scheme	Scheme type	Scheme name	Total area	cultivated area	% cultivated (from RS)	% cultivated from HH data
03-02-041-17-081	Check Dam	Gadadhapur Check Dam	7.5	4.3	57.3%	84.6%
03-18-190-17-070	Check Dam	Khorddanagari Check Dam	6.7	4.3	64.2%	70.8%
14-17-374-17-044	Check Dam	Bindukuta CD (Nongarkhal)	12.8	1.3	10.2%	38.2%
03-03-075-12-009	LDTW	Khudrapur	13.6	11.7	86.0%	85.6%
03-08-114-12-012	LDTW	Nandulia LDTW	26.5	26.4	99.6%	100.0%
01-17-178-01-014	Mini(E) RLI	Kusumtikri	13.1	1.4	10.7%	12.7%
14-17-490-03-003	Midi(E) RLI	Baida	18.8	14.1	75.0%	64.4%
03-14-005-14-041	PDW	Talpukur-II PDW	2.4	1.1	45.8%	67.5%
03-14-053-15-025	PDW (S)	Barkonda Solar PDW	1.5	1.1	73.3%	74.2%
01-05-137-07-053	SFMIS	Kharbona	11.9	1.5	12.6%	6.3%
16-20-088-18-114	SFMIS	Shyam Bundh SFMIS	5.9	1.1	18.6%	45.5%
16-18-178-18-072	SFMIS	Rameswar Bundh SFMIS	6.2	1.3	21.0%	52.4%
03-14-006-05-045	WDS/WHT	Ruhida-IV WDS	5.6	5.3	94.6%	85.9%
16-20-099-05-015	WDS/WHT	Nandi bundh SFMIS	14.1	1.9	13.5%	31.4%

4.1.2 Cropping intensity

The increase in rabi and pre-kharif area as discussed above is more evident when looked into cropping intensity. For each of the sampled 42 schemes, gross cropped area and net sown area was summed up for sampled farmers and, thereafter, cropping intensity at scheme level was estimated using the formula:

Cropping intensity = (Gross Cropped Area/Net sown area) ∗100

Cropping Intensity increased from 113.8% to 168.2% during the four-year period in sampled project villages. This increase in cropping intensity is reflection of significant increase in rabi cultivation in project villages, which was previously non-existent. However, in terms of cropping intensity there was a substantial difference across scheme types (Figure 11). Overall cropping intensity is highest for Tubewell schemes 212.8%, which is significantly higher than all other schemes, followed by RLI (182.5%), PDW (180.3%), CD (157.6%), WDS (144.6%) and SFMIS (127.8%) schemes. In total, there were five schemes with cropping intensity above 200% (three Tube well and two RLI schemes). Out of 24 schemes with cropping intensity between 150 and 200, only two were SFMIS or WDS and out of 13 schemes in our sample that had cropping intensity below 150 percent, all were surface irrigation schemes. This indicates the better performance of TW, RLI and PDW schemes relative to surface water schemes of CD, WDS and SFMIS. This decreasing order is reflected when cropping intensity increase is evaluated for overall change. Highest cropping intensity increase is seen in Pump Dugwell schemes (80.3%), followed by Tubewell schemes (75.3%), and Lift Irrigation schemes (44.4%), while cropping intensity increase have been lowest for surface–irrigation schemes like SFMIS (18.7%), Check dam (40.2%) & Water Detention structures (40.6%).

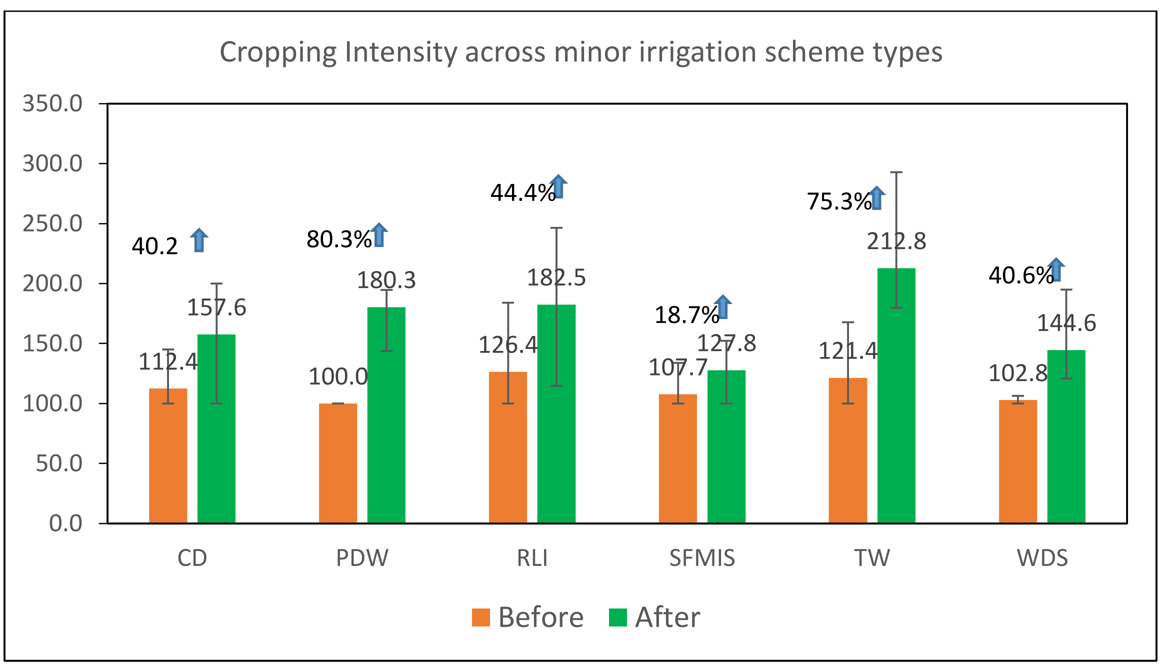


Figure 11: Cropping Intensity across minor irrigation scheme types

There is a substantial variation in cropping intensity across districts. Overall, Birbhum (193.2%) and Paschim Medinipur (176.2%) has high cropping intensity under MI-scheme, significantly higher than Bankura (142.8%) and Purulia (140.2%) (Figure 12). Since not all scheme types are suitable for all districts, it is instructive to look at performance of a particular scheme type across districts. Figure 12 shows the comparison of scheme type performance across districts. Comparing performance of RLI schemes across all districts, it is seen that cropping intensity is highest in Paschim Medinipur (226.9%) and lowest in Bankura (147.4%). For all other scheme types, Birbhum performs the best in terms of cropping intensity when compared to the same scheme type in other districts – for example Check Dam (189.0%), Tubewell (259.9%) and WDS (163.1%). This difference in performance across districts is a reflection of both the type of schemes operating within each district and differential efficiency in operation and management of schemes. Paschim Medinipur has high proportion of TW, PDW and RLI which are found to be relatively better than other schemes which gets translated into overall high cropping intensity in the district. Whereas, Birbhum despite having equal proportion of surface schemes (CS, WDS and SFMIS) performs better due to its above average performance across these scheme types as seen in Figure 13. This underlies the importance of district project units and outreach which are discussed more in next sections. However, it is also worth noting that in areas like Purulia district where TW is not a very feasible MI proposition surface schemes have an important role to play when planned, sited and designed scientifically.

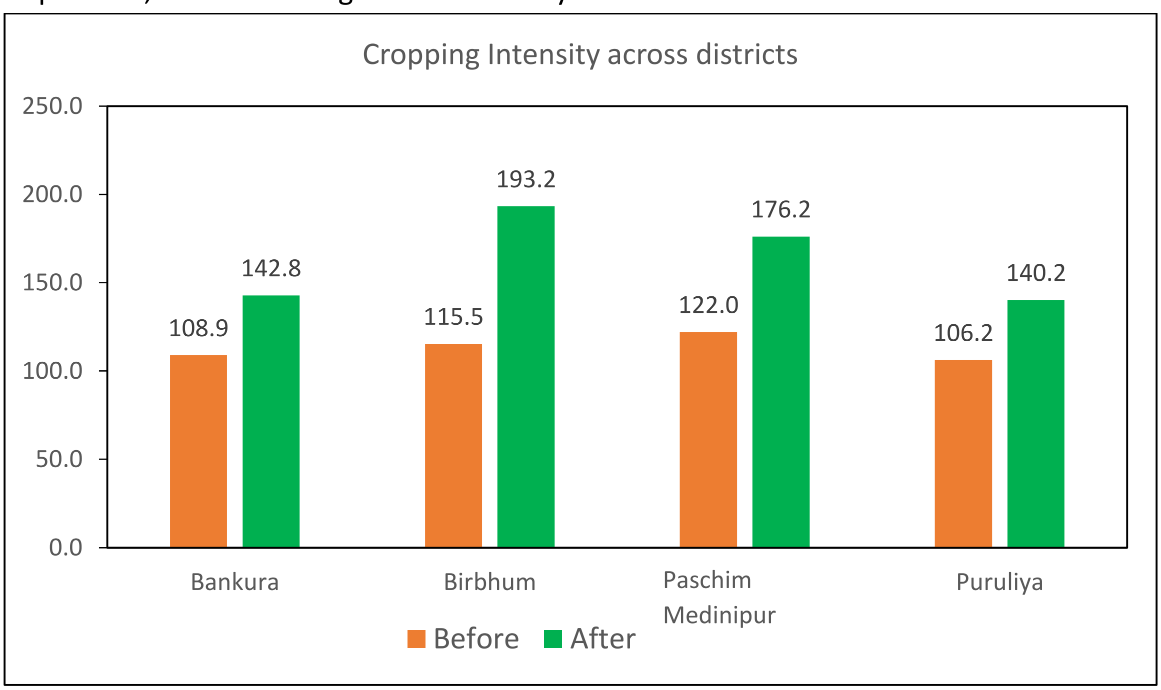


Figure 12: Cropping Intensity across districts

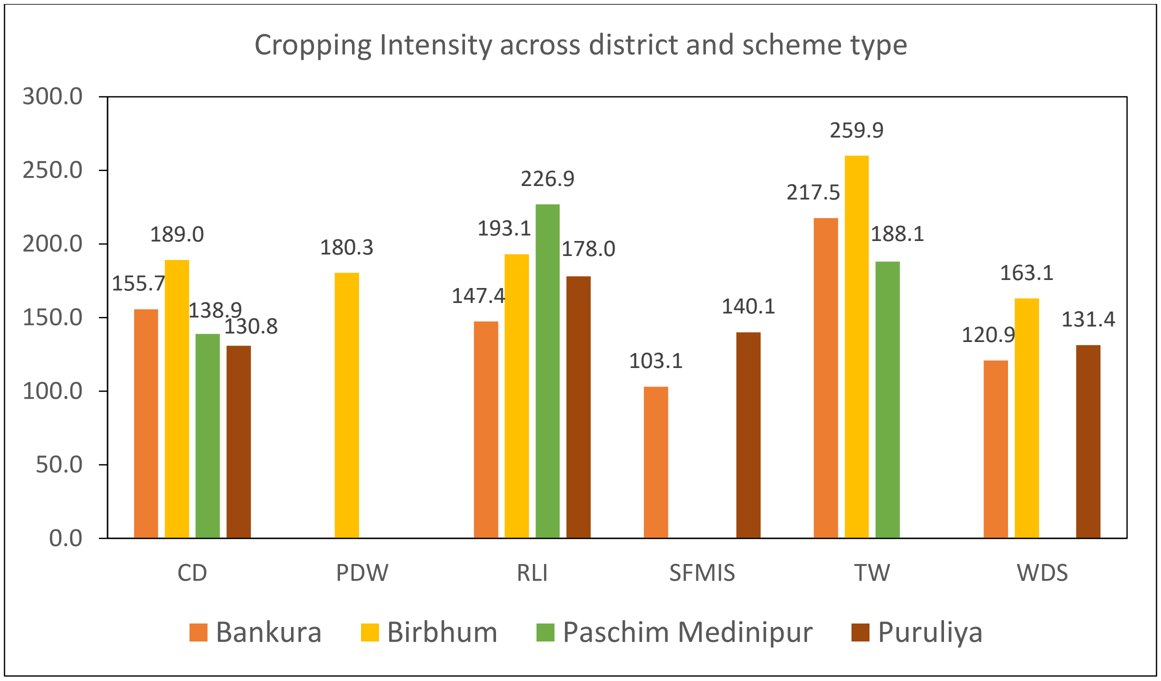


Figure 13: Cropping Intensity across district and scheme type

4.1.3 Crop Diversification

There is a significant increase in both number of different crops and proportion of area under them in project villages. Farmers in project villages have started growing many vegetables during rabi season like brinjal, cauliflower, leafy vegetables, onion, pumpkin, ridge-gourd, sesame etc. (Figure 15). The proportion of gross cropped area under potato and mustard have also shown an increase in sampled villages under this project. Due to this, the dependence on paddy as the only source of income has slowly decreased.

As we can see in the Figure 15, area under mustard increased from 5.2 hectares in rabi 2013/14 to 39.5 hectares in rabi 2017/18 (increased by 7.5 times), area under potato increased by 4 times from 6 hectares to 24.4 hectares. Previously mustard area was 28.0% of total rabi area, while potato was 31.8% of total rabi area. Currently, in sampled schemes mustard area is 37.8% of total rabi area and potato area is 23.4%. Rabi paddy is also quite prevalent, especially in Paschim Medinipur, despite its high irrigation water requirements.

Overall area under rabi paddy has increased from 4.0 hectares to 23.7 hectares, however proportion of paddy area during rabi has almost remained same (21.2% previously and currently it is 22.7%). Rabi vegetables also saw a substantial increase from baseline year.

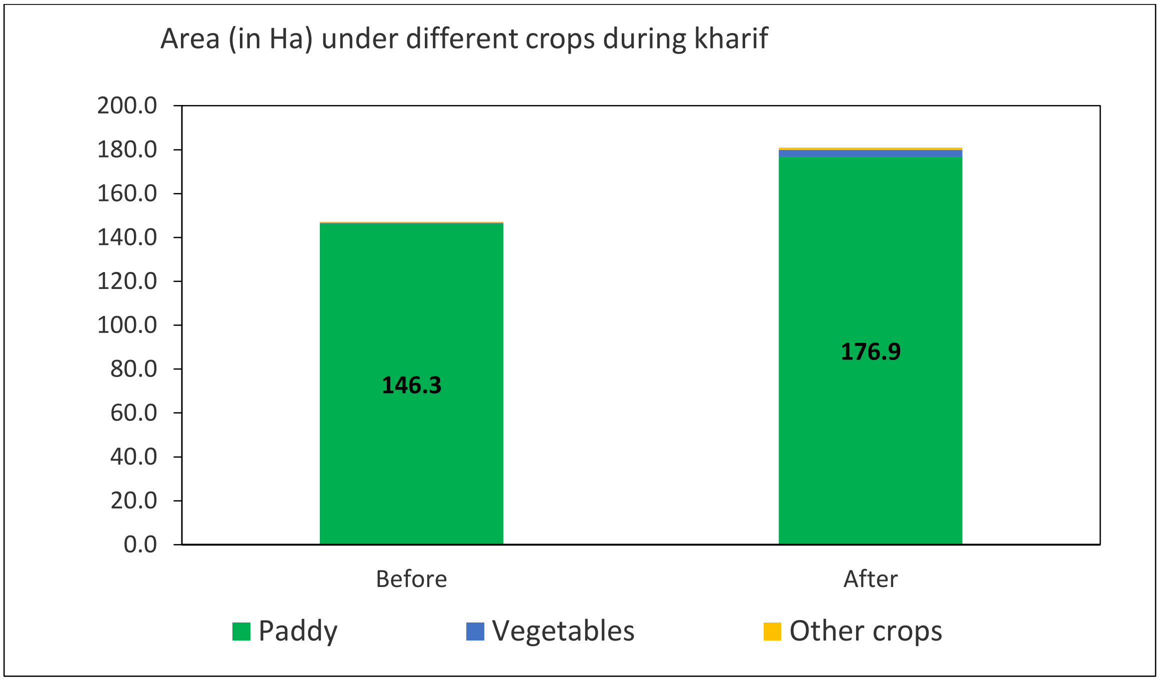


Figure 14: Cultivated area (ha) under different crops- kharif season

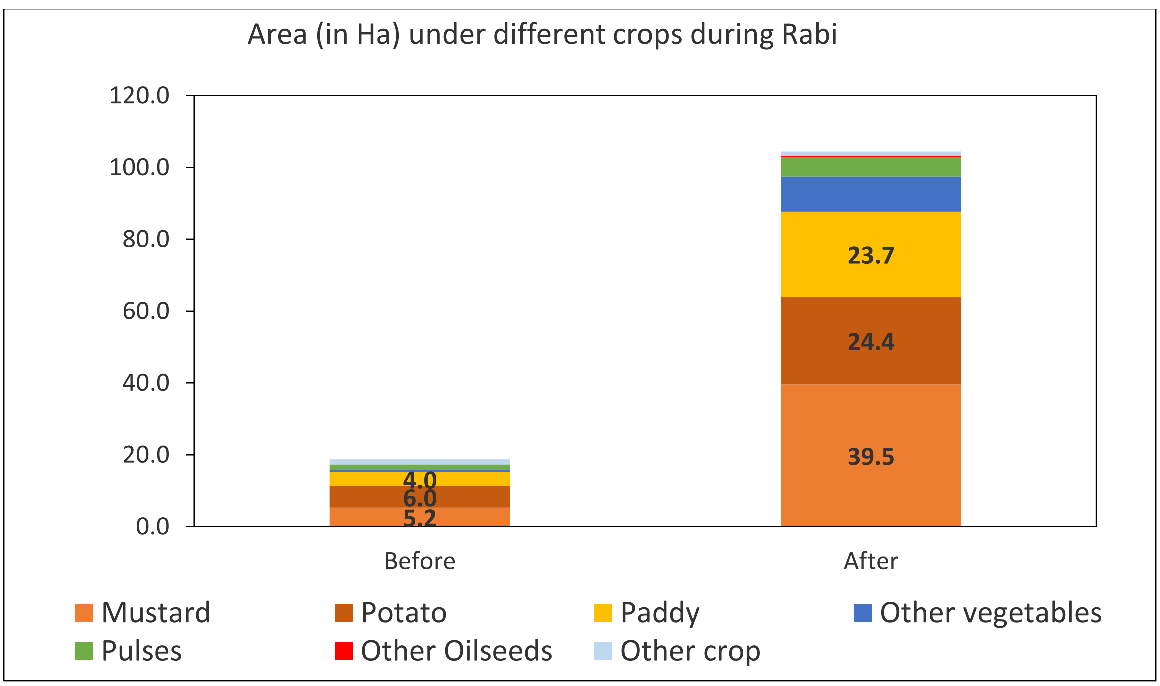


Figure 15: Cultivated area (ha) under different crops- rabi season

During kharif season, paddy is still the primary crop (Figure 14). In sampled schemes, during kharif 2014, 146.3 hectare was under paddy cultivation, which was 99.5% of cropped kharif area. During kharif 2018, area under paddy in the project schemes was 176.9 hectares (97.7% of total kharif cultivated area). The area under vegetable cultivation during kharif 2018 has increased a little, but it is still quite less (3 hectares i.e. 1.6%).

However, overall dependence on paddy has decreased because area under different crops during rabi season has increased by significant amount. Consequently, the overall crop diversification has improved. To measure overall crop diversity, we use the following formula:

$$\text{Crop diversity} = -\sum pi * \log pi$$

where p_i is the proportion of area under crop *i* in a particular scheme. This crop diversification index is lowest (i.e. 0) when there is only 1 crop and $p_i=1$. As the number of crops increase and area under each crop is more equally distributed (i.e. no single crop dominates), the index value increases, indicating more crop diversification. Comparing this crop-diversity index for WBADMIP schemes, we found that it made a huge jump from 0.28 in 2014 to 0.87 in 2018 after scheme implementation. Figure 16 shows similar before and after comparison of CDI across districts. The CDI change is highest for Birbhum from 0.36 to 1.12 and is lowest for Bankura (0.26 to 0.67) and Paschim Medinipur (0.28 to 0.69). This is consistent with the finding above: as cropping intensity was highest in Birbhum, the area under rabi crop has diversified a lot, it has led to overall higher crop diversity. Paschim-Medinipur also had high cropping intensity but substantial rabi area in Paschim-Medinipur is under paddy. Consequently, overall dependence on paddy is still quite high in this district. This needs to be looked into as to how can the project through its agricultural support services, awareness campaigns, convergence and market linkages, motivate farmers to increase diversification in rabi paddy areas.

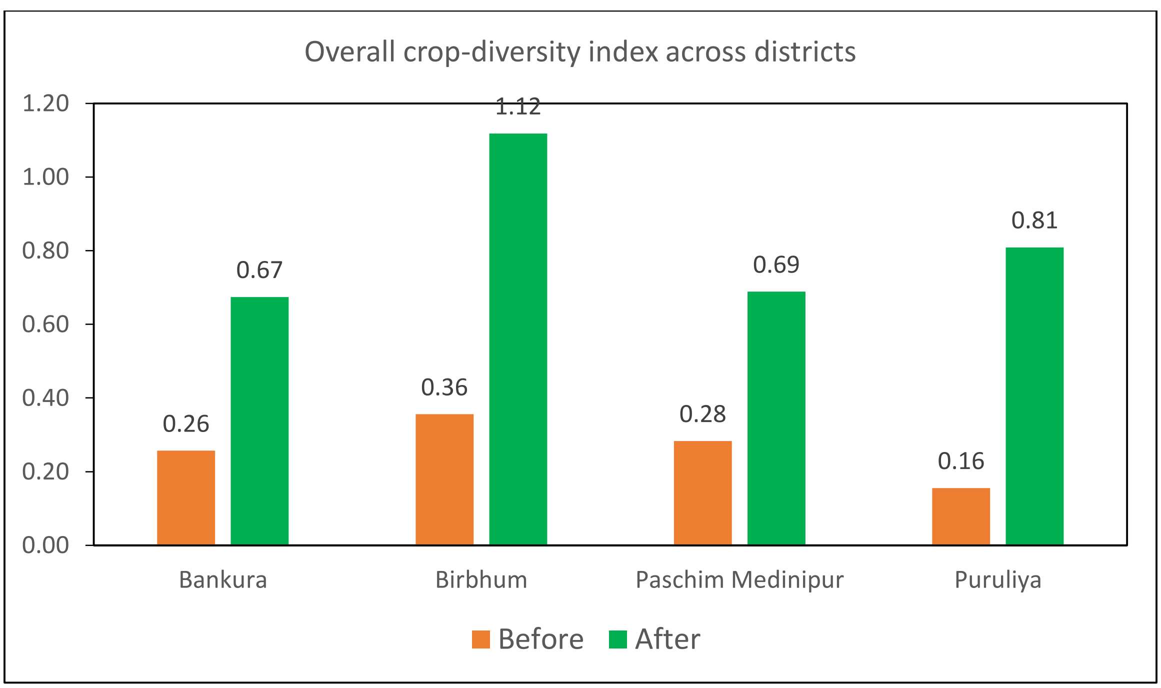


Figure 16: Overall crop-diversity index across districts before and after project implementation

4.1.4 Crop Yield

In sampled schemes, average yield was estimated and its change examined from pre project implementation year for three most important crops in this region – kharif paddy, mustard and potato during rabi season (Table 7). Overall, paddy yield has increased significantly from 2.8 tonnes/hectare to 4.4 tonnes/ hectare post project implementation. For mustard also, the average yield increased from 0.7 tonnes per hectare to 1 tonne/per hectare amongst our sample farmers. For potato we find a significant increase in yield from 14.5 tonnes/hectare to 23.4 tonnes/hectare after the implementation of scheme.

Table 7: Comparison between yield of crops before and after implementation of scheme

	Kharif Paddy Yield (Tonnes /hectare)	Rabi Mustard Yield (Tonnes /hectare)	Rabi Potato Yield (Tonnes /hectare)
Before	2.8	0.7	14.5
After	4.4	1.0	23.4

For the most important crop for the farmers in sampled schemes, kharif paddy, the change in average yield is estimated across all scheme types (Figure 17). The highest yield in kharif paddy was observed in tubewell schemes (4.5 tonnes/hectare) followed by RLI schemes (4.4 tonnes/hectare) and PDW schemes (4.4 tonnes/hectare). Across all scheme-types, paddy yield has increased significantly when compared to the situation before scheme implementation. This increase in yield is partly because of irrigation availability during intermittent dry spells within the kharif season from these MI schemes. But the reason is not just improved irrigation but also adoption of new technologies and better agronomic practices such as adoption of line sowing of paddy, direct seeded rice, seed treatment, use of HYV seeds among farmers through agricultural support services provided by scheme. We expand on this more in the next section.

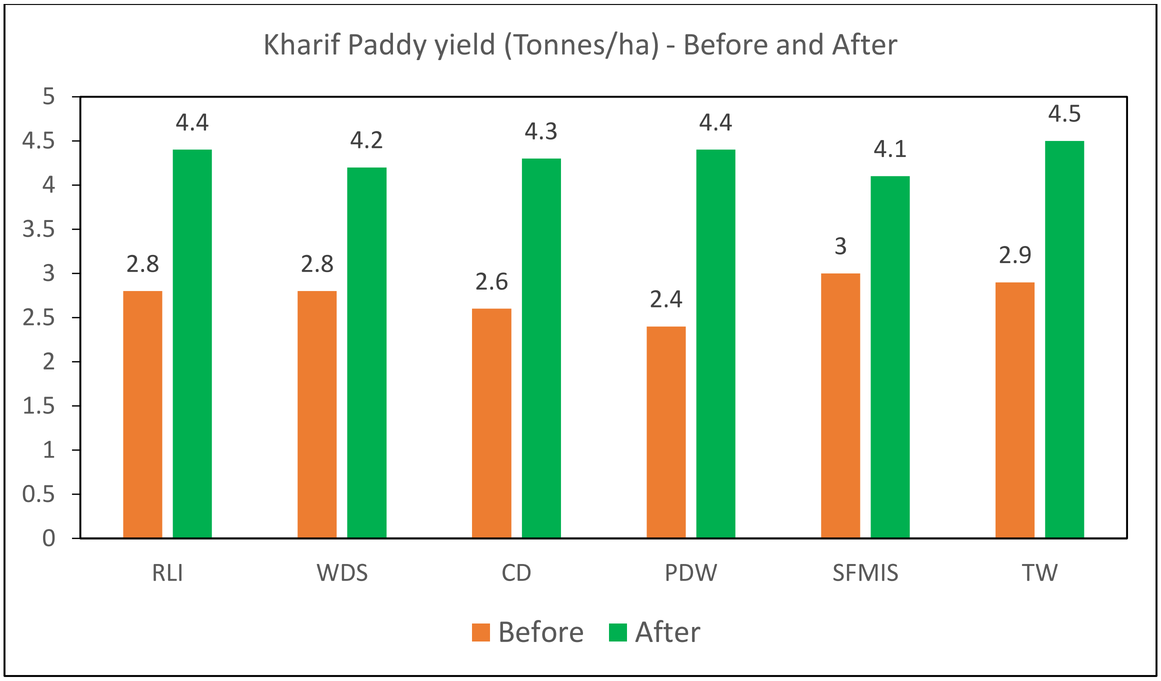


Figure 17: Yield of paddy in kharif season before and after the scheme was implemented

4.1.5 Adoption of new technologies/ improved agricultural practices

One important aspect of the WBADMI project has been to train and demonstrate new and improved agricultural practices to farmers and provide some farmers with input support to increase their productivity. This is expected to enable full utilization of the potential created under new irrigation schemes. Overall 54.2% of households who are member of WUA reported to have received some form of training/exposure visit/demonstration on improved agricultural practices other than fisheries/horticulture (like improved varieties, farm machineries, better water management, optimum fertilizer use etc.). There is a lot of variation in exposure to new technology under project scheme across districts (Figure 18). Birbhum (64.9%) and Paschim-Medinipur (69.0%) had the highest percentage of households reported to have received training and exposure visit/demonstration on improved agricultural practices.

In terms of direct input support from the project to adopt these improved agricultural practices, 46.4% households reported to have received input support. Again, Birbhum has the highest percentage of households who have received input support (52.7%), followed by Paschim-Medinipur (46.2%). Most of the input support was in the form of improved variety seeds and fertilizer. The relatively high rate of extension services and input support provided to Birbhum farmers is reflected in their higher paddy yield as discussed and described above.

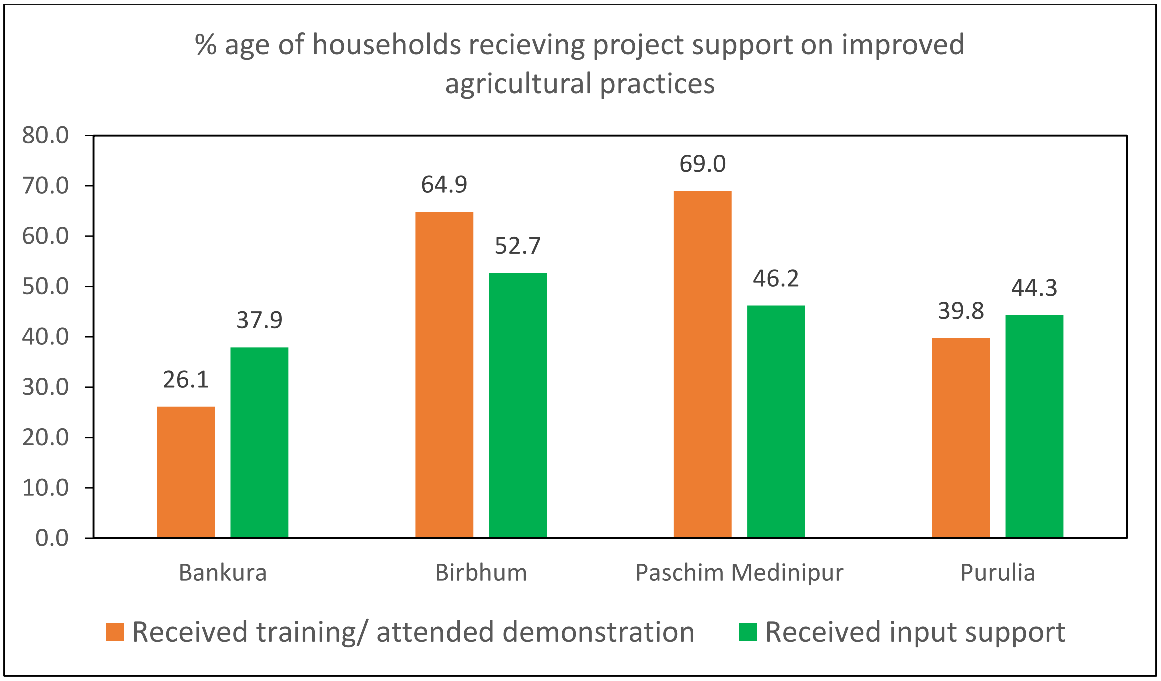


Figure 18: Percentage of households receiving project support on improved agricultural practices

In terms of reaching out to WUA farmers, the project has done moderately well with only 30.9% of sampled WUA households in project villages receiving neither any input support nor exposed to new technology (mostly in Bankura). If we look at the profile of farmers who have received training/ attended demonstrations on improved agricultural practices (Figure 19), it is observed that average landholding size of farmers receiving these trainings is slightly higher than those which didn't receive any training. Similar observations were made with regard to input support services. The fact that the WBADMI project is successful in providing agricultural support services to small and marginal farmers is illustrated by the fact that 77% of households who received either any form of training/ attended demonstration or received any input support were marginal farmers (i.e. net cultivable area less than one hectare). Also, in our project villages, 48.2% household belonged to either scheduled tribe or scheduled caste. In terms of receiving support services on improved agricultural practices from the scheme, 46.1% of the families which reported to have received services belonged to SC/ST groups, showing non-biased approach of WBADMI project.

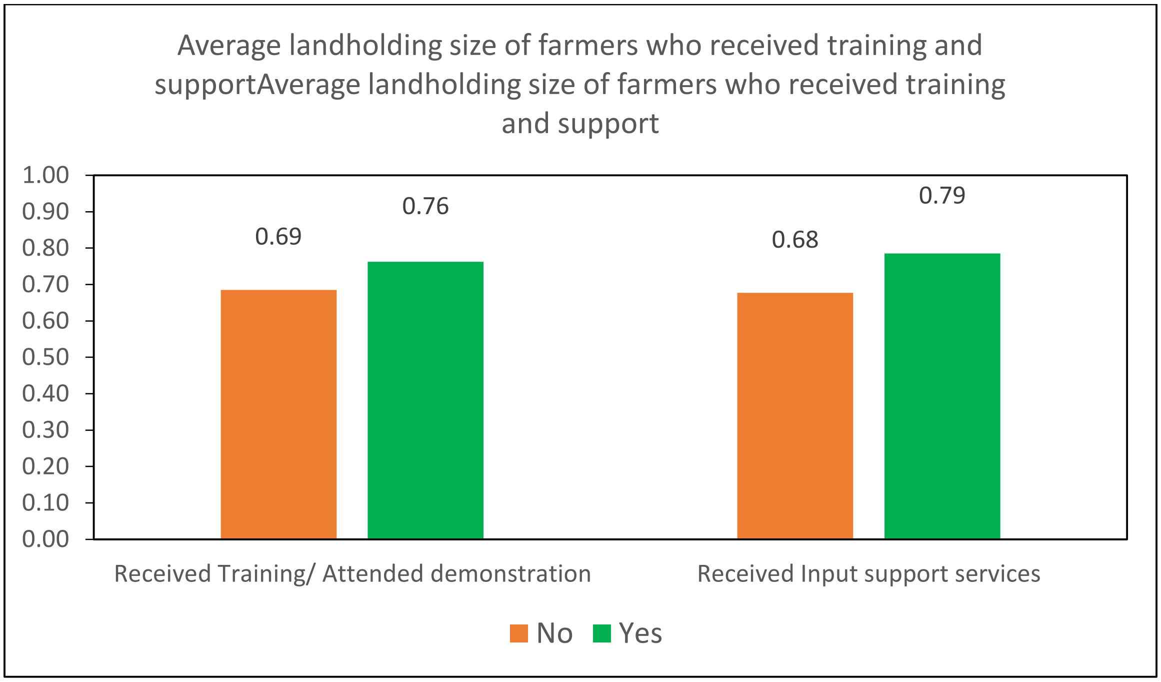


Figure 19: Average landholding size of farmers who received training and support

Overall, 46.8% of our project farmers indicated that they have changed their seed variety (from local variety seeds to High yielding variety seeds) for any one crop or vegetables after project intervention. Substantial number of farmers shifted from using desi variety to HYV seeds not only for paddy (45.4% changed from desi to HYV), but also for oilseeds (14.1%), vegetables (11.3%) and pulses (2.1%). Figure 20 gives the percentage of project farmers who changed from using local variety seeds to High yielding variety seeds across districts. Again, in terms of project farmers adopting HYV seeds, Birbhum was most successful where 67.6% farmers reporting change to better seeds for paddy followed by Paschim-Medinipur (40.7%), Purulia (30.7%) and Bankura (30.7%). Oilseeds was another crop where high percentage of farmers reporting change to better seeds but this was largely limited to Birbhum. Above average performance of Birbhum is an example, and probably the result, of better outreach and extension activities done through district project staff with support organization.

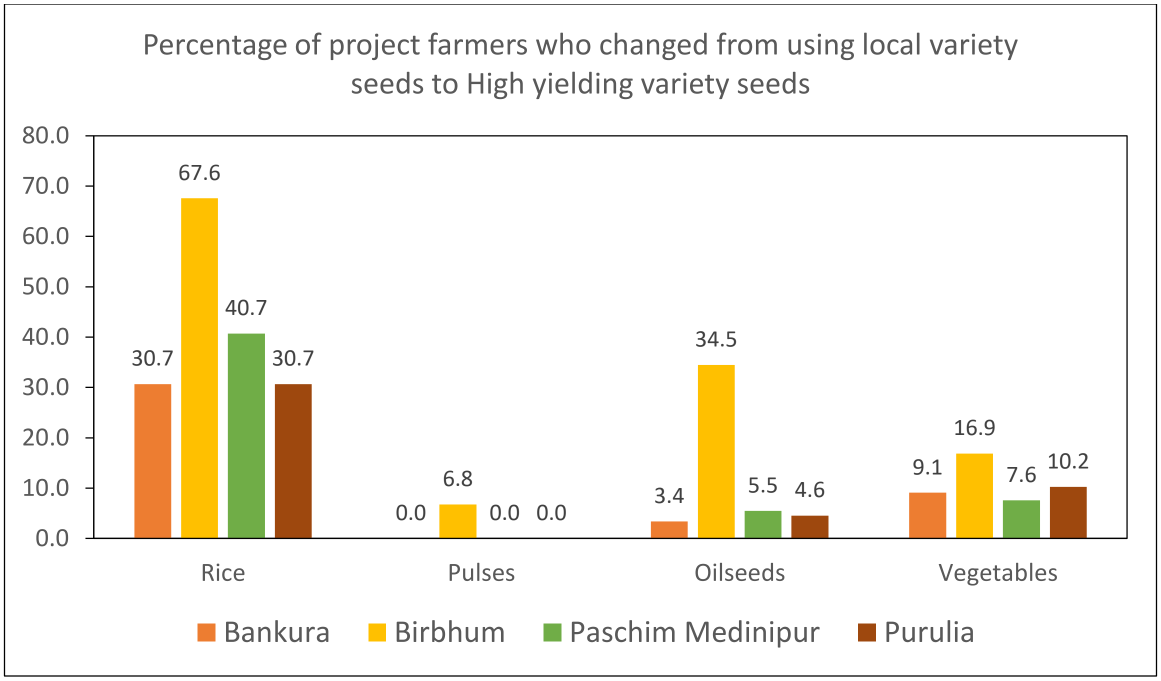


Figure 20: Percentage of project farmers who changed from local variety seeds to HYV seeds

Figure 21 gives the percentage of farmers who started using more organic fertilizers across each district. In terms of fertilizer use, overall 7.7% of project farmers started using more organic fertilizers after project intervention, with the highest percentage in Birbhum (13.5%).

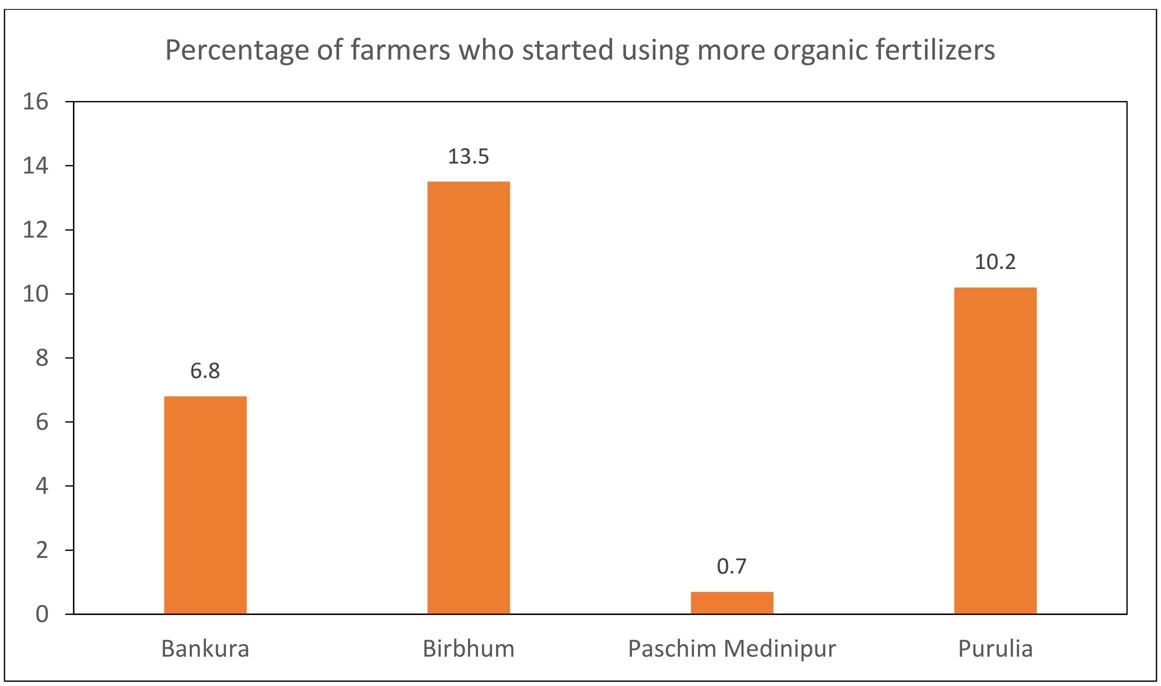


Figure 21: Percentage of farmers who started using more organic fertilizers

The impact of training, input support services from the WBADMI project in encouraging farmers in adopting new technology and improved agricultural practices is further exemplified in the Table 8 below. The first column shows adoption of different technology by farmers receiving training/ demonstration or any input services, while the second column shows adoption of these practices/technologies for farmers with access to no such support services. It is clearly evident that, adoption is higher for farmers with training and input support services. The highest adoption is seen for Line-Sown rice, HYV seeds and power-tiller. At the same time, some new practices like improved vegetable nursery, seed treatment, SRI and organic fertilizer have started making inroads and more effective outreach and extension can help increase their use.

Although to a large extent inclusive, these extension services have not been accessible across all districts. In districts like Birbhum where access to these extension services have been the highest gets reflected in higher yield. Thus more emphasis is needed in making these extension services available to all farmers.

Table 8: Training and demonstrations provided to farmers on agricultural practices

	% of farmers using improved practices/technologies	
	Farmers who attended training/ demonstration or received input support	Farmers NOT received any training/ demonstration or input support
Sunflower cultivation	1.2	0.0
Maize cultivation	0.3	0.0
Red/Black Gram cultivation	0.9	0.7
Line planting Rice	65.6	9.6
HYV Seeds	71.5	19.2
Improved Vegetable Nursey	5.6	0.0
Drip Irrigation	0.9	0.0
Nutrient management	0.3	0.0
Mobile agro advisory (ICT)	0.6	0.0
Power Tiller	15.5	4.8
Potato planter & digger	0.6	0.0
Zero-Tillage	0.6	0.0
Rice transplanter	0.6	2.1
Seed Treatment	2.2	0.0
Organic fertilizer use	1.2	0.0
SRI	2.2	0.0

4.1.6 Horticulture

Depending not just on paddy and other food crops, if farmers diversify into growing fruits and vegetables it can be an additional source of income and food. The WBADMI project scheme has encouraged farmers to cultivate more vegetables and fruits in their area through training and input support services. Amongst our sample farmers in project schemes, 29.4% reported to have cultivated vegetables and fruits in 2018. This is much higher than before the start of project when only 5.3% were cultivating either fruits or vegetables, indicating that there was a marked increase in horticulture practice among project farmers.

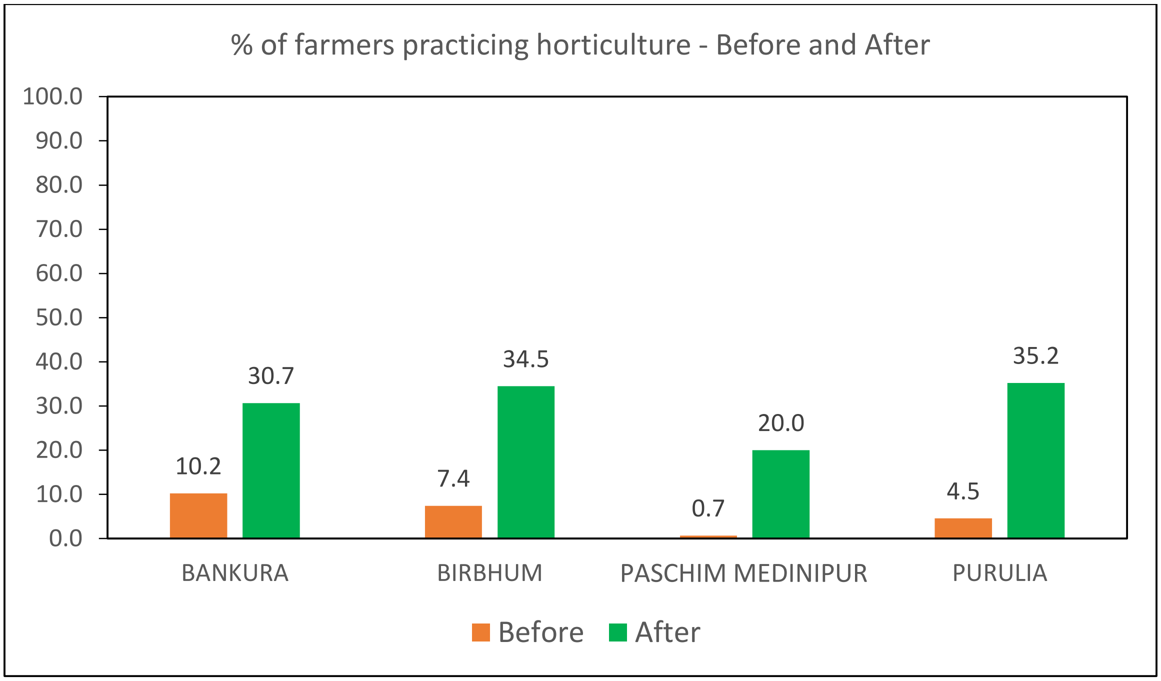


Figure 22: Percentage of farmers practicing horticulture across districts, before and after the scheme was implemented

Figure 22 gives the percentage of farmers involved in horticulture before and after the implementation of the project. Across all 4 districts there is increase in cultivation of vegetable and fruits with the largest increase in percentage points observed in Purulia (30.7 percentage points) and Birbhum (27.0 percentage points). This increase that we observe is primarily because of the increase in vegetable cultivation that is facilitated by improved irrigation water availability during rabi season. However, the importance of training and extension services in horticulture cannot be discounted. Mean income from horticulture also increased after scheme implementation with adoption of improved practices by farmers. Previously, the median profit per hectare of land under horticulture was INR 41,184. After project implementation, median profit from horticulture increased to INR 74,880/hectare.

To make a more in-depth assessment of the horticulture component of WBADMI project scheme, a horticulture expert visited five WUA schemes in Purulia, Bankura and Paschim Medinipur and interviewed the group of farmers practicing horticulture. Out of these five, three were mixed fruit orchards, one was Arjun tree plantation and one was cashew plantation.

Discussion with DPMU officials and farmers in the field made it clear that horticultural activities have been implemented with active participation from the farmers' side, right from the planning stage. After the initial induction meeting and motivational camp with farmers, the WUA members themselves selected the type of plants to be planted based on local soil condition, market demand, existing skill of farmers (for ex. Arjuna was chosen as main plant by "Siyarbinda Rimil" WUA members in Jhargram as the villagers were trained to cultivate cocoon for Tashar). The farmers also planned for land preparation, fencing, pit digging, pit filling, plantation, inter cropping, nurturing the plants etc.

After receiving application from the WUA, DPMU gets it sanctioned from PMU and issues the work order to the concerned WUA. Finance for developing the orchards are provided by WBADMI project in such a way that the farmer group can also earn some wage during the process of developing the orchard. Accordingly, all the expenditure for manual labor is paid to the members of the WUA who employ themselves to develop orchard. The wage for land preparation, fencing, pit digging, pit filling, plantation, inter cropping, nurturing the plants are paid through the bank account from DPMU to the bank account of WUA.

The DPMU follows up continuously on all the activities of developing the orchard from land preparation to plantation. Depending on the feasibility, they also facilitate the farmers with intercropping of the orchard field with pulses & vegetables like arhar, black-gram, bottle-gourd, pumpkin, tomato etc. The DPMU has also provided training to farmers on land preparation, pit cutting, hapa digging, plantation, application manure, termite control, weeds managements, seed treatment with rhizobium etc. In some WUAs, farmers have also done exposure visit to Agriculture University farms or other good orchard fields.

The collaborative way in which the scheme has involved farmers in developing horticultural activities have resulted in positive impacts on the field. Most of the land that has been developed into orchards under the scheme was previously barren. These plantations have resulted in conversion of barren land into cultivable land. Also the emphasis given by the WBADMI project scheme in introducing inter-cropping in the orchard land has resulted in early returns for the participating farmers and instilled confidence in them during the gestation period. This has been very important in sustaining these horticulture interventions. Fruit orchards along with scientifically managed intercropping practice has generated new source of income and food for the farmers besides much desired crop/land use diversification. This extra income adds value in childcare and child education.

Also, women participation in these horticulture groups has been substantial. Active involvement in management and development of the orchard area have empowered the women in these groups. As one female farmer in horticulture group of Mankanali WUA in Bankura commented *"What we never did before we are doing now. The women are doing the harvest and they themselves are selling it in market……We do not want to depend on our husbands anymore, we are doing this to improve our lives"*

Among the horticultural groups visited by our expert, the average survival percentage of plants supplied to farmers was reported to be 91.9% (see Table 9). Given average rainfall received and nature of soil in these districts with poor farming history, the reported survival rate does indicate successful planning, execution and monitoring. However, there is room for improvement. Instead of using pot irrigation that requires high labor engagement, if pitcher irrigation is used then it can lead to less mortality and better water use efficiency.

Table 9: Average survival percentage of plants provided to WUAs

District	WUA	Plants Supplied	Plants at present situation	Survival Percentage
Purulia	Ketankari	435	382	87.82
Bankura	Bagdiha-Metala	2585	2483	96.05
Bankura	Mankanali	422	378	89.57
Paschim Medinipur/ Jhargram	Raibundh-Srihari	1960	1699	86.68
Paschim Medinipur/ Jhargram	Dahatmul Samanya	960	904	94.17

As mother-plantation is already developed, if in-situ nursey development is encouraged, then it will provide good quality planting material and extra local earning for the farmers. Also, if stored water in '*dapa'* remains unutilized (as observed in Bagdiha-Metala), then cat fish culture can be introduced there to get more return. In-situ vermi-compost preparation using fallen forest waste. Also if composting/ vermicomposting or use of waste decomposer is incorporated in these areas then it can add to the benefits accruing to farmers. Such minor technical improvements in management and operation of the orchards can have substantial impacts on the final outcome. This necessitates that up-scaling training/ workshop be arranged regularly for the field staff, who can then subsequently help the farmers in implementing improved practices.

4.1.7 Fisheries

Out of sampled farmers selected from Water User Association members, 14.3% reported to be practicing fisheries in the current year. Only 4.3% among these farmers were practicing fisheries before the start of WBADMI project, indicating increase in fishery practice among project farmers.

Figure 23 gives the percentage of farmers involved in fisheries before and after the implementation of the project. This increase in fishery practice can be observed across all 4 districts. However, the greatest increase was observed for Purulia and Bankura. In SFMIS & WDS schemes fisheries uptake is found to be more and consequently larger uptake was observed in Purulia and Bankura, which had more surface irrigation schemes.

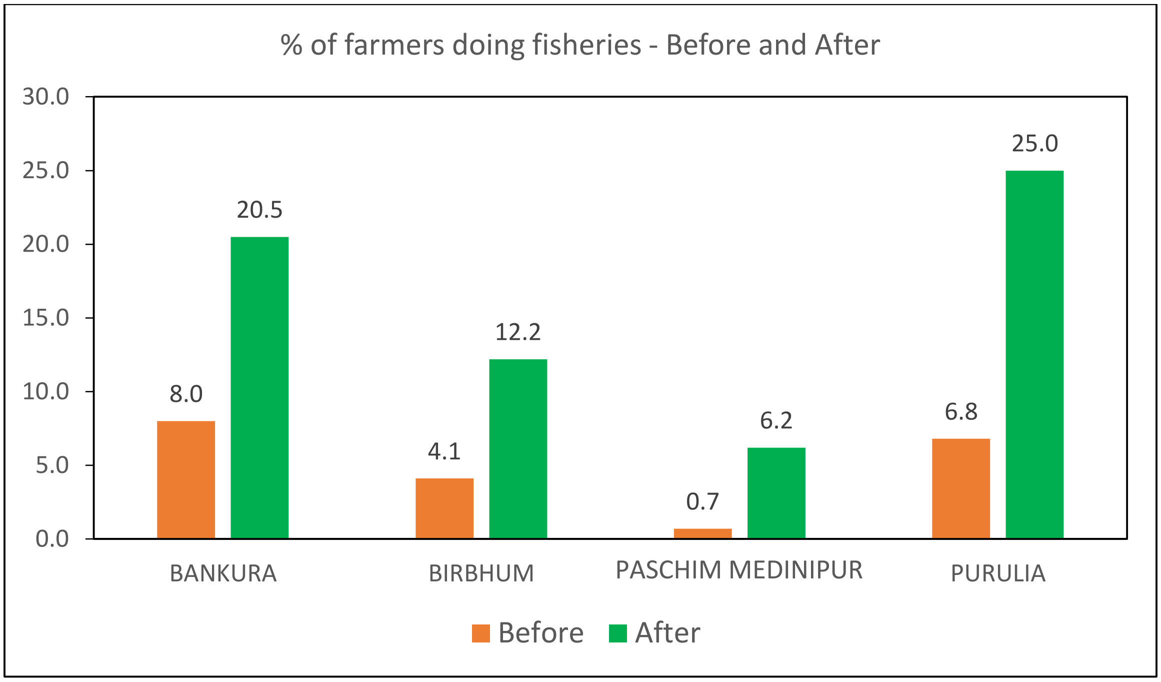


Figure 23: Percent of farmers doing fisheries - before versus after scheme was implemented

It is also found that this increase in fisheries practice was more in case of large farmers as seen in Figure 24 below. Farmers involved in fisheries have average net cultivated area of 0.97 hectare, which is significantly higher than average net cultivated area for farmers not doing fisheries. This is to be expected since bigger farmers are likely to have access to suitable ponds for fisheries. In fact, for our project farmers who were not involved in fisheries, overwhelming majority (72%) cited “No access to suitable waterbody” as their reason for not doing fisheries.

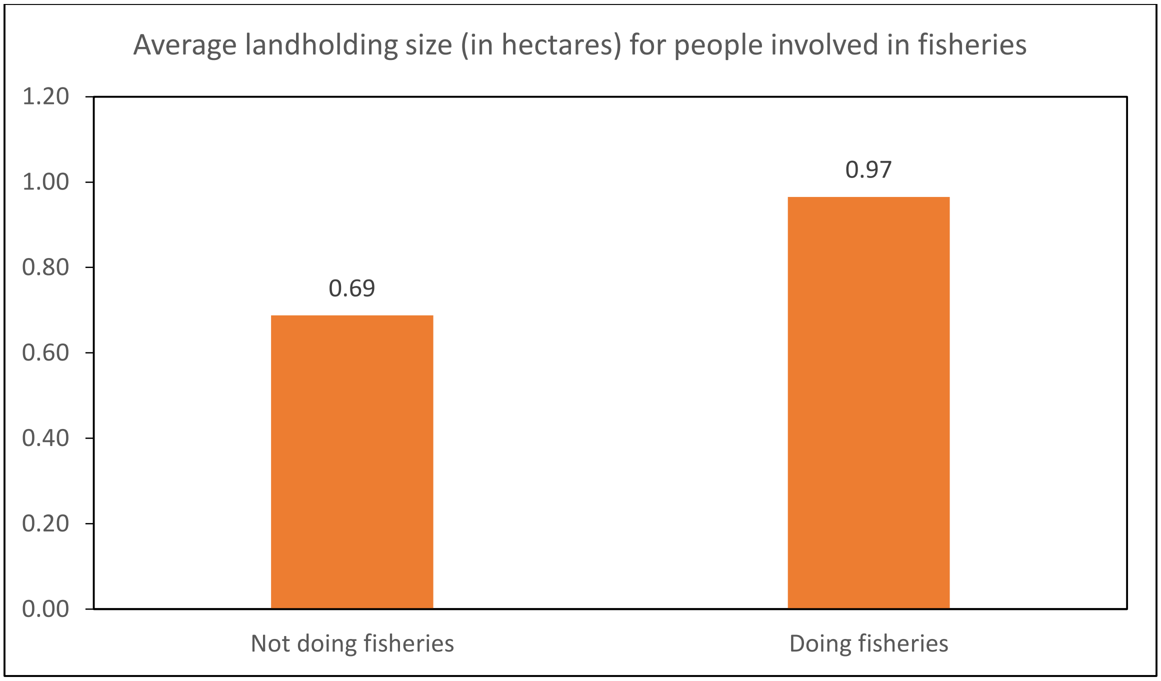


Figure 24: Average landholding size (in hectares) for people involved in fisheries

Overall, 13.7% of our sampled WUA members received training on fisheries. Training was highest in Birbhum (23.0%), followed by Purulia (15.9%), Bankura (11.4%) and Paschim-Medinipur (4.1%).

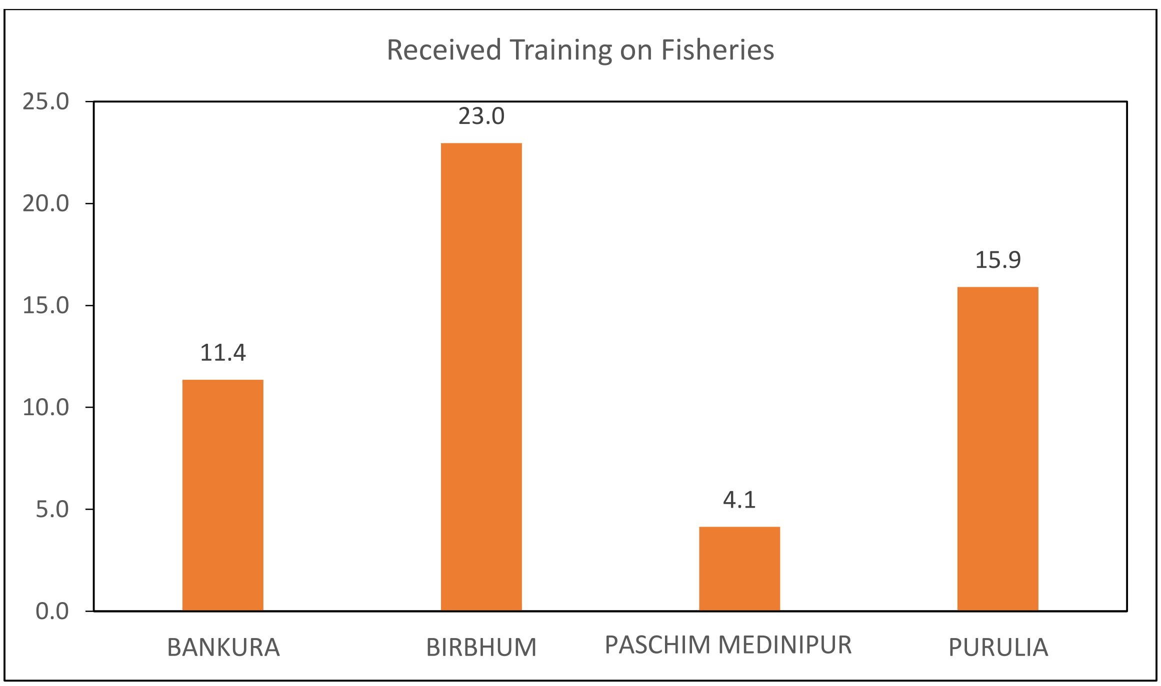


Figure 25: Percent of farmers received training in fisheries, across districts

Major fish species cultivated by project farmers are Rohu (99%), Katla (96%), Mrigel (63%), Silver (39%), Tilapiya (18%) etc. While previously Rohu, Katla were the dominant (100%), followed by few doing other fishes like Mrigel (20%), Silver (15%) etc. suggesting that diversity of fish under cultivation has increased.

Mean income per hectare of pond was also substantially higher after scheme intervention at around INR 95714 /hectare, which was only INR 26104/ hectare before WBADMI project. Even if considering farmers who practiced fishery both before and after scheme, there is significant increase in income per hectare from fishery. Current yield for farmers practising fishery was observed at 14.3 quintal/hectare. This increase in fishery income compared to before scheme was primarily because of yield gain observed after scheme intervention. The average cost per hectare in baseline year was INR 23541 / ha, while current average cost was INR 29498 /ha. This increase in yield in fisheries from baseline year to current year came out more clearly from our analysis of some of the Fishery Interest Groups (FIGs) that we considered for our analysis.

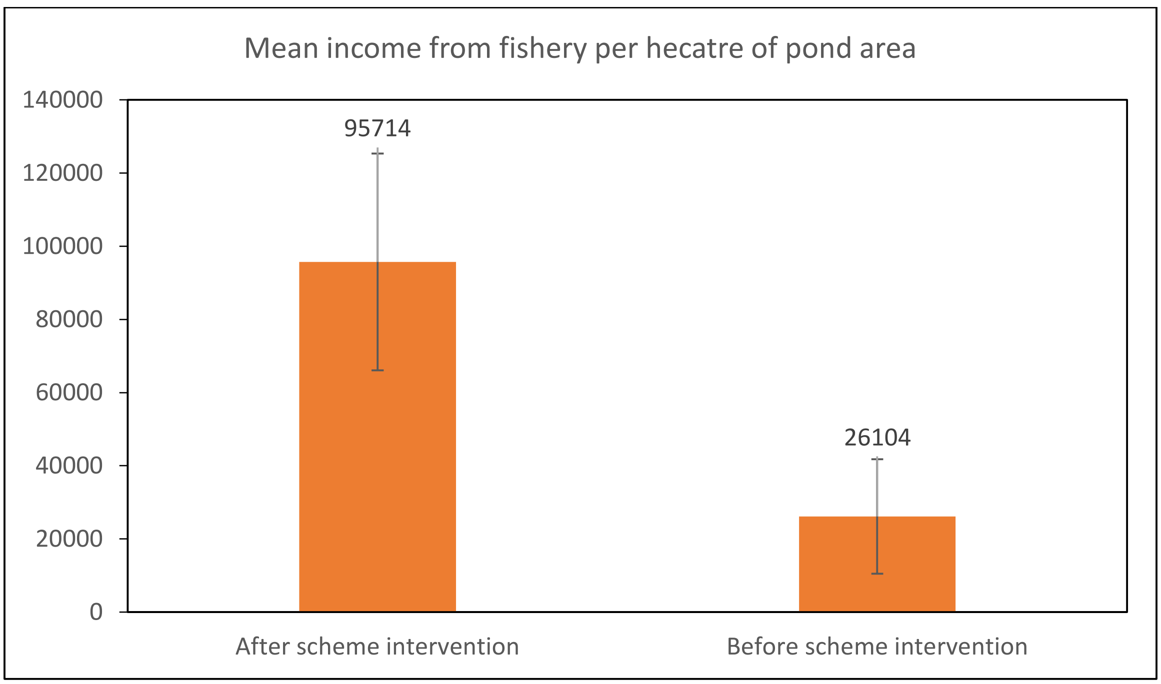


Figure 26: Mean income from fishery per hectare of pond area, before and after the scheme

A fishery expert visited designated Water User Association in the districts of Purulia, Bankura and Birbhum to undertake fishery specific assessment of the various activities under the project of WBADMI. Overall, six WUAs and an air breathing fish (indigenous) hatchery in Bankura were visited and assessed. Based on discussions held with the District Project Management Unit staffs regarding institutional functioning and funding of DPMU activities and through group discussions with members of fisheries interest group, a technical assessment of the fisheries component of project scheme was done.

Through field visits, it is observed that DPMU regularly organizes training of beneficiaries by fishery specialists, both on field and on station. On field trainings are conducted in the line of the very effective farmer field school (FFS) mode. DPMU also implements particular technology through adopting DCs (Demonstration Centre) where all technological inputs are provided for a period of maximum 12 months and through MP (mass production) where only seed & feed are supplied. DCs are conducted in a single water body which is either taken on lease by the FIG or may even be excavated by the DPMU. Beneficiaries in DCs are those residing adjacent to the adopted water body. The minimum number of beneficiaries of a particular DC is ten. On the other hand, mass production units are carried out in those water bodies, the owner of which agrees to get registered under the WUA. In either case, normally 3% of the profit is deposited into the account of WUA, 50% is shared among the members and 47% is kept aside for meeting expenses like lease of water body and seed money for next year's culture. However, to observe any discernable change in the culture system, it is required that the DC and the Mass Production in a WUA should be for at least two years. Also for more effective training of all the FIG members should be given at least four days in house training on the particular culture or fish breeding, they wish to pursue, from any KVK having sound farm infrastructure.

Based on field visits, it was determined that even before project intervention farmers were doing fishery to some extent but without any regard to scientific stocking. No scientific management was followed and fishes were grown only for domestic consumption. Such extensive management practice and zero maintenance of water quality parameters resulted in poor fish growth and reduced environmental hygiene leading to disease out breaks and mortality. As a result, annual productivity was very low. Poor health of the fish also fetched negligible price. Through proper training on scientific fishery management there has been appreciable increase in yield and quality of fish, fetching better prices. This has led to higher income and access to more nutritious food. Area of fish culture has also increased and more and more farmers are becoming interested to pursue fish culture. There is a growing interest among women to get involved in fisheries activities.

The overall performance was found to be highly positive with the FIG under Ramchandrapur WUA and Amkhoi WUA being "over achievers". FIG's under Uluberia WUA and Khardanagari WUA may be rated as "achievers" while the women FIG of Ashna WUA needs time to graduate from "under achievers" to higher levels. The details of the achievement of all the FIG's are discussed in separate case studies.

Fisheries activities under the WBADMI project run by the DPMUs are guided by a set of methodical and well justifiable rules which makes the project very much viable with regards to accountability, sustainability, equitability and profitability and effective showcasing of the implemented technologies, in some cases, provide a visible impact on the socio-economic development of the target communities.

However, there is scope for even greater income generation from the fisheries component. If more diverse fish species are stocked in each of the ponds where carp culture/composite fish culture/desi fish culture is undertaken (of course maintain the standard stocking density), production and income will increase substantially. Also by properly renovating small, shallow and derelict water bodies and utilizing for culture of air breathing fish, particularly desi magur, singhi and koi can definitely make the fisheries component more widespread in its application. Experienced FIG may also take up monosex tilapia farming in medium sized shallow ponds. As the duration of culture for this fish is only 3.5 to 4 months, 2-3 culture operations are possible in a year with prospects of a greater return.

For assured, timely and doorstep supply of quality seeds of carps like katla, rohu, mrigel, bata, calbasu, silver carp, etc. and indigenous high value fish like desi magur, singhi, tangra, koi, pabda, etc., small scale carp and indigenous catfish hatcheries, set up by RAKVK, Nimpith in its ICAR-ARYA project villages, may be established in some of the blocks of each of the 3 districts.

In order to further improve the income generated from fishery activities, it is also suggested that instead of taking up spawn to fingerling culture, 3 sub-groups may be made within each FIG for spawn to fry, fry to fingerlings and fingerlings to table fish. This will ensure round the year income for the group instead of only 3-4 months. For spawn to culture, small ponds of 0.02 – 0.06 ha water area and depth of 3-4 feet should be selected. For fry rearing up to fingerlings stage, ponds with water area of 0.08 – 0.13 ha and depth of 4-5 feet. should be selected and ponds bigger than these with more depth may be utilized for fingerlings to table fish culture. The “spawn to fry” group may supply fry to outside farmers to maintain a steady income. The same holds true for the fry to fingerling group. The fingerling to table fish group may follow the process of multiple stocking and repeated harvesting to guarantee regular income throughout the year by selling advanced fingerlings of 150-200 g which has good consumer preference. However proper pond preparation and management is a must for undertaking each of the culture practice.

Also more stress should be given on integrating fish culture with animal husbandry and horticulture in the form of integrated farming system for optimum utilization of all available resources, thereby maximizing profit and minimizing risk.

4.2 Irrigation Indicators

The primary purpose of the WBADMI project scheme is to create new minor irrigation resources locally or rejuvenate existing irrigation infrastructure/sources that can provide assured irrigation to farmers who do not currently have access to irrigation. This has ultimate objective of improving productivity, production, and income of farmers in the project area. In this section, we assess how access to irrigation water availability has improved due to the WBADMI project scheme amongst our sample schemes. Increase in irrigated area, water storages, design and performance of minor irrigation schemes, water distribution mechanism and water use management have been discussed as irrigation impact indicators in this section.

4.2.1 Increase in irrigated area

Figure 9 in section 4.1 gives the extent of cultivated area in sampled project schemes before and after the implementation of WBADMI project. The percent of cultivated area receiving irrigation during each season is given in Figure 27. Overall, in kharif season cultivated area shows an increase of 23.1 % relative to before scenario, however area receiving irrigation shows a high jump from just 21.5 % before the project to 89.4 % after implementation of project. Before the scheme most of the project area used to cultivate paddy during kharif season as rainfed crop relying on monsoon rainfall, and therefore overall increase in cultivated area is only 23.1 %. However, deficit monsoon rainfall and dry spells during monsoon had damaging impact on crop quite often. The considerable risk and damage from reliance on rain due to both intra and inter year rainfall variability before the implementation of project was a common characteristics reported by farmers across all project schemes. It was evident from the field visits and FGDs that instances of crop damage due to long dry spells has considerably reduced after the project due to increased water availability post WBADMI project schemes.

With almost non-existent irrigation water supply in project schemes during rabi season, very minimal crop area (12.7 % of kharif cultivated area) was cultivated before the implementation of project which increased to 56 % of kharif cultivated area after the implementation of project. This change was brought by enhanced access to irrigation with area under irrigation increasing from 2.3% before the project to 53.6 % after the project in sampled scheme command area.

In pre-kharif season, though cultivated area has shown increase from 1.7 % (before) to 10.5 % (after) of kharif cultivated area), but is still very low, reflecting that irrigation storage created is not sufficient for pre-kharif cultivation. Scheme area receiving irrigation increased from 0 % to 9.6 % after the project implementation. Again though cultivated area is small but it reflects better access to irrigation water.

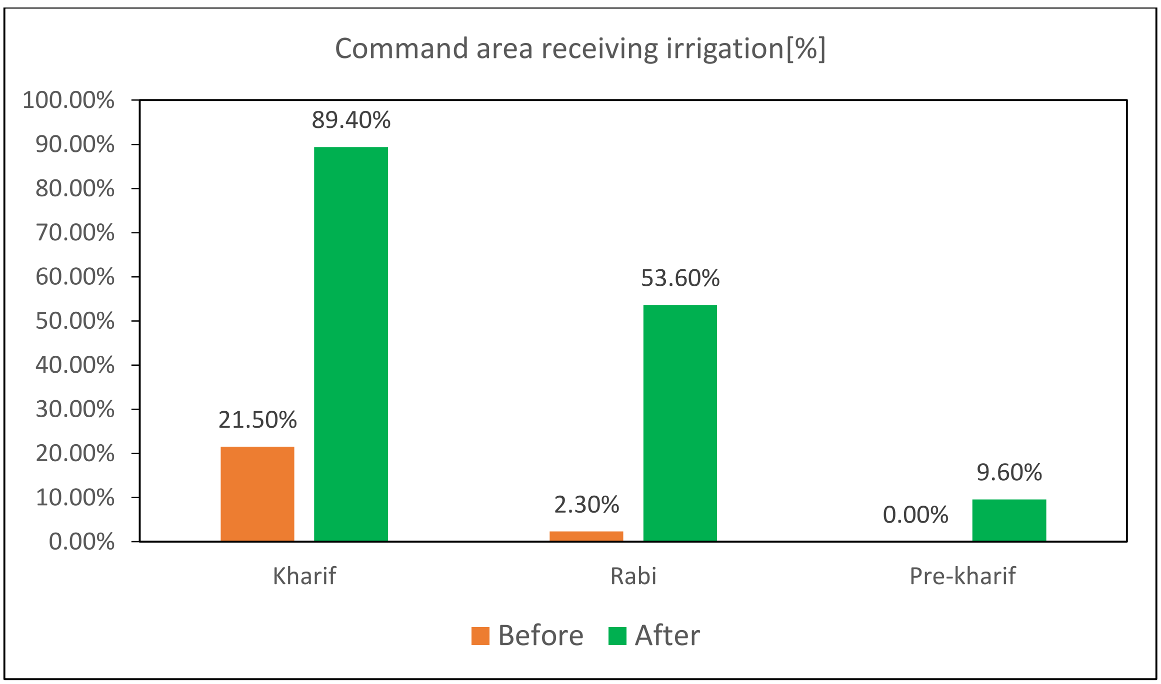


Figure 27: Command area (%age) which received irrigation, before and after the scheme

The limited cultivated area, relative to kharif season, in rabi and pre-kharif season was observed in project schemes during field visits and is largely due to:

- low storage in surface water schemes of CD, WDS and SFMIS, reduced water yield (pump water discharge) in sub-surface scheme, low flow in RLI schemes
- high crop irrigation water requirements during rabi and pre-kharif season
- low irrigation efficiency as flood irrigation is still the most dominant irrigation method

The last point above presents an opportunity to increase cultivated area in rabi and pre-kharif season by including demand management and using irrigation efficiency increasing measures (sprinkler, drip irrigation etc.) in project schemes. Lack of demand management was evident in most the sampled project schemes and despite limited water storage in post-monsoon season, with flood irrigation as the most dominant way of irrigation. Few schemes (for example Kanmora solar PDW) did receive sprinkler irrigation system as a way to increase irrigation efficiency, however due to lack of training on operational and maintenance this was used only for one season. Thus, going in future and next stages, there is a need to incorporate better training on agronomical and water management measures in project schemes that would lead to increase rabi and pre-kharif cultivated area significantly.

Figure 28 gives performance of cultivated area receiving irrigation across different scheme types. As can be seen, performance of all schemes types is high and similar in kharif season with cultivated area receiving irrigation in the range of 75-100 %. However, large differences become evident in rabi when performance across schemes varies a lot with values of cultivated area receiving irrigation ranging from low of 27 % to high of 89 %. In pre-kharif season, value of all scheme types is low (> 20 %). During kharif season, when irrigation is mostly provided to supplement rainfall, all schemes have sufficient water to meet the demand. However, in rabi and pre-kharif season total irrigation requirement has to be met from the project schemes. Thus, the schemes with reliability and high storage perform best in post-monsoon season and contrast in performance is reflection of both magnitude and kinds of irrigation storage created. Tube well (TW), Pump dug well (PDW) and River lifting schemes (RLI) tapping high groundwater storage and flowing rivers with large catchment area, respectively performed better over the surface water scheme (CD, WDS and SFMI) where limited storage is created by impoundment of water from small local catchment area. This limited storage gets depleted soon due to use, evaporation and seepage. But, they do have an important role especially when other scheme types like tube wells and RLI are not feasible in those locations due to technical and other reasons.

Across all schemes during rabi season, TW shows the best performance with 89 % of area receiving irrigation. This is followed by PDW (74 %) and RLI (56 %). TW performs better than PDW as it taps groundwater reservoir at a much deeper depth and are constructed in high yielding storage aquifer systems where water remains available year around whereas PDW taps groundwater reservoir to a limited depth. After monsoon as time goes by, groundwater storage decreases which gets reflected in the depth of groundwater. TW tapping deep and high storage aquifer system can still access it, however yield decreases whereas PDW with its limited depth cannot access groundwater reservoir in later part of the year. Similarly, in RLI water remains available year round, however water flow decreases post monsoon season thus limiting irrigation to cultivated area. TW schemes that have been implemented in regions with good aquifer storage properties (storage and yield) are tapping groundwater that are of many magnitudes higher than storage created under any other schemes and thus doesn't face constraints of depleting storage as faced by other schemes. However, over long term, due to no demand management in place and no restriction on abstraction, there may be risk of groundwater exploitation.

All surface water schemes have relatively much smaller area receiving irrigation in rabi season (CD dam at 35%, WDS at 36 % and SFMIS at 27%). However, comparison between surface and sub-surface cannot be direct as it depends on the local contextual situation which limits implementation of sub-surface schemes in some locations due to bio-physical constraints. Thus, relative low performance of surface water schemes brings out the limitation of such schemes rather than their shortcomings against sub-surface schemes.

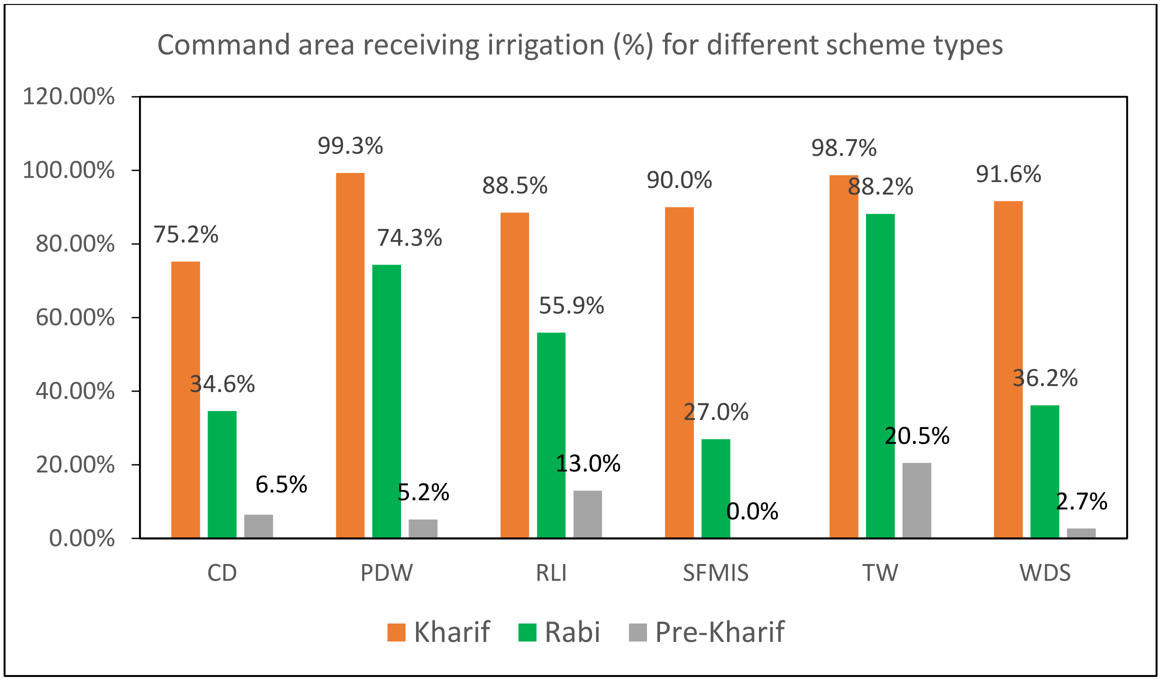


Figure 28: Percent of Command area receiving irrigation for different scheme types

Figure 29 gives the cultivated area receiving irrigation in each season across districts covered in the study. The difference in area receiving irrigation across districts is largely seen in post monsoon, rabi season and is a reflection of both type of schemes operating within each districts and efficient operation and management of schemes.

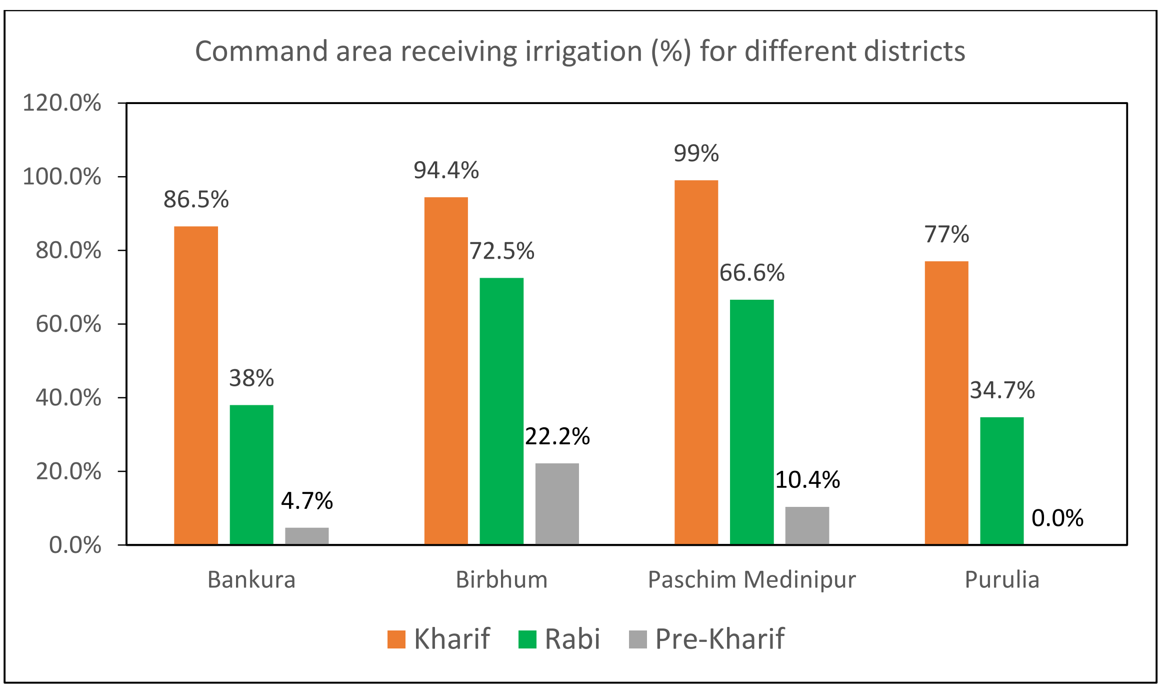


Figure 29: Percent of command area receiving irrigation for different districts

Lowest performance (in terms of area receiving irrigation) is observed in Purulia where out of 9 sampled schemes, 8 were surface water schemes (SFMIS, CD or WDS). Similarly, high performance in Paschim Medinipur is reflection of high number TW, PDW and RLI schemes (10 out 14 sampled schemes). Whereas in Birbhum and Bankura, where distribution of high performance schemes (TW, PDW and RLI) and low performing schemes (SFMIS, WDS and CD) are same (In Birbhum, out of 15 samples schemes, 7 are CD, SFMIS and WDS; whereas in Bankura out of 8 samples schemes, 4 are CD, SFMIS and WDS) difference in performance would be more reflection of operational and management performance as already discussed before in section 4.1.2 on cropping intensity. This becomes evident from Figure 30 which shows the performance of difference scheme types across districts. Performance of surface water schemes in Birbhum is almost two time better then performance of Bankura. Such a large difference reflects the much better operation and management of schemes in Birbhum which could be because of local contextual differences include better design, training, better DPMU team, effective social outreach etc.

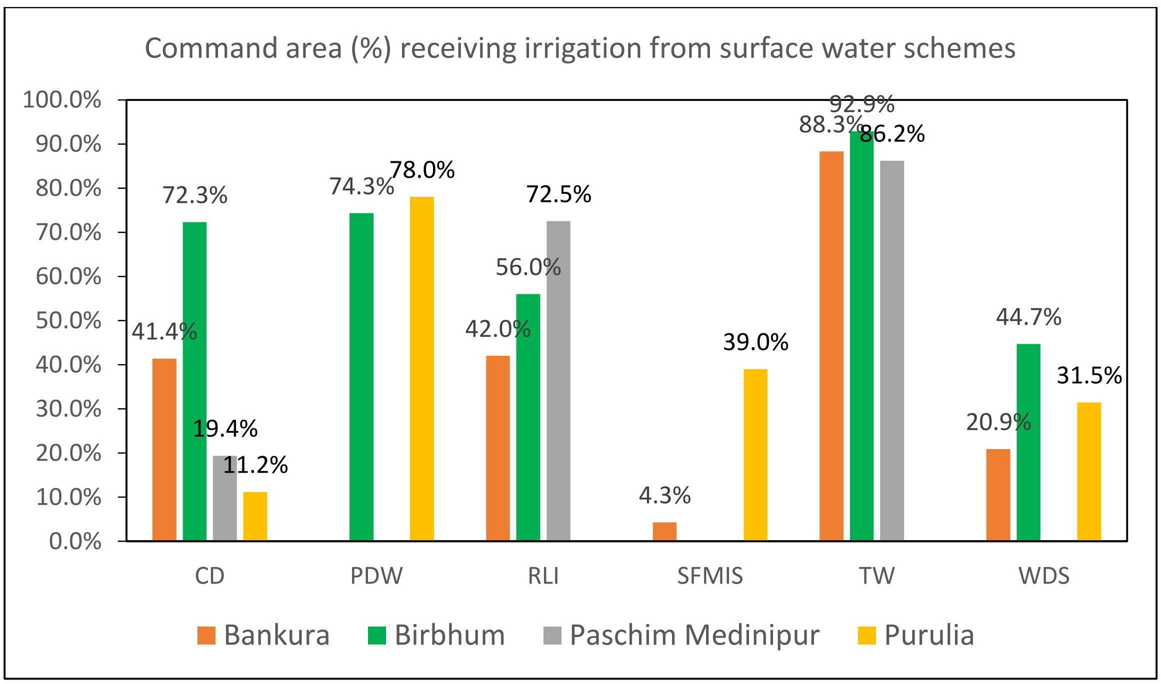


Figure 30: Percent of command area receiving irrigation from surface water schemes

Evaluating performance of sampled schemes individually across each scheme type shows large variation within scheme type. Table 10 gives summary of range of area receiving irrigation in each season. Couple of important point observed are:

- Even in kharif season, when overall average for all scheme types of area receiving irrigation is high (Figures 28 and 30), there are schemes with low performance.

- In rabi season, where overall average for surface schemes (CD, WDS and SFMIS) is low (Figures 28 and 30), there are some schemes with their performance comparable to groundwater schemes.

The existence of outliers in each season shows the importance of considering local context, design, operation, management and structural issues in analyzing scheme performance. Table 11 gives details of few schemes under both categories highlighting the reason for departure from average area irrigated (either lower or higher performance).

Table 10: Range of area receiving irrigation in each season

	Kharif (%)			Rabi (%)			Pre-kharif (%)		
	Overall	Min	Max	Overall	Min	Max	Overall	Min	Max
CD	75.2	16.1	100	34.7	0	84	6.5	0	58
PDW	99.2	93	100	74.3	67	80	3.8	0	17
RLI	88.6	29	100	55.8	4	97	13.0	0	49.1
SFMIS	89.9	22	100	27.0	0	52	0.0	0	0
TW	98.6	97	100	88.2	80	100	20.4	0	93
WDS	91.6	78	100	36.1	21	78	2.6	0	8

Primary reason for low performance amongst schemes in kharif season was planning, location, design and structural issues of infrastructure, especially in surface water schemes (CD and SFMIS). Soil erosion from earthen embankments due to poor slope stabilization and improper location of inlet has been observed in few schemes (e.g. Bara Natun Bundh SFMIS, Mati Dundra WDS) impacting performance of schemes. Kusumtikri RLI is an exception as other RLI schemes have worked well. In Kusumtikri, a Mini River Lift Irrigation (RLI) scheme handed over in January 2016, water source is not perennial and very small. Even in kharif season there is not enough water because of another check dam that is constructed upstream by panchayat. Also, Panchayat Samiti has donated 5-6 submersible pumps in nearby areas and bigger farmers have their own submersible pumps. As observed during field visits, most of the villagers rely on private TW rather than getting irrigation water from RLI scheme. Since the project has not really functioned well, the WUA itself is quite weak. This case reflects the importance of considering existing irrigation facilities and properly assessing the real needs for planning a suitable MI scheme.

Above average performers in rabi season distributed across CD, WDS, RLI and PDW can act as a learning for other project schemes. Most of these schemes in Birbhum, as discussed above and also in section on agricultural indictors, have shown above average performance. For example, in Gadadhapur CD, as noticed during FGD, very strong WUA supported and connected to local cooperative bank, has created a very supportive environment that leads to better access to funds and inputs leading to efficient use of available water resources. At the same time, series of CDs created have a large storage.

Table 11: Percent of area under irrigation across seasons for specified schemes

Scheme	% area with irrigation	Reason
Kharif		
Siada check dam (Purulia)	16 % against average of 75.2 % of CD	In all the schemes, planning, design and location of structures, and structural issues limiting its overall use and efficacy
Kusumtikri RLI (Bankura)	30 % against average of 88.6 % of RLI	
Gopinathdihi SFMIS (Bankura)	22 % against average of 89.6 % of SFMIS	
Rabi		
Gadadhapur check dam (Birbhum)	84 % against average of 34.7 % of CD	Strong WUA with good outreach, extension and support by DPMU
Dhaka Lauberia PDW (Birbhum)	80 % against average of 54.2 % of PDW	
Tella RLI (Paschim Medinipur)	97 % against average of 55.8 % of RLI	
Ruhida IV WDS (Birbhum)	78 % against average of 36.1 % of WDS	

4.2.2 Actual vs designed command area

We also estimated total area cultivated under schemes during kharif and rabi seasons from focus group discussions and key informant interviews. The actual cultivated area is compared against the proposed average command area under each scheme (as obtained from SMPU). We find that there is a substantial gap between average area actually cultivated under the schemes during kharif and rabi and the proposed command area. Overall, cultivated area during kharif and rabi comes to 67.5% and 47.6% of the proposed command area for the sampled project schemes. This gap is not uniform and varies across scheme types (Figure 31).

The gap between cultivated area and proposed command area for kharif is highest for SFMIS (51.7%) followed by RLI (36.9%), WDS (34.2%), Check Dam (26.9% gap) and TW (26.4% gap) schemes. In contrast, for PDW actual command area is 31.4% higher in kharif. In rabi, this gap is much higher with highest value for SFMIS (78.7%) followed by WDS (61.3%), Check Dam (58.2%), RLI (56.3%), PDW (34.3%) and TW (24. 2%).The much higher gap in surface water schemes relative to sub-surface water schemes (PDW and TW) during rabi season is a reflection of limited water storage that gets depleted quickly post-monsoon season.

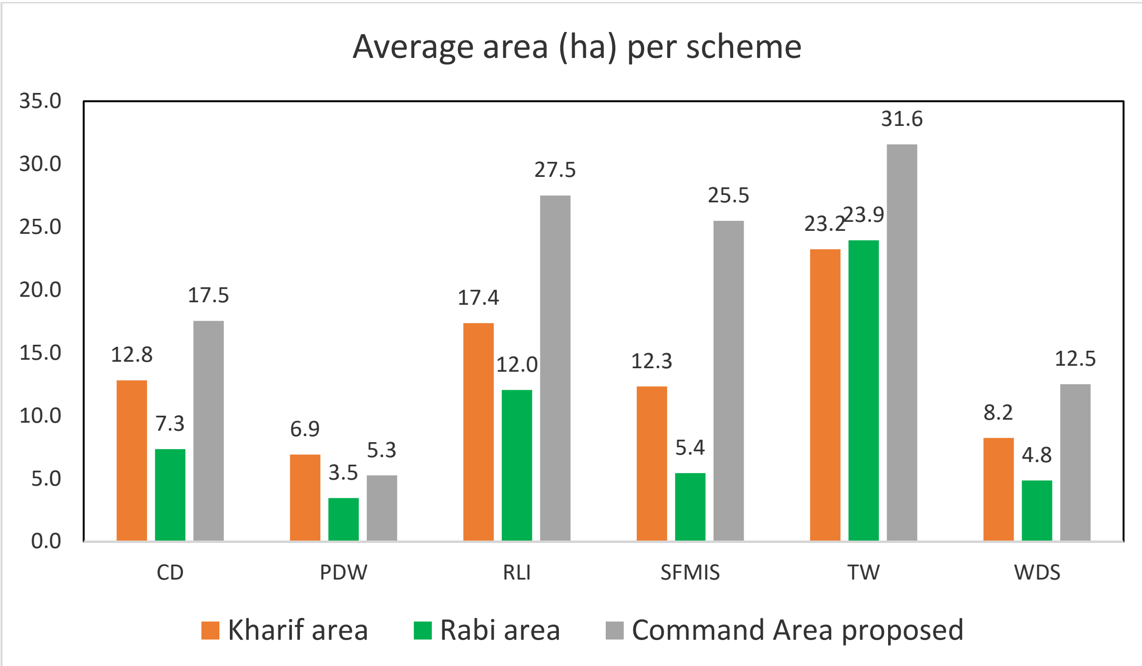


Figure 31: Average area in hectare receiving irrigation across schemes

The above discussion does not imply on the success of the schemes, rather it indicates the need for a more realistic planning and estimates for command area. The gap between actual cultivated area and proposed command area can lead to attrition and overall lack of interest in WUA activities when promised benefits are not materialised. This was observed clearly in schemes during field visits. For example, in Bara Natun Bundh SFMIS scheme, due to much lower availability of water curtailing cultivated area lead to many initial WUA members exiting the WUA. Our field visits also demonstrated that the command area shape files based on initial plans needs to be re-visited.

4.2.3 Irrigation water productivity

Irrigation water productivity is defined as the amount or value of product over volume or value of water depleted or diverted where the value of the product might be expressed in different terms (biomass, grain, money). In simple terms, it is the measure of the economic or biophysical gain from the use of a unit of irrigation water applied or consumed in crop production. It is an important indicator and improving water productivity is one of the key targets in irrigated area. In project scheme area where rabi cultivation is completely dependent on limited irrigation source created, it becomes critical to have higher water productivity.

To assess the current level of water productivity for WBADMI project, we have estimated here physical water productivity (PWP) (kg/m^3) and economic water productivity (EWP) (INR/m^3) of select schemes. Both PWP and EWP are calculated only for rabi season as in kharif season, irrigation is only supplementary and varies a lot across schemes. During rabi season, when irrigation is the primary source, PWP and EWP can help in understanding how productively water is being used.

$$PWP(kg/m^3) = \frac{\text{Crop prodcution(kg)}}{\text{Irrigation water applied (m}^3\text{)}}$$

$$EWP(INR/m^3) = \frac{\text{Crop prodcution value(INR)}}{\text{Irrigation water applied (m}^3\text{)}}$$

PWP and EWP is calculated for the schemes given in Table 12 using available data on number of pumps, pump capacity and irrigation hours from DPMU. This covered only Subsurface (PDW, TW) and RLI schemes where centralized pumps are working. Crop production (kg) is calculated from survey data. For the analysis, efficiency of pump is assumed to be 0.45 which is generally the acceptable value of electric pumps and depth of groundwater is taken as average of groundwater depth values of CGWM monitoring well in the block where scheme is located.

In schemes where one crop dominates in rabi season (area > 90%), both PWP and EWP is calculated. On the other hand, where two or more crops are grown in equal proportion, only EWP is calculated as data on how irrigation water was diverted to each crop was not available. Table 12 gives estimates of PWP and EWP of selected schemes. In terms of PWP, value for only rice and potato is estimated as there were two schemes each where paddy and potato is exclusively grown.

PWP of paddy comes to 0.45 kg/m^3 whereas potato PWP is estimated to be 8.2 and 23.8 kg/m^3. Overall, PWP in paddy is low and there is scope for significant improvement. Growing of paddy in rabi season with low PWP represents the inefficient use of water and water used could be diverted to high productive and more remunerative crops. This was mostly observed in Paschim Medinipur district where TW schemes are constructed. In terms EWP, it is clear that rice EWP (6.2 INR/m^3) is very low as compared to Potato (57-163.2 INR/m^3) and Mustard-Potato systems (33-36 INR/m^3). This clearly suggests diversifying paddy to other crops in these districts to increase both PWP and EWP.

Table 12: Calculated PWP and EWP of schemes

District	Type of the Scheme	Rabi area (%)			PWP	EWP
		Mustard	Potato	Paddy	kg/m3	INR/m3
Birbhum	Khudrapur TW	44.3	32.1	0	-	33.3
Birbhum	Kanmora Solar II PDW	75.9	0	0	-	36.0
Birbhum	Nandulia TW	2.4	97.6	0	23.8	163.2
Paschim Medinipur	Gogram Gopinathpur TW	0	0	100	0.45	6.2
Paschim Medinipur	Pakurseni Chakarjuni TW	0	0	95	0.45	6.3
Paschim Medinipur	Tella RLI	0	100	0	8.2	57.3
Jhargram	Khasjangal TW	52.2	0	0	-	29.1
Jhargram	Baida RLI	22.99	58.62	0	-	33.3

4.2.4 Design and performance of minor irrigation schemes: Infrastructure

Planning, design and performance of the minor irrigation infrastructure is one of the most important and critical criteria that controls the long term sustainability of project. Poor design leading to dilapidated infrastructures makes scheme underperform and as a result WUA members lose interest due to limited benefits and high maintenance costs. In the analysis, design and performance of scheme was evaluated on the existing condition[1] of the scheme infrastructure including associated assets such pump, distribution pipe, pump house, etc.

Details of schemes with infrastructure design rated as good (if more than *50% respondents rate infrastructure to be either good or very good*), moderate (if more than 50% respondents rate infrastructure to be moderate i.e. neither bad nor good) and bad (if more than50 % respondents rate infrastructure to be either bad or very bad) is given in Table 13. Figure 32 shows the percent of respondents rating infrastructure across scheme types. Overall, the existing condition of infrastructure of the schemes was found be good or very good in 36 of 42 schemes sampled and also rated to be either good or very good by 85 % of the respondents. This was also substantiated with field visits. In line with irrigation performance, TW and PDW are rated the best and almost

[1] On a scale of 1 to 5: 1=Very Bad 2=Bad 3=Neither bad nor good 4=Good 5=Very Good

95 % respondents rating infrastructure to be very good (Figure 32). Most of the moderate and poor ratings are concentrated across surface water schemes.

Three schemes that have been rated poor are i) Ruhida RLI in Birbhum, ii) Kusumtikri RLI in Bankura and iii) Siada check-1 dam in Purulia. Reason for Kusumtikri RLI has been already discussed and it is rated low as water source is not perennial and very small. Even in kharif season there is not enough water due to presence of another upstream check dam. One the other hand, almost 33.3 % of respondents in SFMIS scheme reported the infrastructure design to be "moderate". In case of SFMIS, most of the respondents under Gopinathdihi SFMIS in Bankura rated infrastructure to be "moderate" only, whereas same number stood at 50 % for Maharajnagar Bara Bundh SFMIS in Purulia. Condition of SFMIS was found be moderate in many cases due to design deficits in the inlet design and high siltation that was observed during field visit. It would be highly beneficial for WBADMI project schemes if technical design team can revisit these schemes to understand and analyse the reasons as a feedback for future planning and designing.

Table 13: Rating of infrastructure condition across schemes

		Infrastructure condition rating		
	Schemes sampled	Good	Moderate	Bad
Total	42	36	3	3
TW	7	7	0	0
PDW	4	4	0	0
RLI	8	6	0	2
CD	13	11	1	1
WDS	4	4	0	0
SFMIS	6	4	2	0

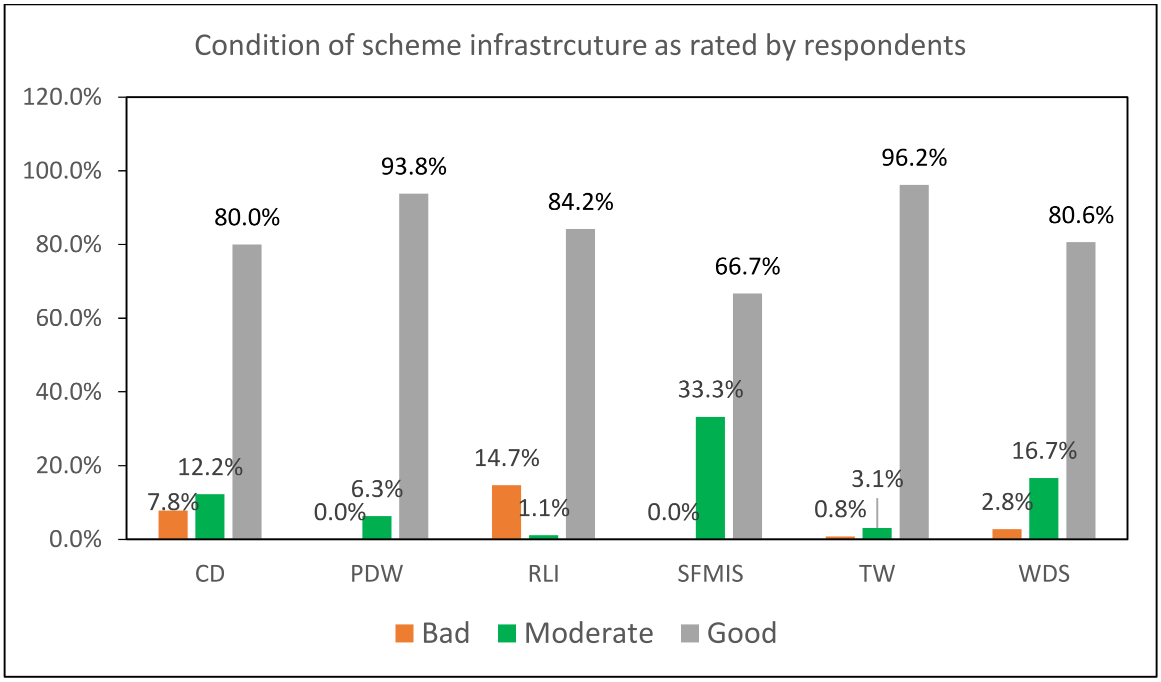


Figure 32: Respondents rating for scheme infrastructure condition. Bad (rating 1 and 2), Moderate (3) and Good (rating 4 and 5)

When the sampled project schemes are compared against similar non-project minor irrigation schemes under other government projects, their infrastructure condition is far better. In non-project schemes, only 38.8 % scheme infrastructure is rated to be good (against 84.6 % in project schemes) by respondents whereas almost 1/4th rate infrastructure as bad. This reflects the importance of WUA model with existing support from DPMU offices in project schemes. It may also be noted that many project schemes are comparatively new.

Leakages from water delivery pipe lines and pump breakdown are few key important issues for consideration. Some schemes like Baida RLI have been good in handling such problems by learning to repair it by themselves, whereas in other schemes (like Khasjangal TW) leakage has not been repaired and still some spouts were found to be non-functional. There is a risk that as scheme ages, leakage and damage would be more frequent for which adequate O&M fund needs to be collected and training imparted locally. Similarly, many schemes have high capacity centralised pumps that require regular O&M which for now is being taken care of. But the risk of serious breakdown requiring expensive repair and maintenance would demand a pro-active response mechanism to mobilize funds for such contingency. This was not observed in these schemes and many were concerned only with collecting electricity bills only. This could impact the long term sustainability of project schemes unless suitable anticipatory measures are taken including convergence of resources from locally available schemes including Panchayat.

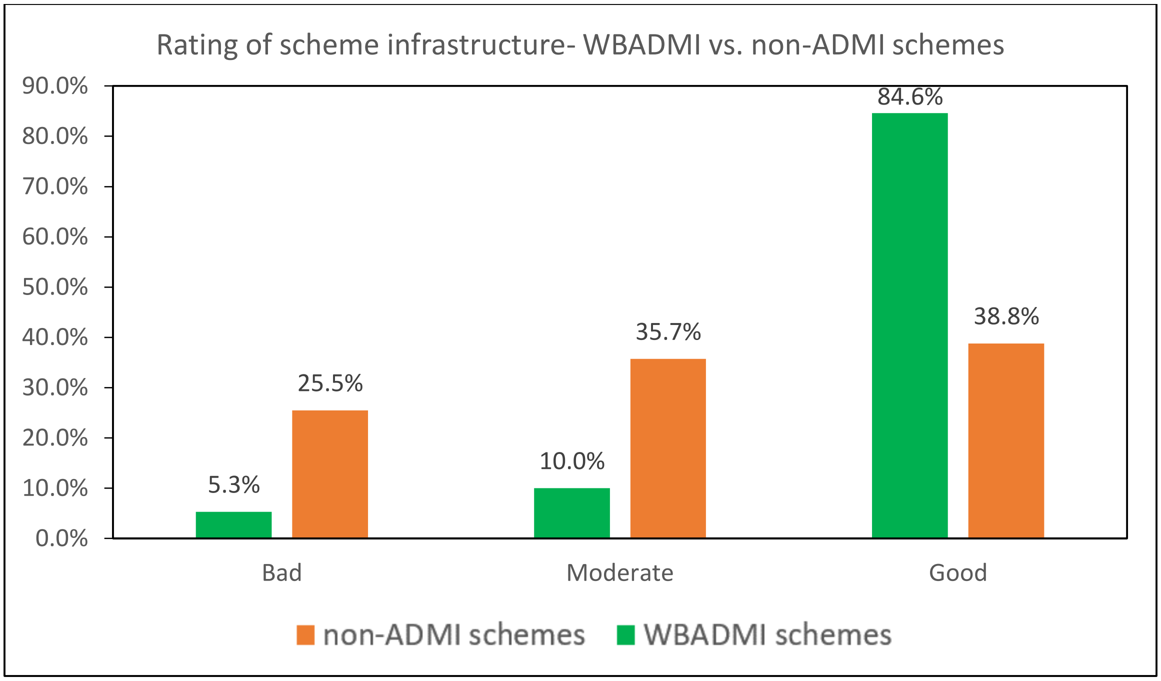


Figure 33: Rating of scheme infrastructure- WBADMI versus non-project (non-ADMI) schemes

4.2.5 Water management planning by WUA

For fair, equitable and efficient use of available water, it is necessary to have water management and distribution plan that is agreed by WUA members. In the study, WUA water management is evaluated against two indicators: 1) Number of WUA with existing water distribution schedule plan and respondents' awareness about water schedule and 2) Extent to which distribution schedule plan is followed. Water distribution schedule plan consists of prior planning of cropping pattern and number of irrigation (linked to volumetric water requirements) before each season based on the water availability.

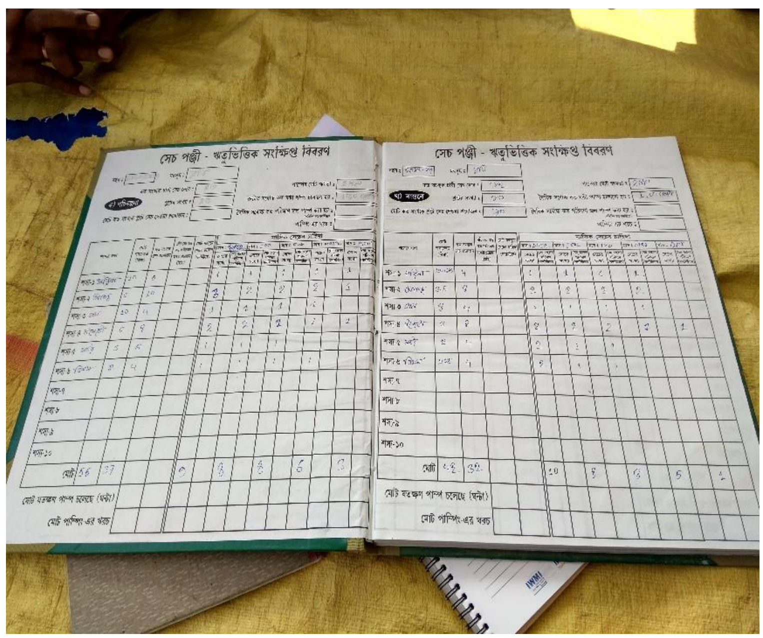


Table 14 gives number of sampled schemes that have water distribution plans (schemes where WUA members reported having existing plan) and schemes that doesn't have water distribution plans. Any scheme where >= 40 % sampled farmers indicate absence of water distribution schedule plan is considered having no such plan in place. Overall, out of 42 schemes sampled, 28 (or 66 %) have existing water distribution plans. When compared across scheme types, it becomes evident that most of the schemes with non-existing plans are concentrated in CD and WDS schemes. This lack of water schedules plan reflects the non-centralized operation of these surface water schemes where water from schemes is accessed via individual pumps, in contrast to PDW, RLI and TW where there is centralized pump house and associated distribution infrastructure to distribute water. The non-existence of centralized distribution infrastructure leads to little or no control over water use and management and is largely governed by individual capacity to pump and distance of farm fields from scheme infrastructure. In case where fishing is practiced, as in many SFMIS schemes, abstraction to a point is limited as there is requirement of maintaining minimum depth of water.

There is a direct co-relation among existence of water schedule and irrigation performance with scheme type with high percentage of existing water distribution schedule (Table 14) showing high performance in terms of providing irrigation water. This reflects the importance of developing water distribution plans and this need to be taken up more efficiently in all the projects.

Table 14: Number of schemes where water schedule plan exists

	Schemes sampled	Plan exists	Plan doesn't exist
Total	42	28	14
TW	7	7	0
PDW	4	3	1
RLI	8	6	2
CD	13	7	6
WDS	4	0	4
SFMIS	6	5	1

Existence of water distribution schedule plan as shown in Table 14 doesn't reflect WUA members' awareness about such plan. Awareness is important for both efficient roll out of any plan and reflects how transparently such plans were developed for equitable distribution of water. Figure 34 gives % of WUA response about existence and awareness about plans. Overall, 78.6 % of respondents say water schedule exists at WUA level. This is higher than 66 % of schemes reported to having any such plans. This reflects that in many schemes, awareness about existing plan is limited to only few members and thus such plans are not based on wider consultations among members. Out of this (78.6 %), only 42 % have reported full awareness about water schedule whereas 18.6 % reports only partial awareness and 17.1 % are completely unaware. About 22 % of respondents reported that no water schedule exists. Figure 35 gives the same numbers across different scheme types. As reflected in Table 14, highest number of WUA which respond either non-existing plans or lack of awareness are highest in surface water schemes of WDS (~80 %), CD (~68 %) and SFMIS (~30 %).

These numbers are low when evaluated against the role and responsibilities of WUA to distribute water efficiently and transparently. With only 42 % of respondents reporting complete awareness about water schedule points to lack of consultations and transparency in creating water schedule. Thus, it is not adequate to create water distribution plans but also to have them formulated based on wider consultations. This would lead to better and more efficient use of water and at the same time, make WUA more strong that is necessary for long term sustainability of project schemes.

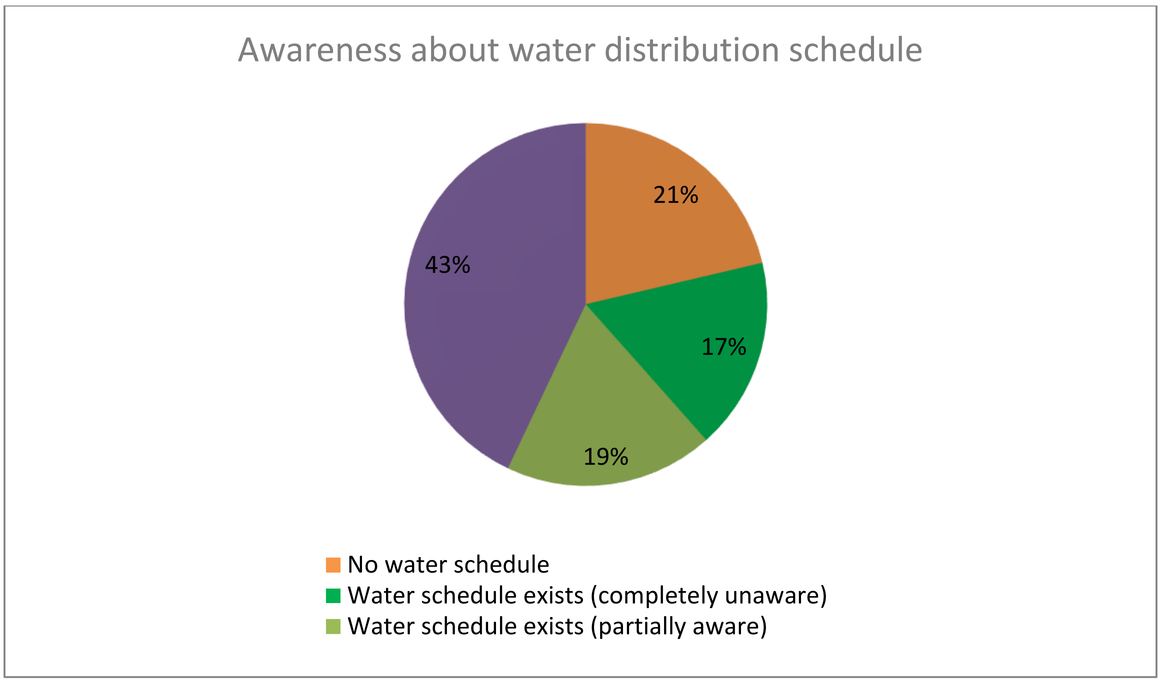


Figure 34: Awareness of beneficiaries of water schedule in their scheme

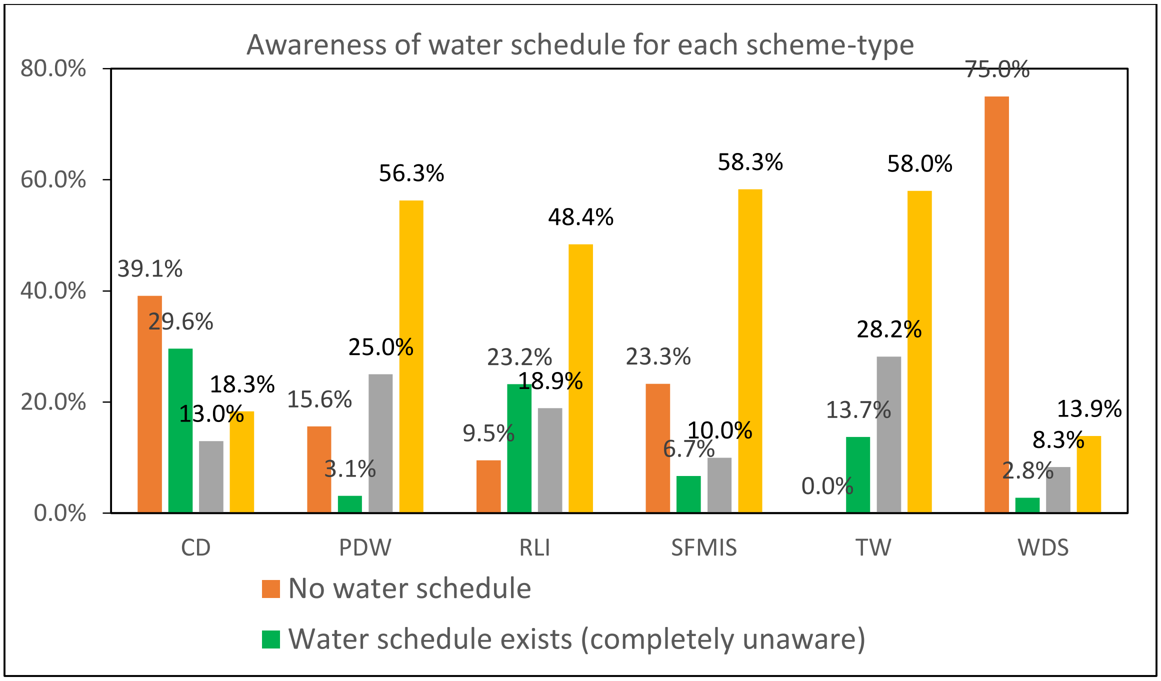


Figure 35: Awareness of water schedule for each scheme-type

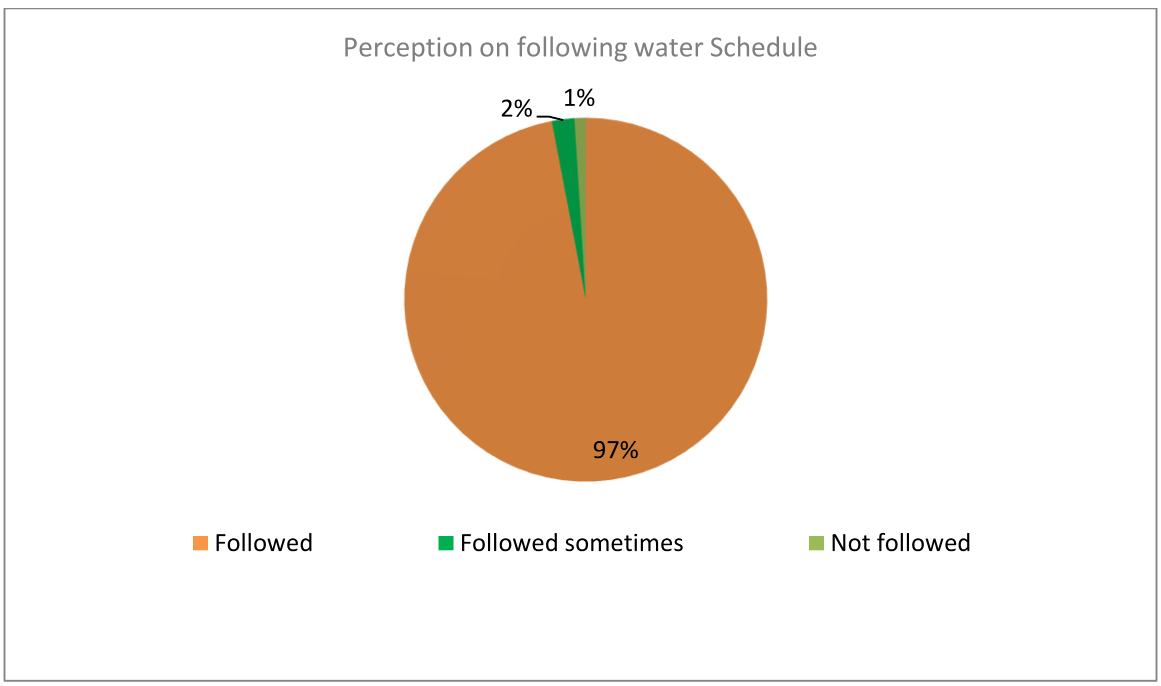


Figure 36: Perception if the water schedule is followed

Respondents, who are fully or partially aware about water schedule, 96.9 % reported water schedule is followed and only 1 % reported that it is not. This high number reflects the efficacy and meticulous planning that goes into planning water schedule in such schemes. Example of this was evident on field visits, where many schemes plan their cropping pattern and plan based on available water in democratic manner with full agreement.

4.2.6 Surface water schemes: water surface area dynamics

Change analysis for surface water area, as a proxy for detecting change in water storage of surface water schemes, for minor irrigation structures was carried out using geospatial analysis. For this, both optical (Landsat – 8 and Sentinel -1) and SAR Sentinel-1 data were used by applying rule-based threshold segmentation method.

For optical data, first composite images were created and then using them, Normalized Different Water Index (NDWI) was calculated. Then applying an appropriate threshold to NDWI, water pixels from optical data were extracted. For SAR data, based on behavior of water and non-water pixels and pixel's histogram of sentinel-1 SAR images, the lower and upper threshold values of flood pixels were determined. All the data processing and tabular data extraction was carried out in GEE interface.

Water surface spread area and its change over year reflects the storage capacity in surface water schemes and is a crucial indicator to assess water availability. However, assessing it through survey or field visits is difficult as it requires frequent visits with both human and financial capital investment. Therefore, RS data has been used to assess water surface area dynamics and this can set a methodological framework to apply to other project areas.

For example, this was done for Maharajnagar Bara Bundh SFMIS located in Purulia district that was hander over in March 2016. Figure 37 gives the visible water surface area post monsoon as accessed via google earth imagery for year 2003, 2010, 2014 (before implementation) and 2016 (After implementation). It is evident from the images that water spread has increased significantly with a clearly defined boundary.

Figure 38 is gives the monthly water surface area (m^2) changes over 2015, 2017 and 2018 for Maharajnagar Bara Bundh SFMIS. It clearly represents that the water availability has increased during 2017 and 2018 compared to 2015 as SFMIS was constructed after 2015. On absolute scale, it shows that water spread has increased from ~ 27,500 m^2 to 40,000 m^2 i.e. an increase of almost 45.5 %. However, corresponding increase in storage volume would have been much higher as storage depth also increases with increase in water spread are. However, the increase in storage and water availability could not be estimated for the want of depth-storage relationship as we could not access project DPR.

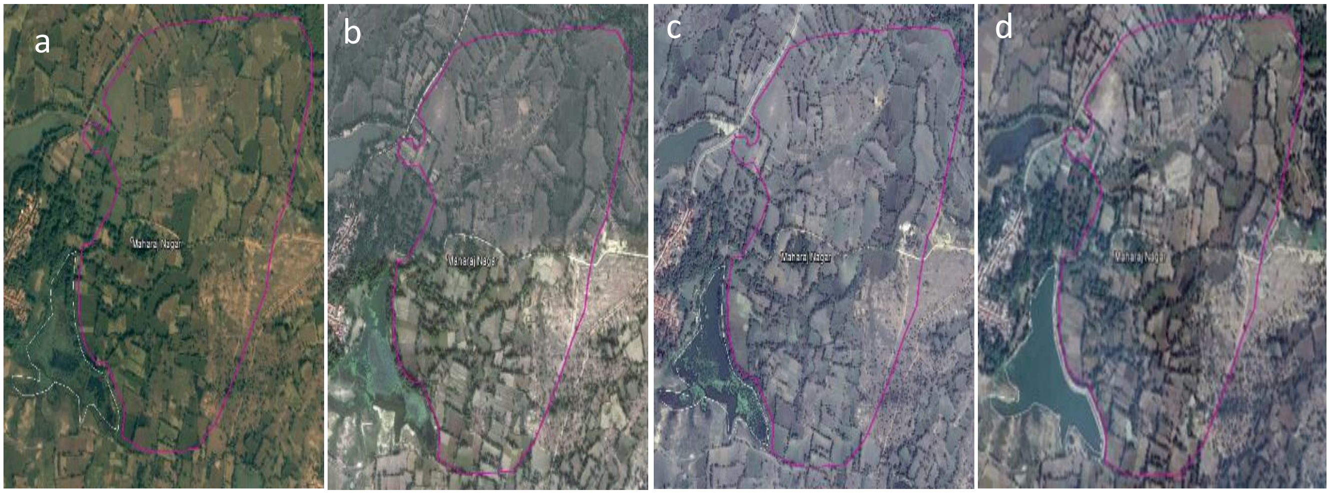


Figure 37: Represents increased water surface area after the SFMIS , (a) Google Earth image taken on November 2003, (b) December 2010, (c) January 2014 and (d) December 2016

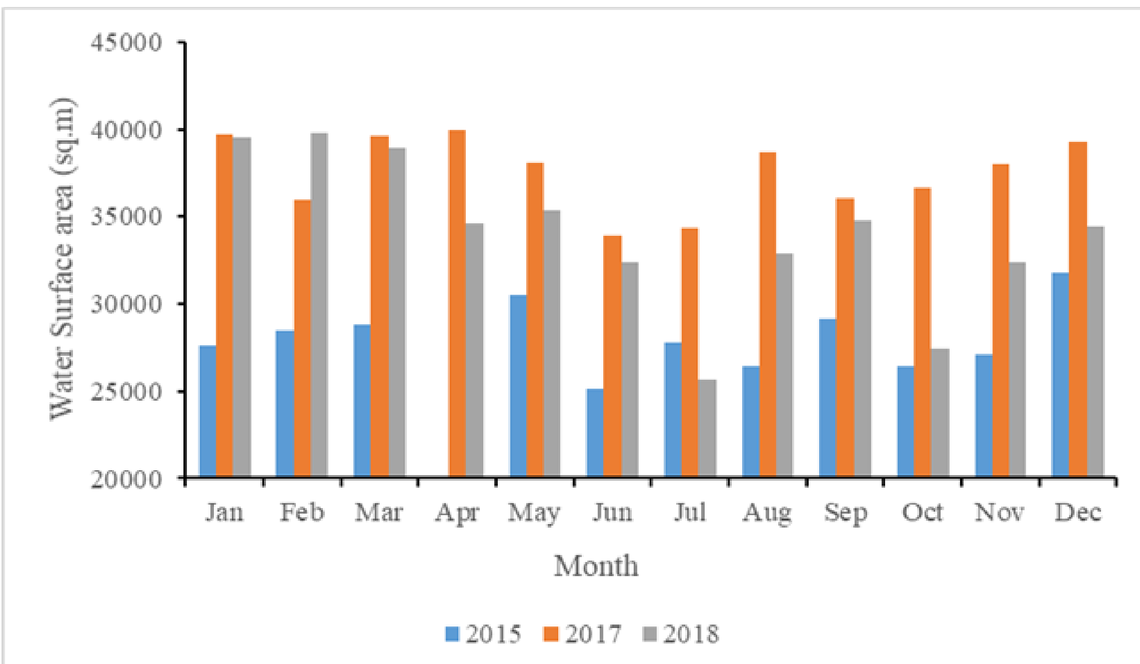


Figure 38: Represents absolute value of water surface area from 2015 to 2018 after implementation of SFMIS MI scheme

4.3 Institutions and management indicators

The positive impacts of the WBADMI project schemes that we have discussed in the above sections are to a great extent results of the Water User Associations that have been created under the project. This impact is clear when we see that WBADMI project scheme areas are performing better than non-WBADMI project schemes, that have similar minor irrigation infrastructure but without any Water User Association. It is of utmost importance that this institution of Water User Association continues to remain strong even in future after the project has ended. To judge the institutional and management aspects of the Water User Associations, we have evaluated them against the following criteria -

1. Universality of membership
2. Democratic functioning and outreach of the WUA
3. WUA fee collection and funds for maintenance
4. Financial accountability and transparency

4.3.1 Universality of Membership

One crucial element in judging the institutional aspect of a WUA is to see how successful it has been in including all sections of the farming community. Marginalized sections of the farming community should not be left out from becoming WUA members. Under this project, any landholder within the command area of a scheme as well as any user of water from the scheme can be member of WUA. In that context there were no barriers to become members of WUA once the irrigation structure has been constructed. Our sample farmers were selected from the list of WUA members shared by the DPMU. 94.7% of these sample farmers identified themselves as WUA members. For 42 schemes we were provided with 2319 WUA members in total, and extrapolating our sample estimates would suggest that 94.7% i.e. 2196 out of them would identify as members of WUA. Also interestingly even the farmers who did not identify as members of WUA, almost all (except 2 out of 25) were receiving at least some water from the ADMI scheme. This implies that farmers who were enrolled in WUA, did mostly identify themselves as members and almost all of them did receive some water from the scheme.

Given that the project has to be implemented within the existing social condition with its hierarchies and power structures, the choice of location of the minor-irrigation infrastructure within the village or the type of villages where project activities are undertaken can sometimes lead to marginalization of certain groups even without any such intent. Therefore, these interventions often require effort from the implementer's side to actively include marginalized sections of the society.

The project has tried actively that the benefits reach the marginalized sections, for example, small & marginal farmers, female farmers and tribal farmers. To involve the beneficiaries in the pre-planning and planning stage of a particular MI scheme, the project officials had organized meetings at village-level to inform them about the project and discuss about potential schemes that can be implemented. The beneficiaries had to write an application for project implementation in their village. This application went through a thorough assessment for selection, and work was done for only those applications which were approved. From our discussions, it reflected that beneficiaries were informed and their feedback was received during this planning and implementation phase through meetings organized between project officials, engineers and farmers.

To measure the success of the project achieving this objective of universality of membership, we looked into equitable representation of gender, schedule caste and schedule tribe farmers and marginal or small farmers among WUA members in our sample. Our sample, selected randomly from the full list of WUA members, is a representative sample of WUA members across schemes. Table 15 gives the percentage of different farmer groups in sampled WUAs as obtained from WBADMI project website at the planning stage and among our sample farmers. Although female membership in WUA was 24.4% at the start as obtained from website record, in our sample only 15.4% households had any female members within WUA. However, amongst our sampled farmers, 36.5% were scheduled tribe farmers and 72.7% were marginal farmers. These numbers are much higher than their share amongst WUA members at the very beginning (22.7% ST farmers and 64.4% marginal farmers) as captured in WBADMI project website records. It indicates that project has actively tried to bring in more ST and marginal farmers.

Table 15: Percentage of different farmer categories in 42 sampled schemes

	WBADMI project website record	Sampled WUA members
Total WUA member	2814	469
Female member	686 (24.4%)	72 (15.4%)
Scheduled Tribe (ST)	640 (22.7%)	171 (36.5%)
Marginal Farmer (<=1 hectare)	1811 (64.4%)	341 (72.7%)

➢ Women membership in WUA

As already mentioned above, only 15.4% households had female WUA members. It is reflective of the fact that in these rural communities, men are considered the main farmer of the household and consequently, the male farmer becomes WUA member by default. Including women in WUA and making them active participants in groups where women are not considered as primary decision makers for agriculture activities will require intensive and sustained social outreach efforts over long term. However, there are examples where the entire WUA is exclusively managed by women and these groups have been tremendously successful (we discuss such exceptions later in case studies). These groups can act as benchmark for other WUAs in integrating women.

There is also some contrast in female membership in WUA when compared across districts (Figure 39). Highest proportion of female in WUA is in Purulia (36%), followed by Bankura (24%), whereas Birbhum has the lowest proportion (7%) and Paschim-Medinipur is only marginally better (11 %). Analyzing across scheme types (Figure 40), we see that female membership is highest in SFMIS WUAs (39.6%) and lowest in groundwater schemes (TW – 7.9% and PDW – 6.7%).

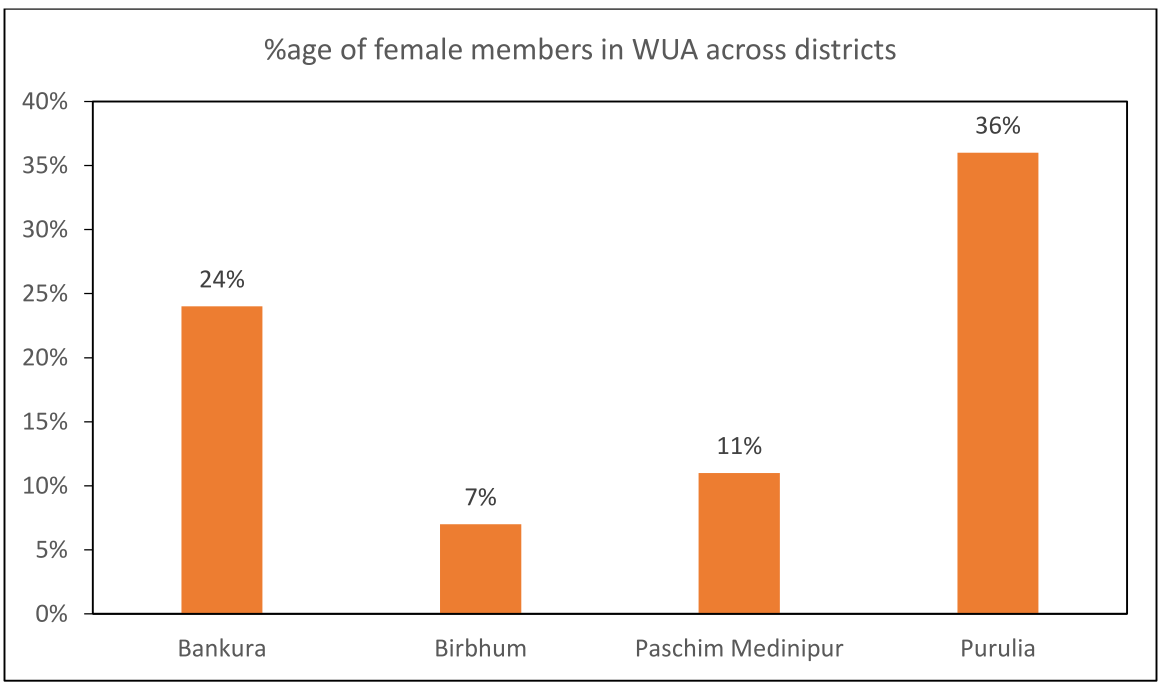


Figure 39: Percentage of female members in WUA across districts

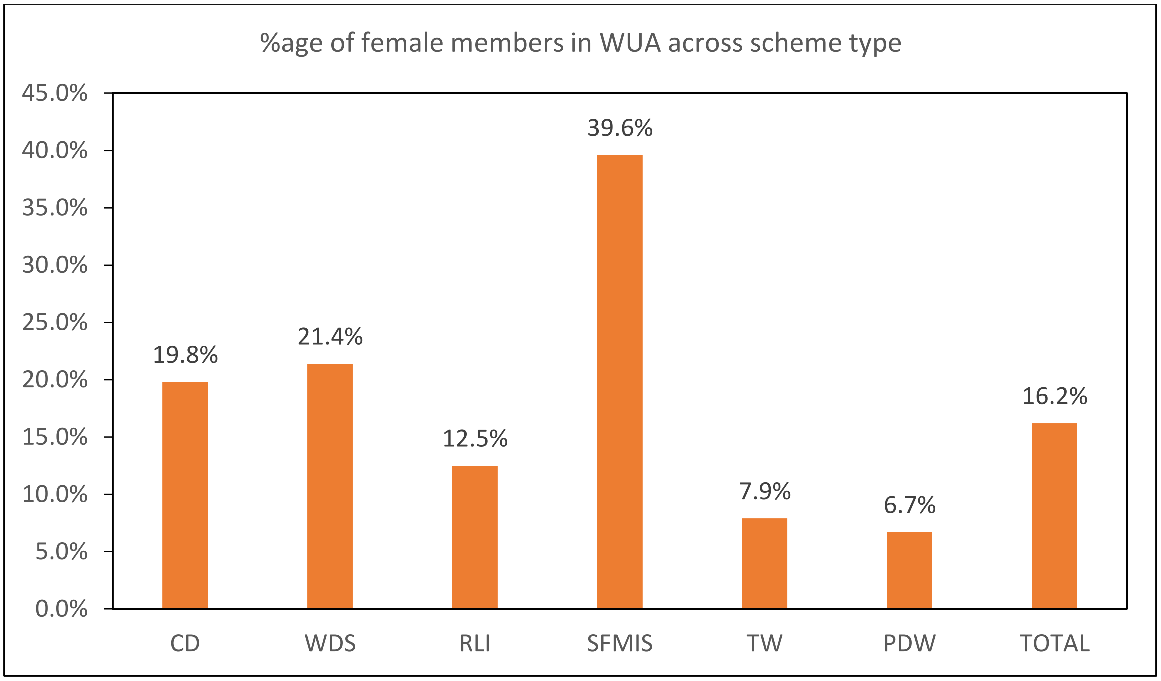


Figure 40: Percentage of female members in WUA across scheme types

There can be two reasons for this variation across districts and scheme types: In districts like Purulia, tribal communities more prevalent. In tribal communities, women are comparatively more involved in agriculture and hence their involvement in WUA is also higher. As a result, Purulia has a higher proportion of female farmers in WUA.

Also, in surface water schemes (WDS, CD and SFMIS) where rabi cultivation is low, men are more involved in other activities of labor or they migrate. Hence, women have higher scope to be more involved in WUA activities. In contrast, in groundwater schemes or RLI, water source is perennial requiring year around involvement in agriculture with relatively higher costs of O&M. In such schemes, agriculture is the primary occupation and is controlled by men.

- Tribal and scheduled caste representation in WUA

We also evaluated the extent of representation of marginalized groups like scheduled tribe (ST) and scheduled caste (SC) farmers through WUA membership. We compared the proportion of ST and SC farmers in sampled WUA against the proportion of ST and SC population in each of the blocks where we did our survey (as taken from census 2011).

The focus and effort of the project in bringing tribal farmers as beneficiaries is clearly reflected in Table 16 where almost in each block, ST farmers in WUA is higher than the population proportion of ST families in the block. On the other hand, without any targeted effort to include more scheduled caste farmers in WUAs, the representation of SC in WUA is quite less than their population proportion in many blocks. This indicates that more targeted and conscious approach is needed to ensure that no marginalized groups are excluded.

Table 16: Percentage of farmers across caste groups in household survey and census data

		Sample		Census 2011	
District	**Block**	**SC**	**ST**	**SC**	**ST**
Bankura	Chhatna	2.8	47.2	30.0	21.1
Bankura	Katulpur	26.7	0.0	35.8	3.4
Bankura	Khatra 1	0.0	0.0	26.5	24
Bankura	Sarenga	0.0	90.9	29.2	19.1
Bankura	Simlapal	15.4	23.1	26.7	15.6
Birbhum	Dubrajpur	23.5	11.8	34.7	5.4
Birbhum	Illambazar	16.0	0.0	23.7	9.2
Birbhum	Mayurswar II	8.3	50.0	30.7	7.1
Birbhum	Rajnagar	1.2	23.3	36.9	19.4
Birbhum	Suri I	75.0	0.0	35.2	10.1
Paschim-Medinipur	Binpur 1	0.0	100.0	25	28.2
Paschim-Medinipur	Binpur II	0.0	80.0	15.4	41.2
Paschim-Medinipur	Garbeta I	0.0	0.0	23.4	8.2
Paschim-Medinipur	Jamboni	0.0	100.0	18.1	28.6
Paschim-Medinipur	Jhargram	14.7	79.4	14.8	22.7
Paschim-Medinipur	Naryangarh	25.9	12.1	18.8	22.8
Paschim-Medinipur	Pingla	0.0	0.0	8.4	9.9
Purulia	Balrampur	0.0	25.0	11.2	37.3
Purulia	Kashipur	25.7	60.0	29.5	27.9
Purulia	Neturia	0.0	100.0	29.7	25.3
Purulia	Raghunathpur I	27.3	72.7	39.4	12.9
Purulia	Santuri	0.0	59.1	27.2	34.6

- Marginal farmer membership in WUA

In terms of inclusivity of marginal farmers, the project has been very successful. Overall 79.3% of WUA members that we surveyed were marginal farmers (i.e. cultivated area less than 1 hectare). In fact, as shown in Table 17 below, across all 4 districts less than 5% of WUA members had area above 2 hectares.

Table 17: Percentage of Marginal farmers in WUA

	Marginal Farmers (<=1 hectare)	Small farmers (1-2 hectares)	Medium or large farmers (>2 hectares)
Bankura	81.82	13.64	4.5
Birbhum	75.0	20.3	4.7

Paschim-Medinipur	82.7	15.9	1.4
Purulia	78.4	17.1	4.5

➢ Irrigation services received by WUA members across social groups

It is also interesting to see if the irrigation services received by WUA members are different for marginalized groups. Figure 41 shows the percentage of WUA members receiving irrigation across different groups. Overall 86.3 %, 53.6 % and 10.6 % receive irrigation in kharif, rabi and pre-kharif season, respectively. Access to kharif irrigation amongst female, tribal and marginal members stand at 70.4 %, 85.4 % and 89.7 % respectively. Female WUA members have the lowest numbers relative to all other categories. This is also reflective of the fact that female membership is comparatively higher in surface water schemes.

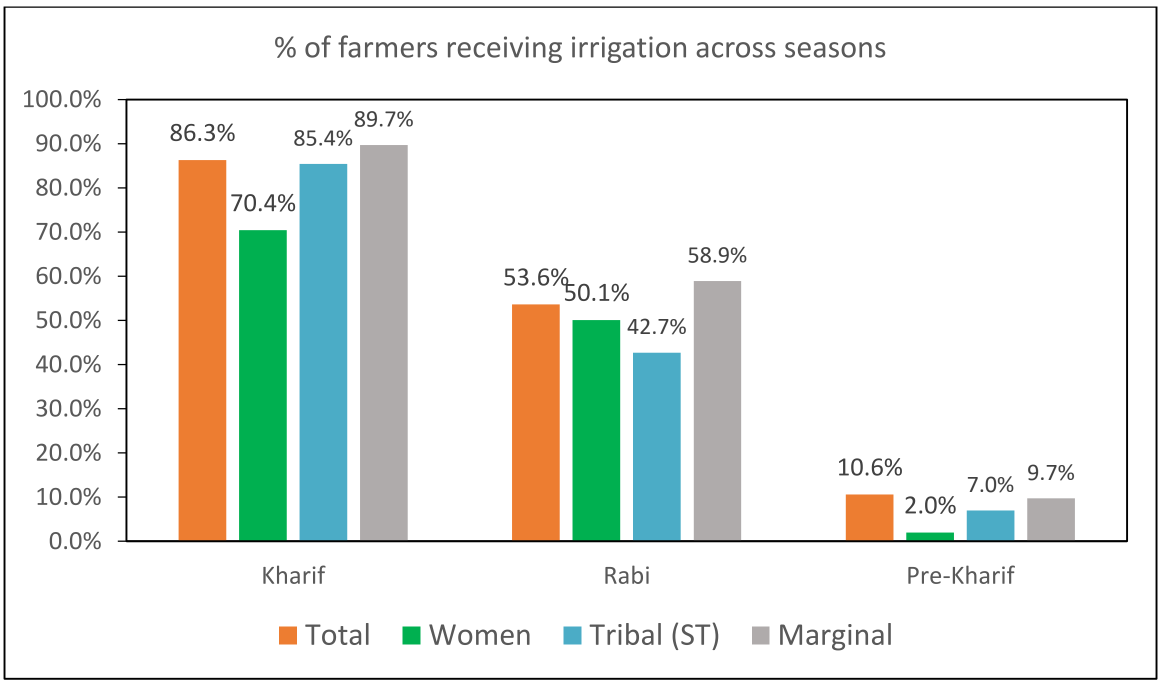


Figure 41: Percentage farmers provided with irrigation across seasons

➢ Representation in executive committee

Another important aspect of equal representation of different marginalized groups within WUA is their presence in the Executive committee of the WUA, which has a lot of decision making power. There is a rule that one-third of the Executive committee members should be female. From our FGDs we found that although this rule is followed, in some cases it is just tokenism. The female executive members are wife of relatively powerful men in the village and it is mostly their husband who control the WUA meetings. There were 9 sample WUA members who reported to be WUA president, out of which only 1 was female. Similarly, out of 11 WUA members holding Treasurer Position, only 3 were female and out of 7 families holding Secretary Position, only 1 was woman. This indicates that even in executive committees, the more powerful positions are primarily held by men.

In term of SC and ST farmers' representation in Executive committee, out of 9 households where the member is WUA President, 3 are OBC, 2 are SC & 4 are ST. Similarly, for treasurer, there were 11 households where the member is WUA Treasurer out of which 5 are ST, 2 are General, 1 is OBC & 3 are SC. One important reason behind the higher representation of marginalized caste categories in powerful positions within WUA is because these WUAs for minor irrigation schemes are small in size and very homogenous - 25 out of our 42 schemes had 80% or more members belonging to same caste category *(by caste categories we mean the four broad governmental categories i.e. General, OBC, SC & ST).*

4.3.2 Democratic functioning and outreach of the WUA

WUA is expected to be a platform for social inclusion and promoting equity in the social structure. After scheme was handed over, the WUA is supposed to take control over the operation and maintenance activities. For the WUA to do this effectively it is necessary that it functions democratically. Each scheme has an Executive committee (main committee) which comprises of about 7 to 9 members. One important indicator of democratic functioning is how these members are selected. Sampled WUA members were asked to rate[2] how democratic the selection of the Executive committee, Chairman and President was.

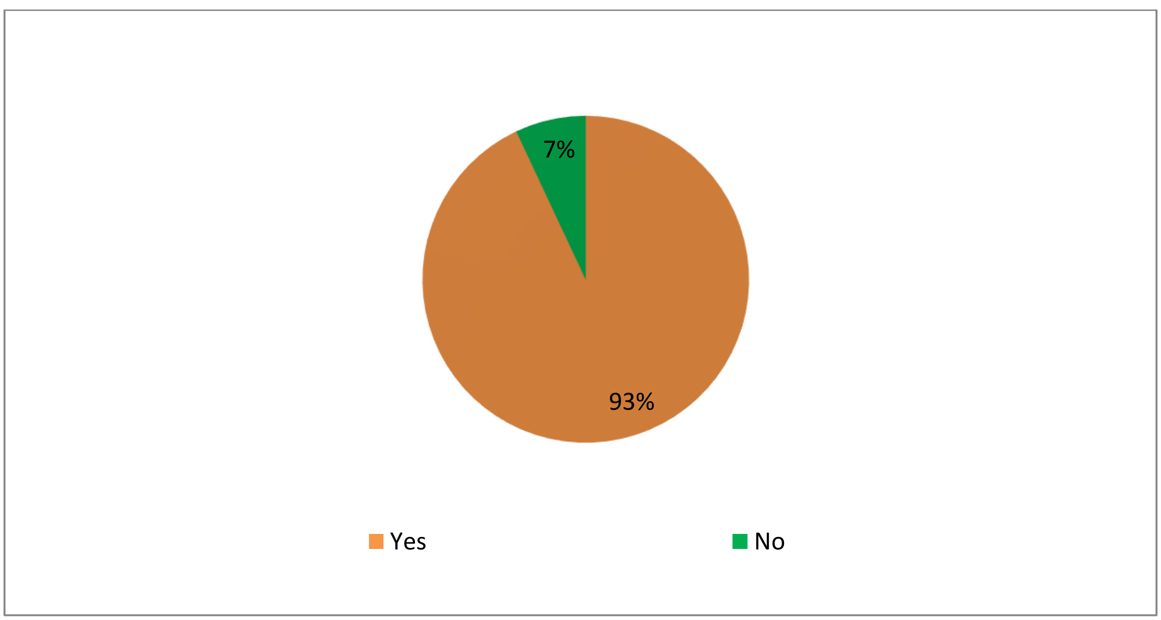


Figure 42: WUA members perception on democratic election

[2] Rating is 1-5, where 1=not democratic at all, 5=fully democratic. Rating above 3 was taken as "democratically selected"

Overall, 93% of respondents felt that committee was democratically elected (Figure 42). When evaluated across different districts and scheme types some small differences become evident. Bankura has the lowest number of respondents rating that the selection of committee as democratic, whereas in Birbhum and Paschim-Medinipur almost everyone rated committee selection as democratic. When compared across scheme types, CD, SFMIS and RLI shows the highest percentage of respondents rating the selection process as undemocratic.

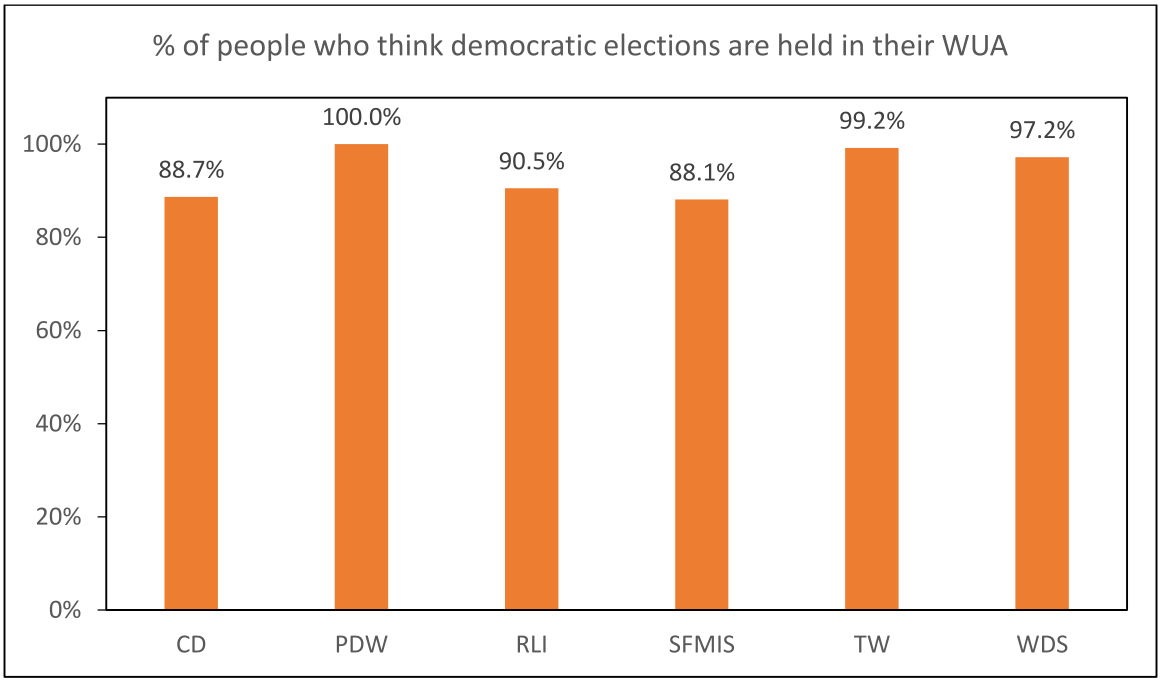


Figure 43: Perception of democratic election in WUA- by scheme-type

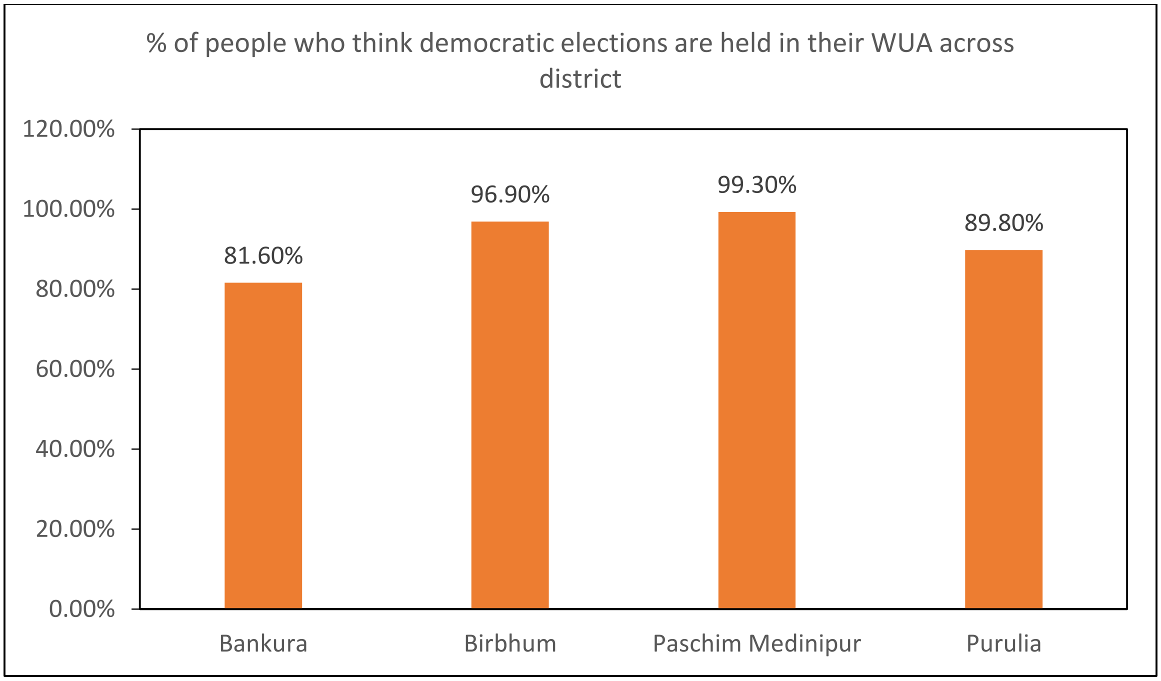


Figure 44: Perception of democratic election in WUA- by district

Even in our FGDs and field visits, when asked about the process of selection of the Executive committee, Chairman and President, response was very similar with most people saying that it was done through meeting and discussion of all members of the WUA. However, further probing revealed some interesting insights. Out of all schemes visited for FGDs, only one (Kapishta-Majramura) had any change in the Executive Committee since the first year it was formed. Also, no explicit voting was done for selection of Executive committee members and usually at the end of the year, previous committee gets reelected. This was generally found to be either due to WUA members being satisfied with working of committee or not giving much importance to the election or to avoid any social conflicts and maintaining social harmony as election might bring some friction among its members. Over long term, this carries

the risk of WUA being dominated by existing committee members as they would be more trained and capable of managing the official work (finance, renewal etc.) and also keeps the status quo intact in cases where some WUA members were disfranchised at the start. Thus, there is a need for mechanism that ensures the managing committee is changed after some time (two years or three years). Making this mandatory would remove factors that currently prevents sufficient shuffling in the managing committee and over long term would prevent manifestation of power in hands of few.

In addition, there are also supposed to be four more sub-committees, but existence of these sub-committees was often only found on paper. Not all participants were even aware of these sub-committees and very few could name all these sub-committees. It was clear that all activities (financial, operation, maintenance) were carried out by few members. The reasoning provided for the state of things was that very few people had the skills or time to look after the operation and maintenance, keeping financial records etc. This reflects the need for capacity building of WUA members at even larger scale. As WUAs are small (mostly with less than 50 members), it might not be possible to operate multiple sub-committees. Thus existence of such committees in future should be re-evaluated and framework should be made leaner.

4.3.3 WUA fee collection and funds for maintenance

In an operational and sustainable WUA, water fees and funds collected play a critical role in ensuring long term sustainability of WUA by generating funds for required maintenance and operations. We have analyzed below what type of fees are being collected by the WUAs, satisfaction of members with existing WUA fees, maintenance fee along with funds generated against maintenance cost required and existing mechanism to deal with no payment of fees.

- Registration Fee

The practice of collecting registration fee is very low in the surveyed areas, with only 18.7 % of the respondents reporting that they paid some money (Figure 45). Most of the registration fee was in the INR 60-INR 120 bracket. Overall, existence of registration fee is low across all scheme types (Figure 45) and the least registration was reported by members of WDS with only 3% reporting to have paid any fee.

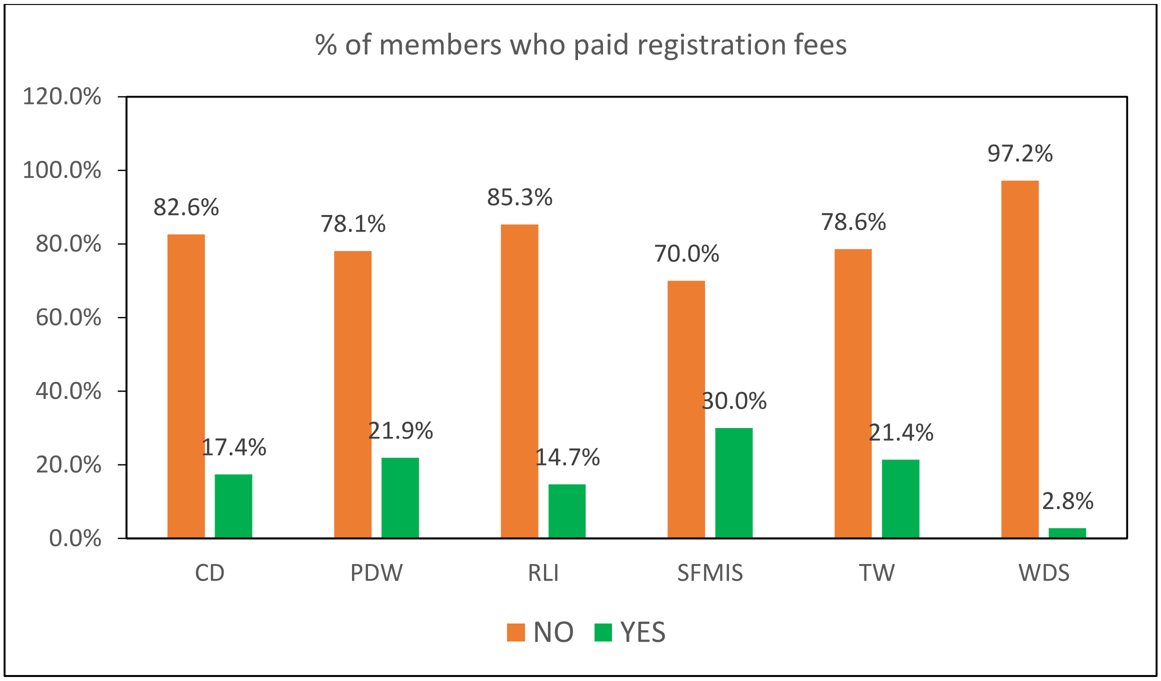


Figure 45: Proportion of WUA members who paid registration fee- by scheme-type

- Water Fee

There is large variation in water fees charged across schemes. In most of the project schemes, farmers reported that fees are decided through a general body meeting. Predominantly it is either charged on area basis (per bigha/season or year /katha) or per unit hour basis. For most of the schemes, WUA water fee is same across three season and across different crops, whereas for some it varies depending on season and crop type. Table 18 gives a brief summary of WUA fees across each season. As can be seen, almost half of the schemes have their fee charged based on land unit and other half based on hour of irrigation. There is a wide range in both classes with rates ranging from INR 10 to 125/hour and INR 50-2400/bigha across schemes. Schemes charging based on hour has almost same charges across three seasons as increased irrigation requirements during rabi season gets factored in increased hours of irrigation. On the other hand, schemes charging based on land unit shows much higher average charges in rabi as compared to kharif season to factor in higher irrigation requirements in rabi season. Similarly, it is during rabi season where maximum schemes have different rates for different crops. This is done to factor in different irrigation requirements of crops. However, this practice is limited to only 7 out 22 schemes in rabi that charges based on land unit.

The higher charges in rabi season on average and presence of schemes with different water fee based on crops reflects to an extent an effort towards determining water fee based on cost recovery principle. However, this was observed to be limited largely in centralized water distribution schemes (TW, RLI) where high operating electricity charges makes it necessary to set water fee to cover operating expenses. In other schemes where centralized water distribution doesn't exist, water fee charges mostly were nominal. This is reflected in Table 19 that gives average charges across different scheme types. TW, RLI and PDW which have centralized water distribution pumps have the highest charges per/hour and RLI, TW (all PDW charger per hour only) have per land unit charges 3-4 times higher than other schemes. In comparison, surface schemes of WDS, SFMIS have very nominal charges.

However, whether these charges can cover the entire O&M cost over long term (5 or 10 % of capital cost annually) is not clear from this and in FGDs and discussions, no indication was received that charges were set after considering the need to recover cost for O&M.

Table 18: Range of WUA water fees across seasons

Unit	Kharif		Rabi		Pre-kharif	
	Number of schemes	Range [average]	Number of schemes	Range [average]	Number of schemes	Range [average]
Per Hour Fees	20	10-125 [32.2]	18	10-125 [29.7]	20	10-125 [32.25]
Bigha/season[a]	20	50-1600 [390.1]	22	50-1600 [541]	20	50-2400 [406]
No fee/not reported	2	-	2	-	2	-
Number of schemes with different Water fee based on crops	3		7		3	
Type of crop based difference	Difference for paddy and other crops		Different fess for Multiple crops [paddy, potato, mustard and vegetables]			

[a] Only 2 schemes show bigha/year and are included in it

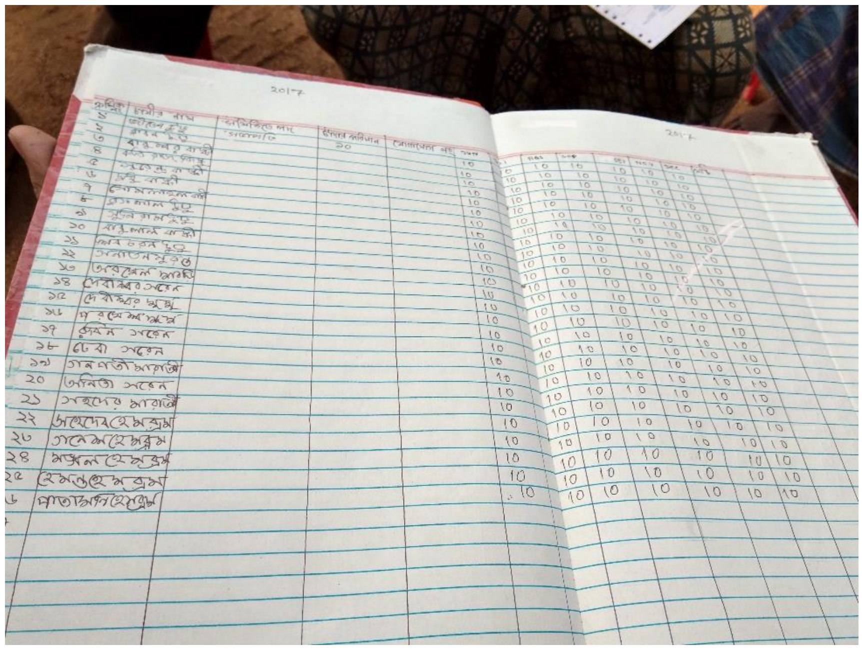
Table 19: Average water fee across seasons for each scheme-type

	Per/hour			Per/bigha		
	kharif	rabi	pre-kharif	kharif	rabi	pre-kharif
TW	53	50	53	640	1025	990
PDW	35	35	35	-	-	-
RLI	51	51	51	808	753	456
CD	22	22	22	212	302	253
WDS	10	10	10	83	83	83
SFMIS	10	10	10	60	60	60

➢ **WUA fees collected/per irrigated area and satisfaction level**

Figure 46 gives average WUA fees collected against area receiving irrigation water (sum of kharif, rabi and pre-kharif season) across different scheme types. Highest rates are seen in TW schemes (INR 1988/acre), followed by RLI (INR 1290/acre) and CD (INR 779/acre). Lowest rates are observed in WDS schemes with rate of INR 184/acre. High WUA fees collected reflects the higher use in TW and RLI schemes and the need to cover the electricity operational costs.

High WUA fee in both RLI and TW is refection of the use of centralized large capacity electric pumps. The high use of TW schemes was largely evident on field and in many areas, multiple paddy crops were being taken (for e.g. in Horogobindopur TW scheme in Paschim-Medinipur) despite its high water requirements. One constraint that does act as a self-constraining factor in TW schemes is the operational cost of electricity usage. This has both positive and negative implication. Positive implications are seen in schemes where WUA considering large operational electricity costs come together to effectively manage cropping patter reducing water usage (for e.g. Baida RLI) and at the same time, sufficient availability of water leads to equitable distribution of water leading to high fund collection efficiency thus making WUA strong and sustainable. However, on the flip side, one negative implications that could arise is that if WUA are not trained, with no risk mitigation measures and are not aware of high operational costs (as happened in Khasjangal TW scheme in Jhargram), high operational cost act as impediment to use. In Khasjangal TW scheme, crop damage that happened from hailstorm in one season and in lack of any other risk mitigation measures (like insurance etc.) made the payment of high operational electricity cost impossible. This lead to non-payment of electricity bill to utility which has threatened to cut electricity connection. Due to threat of another extreme weather event damaging crop and utility cutting electricity connection, use of scheme has become very limited. This could happen in any other scheme where large centralized pumps are used (for e.g. RLI schemes) and thus, there is a need of having risk mitigation measures like crop insurance or any other safety net in project schemes.



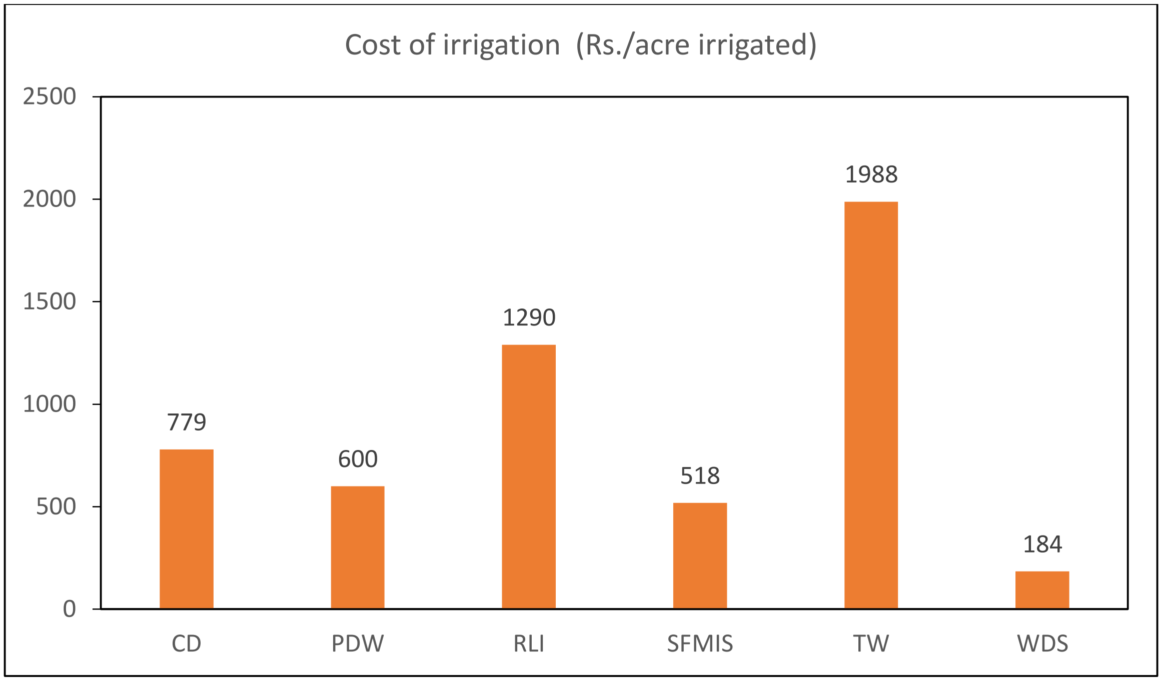


Figure 46: Cost of irrigation across scheme-types

Figure 47 gives the satisfaction with WUA fees across scheme types. It becomes evident, that even though WUA fees collected per irrigated area is quite high in TW and RLI but that doesn't lead to any dissatisfaction, with more than 80 % WUA members satisfied with WUA fees.

In respect of performance and overall operational cost and efficiency, PDW were found to be most efficient. This is reflected in good performance of PDW schemes, low WUA fees collected and highest satisfaction among WUA members. PDW installed as cluster approach having small pumps (mostly 2 kW pumps) and limited command area with each pump (around 10-12 Bigha) leads to much lower cost of operation and better crop water planning as in each dug well, visible depth of water in well acts as a good indicator of how much is available and how much area could be cropped. Among PDW schemes, PDW solar schemes were found to be performing quite good as solar pump leads to almost no recurring electricity operational costs thus they can afford low fee and fund collected could be directed for infrastructure maintenance.

High percentage of "No answer" response from WUA members in case of surface water schemes of WDS and CD in response to satisfaction levels reflects the lack of any existing fees collection. This is in direct correlation to lack of water distribution schedule plan in these schemes as discussed before. Such lack of plan and lack of centralized control and use of individual pump sets makes WUA fees collection mechanism inefficient. This going forward would be a concern as without WUA fees collection, fund needed to maintain schemes infrastructure couldn't be generated. This is discussed in next section.

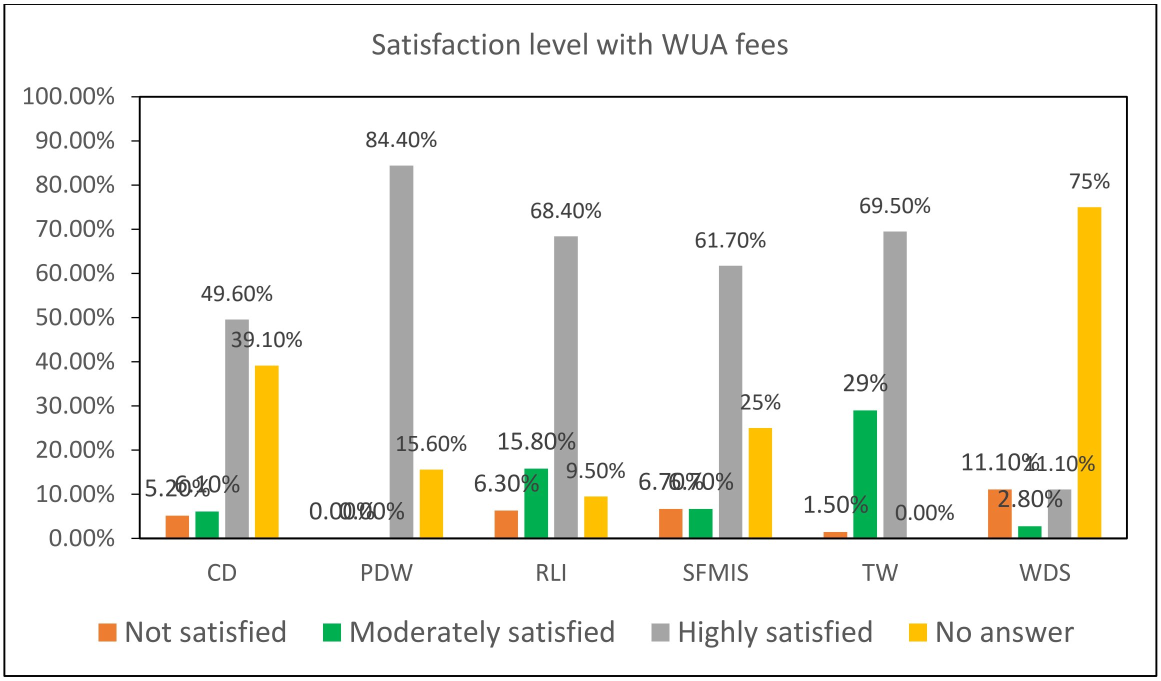


Figure 47: Satisfaction level of members with WUA fees

- **Maintenance fee**

Contribution towards maintenance was evaluated either as paying maintenance fee over last 12 months or contributing voluntarily labor (estimated by number of man days) towards maintenance. In most of the respondents doing either is negligible. Most of the money collected is used to cover operational costs and any leftover money goes towards bank balance that could be used for maintenance. Overall, 83.4 % of respondent did not pay any maintenance fee or did any voluntarily labor for the scheme in the past 12 months. The percentage is high across all schemes and there is no significant difference across scheme types (Figure 48).

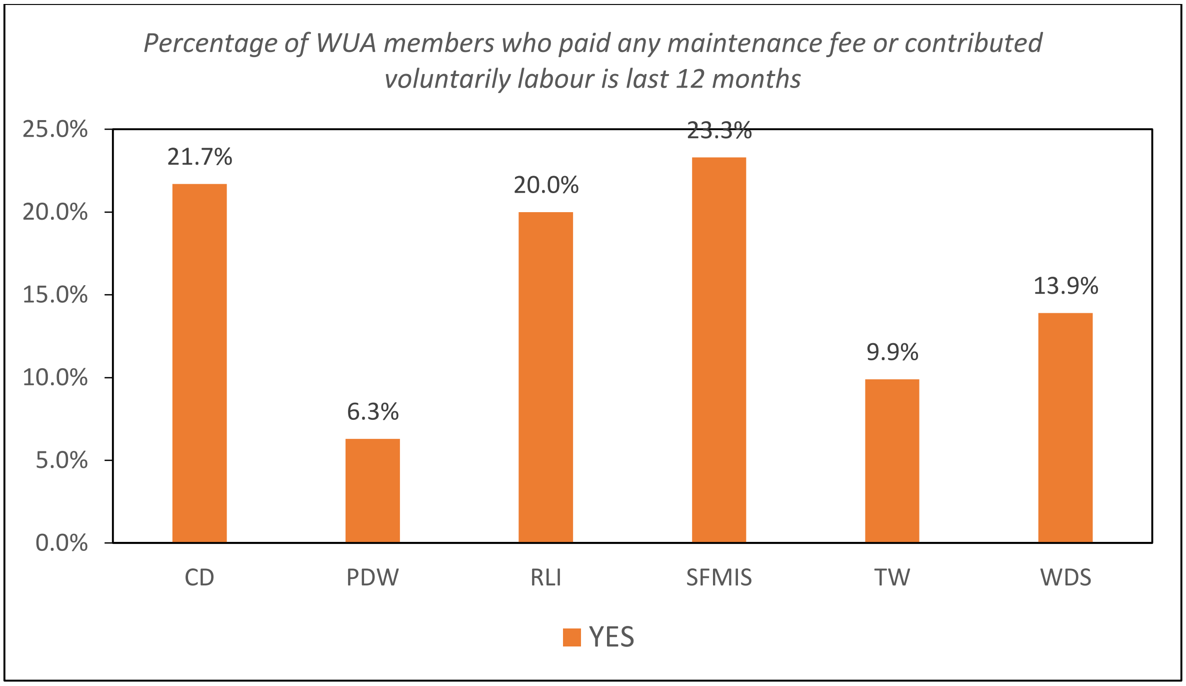


Figure 48- Percentage of WUA members who paid any maintenance fee or contributed voluntarily labour is last 12 months

WUA funds collected by charging water, subscription and maintenance fee is compared against required maintenance cost for each schemes. For the analysis, two scenarios are considered: maintenance cost of 5% and 10 % of total scheme capital cost. For the analysis, total capital cost is taken as provided by SPMU and is divided by SPMU reported command area to get capital cost/acre. This capital cost/acre is compared against WUA fees collected/acre to give a reflection of how many schemes are generating enough funds sufficient for O&M activities. Table 20 gives the average WUA funds generated (% of capital costs) and number of schemes generating funds over 5 % and 10 % of capital costs. On average across all schemes, WUA generated 2.6 % of capital costs with only 8 schemes generating more than 5 % and only 2 schemes over 10 % threshold of O&M.

In case of 8 schemes generating above 5 % of capital costs for O&M, 5 are TW and 3 are RLI schemes. These schemes have centralized pump and distribution system thus fund collection is necessary for covering electricity costs. However, as noticed during FGDs and field visits, in many of such schemes most of fund collected is used to pay electricity costs only and hardly small amount is put in bank for future activities. This is an area of concern.

Table 20: Comparison of funds generated (as % of capital costs) versus required funds against benchmark of 5 and 10 %

	Number of schemes	Average WUA funds generated (%)	Schemes generating funds > 5 %	Schemes generating funds > 10 %
TW	7	9.3	5	2
PDW	4	0.34	0	0
RLI	8	4.5	3	0
CD	13	0.43	0	0
WDS	4	0.14	0	0
SFMIS	6	0.17	0	0
Total	42	2.6	8	2

In one of the ground-water schemes that we visited in Palpushkarini, we could find that the WUA has already taken care of relatively smaller maintenance issues from their funds. They have spent INR 16000 for spout repair, INR 12000 for pump house gate repair, INR 5000 for pipeline repair & INR 16000 for pump repair. However, leaking pipelines are posing a serious concern as their potato cultivation would require huge costs for repair of leakages. For such major repair, WUA would require external help and convergence with block level programs is one option.

For surface water schemes, it would be prudent to connecting schemes to local panchayat for maintenance, possibly through MGNREGA There is scope of informing and training the WUAs about available alternatives for maintenance from Panchayat or other Government programs/schemes.

- **Bank account and savings**

All the WUAs visited by us during our FGDs had a bank account, carrying out all its transactions like depositing fees and making payments for O&M. The large gap in fee collection discussed above is reflected also in low savings across most of the sampled schemes (as seen in Table 21 below).

Table 21: Information collected through FGDs of bank account details and balance

	Membership Fee	Total Cash in hand + bank balance
Palpushkarini (MDTW)	5 Rs./month	26000 Rs. in total. Also 20000 Rs. is in arrears to be collected.

Jiadoba (WDS)	5 Rs./month	Around 2000 Rs. in bank. Also 1200-1300 Rs. is in arrears to be collected.
Kusumtikri (RLI)	5 Rs./month	Could not tell
Mati Dundra (WDS)	5 Rs./month	2000 Rs. in savings
Maharajnagar-Bara Bundh (SFMIS)	5 Rs./month	200 Rs. in savings in Bank
Kapishta-Majramura	20 Rs./month	Approximately 12000 Rs. as savings currently.
Horogobindopur (LDTW)	5 Rs./month	26000 Rs. in total. Also 20000 Rs. is in arrears to be collected.
Ghagra (CD)	5 Rs./month	Around 2000 Rs. in bank. Also 1200-1300 Rs. is in arrears to be collected.
Khasjangal (MDTW)	5 Rs./month	Could not tell
Baida (RLI)	5 Rs./month	2000 Rs. in savings
Banpatna (SFMIS)	5 Rs./month	200 Rs. in savings in Bank
Gadadhapur (CD)	20 Rs./month	Approximately 12000 Rs. as savings currently.

Amongst the schemes visited WUA savings varied from INR 200 – INR 26,000. The highest savings were seen for the tubewell scheme at Palpushkarini with INR 26000 in savings and arrears of INR 20000, while Maharajnagar-Bara Bundh (SFMIS) had saved only INR 200. It is encouraging to see that the WUA savings is kept in bank accounts and not as cash, ensuring financial transparency. However, the savings itself is often quite inadequate.

4.3.4 Financial transparency of WUA

Maintenance of all financial transactions is an important function of the WUA. The WUAs are required to keep Cash book, Stock ledger, Irrigation log book, Crop planning book, Meeting log book etc. We evaluated financial transparency based on respondent awareness[3] about financial transactions of WUA (i.e. amount collected, expenses incurred, current savings etc.).

Overall, 81.6 % of the respondents felt their WUA was financially transparent, whereas only 12.0% rated its transparency as low. The rest 6.4% gave a medium rating. This represents that to a large extent WUA members are aware of financial transactions taking place which is necessary to keep the WUA strong. When financial transparency is evaluated across scheme types and districts, some differences becomes evident.

Financial transparency is lowest among surface water schemes of WDS, CD and SFMIS. This, as discussed before, reflects the decentralized operation of these schemes with expenses incurred individually and WUA has little control on overall management. Very high transparency ratings of TW and PDW also highlight this contrast.

When compared across districts, Paschim-Medinipur and Birbhum have highest financial transparency whereas Bankura and Purulia have the lowest. This, as discussed before, is due to proportion of surface water schemes in each district and good extension and outreach activities in Birbhum.

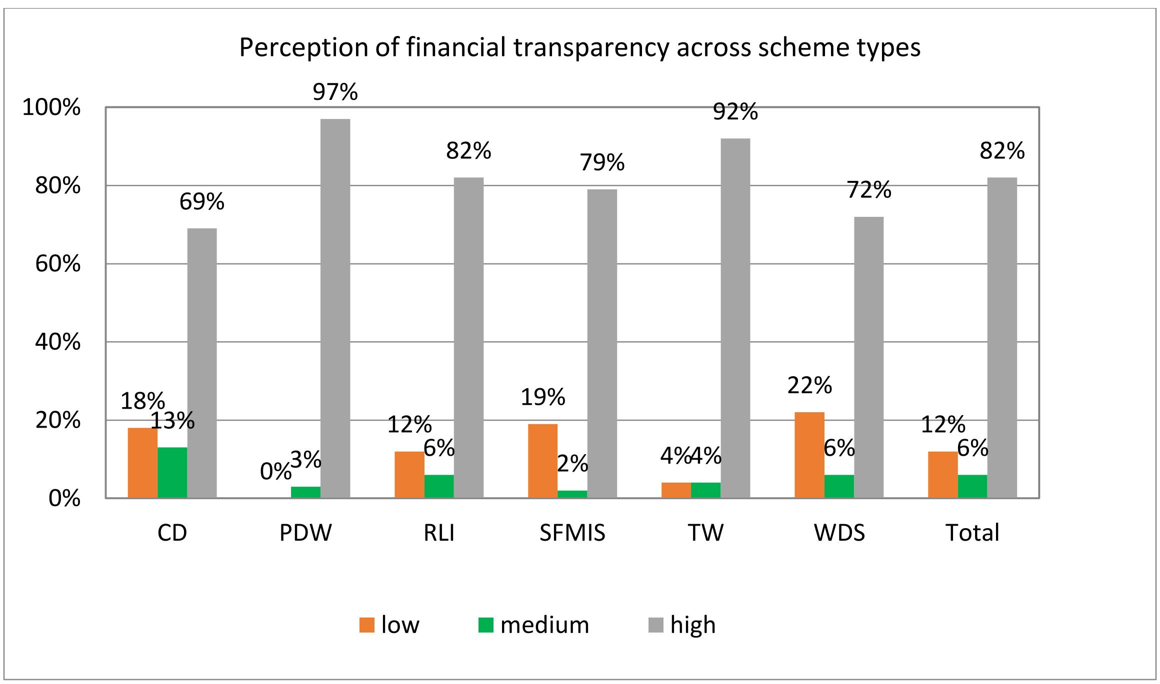


Figure 49: Perception of financial transparency across scheme types

[3] 1= Not at all aware, 2= Slightly aware, 3= Somewhat aware, 4= Moderately aware, 5= Extremely aware. Rating reclassified as Low (1 & 2), Medium (3) and High (4&5).

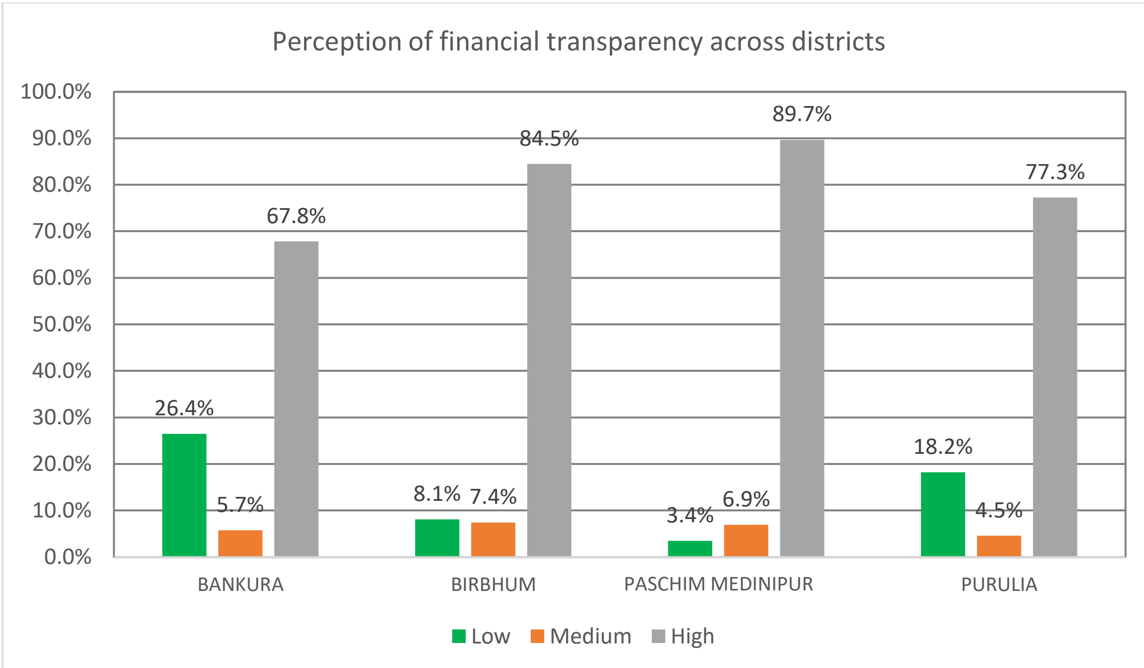


Figure 50: Perception of financial transparency across districts

4.4 Economic Indicators

4.4.1 Impact of the scheme on agriculture income

To understand the change in income of an average farmer family in project villages due to increase in net sown area, cropping intensity and crop choices under the scheme, we estimate the incremental increase in family income. For this purpose, at first we estimate per hectare profit for each crop in the current year using current prices, yield and per hectare cost of cultivation. Then keeping cropping pattern and cropping intensity same as baseline year, we multiply by the current per hectare profit to arrive at the **counterfactual** income. By comparing current actual income with this counterfactual income, incremental income per year for a farmer is estimated. This incremental income captures the monetary value of increased area under cultivation and diversified crop choices for our project farmer families. Measuring incremental income in this way captures the effect of the additional income generated due to new or improved minor irrigation structure, ignoring any effect of inflation or improvement in cultivation practice or input use. For comparing with the cost of irrigation infrastructure, this incremental income is the most suitable indicator of additional benefit of new infrastructure.

For calculating profit per hectare, following formula is used

$$Profit\ per\ hectare\ for\ crop\ i = \frac{(Total\ quantity\ produced\ of\ crop\ i\ *\ price\ of\ crop\ i) - Total\ paid\ out\ cost\ [Cost\ A2])}{Total\ area\ under\ crop\ i}$$

The median value of profit per hectare for three major crops is estimated as: Rs. 38,563/ ha for Kharif Paddy, Rs. 29203/ha for Rabi Mustard and Rs. 111554/ha for Rabi potato respectively. Taking the median value ensures that estimate is not influenced by outliers. The median yearly net profit from cultivation for sampled farmers under WBADMI scheme comes to Rs. 68487 per hectare of net sown area. Figure 51 gives the median yearly net profit per hectare of net sown area across different schemes types. In terms of yearly profit per hectare of net sown area, RLI (Rs. 84813) and Tubewell (Rs. 80062) are the highest. SFMIS (Rs. 49795) and WDS (Rs. 50419) have the lowest profit per hectare because of lower cropping intensity and lower yield.

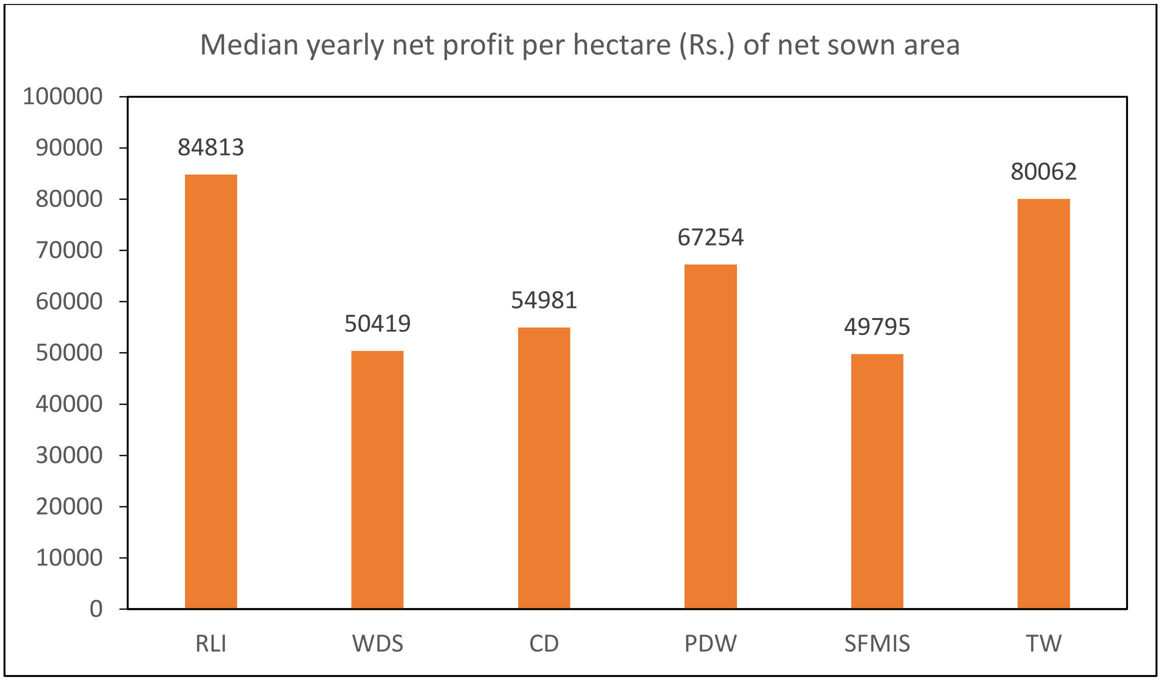


Figure 51: Median yearly net profit per hectare of net sown area

However, to understand how much additional income was generated due to more cultivated area, higher cropping intensity and new cropping pattern after the creation of new/improved minor irrigation infrastructure we estimate total yearly incremental income from agriculture. As described before this is the difference between current actual agricultural income with the yearly counterfactual income. Figure 52 gives the median yearly incremental income for the average farmer across scheme types. Median yearly income is highest in groundwater schemes like TW (Rs. 12500) and PDW (Rs. 12950) and in RLI (Rs. 11531). Incremental income for an average farmer family is lowest in Check Dam (Rs. 3130), WDS (Rs. 5164) and SFMIS (Rs. 5045). This follows directly from earlier results where increase in cropping area and intensity was found to be highest across RLI, TW and PDW schemes. This yearly incremental income forms the basis for comparing our schemes' benefits with the cost incurred.

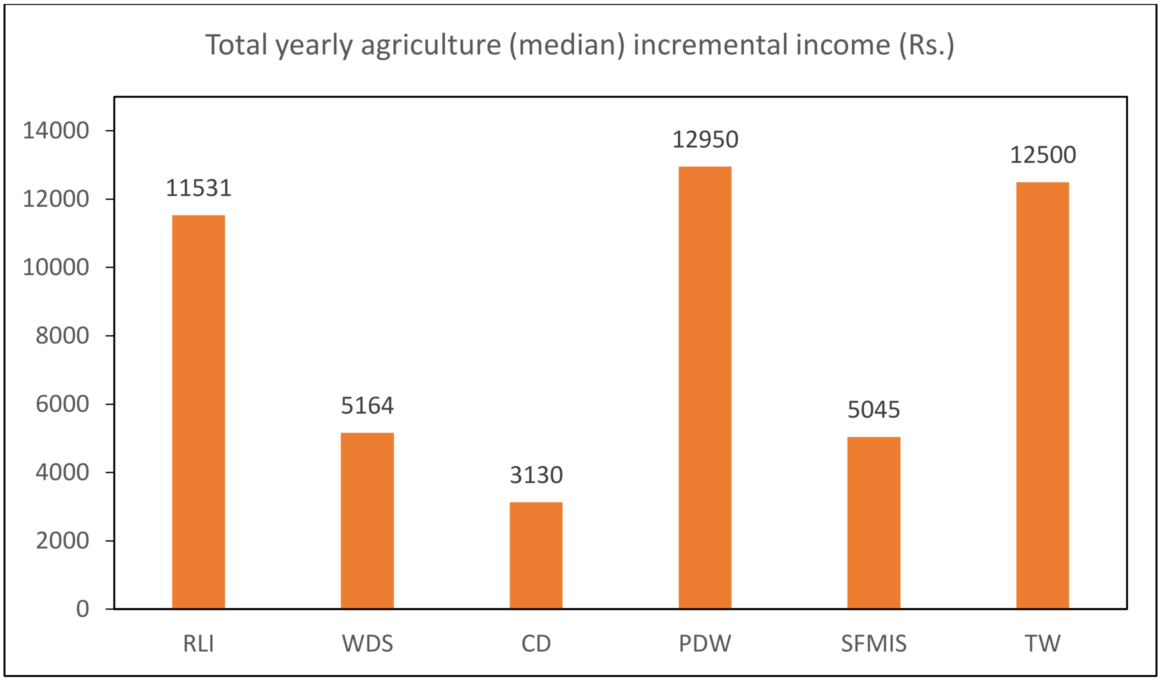


Figure 52: Total yearly agriculture (median) incremental income across schemes

Next we estimate the yearly incremental income per hectare of net sown area at the scheme level i.e. it gives us the additional yearly income from agriculture after project completion for each hectare of current command area. In Figure 53, per hectare incremental income across scheme types is given. Per hectare incremental income is highest for Tubewell schemes (Rs. 61146), followed by RLI (Rs. 48337) and PDW (Rs. 46512). One reason for such high values of incremental income for PDW is because often PDW has been introduced in areas where there was no previous source of irrigation. So PDW has converted barren land into cultivated area, and consequently have values of incremental income. Check Dam, SFMIS and WDS have low values of incremental incomes. This matches with the fact the cropping intensity is low for these schemes. But it also reflects the fact that often these schemes are not new but rejuvenated. As a result, even before scheme it acted as a source of limited irrigation and the impact of rejuvenation on income is comparatively less.

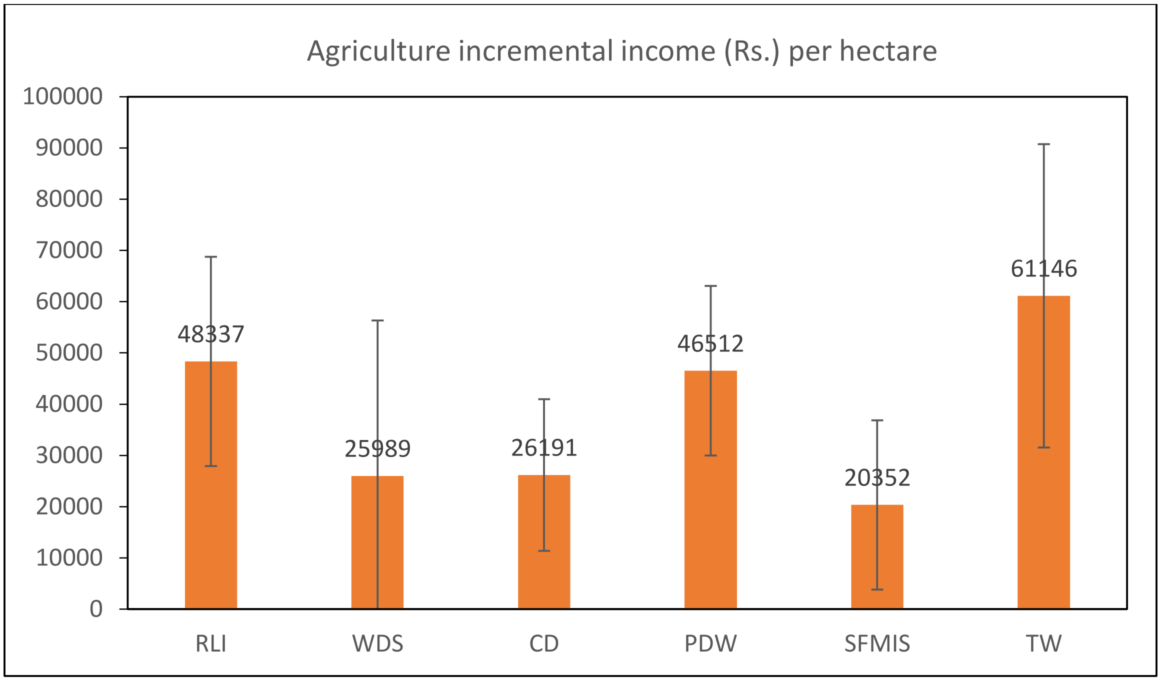


Figure 53: Agriculture incremental income per hectare across schemes

4.4.2 Impact on food availability, wage rate, farm and nonfarm employment opportunities

As discussed before, one of the major impacts of these MI schemes has been to increase agricultural productivity for kharif crops & increase area under rabi crops. The increased family income is spent on health, education, savings etc. The project has provided quite strong agricultural support services to farmers to encourage them into adopting improved cropping practices and diversifying their income source through horticulture and aquaculture. This has not only increased their income, but also improved their domestic consumption of vegetables and fish. As Nilmoni Murmu from Majramura village puts it as "*Now we grow our own vegetables, previously we had to buy from market. Also we have started fish cultivation so our children can eat properly. Before we could have fish only once a month or even less, now every week once or twice our family can eat fish*". This also tends to suggest some positive signs on improved nutrition, though this needs to be studied in more detail.

For groundwater schemes, PDW and TW, more than 90% of project sampled farmers indicated increase in income and food availability after scheme implementation (Table 22). For WDS scheme, only 47.2% indicated increase in income and 61.1% indicated increase in food availability. The limited command area served by WDS schemes is reflected in less number of farmers reporting higher income and food availability. Overall 82.1% project farmers indicated increase in income after project implementation and 86.5% indicated increase in food availability. Both these numbers suggest substantial achievement of this scheme in generating additional income and food for the farmers.

Table 22: Percentage of farmers indicating increase in income and in food availability

	% farmers indicating increase in income after project	% farmers indicating increase in food availability after project
Water Detention Structures	47.2	61.1
Check Dam	76.5	82.6
SFMIS	78.0	83.1
Lift Irrigation Schemes	83.2	85.3
Pump Dugwell	96.9	100.0
Tubewell Schemes	93.9	96.2
Total	82.1	86.5

Increased agricultural activities across seasons within project village with the introduction of WBADMI scheme might also generate increased demand for agricultural labor and raise the wage rate for agricultural labor. Figure 54 gives the perceived changed in number of person days working as agricultural laborer and the change in average wage received as agricultural laborer after completion of the project by sampled farmers. Overall 35.2% of our project farmers reported that number of person days worked as agricultural laborer has increased after project, while 36.2% reported increase in average wage. This increase observed in agricultural labor employment is higher in Purulia and Paschim-Medinipur, compared to Birbhum and Bankura.

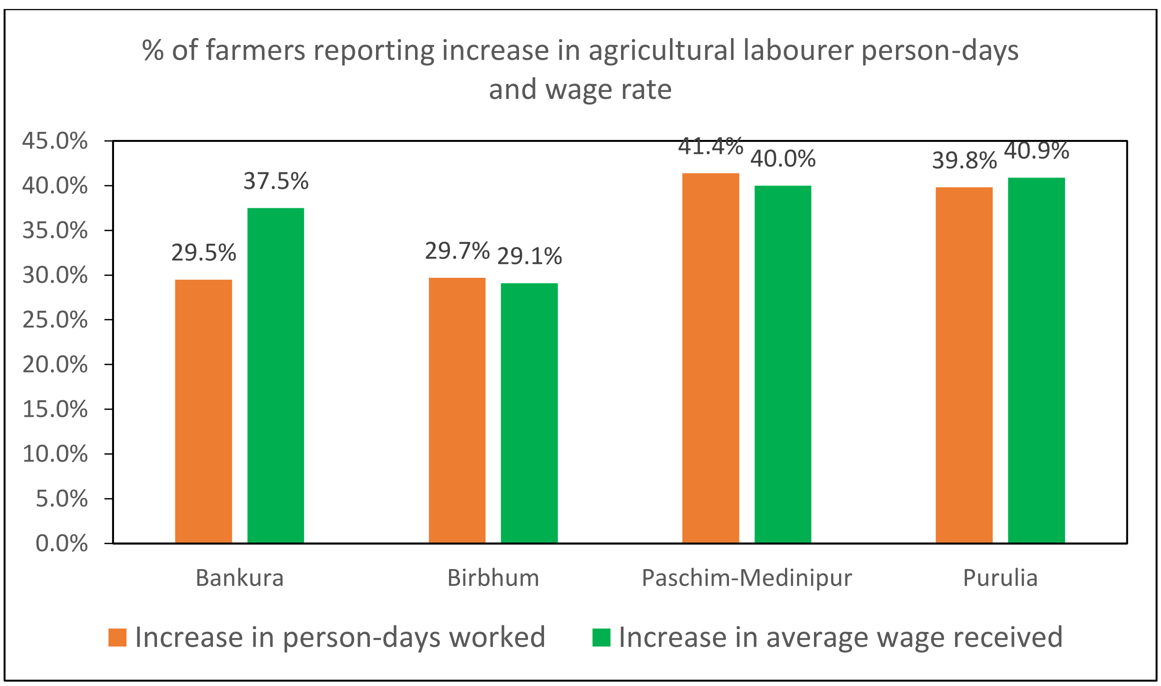


Figure 54: Percent of farmers reporting increase in agricultural labor work across districts

4.5 Participatory Indicators

Participation is an important indicator to ensure sustainability and functionality of the irrigation system after it is handed over. The success of a WUA is dependent on how inclusive and democratic it is in its decision-making. These instill a sense of ownership among its members, making WUA more effective and cater to everyone's needs. Participation in WUA activities has been evaluated against indicators of participation and attendance of members in WUA meetings, active involvement and awareness about operation and management of WUA.

Participation of WUA members has been measured against the following indicators:

- Regularity and attendance of WUA meetings
- Participation in deciding water distribution schedule
- Respondents receiving WUA trainings

4.5.1 Regularity and attendance of WUA meetings

The WUA is supposed to hold frequent meetings with its managing Committee and an annual General Body Meeting with attendance of all the water-user members. In our survey, we have not distinguished the two, and have asked for general attendance to any WUA meetings.

- Number of WUA meetings

To get an estimate on number of WUA meetings, recall method was used and respondents were asked on number of WUA meetings they were aware of being held in the last 12 months and how many they attended. Table 23 gives overall mean and median of frequency of meetings and attendance. The average number of meetings that people were aware of was 10 in the last 12 months. However, on an average, only 70% of the meetings were attended. If we consider the medians of the awareness of meetings and attendance of meetings in the last 12 months, the percentage drops down to 50%. Overall, number of WUA meetings held is satisfactory and in general shows that meetings are held on monthly frequency. This is important as meetings are crucial to decide management and operational issues in WUA.

However, one has to keep in mind that meetings are mostly held at one of the powerful member's house. This could lead to power imbalance in the WUA, when there is no neutral place where the meetings are conducted. For such villages, WUA can hold meetings in a community-owned location like the school-yard or panchayat office for a more inclusive environment. People would need to be incentivized or motivated to attend all the meetings they are aware of.

Table 23: Awareness versus Attendance of WUA meetings in last 12 months

WUA meeting	Average frequency	Median
Awareness	10	12
Attendance	7	6

- Regular attendance in WUA meeting

Overall, 62% of WUA members responded affirmatively to attending meetings regularly (Figure 55). When meeting attendance is compared across scheme types (Figure 56), other than the exception of PDW where attendance is relatively much higher at 78 %, all other schemes' attendance rates is in the range of 56-64 %. The much higher attendance in PDW could be because of the very small group sizes of pump dug-well schemes and clustered implementation approach thus making process of decision taking more universal and high participation in meeting.

When accessed across districts, there is no major variation in attending meetings, with the range lying between 57%-64% overall (Figure 57). Overall, there is scope of improvement in making WUA members attend more meetings as currently about ~ 40 % don't attend meeting regularly.

When asked about the reason for not attending meeting (Figure 58), most often cited reason was "lack of time". Thus, one way to increase attendance in meetings is to hold the meetings at time when most of the farmers are available (in evenings or as decided by consultations) and communicate the schedule well in advance. A higher attendance would lead to higher transparency and could also increase the financial transparency and accountability.

However, from both our field visits and our FGDs, we observed that the executive committee members and farmers who have land near the scheme are more involved in the workings of WUA, while for other farmers the relation is often like a water-buyer who gets water on payment of fees, lacking ownership over the scheme. This imbalance in power needs more focus and inreasing participation by increaseing attendance rates could help address this.

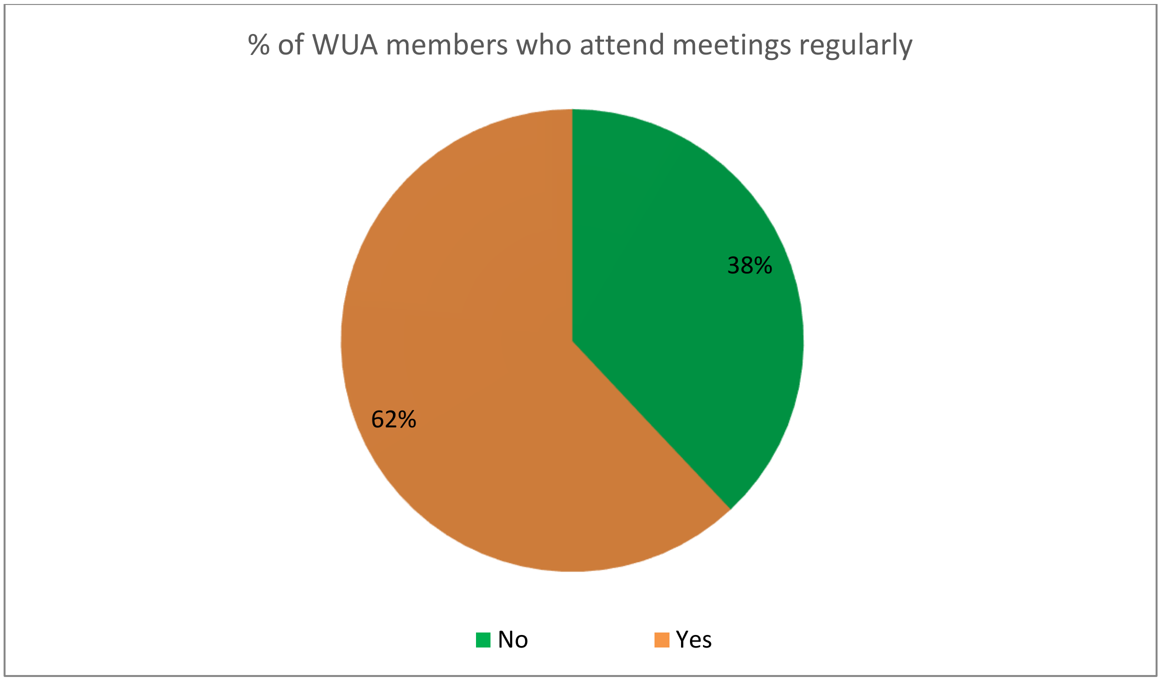


Figure 55: Percentage of WUA members who attend any meeting

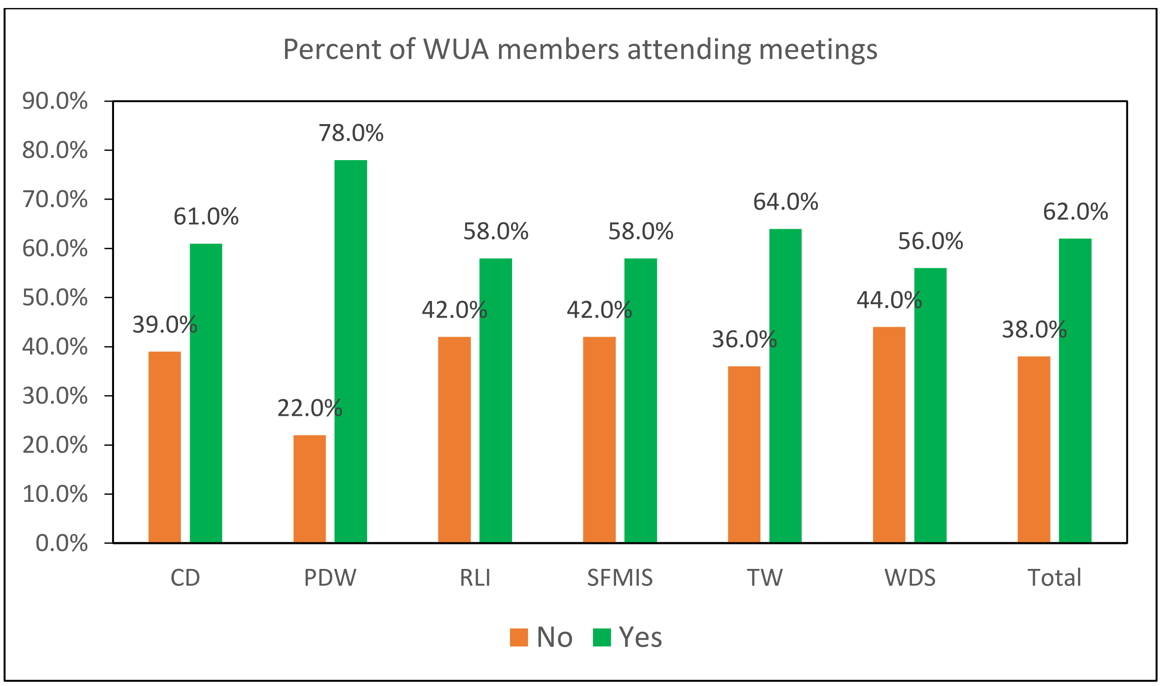


Figure 56: Percentage of WUA members who attend any meeting- scheme-type

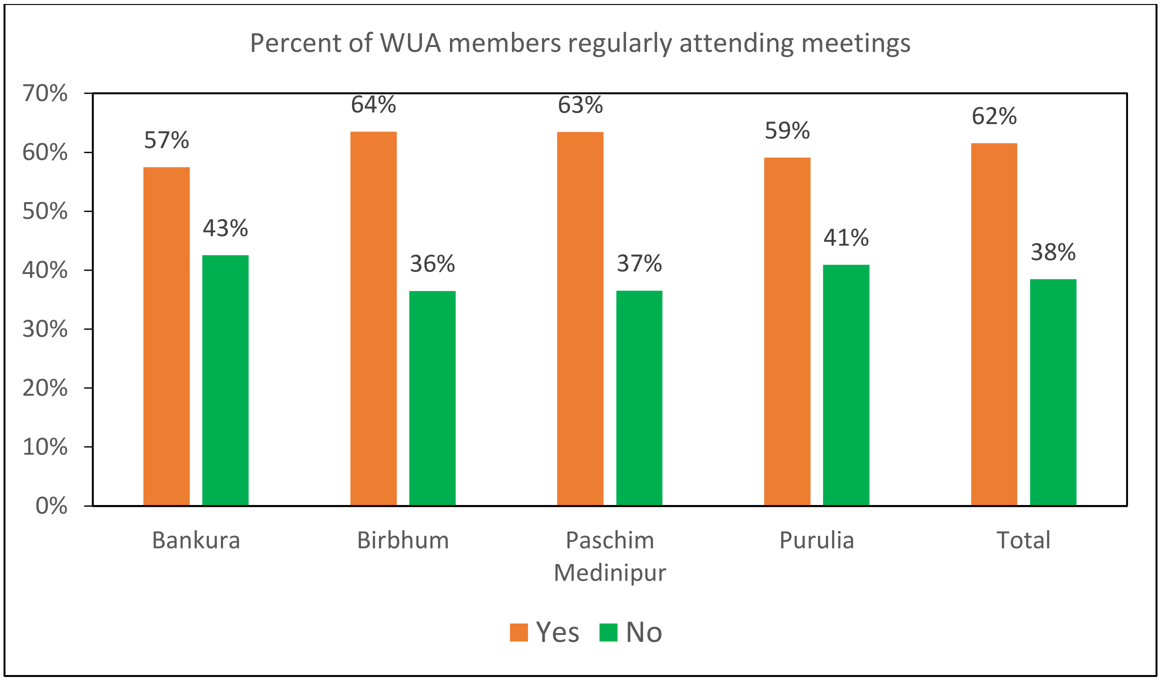


Figure 57: Percentage of WUA members who attend any meeting- district wise

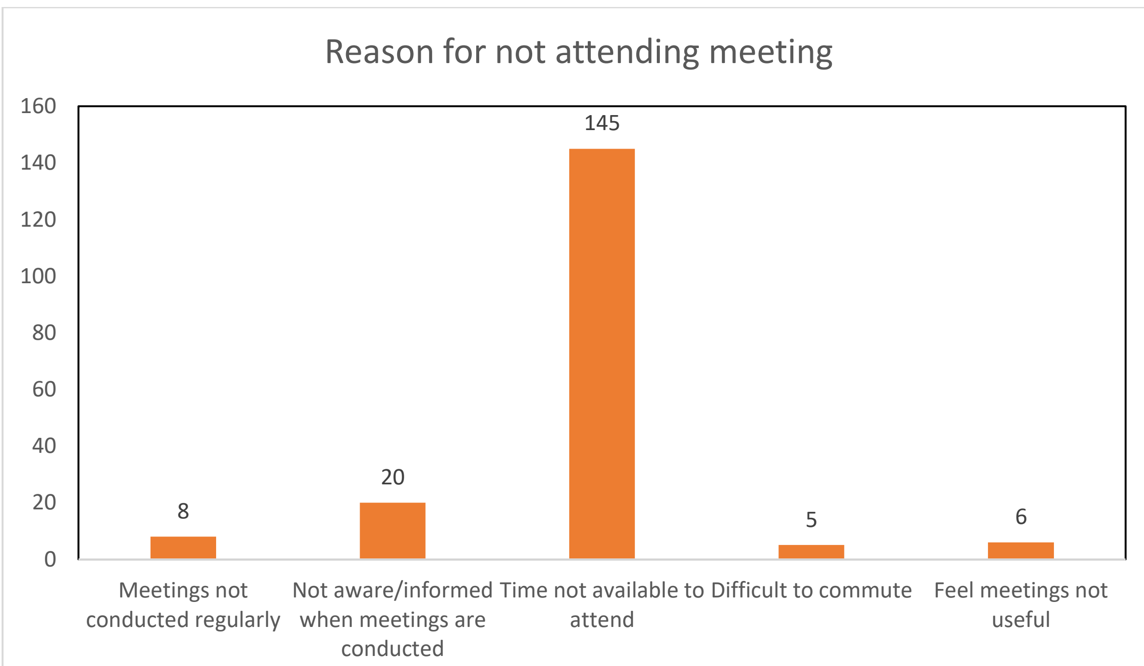


Figure 58: Reasons given for not attending WUA meetings regularly

4.5.2 Participation in WUA meetings

We asked the opinions of WUA meetings attendees regarding transparency and openness of these meetings. Specifcally, respondents were asked if they share their opinions during meeting and if so, are their opinions listened to. Almost everyone said that they can voice their opinion (Figure 59) and in almost all cases felt that their opinions were heard (Figure 60). From field visits and FGDs, it was also observed that the WUA meetings are important platform to take decisions which are acceptable to all WUA members. For example, in Baida RLI, at WUA meeting it was decided not to plant paddy and successfully desist those who do paddy cultivation. This shows that the WUA can be responsible for bringing about changes in cropping activities and adopting technologies that benefit all its members.

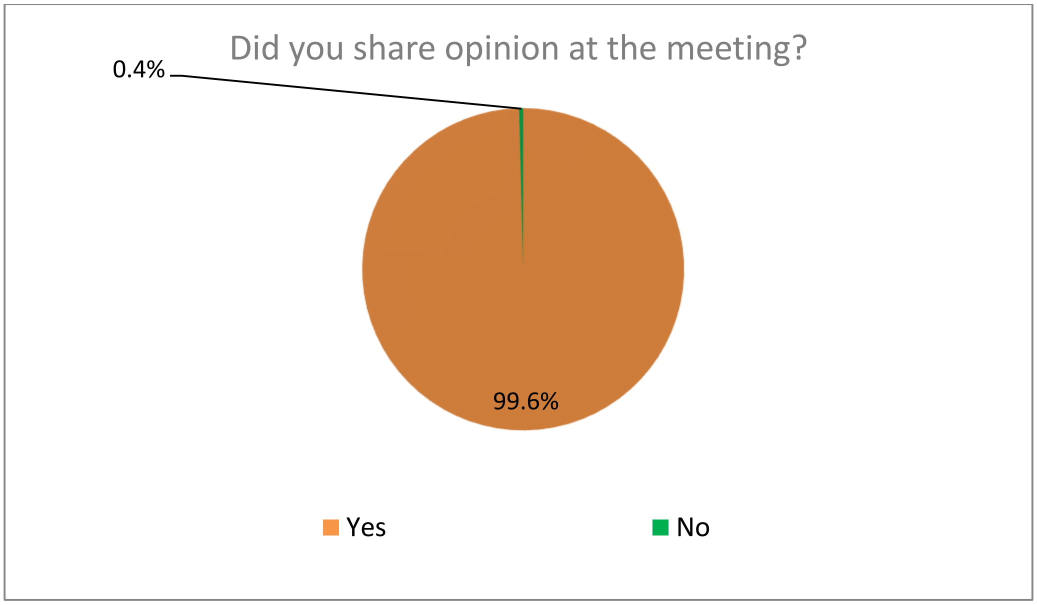


Figure 59: Percentage of WUA members who shared opinion at meeting

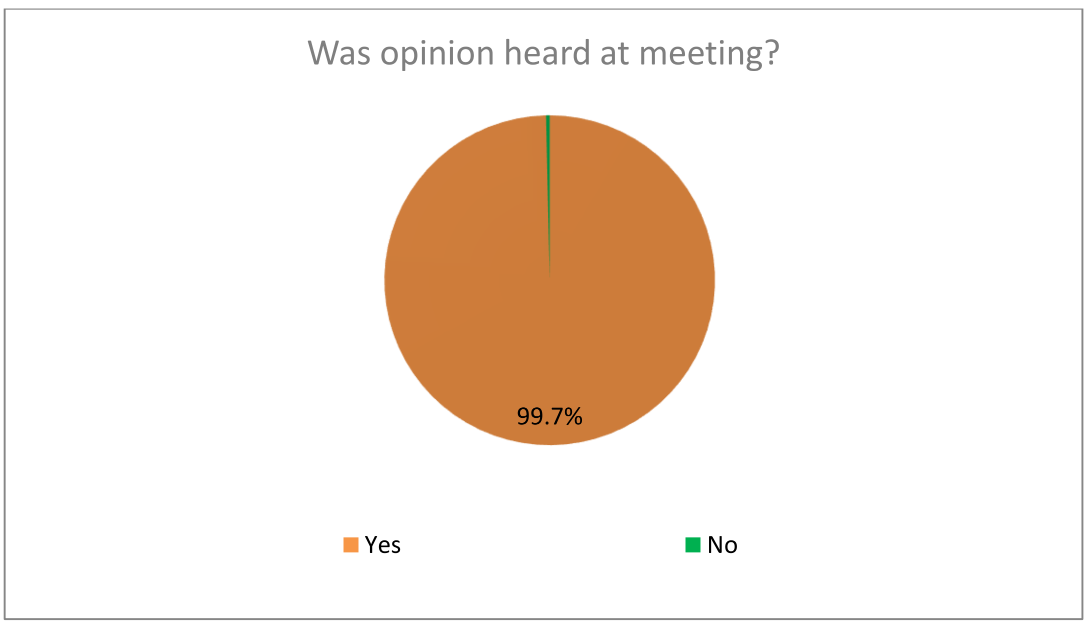


Figure 60: People whose opinion was heard

4.5.3 Participation in deciding water schedule

The water schedule is an important task of the WUA to ensure that season-specific and crop-specific water requirements of its members are met. The involvement of all the members is crucial to make sure that a collective decision is made and everyone's irrigation needs are reasonably met. The existence of water distribution schedule plan and its differences across different scheme types and districts is discussed in detail in section 4.2.5. Overall 78.6 % of respondents says water schedule exists at WUA level and out of this 78.6 %, only 42 % have reported that they are fully aware of water schedule. 18.6 % reports only partial awareness and 17.1 % reports to be completely unaware (Figure 61).

Here we discuss the participation of people in deciding water distribution schedule plans among people who reported existence of water schedule in their area.

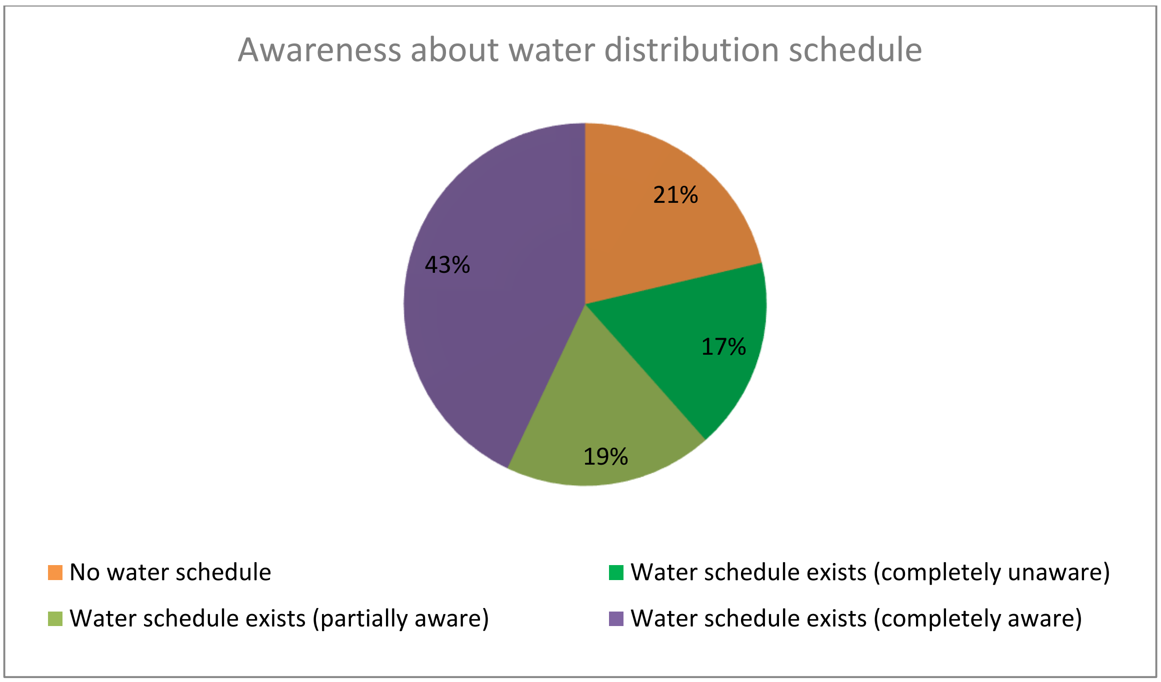


Figure 61: Degree of awareness of water schedule

Overall, majority of WUA members are involved in deciding water schedule (87 %) (Figure 62). No difference observed in participation between men and women (Figure 63). The numbers reflect high level of participation from members who were aware of water-schedule.

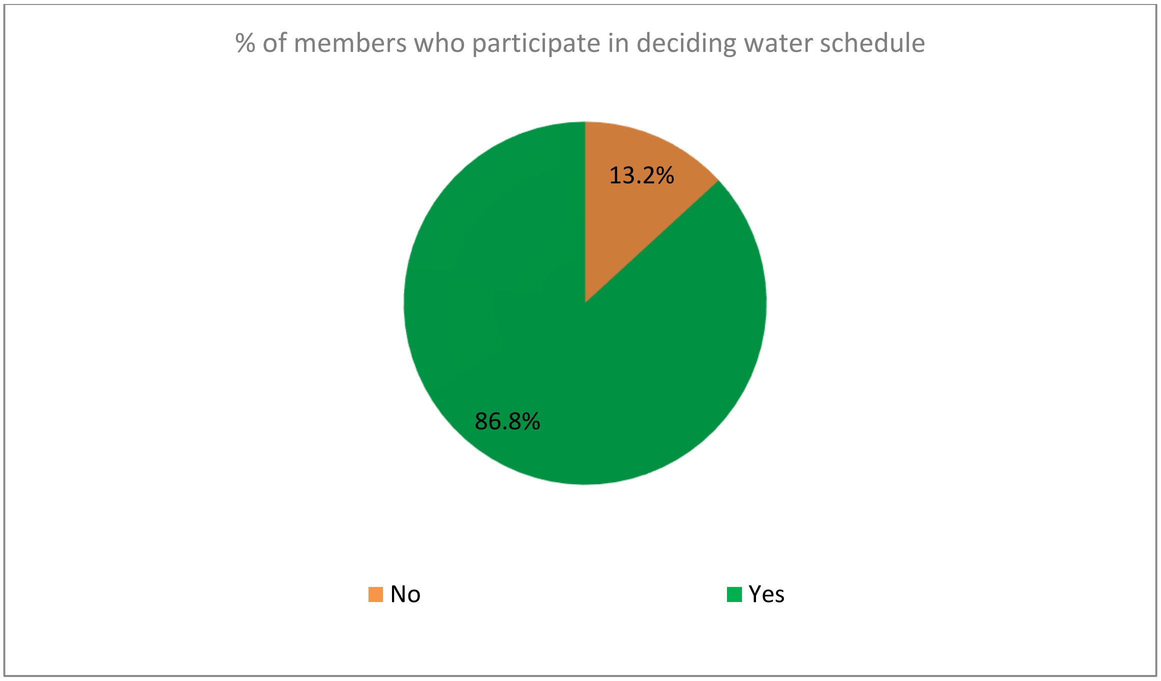


Figure 62: members who participate in deciding water schedule

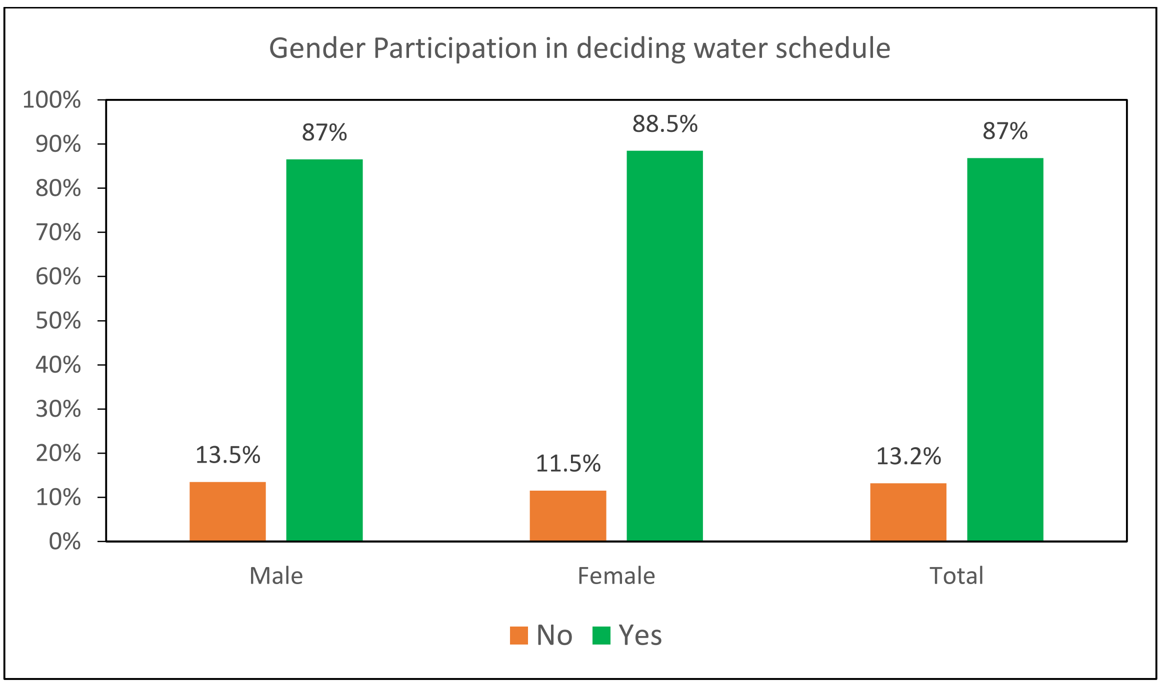


Figure 63: Gender in Decision-making for water schedule

Figure 64 gives the participation of members in deciding water distribution schedule across scheme types. Participation in decision-making regarding the water schedule is overall high for all schemes, with PDW showing highest percentages at 96% and participation in water detention schemes is well below the average of 87% at 78%. As discussed before, PDW with its smaller group size and clustered approach performs well which is reflected high percentage of attendance in WUA meetings (Figure 56).

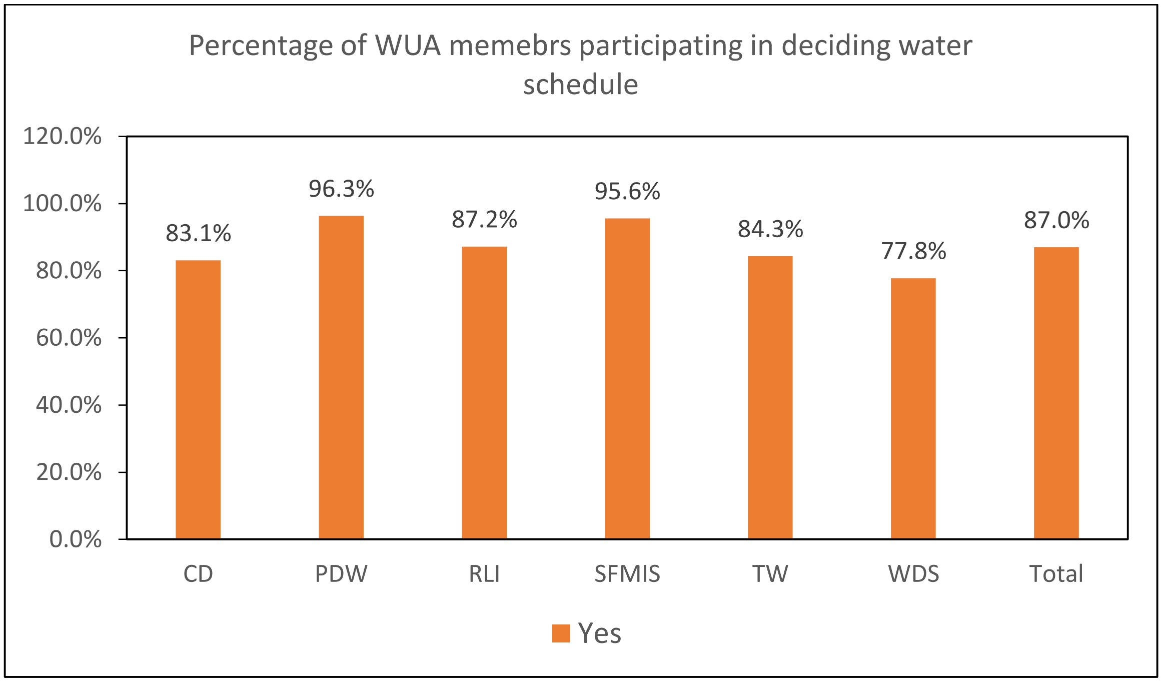


Figure 64: Participation in decision-making for water schedule across schemes

We also asked the respondents if the water schedule met their needs such as timely irrigation of water, adequate water for irrigation, adequate area getting irrigation water and fee paid for the water. Based on these four indicators, we see that the current water schedule satisfactorily meets the needs of 92% of the respondents[4].

[4] Low= rated 1 or 2; Medium = rated 3; High = rated 4 or 5, for each of the four indicators.

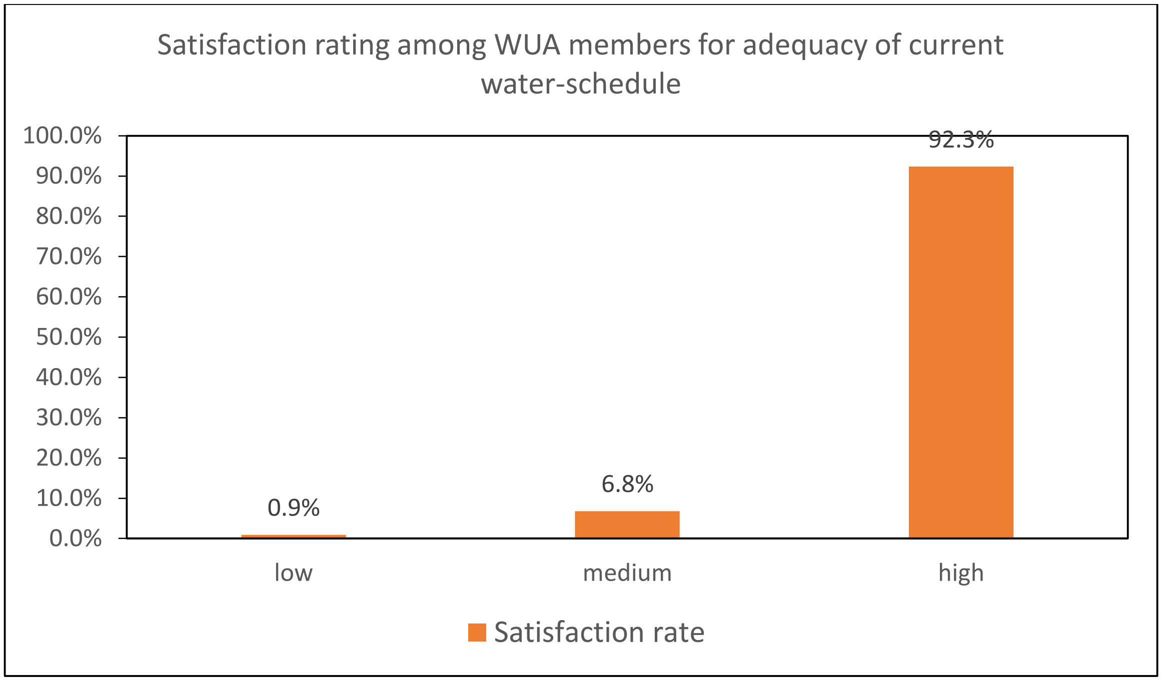


Figure 65: Satisfaction rating for adequacy of current water-schedule

4.5.4 Respondents receiving WUA trainings

Before handing over the irrigation system to the concerned WUA, the external support team is required to train and hand-hold the members in the initial stages. Training is an essential pre-requisite for a WUA to function successfully as it is assumed that the local members are ill-prepared for the various managerial responsibilities that they will have to undertake. Trainings are provided for topics like operation, maintenance, financial management, rules and regulations, and book-keeping. WUA staff members need to be trained in distribution and irrigation plans for smooth functioning and sustainable water use.

We asked the WUA members if they have received trainings under:

- Government policies on WUA
- WUA formation steps
- Roles of WUA members
- Water-conflict resolution
- Maintenance of infrastructure
- Operation of infrastructure
- Financial management of WUA
- Efficient use of irrigation water
- Others- training on horticulture, fisheries, agriculture etc.

Of the total respondents 69% said that they have received some training (Figure 66).

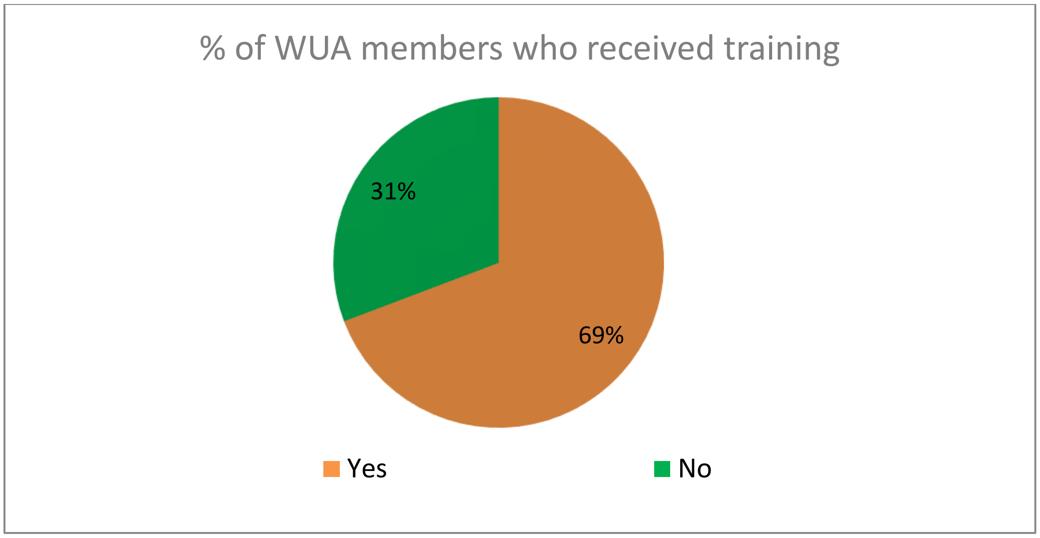


Figure 66: Proportion of WUA members who received any training

We found large variation in respondents receiving training across scheme-type. The highest percentage respondents receiving training was from PDW scheme members (78%), while the lowest at 59% were reported for RLI and SFMI schemes (Figure 67). Bankura and Purulia districts respondents reported low percentages of trainings at only 49% and 59%, respectively. This is in line with earlier findings where performance of schemes (in Agriculture, irrigation and institutional indicators) were found to be low in these districts. Birbhum again performs remarkably well with 86% respondents reporting that they received trainings. This indicator also reflects how well the pre-implementation phase was carried out.

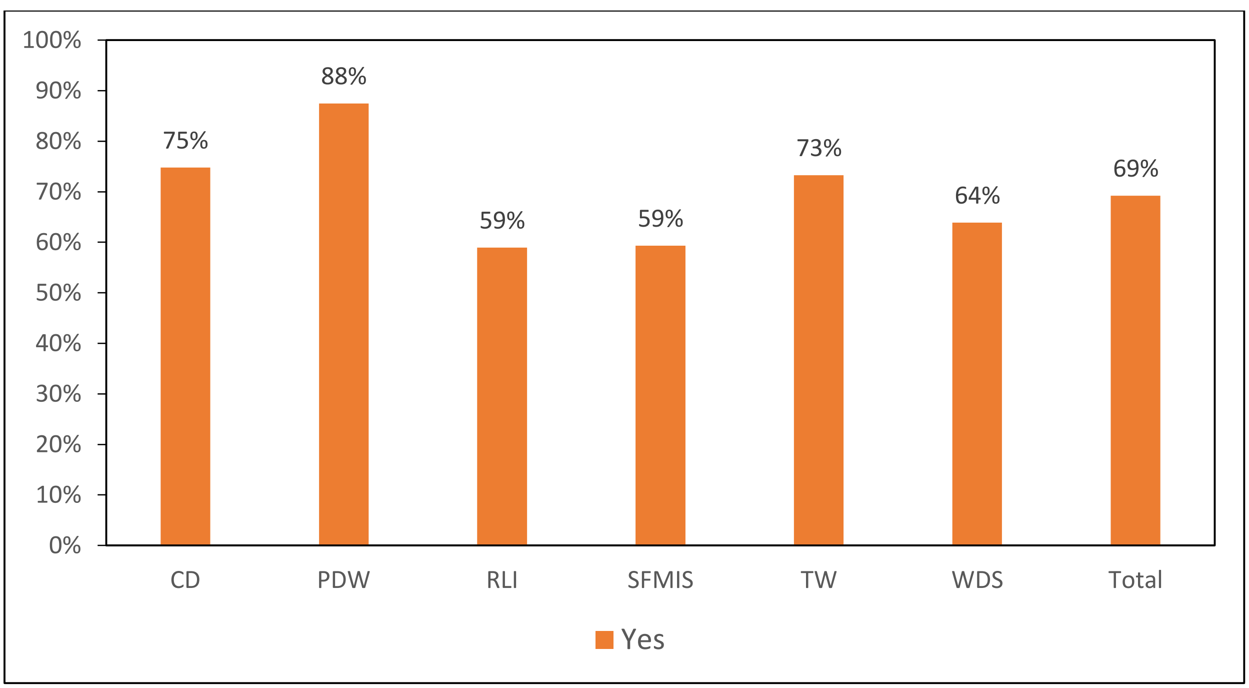


Figure 67: Proportion of WUA members who received any training- scheme type

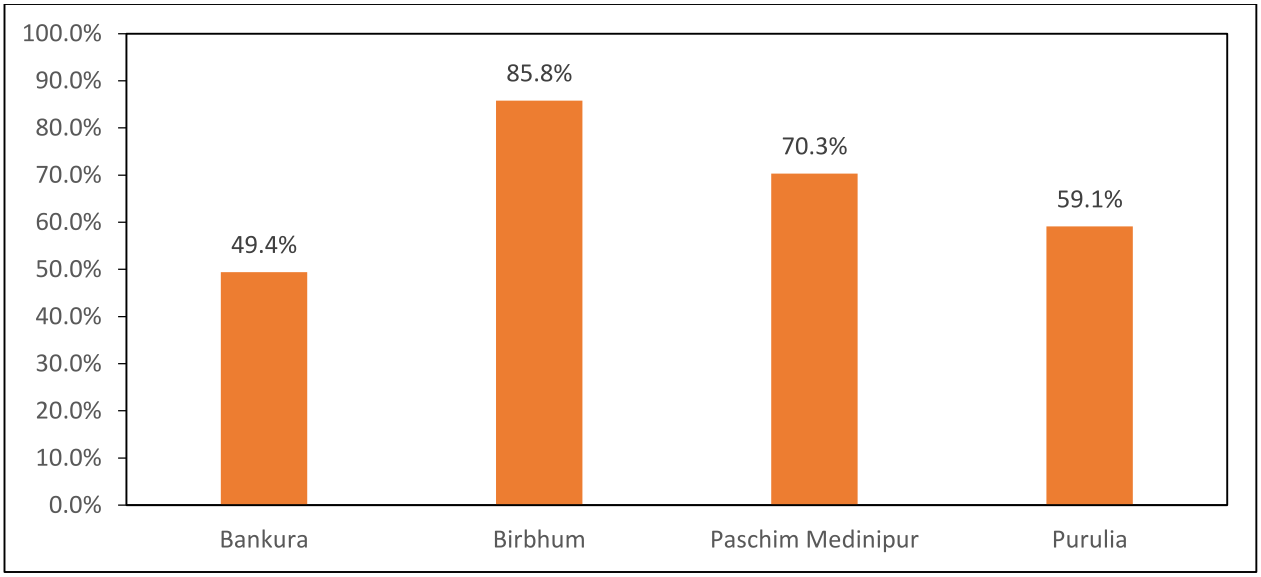


Figure 68: Proportion of WUA members who received any training- district wise

When assessing coverage of training across different topics, it was found that coverage of topics is not uniform (Figure 69). Most of WUA members responded receiving training on steps to form a WUA (69%), followed by government policies on WUA (54%) and maintenance of infrastructure (51%). On all other important topics like role of members, financial management, and operation of infrastructure, training provided is quite low. These are essential topics that the WUA members need to be trained on for sustainable management and efficient working after the schemes are handed over. With proper training provided from a year before handing over, internal capacities could be built better and the WUA would be more capable of functioning independently at the end of the project period. This gap in training need to be revisited and more targeted trainings can be provided to schemes where project team is still involved.

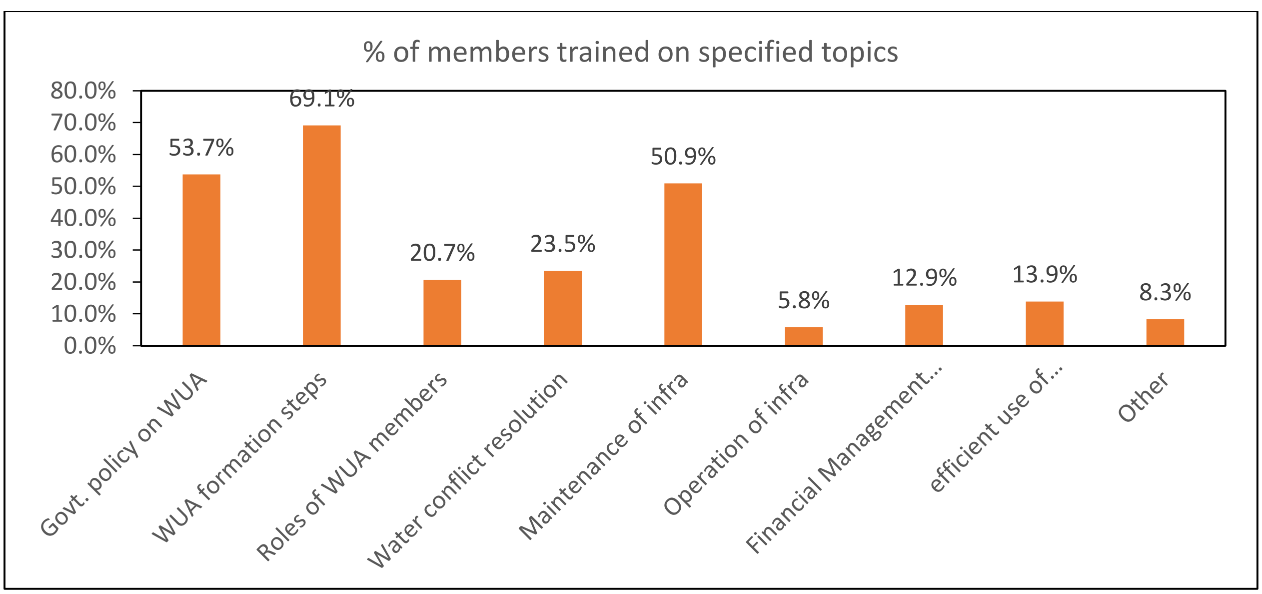


Figure 69: Topics WUA members received training on

Out of the 31% respondents who did not receive trainings, 40% said that either trainings were not held or they were not aware and not invited for it. 32% reported lack of time as a reason, while 16% reported that this was not of interest to them. The high percentage of people reporting lack of training held or not being invited is a cause of concern as it shows that WUA trainings were targeted to select members only. This select training manifests later on in terms of who has the capability of being in managing committee and can distort the power structure of WUA members. On the other hand, 32 % reporting lack of time is again a concern as this could be due to no communication beforehand or not consulting people when deciding the time. In going forward, there is a need to assess capacity of WUA members to run WUA sustainably over long term and if need be, going back to schemes to provide training again.

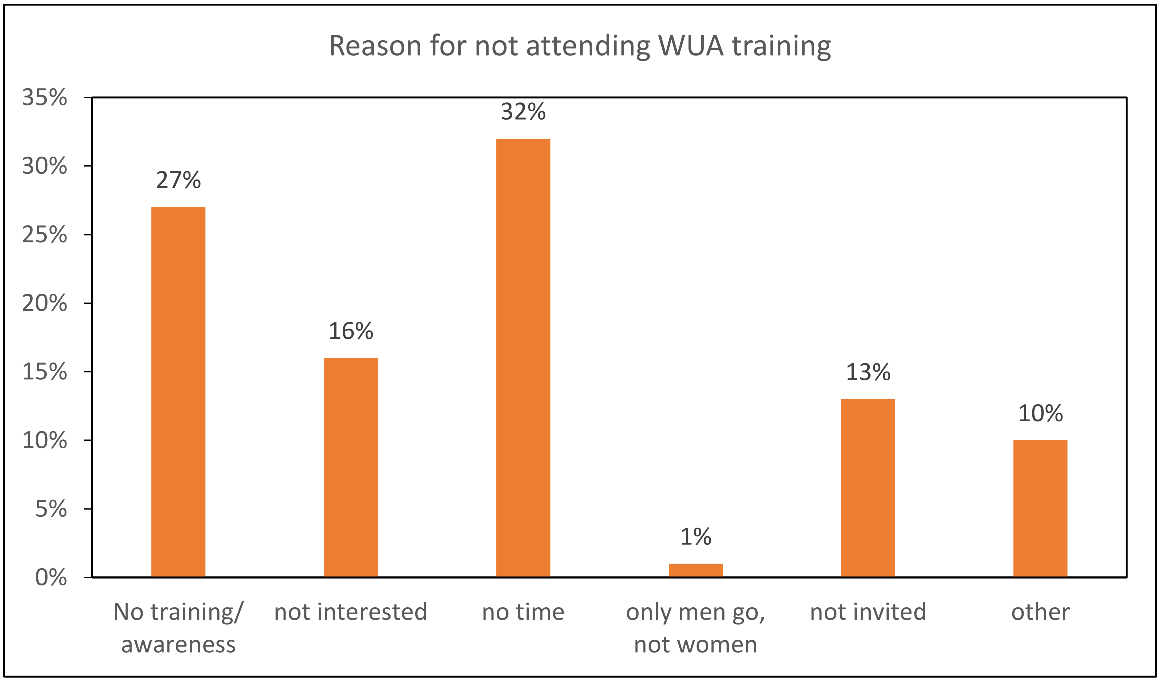


Figure 70: Reasons of the respondents for not attending WUA training

4.6 Social Indicators

An important pillar of integrated water management, social equity is one of the primary goals of the project. If implemented correctly, a water-user group can advance the goal towards social equity, and not be studied as an end in itself. It should provide entitlement, access and control to all the farmers within its command area and who wish to be a part of the water-user group. Two major social indicators, gender and societal class in the communities, are the focus of our study in equity.

Talking about gender, women constitute an important part of the daily agricultural activities in the study area. Their inclusion and participation in the Water User Association can lead to a more equal standing in society. This can also permeate into decision-making in household affairs.

4.6.1 Women involvement in agricultural activities

Women are involved in various agriculture-related and non-agriculture related activities. In case of agricultural activities (Figure 71), women are mainly involved in threshing or drying (68.6%), sowing (24%) and weeding (18%). Their involvement in other activities is below 20%. From our discussions, it was noted that generally women (especially from upper caste families) did not participate in any agricultural activity outside their homes. Hence their contribution to agriculture was restricted to preparing seeds, threshing and drying.

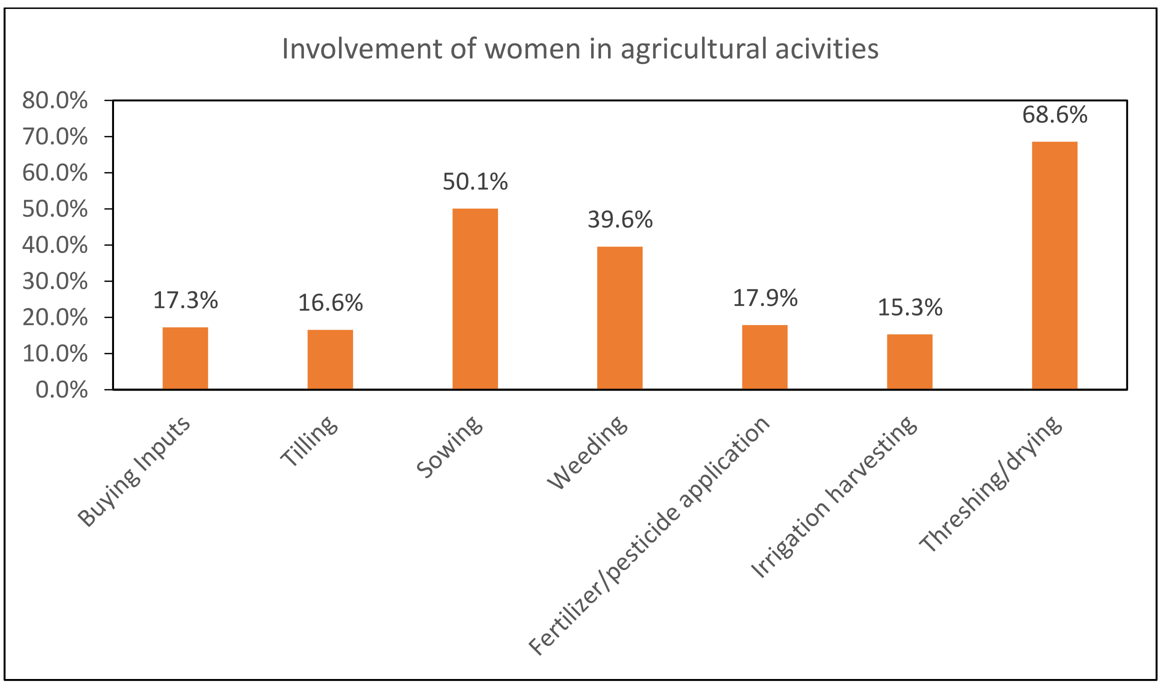


Figure 71: Percentage of women participating in agriculture-related activities

4.6.2 Female decision making

Women's participation in decision-making on large expenses of the household is one of the crucial indicators used to measure her level of empowerment. Institutions, social structures, and her own capabilities are main factors that can enable or restrain a woman's decision-making capacity and women empowerment in general. Through the WUA, we can provide institutional platform for the empowerment of women which would reflect in her involvement in decision-making at home too. Accordingly, we asked the respondents who takes the final decision regarding various topics at home.

As can be seen from Figure 72, overall decision-making power of women lies in the range of 18%-55%. The highest autonomy in making decisions is regarding livestock (55%) and minor household expenses (46%), while decisions regarding agriculture hover in the vicinity of 20%. If we look at the role of women in decisions regarding other non-farming activities like household expenditure and livestock/ fisheries, we find a more inclusive scenario than their role in farming-related activities. As discussed previously, although women participation in agricultural activities (like sowing, threshing and weeding) is quite high, their involvement in agricultural decision making is quite low. Men are considered the main farmer and the primary decision maker. This poses a challenge to include women as active participants of WUA. Planned and effective interventions with focus on gender can have huge success in bringing female farmers to the forefront. This is already happening in some WUAs and is illustrated in some of the case studies we discuss later.

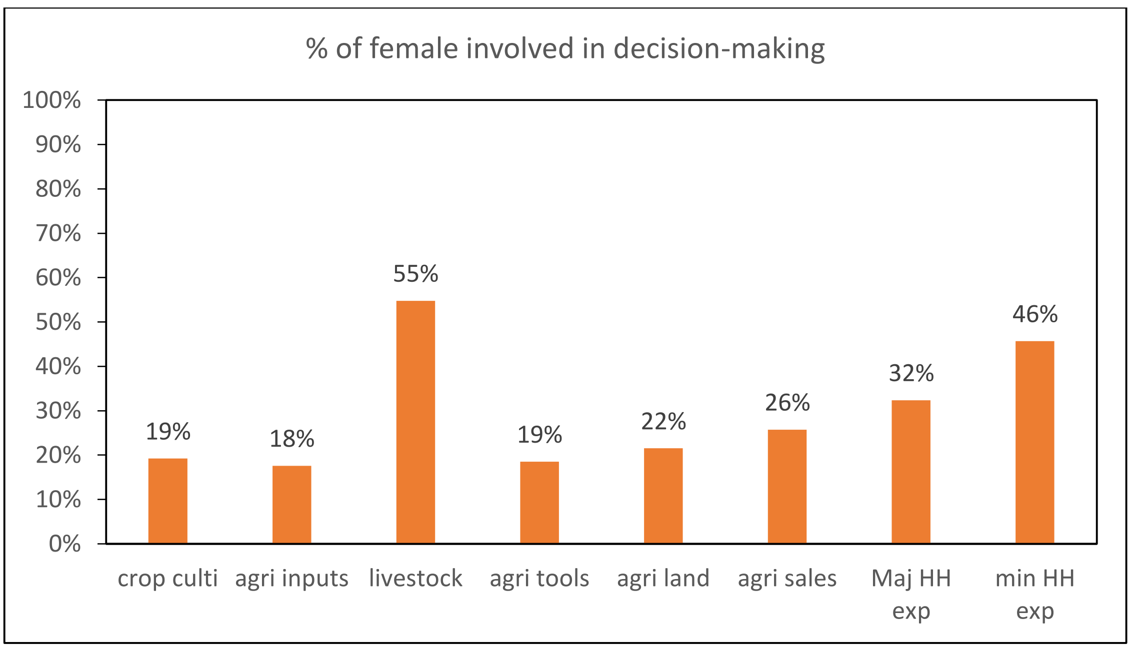


Figure 72: Person taking decisions with regard to various activities

4.6.3 Migration and its impact on sustainability of WUAs

Unsustainable agriculture and lack of alternate sources of sufficient income propel migration from rural India to urbanized centers. With assured irrigation water through the minor irrigation schemes, it is hoped that the farmers will be able to cultivate their land without having to rely on erratic rainwater supply, which might help in decreasing migration.

However, in our sample population, currently migration is not a major issue (Table 24). There was negligible permanent migration in the sample. A total of 16 people (N=567) reported permanent migration, out of which 14 are from treatment group and migrated before the completion of the minor-irrigation project. Seasonal migration is also very low, with only 3.5% of the people migrating from project areas. There is no difference that can be accounted to the districts that the migrants belong to, it is equal across all.

Table 24: Migration and its effects on the members

	Indicator (for treatment group)	Frequency (N=469)
1	Migration before project implementation	n=14
2	Reason for permanent migration	
	Better employment	n=10
	Education	n=3
3	Type of problems faced	
	Increased workload in agriculture	n=3
	Increased workload in household chores	n=4
4	Problem faced with WUA	
	Access to irrigation water reduced/stopped	n=1

4.6.4 Incidence of water disputes and conflict resolution

The diversity of water users for multiple purposes frequently causes local conflict of water sources and infrastructure, particularly related to irrigation and livestock. Conflict resolution is one of the mandates of the WUA to ensure trust amongst its members.

Data on cases of water disputes is very low, with only 25 cases saying they faced any problems (Table 25). When the follow-up questions were asked, responses drastically fell. 5% of the respondents (N=469) responded to facing some issues or conflicts after implementation of the WBADMI scheme. Out of these, 14 belonged to check dam and RLI schemes. Three responses were received that claimed that their fight was with WUA members. Of these, only two reported their conflict to the WUA body.

Table 25: Frequency on cases of water disputes

Variable	Frequency (N=469)
Cases of conflict	25

Conflict with WUA	3
Conflict reported to WUA	2
Reason for conflict: timing of irrigation water	2
Reason for conflict: irrigation over other farmer plots	1

If not handled well, conflicts can hinder substantial user participation in practice and may also obscure the allocation of funds by WUA leaders and constrain cost recovery objectives. The solution does not lie in a top-down imposed directive but from local WUA leadership and user participation. There needs to be more efficient reporting and handling of conflicts by the WUA. The WUA needs to be equipped to settle disputes satisfactorily to maintain social cohesion and ensuring everyone gets benefitted by the water irrigation scheme. This can be done by providing the required training and taking the inputs during training from the members also.

4.7 Comparison of WBADMIP with other non-project government minor irrigation schemes

4.7.1 Agricultural and Economic Indicator comparisons with non-project schemes

To capture how WBADMI project has resulted in added benefits, we compared the results of not just before-after implementation, but also with results of non-ADMI project minor irrigation schemes under other government programs. The WBADMI scheme is unique from other minor irrigation schemes because it has created Water User Associations for operation and maintenance of the schemes and it has given due importance to agricultural support services to enhance further the benefits of increased irrigation water availability. So we have compared WBADMI schemes with non-project minor irrigation schemes nearby under different government departments, which do not have WUAs and no such agricultural support services. Since all non-ADMI project schemes were surface irrigation schemes, to make a valid comparison we excluded ground water schemes (i.e. PDW and TW) from our comparison below.

In terms of performance, cropping intensity increased from 113.9% to 156.6% during the four-year period in WBADMI surface water schemes, while for non-ADMI project schemes it rose from 120.1% to only 145.1%. So the increase in cropping intensity has been substantially more in ADMI schemes as compared to non-ADMI project schemes.

Table 26: Comparison of cropping intensity between WBADMI and non-ADMI irrigation schemes

		Cropping Intensity ***(Standard deviation)***
2014 (Before)	WBADMI surface water schemes	113.9 *(21.1)*
	non-WBADMI schemes	120.1 *(18.8)*
2018 (After)	WBADMI surface water schemes	156.6 *(38.7)*

non-WBADMI schemes	145.1 *(40.1)*

After project implementation, cultivated area receiving irrigation in sampled project schemes stands at 84.9 % and 38.3 % in kharif and rabi, respectively in comparison to 53.3 % and 25.8 % in non-ADMI project schemes (Figure 73). The increase in non-ADMI project schemes is significantly smaller than sampled project schemes. The better performance of project schemes largely reflects the importance of managing project schemes through WUAs and agricultural support services.

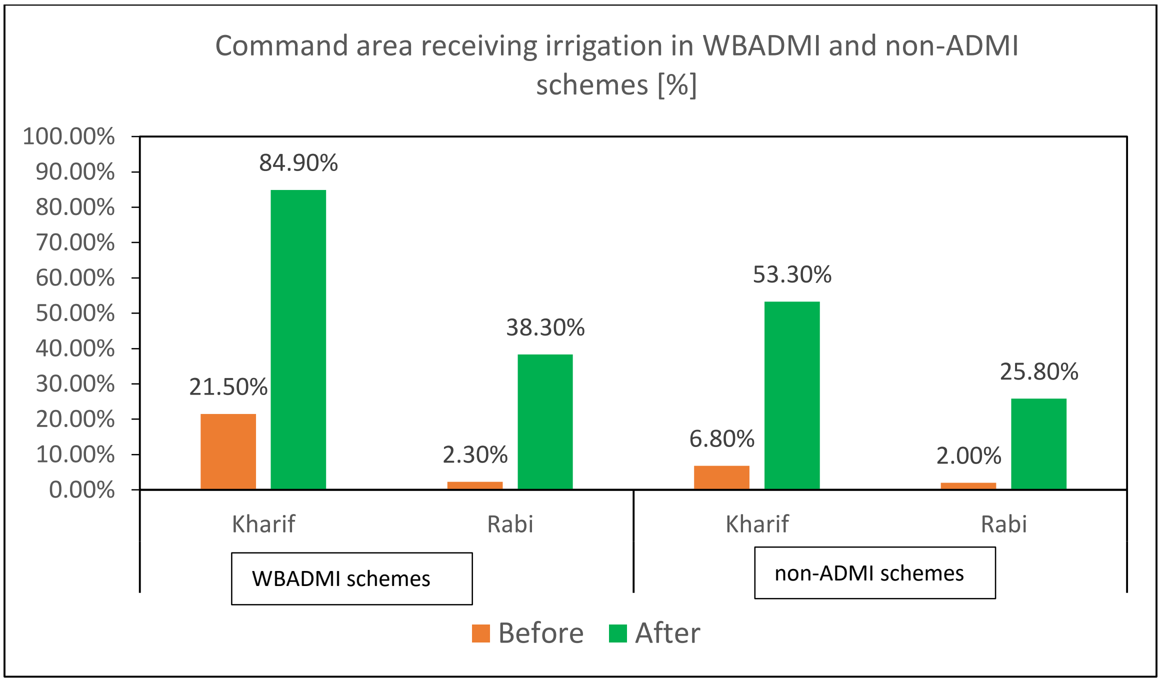


Figure 73: Percent of command area receiving irrigation in WBADMI and non-ADMI schemes

Similar results can be seen by comparing the crop diversification index (CDI) in project villages with other non-ADMI project schemes. As seen from Figure 74 below, before the scheme for 2014, the CDI was 0.23 in non-ADMI project schemes and 0.29 in WBADMI surface water schemes. For current year, the index in non-ADMI project scheme has hardly increased to 0.28, but for WBADMI schemes it has increased dramatically to 0.87. Using the difference-in-difference method, we found significant increase by about 0.53 index points in overall crop diversity index among project village farmers.

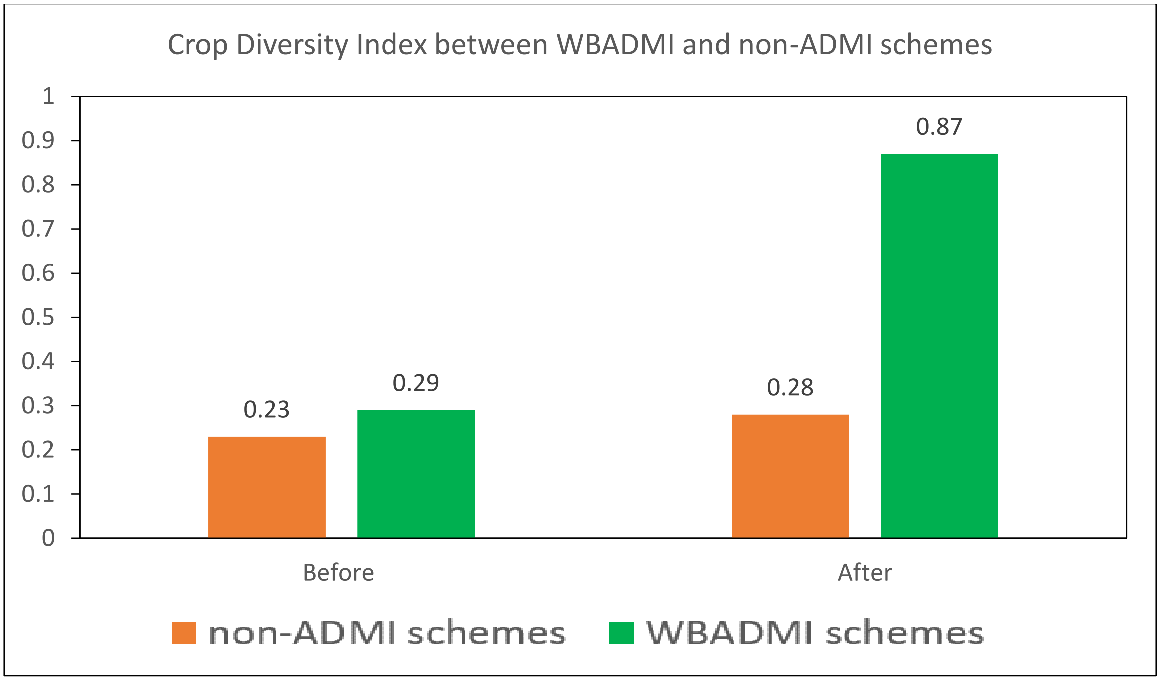


Figure 74: Crop Diversity index for WBADMI and non-ADMI schemes before and after project implementation

The beneficial effects of WUA management, relevant agro-advisory support, trainings on improved practices and input support etc. from the project are also reflected in added yield benefits. In all districts except Paschim-Medinipur, significantly better yield for kharif paddy was observed for project villages compared to non-ADMI project schemes (Figure 75). This difference with non-ADMI project schemes is most stark in Birbhum, where average yield for paddy was 4.8 tonnes/ha in project schemes which is far greater than the average yield of 3.6 tonnes observed in non-ADMI schemes of Birbhum.

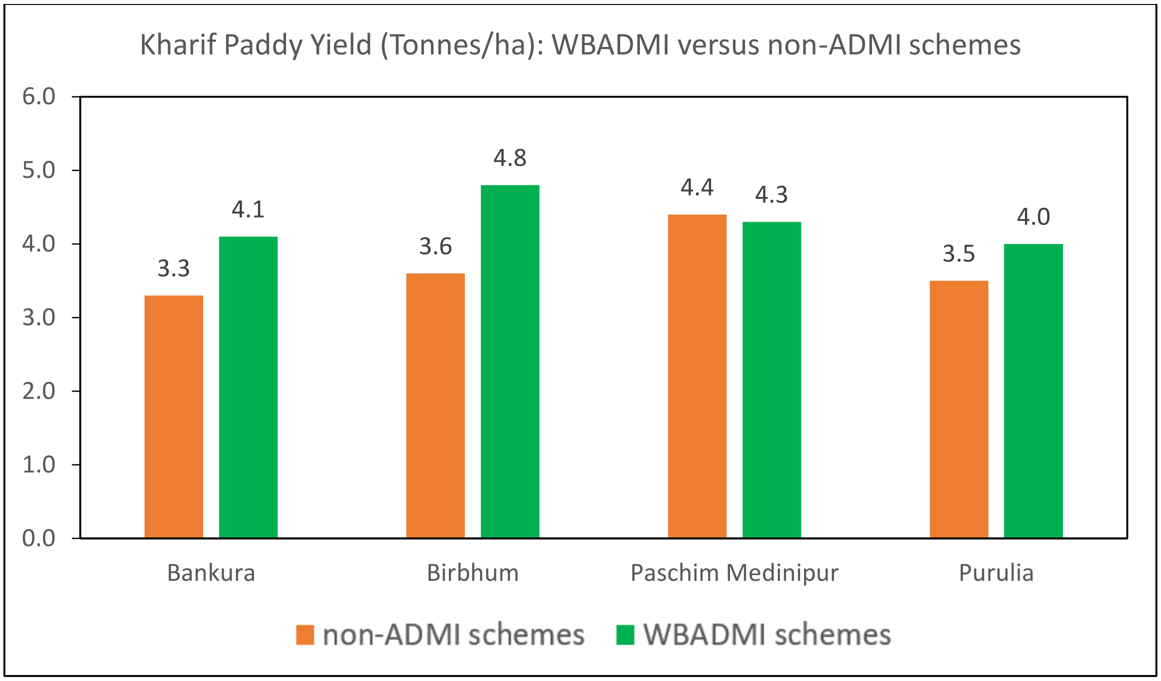


Figure 75: Yield of paddy in kharif in WBADMI and non-ADMI schemes, across districts

The difference in yield is also reflected in profit for farmers. Table 27 compares the median value of profit per hectare for three major crops: Paddy in kharif, Mustard and Potato in rabi, along with total yearly profit per hectare between WBADMI surface water schemes versus non-ADMI schemes. For farmers under WBADMI surface water schemes, median profit per hectare of kharif paddy is estimated at Rs. 39080, which is significantly higher than the profit estimated for non-ADMI project scheme farmers at Rs. 34595 / hectare. For both Mustard and potato cultivated during rabi season, project farmers under surface water schemes reported higher profit per hectare compared to non-ADMI project scheme farmers. For potato, project farmers reported a significantly higher profit of around Rs. 1 Lakh/hectare compared to Rs. 51,667 for non-ADMI project scheme farmers.

The median yearly net profit from cultivation for sampled farmers under WBADMI surface water schemes comes to Rs. 59305 per hectare of net sown area, which is significantly higher than median yearly profit per hectare for farmers from non-ADMI project schemes at Rs. 46703.

Table 27: Median value of profit per hectare for farmers of WBADMI surface water schemes and non-ADMI surface water schemes

	kharif Paddy Profit (Rs/hectare) – *median value*	**rabi Mustard Profit (Rs/hectare) – *median value***	**rabi Potato Profit (Rs/hectare) – *median value***	**Total yearly profit (Rs/hectare) – *median value***

WBADMI surface water scheme farmers	39080	29119	113963	59305
Non-ADMI scheme farmers	34595	27696	51667	46703

4.7.2 Social Indicator comparisons with non-project schemes

The effect of increased agricultural activities within WBADMI scheme villages in increasing the demand for agricultural labor and in raising the wage rate for agricultural labor is also clear when we compare WBADMI villages with non-ADMI scheme villages (Figure 76). In WBADMI project villages, average number of man-days that farmers worked as agricultural laborers is 61.5 days and is much higher than 22.6 man-days that farmers work as agricultural laborers in a year in non-ADMI project schemes. Increased demand for agricultural laborer is also reflected in higher wage rate for both male and female laborers in project villages as compared to non-ADMI project villages. However, if we look at non-agricultural labor availability, no such trend can be observed between WBADMI scheme and non-ADMI project scheme farmers (Figure 77). This is to be expected, since project interventions were primarily targeted for agricultural activities.

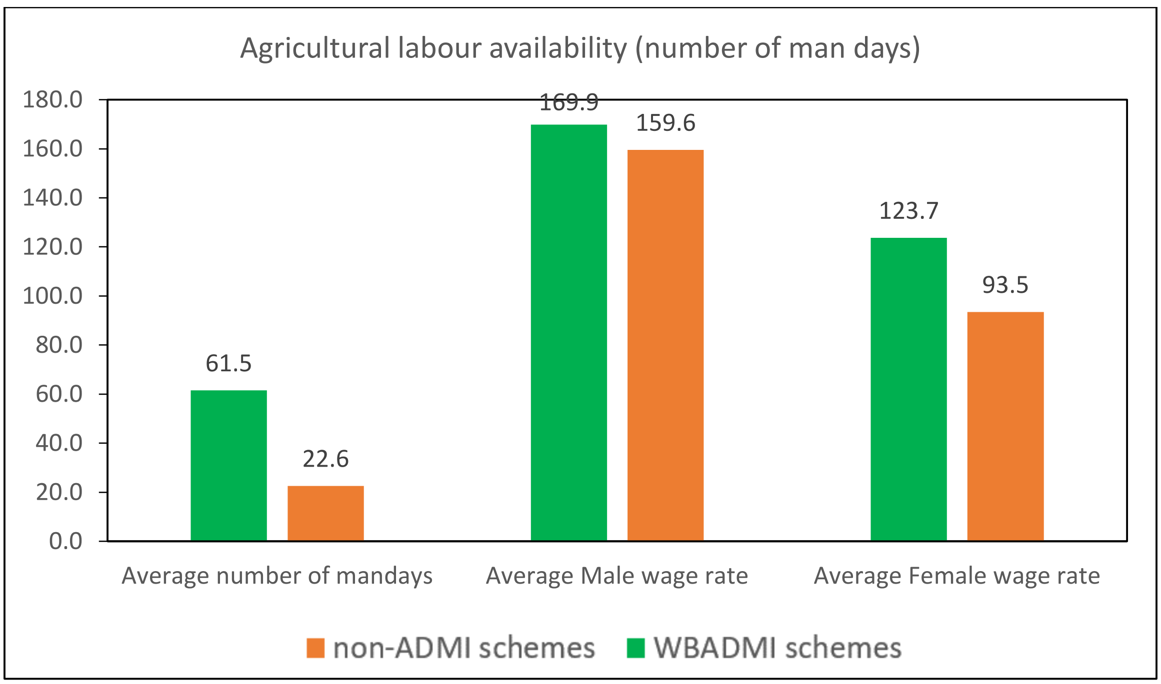


Figure 76: Agricultural labor availability for WBADMI and non-ADMI schemes

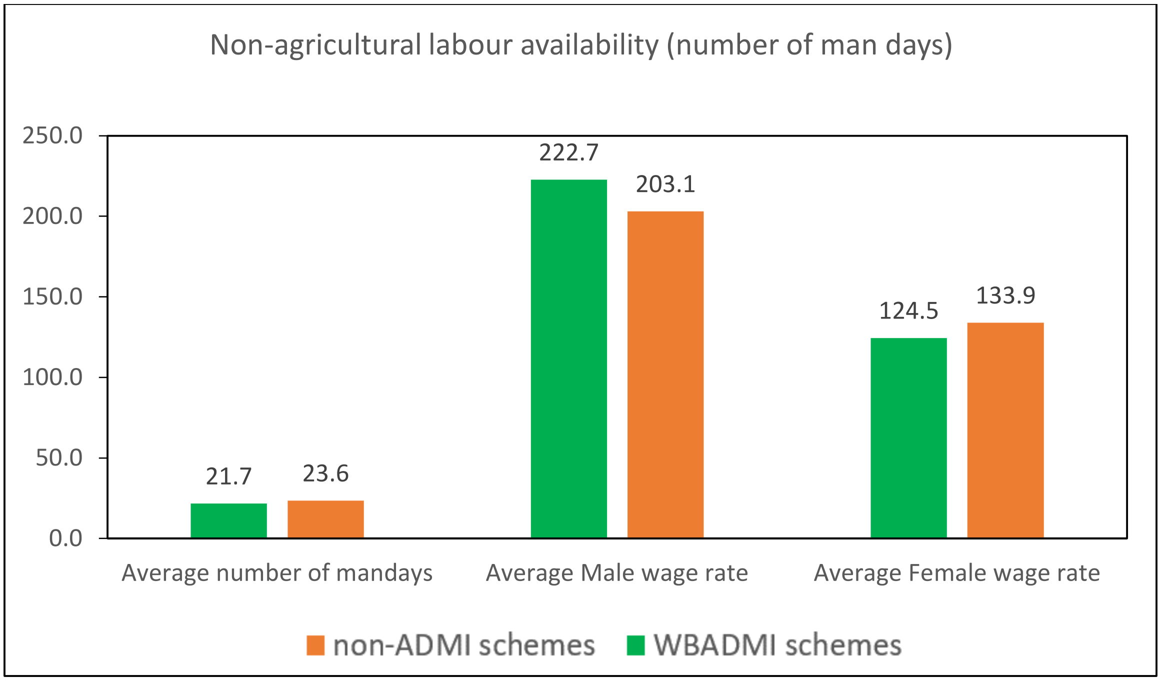


Figure 77: Non-agricultural labor availability for WBADMI and non-ADMI project schemes

To see if the WUA had any effect on women participation and decision making in the ADMI project areas, we compared the women from WBADMI scheme areas with those from non-ADMI schemes. As seen in Figure 78, in terms of involvement in cultivation, 72% of households in WBADMI scheme areas had women working in agriculture, which is slightly lower than 78% participation in non-ADMI project schemes. The difference is not significant. But in other activities such as livestock rearing (WBADMIP: 70%, non-ADMI: 43%), vegetable cultivation (WBADMIP: 19%, non-ADMI: 10%) and attending trainings and meetings held in the village by various associations and groups (WBADMIP: 21%, non-ADMI: 6%), women from the WBADMI project areas were much more involved compared to women in non-ADMI scheme areas.

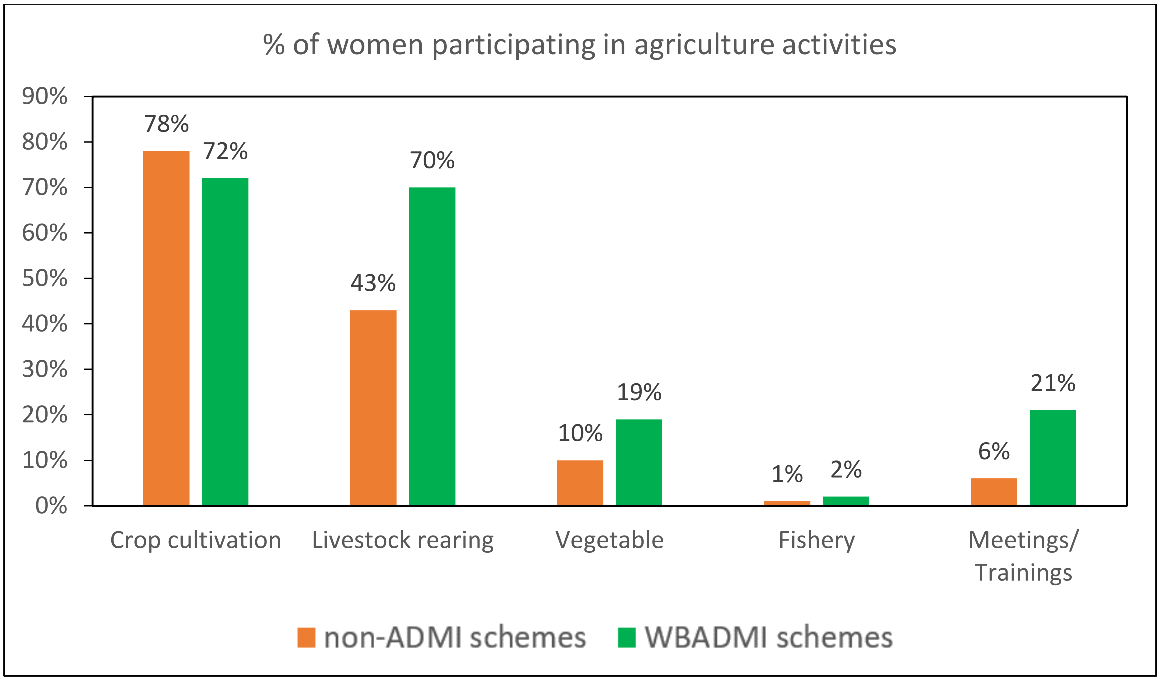


Figure 78: Participation of women in agriculture - WBADMI versus non-ADMI schemes

We also compared to see if the level of input provided by women in decisions at home differed between WBADMI scheme areas and non-ADMI scheme areas (Figure 79 and Figure 80). We find that overall input in most or all decisions (purple bar) concerned with agricultural activities is low for women (~15%), though women from WBADMI scheme areas do show higher percentages than non-ADMI scheme areas.

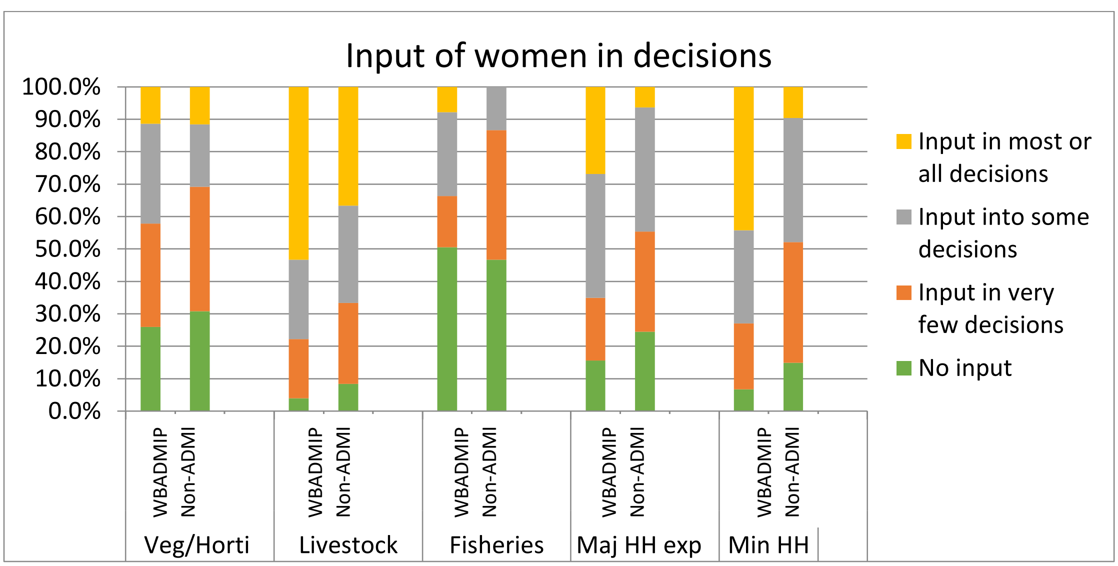


Figure 79: Comparison between WBADMI versus non-ADMI schemes on the level of input of women in decisions- I

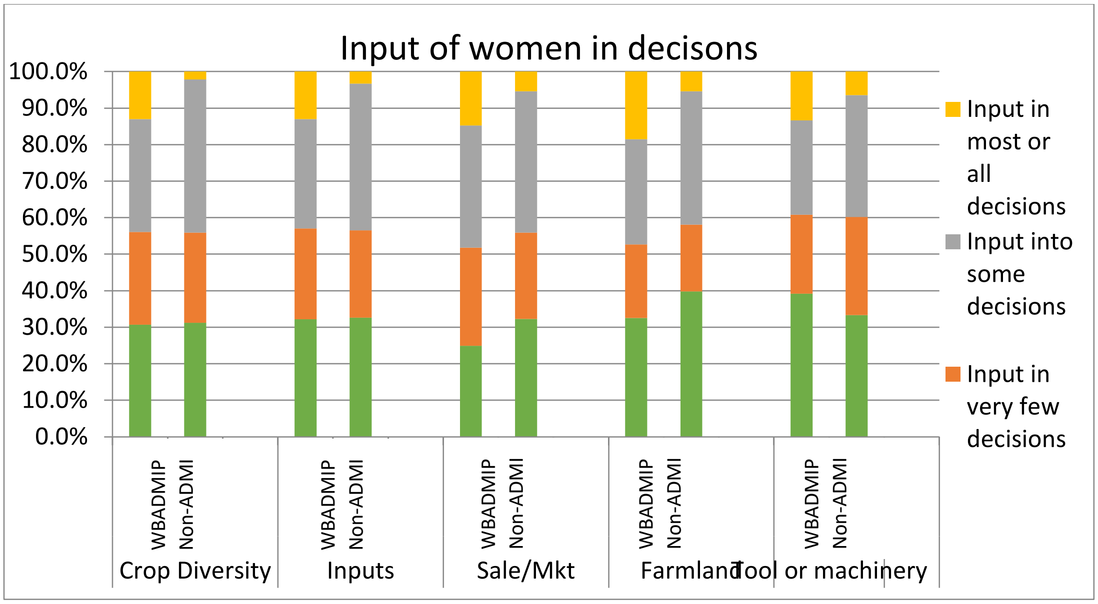


Figure 80: Comparison between WBADMI versus non-ADMI schemes on the level of input of women in decisions -II

Comparison of the performance of WBADMI schemes with respect to other non-ADMI project minor irrigation schemes of the government do indicate the added benefits of WUA and agricultural support services, which are part of the WBADMI scheme. The benefits are not only reflected in increased cropping intensity, higher crop diversification, higher yield and higher income, but also in agricultural labor demand in village and in women participation and decision making in agricultural activities.

5. Recommendations and way forward

Overall, the WBADMIP has done very well in achieving its Project Development Objectives of enhancing agricultural production, especially of small and marginal farmers and tribal farmers in the Project area by developing minor irrigation services and particularly bringing in community based irrigation management through WUAs. Our impact assessment study based on instruments of household sample survey, FGDs, KII, field visits and application of RS and GIS tools has demonstrated increase in cropping intensity, cropped area especially in Rabi season, increased irrigated area, and crop diversification. When compared with the similar micro irrigation schemes of the government, it clearly suggests the advantage of value addition through community based irrigation management and integrating this with agricultural support services. This arrangement has helped the project in converting '**Means**' in the form of improved access to irrigation water with '**Ends**' in the form of increased agricultural production and livelihood generation.

The Project has largely focused on supply side augmentation and rightly so to enhance water availability and access. However, the demand side management and on-farm water management has been almost missing. The element of convergence with other relevant schemes and programs has also been very weak.

Following recommendations have been made based on our impact assessment study for future consideration. Some of these have potential for consideration in formulating future policies and programs at the state and central level.

- **On-farm water management:** The project has helped in enhancing access to irrigation water through minor surface as well as groundwater schemes. One of the most critical observation is that on-farm water management in the sampled project schemes is almost missing. Irrigation is being generally practiced from field to field without any channel to field irrigation. At places, there are temporary channels without any planned network. Investments on improving on-farm water management including land leveling, channel to field irrigation, piped irrigation is critical to improve the water use efficiency and cover the proposed command area.

- **Water demand management:** Bringing focus to water demand management should now be one of the key priority area in order to achieve targeted coverage of irrigation during Rabi and pre-kharif season. In schemes with limited water storage (surface water schemes, PDW, RLI) this will help in covering more area and in TW schemes over-abstraction leading to long term risk of groundwater depletion can be avoided. Thus, going forward, there is a need to incorporate demand side management interventions including training on efficient agronomical and water management practices, promotion of drip, sprinkler and rain gun, better irrigation scheduling like AWD, DSR, soil moisture sensor based irrigation, surface or sub-surface water distribution pipe, and water budget based crop and water use management planning.

- **Shift away from *boro* rice** to low water consuming and remunerative crops through crop diversification has to be vigorously pursued through education, awareness, capacity building, needs based incentivization, better market linkages etc. Especially, for example, in TW schemes of Paschim Medinipur this is a serious concern where rabi paddy is taken as second crop with low physical as well as economic water productivity**.**

- **Convergence with development schemes:** WBADMI project schemes fulfil an important gap by creating water storage and/or enhanced access to irrigation in rainfed areas. Water, in itself is a vital means and when appropriately connected with production and livelihood support systems it helps in achieving the means. There is a considerable scope of convergence with development schemes of the state and central government including MGNREGA, RKVY, PMKSY, Finance Commission, NRLM, KUSUM and others for mutual benefit and effective use of resources.

The aspect on convergence has been largely missing with few exceptions (e.g. case study 6.4) and this example has demonstrated potential advantage of resource convergence. Thus, convergence with existing institutions including Agriculture, Fishery, Rural Development and relevant schemes is to be assigned high priority to harmonize synergy and optimize the benefits from investments made under WBADMI project. One proposition is to institutionalize convergence starting at District Level Implementation Committee (DLIC) with collector as the Chair.

- **Horticulture initiatives** undertaken in the project are showing encouraging response. Multi-tier horticulture with intercropping of field and vegetable crops, supported with micro-catchment based runoff harvesting, HDPE or Sipoline lined Jalkund (3-4 cubic meter *doba*), mulching, pitcher irrigation, vermicomposting may be further strengthened. Drip irrigation may be promoted for establishing orchards and this could be connected with fixed or portable solar panels especially in remote tribal areas of Bankura, Purulia for life saving irrigation.

- **Cluster based area plantations** of marketable fruits and vegetables with Farmers Producer Organizations or other such models of collective marketing will be a good option. Viable business model(s) may be developed.
- **Consider starting in-situ nursery** development as mother plantation is already developed. Successful example of women nursery with buy back arrangements by the project is worth scaling up. In order for the nurseries to become a viable enterprise, necessary material, technical knowledge, and hand holding support should be extended.

- **Fishery-a remunerative proposition:** The project has engaged fishery experts and made some welcomed interventions through Fishery Interest Groups (FIGs). There is a growing interest among women to get involved in fisheries activities. Stocking of more diverse fish species in the ponds where carp culture/composite fish culture/desi fish culture is undertaken will increase income substantially. Also, instead of just taking up spawn to fingerling culture, FIG may go for spawn to fry, fry to fingerlings and fingerlings to table fish to ensure round the year income.

- **Integrated farming system models:** There is a vast scope to introduce and promote crop-horticulture-livestock-fishery integrated farming system models around the ponds/water bodies/WDS to encourage multiple use of water, increase economic water productivity, ensure round the year income and risk minimization.

- **Process of approvals**: The gestation period (from the time of mass application by the local community to the handing over of the scheme) is very high and in some cases it was even about 3 years. This not only delays the targeted benefits but also de-motivates the community. The process of scrutiny and approvals may be smoothened at the SPMU and DPMU levels to clear the projects within a reasonable time period and responsibilities fixed for inordinate delays.

- **Withdrawal / Exit Policy**: For smooth exit of the project from the WUA and ensure sustainability after withdrawal, exit protocol or mechanism has to be devised and discussed with WUA well before the exit for smooth transition. This may include among other things building capacity of WUA for sustainable use of developed water resources, repair and maintenance of scheme infrastructure and associated equipment, collection of user charges/fees, involvement of gram panchayat/corresponding institutions (as a governance body), linkages and convergence for sourcing funds in case of major repairs, etc. This needs to be brain stormed to develop exit guidelines/protocols.

- **Making surface water schemes more centralized:** The centralized controlled schemes (where there is a common pump with distribution infrastructure such as TW, PDW, RLI) have performed relatively better compared to decentralized schemes (where individual pumps are used to abstract water from WDS, SFMIS). This has manifested in weak WUAs with much lower fee collection, non-existence of water management plans and overall low performance besides disfranchised economically weaker members. Going forward this needs to be examined and one way forward could be to have WUA owned centralized pumps with a piped distribution network or where possible gravity fed distribution system.

- **Training local youth on maintenance and repair:** It was observed during field visits that regular maintenance is necessary to operate these schemes but in many project schemes, knowledge to manage O&M was missing and members were unaware of facilities nearby where they can approach. This would have implications for long term sustainability of scheme infrastructure after handing over. Thus, project could work on developing local skills though targeted training among local youths who can provide long term solution for O&M.

- **Make WUA water fee and fund collection efficient:** The current level of water fee is insufficient to cover future maintenance requirement of aging infrastructure. There is a need to revisit the WUA fee and collection mechanism to create corpus for future maintenance activities. Viable mechanisms to create corpus for future maintenance fund should be explored.

- **Solar irrigation:** Major share of water fee collected from users goes for paying increasing cost of pumping due to electricity charges. With solar pumps, this operating cost could be minimized and even in remote locations pumps can be energized for accessing water. There are successful models of Solar Cooperative to incentivize farmers for saving energy by evacuating and selling the unused solar energy to grid and thereby also help conserve groundwater.

- **Capacity building** interventions for different stakeholders involving project staff, WUAs and other key agencies and personals are required to improve irrigation systems and agricultural practices as well as implementing similar projects.

- The Project is now matured enough to have its communication and knowledge dissemination strategy to widely share their experiences. May establish farmers' information hub linked with internet and mobile phone.

- **Intensifying and diversifying extension and outreach activities:** With extension and outreach activities as a critical pathway to achieve impact, it is important to intensify and diversify extension and outreach activities that include training and demonstration of new and improved agricultural practices and other innovative practices as still about half of the respondents don't appear to have received any training. Learning from Birbhum should be shared with the other WUAs.

- **More active women participation** Overall women representation in WUA membership and activities is low. It was observed that in many schemes, women members of WUA are only for the sake of formality to achieve project target of having 25 % women members. Interventions to increase women participation and involvement should be more nuanced and holistic considering local social dynamics.

- **WUA executive committee selection:** In many schemes, no explicit voting is done for selection of Executive Committee members and usually at the end of year, previous committee gets re-elected. Over the long term, this carries the risk of putting WUA power with few members creating power imbalance and alienating weaker members. There is need to evolve a mechanism to revolve the WUA leadership that restricts continuing in managing committee for not more than 2 years continuously. Also, there is need to make WUA institutional framework more lean as there was hardly existence of sub-committees in practice.

- **Revisit command area maps of project schemes:** It was observed from the field visits that in many cases extent of command area as mapped didn't match well with actual command area receiving irrigation. Thus, there is a need to re-visit and accurately map command areas of the schemes.

- **Revisit planning & design of surface water structures:** In some of the surface water schemes, the structures including embankments, inlet and outlet are damaged due to undercutting below the structure, faulty inlet/outlet, slope failures and as a result they underperform. Given that a significant fund has already been invested in these schemes, it would be prudent to revisit such schemes where infrastructure is not up to the standard and lessons from such failures thoroughly examined from hydrological, hydraulic and structural design aspects for future planning and design of such structures.

- **Advance tools for monitoring:** Going forward, significant opportunity exists for near real-time monitoring of schemes through technology integration from satellite data, Open Data Kit, Google Earth Engine to support large-scale impact evaluation of irrigation schemes in West Bengal. Seamless front-to-back solutions using Google Earth Engine apps have a potential for greater operational efficiency and effectiveness and better governance.

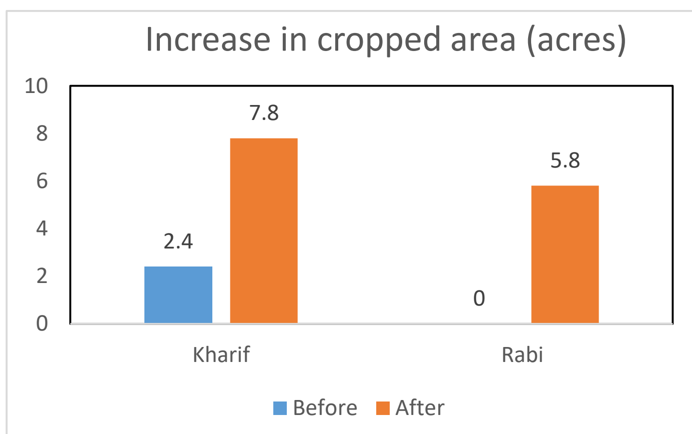
ANNEX 1 – Case Studies

A. Solar irrigation: Kanmora Solar PDW

A case of small dynamic community where no-cost solar irrigation has led to high and efficient community participation

Kanmora solar pump-dugwell (cluster 1) located in Rajnagar block of Birbhum district is an example of how solar irrigation, about which only a few villages had heard before the WBADMI project, is bringing significant positive changes in the village's agro-economy. Kanmora solar PDW is a cluster of five dug-wells, each powered with a solar pump (2 kW solar panels attached to a 2 HP pump) which covers individual command areas of 12 bighas. The cluster consists of a total of 23 WUA members.

The village has an uneven topography and an arid landscape. With no source of irrigation and exorbitant cost of constructing private pump-dugwells, there was no Rabi cultivation before the arrival of the WBADMI scheme. Even in Kharif, due to uneven topography and non-reliability of rainfall, cultivated area was very minimal. However, this changed soon after the implementation of WBADMI scheme. Currently, among sampled farmers, 7.8 acres and 5.8 acres of area is under irrigated agriculture in Kharif and Rabi, respectively. It shows a significant increase from just 2.8 acres in Kharif and no cultivation in Rabi before the project was implemented. Due to this, seasonal migration has reduced to a large extent and there is more demand from villagers who are not part of WUA. However, this is attributable not only to the irrigation infrastructure but also to how the community manages it through WUA.



Power of Solar

In this village, where electricity is a recent phenomenon, solar energy is paving the way for prosperity among members. The often reported benefit by villagers was that *it runs without any cost.* This availability of free power and freedom from electricity bills that solar irrigation brings helps achieve two things:

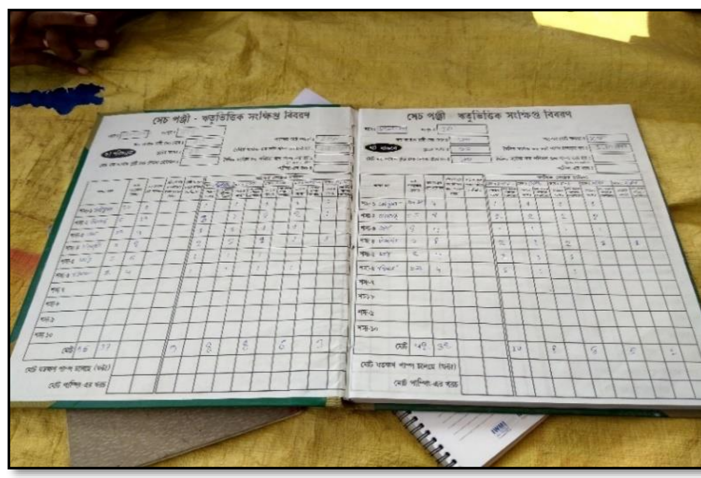
1) It significantly reduces WUA water fee, making it affordable and equitable for all the water-user members and leads to prompt and efficient fund collection.

2) All the fund collected can be utilized for regular repair

The above are necessary to make WUA sustainable by making community participation stronger. This is evidently visible in the WUA's planning and management. The only hindrance to widespread adoption of the solar pump dugwell once the project aid is withdrawn is due to its high costs of setting-up and maintenance of solar panels. This could also be explored through on-going solar irrigation schemes.

Efficient cropping pattern planning and management

The WUA has demonstrated an impressive water management. Before each season, the members hold a meeting to plan cropping pattern and water distribution schedule based on availability of water. They maintain very robust and detailed records of such decisions and record what was achieved against their planned targets. This has helped WUA become more efficient in planning and managing water by way of past records acting as learning for subsequent seasons.

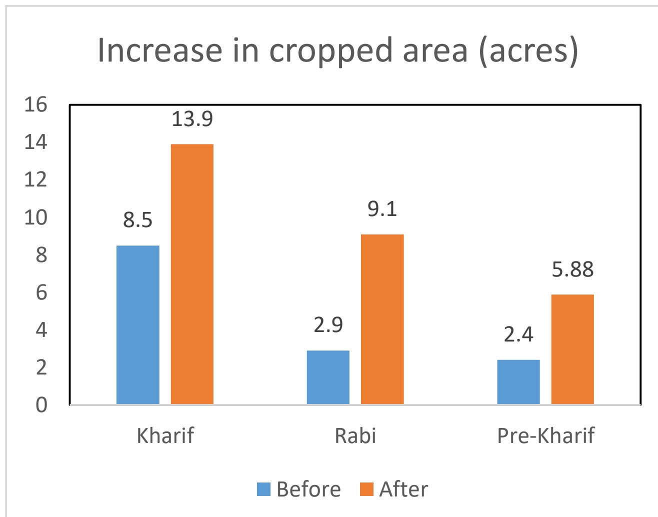


B. Baida RLI – Paschim-Medinipur

A case of strong local leadership leading to increase in productivity and crop diversity

Baida River Lift Irrigation (RLI) located in Jhargram district (previously part of Paschim-Medinipur) is an example where the WBADMI scheme has energized a community led by strong leadership. WBADMIP has made accessible the river water that was flowing nearby but was always out of reach. Farmers relied on diesel pump sets to draw water. This was expensive and it limited the area cultivated by the farmers. This RLI scheme, which consists of two electric 10 HP pumps and supplies water to a large command area of 80 bighas using 13 distribution spouts, has replaced the diesel pumps. The WUA for this scheme has a total of 72 members.

The positive impact of the RLI scheme is clearly observed in increased cropping area across all seasons. There used to be very minimal Rabi cultivation as irrigation with diesel pumps was expensive and not everyone could afford it. Even in Kharif, due to uneven topography, upland areas had limited cropped area and non-reliability of rainfall led to regular crop damage. However, this changed soon after the implementation of the WBADMI scheme. Currently, among sampled farmers, 13.9 acres, 9.1 acres and 5.8 acres of command area is reported to be cultivated in Kharif, Rabi and pre-Kharif, respectively, increasing significantly from just 8.5, 2.9 and 2.4 acres. However, achieving this was not easy and straightforward in a large WUA comprising of 72 members, 80 bighas of command area and expensive infrastructure and machinery that requires regular maintenance.



Strong and young leadership

Leadership provided by their young WUA president has gone a long way in setting-up a smooth and sustainable operation of RLI schemes where annual electricity costs of running the schemes goes over 1 lakh rupees and infrastructure requires regular maintenance.

This was achieved through clear communication and bringing transparency and accountability in financial operations, supported by robust reporting mechanism that went beyond the training they received. The financial books kept here for 72 farmers was among the most detailed, keeping track of each transaction (however small the amount) along with records of all receipts. This transparency and accountability was identified to be critical by the WUA leadership for smooth operation.

Do it yourself

Another area where this particular WUA showed remarkable attitude was in how they managed the infrastructure. The large command area with 13 spouts came with a long underground pipe system which is prone to leakages. The farmers understood at the start itself that leakages would need to be dealt with regularly and that it wouldn't be financially feasible to pay for repair each time. The young and enterprising farmers took the initiative and learned how to repair the pipe themselves by observing the technician at work. This has made the WUA independent and able to sustain with little outside support.

One reason of such dynamic involvement was also that people were already doing irrigation and cropping before WBADMI scheme was implemented, and awaited the opportunity to expand, which they grabbed when it came. With this scheme, they adapted to a low-cost way and expanded rather than starting from scratch, which is the case in many other schemes. Involvement of youth in WUA leadership brought more ingenuity and dynamism in its operations. Market linkage was another crucial factor that paved the way as during Rabi Season large number of buyers of potato & vegetables come into the village – crucial for their success.

C. WDS Gokulnagarpally Unnayan WUA: Purulia

Tribal Women Empowerment- The success of Purulia

Gokulnagarpally Unnayan WUA located in Purulia district, though being only a year old, is setting an example in tribal movement empowerment. The WUA is comprised of only women who are vibrant and courageous. This has been possible through effective outreach, support and extension activities provided by WBADMI project. The support has been on two sides: institutional and agri-technologies. This has brought the paradigm change on how women contribute and participate in agri-economy along with a welcome shift in attitude among the village males towards the women.

Institutional linkages and introduction in agri-technologies

On the institutional side, project focused on strengthening connections with local authorities and linkages with other government schemes in the area. This helped in getting additional and complementary support from other schemes to multiply the benefits. On the agri- technologies side, project introduced new technologies and practices including short-duration drought-resistant paddy, SRI practices and line sowing, seed treatment and preservation. They also installed a community pump. The outcomes of above activities have been remarkable. It has led to inclusion of other IGAs (income generating activities) like nursery for drumsticks and fishery. These have helped increase income substantially and have reduced migration among the local youths from 40% to 5 % at the end of Kharif. The WUA earned Rs. 50,264 from drumstick nursery that was established with project assistance. Spawn to fingerlings culture which was introduced under the project's fisheries wing fetched them Rs. 1,40,880 by selling the fingerlings to other WUAs.

With better agricultural practices and technology provided, Kharif paddy crop is harvested earlier, vacating land sooner for crops like potato (use of residual moisture reduced irrigation requirement) and at the same time has reduced overall mortality of the crops. In one case, assured irrigation as well as drought tolerant short duration paddy variety has doubled the production from 2.5 quintal per bigha to 5 quintals per bigha.


Difference in rice crop: improved vs traditional

Bringing social change

The empowerment brought by the scheme to the women in the WUA has implication for social issues as well. The empowered women contributing to economic activity have taken the lead and their collective effort led the local authority to stop illegal liquor from being sold in their village. This brought about more participation of men in farming and also improved the status of women in their community.

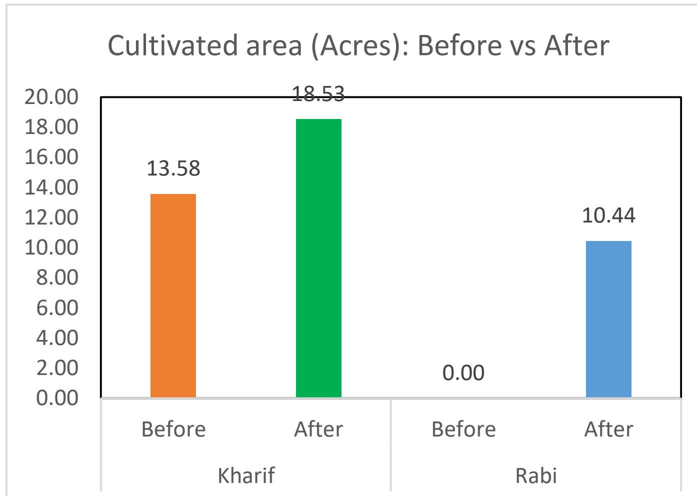

Early vacated SD Sahbhagi dhan field for potato

D. Bankati RLI scheme: Bankura

A case showing the way towards convergence

Bankati river scheme is located in Kharta-1 block of Bankura. The scheme was handed over to the WUA in September, 2015. The WUA has strong connections with local panchayat, which has led the way to convergence of multiple government schemes centering around the WBADMI scheme. This was made possible through local leadership and strong community participation.

Under the WBADMI scheme, the funding agency invested Rs. 32,97,277 in the project. However, WUA has till now attracted investment worth Rs. 59,35,000 through convergence of government schemes, which is in addition to other inputs (like seeds, fertilizers, fingerlings) that have been provided. The success of scheme is visible with cultivated area of sampled farmers increasing by 36 % in Kharif and in Rabi, where no cultivation used to take place before, now more than 50 % of Kharif area is cultivated.



Below gives list of works that has been done under convergence drive in WUA:

- Plantation through MNREGA
- Extended Pump House for smooth water lifting through Central Finance Commission (CFC) & State Finance Commission (4th SFC) grants
- Irrigation Channel by 14TH FC
- Pond Re-excavation by MGNREGS
- Cashew nut Garden
- Converting complete village to village of pulses
- Fishery and horticulture
- Field channels through Department of Agriculture

Case of Bankati WUA sets an example on how convergence with other government schemes can help make WUA stronger, multiplying the benefits and can ensure long term sustainability of WUA. This model should be used in other project schemes.

E. Uluberia WUA: Carp culture

Improving health, food security, and livelihoods through training in scientific management of fisheries

Uluberia WUA located in Purulia, westernmost district of West Bengal, has shown the way on how WBADMIP schemes has brought positive and remarkable changes in fisheries, adding to both income, food and nutritional security. There are six water bodies suitable for aquaculture in Uluberia village. **Prior to implementation of the project**, the beneficiaries used to stock mixed seeds (both fry and fingerling) of Indian Major Carps (Katla, Rohu & Mrigel) in the same water body without any regard to scientific stocking. No scientific management was followed and fishes were grown only for domestic consumption. Such extensive management practice and zero maintenance of water quality parameters resulted in poor fish growth and reduced environmental hygiene leading to disease out-breaks and mortality. As a result, annual productivity was very low and generally varied from 600-800 kg /ha. Poor health of the fish also fetched negligible price of around Rs. 50/- to Rs. 60/- per kilogram of fish. Lands were mono-cropped where *kharif* paddy was only grown. Most of the villagers used to migrate to other districts, cities or even other states to work as daily laborers. Access to food was limited and malnutrition was rampant, particularly visible among children.

Turning failure to success

Intervention by WBADMIP mainly started from the year of 2015 (FY 2015-16) by providing inputs and hand-holding training in the following water bodies with ten FIG (Fisheries Interest Group) members and 20 secondary FIG group members. But, the results were not very encouraging due to drought situation and rapid early utilization of water for providing lifesaving irrigation to agricultural crops. Due to such adverse climatic conditions, in 2016-17 financial year, another initiative was taken up in the project for

Year	Type of intervention	No of ponds and area	Net income (Rs.)
2015-16	Direct and secondary	4 ponds and area of 5.98 ha	220064
2016-17	Market linkages	3 ponds and area of 5.56 ha	818874
2017-18	Mass production	4 ponds and area of 7.98 ha	924704

sustaining carp culture technology through fisheries market linkage scheme, with additional number of beneficiaries. Results were far more encouraging this time around and building upon this success, in 2017-18 under the fisheries mass production scheme, beneficiaries were provided with proper training and essential critical inputs like carp fingerlings, supplementary feed, dragnet and *handi* to get an ideal productivity commensurate with scientific carp culture practice. Due to these interventions, net income from fisheries increased from Rs. **2.2 Lakhs in 2015-16 to 8.2 Lakh in 2016-17 and 9.2 Lakh in 2017-18.**

Improving livelihoods while reducing migration

After completion of the project period, it seems that a significant change has taken place with regard to fisheries activity, socio-economic status, nutritional status, and job opportunities in Uluberia. With the harvested rain water in the pond, farmers have started cultivating vegetables, pulses, oilseeds, maize etc. in Rabi and summer season in addition to the now assured Kharif paddy cultivation. Scientific fish culture techniques like pond preparation, water testing, scientific stocking, feeding, netting, liming, etc. are now meticulously followed. In addition to Indian major carps, exotic carps and even high value fish like the featherback fish (Notopterus chitala) is also stocked in the pond. Area of fish culture has increased and more farmers are becoming interested in pursuing fish culture. There is even a growing interest among women to get involved in fisheries activities. Migration has sharply declined and fish productivity has now increased to 2000-2500 kg/ha. Surplus fish production has also given the farmers the viable option of earning livelihood from fish culture.

F. Kalidaha Purbundh WUA: Spawn-fingerlings

In 2018, through spawn to fingerling production scheme of WBADMIP under DPMU Purulia, Kalidaha PurBundh Water User Association (WUA), the members of which are tribal women of Kashipur block, were engaged in spawn to fingerling production activity. The age-group ranges from 23 to 58 years old and education level is from primary to secondary, although 5 members, out of the 10, don't have even that much education. The group selected one of their village seasonal pond with 0.25 ha effective water area called "Barir Bundh".

It was noted that **before the intervention**, the group members did not have adequate operating capital, knowledge or technical skill regarding scientific fish culture practices and were only engaged in domestic work. **Thereafter**, efforts were taken by the project staff to empower this group of women with technical skill, providing critical inputs for fingerling production and create market linkages for selling the produced fingerlings to other farmers who have demand.

Leap in income and social standing

At the end of the culture duration, women FIG members saw a production of 20,115 nos. of fingerlings, which were purchased by WBADMIP, DPMU, Purulia at stipulated rate of Rs. 2/- per piece, which helped the group earn Rs. 40,230 /-. The group also sold 16,300 nos. of fingerlings to DPMU, Burdwan, from which Rs. 32600/- was generated. Furthermore, they sold about 7390 nos. fingerlings to the neighbouring farmers at Rs. 3/- per piece from which INR 22170/- income was generated. Hence, a total of INR 95000/- was generated by this group within four months against an expenditure of INR 22450/- (INR 12450/- by beneficiaries and Rs.10000/- as project contribution).

The project has helped the group to inculcate self-confidence among them, raise their socio-economic status and earn money within a short period of time without much drudgery. At present, the remaining fingerlings have been sustained in the pond at stunted growth condition and the group is planning to culture them in a nearby water body called Kalidaha Mahato Bundh SFMIS scheme, after taking lease from the available balance they have from selling fingerlings.

Within a year, this group has established that fish culture offers lucrative returns. As a result, more and more women have shown interest in joining the group for which the members have decided to include another 20 of them for next year's culture and utilize five remaining feasible seasonal water bodies for the purpose of fingerling production.

G. Ma Mangal Chandi: Hatchery of indigenous fish

Ma Mangal Chandi SHG was formed in 2005 in the village of Chotobazar in Rajnagar block of Birbhum. In July 2017, the WBADMIP provided necessary funds for capacity building of 12 women members of the group, from Ramkrishna Ashram Krishi Vigyan Kendra, Nimpith, and South 24 Parganas. Accordingly, three of the members were trained in indigenous fish breeding and hatchery technologies, and the remaining 9 received training on culture of the indigenous fish in ponds. All the trainings were over the duration of five days and the members participated in the training programmes along with other WBADMIP selected beneficiaries of different districts and State Fisheries Dept. personnel of each of the districts.

After receiving the practical-oriented training, this particular SHG started construction of the hatchery in 2017 itself, according to the RAKVK hatchery and budget plan with the active support of the State Fisheries Dept. of the district and financial support from WBADMIP. By this time, it was almost end of September and the breeding season of the indigenous fish (desi magur) was coming to an end. In spite of this, the group members tried their level best and were successful to breed the fish, for the first time ever, in this semi-arid zone of the state. Their perseverance yielded 2000 fingerlings in 2017. They sold 1300 at the rate of INR 4/- a piece and stocked 700 in their pond. Last year, i.e. in 2018, they could produce 60000 fingerlings of desi magur of which 15000 were sold at INR 3/- a piece and hence earned INR 45000/- which is deposited in their bank account. Rest of the seeds is released in the pond and its management is continuing till date. The members are expecting a rich haul and more income from table catfish, which are very expensive and have huge consumer preference.

The success of this SHG has changed the outlook of the villagers who are now eager to learn the trade from this group and are also interested to form their own group. The socio-economic status of the group members has also changed drastically with more leaning towards educating their children, improving healthy food intake and they wear a pride on their face to be able to eke a decent livelihood by adopting this particular technology.

Problem, need and suggestion:

1. There is a genuine problem of iron in the water used for breeding the fish for which the hatching percentage is not up to the mark. Hence, the group needs help from concerned quarters to install an iron filter to facilitate proper hatching of the fertilized eggs.

   Recommendation: Harvesting rooftop rainwater, via PVC pipelines, and storing in big PVC containers, as the rain water is suitable for undertaking breeding operation of any type of fish. This may be a very simple yet cost effective technology than installing an iron filter.

2. The hatchery trays are placed on the floor which is "kuchcha" and the room in which the trays are kept is a bamboo enclosure. So, the wind brings dust from all over, including the floor, into the hatching trays resulting in mass mortality of the larvae/fry. Hence, the groups want a concrete floor and a proper room for carrying out their trade.

   Recommendation: Till help in this regard comes from concerned quarters, the members may consider plastering the floor with a mixture of cow dung, mud and water (which is a common practice in villages of Bengal) to suppress the dust from the floor. Likewise, the bamboo structure all around may also be plastered up to a height of 4-5 ft. to prevent the dust from entering.

H. Ashna WUA: Spawn-fingerlings

Ashna WUA is located in Simlapal block of Bankura district. In Bankura district, fisheries play an important role in the economic development and the district ranks first in pisci-culture within West Bengal. The WUA was registered in 2013 and scheme handover took place in 2015 with a total of 75 members. Fisheries Interest Group (FIG) formation took place in 2016 with a total of 15 members (ten men and five women).

In 2016-17, schemes demonstrated Composite Fish Culture in one hectare of effective water spread area and provided inputs (IMC fingerlings, Feed – 7600 kg, Lime – 500 kg, KMnO4 – 2 kg, drag net, aluminum hundi, insulated vending box). With this, a significant increase in production took place with total production of 4.9 tonnes compared to 1.2 tonnes before. In 2017-18 – practice of spawn to fingerling through local women SHG (Maa Garam Mohila Dal) was started with ten members in effective water area of 2 Bighas (0.26 ha). Inputs in term of spawn and feed were provided. However, it turned out to be unsuccessful with total profit of only INR 755.

Critical observations/reasons for failure of spawn to fingerling culture

- Lack of proper skill and training before initiating culture.
- Large water body, not ideal for such culture. It was considered perhaps due to dearth of small, shallow ponds.
- Heavy rains led to an increase in the water depth, which in turn increased mortality of growing fry
- Heavy rains resulted in flowing of agriculture run-off water into the pond which deteriorated the water quality.
- High rate of pond lease resulted in reduced profit margin.

Recommendation for reviving the group

The group may be trained in indigenous fish breeding to earn livelihood through selling of seeds. This trade does not a require pond and, as none of the group members possess one, income from fisheries may be done by pursuing this activity. Moreover, this activity requires clean freshwater which is available in plenty through artichokes and freshwater aquifer in the region.

I. Ketankari WUA: Mixed fruit planting

In Ketankari WUA located in Kashipur block of Purulia, mixed fruit plantation program was initiated in the month of August 2017. After doing induction meeting with the farmers and motivational camp, the WUA themselves selected the types of plants to be planted and did the plan for land preparation, fencing, pit digging, pit filling, plantation, inter cropping, nurturing the plants etc. The plantation included mango (Amrapalli, Himasagar, Baromasi), jack fruit, mosambi and citrus. The WBADMIP provided finance for the orchard in such a way so that the farmer on whose land the orchard was being developed could earn some wage during the process of developing orchard. The DPMU has already imparted training to the farmers related to land preparation, pit cutting, hapa digging, plantation, application manure, and application of termiticides, weed managements etc.

Name of Plant	Plants Supplied	Survival Percentage
Mango (Amrapalli)	220	94.55
Mango (Himsagar)	120	86.67
Mango (Baromasi)	30	73.33
Jack fruit	20	25.00
Mosambi	15	93.33
Citrus (kagji)	30	96.67
Total	**435**	**87.82**

Mixed fruit plantation has been a success with current average survival rate of 88% (which could be improved further). The mixed fruit plantation has converted the barren land into a cultivable one which, within 2-3 years, will yield sustained returns. Introduction of inter cropping resulted in early returns and confidence in the gestation period. The extra income made through wage earning from orchard development has added value in childcare and child development. Overall, mixed fruit plantation, taken-up as a group, adds positive value to group dynamics by building a community approach of crop management and conservation. In the next two to three years, when this plantation matures, WUA is expected to get good return for the effort they have put in.

Some gaps and recommendation are as below:

1. Mortality rate is >10%
   Recommendation: Pitcher irrigation/ modified pitcher method would result in less mortality and high water use efficiency. Jalkund (small 3-4 cubic meter HDPE or silpoline pit) for harvesting and storing direct rainwater and applying water through hand watering for life saving irrigation. For more effective results, Jalkund may be covered with locally available thatch material to check evaporation.

2. Number of Mosambi plants is less
   Recommendation: Number of plants is to be adjusted in such a way that a marketable volume produce may be available.

J. Siyarbinda Rimil WUA: Arjuna plantation

Siyarbinda Rimil WUA located in Binpur-II block of Jhargram district started the Arjuna plantation (including some pineapple) plantation program in June 2018. After the induction meeting with farmers and conducting a motivational camp, the WUA themselves selected Arjuna plant as the villagers are skilled to cultivate cocoon for Tashar. WUA members did the activities of land preparation, fencing, pit digging, pit filling, plantation, inter cropping, nurturing the plants etc. and WBADMIP provide finance for the orchard with wage for preparation activities paid through the bank account from DPMU to the bank account of WUA. DPMU has been following up all the activities from land preparation to plantation along with inter cropping of the orchard field where they facilitated the farmers to cultivate pulses & vegetables i.e. Arahar, Black Gram, Bottle Gourd, Pumpkin etc.

Name of Plant	Plants Supplied	Survival Percentage
Arjuna	1780	88.03
Pine Apple	180	91.00
Total	**1960**	**86.68**

The survival rate of the plants is quite satisfactory depending on the rainfall and the moisture retained through the dapa developed in due course which would help the plants sustain for long. Overall survival rate was high, at 88% in Arjuna and 91 % in pineapple, but vegetative growth was not satisfactory at the time of visit. This could be due to a hail storm which caused growth loss just few days before the visit. Inter cropping with low water requiring crops like pulses is adding to crop diversity and income of WUA. The newly formed WUA with horticulture as one of the main activity is well organized in implementation, monitoring and supervision.

Specific gaps and recommendations:

1. Mortality rate is < 10 % but stunted vegetative growth due to natural climatic event.
   Recommendation: Pitcher irrigation/ modified pitcher method and use of liquid fertilizer through pitcher method will lead to better vegetative growth.

2. Use of organic matter is less
   Recommendation: In-situ vermi-compost preparation using fallen forest waste would reduce costs of fertilizer and increase use of organic matter.

3. Knowledge gap in sericulture
   Recommendation: Knowledge up-scaling training/workshop can be held for both, the specialist and WUA members, especially on cocoon-rearing and disease management.

K. Mati Dundra WDS and Bara Natun Bundh SFMIS, Purulia

Not successful cases of surface water storage schemes

Mati Dundra WDS

WDS, a surface water storage system for harvesting and storing runoff from nearby local micro-watershed area in Mati Dundra in Purulia district is designed with proposed command area of 5 ha in the lateritic soils. Field visit to the WDS and discussion with local community and WUA members revealed a case of unsuccessful and underperforming minor irrigation system. Photographs depict the deteriorated condition of the structure just within a span of three years after its handing over.

It appears that the locally existing site was remodeled in the present WDS. Based on the field inspection of the WDS, the following specific points have emerged:

- Severe soil erosion from body and slope of the earthen embankments due to poor slope stabilization measures.
- Severe undercutting of the structure on the inflow side and this could possibly be due to shallow depth of structure and exposure of its foundation.
- Lack of pitching

In the absence of DPR of the scheme, it’s not possible to examine design details. It’s recommended that lessons from such failures may be re-visited and thoroughly examined from hydrological, hydraulic and structural design aspects.

Bara Natun Bundh SFMIS

Similar case of underperforming surface storage schemes was observed in Bara Natun Bundh SFMIS in Purulia. In this case, improper location of inlet was observed with catchment area on inlet side at lower elevation. Due to this, inflow to SFMIS in limited and very small area in Rabi is cropped.

Area upstream of inlet in at lower elevation

Low storage in SFMIS

Other SFMIS downstream with proper design has much storage

ANNEX 2 - List of schemes selected for Household Survey

Scheme Name	Type Of Scheme	District	ADMI / other Government department Scheme
Gopinathdihi SFMIS	SFMIS	Bankura	WBADMI schemes
Jiadoba Natun Pukur WDS	WDS	Bankura	
Kharbona	SFMIS	Bankura	
Malpara CD	CD	Bankura	
Bankati	RLI	Bankura	
Palpuskarini	TW	Bankura	
Kusumtikri	RLI	Bankura	
Arrah-II	RLI	Bankura	
Gadadhapur CD	CD	Birbhum	
Gadhadharpur II CD	CD	Birbhum	
Khudrapur	TW	Birbhum	
Nandulia LDTW	TW	Birbhum	
Madarpur LI -I	RLI	Birbhum	
Talpukur-II PDW	PDW	Birbhum	
Ruhida LI	RLI	Birbhum	
Ruhida-IV WDS	WDS	Birbhum	
Ruhida-V WDS	WDS	Birbhum	
Bandi BR-4	CD	Birbhum	
Barkonda Solar PDW	PDW	Birbhum	
Kanmora Solar PDW-II	PDW	Birbhum	
Dhaka-Lauberia PDW	PDW	Birbhum	
Bhabanandapur CD	CD	Birbhum	
Khorddanagari CD	CD	Birbhum	
Tella RLI	RLI	Paschim-Medinipur	
Amlatora CD	CD	Paschim-Medinipur	
Bhulagara	CD	Paschim-Medinipur	
Bindukuta CD (Nongarkhal)	CD	Paschim-Medinipur	
Baida	RLI	Paschim-Medinipur	
Ghagra CD	CD	Paschim-Medinipur	
Horogobindopur	TW	Paschim-Medinipur	
Pakurseni Chakarjuni LDTW	TW	Paschim-Medinipur	
Khasjangal	TW	Paschim-Medinipur	
Gogram Gopinathpur	TW	Paschim-Medinipur	
Fatepur Mini (E) RLI	RLI	Purulia	
Kapishta CD	CD	Purulia	
Siada CD-I	CD	Purulia	
Bara Natun Bundh SFMIS	SFMIS	Purulia	
Namo Panchmahali CD-I	CD	Purulia	
Maharajnagar Bara Bundh SFMIS	SFMIS	Purulia	
Joyramdih Rameswar Bundh SFMIS	SFMIS	Purulia	

Shyam Bundh SFMIS	SFMIS	Purulia	
Mati Dundra WDS	WDS	Purulia	
Adiljore CD	CD	Bankura	Other Government Minor irrigation (non-WBADMI) Schemes
Satmouli CD & RLI	CD & RLI	Bankura	
Chandrapur WDS	WDS	Birbhum	
Amlakuri CD	CD	Birbhum	
Mahishagram WDS	WDS	Birbhum	
Baikunthapur	Major LI	Paschim Medinipur	
Gopal Bundh	SFMIS	Paschim Medinipur	
Khanamohan	Major LI	Paschim Medinipur	
Tiyasi bara Bundh	SFMIS	Purulia	
Ghutlia CD	CD	Purulia	

ANNEX 3 - List of schemes selected for Focus Group Discussions

Scheme Name	District	Activity
Bagdiha Metala	Bankura	Horticulture FGD
Mankanali	Bankura	
Siarbindha Rimil Samity	Paschim-Medinipur	
Dahatmul	Paschim-Medinipur	
Ketankari	Purulia	
Ashna	Bankura	Fishery Interest Group FGD
Ramchandrapur	Bankura	
Khardanagari	Birbhum	
Amkhoi	Birbhum	
Uluberia	Purulia	
Kalidaha Purbad	Purulia	
Palpushkarini	Bankura	FGD with WUA members
Jiadoba	Bankura	
Kusumtikri	Bankura	
Gadadhapur	Birbhum	
Kanmora	Birbhum	
Dhaka-Lauberia	Birbhum	
Chandrapur control scheme	Birbhum	
Horogobindopur	Paschim-Medinipur	
Ghagra	Paschim-Medinipur	
Khasjangal	Paschim-Medinipur	
Baida	Paschim-Medinipur	
Banpatna control scheme	Paschim-Medinipur	
Mati Dundra	Purulia	
Maharajnagar-Bara Bundh	Purulia	
Kapishta-Majramura	Purulia	
Gokulnagarpally Unnayan	Purulia	

ANNEX 4 - Summarized indicators

Impact Assessment [corresponding/matching indicators]				Matching PDO indicators
Indicator	Unit	Pre (2013-14)	Post (2017-18)	
PDO Indicators				
Percent of sample farmers from government's WUA list who were identified as WUA members	%	NA	94.7	PDO Indicator 2: Water users provided with new/improved irrigation and drainage services
Female farmers membership in WUA	%	NA	15.4	PDO Indicator 3: Water users provided with irrigation and drainage services - female
Schemes with good or very good infrastructure condition	%	NA	85.7	PDO Indicator 4: Operational water user associations created and/or strengthened *
Schemes with water management and distribution plan	%	NA	66	
Number of WUAs democratically functioning	%	NA	93	
Crop Yield				PDO Indicator 5: Increase in production of major outputs: (Rice, Oil Seed, Vegetable) (Metric tons/year, Custom Supplement)
(i) Paddy (Kharif)	Tonnes/ha	2.8	4.4	
(ii) Mustard (Rabi)	Tonnes/ha	0.7	1	
(iii) Potato (Rabi)	Tonnes/ha	14.5	23.4	
Marginal farmers membership in WUA	%	NA	72.7	PDO Indicator 6: Water users provided with new/improved irrigation and drainage services: Small and Marginal Farmers
Tribal farmers membership in WUA	%	NA	36.5	PDO Indicator 7: Water users provided with new/improved irrigation and drainage services: Tribal farmers

Generating O&M: Water user association that are generating at least 5% of total capital cost	%	NA	19	PDO Indicator 8: Water user association that are generating at least 80% of resources required to manage, operate and maintain the developed schemes
Intermediate Results Indicators				
Increase in irrigated crop area				Intermediate Results Indicators 9 and 10: Area provided with new/improved irrigation or drainage services (Hectare(Ha))
(i) Kharif	%	21.5	89.4	
(ii) Rabi	%	2.3	53.6	
(iii) Summer	%	0	9.6	
Crop Diversification	Crop diversity index[5]	0.29	0.87	Intermediate Results Indicators 12: Area diversified to less water intensive cash crops
Change in cropping intensity in areas provided with new/improved irrigation services	%	113.8	168.2	Intermediate Results Indicators 13: Change in cropping intensity in areas provided with new/improved irrigation services

[5] Crop Diversity Index = $-\sum p_i * \log p_i$; where p_i is the proportion of area under crop i in a particular scheme.