International Water Management Institute

WBADMIP
West Bengal Accelerated Development of Minor Irrigation Project

WORLD BANK GROUP

Project Report

State level impact study of WBADMI project

Implemented by Water Resources Investigation & Development Department, Government of West Bengal

2020

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Acronyms

ADA	Assistant Director of Agriculture
AEZ	Agro-Ecological Zones
AGM	Annual General Meeting
ATMA	Agricultural Technology Management Agency
AWD	Alternate Wetting and Drying
BDO	Block Development Officer
BPL	Below Poverty Line
CD	Check Dam
CDI	Crop Diversification Index
CFC	Central Finance Commission
DPMU	District Project Management Unit
DSR	Direct Seeding of Rice
DWRID	Department of Water Resources Investigation and Development
ESA	Europe Space Agency
FPC	Farmer Producer Company
FPO	Farmer Producer Organisation
FGD	Focus Group Discussion
FIG	Fishery Interest Group
GCA	Gross Cropped Area
Ha	Hectares
HH	Household
HYDRAM	Hydraulic ram pumps
HYV	High Yielding Variety
IBRD	International Bank of Reconstruction and Development
IMC	Indian Major Carp
IPM	Integrated Pest Management
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 2005
MI	Minor Irrigation
MPCI	Monthly Per-Capita Income
MWS	Micro-Watershed
NDVI	Normalized Different Vegetation Index
NGO	Non-Governmental Organisation
NRLM	National Rural Livelihood Mission
O&M	Operations and Maintenance
OBC	Other Backward Classes
PDO	Project Development Objective
PDW	Pump Dug Well
PDW (S)	Pump Dug Well (Solar)
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana
PM KUSUM	Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan
PWP	Physical Water Productivity
RKVY	Rashtriya Krishi Vikas Yojana
RLI/LI	River Lift Irrigation/Lift Irrigation
RS	Remote Sensing
SC	Scheduled Castes
SFC	State Finance Commission
SPMU	State Project Management Unit
SRI	System of Rice Intensification
ST	Scheduled Tribes
TW	Tube Well
WBADMI	West Bengal Accelerated Development of Minor Irrigation
WDS	Water Detention Structures
WRIDD	Water Resources Investigation & Development Department
WUA	Water Users' Association

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Executive Summary

The 'West Bengal Accelerated Development of Minor Irrigation' (WBADMI) project launched in 2012 by the Government of West Bengal had the goal to increase the agricultural production of small and marginal farmers by creating new minor irrigation infrastructure and rejuvenating existing structures. The priority of the ADMI project is to focus on farmers in rainfed single cropped areas of the state. The project's approach differs from similar micro irrigation projects of the government in two main ways. Along with creation of irrigation infrastructure, the project has created Water Users' Associations (WUAs) for community-led management of the said infrastructure and also it provides agricultural support services for crops, horticulture and fishery activities in the scheme area. The expectation is that, through these activities, full potential of the irrigation infrastructure can be realized. The project has completed 5 years in 2019. This report presents the results from an evaluation study that International Water Management Institute undertook to investigate the WBADMI project's impact on agricultural productivity, profitability and livelihood status; and also to assess WUA as an institution and to share learnings from our findings for future such schemes.

The report studies the effect of the WBADMI project for nineteen districts of West Bengal by analyzing key indicators from the pre-ADMI period (2013) with the post project period outcomes (2018-2019). 'Ground-truthing' data collected by DPMU officials and primary data collected by IWMI have been used for our assessment. The 'Ground-truthing' data that has been collected by DPMU officials consists of scheme-level data for 240 schemes across the state and individual-level data of 670 farmers (both WUA and non-WUA) in these schemes. Our main analysis uses the 'Ground-truthing' data to compute the indicators and correlate outcomes with project implementation. In order to test the consistency of the findings from our main study, we also compare the indicators with the primary data collected via a telephonic survey (due to travel restrictions imposed by COVID-19 pandemic for conducting field survey) to check the extent to which the results match with each other.

The results reveal that there has been a substantial increase in the gross cropped area for our sample schemes with the creation of these irrigation infrastructure, as previously fallow land during non-monsoon season were brought under cultivation. This is reflected in the fact that cultivated area during the *Rabi* and *Pre-Kharif* seasons increased by 317% and 235% respectively. The net sown area has also risen after the project. This is indicated as the cultivated area during the *Kharif* season also increased by 21%. As a result, the overall estimates for cropping intensity have grown from 129.3% to 183.1%. The WUA Members in our sample, have experienced an increase in cropping intensity which is almost 24.6 percentage points higher than their non-WUA counterparts. The Tube Well (TW) schemes have performed the best (with cropping intensities close to 200%, and a 60.5 percentage point increase relative to the baseline). In terms of improvement in cropping intensity, the top four districts are Cooch Behar, Bankura, Paschim-Midnapore and Darjeeling, where cropping intensity increased by more than 70 percentage points.

The ADMI project achieved crop diversification and reduced dependency on paddy by promoting high value cash crops (especially vegetables), as evident from the overall Crop Diversification Index (CDI) doubling from 0.21 at baseline to 0.45 in 2018-19.

As more area was brought under cultivation, different types of crops started to be cultivated (especially vegetables), reducing dependence on paddy. Prior to the intervention, Aman paddy was the only crop for many of the farmers. The ADMI schemes, promoted the cultivation of other high value crops amongst the Members. As a result, the overall Crop Diversification Index (CDI) doubled from 0.21 at baseline to 0.45 in

2018-19. CDI at endline is highest for LI schemes (0.53) and lowest for Creek schemes (0.16). For the rest of the scheme types, the CDI is between 0.44 to 0.48. However, in terms of change in CDI, this is largest for PDW schemes (0.39) and WDS schemes (0.36). This is mainly due to a considerable decline in share of paddy in gross cropped area from 77% to 58% for PDW schemes and a stark increase in the share of vegetables from 2% to 16%. Similarly, for WDS schemes, we find that proportion of total cultivated area under paddy has sharply fallen from 88% to 56% and area under vegetables has *increased* from 3% to 14%. The share of mustard has also double from 5% to 10% in the post-ADMI period. Increase in CDI across districts is the highest in the Western Lateritic Districts of Bankura, Birbhum, Jhargram and Purulia; and that success can be credited to the adoption of mustard, sesame and other oil seeds by farmers as their main crops of choice. The proportion of farmers growing mustard (14.1% to 32.8%), potato (22.3% to 37.3%), brinjal (7.9% to 14.5%) and other vegetables (from 9% to 27.6%) has vastly increased after project implementation. The proportion of farmers growing Boro paddy also saw an increase in our sample from 19% to 34%. The increase in Boro paddy is primarily in the South 24 Parganas and Cooch Behar districts.

We also find an effect of the agricultural support services provided under the project, in terms of higher yield for WUA farmers. All the four main crops (Aman paddy, Boro paddy, potato and mustard) have registered yield gains since the scheme handover. The impressive growth in yield, is a result of the numerous capacity building trainings in agricultural practices, conducted across all the schemes. These trainings have been provided under nine categories, ranging from High Yielding Variety (HYV) cropping, Seed Treatment, Vermicomposting to Organic Farming, with the core aim of targeting the poorest farmers hailing from marginalised and disadvantaged communities. Seed treatment had the most reach with 80% of WUA farmer participation and Polyhouse had the least number of trained farmers as the latter was offered only in a small number of schemes, where such cultivation would be profitable. The trainings achieved the objective of inclusivity as a high proportion of marginal farmers reaped its benefits. In terms of the total number of trainings received though, there is a lot of variation among the districts. Hooghly and North 24 Parganas had almost full participation for at least 5 out of the 9 training types, whereas Uttar Dinajpur featured on the lowest end of the spectrum as only 2% of WUA Members received more than 5 capacity building trainings.

The contribution of these agricultural support services in enhancing farm growth is evident from the fact that, the amount of training received is correlated with better agricultural outcomes. The cropping intensity of WUA farmers receiving training increased significantly by 34 percentage points in contrast with just 5 percentage point increase in the case of WUA farmers who did not receive any form of training. This is thus a testimonial to the effectiveness of capacity building in shaping agricultural outcomes for the WUA farmers. This could be expected to spill over to other WUAs as well as to the non-WUA farmers in their vicinity through knowledge sharing.

The ADMI project has set up schemes all across the state covering different Agro-Ecological Zones (AEZs), and in this report we explore how different types of schemes have performed across different AEZs including the Hilly Zone, Red Lateritic Semi-Arid Zone, Alluvial (Vindhyan and Gangetic) Zone, Saline Coastal Zone and Terai Teesta Zone. Overall, all five zones have experienced significant progress towards increasing the cropping intensity. The largest increase in cropping intensity is in the Hilly Zone (78.2 percentage point), followed by Red Lateritic (57.1 percentage point) and Terai Teesta Zone (53.2 percentage point). At baseline, in all the zones, the Crop Diversification Index was very low, especially for the Red Lateritic Semi-Arid Zone (0.009), where it was almost always just one crop cultivated during the year. This zone however, experienced the largest increase to 0.45 at endline. In the Red Lateritic Zone with more surface water schemes, the project gave emphasis on the cultivation of less water intensive (compared to Boro) but high-value crops like vegetable, sesame, mustard etc., which is reflected in the substantial rise in CDI. In terms of crop diversification, next is the Hilly Zone where CDI increased from 0.2 to 0.52 after scheme

implementation. There has also been an increase in the productivity of Aman paddy, since the scheme handover in all 5 zones. At endline, for all zones except Saline Coastal, the yield has crossed 4 tonnes/ha. The Hilly Zone has achieved the highest gains in Aman paddy yield from 3.3 tonnes/ha to 5.5 tonnes/ha. This zone also has the highest endline yield. When we look at the yield for Boro paddy, we again find that all zones have shown substantial improvement in this aspect. The Red Lateritic and the Saline Coastal Zones have shown the greatest increase of 1.4 tonnes/ha; the Hilly Zone has the highest endline yield at 8.9 tonnes/ha. For potato yield also, the Terai Teesta Zone and Red Lateritic Zone have exhibited the most progress in the post-ADMI period, growing from 15.4 tonnes/ha to 24.3 tonnes/ha and from 20.2 tonnes/ha to 27.1 tonnes/ha respectively.

Overall, in our analysis we conclude that the Hilly Zone and the Red Lateritic Zone have made the most substantial progress in increasing agricultural outputs under this project.

In the Red Lateritic Zone, the groundwater schemes emerged to be better in almost all indicators, which is not surprising. But it is important to note that even the WDS schemes have performed well in this zone. Generally, WDS schemes are set up in regions where it is often difficult to use groundwater and, therefore, this shows promise in this zone. The good performance of our sample WDS schemes highlights the need for smaller schemes which leads to better management.

If we compare the agricultural income of farmers across different schemes, we find that TW schemes have the highest net agricultural income per hectare at Rs. 77,454 and the Creek schemes had the lowest net agricultural income per hectare at Rs. 19,182. Further, the incremental income per hectare has been derived to show the change from the pre-ADMI years. Again this has been estimated to be the largest for Tube Well (TW) schemes at Rs 59,647. Farmers within the WUAs have also organised themselves into Fishery Interest Groups (FIGs) to collectively engage in fishery activities as an additional source of revenue. Around 13% of WUA farmers are Members of a FIG, and the mean net income from fisheries for our sample farmers is Rs. 9,432 with no private cultivation of fish, while this is Rs. 17,312 for Members cultivating fish privately also, in addition to ADMI support. The increase in agricultural income, has culminated in a subsequent increase in the household consumption of vegetables, meat and fish by at least 70%. This implies that the project has achieved the target of improving farmers' and their families' well-being through the increase in their total earnings. We also calculated the monthly per capita income for baseline and endline years to compare the magnitude of change for WUA and non-WUA farmers. We notice that WUA Members' income have increased at a much faster rate than non-WUA farmers. As a result, there has clearly been a larger shift of WUA Members above the poverty line by 17 percentage points versus the 11 percentage point for non-WUA Members. Using a regression analysis, we also find that there is a positive and significant correlation between WUA Membership and change in monthly per capita income – for WUA Members the change in monthly per capita income is upto Rs. 718 higher than that of the non-WUA Members.

The phone survey estimates were analysed alongside our original results. The telephone survey includes 65 schemes from both datasets in order to ensure that we are comparing the same WUAs. We find, that the results from both estimates match across most of the key indicators such as gross cropped area, net sown area, cropping intensity etc.

The Water Users' Associations created under this project can claim some of the credit for the positive impacts discussed above. As the project ends and support from the project is withdrawn, it is expected that these WUAs will be looking after the operation and maintenance of these irrigation infrastructures, and help in running them smoothly. It is of utmost importance that this institution of Water Users' Association continues to remain strong and vibrant even in the future after the project has ended to ensure sustainability. WUAs as an institution are to a large extent democratic in nature, where the Executive Committee Members were

selected through an election in a meeting attended by WUA Members. About 98.7% of WUA Members are marginal farmers as the project has effectively targeted the poorest. The proportion of female Members in WUA is 16.9% and even higher in the Executive Committee at 32.4%. Also, there is high representation of Scheduled Caste and Scheduled Tribe Members at 30.9% and 22.7% among WUA farmers, particularly in the PDW and WDS schemes in Purulia and Jhargram districts for Scheduled Tribes. Cooch Behar and Murshidabad districts have the highest representation among the Scheduled Castes.

In conclusion, our assessment finds that the ADMI project has greatly improved agricultural, institutional and economic outcomes since the project inception and it has focused on small and marginal farmers and tribal farmers in regions which were mostly rain-fed with low irrigation access. One of the distinctive feature of this project is to combine agricultural support services with improved irrigation access, in order to maximize the farmer's income and livelihood. Moreover, this project prioritized community-based irrigation management by creating Water Users' Associations for running these schemes even after the project has ended. This is an important model for the expansion of government minor irrigation schemes. Nonetheless, the benefits reported in this document are based on the assessment done while there is still active support from the project officials for project farmers. The success of ADMI is impressive but ultimately the project should be judged on how these WUAs will function in future and whether the irrigation infrastructures will be maintained properly once the project ends and support from the project stops. This is a question for future, but our analysis identifies some key learnings and suggestions, that can be useful for the future sustainability of these schemes.

Convergence with Other Government Development Schemes: The ADMI project provides considerable scope for convergence with other developmental schemes of the state and central government including MGNREGA, RKVY, PMKSY, NRLM, KUSUM and others. One way to institutionalize this convergence procedure would be to create District-Level Implementation Committees, with the District Collector as the chairman. Such convergence with existing institutions could be crucial in long-term sustainability of the project.

Collective Marketing for Farmer Produce: While the introduction and promotion of vermicomposting, Polyhouse cultivation and seed production of paddy and pulses have contributed towards the increase in productivity and profitability in WUAs, it is also important to ensure that there is a strong value chain in existence to supplement these activities. This means that there should be adequate market linkages for farmers to earn maximum profits, especially for high value vegetables. Collective marketing in a cluster-based approach can be a very good option for increasing WUA farmer's profitability. This would also provide strength for aggregating input requirements as well as aggregating producers' outputs for better marketing and bargaining capacity. The existence of WUAs make such an approach a very practical option for development.

Capacity Building to Prevent Electricity Payment Default: West Bengal has a comparatively high electricity tariff and if bills are irregular then farmers are often unaware of how much electricity is being consumed and what is the charge that has accumulated. This has resulted in quite a few cases where the WUA has failed to pay for electricity and their connection has been cut. There is scope of more cases of non-payment in future for electric tube wells under the scheme. In this context, it can be helpful to give training to WUA farmers to understand the tariff structure and how the water fees should be determined. In some cases, it can also be useful to shift to solar pumps (the Tube Well and distribution infrastructure is already there) via convergence with existing government programme on solar irrigation.

Need for Water Demand Management: Emphasizing water management practices would help bring more area under irrigation and achieve the targeted command area and enhance water productivity, especially for small size irrigation schemes like WDS and PDW, with limited storage capacity. There is need to promote water management interventions like Alternate Wetting and Drying (AWD), Direct Seeding of Rice (DSR), soil moisture sensor based irrigation; promotion of drip, sprinkler and rain gun; land levelling, channel to field irrigation, and better irrigation scheduling. For this purpose, convergence with relevant schemes and programmes could also be explored. Also capacity building of farmers on developing the cropping plans for the season to ensure efficient use of water is necessary.

Prevent Capture of WUA by Local Elite: Our interaction with farmers reflect mostly positive evaluation of the WUA as an inclusive institution with high participation of marginal farmers and representation from farmers belonging to SC and ST categories. But in many schemes, female Members of WUA are only as a form of tokenism. Most of the top Members of the Executive Committee i.e. Chairman, Secretary and Treasurer are overwhelmingly male. Also in many schemes, no explicit voting is done for reselection of Executive Committee Members at the end of year, and previous Committee gets re-elected. Efforts should be made to prevent elite capture of WUA in the long term by proper capacity building exercises to train more people for leadership activities and, if needed, restricting the length of WUA leadership.

Success of Integrated Farming System Model: Providing training and input support for fisheries and horticultural activities have already proved to be successful with the project. Efforts should be put to connect the farmers to relevant government schemes and departments, so that hand-holding support is provided even after the project has ended.

Training Local Technicians for Maintenance and Repair: Capacity development of local people in non-major repair and maintenance of irrigation infrastructure is crucially needed.

As the project term has been completed, the government would soon be withdrawing its support from the WUAs. Hence, there looms the risk of reverting to the existing issues prevalent before the schemes were introduced. The WUAs could fail to operate independently and farmers face the possibility of losing the benefits of increased income and going back to reduced levels of productivity. It is required to develop a comprehensive exit protocol that will focus, among other things, on capacity building of WUA farmers, repair and maintenance of scheme infrastructure and associated equipment, create linkages for sourcing funds required for major repairs, encourage on farm water management, promote convergence, develop models for marketing farmer produce etc. The long-term sustainability is dependent on a successful exit strategy for this project.

1. BACKGROUND

West Bengal has witnessed the successful implementation of a number of government irrigation projects over the years.[1] Initially, the irrigation potential created through government projects, were the major and medium-scale irrigation projects like the Damodar Valley Corporation (DVC) Project from 1964 (irrigation potential of 4.8 million hectares in south-Western districts) and the Teesta Barrage Project commencing in 1975-1976 (irrigation potential of 9.22 lakh hectares in the northern districts). From the 1980s, however, there has been a steady increase in private investments in minor irrigation that saw the spread of shallow tube wells across West Bengal and contributed towards its agricultural productivity growth. The period post-2010 saw the launch of a number of government projects for creating surface water minor irrigation structures across the state. 'Jal Dharo-Jal Bharo'[2] was one such project launched in 2011-2012. The main objective was to make water available throughout the year by harvesting rain water and reducing surface runoff through creation of water bodies including tanks, ponds and reservoirs. In a similar vein, the ambitious 'Jalatirtha Scheme'[3] was initiated in 2014-2015 to build check dams, water harvesting structures and surface flow minor irrigation schemes to conserve rain water and surface water that can provide round the year irrigation for farmers. The Jalatirtha project focused on the arid zone of West Bengal covering the districts of Bankura, Birbhum, Purulia and Paschim-Midnapore, with a target of setting up 800 structures to help irrigate an area of 32,000 hectares.

The West Bengal Accelerated Development of Minor Irrigation (WBADMI) project was also launched during this same decade (2012) with an even larger scope. It was launched with the target of promoting sustainable irrigation over an area of 75,000 hectares and improving livelihoods of 1,00,000 farmers (particularly marginal farmers) through reinforced growth of Minor Irrigation (MI) schemes. The project adopted an approach to ensure accelerated agricultural growth in tribal and backward districts, wherein rain-fed area is prevalent with very low cropping intensity. This was financed through a loan from the International Bank of Reconstruction and Development (IBRD) and the International Development Association (IDA) for implementation across the state by the Department of Water Resources Investigation and Development (DWRID), Government of West Bengal. The duration of the project was for seven years, extending till December 2019. It spanned over 20 districts and 1,598 villages. Through this project, thousands of schemes were handed over to Water Users' Association, covering 0.075 million hectares of irrigated area.[4]

The WBADMI Project Development Objective (PDO) was to enhance agricultural production of small and marginal farmers in project areas across the state. This was 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. Specifically, the results of the project are to be measured across the following key indicators:

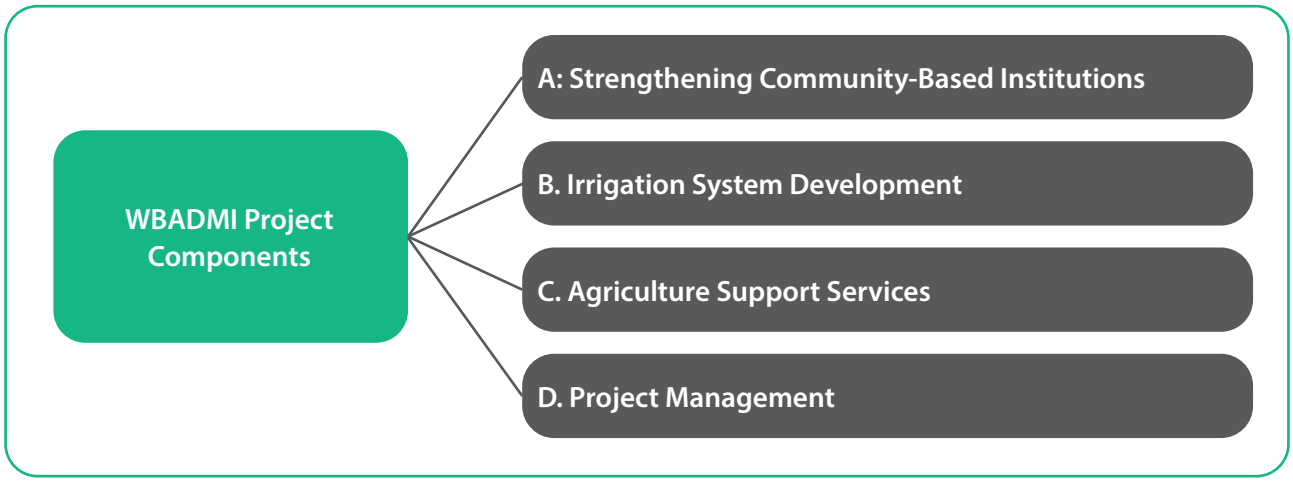
i. Increase in agricultural production/crop yield

ii. Proper functioning of WUAs

iii. Number of male and female WUA Members, with a focus on increasing female participation in decision-making

iv. Total resources generated by the Members required to run the schemes

1 https://wbiwd.gov.in/ (Irrigations and Water Ways Department, Government of West Bengal)
2 https://wb.gov.in/government-schemes-details-joldharo.aspx (Jal Dharo-Jal Bharo)
3 http://wbwridd.gov.in/wrdd/jalathirtha.html#:~:text=WRDD,%2C%20Birbhum%2C%20Purulia%20and%20PaschimMedinipur. (Jalatirtha Scheme)
4 WBADMIP Official Website

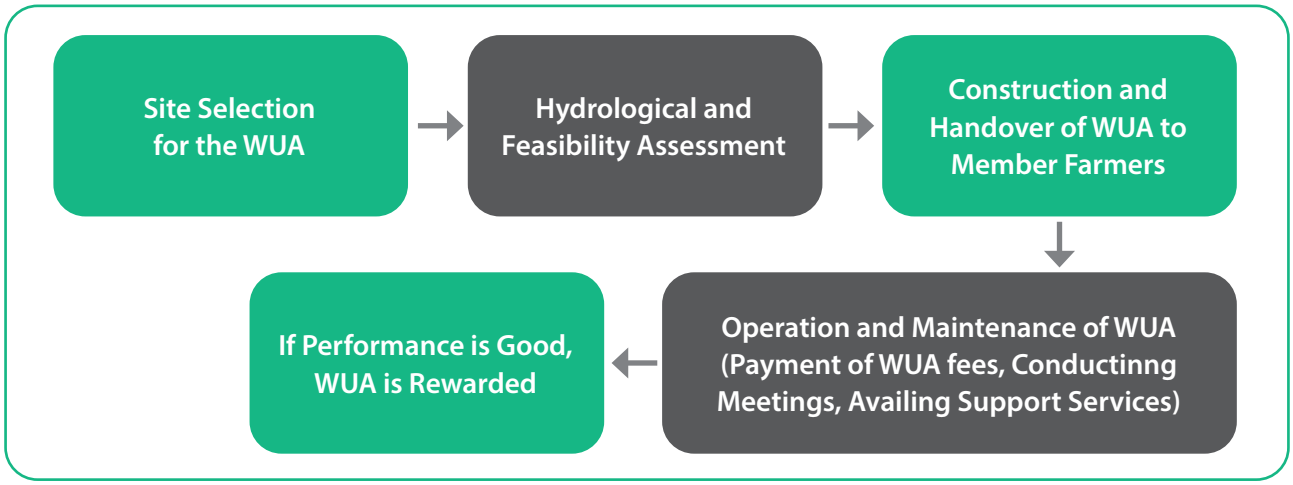


Project Components

The project components are split into four categories. The activities under Component A include capacity building, knowledge-sharing, institutional development etc. to strengthen community-based institutions like WUAs to look after the operation and maintenance of irrigation infrastructure. Component B primarily involves construction of the minor irrigation infrastructure (surface, groundwater and lift irrigation systems). The third one comprises of scaling up agricultural support services to crops, horticulture and fishery, primarily through defined cropping and irrigation plans, WUA investment in equipment, and WUA-level seed production. The final component, i.e. project management, is responsible for the overall monitoring of the project at the district and scheme levels and coordinating between different departments.

This is one major way that the ADMI scheme differs from other minor irrigation schemes launched by the Government in the same period. In the ADMI project, construction of irrigation infrastructure was accompanied by the creation of WUAs for the operation and maintenance of the infrastructure. The emphasis of the project has been to involve the community right from the start in developing, running and ensuring future sustainability of the irrigation infrastructure created under the project. The ADMI project heavily relied on partnership with NGOs to ensure better engagement between the community and government departments. Along with the irrigation potential created, the project also invested in providing agricultural support services to farmers. The rationale was that it will help achieve the full potential of productivity growth in the irrigated areas.

Community involvement being central for the ADMI project, creation and functioning of the WUA is critical. Farmers within the command area of the MI scheme are eligible for WUA Membership, after the payment of a stipulated 'WUA fee'. The WUA farmers receive irrigation from the scheme in exchange for irrigation charges. All the fees and charges are collected and saved for maintenance and proper functioning of the WUA. The Members elect the Management and Sub-Committee of the WUA to perform different functions such as finance, record keeping and maintenance of water schedules. The beneficiaries of the project are also regularly trained in the best practices in crop cultivation and water conservation. The most prioritised goals are to diversify from mono-cropping, increase crop yield and incomes. WUAs that perform well and demonstrate significant progress are recognised and rewarded with agricultural machines.



Till August 2020, 2,677 schemes spread over 1,535 villages in 202 blocks and 20 districts have been handed-over across West Bengal, with another 1,026 schemes as 'work in progress' and further 446 schemes approved by the administration. Out of the 2,677 handed over schemes, 1,179 schemes (44%) were Water Detention Structure (WDS), followed by 704 (26%) Tube Well (TW) schemes, 418 (16%) Pump Dug Well (PDW) schemes, 198 (7%) River Lift Irrigation/Lift Irrigation (RLI/LI) schemes, 167 (6%) Check Dam (CD) schemes, along with 7 Happa (small tank) schemes and 4 Sprinkler Irrigation schemes. As we can see in Figure 1, WDS schemes are primarily in the arid districts in the Western part of the state covering Jhargram, Purulia, Purba and Paschim-Midnapore and South 24 Parganas. Most of the schemes in Northern West Bengal are TW, followed by LI and PDW. Most of the surface water schemes are located in the arid districts of Bankura, Birbhum, Paschim-Midnapore, Jhargram and Purulia, where the use of groundwater is limited due to various reasons.

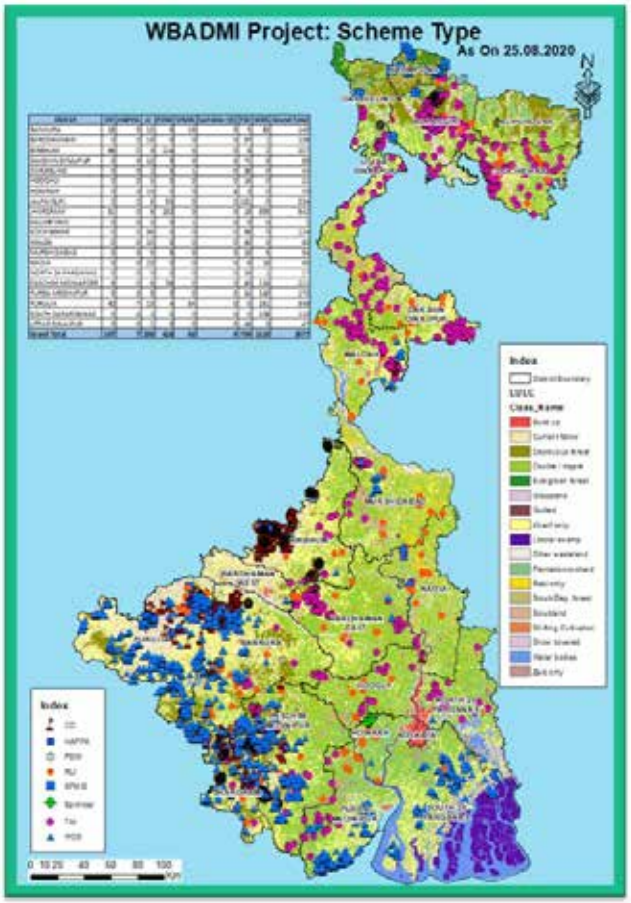


Figure 1 - Scheme type across West Bengal[5] (Source: WBADMIP Official Website)

As part of agricultural support services provided under the project, WUA farmers have been receiving training in agricultural practices (seed treatment and soil testing) and water management practices such as SRI (System of Rice Intensification), flexible pipes, drip & sprinkler, etc. They have begun utilising farm equipment like power tiller and zero tillage machine and planting High Yielding Varieties (HYV) of crops (short duration drought tolerant variety - Sahabhagi and Gontra Bidhan-1 for paddy; PDM 539 for green gram; Subrata for lentil; Sarada for black gram etc.). Farmers have been trained to make vermicompost units to use the manure for crops, especially vegetables.

The project also includes plantation programmes, which make use of current fallow land and involve female farmers and Members of the tribal community. They cultivate crops with low water requirements to generate an additional source of income. Different types of fruits were grown throughout the year across 1,334 Ha.

It has been extremely successful with three-fold growth from 4 lakh saplings planted in 2018-2019 to 12 lakh saplings planted in 2019-2020. The project also promoted fisheries through the creation of Fishery Interest Groups (FIGs) in villages where the scheme has been set up, often using the water detention structures developed under the project. Many of these FIGs have focused on female farmers, to promote female entrepreneurship, with fisheries in small ponds. The FIG activities under the project included spawn to fry to fingerlings mass production along with short duration fishery in small ponds, polyculture of Indian major carps and prawns.

5 WBADMIP Official Website

2. STUDY FRAMEWORK

2.1 Objective of the Study

The key objective of this assessment study is to investigate the developmental outcomes of the WBADMI project in enhancing agricultural, horticulture and fishery production of small and marginal farmers through community managed minor irrigation schemes. In addition, the study will help identify programmatic and policy-level recommendations that can further strengthen the Water Users' Associations (WUAs), the irrigation system infrastructure developments (surface, groundwater and lift irrigation schemes) and agricultural support services. The study will assist the WBADMI project to identify the opportunities and challenges that will be crucial for the long term sustainability of schemes after direct support from the government has stopped.

The key objectives of this study are to:

i. **Assess changes in agricultural, horticultural and fishery production and in other indicators of socio-economic, institutional, and livelihood status under WBADMI project**

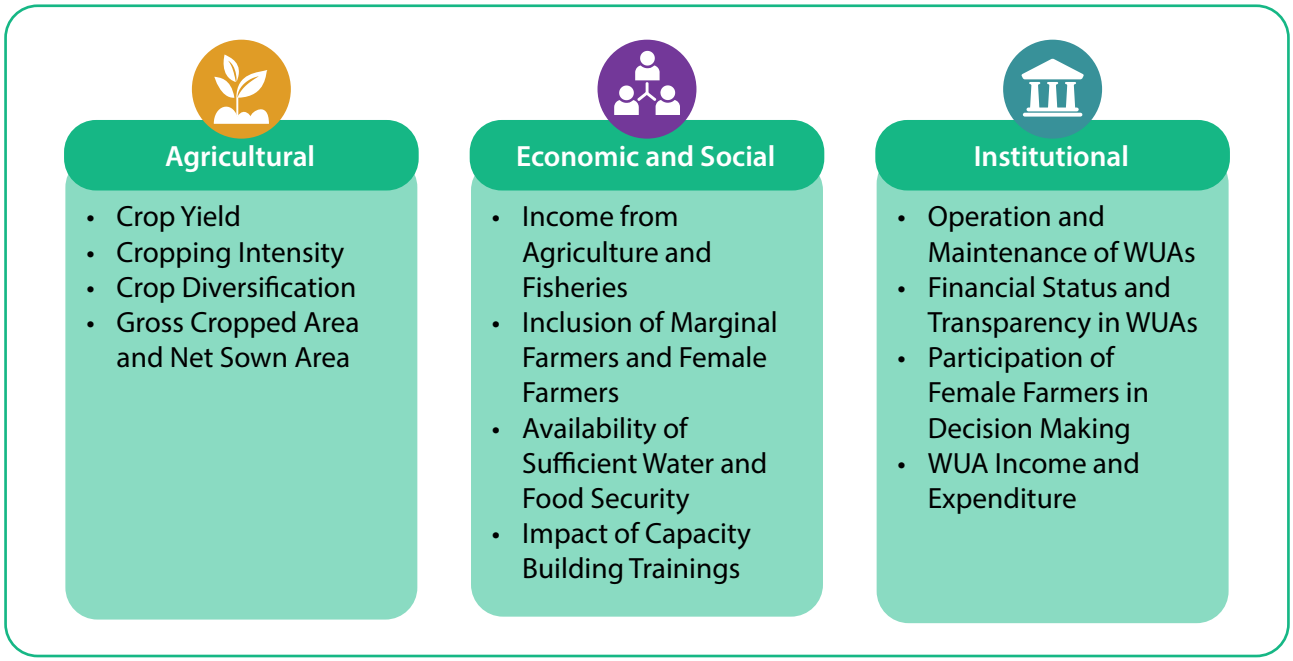
ii. **Assess performance of the WUAs to understand the value addition from WUAs in terms of achieving sustainable and equitable management of irrigation services**

iii. **Provide recommendations on emerging lessons and best practices for future policies in improving agricultural productivity through minor irrigation schemes**

To understand how the project has enhanced agricultural productivity, profitability, livelihood status and food security of farmers in West Bengal, International Water Management Institute (IWMI) undertook the assessment study across the state using data collected by the department internally and also collecting additional field-level data. Both these data sources were used to examine the project's correlation with a wide range of outcomes at the scheme and farmer levels against their pre-ADMI levels. We also compare changes in some

relevant indicators for WUA farmers in comparison, to control farmers who are from the same villages but are not WUA beneficiaries. Our study further examines the heterogeneity of project impact across scheme type, Agro-Ecological Zone and district. The assessment period is from 2012-2013 to 2019-2020[6]. In particular, the study focused on the following indicators, broadly classified into three categories:

Study Components



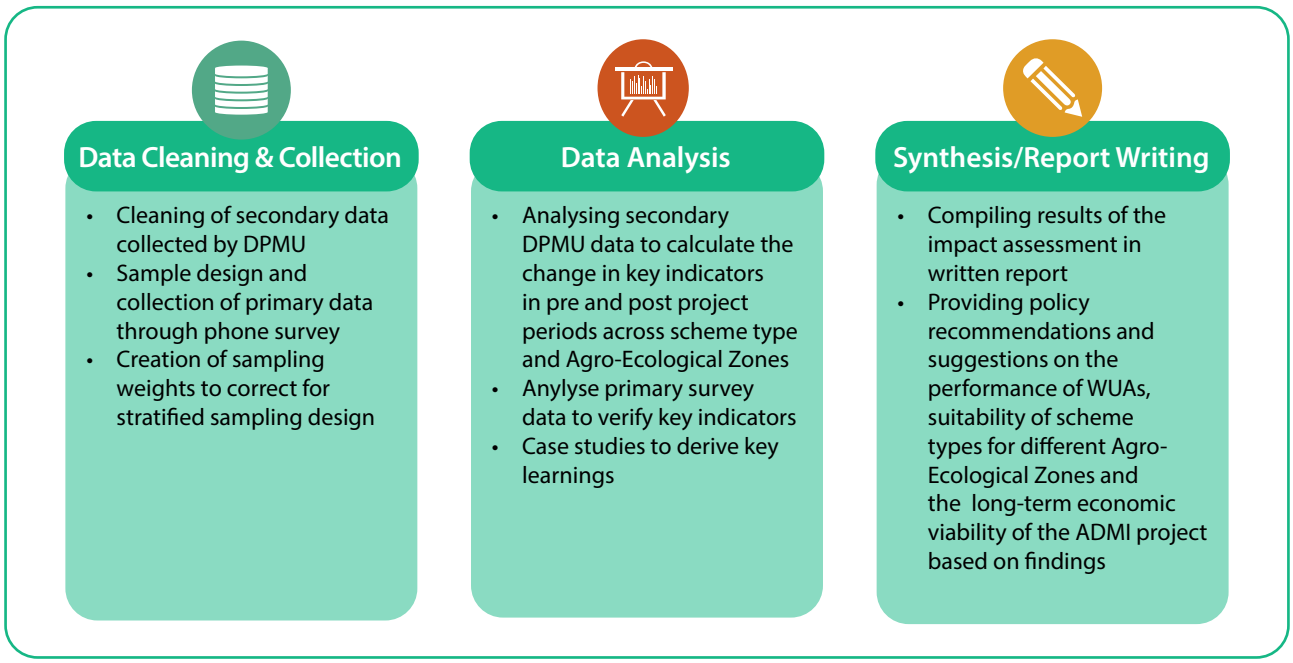
2.2 Methodological Framework

This report tries to answer the above questions mentioned in the project objectives through a comprehensive process of combining 'ground-truthing' data collected by DPMU and primary data collected by IWMI, along with case studies conducted at a few sites. We look at the key outcome indicators as mentioned above and compare pre-ADMI and post-ADMI levels to examine the impact of the project. The study also compares these outcomes for both project beneficiaries and non-WUA farmers (who did not receive any benefits) in order to measure how the changes between pre and post project periods varied across these two groups. Additionally, material and reports from the WBADMI Project website, Department of Water Resources Investigation and Development (DWRID) website and other literature have been reviewed and referenced.

Our study framework can be categorized into the following three phases - data cleaning and data collection; data analysis and synthesis.

6 In our analysis the pre-ADMI data is based on recall information on the usual agricultural practices before the scheme hand-over (without any defined year as baseline year). Since each scheme had a different hand-over date, in principle the respondents from different schemes might have a different reference year as baseline in their mind, but they were asked to answer keeping in mind a normal year as a reference year for the baseline.

Study Framework



2.3 Study Components

This impact assessment study is based on three complementary components as described below:

2.3.1 Analysis of data collected by DPMU for the WBADMI schemes

2.3.2 Verification of DPMU data through primary survey

2.3.3 Case studies of select WUAs in consultation with Project Management

A. World Bank 'Ground-Truthing' survey data (Individual Level and Scheme Level)

With the completion of the WBADMI scheme in 2019, SPMU along with World Bank, jointly collected data for an internal impact assessment of randomly selected 240 MI schemes across all districts in West Bengal. The data collection in each district was done by the neighbouring district team. Our primary analysis is based on this data that has been originally collected by project officials for internal assessment. This data had two components – first, WUA-level/ scheme-level information; second, farmer-level information of WUA Members along with non-WUA Members in the same village. The scheme-level data constitutes information on agricultural and institutional indicators at the aggregate level, while the farmer-level survey focused on individual-level outcomes of agriculture, irrigation, income and livelihood. It covered 670 farmers in total, out of which 445 were WUA farmers and the remaining 225 were non-WUA farmers. Two Members from each WUA were selected randomly and one non-WUA member was subsequently selected non-randomly. Thus, the farmer-level data facilitates a comparison between WUA and non-WUA Members in agricultural and economic aspects. Both the scheme-level and farmer-level data collected recall data for the baseline period (defined as the pre-ADMI period without any defined year) and for the endline or post–project data for the year 2018-2019. The sample consists of schemes handed-over between 2014 and 2018.

Questionnaires were developed by the project management team to collect information on a wide range of topics including income from agriculture and fisheries, cropping pattern, crop yield and area, participation in capacity building trainings, irrigation charges, perception on WUA functioning etc. In our analysis we use both scheme-level and farmer-level data to estimate major agricultural, irrigation and economic indicators for the WBADMI project and how it has changed from pre-intervention levels. We also compare WUA and non-WUA Members in

our analysis and assess the effect of the scheme across different Agro-Ecological Zones and districts of West Bengal. This component of the analysis is solely based on data provided to IWMI from the project. Out of the 240 schemes, consistent data with non-missing information for both agricultural and institutional indicators were available for 215 schemes which have been included in our analysis. Out of these, TW, LI and WDS are the most common types. 8 schemes are Creeks and exist only in the South 24 Parganas district. Jalpaiguri, Jhargram, Birbhum and Cooch Behar constitute 47% of the total number of schemes, while North 24 Parganas, Hooghly, Purba-Midnapore and Howrah have less than 5 schemes each.

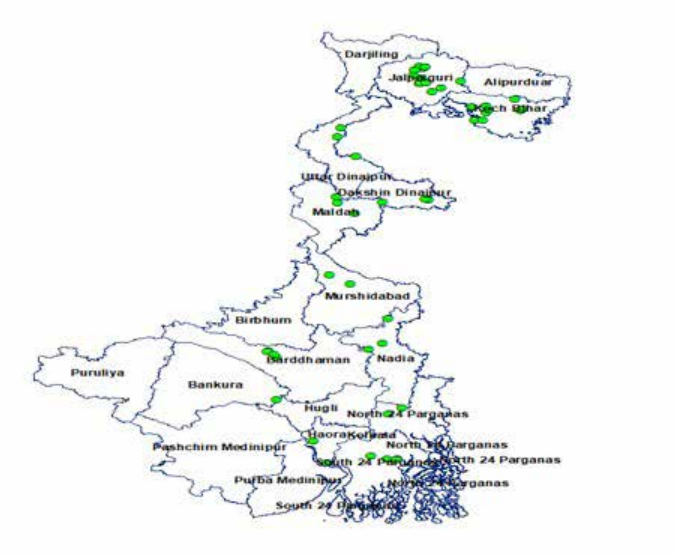
Table 1 - Distribution of Sample Schemes for 'Ground-Truthing Data' Across Districts

District	CD	WDS	LI	TW	PDW	Creek	Total
Bankura	1	2	5	1			9
Bardhaman			4	13			17
Birbhum	8	2	2	1	8		21
Dakshin-Dinajpur			3	9			12
Darjeeling				6	2		8
Hooghly			1	2			3
Howrah				1			1
Jalpaiguri			2	24	7		33
Jhargram	5	18	1	2	2		28
Cooch Behar			6	14			20
Malda			3	6			9
Murshidabad			3	4			7
Nadia			7	1			8
North 24 Parganas		1		3			4
Paschim-Midnapore		2		4	1		7
Purba-Midnapore				2			2
Purulia	2	7	3				12
South 24 Parganas						8	8
Uttar-Dinajpur			1	5			6
Total	16	32	41	98	20	8	215

The selection of schemes was done by the project team using a stratified random sampling design, with the first level of stratification based on scheme type from the districts. The next level of sub-stratification was done by Membership status in the WUA and gender of the farmer. For our results in Section 4, we use sampling weights (constructed as the inverse of the selection probability) to ensure that the results are representative of the population.[7]

7 The probability of selecting a scheme of type i from district j was computed as: Pr(Selection of Scheme)= (Number of type i schemes selected in district j)/(Total number of type i schemes in district j) ; where the list of total schemes constitutes 1396 schemes that have been 100% completed or handed over before June 2019. Similarly, for farmer level data, sampling weights were calculated as 1/(Pr(Selection of scheme)*Pr(Selection of farmer within the scheme)) ; wherein the probability of selecting an individual male or female WUA farmer was estimated as 1/ (Total number of WUA Male Members) OR 1/ (Total number of WUA Female Members). The total number of non-WUA Members in each WUA was not available in our dataset. Hence, a rough estimate was computed by utilising the Population Enumeration tables at village levels for West Bengal from the 2011 Indian Census data website. The total male and female population of each village in our dataset were compiled from the Census and the total number of male and female WUA Members were subtracted from the total population of village to determine the total number of non-WUA Members. Following this, we estimated the probability of farmer selection in the same manner done for WUA male and female farmers and calculated the sampling weights.

B. Verification through Primary Survey by IWMI



To verify certain key agricultural and institutional indicators estimated from DPMU data and to supplement the analysis of secondary data, we independently collected primary data from a random subset of schemes. DPMU has collected data from 240 randomly selected MI schemes across all districts in West Bengal. To verify the data collected by DPMU, we proposed to randomly select 52 MI schemes out of the 240 schemes to ensure that we cover 20% of the schemes for data verification. IWMI has already done a detailed assessment report on this project in 5 districts - namely Purulia, Paschim-Midnapore, Bankura, Birbhum and Jhargram - which covers mainly the Western Lateritic Agro-Climatic Zone of West Bengal. So for the second phase of the survey, we prioritized the remaining districts that have not been covered before. We dropped all MI schemes in these 5 districts and the Western Lateritic Agro-Climatic Zone from the list of 240 schemes covered by DPMU. Also, for logistical purposes we dropped Darjeeling and Purba-Midnapore districts from our sample. We were left with 128 schemes to choose from across 12 districts, with 4 categories of MI scheme types (PDW, LI, TW and WDS) spread across 4 Agro-Climatic Zones. In order to cover all Agro-Climatic Zones (except Western Lateritic Zone) and scheme-types in our sample, and to cover as many districts as possible in our sample, we did a purposive sampling of 2 LI schemes in Coastal Floodplain Zone and chose the remaining 50 schemes stratified across Agro-Climatic Zone, scheme type and districts (proportional stratified sampling) to have an even distribution across these parameters. Consequently, we ended up with 52 schemes for our primary survey as below:

The primary surveys were planned as face-to-face, but in light of the COVID-19 pandemic, it was no longer possible to do so through field visits. After discussion with project officials, an alternative method of telephonic interviews was adopted. Under the revised strategy, we did telephonic surveys of farmers in those 52 schemes, by randomly selecting 2 farmers in each site from the list of WUA Members of whom we got telephone numbers from the department.[8] With the help of local NGO partners, we also collected telephone numbers of 2 non-WUA farmers in the same village and interviewed them over phone. Additionally, telephonic interviews were conducted with a group of key informants in the WUAs to ascertain information on how the WUAs are functioning as an institution in terms of finance, command area, institutional structure etc. These WUA level interviews were conducted with 2-3 key informants via phone call and with the help of local NGO partners. In addition to the 52 schemes selected initially, we increased our sample size by 17 more schemes. These additional 17 schemes were identified based on the data analysis done on the secondary data collected by DPMU, and where the data for certain key indicators needed to be verified further, to corroborate the findings. Thus, these 17 schemes were not in our original sample of 52 schemes, but we included these schemes purposefully to verify the data. See Annexure 1 for the list of 52 original schemes and additional 17 schemes selected for our telephonic survey.

8 It is worth mentioning here that the phone numbers received from the department were not always available for all the WUA Members, which can lead to selection bias in our telephone survey, especially in terms of our ability to reach female Members or marginalised communities who may have lower access to phone. So we should interpret the results with caution, but overall our results from telephone survey match quite well with the primary data from the department.

This primary survey was done both at the farmer level (WUA and non-WUA Members) and at the WUA level through interview of a group of key informants. The questionnaires were developed by IWMI and digital forms for the questionnaires were used for data collection. The data collection was done with the support of a locally hired consultant and DPMU. The questionnaire was developed as a shorter version based on the original, to complement the telephone interview format. It covered key outcomes such as total cultivated area, number of crops grown, crop yields, land kept fallow, gross and net income and more detailed irrigation related questions. Apart from baseline data for some indicators, it also covers endline data for 2019-2020 (beginning from *Kharif* 2019 - May/June 2020), which was not previously available.[9] In total, telephonic interviews were conducted for 273 farmers (137 WUA and 136 non-WUA farmers) belonging to 69 WUAs in 15 districts. By matching the WUAs common to both samples

Table 2 - Selection of Sample Schemes for Phone Survey

District	CD	WDS	LI	TW	PDW	Creek	Total
Bardhaman			1	3			4
Birbhum	2			1	1		4
Dakshin-Dinajpur			1	3			4
Darjeeling				2	1		3
Hooghly				3			3
Howrah			2				2
Jalpaiguri			1	12	3		16
Cooch Behar			3	6			9
Malda			1	2			3
Murshidabad			1	2			3
Nadia			3				3
North 24 Parganas				2			2
Paschim-Midnapore		2	1		1		4
South 24 Parganas						4	4
Uttar-Dinajpur				5			5
Total	2	2	14	41	6	4	69

9 For the pre-ADMI information the respondents were asked to think of agricultural practices in a normal monsoon year before the scheme handover. It has its limitations since it does not specify one particular year, but from our field testing we realised that for recall data a particular reference year which is 3-4 years in the past is not feasible to remember. In contrast asking for a normal monsoon year is easier to answer correctly. Also in the telephone survey our endline reference year is 2019-20, where the *Rabi* harvesting and selling might have been affected by COVID lockdown. However anecdotal evidence based on our conversations with farmers indicate that probably the COVID effect for *Rabi* 2020 was not so high. If however, COVID lockdown in 2020 had a substantial negative shock on the total income from 2019-2020, even then we are likely to under-estimate the effect, and not over-estimate.

Table 3 - Summary Statistics of Farmer Characteristics (Primary and Secondary Data Sources)

	Phone Survey	World Bank Ground Truthing Survey
Total Sample Size	273	670
WUA Members	137 (50.2%)	455 (67.9%)
ST Farmer	29 (10.6%)	123 (18.4%)
Female	19 (6.9%)	236 (35.2%)
Marginal Farmers	179 (65.5%)	500 (74.6%)

we corroborate our findings as estimated in Study Component 1.

About 23% of the total handed-over schemes come from Jalpaiguri followed by Cooch Behar (13%). The spread of the other schemes across districts is more even. TW schemes are the largest in number (41), followed by LI (14) and PDW schemes (6).

The total sample size of the phone survey is 40.7% of that of the World Bank survey. The proportion of WUA Members differ slightly between the two. In the phone survey, 50.2% were WUA Members and the rest 49.8% were control farmers. On the other hand, 67.9% in the secondary data sample were WUA Members, with 32.1% control farmers. However, the percentage of female farmers is much lower in the phone survey (6.9%) versus the secondary data sample (35.2%). This could be attributed to the lower likelihood of female Members of the household attending to the phone, as interviews were held remotely. There is a sufficiently high number of Scheduled Tribe (ST) and marginal/poor farmers in both datasets, implying that the sample has been inclusive of backward and disadvantaged communities. As the project targeted Scheduled Tribe (ST) and marginal/poor farmers as its beneficiaries, our sample is representative of project beneficiaries.

C. Case Studies

Case studies of a few key selected interventions and different approaches of development were undertaken for an in-depth analysis. The case studies were identified in consultation with the project implementation team. The criteria for selecting these cases were to highlight certain focus areas like gender inclusion, additional income generation and empowerment of women through horticulture and fishery activities, institutional success and overall contribution to the growth of the village economy and farmer livelihoods. The case studies focused on the strengths and constraints of these specific interventions, where we worked with Krishi Vigyan Kendra (KVK) experts on these specific focus areas to conduct 11 such case studies as below (Table 4):

Table 4 - List of Sites for Case Study

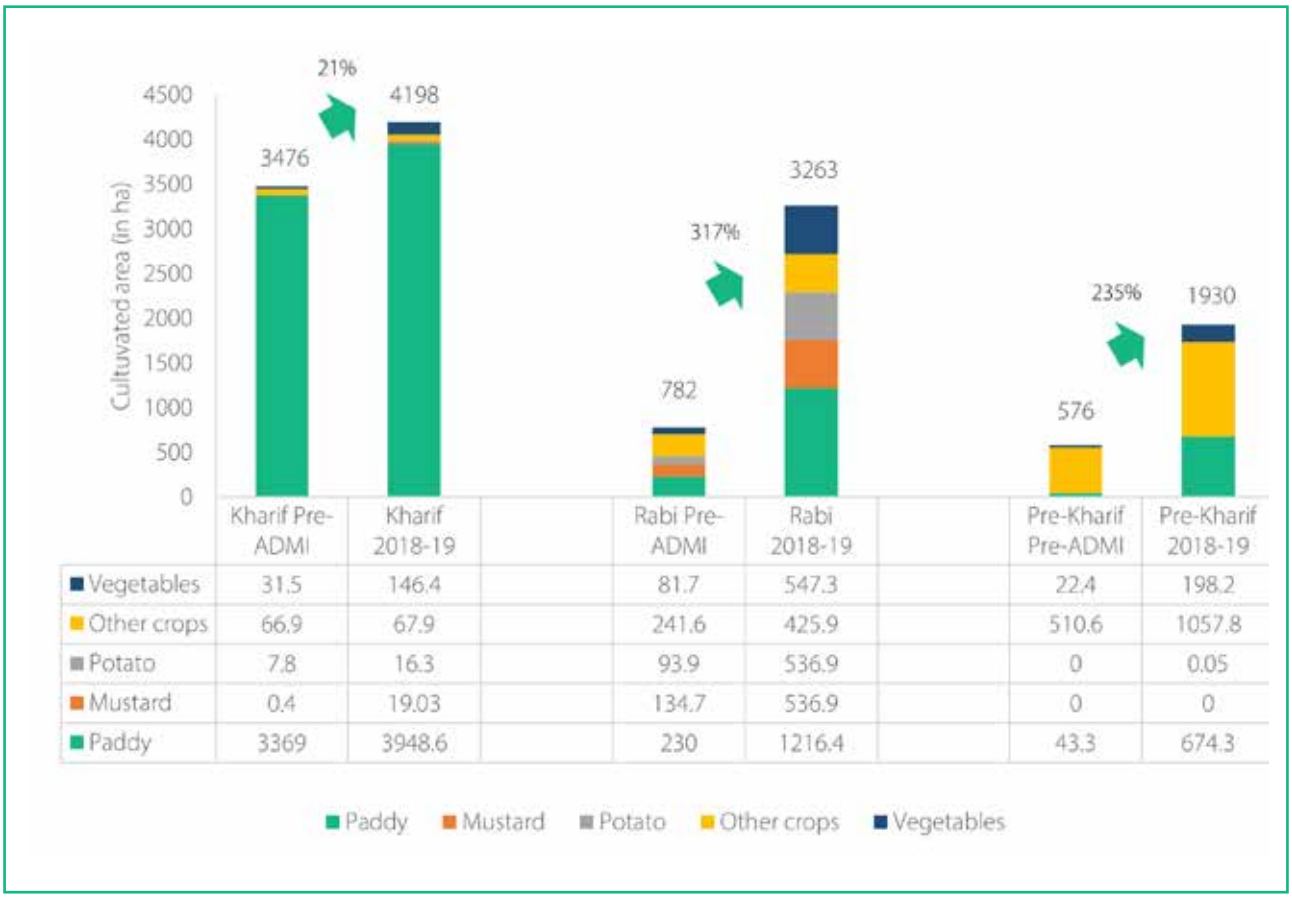
District	Block	WUA Name	Focus Area
South 24 Parganas	Kultali	Kailashnagar WDS WUA	Fishery
South 24 Parganas	Gosaba	Kumirmari WDS WUA	Integrated all women
Hooghly	Tarakeswar	Naskarpur Ghatipara WUA	Institution federation
Bankura	Simlapal	Arrah II Mini RLI WUA	Women institution
Kalimpong	Kalimpong-II	Benda Krishak Bandhu & Bich Kagay Tulsi WUA	Floriculture
Howrah	Amta-I	Balichak Thakuranichak WUA	Polyhouse
North 24 Parganas	Amdanga	Durlavpur WUA	Agri-horticulture
Bankura	Simlapal	Jamirdiha Atu Utnao WUA	Orchard
Birbhum	Illambazar	Kartick Danga Kalimata WUA	Orchard
Purulia	Raghunathpur-I	Amtore RLI WUA	Orchard

3. RESULTS

3.1 Impact on Cropping Patterns

The primary impact of the ADMI project scheme is in terms of bringing more area under agriculture and cultivating previously fallow land during non-monsoon season. As can be seen from Figure 2, total cultivated area for all our sample schemes together shows substantial increase after ADMI project implementation. Total *Kharif* area increased from 3,476 hectares in pre-ADMI years to 4,198 hectares in *Kharif* 2018 i.e. by 21%. Most of the command area was under paddy cultivation in pre-ADMI years. With assured irrigation under the ADMI project, it has been possible to increase *Kharif* area by almost 21%, with some increase in vegetable area as well. But more than 90% of the command area is still under paddy during the *Kharif* season.

The crucial change can however be observed during *Rabi* and *Pre-Kharif* season. Total *Rabi* area of all sample schemes, together saw a substantial jump from 782 hectares in pre-ADMI years to 3,263 hectares in *Rabi* 2018-19 (more than three times increase). For *Pre-Kharif* season also, total cultivated area increased from just 576 hectares to 1,930 hectares (more than doubled). In both *Rabi* and *Pre-Kharif* seasons, area under paddy (Boro paddy in *Rabi* and Aus paddy in *Pre-Kharif*) and vegetables saw substantial increase. In Figure 2, we can see the three main impacts of the ADMI scheme on farmers within the WUA command area:



	Kharif Pre-ADMI	Kharif 2018-19	Rabi Pre-ADMI	Rabi 2018-19	Pre-Kharif Pre-ADMI	Pre-Kharif 2018-19
Vegetables	31.5	146.4	81.7	547.3	22.4	198.2
Other crops	66.9	67.9	241.6	425.9	510.6	1057.8
Potato	7.8	16.3	93.9	536.9	0	0.05
Mustard	0.4	19.03	134.7	536.9	0	0
Paddy	3369	3948.6	230	1216.4	43.3	674.3

Figure 2 - Total Cultivated Area (in ha) of Sample Schemes, Season-Wise

i. Around 20% increase in net sown area as new land was brought under cultivation

ii. Gross cropped area increased substantially as previously fallow land during non-monsoon season was brought under cultivation

iii. Different types of crops started to be cultivated (especially vegetables), reducing dependence on paddy

We look into these changes in more detail in the sections below.

3.1.1 Cropping Intensity

Increased access to irrigation through the ADMI project brought more area under cultivation during the *Rabi* and *Pre-Kharif* seasons i.e. more crops can be cultivated during the year from the same field. Cropping Intensity is defined as the ratio between Gross Cropped Area and Net Sown Area and it is measured as

$$Cropping\ Intensity = \frac{Gross\ Cropped\ Area}{Net\ Sown\ Area} * 100$$

Based on the scheme-level data we find that within ADMI command area, average cropping intensity increased from 129.3% in pre-ADMI years to 183.1% after scheme handover (2018-19 is the reference year for post-ADMI estimates). This increase in cropping intensity by 53.8 percentage points is a reflection of the fact, that more area is being cultivated during *Rabi* and *Pre-Kharif* seasons, which were previously left fallow due to lack of irrigation. Overall, cropping intensity in the post-ADMI period ranges from 199.8% (LI schemes) to 157% (Creek Schemes). The LI (199.8%) and TW (194.7%) schemes have the highest cropping intensities at endline which are close to 200%. In the sample, approximately 36% schemes have cropping intensity greater than 200%. Among the scheme types, LI (46%) and TW (43%) have the largest proportion of schemes with a cropping intensity higher than 200%, while Creek schemes have the lowest proportion (13%).

Measuring from endline, we obtain the changes in cropping intensity which reflects the actual performance of the schemes. This change is the highest for TW schemes (60.5 percentage points), followed by Creek (54.3 percentage points) and WDS (50.4 percentage points). The change in LI schemes is comparatively modest at 49.2 percentage points (this is explained by the fact, that due to the existence of the river as a water source before the scheme, the baseline cropping intensity in those areas was comparatively higher at 150.6%). The success of TW schemes (Tube Well schemes) and LI is not surprising, but it is interesting to find

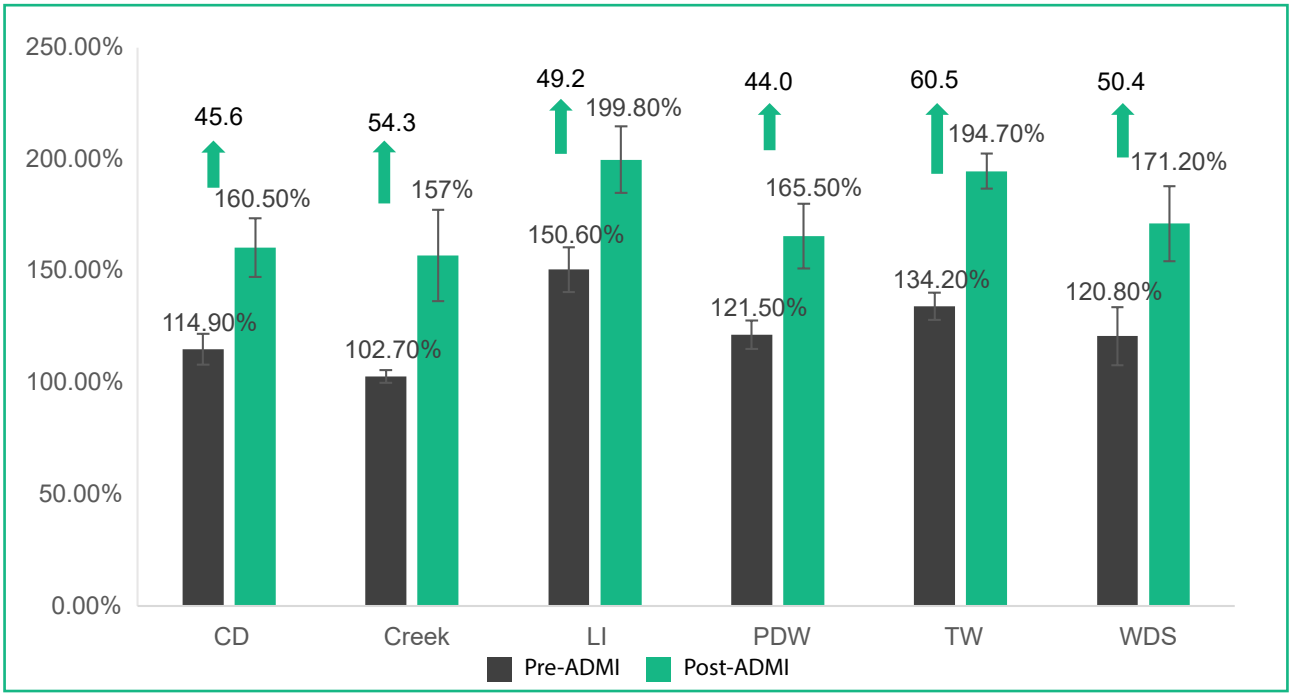


Figure 3 - Cropping Intensity Across Minor Irrigation Scheme Types

Table 5 - Cropping Intensity Between WUA and Non-WUA Farmers

	All Farmers			Only Male Farmers		
	WUA	Non-WUA	Sig.	WUA	Non-WUA	Sig.
Pre-ADMI	127.1pp	123.9pp	n.s.	128.1pp	124.9pp	n.s.
2018-19	165.5pp	137.7pp	***	165.6pp	137.1pp	***
Percentage Point Change	38.4pp	13.8pp		37.5pp	12.2pp	

*(**){***}[****] Statistically significant at the 10pp (5pp) {1pp} [0.1pp] level of alpha error probability. Based on multiple Mann-Whitney tests.

that surface water schemes with limited storage like WDS have been quite successful.

In terms of improvement in cropping intensity, the top four districts are Cooch Behar, Bankura, Paschim-Midnapore and Darjeeling (Table 38), where cropping intensity increased by more than 70 percentage points. While for 3 districts, the post-ADMI cropping intensity was less than pre-ADMI values – these were Howrah (-34.3 percentage points), Nadia (-10.7 percentage points) and Purba-Midnapore (-0.4 percentage points). Howrah and Purba-Midnapore had very few schemes in the sample – one and two schemes, respectively - while Nadia had very high baseline cropping intensities (Nadia mostly had LI schemes), which did not increase post-ADMI.

The average cropping intensity increased in pre-ADMI years after the scheme handover.

This is a reflection of the fact, that more area is being cultivated during *Rabi* and *Pre-Kharif* seasons, which were previously left fallow due to lack of irrigation.

The changes in cropping intensity is the highest for TW schemes, followed by and then WDS. The success of TW schemes (Tube Well schemes) and LI is not surprising, but it is interesting to find that surface water schemes with limited storage like WDS have also been quite successful.

The change in cropping intensity within ADMI command area, described in Table 5 could also be the result of other changes (technological, social and economic) over time that affected all farmers, irrespective of ADMI scheme. For a more accurate estimate of ADMI's impact on changes in cropping intensity, we compare a sample of WUA farmers and non-WUA farmers from these ADMI schemes across West Bengal. Pre-ADMI, both WUA Members (127.1%) and non-WUA farmers (123.9%) had similar cropping intensities (no significant difference). But for WUA Members, post-ADMI cropping intensity increased by 38.4 percentage points to 165.5%; while it increased by only 13.8 percentage points for non-WUA Members. Since WUA Members were sampled to include equal number of male and female Members, while for non-WUA Members it is mostly male farmers, we also look at the sub-sample of only male WUA Members versus male non-WUA farmers. As we can see in Table 5, even then the change in cropping intensity for WUA Members is 37.5 percentage points compared to just 12.2 percentage point increase for non-WUA farmers. It implies that average increase in cropping intensity was 24.6 percentage points higher for WUA Members.

3.1.2 Crop Diversification

Not only are the farmers now cultivating more area because of the ADMI scheme, but we find that they are also growing many different types of crops. Both the number of different crops and proportion of area under these different crops have increased in ADMI command areas. WUA Members are now growing many vegetables during *Rabi* season like brinjal, cauliflower, leafy vegetables, onion, pumpkin, ridge-gourd, sesame, etc. The proportion of gross cropped area under potato and mustard have also shown an increase in sampled villages under this project (Figure 2). Consequently, the dependence on paddy as the only source of income has declined.

Overwhelming majority of our sample farmers have been cultivating Aman paddy in the pre-ADMI period (more than 90%). Even after ADMI scheme implementation, majority of farmers in our sample

Table 6 - Percentage of WUA Farmers Cultivating Different Major Type of Crops

Crop	Pre-ADMI	2018-19
Aman Paddy	91.1%	93.9%
Boro Paddy	19.2%	34.2%
Aus Paddy	2.9%	1.4%
Potato	22.3%	37.3%
Brinjal	7.9%	14.5%
Mustard	14.1%	32.8%
Other Vegetables	9.0%	27.6%
Sesame	4.6%	7.7%
Pulse	2.9%	6.3%

continued to cultivate Aman paddy during the *Kharif* season. But as irrigation became accessible during *Rabi* and *Pre-Kharif* season, more farmers started to cultivate other crops like Boro paddy (19.2% farmers to 34.2% farmers), mustard (14.1% to 32.8%), potato (22.3% to 37.3%), brinjal (7.9% to 14.5%) and other vegetables (from 9% to 27.6%).

Boro cultivation is very high in Dakshin-Dinajpur but it was already at a high level relative to the other districts before ADMI implementation (more than 70% farmers). The districts where the largest proportion of our sample farmers started cultivating Boro, were South 24 Parganas (17% to 94%); Cooch Behar (from 42% to close to 81%); Paschim-Midnapore (22% to 60%); Murshidabad (0 to 30%); Uttar-Dinajpur (38% to 53%) and Malda (6% to 24%). The farmers cultivating Boro are mostly from Creek schemes, or from TW or LI schemes. Potato cultivation increased primarily in the Vindhiyan Old Flood Plains of North Bengal in Malda, Murshidabad and Cooch Behar; and in the Western Lateritic Zone of Purulia, Bankura and Birbhum. Similarly, mustard cultivation picked up in Western Lateritic Districts of Purulia, Jhargram, and Birbhum. Vegetable cultivation also picked up in almost all of West Bengal for the ADMI command area farmers.

The fact that WUA farmers' dependence on paddy has gone down and they have diversified towards other crops namely, vegetables like brinjal, onion, okra and tomato and oilseeds like sesame and mustard, is also evident in Figure 4 which shows the share of different crops in farmer's gross cropped

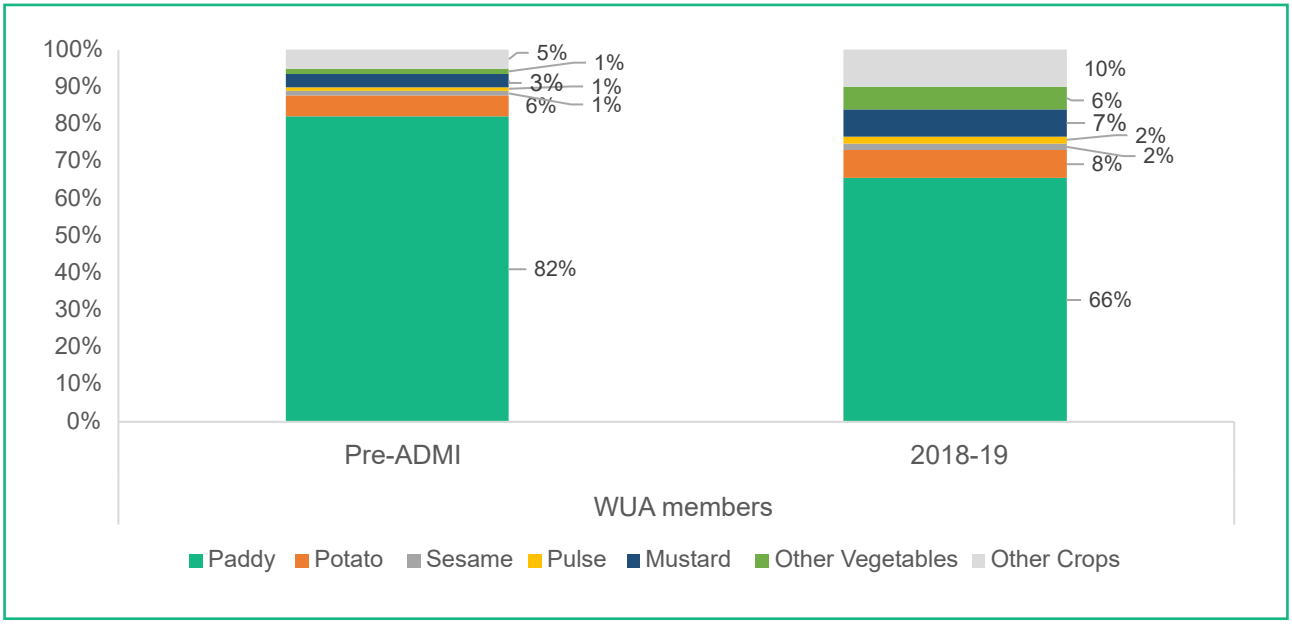


Figure 4 - Share of Different Crops in Farmer's Gross Cropped Area

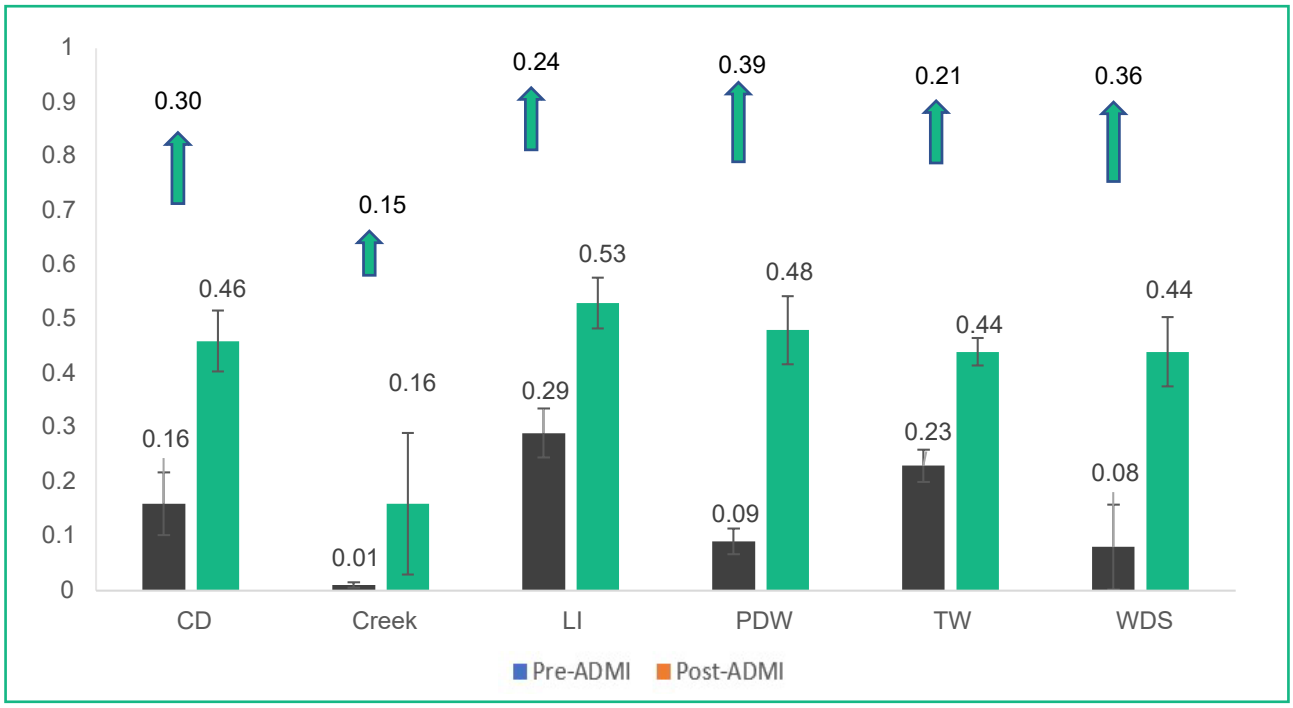


Figure 5 - Crop Diversification Index Across Scheme Type

area. Share of paddy (Boro + Aman + Aus) has gone down from 82% (mostly Aman - 72%) in pre-ADMI years to 66% (53% share is Aman) in 2018-19 for WUA farmers; while in the same period share of potato grew from 6% to 8%, other vegetables grew from 1% to 6% and mustard from 3% to 7%. Boro share also increased from 9% to 12%.

Both the number of different crops and proportion of area under these different crops have increased in ADMI command areas. WUA Members are now growing many vegetables during *Rabi* season like brinjal, cauliflower, leafy vegetables, onion, pumpkin, ridge-gourd, sesame, etc. But as irrigation became accessible during *Rabi* and *Pre-Kharif* season, more farmers started to cultivate other crops like Boro paddy, mustard, potato, brinjal and other vegetables (from 9% to 27.6%). The overall Crop Diversification Index increased in 2018-19.

So, WUA farmers have diversified from paddy, to cultivate more than one type of crop and this is reflected in the Crop Diversification Index, which captures this change in crop diversity more systematically and is measured using the following formula

$$\text{Crop Diversification Index} = -\Sigma\, p_i * \log[p_i]$$

where p_i is the proportion of area under crop i in a particular scheme. This Crop Diversification Index is lowest at 0 when there is only one crop grown 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.

The overall Crop Diversification Index increased from 0.21 in pre-ADMI years to 0.45 in 2018-19. Figure 5 indicates that across all scheme types the Crop Diversification Index increased post-ADMI scheme. CDI at endline is highest for LI schemes (0.53) and lowest for Creek schemes (0.16). For the rest of the scheme types, the CDI is between 0.44 to 0.48. However, in terms of change in CDI, this is largest for PDW schemes (0.39) and WDS schemes (0.36). This is mainly due to a considerable decline in share of paddy in gross cropped area from 77% to 58% for PDW schemes and a stark increase in the share of vegetables from 2% to 16%. Similarly, for WDS schemes, we find that proportion of total cultivated area under paddy has sharply fallen from 88% to 56% and area under vegetables has increased from 3% to 14%. The share of mustard has also doubled from 5% to 10% in the post-ADMI period. Hence, the rise in CDI can be credited to the increase in area cultivated during *Rabi* and *Pre-Kharif* seasons due to the addition of new crops. Creek schemes (in South 24 Parganas) have the lowest CDI, where most of

the shift was towards Boro paddy (38% schemes growing Boro paddy at baseline to 100% schemes growing in endline), without much increase in vegetables or other crops (0.7% to 4%)[10]. The share of paddy continues to remain very high (~90%) in these schemes.

Increase in CDI across districts is the highest in the Western Lateritic Districts of Bankura, Birbhum, Jhargram and Purulia as farmers in this region shifted to other crops like vegetables, mustard, sesame rather than Boro paddy after scheme introduction. Given the limited use of groundwater in these regions, the project officials have promoted and supported other crops among farmers instead of paddy.

3.1.3 Crop Yield

The ADMI programme has not only increased access to irrigation, but has also provided agricultural support services. Thus, it is important to assess the project's impact on crop yield. We estimate and compare the yield for the three most important crops for our selected sample of farmers – paddy, mustard and potato. Table 7 compares West Bengal's average yield for paddy, potato and mustard with the average yields obtained from WUA farmers in our sample, after the project. Mean paddy yield for WUA farmers is 1.6 times higher than the state average of 2.9 tonnes/ha. In fact, more than 99% of WUA farmers in our sample had paddy yield above state average. Similarly, for mustard the average yield for WUA farmers is greater than the state average of 1.3 tonnes/ha. However, for potato, the WUA farmers have a slightly lower yield at 28.2 tonnes/ha than the state average of 29.3 tonnes/ha. Only 30% farmers in our sample had potato yields higher than state average. ~48% of farmers having potato yield greater than the state average are from Jalpaiguri (14.3%), Jhargram (16.7%), Birbhum (9.1%) and Cooch Behar (7.7%). The rest of the districts have less than 7% of farmers having potato yield greater than the average.

Paddy yield has increased from 3.3 tonnes/ha to 4.6 tonnes/ha for WUA farmers post project implementation. For potato also there has been a substantial increase in yield as it almost doubled from 14.3 tonnes/ha to 28.2 tonnes/ha after the implementation of the project. For mustard, the average yield increased from 1.2 tonnes/ha to 1.5 tonnes/ha post-ADMI. The yield increase can be credited to the WUA schemes through increased availability of sufficient irrigation and training in agricultural practices. This increase in yield (especially for Aman paddy) is also partly because of irrigation availability during intermittent dry spells

Table 7 - Average Yield of WUA Farmers in Tonnes/Ha

Crop	Average Yield for WUA Farmers Pre-ADMI	Average Yield for WUA Farmers in 2018-19	State Average Yield Estimate (2011-12)	State Average Yield Estimates (2017-18)[11]	% of WUA Sample Farmers with Yield Above State Average
Paddy	3.3	4.6	2.7	2.9	99% (N=422 out of 426 Paddy Farmers)
Potato	14.3	28.2	28.9	29.3	30% (N=50 out of 166 Potato Farmers)
Mustard	1.2	1.5	1	1.3	100% (N=150 out of 150 Mustard Farmers)

10 We do not differentiate between Aman and Boro paddy as separate crops in the calculation of CDI, but even if we treat them as separate crops, CDI is still lower for Creeks in South 24 Parganas.

11 The State Average figures have been obtained from the Agricultural Statistics Handbook published by the Government of India Ministry of Agriculture and Farmers' Welfare, Department of Agriculture, Cooperation and Farmers' Welfare, Directorate of Economics and Statistics. (www.agricoop.nic.in & http://eands.dacnet.nic.in)

Table 8 - Crop Yield Across Scheme Types

Yield (Tonnes/ ha)	Aman Paddy		Boro Paddy		Potato		Mustard	
	Pre-ADMI	2018-19	Pre-ADMI	2018-19	Pre-ADMI	2018-19	Pre-ADMI	2018-19
CD	3.3	4.8	3.3	5.7	18.7	24.2	0.9	1.3
Creek	1.9	3.1	4.2	5.8	.	.	.	0.9
LI	3.4	4.6	4.4	5.2	20.6	26.6	1	1.2
PDW	3.4	4.6	3.4	4.7	13.1	22.7	0.9	1.3
TW	3.3	4.6	5.3	6.3	20.5	26.1	0.9	1.3
WDS	3	4.2	4.9	5.9	20.7	26.8	0.8	1.1

within the *Kharif* season from these MI schemes, which act as life saving irrigation, reducing crop damage and increase in yield. Interestingly, when we look at the state averages for yield of these crops we do not find such a high increase between pre and post-ADMI periods. (Between 2011-12 to 2018-19, potato yield went from 28.9 tonnes/ha to 29.3 tonnes/ha in 2018-2019; and paddy went from 2.7 tonnes/ha to 2.9 tonnes/ha).

Paddy yield has increased for WUA farmers post project implementation. For potato also there has been a substantial increase in yield as it almost doubled after the implementation of the project. The yield increase can be credited to the WUA schemes through increased availability of sufficient irrigation and training in agricultural practices. This increase in yield (especially for Aman paddy) is also partly because of irrigation availability during intermittent dry spells within the *Kharif* season from these MI schemes, which act as life saving irrigation, reducing crop damage and increase in yield.

Table 8, indicates that yield for the main crops across all scheme types have greatly increased and this is due to a combination of irrigation availability, training in seed treatment and adoption of new technologies. The change in yield for Aman paddy ranges from 1.2 to 1.5 tonnes/ha. This is highest for CD schemes at 1.5 tonnes/ha, while for Creek, LI, PDW and WDS schemes, it has increased by 1.2 tonnes/ha. The highest increase in yield for Boro paddy occurred for CD schemes (2.4 tonnes/ha) followed by Creek (1.6 tonnes/ha) and PDW schemes (1.3 tonnes/ha). The rise in Boro yield is least for LI schemes (0.8 tonne/ha) followed by TW and WDS schemes (both 1 tonne/ha). In the case of potato yield, Creek schemes did not have any cultivation at both baseline and endline. PDW schemes have the lowest average yield (22.7 tonnes/ha) but have the largest increase in yield (9.6 tonnes/ha). Finally, mustard has had a more uniform increase in yield (0.2-0.4 tonnes/ha) across all schemes.

However, the improved yield is not just because of improved irrigation, but also adoption of new technologies and better agronomic practices such as line sowing of paddy, direct seeded rice, seed treatment, use of HYV seeds among farmers through agricultural support services provided by the scheme. We expand on this more in the next section.

3.1.4 Capacity Building Training in Agricultural Practices

As mentioned before, one important aspect of the WBADMI project has been to demonstrate new and improved agricultural practices to farmers, train them as well as provide them with support to help increase their productivity. This is expected to enable full utilization of the potential created under the new irrigation schemes. The extensiveness of the training component can be understood from the fact that overall 90% of farmers in our sample reported to have received some form of training on improved agricultural practices other than fisheries/ horticulture or on institutional aspects.

Table 9 - WUA Farmer Participation in Capacity Building Trainings

	% of WUA Farmer Participation	% of Marginal WUA Farmer Participation
Top Three		
Seed Treatment	80% (N=357)	80% (N=263)
Seed Preservation	64% (N=283)	63% (N=205)
Pest Management	62% (N=275)	61% (N=200)
Bottom Three		
Polyhouse	18% (N=80)	17% (N=57)
High Value Cropping	40% (N=177)	40% (N=131)
Vermicompost	40% (N=179)	39% (N=127)
TOTAL (N)	**N=445**	**N=327**

Through the ADMI project, farmers received training in nine primary practice areas: **Seed Treatment, Seed Preservation, Farm Mechanics, Polyhouse, High Value Cropping, Vermicompost, Organic Farming, SRI and Pest Management.** Table 9, presents the trainings with the most and least amount of participation among total number of farmers in the sample. The last column of Table 9, also displays the proportion of marginal WUA farmers who received these trainings.

Seed Treatment had the most reach with 80% of the 445 WUA farmers undertaking the training. Seed treatment is followed by seed-preservation (64%) and pest-management (62%). Unsurprisingly, Polyhouse has had the least participation at 18%, since it is targeted in few scheme sites where Polyhouse cultivation is being practiced. The fact that the proportion of marginal WUA farmers receiving training is same as the proportion of total WUA farmers receiving training, implies that the training has been inclusive of marginal farmers.

There is however, substantial difference across districts in terms of exposure to new technologies through trainings received under ADMI project. Except Bardhaman, in all other districts more than 90% of WUA farmers reported to have received at least 1 training from the ADMI project. In Hooghly or North 24 Parganas, almost 100% WUA farmers in our sample received training on 5 or more topics from the ADMI project. In Howrah, Nadia and Murshidabad training has also been higher, with reported more than 80% WUA farmers receiving training on 5 or

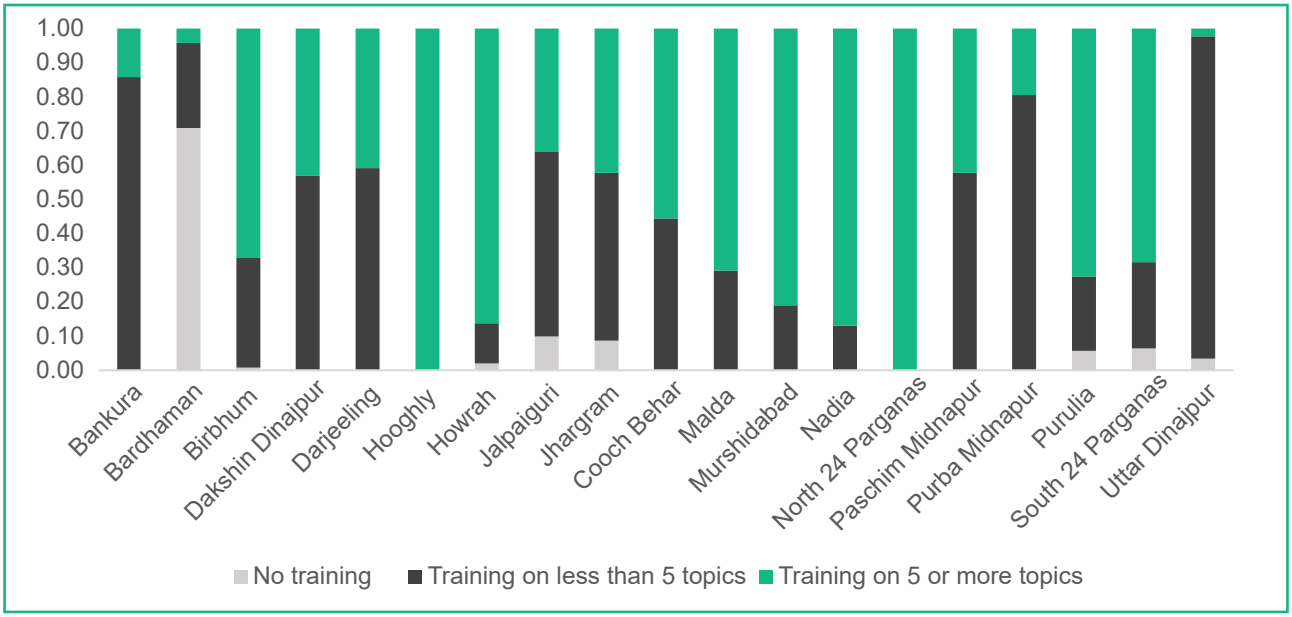


Figure 6 - Training Received Across Districts

Table 10 - Agricultural Outcomes Correlated with Training

	No Training		At Least 1 Training but <5 Training		>=5 Training	
	Before	After	Before	After	Before	After
Cropping Intensity (CI)	125.2%	130.1%	121.1%	155.9%	127.0%	161.0%
Paddy Yield (tonnes/ha)	3.5	4.5	3.2	4.6	3.3	5.3
Potato Yield (tonnes/ha)	11.3	27.5	13.3	28.4	15.7	28.6
Mustard Yield (tonnes/ha)	0.79	1.4	1.57	1.7	1.29	1.5

more topics. Comparatively in Purba-Midnapore, only 19% of WUA farmers received training on more than 5 topics. This was even lower for Uttar-Dinajpur (2%), Bardhaman (4%) and Bankura (14%).

Through the ADMI project, farmers received training in nine primary practice areas: Seed Treatment, Seed Preservation, Farm Mechanics, Polyhouse, High Value Cropping, Vermicompost, Organic Farming, SRI and Pest Management and the extent of training received is correlated with better agricultural outcomes. The cropping intensity for those WUA farmers who received at least some training increased by 34-35 percentage points after the handover, while it increased by only 5 percentage points for farmers who received no training.

In Table 10, we can see that the extent of training received is correlated with better agricultural outcomes in terms of higher cropping intensity and higher crop yield. The cropping intensity for those WUA farmers who received at least some training increased by 34-35 percentage points after the handover, while it increased by only 5 percentage points for farmers who received no training. Similarly, it can be seen that the farmers receiving at least 5 trainings, have witnessed the highest average paddy yield of 5.3 tonnes/ha; approximately 17% higher than those WUA farmers who received no training or less than 5 trainings. Also, in the pre-ADMI years, the yield of paddy was very similar across farmers, but after project implementation, farmers receiving 5 trainings or more increased yield by 60% (from 3.3 to 5.3 tonnes/ha), farmers receiving at least 1 training but less than 5 trainings increased paddy yield by 43% (from 3.2 tonnes/ha to 4.6 tonnes/ha); while for farmers receiving no training, the increase in yield was only 29% (from 3.5 tonnes/ha to 4.5 tonnes/ha). For potato and mustard, on the other hand, the pre-ADMI yield for farmers receiving no training were comparatively lower, but they attain yield levels almost equivalent with those farmers receiving training in 5 or more topics. So the positive correlation between training and improved outcomes are reflected in improved cropping intensity and paddy yield but not quite for potato and mustard yield. We can thus infer that the WBADMI project has been successful in providing agricultural support services to marginal farmers and female farmers. In our sample of farmers, we find that 89% of marginal WUA farmers received at least some training and 90% of female WUA Members received at least one training which is an indicator that there has been a high level of inclusivity.

The agricultural support services also resulted in more farmers adopting climate resilient practices and also improved agricultural practices. The adoption of these best practices increased for WUA farmers much more than non-WUA farmers. Table 11 indicates for WUA farmers the practice of

Table 11 - Climate Resilience Practices Amongst WUA Farmers in Comparison to Non-WUA Farmers

	Non-WUA Farmers		WUA Members	
	Pre-ADMI	Post-ADMI	Pre-ADMI	Post-ADMI
Mulching	1%	3%	6%	16%
Inter-Cropping	3%	11%	8%	37%
Pulse-Intensification	2%	6%	6%	25%
Zero-Tillage	1%	3%	2%	9%

mulching increased from 6% to 16% post-ADMI, while for non-WUA farmers the increase was much smaller from 1% to 3%. Inter-cropping and pulse intensification also saw substantial increase from 8% to 37% and 6% to 25% for WUA farmers, as the project put emphasis on farmers to diversify into different crops and practice inter-cropping. No such increase was observed for non-WUA farmers in our sample. Zero-tillage adoption even post project for WUA farmers is still quite low at 9%, but it is still higher than for non-WUA farmers at just 3%.

Similar trends could be observed for improved agricultural practices also amongst WUA farmers as described in Table 12. There was substantial increase observed in the proportion of WUA farmers practicing seed treatment (11% to 45%), seed preservation (20% to 33%), SRI (4% to 31%), mechanised farming (7% to 33%), cultivation of high-value crops (2% to 26%), improved pest management (6% to 36%), use of vermicompost (3% to 19%) and organic farming (11% to 28%). This extent of increase could not be observed for non-WUA farmers during the same period. This is an important contribution of the ADMI scheme in introducing new practices to farmers. However, as we can see, adoption of these practices (except seed treatment) are often limited to less than one-third of farmers. So there is substantial scope for improvement in this area. Additionally, there is quite a lot of variation across districts (Table 43). Dakshin-Dinajpur has managed to cover 70% and 71% of total farmers under seed treatment and seed preservation, respectively. Similarly, Hooghly and Darjeeling have much higher level of adoption (at least 60% adoption across all training topics in Hooghly and more than 50% uptake in Darjeeling for four types of training) than districts like Bankura which under-performs in improved practice adoption (less than 10% participation each for 8 training categories). Additionally, farmers were asked to state whether they would like to have any additional training services. As expected, majority of the farmers in poorly performing districts demanded for an extension of training facilities. 96% of Bankura's WUA farmers gave feedback that they would require more training, with the highest demand for seed treatment (51%).

3.1.5 Comparison Across Agro-Ecological Zones

The Agro-Ecological Zones in West Bengal are divided into five regions; Hilly, Red Lateritic Semi-Arid, Alluvial (Vindhyan and Gangetic), Saline Coastal and Terai Teesta Zone respectively. The Red Lateritic Zone is characterised by red soil and has an average annual rainfall of 1100 - 1400 mm and an average temperature ranging from 15^0C - 37^0C. Primarily the districts of Purulia, Paschim-Midnapore, Bankura, Birbhum and Jhargram constitute this Red Lateritic Zone. Surface water schemes (check dam and water detention structures) are dominant in this zone. The Alluvial Zone is spread over the most number of districts – Uttar-Dinajpur, Dakshin-Dinajpur, Murshidabad, Malda, Nadia, 24 Parganas North, Howrah, Hooghly and Bardhaman. It has higher

Table 12 – Improved Agricultural Practices Amongst WUA and Non-WUA Farmers

	Non-WUA Farmers		WUA Members	
	Pre-ADMI	Post-ADMI	Pre-ADMI	Post-ADMI
Seed Treatment	7%	20%	11%	45%
Seed Preservation	11%	16%	20%	33%
SRI	2%	8%	4%	31%
Farm-Mechanization	1%	12%	7%	33%
Polyhouse	0%	1%	1%	6%
High Value Crops	1%	6%	2%	26%
Pest-Management	5%	16%	6%	36%
Vermicompost	1%	6%	3%	19%
Organic Farming	3%	5%	11%	28%

average rainfall at 1300-2000 mm and average temperature between 15^{o}C and 35.5^{o}C. It is the most fertile belt in West Bengal. Groundwater schemes are dominant in this Zone. The Hilly Zone spans across Darjeeling and Kalimpong. It is a highly water scarce region with low irrigation potential and the Saline Coastal Zone, comprises of the South 24 Parganas and Purba-Midnapore districts with saline coastal soil and is mostly a single cropped rainfed area. The key agricultural developments that have taken place in these five zones are sustainable land management (through cultivation in the upland and medium land) for the Lateritic Zone, improved paddy variety and introduction of additional salt tolerant crops for Saline Zone, zero budget natural farming in the Hilly Zone, SRI and maize intensification in the Terai Teesta Zone and pulses and oil seeds intensification in the Alluvial Zone.

In this section, we will be breaking down the geographical area of the state into these five Agro-Ecological Zones, and assess the overall performance of ADMI schemes across these zones. The objective is to determine which schemes have been well-suited to a particular Agro-Ecological Zone. We used the scheme level agricultural dataset comprising of 215 schemes to conduct this analysis. The following maps highlight the comparison of agricultural indicators across different Agro-Ecological Zones.

Cropping Intensity

The cropping intensity at baseline is 129.3% and at endline is 183.1%. Figure 7, shows that the Hilly Zone has fared the best in terms of performance at endline (212.6%) followed by the Terai Teesta Zone (191.3%). In the Hilly Zone 6 of the 8 schemes and in Terai Teesta 47 of the 53 schemes have a cropping intensity greater than 150% at endline. Overall, all five zones have experienced significant progress towards increasing the cropping intensity. They started at less than 150% at baseline and the change in cropping intensity ranges from 44.1 percentage point to 78.2 percentage point increase. The largest increase in cropping intensity is in the Hilly Zone (78.2 percentage point), followed by Red Lateritic (57.1 percentage point) and Terai Teesta Zone

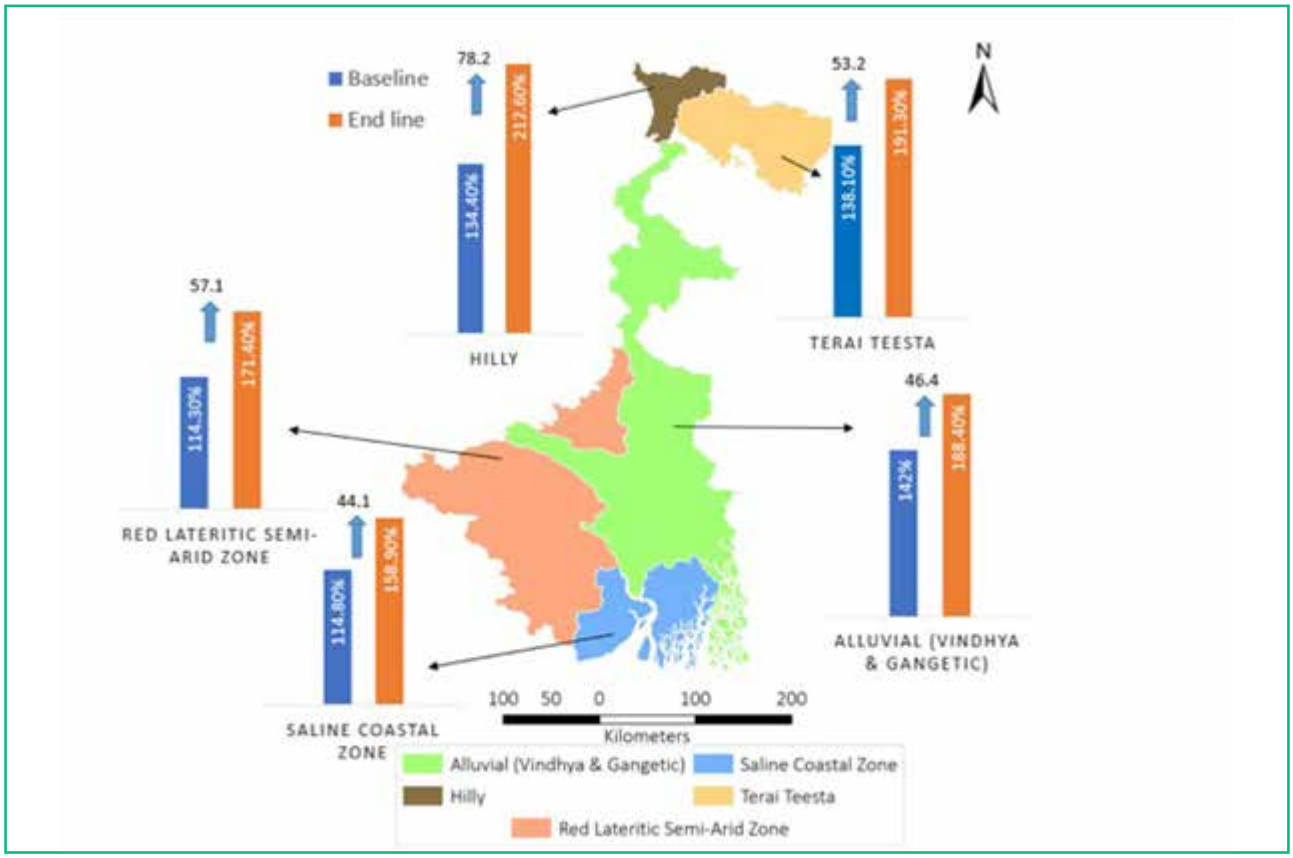


Figure 7 - Overall Cropping Intensity – Baseline (Pre-ADMI) and Endline (Post-ADMI) - Agro-Ecological Zone-Wise

(53.2 percentage point). It is important to highlight that the water stressed zones of Saline Coastal and Red Lateritic Semi-Arid Zones of the state, which had a very low baseline cropping intensity of about 114% due to limited access to irrigation, witnessed substantial improvement in cropping intensity under the scheme to move above 150% cropping intensity.

Crop Diversification

Similar improvement is also witnessed in the Crop Diversification Index as farmers started cultivating multiple types of crops across the year under this scheme, moving away from dependency on a single crop. The overall Crop Diversification Index increased from 0.21 in pre-ADMI years to 0.45 in 2018-19. At baseline, in all the zones, the Crop Diversification Index was very low, especially for the Red Lateritic Semi-Arid Zone (0.009), where it was almost always just one crop across the year. This however, experienced the largest increase after the scheme to rise to 0.45 at endline. The Terai Teesta Zone had a much higher CDI of 0.27 at baseline and it also increased to 0.47 at endline, which is almost the same as the CDI in Red Lateritic Zone at endline. In the Red Lateritic Zone with more surface water schemes, the project gave emphasis on the cultivation of less water intensive (compared to Boro) but high-value crops like vegetable, sesame, mustard etc., which is reflected in the substantial rise in CDI. The Saline Coastal Zone however witnessed a much lower crop diversification, with the CDI growing from 0.03 to just 0.13, mostly because under the Creek schemes in this region farmers gave preference to Boro paddy during *Rabi* season. Boro was also more prevalent in Alluvial and Terai Teesta Zones, and this therefore translates into less cultivation of other crops.

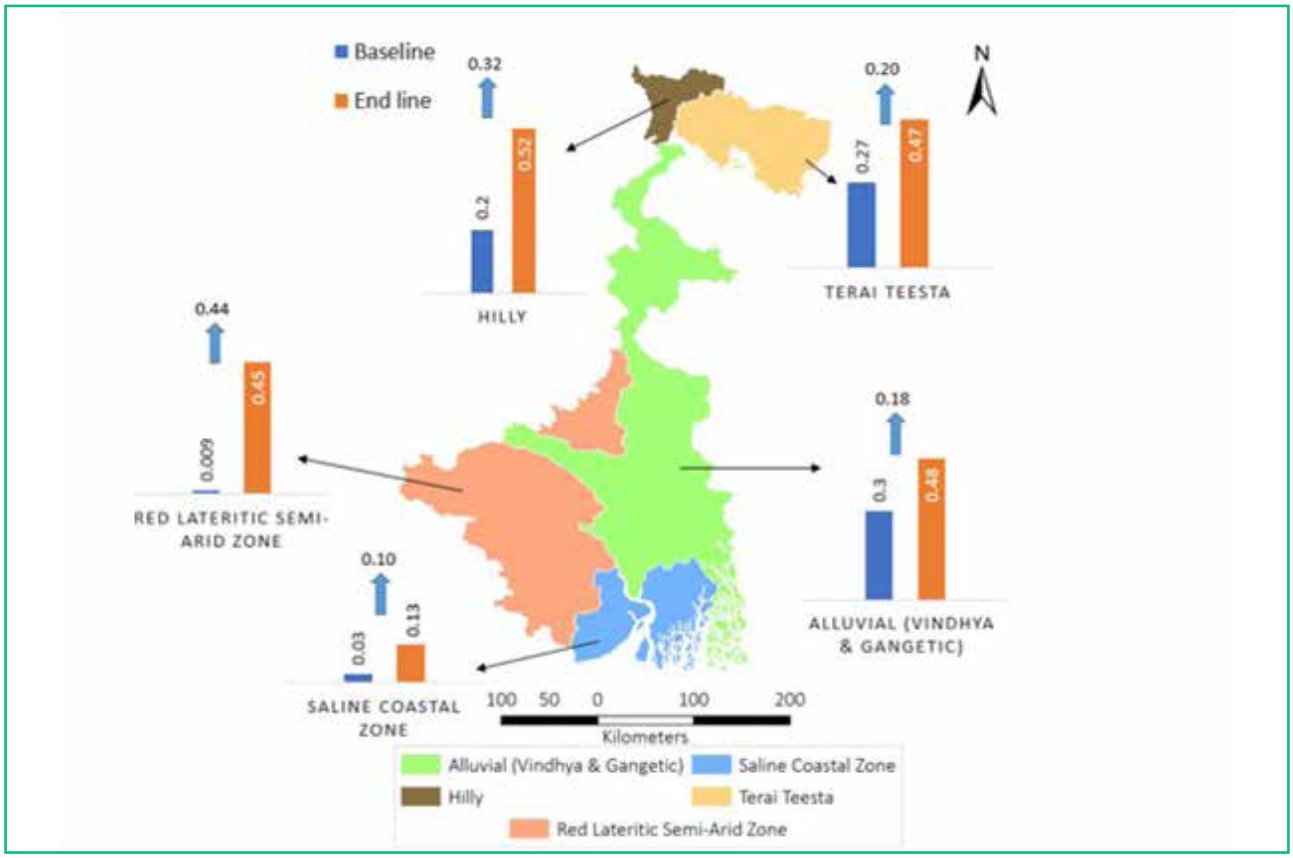


Figure 8 - Crop Diversification Index: Baseline (Pre-ADMI) and Endline (Post-ADMI) Agro-Ecological Zone-Wise

Average Crop Yield (tonnes/ha)

The average yield has been presented in Figure 9 for the four key crops. There has been an increase in the productivity of Aman paddy since the scheme handover in all 5 zones. At endline, for all zones except Saline Coastal, the yield has crossed 4 tonnes/ha. The Hilly Zone has achieved the highest gains in Aman paddy yield from 3.3 tonnes/ha to 5.5 tonnes/ha. This zone also has the highest endline yield. When we look at the yield for Boro paddy, we again find that all zones have shown substantial improvement in this aspect. The Red Lateritic Zone and the Saline Coastal Zones have emerged to have the greatest increase of 1.4 tonnes/ha; the Hilly Zone has the highest endline yield at 8.9 tonnes/ha. For potato yield also, the Terai Teesta Zone and Red Lateritic Zone have exhibited highest progress in the post-ADMI period, growing from 15.4 tonnes/ha to 24.3 tonnes/ha and from 20.2 tonnes/ha to 27.1 tonnes/ha respectively. The fertile Alluvial Zone had highest endline yield (27.3 tonnes/ha) but it already had a high baseline and the increase was comparatively smaller. Mustard yield at baseline was less than one tonne/ha for all zones. At endline, the Alluvial Zone had the highest yield (1.4 tonnes/ha) and the largest increase in mustard yield at 0.45 tonne/ha. But overall all the zones have performed well in terms of crop productivity.

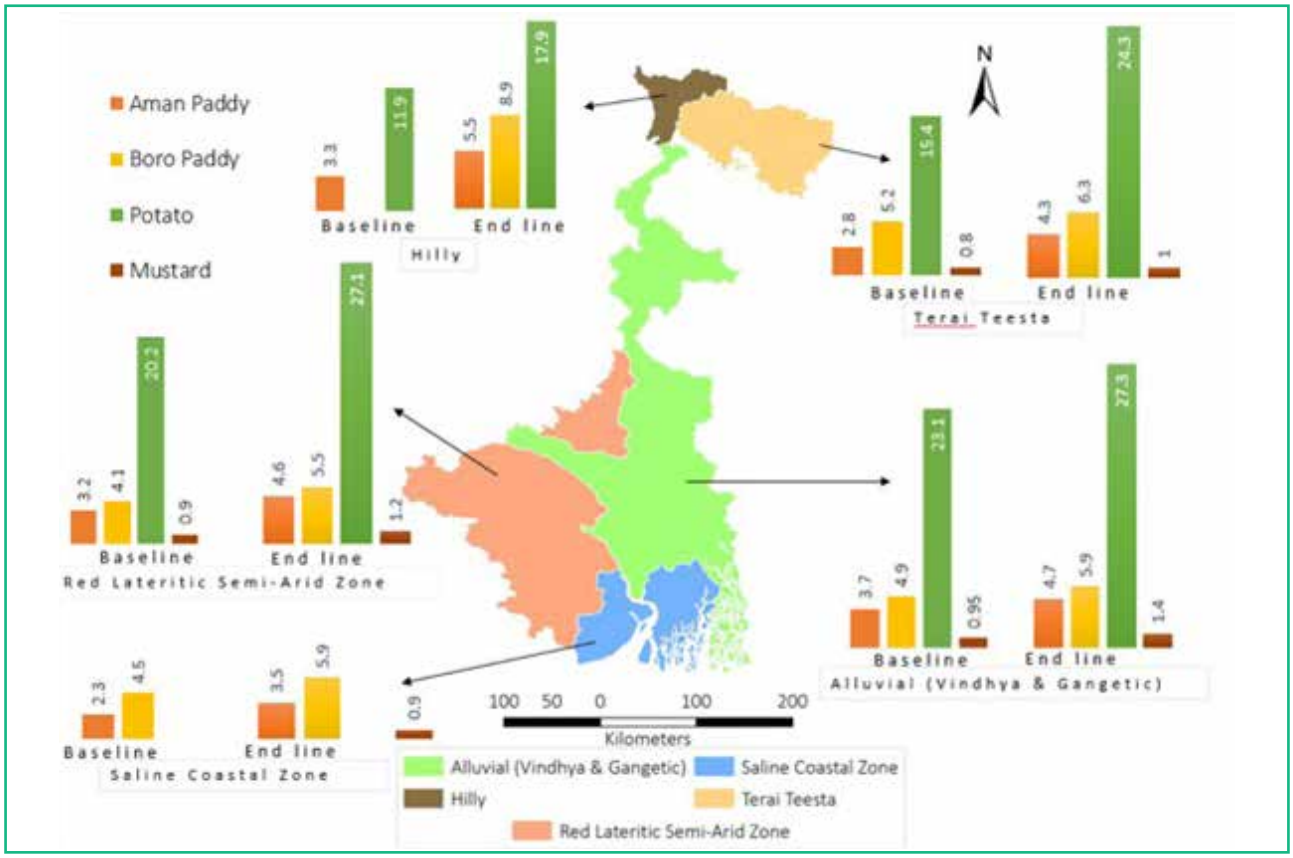


Figure 9 - Overall Average Crop Yield (Baseline and Endline) Agro-Ecological Zone-Wise

Cropping Patterns

Finally, we look at the cropping patterns computed for paddy, potato, mustard, other vegetables, other oil seeds and pulses as a percentage of the gross cropped area. Before the project, it is clear that majority of the total cultivated area fell under paddy across all the zones. The Saline Coastal Zone had the highest proportion of total cultivated area under paddy which fell marginally to 91% in post-ADMI years. This is because farmers in this zone grew paddy in both the *Kharif* and *Rabi* seasons and did not shift to other crops much. The Alluvial, Red Lateritic and Hilly Zones on the other hand, have the lowest endline proportion of paddy at 59%, 55% and 57% respectively. This is an indication of a marked diversification towards new crops. Potato was not generally grown before these schemes in any of the zones, but it has changed since the project, especially in the case of Terai Teesta Zone (from 0.9% to 9%) and Alluvial Zone (7%). We also find that mustard has become a popular crop, with 13% of GCA being taken up for its cultivation in the Red Lateritic Zone followed by 9% of GCA in the Alluvial Zone. Farmers have also started cultivating vegetables other than potato after the scheme handover. From at most 3% of GCA (Alluvial Zone) falling under vegetables at baseline, this has grown to a maximum of 28% of total cropped area at endline in the Hilly Zone. Oil seeds cultivation (other than mustard) has also picked up in the Alluvial (2% to 6%) and Red Lateritic Semi-Arid Zone (1% to 7%).

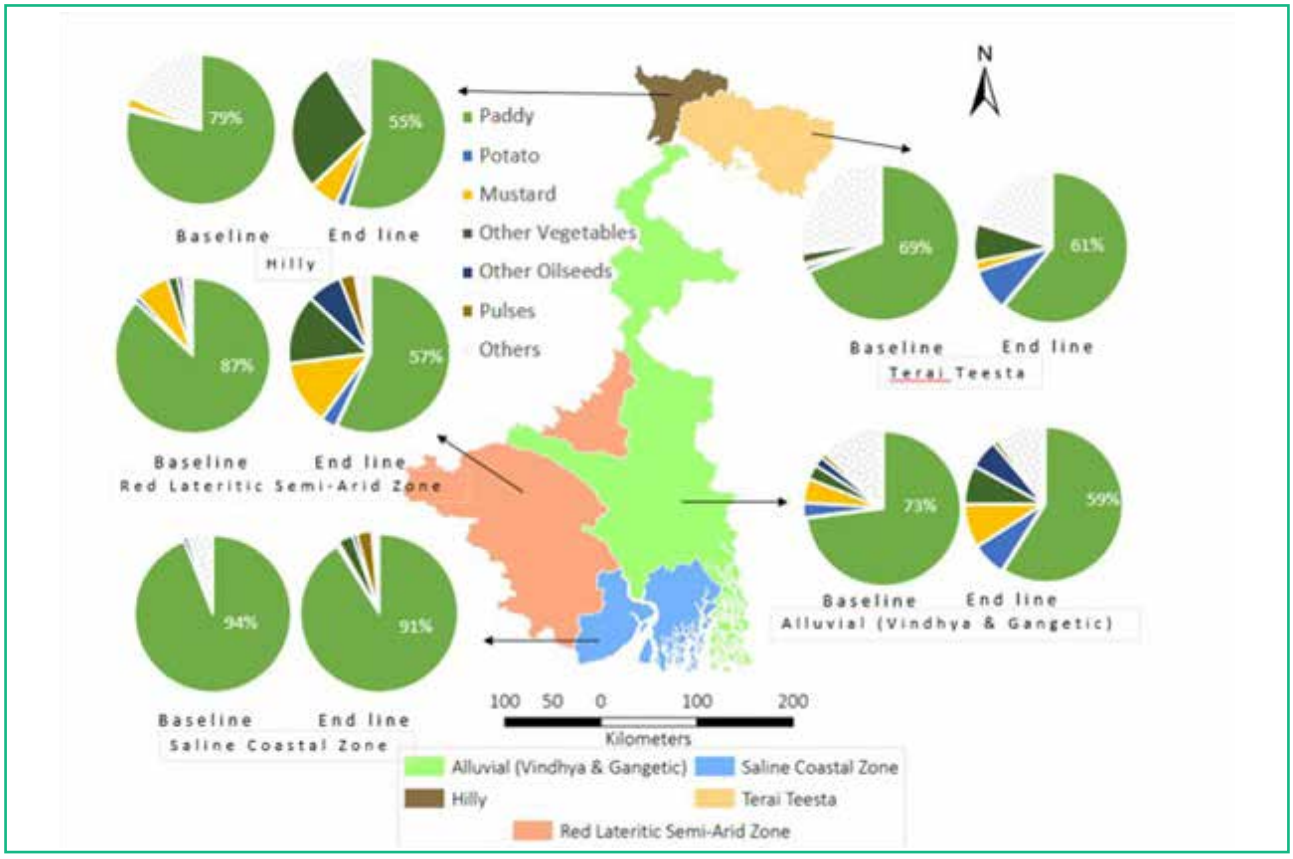


Figure 10 - Overall Cropping Patterns (Baseline and Endline) Agro-Ecological Zone-Wise

Table 13 - Distribution of Scheme Types within Agro-Ecological Zones for all 215 Schemes

Scheme Type/ Agro-Ecological Zone	Alluvial Zone	Hilly Zone	Red Lateritic Zone	Saline Coastal Zone	Terai Teesta Zone	Total
CD			16	0	0	16
WDS	1		31		0	32
LI	22		11	0	8	41
PDW		2	11		7	20
TW	44	6	8	2	38	98
Creek				8	0	8
Total	**67**	**8**	**77**	**10**	**53**	**215**

Agricultural Indicators for Specific Agro-Ecological Zones and Scheme Types

In this section we will first compare the performance of different scheme-types within particular Agro-Ecological Zones; and then compare the scheme-types across different Agro-Ecological Zones. So in this analysis we will be focusing on zones that have enough variation of scheme types in our sample– i.e. Red Lateritic Zone, the Alluvial Zone and the Terai Teesta Zone. The Red Lateritic Zone has the most variety in terms of scheme types (31 WDS, 16 CD, 11 LI, 11 PDW and 8 TW schemes); followed by Terai Teesta Zone (38 TW, 8 LI and 7 PDW) and Alluvial Zone (44 TW and 22 LI schemes). In the Hilly Zone, it is mostly TWs and the Saline Zone largely comprises of Creeks, which does not allow for a meaningful comparison of scheme types within these two zones. We also compare the performance of particular scheme types across different Agro-Ecological Zones, provided our sample has such scheme types setup in many Agro-Ecological Zones. In our sample, three scheme types, namely TW, LI and PDW schemes, satisfy this condition (Table 13), while CD, WDS are primarily in the Red Lateritic Zone and the Creek schemes are only located in the Saline Coastal Zone.

Comparison of Different Scheme Types within a Specific Zone

A. Red Lateritic Semi-Arid Zone

Among the scheme types in the Red Lateritic Zone, we can see that majority of schemes are surface water schemes (31), since in many parts it is not possible to use groundwater. In terms of Crop Diversification Index, we find that CD, PDW and WDS schemes in this zone have very similar endline values (0.44-0.46). TW schemes have comparatively lower CDI value at 0.32; while LI schemes have the largest CDI at endline (0.59). In terms of the largest change in CDI after scheme implementation in the Red Lateritic Zone, we find that LI schemes lead the tally as it went from 0.13 to 0.59; and lowest increase was for PDW schemes (0.39 – 0.44). In terms of cropping intensity, the LI schemes have the largest cropping intensity (205.1%) at endline, followed closely by

Table 14 - Change in Agricultural Indicators Across Scheme Types in Red Lateritic Semi-Arid Zone

Scheme Type	Crop Diversification Index		Cropping Intensity		Aman Paddy Yield	
	Baseline	Endline	Baseline	Endline	Baseline	Endline
CD (N=16)	0.15	0.46	114.80%	160.20%	3.2	4.8
LI (N=11)	0.13	0.59	118.20%	205.10%	3.2	4.5
PDW (N=11)	0.39	0.44	105.70%	158.60%	3.5	4.9
TW (N=8)	0.04	0.32	103.40%	199.60%	3.2	4.7
WDS (N=31)	0.09	0.44	120.70%	170.90%	2.9	4.2

Table 15 - Change in Agricultural Indicators Across Scheme Types in Terai Teesta Zone

Scheme Type	Crop Diversification Index		Cropping Intensity		Aman Paddy Yield	
	Baseline	Endline	Baseline	Endline	Baseline	Endline
LI (N=8)	0.22	0.43	148.80%	209.90%	2.5	4.7
PDW (N=7)	0.35	0.52	139.80%	172.90%	3.2	3.9
TW (N=38)	0.25	0.46	136.10%	193.90%	2.7	4.4

TW (199.6%) which are considerably greater than WDS schemes (170.9%) and CD schemes (160.2%). All schemes have made immense progress, from an average baseline cropping intensity. Within this zone, 69% of schemes have a cropping intensity greater than 150%, with TW (50%) and LI (45%) schemes having the highest proportion of schemes greater than 200%. There has also been a growth in paddy yield across all schemes in a similar range of 1.3 to 1.6 tonnes/ha. All schemes at endline have an average yield greater than 4 tonnes/ha.

It is not surprising that TW and LI schemes have come out to have the higher levels of cropping intensity and crop diversification, but not everywhere in Red Lateritic Zone are these schemes suitable. What is important in our results, is that even WDS schemes have performed very well in this zone, as these schemes are often set up in regions where it is difficult to use groundwater.

B. Terai Teesta Zone

In the Terai Teesta Zone we compare agricultural indicators across three scheme types; LI, TW and PDW. Among all scheme types, there has been a shift towards cultivating new crops and utilising a higher proportion of area to do so. The PDW schemes have the highest CDI estimate at 0.52 in endline. However, the largest increase of 0.21 has taken place for both the TW and LI schemes where the CDI has almost doubled. When comparing cropping intensities, we find again that TW and LI schemes emerge to be the better performing schemes. LI schemes have experienced the largest increase of 61.1 percentage points. TW schemes have also displayed similar rise in cropping intensity from 136.1% to 193.9% (57.8 percentage points). PDW schemes have grown much less by 33.1 percentage points, and have the lowest value at endline at 172.9%. Hence, we find that all schemes have attained cropping intensities greater than 170%. Aman paddy yield at baseline was highest for PDW schemes, at 3.2 tonnes/ha, while the other schemes had a yield less than 3 tonnes/ha. After the introduction of the WUAs, we notice that the productivity has risen to above 4 tonnes/ha for all scheme types except PDW (3.9 tonnes/ha). LI schemes have experienced the largest increase of 2.2 tonnes/ha and have also come out on top (4.7 tonnes/ha). We can conclude that the TW and LI schemes have been much more successful in the Terai Teesta Zone, as compared to PDW which have a much lower irrigation potential.

C. Alluvial Zone

Within the Alluvial Zone, the LI and TW schemes constitute the majority, covering a total of 66 schemes. Hence, it is these two schemes types we will be comparing. Cropping intensity at endline of both LI and TW increased considerably; however, this growth was higher for TW schemes (53.3 percentage point change). Again looking at crop diversification, both scheme types have performed exceptionally well, but TW schemes have shown the most improvement from 0.27 to 0.46. The baseline values for Aman paddy yield were already quite large (greater than 3.5 tonnes/ha). LI schemes have

Table 16 - Change in Agricultural Indicators Across Scheme Types in Alluvial Zone

Scheme Type	Crop Diversification Index		Cropping Intensity		Aman Paddy Yield	
	Baseline	Endline	Baseline	Endline	Baseline	Endline
LI (N=22)	0.41	0.55	169.1%	192.1%	3.8	4.6
TW (N=44)	0.27	0.46	133.90%	187.2%	3.6	4.7

Table 17 - Change in Agricultural Indicators Across AEZs for Tube Well Schemes

Agro-Ecological Zones	Crop Diversification Index		Cropping Intensity		Aman Paddy Yield	
	Baseline	Endline	Baseline	Endline	Baseline	Endline
Alluvial (Vindhya & Gangetic) (N=44)	0.3	0.47	133.90%	187.30%	3.6	4.7
Hilly (N=6)	0.2	0.5	121.70%	211.70%	3.4	5.5
Red Lateritic Semi-Arid Zone (N=8)	0.04	0.32	103.40%	199.60%	3.2	4.7
Terai Teesta (N=38)	0.25	0.46	136.10%	193.90%	2.7	4.4

shown a growth of 0.8 tonne/ha and for TW schemes by 1.1 tonnes/ha. So in the Alluvial Zone, TW schemes have been comparatively more successful than LI schemes in our sample.

Scheme Type Comparison Across Zones

D. Tube Well (TW) Schemes

If we compare the TW schemes across different Agro-Ecological Zones we find that it has the most profound effect in the Hilly Zone (211.7%) and the Lateritic Zone (199.6%) when it comes to cropping intensity. TW schemes in the Lateritic Zone have experienced the highest increase by 96.2 percentage points. Similarly, the growth in Crop Diversification Index for TW schemes have been the highest in the Hilly Zone from 0.2 to 0.5; and in the Red Lateritic Zone from 0.04 to 0.32. The yield at endline for Aman paddy is the highest for TW schemes in the Hilly Zone (5.5 tonnes/ha). The Lateritic and Alluvial Zones have also performed well with an average yield of 4.7 tonnes/ha.

E. LI (Lift Irrigation) Schemes

The LI schemes function well in almost all three zones, that we compare i.e. Alluvial, Red Lateritic and Terai Teesta Zones. In Alluvial (Vindhyan and Gangetic) Zone, the baseline values are already quite high since the region is fertile with access to groundwater resources. In both Red Lateritic and Terai Teesta Zones, LI schemes have transformed the agricultural scenario with increased cropping intensity, higher yield and more crop diversity. This is especially true for the rain-scarce Lateritic Zone which has experienced a significant increase in crop diversification (0.13 to 0.59) and in cropping intensity (118.2% to 205.1%).

Table 18 - Change in Agricultural Indicators Across AEZs for Lift Irrigation Schemes

Agro-Ecological Zones	Crop Diversification Index		Cropping Intensity		Aman Paddy Yield	
	Baseline	Endline	Baseline	Endline	Baseline	Endline
Alluvial (Vindhya & Gangetic) (N=44)	0.42	0.55	169.20%	192.10%	3.9	4.6
Red Lateritic Semi-Arid Zone (N=8)	0.13	0.59	118.20%	205.10%	3.2	4.5
Terai Teesta (N=38)	0.22	0.43	148.80%	209.90%	2.5	4.7

Table 19 - Change in Agricultural Indicators Across AEZs for PDW Schemes[12]

Agro-Ecological Zones	Crop Diversification Index		Cropping Intensity		Aman Paddy Yield	
	Baseline	Endline	Baseline	Endline	Baseline	Endline
Red Lateritic Semi-Arid Zone (N=11)	0.39	0.44	105.7%	158.6%	3.5	4.9
Terai Teesta (N=7)	0.35	0.52	139.8%	172.9%	3.2	3.9

F. PDW (Pump Dug Well) Schemes

The performance of PDW schemes across Red Lateritic and Terai Teesta Zone show substantial progress. In the Red Lateritic Zone, CDI increased from 0.39 to 0.44 and cropping Intensity increased from 105.7% to 158.6%. Aman paddy yield also rose from 3.5 tonnes/ha to 4.9 tonnes/ha. In Terai Teesta Zone also, we can see a substantial increase in CDI (from 0.35 to 0.52), cropping intensity and paddy yield for PDW schemes. So PDW schemes seem to have been more effective in improving cropping intensity and paddy yield in the Red Lateritic Zone, as compared to Terai Teesta Zone.

3.1.6 Evaluation of ADMI Scheme Performance Using Geospatial Data

Earth observation data is used specially to supplement survey data in the assessment of agricultural performance of WBADMI schemes by assessing changes in the cropping intensity. This was done for handed over project schemes to showcase the usefulness and applicability of this method for the future. For this analysis, Sentinel-2 optical satellite data with 10m spatial resolution with 5-day revisit time provided by Europe Space Agency (ESA) was used. Sentinel-2 images for the period 2015-06-01 to 2020-07-30 were used to map the crop dynamics in minor-irrigation schemes in selected districts of West Bengal for the cropping season of 2016-17, 2017-18, 2018-19 and 2019-20. To process large amount of satellite data, Google Earth Engine (GEE) environment was used, which has very high processing capabilities. GEE is a cloud-based platform for planetary-scale geospatial analysis that brings Google's massive computational capabilities to bear on a variety of high-impact societal issues including deforestation, drought, disaster, disease, food security, water management, climate monitoring and environmental protection.[13]

12 Since there were only 2 PDW schemes in the Hilly Zone, we do not include them in this table

13 Gorelick, N., et al., Google Earth Engine: Planetary-Scale Geospatial Analysis for everyone, Remote Sensing of Environment (2017), http://dx.doi.org/10.1016/j.rse.2017.06.031

Table 20 - NDVI Threshold Across Seasons Used in the Analysis

	Period	NDVI Threshold
Kharif	1st Sep – 15th Dec	0.45
Rabi	16th Dec – 15th Feb	0.40
Pre-Kharif	5th Mar – 15th May	0.40

This geospatial analysis focused on assessing cropping intensity of WBADMI schemes. Command area map for the scheme is assumed to be a circle with area equivalent to design command area of WBADMI scheme. Then the optical Sentinel-2 data was used to generate the time series of cropped area across different seasons. At first, composite images were created and from them, Normalized Different Vegetation Index (NDVI) was calculated for the *Kharif*, *Rabi* and *Pre-Kharif* seasons using the NDVI values for the period during which crops are expected to peak in each season.

$$NDVI = \frac{\rho_{NIR} - \rho_{RED}}{\rho_{NIR} + \rho_{RED}}$$

where: ρ_NIR is the reflectance of near infrared (850-880nm, band 5), ρ_RED is the reflectance of the red band (640-670nm, band 4) for Landsat 8 images and ρ_NIR is the reflectance of near infrared (830-860nm, band 8), ρ_RED is the reflectance of the red band (660-670nm, band 4) for Sentinel-2 images.

Thereafter, for *Kharif*, *Rabi* and *Pre-Kharif* a threshold NDVI of 0.45, 0.40 and 0.40, respectively was used to divide the area into cropped and non-cropped area. A filter based on NDVI threshold for removing forest and built-up area was also used. Table 20 gives the period and NDVI threshold used for each season.

Figure 11 shows the comparison of cropping intensity (scheme type wise) for 209 schemes[14] that were both in the survey data and from RS analysis at the endline (actual) which is for the 2018-19 season. Overall cropping intensity estimates from RS analysis is consistently higher than the survey data estimates, except for Check Dam schemes. This mismatch is highest and significantly different for schemes with high cropping intensities (TW and RLI schemes). For the rest of the schemes however, we see a good match between the two results, i.e. the RS estimates corroborate the survey data. Both estimates show a similar pattern i.e. highest cropping intensity for RLI and TW schemes where water is not limited followed by WDS and the least is for CD, PDW and Creek schemes. The reason for the mismatch as observed in RS and survey schemes are multiple and requires a more regionalized approach considering the difference in cropping patterns,

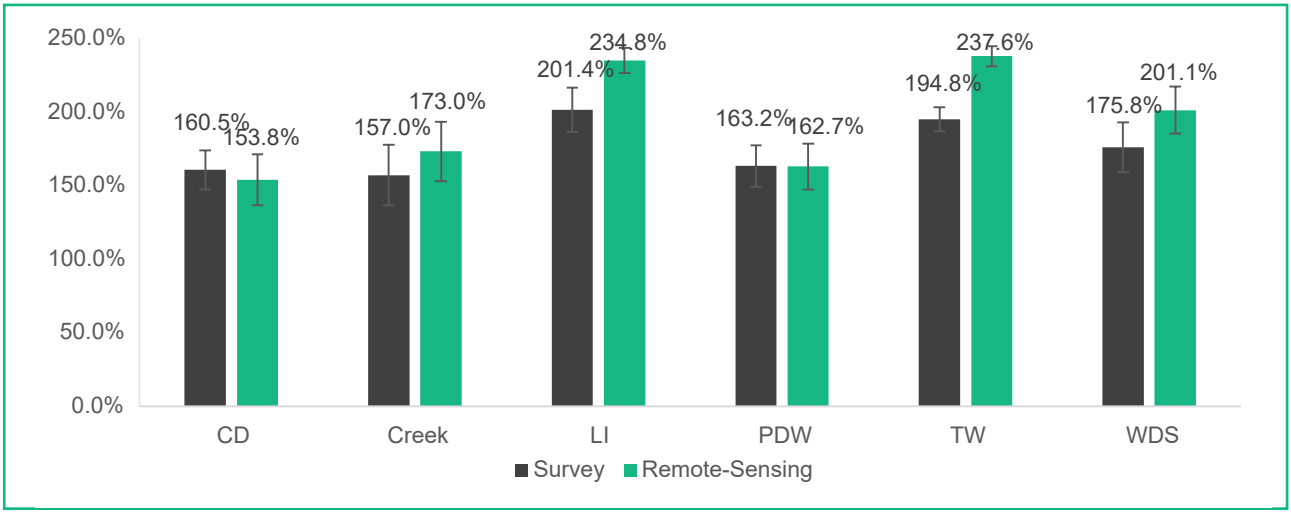


Figure 11 - Comparison of Cropping Intensity Across Scheme Types Between RS and Survey Data

14 Schemes which were not considered in survey assessment are omitted from the analysis.

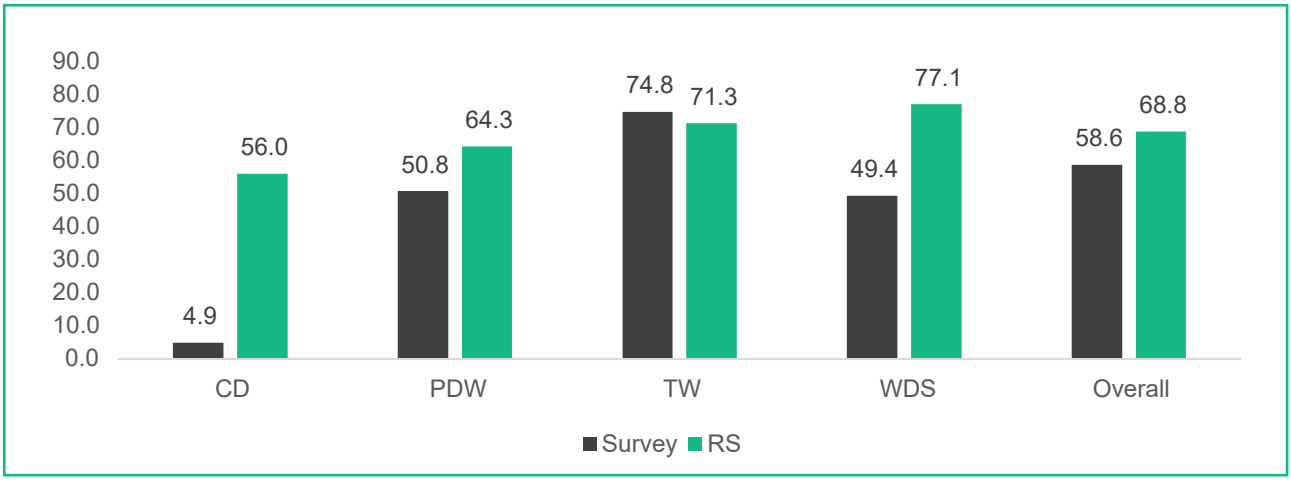


Figure 12 - Comparison of Cropping Intensity Across Scheme Types Between RS and Survey Data

expected time for peak NDVI, rainfall and accurate map of command area which can all influence the RS results. Further data collection on these aspects in future can make the presented methodological framework much stronger and could be used along with HH data for continuous monitoring and impact assessment. However, the similar trend and close match in many cases with survey results show the utility of using RS data to complement survey data for impact evaluation.

We also compare the cropping intensity estimates from the two datasets (RS and survey data) at the district level for endline (i.e. the season 2018-19). In general the match between RS and survey results are satisfactory, except the fact that RS estimates are consistently higher than survey. Largest mismatch is for districts for Howrah, Purba Midnapore and Hooghly, which could be because there were not many number of schemes surveyed in these districts.

For the analysis of change in CI before and after the handover of schemes, those schemes from our survey data which were handed over in the time period Jan-May, 2018 were selected. There were only 36 such schemes which filled this criterion. For these schemes, RS based CI for year 2016-17 is taken as before and average of 2018-19 and 2019-20 taken as after. Figure 12 shows the cropping intensity change comparison from RS and survey based estimates. Overall, RS and survey based estimates match and show CI increasing by 69% and 58% respectively. Other than CD, CI increase from both estimates are consistent and show significant increase post handover of schemes. However, there were only two CD schemes (out of 36 schemes) in the analysis which could distort the analysis. Similar trend and close match with survey results, both for actual and change analysis, show the utility of using RS data to complement survey data for impact evaluation.

3.2 Institutional Indicators

One of the most important differences of the ADMI project from similar minor irrigation projects of West Bengal government is the creation of Water Users' Associations for the operation and maintenance of the irrigation infrastructure. The positive outcomes in ADMI project schemes as discussed above can be partially credited to the farmer groups that have been created under the project and registered as Water Users' Associations. More importantly, as the support from the project officials and field level NGOs will be withdrawn after the end of the project, the expectation is that these WUAs will be looking after the operation and maintenance of these irrigation infrastructures and help in running them smoothly. Through the creation of these farmer groups it is expected that the users of these schemes will jointly develop an ownership over the irrigation infrastructure and see to its upkeep. This is to safeguard that the irrigation infrastructures, do not get discarded over time and farmers continue to use them. So it is of utmost importance that this institution of Water Users' Association continues to remain strong and vibrant even in future, after the project has ended, to ensure sustainability.

Since the project has just ended and farmers are still receiving support from the Government, it is not possible to directly judge to what extent these WUAs will be successful in keeping the schemes running in a just and proper way in the future. However, we can look at how these WUAs perform on certain indicators of the institutional and management aspects currently, to form an opinion on how effective these are as institutions. Specifically, we evaluate the schemes against the following criteria:

i. Inclusive Membership

ii. Democratic functioning and outreach of the WUA

iii. WUA fee collection and funds for maintenance

iv. Financial accountability and transparency

3.2.1 Inclusive Membership

It is important that WUA Membership is inclusive and accessible for all marginalised sections of the society. Under this project, any interested 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 is no barriers to become Members of WUA once the irrigation structure has been constructed. But since 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 marginalisation of certain groups even without any such intent. Therefore, these interventions often require effort from the implementer's side to actively include marginalised sections of the society. The explicit objective for ADMI project officials have been to target regions with substantial tribal population, and to include at least 30% female Members in WUA. Also, the primary objective of the project was to increase the income of small and marginal farmers. The average command area for each scheme is about 23 ha and the average command area per WUA Member is approximately 0.40 ha (based on the 215 schemes).

Figure 13 - Average Number of WUA Members Scheme Type Wise

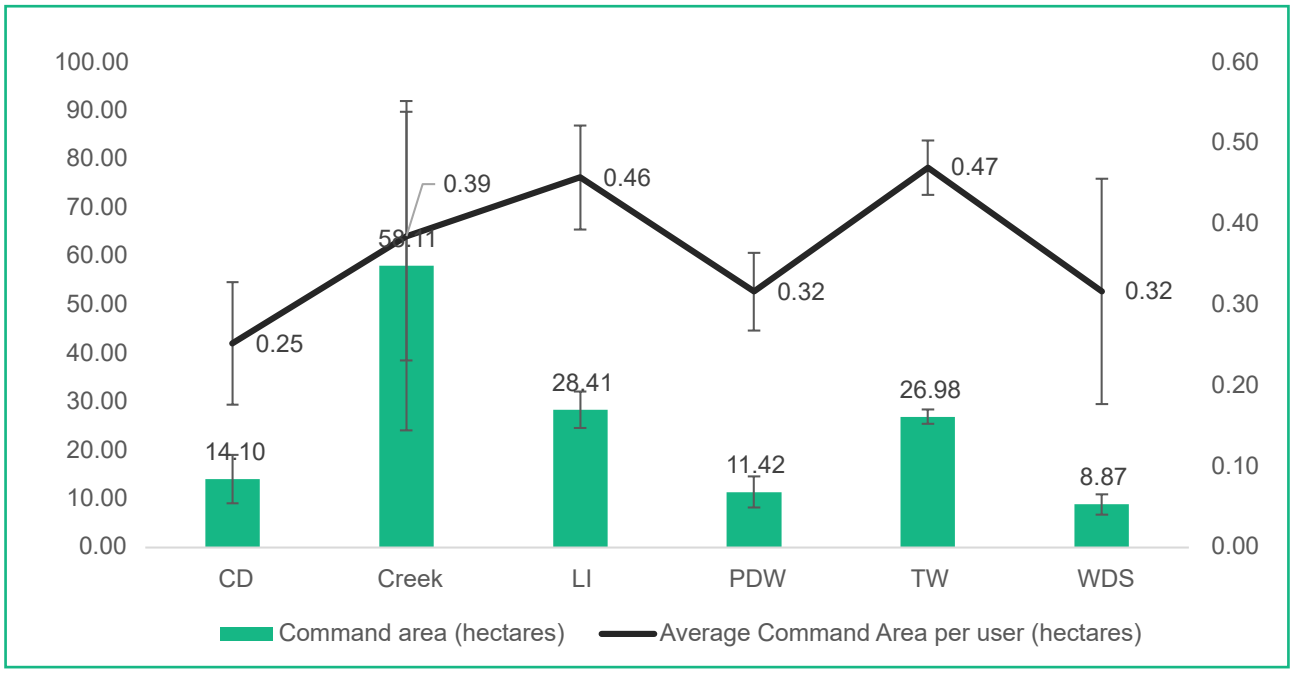


Figure 14 - Average Command Area Across Scheme Type

However, as we can see in Figure 13 and Figure 14, that there is substantial difference across scheme types. Creeks are the largest scheme type (on average 136 Members and 58.11 hectares of command area), followed by LI (on average 72 Members and 28.41 hectares of command area) and TW (on average 73 Members and 26.98 hectares of command area). The smallest type of schemes are WDS schemes (32 Members on average and 8.87 hectares of command area), with PDW and CD schemes being slightly larger.

More interestingly, if we look at the average command area per user, we find that it is the lowest for Check Dam (0.25 hectare per user) followed by PDW and WDS schemes where the average command area per user is between 0.32 hectares. But TW, LI and Creek schemes (0.47 hectares, 0.46 hectares and 0.39 hectares respectively) have a larger command area per user. As we can see, the overall command area per user is much less than 1 hectare. More than 95% of the schemes have average area per user less than 1 hectare. This indicates that the scheme primarily targeted marginal farmers. This becomes even clearer when we find that 98.7% WUA Members were categorized as marginal farmers.

We further investigate WUA Membership through the lens of equitable representation of gender and caste in our sample. In terms of female Membership, we find that in our sample of 232 schemes, average proportion of female WUA Members is 16.9%, while in the Executive Committee of the WUA, the average proportion of female WUA Members is 32.4%, which is above the target of 30% female Executive Committee Members. 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 wives of relatively powerful men in the village and it is mostly their husbands who control the WUA meetings. 34% schemes in our sample had female WUA Membership in the Executive Committee above the 30% threshold; but many had just near the 30% (~27-28%). In 38% of the schemes, either the female Membership in WUA is less than 5% or the female presence in Executive Committee is less than 25%. Mostly these are TW, LI or Creek schemes. In fact, female Membership in WUA and Executive Committee is highest for WDS schemes, followed by PDW and CD schemes, while it is lowest for Creeks, LI and groundwater schemes. There could

be few reasons for this – firstly most of the WDS schemes are set-up in the tribal region of Purulia and Jhargram, and female participation outside family is much higher in tribal societies as compared to other regions. There could however be another reason that the WDS schemes are often smaller and have less scope for revenue generation, while Creeks, TW and LI schemes have larger command area and pumps running on electricity generating larger revenue activity. It could be possible that in these cases male farmers are more reluctant to share power with female farmers. Thirdly, in surface water schemes with limited storage capacity *Rabi* cultivation is low and men are more involved in other activities of labour or they migrate. Hence, women have more scope to be involved in WUA activities. In contrast, in groundwater schemes or LI, water source is perennial, requiring year round involvement in agriculture, with relatively higher costs of O&M. In such schemes, agriculture is the primary occupation and is controlled by men.

As seen in Table 45, there is also substantial variation in female WUA Membership when compared across districts. Highest proportion of females in WUA is in Jhargram (45%), Purulia (23%) Darjeeling (23%) and North 24 Parganas (23%), whereas Purba-Midnapore and Hooghly have less than 5% female participation in WUAs.

Average proportion of female WUA Members is 16.9%, while in the Executive Committee of the WUA, the average proportion of female WUA Members is 32.4%, which is above the target of 30% female Executive Committee Members.

In some cases it is just tokenism. The female executive Members are wives of relatively powerful men in the village and it is mostly their husbands who control the WUA meetings.

Overall 30.9% Members, both in the WUA and in the governing body, were from the Scheduled Caste category; while 22.7% Members in WUA and 21.1% in the governing body were from the Scheduled Tribe category.

By targeting regions with high population share of marginalised communities, and through a conscious choice of encouraging farmers from SC or ST category to join the association, the project has achieved SC and ST farmers' representation in WUA that is higher than the population proportion of SC and ST people in the state (especially so for tribal farmers).

In terms of inclusion of marginalised groups like Scheduled Tribe (ST) and Scheduled Caste (SC) farmers in the Water Users' Associations, we calculated the proportion of ST and SC farmers in

Table 21 - Average Proportion of Female Members in WUA and Executive Committee

	Average Proportion of Female Members in WUA	Average Proportion of Female Members in Governing Body
CD	16.9%	33.0%
TW	14.1%	27.9%
PDW	17.3%	36.3%
LI	10.3%	27.4%
Creek	8.0%	29.6%
WDS	35.4%	47.8%
Total	16.9%	32.4%

our sample. The ADMI project has a specific target of setting up irrigation infrastructure in tribal regions of Purulia and Jhargram. Overall 30.9% Members, both in the WUA and in the governing body, were from the Scheduled Caste category; while 22.7% Members in WUA and 21.1% in the governing body were from the Scheduled Tribe category. Proportion of ST Members are comparatively higher in WDS (41%), PDW (38.4%) and CD schemes (31.8%) since most of these schemes are in Purulia and Jhargram region. In fact, in Jhargram and Purulia, ST Membership in WUA was at 56% and 54% respectively. In terms of SC Membership, it is highest in North Bengal i.e. Cooch Behar (73%), followed by Murshidabad and Jalpaiguri (above 50%). This is because the largest Scheduled Caste group in West Bengal are the 'Rajbongshis' who are mostly in Cooch Behar. According to Census 2011, 23.51% of West Bengal population belong to SC category and 5.5% belong to ST category. So by targeting regions with high population share of marginalised communities, and through a conscious choice of encouraging farmers from SC or ST category to join the association, the project has achieved SC and ST farmers' representation in WUA that is higher than the population proportion of SC and ST people in the state (especially so for tribal farmers).

Table 22 - Average Proportion of SC and ST Farmers in WUA and Executive Committee

	Average Proportion of SC Members in WUA	Average Proportion of ST Members in WUA	Average Proportion of SC Members in Governing Body	Average Proportion of ST Members in Governing Body
CD (N=17)	23.4%	31.8%	21.1%	34.5%
TW (N=39)	36.0%	15.2%	37.5%	13.1%
PDW (N=21)	34.4%	38.4%	34.7%	33.8%
LI (N=47)	32.9%	12.1%	29.1%	13.4%
Creek (N=10)	48.4%	8.1%	53.0%	11.9%
WDS (N=20)	7.7%	41.0%	5.5%	37.3%
Total (N=232)	30.9%	22.7%	30.9%	21.1%

3.2.2 Democratic Functioning and Outreach of the WUA

Along with inclusiveness in Membership, it is also important that the WUA functions democratically. One measure of the extent of democracy within the WUA can be judged from how the Executive Committee got selected. About 40% schemes reported, that Management Committee was selected in an AGM with all Members (lowest in LI schemes; highest in Creek, CD and PDW schemes with 48-56% reporting to have an AGM with all Members to select the Executive Committee). Almost all schemes reported that at least 50% Members were present in the AGM where the Executive Committee was chosen. Although there is room for improvement, this is a positive sign that the Members were selected democratically. Our interactions with different farmers revealed that there is however very little change in the Executive Committee once it gets selected; one reason for this is that not enough farmers have the expertise and time to carry out all the activities for WUA. The different regulations and requirements also imply, that not all farmers have the required education/skill in working as the Executive Members, especially the positions of Chairman, Secretary and Cashier.

3.2.3 WUA Fee Collection and Funds for Maintenance

The most important thing for future sustainability of WUA schemes is the collection of revenue from users as fees, so that corpus can be built, to be used for maintenance. The collection of fees (looking at last 3 years) was highest for TW schemes and followed by LI schemes. These schemes are characterised by group ownership of the pumps that are used for irrigation and the WUA needs to pay back for energy. This makes it all the more important to collect fees. However, if the farmers are using their own pumps (individual pumps) as in the case for WDS schemes, instead of a WUA tube well, it is often much more difficult to collect the payments for usage of water.

Although TW schemes have the highest collection of water fees, given the high charges for electricity, their expenditure is also quite high. Figure 16 below shows the mean surplus for the last 3 years by scheme type[15]. The LI and TW schemes have comparatively larger surplus over the years. Interestingly, Creek schemes saw a huge jump in the surplus in 2018-19. One likely explanation for this increase is that, many FIG groups were established in these schemes and they started earning in 2018-19. Hence, they

15 We exclude three SIPs with extreme expenditure in a particular year. These scheme from TW could reflect one year where past bills were being paid, or there could be error in data. Excluding these three outliers give us more reliable estimates of the mean savings, scheme-wise.

Figure 15 - Selection of Executive Committee of WUA

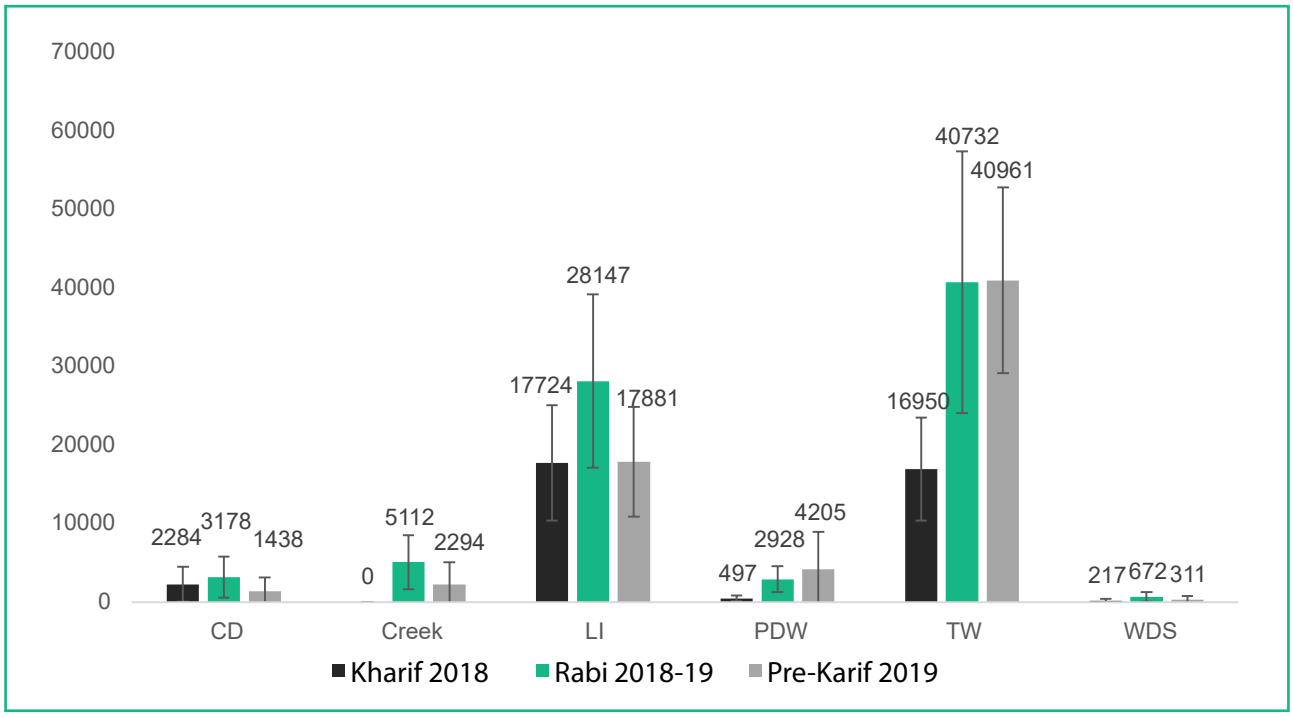


Figure 16 - Average Collection of Water Charges for Last 3 Seasons Across Scheme Types

contributed a part of their profits to the WUA as mandated (as we can see in the above figure, that collection water fees across three years is quite low). This is probably the reason for the spike in surplus for Creek schemes. Unsurprisingly the least surplus accrued to WDS (Rs. 3,013 in 2018-19), PDW (Rs. 4,433 in 2018-19) and CD schemes (Rs. 7,382 in 2018-19) - as they also have the lowest collection in fees. Another common feature in all scheme types is that the mean surplus of the WUA committee has increased over the years. Additionally, the error bars indicate a lot of heterogeneity in surplus, even within a particular scheme type.

The most important thing for future sustainability of WUA schemes is the collection of revenue from users as fees, so that corpus can be built, to be used for maintenance. The collection of fees are highest for TW and LI schemes, characterized by group ownership of the pumps that are used for irrigation. However, if the farmers are using their own pumps (individual pumps) as in the case for WDS schemes, it is often much more difficult to collect the payments for usage of water.

3.2.4 Maintenance of Records and Transparency

Another important factor for the WUAs to function properly is the regular maintenance of records. Almost all the WUAs in our sample, reported to maintain some type of register. Overall, 88% of schemes had 'Crop Planning and Actual Cropping Register', while 67% WUAs maintained the 'Irrigation Schedule Register', 66% maintained 'Pump Log Book'; and just 56% maintained the 'Water Distribution Register'. As expected, maintenance of records is lowest in WDS schemes followed by CD schemes. This is expected because in these schemes, there is often no community pump, but rather farmers use their own pumps. The revenue generation and expenses are all quite low in these schemes and also the fee collection is much lower. As a result, these schemes do not maintain complete records. This is the same reason why none of the Creek schemes in our sample, maintained pump log books, while 100% of them maintained a cropping register. On the other hand, maintenance of records is highest in PDW, TW and LI schemes. Overall, in

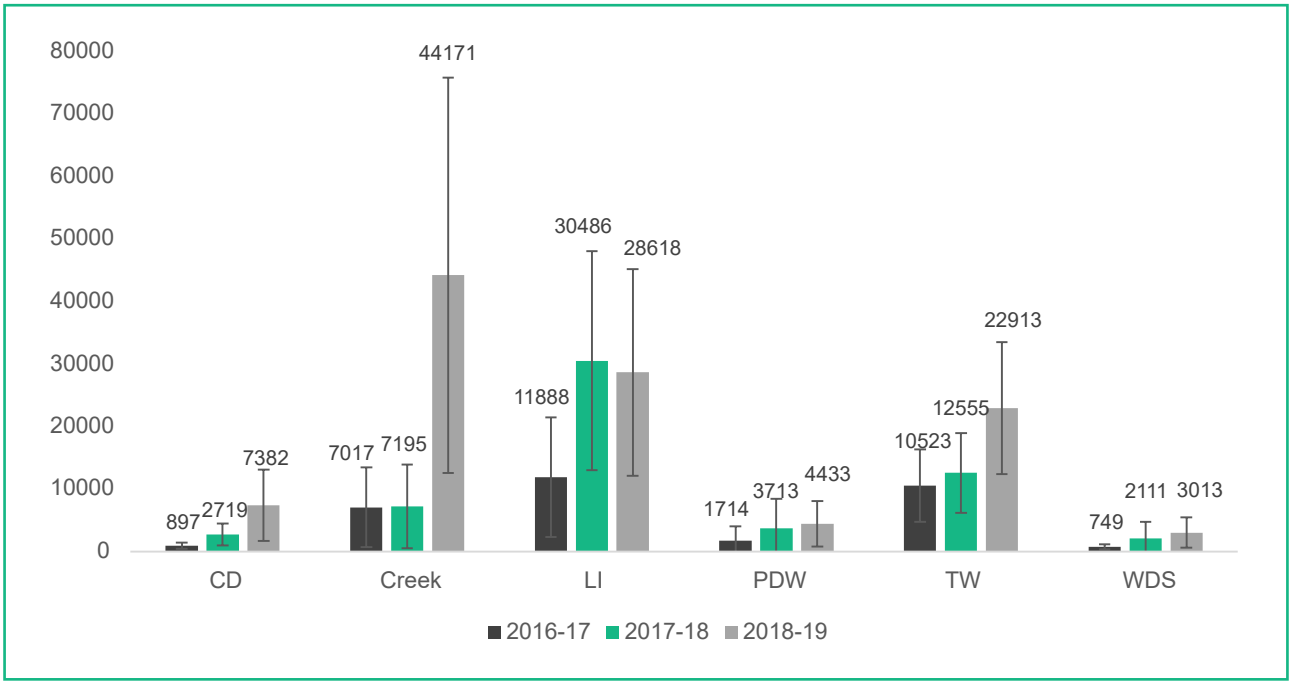


Figure 17 - Mean Surplus of WUA Committee (Income – Expenditure) Across Last 3 Years (in INR)

our sample, only 42% schemes had all 4 registers and 6% kept none of the registers. Maintenance of records is crucial, for the financial transparency and future stability of the WUA.

76% of the WUAs in our sample reported that they shared their Audit reports in the Annual General Meeting (AGM) with all farmers present. CD, PDW and Creek schemes have close to 90% or more of schemes sharing the audit reports in the AGM indicating high levels of transparency. Overall this is not bad, but in certain types of schemes, the performance is much worse; for example, in only 59% of WDS schemes audit reports were shared in the AGM. This is linked to the previous point, regarding very low record maintenance in WDS

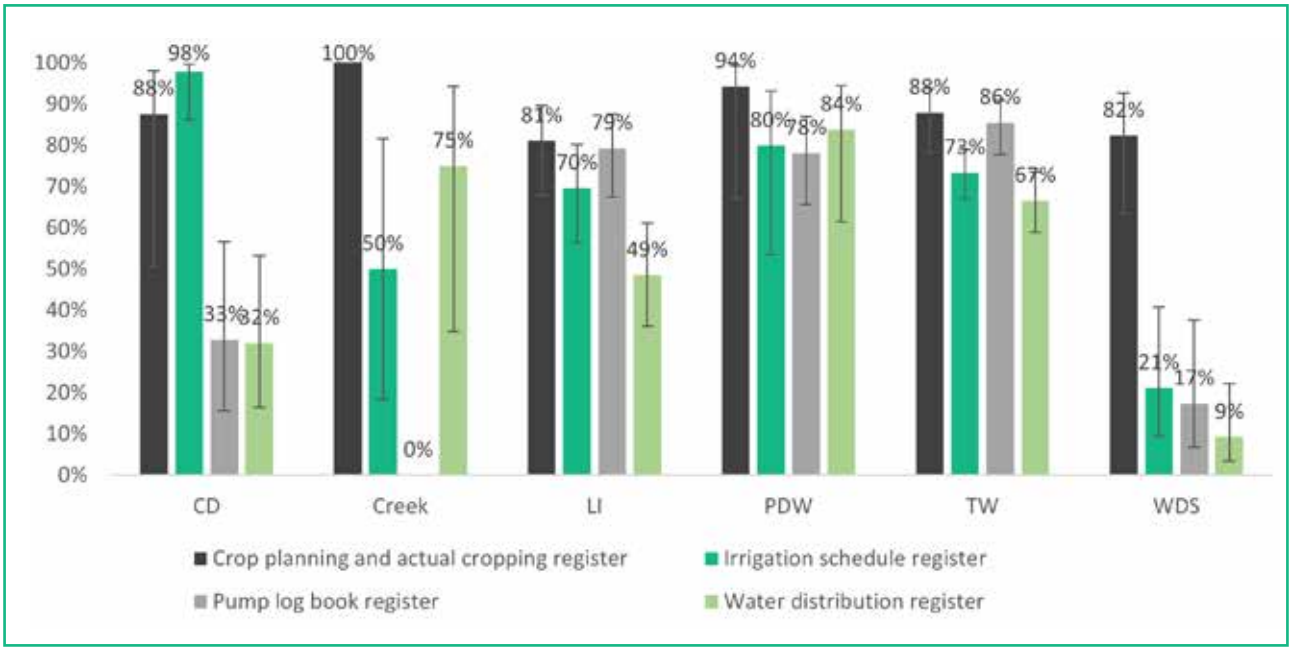


Figure 18 - Maintenance of Records by WUA Committee Across Scheme Types (in INR)

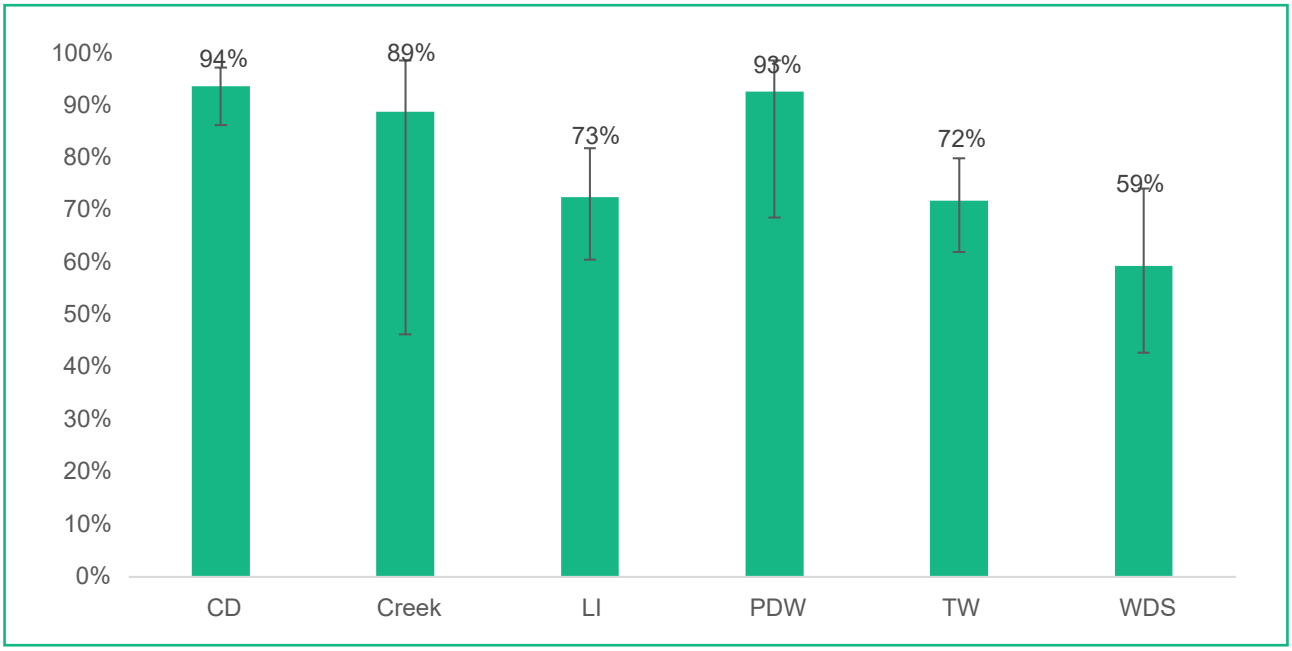


Figure 19 - Percentage of Schemes Where Audit Report Shared in AGM, Across Scheme Types

schemes. This is an area of concern for WDS schemes, as they are not able to perform all the functions of a WUA i.e. collect fees, maintain records and share records etc. Thus, this is a crucial challenge for the sustainability of WDS schemes in the future. In any case, with gradual siltation of the WDS structures, farmers are unlikely to be able to finance desiltation by themselves as it is an expensive activity.

Overall, 88% of schemes had 'Crop Planning and Actual Cropping Register', while 67% WUAs maintained the 'Irrigation Schedule Register', 66% maintained 'Pump Log Book'; and just 56% maintained the 'Water Distribution Register'. As expected, maintenance of records is lowest in WDS schemes followed by CD schemes. In these schemes, there is often no community pump, but rather farmers use their own pumps. The revenue generation and expenses are all quite low in these schemes and also the fee collection is much lower. As a result, these schemes do not maintain complete records.

The situation is very different in Tube Well and LI schemes. In many schemes, farmers reported that the TW or the distribution pipe got damaged due to various reasons; but in most of these cases, farmers collected money or used WUA corpus fund to mend the machines. Since they collected money from farmers, these kinds of repairs could be undertaken when needed and it also encourages better record keeping and financial transparency.

3.3 Economic Indicators

3.3.1 Impact of the Scheme on Agriculture Income

As discussed before, with increased irrigation access and agricultural support services, the WUA farmers cultivate more crops during the year and their yield increases with the adoption of improved practices. As a direct consequence of increase in net sown area, cropping intensity, crop choices and yield gains under the scheme, we would expect the net income from agricultural activities to increase for WUA farmers. For this purpose, we estimate per hectare profit for each crop in the current year, using current prices, yield and per hectare cost of cultivation. The production and price data were provided by farmer respondents in the individual level survey. But since we did not have farmer level data on cost of cultivation, we used District-Wise average cost of cultivation per hectare of each crop, as collected from secondary sources and the estimates provided by district project officials. Then,

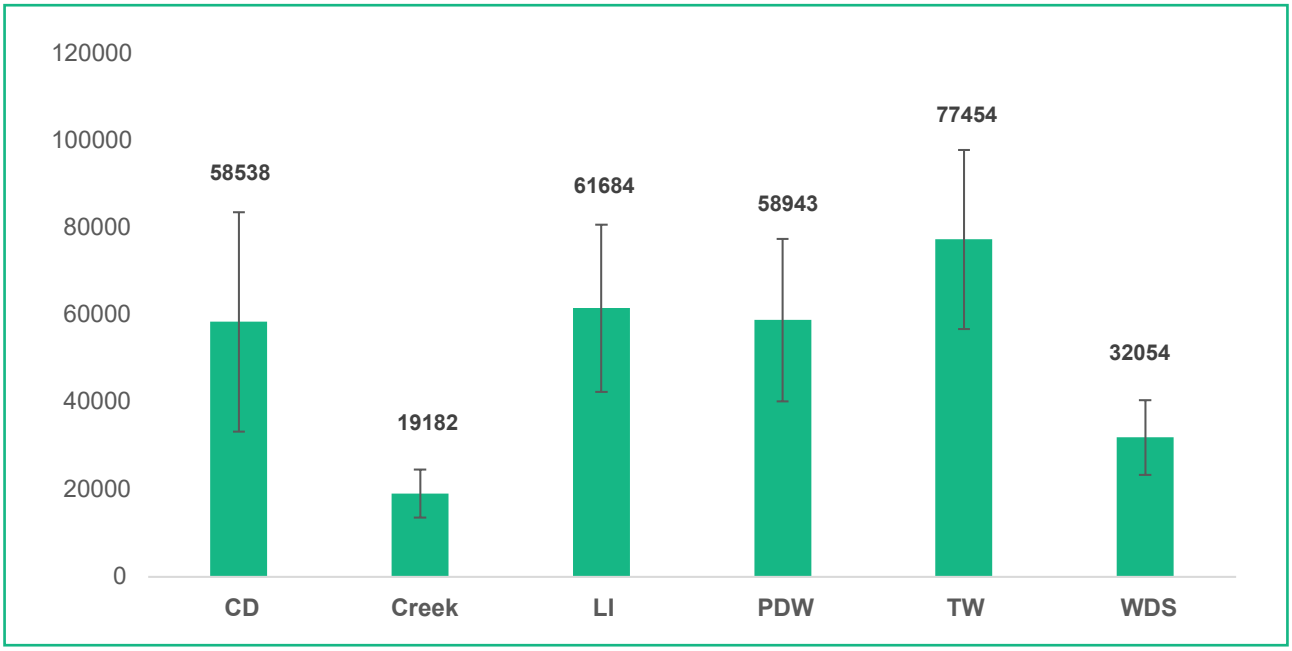


Figure 20 - Net Income Per Hectare Scheme-Wise for WUA Members (in INR)

the gross agricultural revenue was calculated for each crop and the respective cost of cultivation is deducted from it, to get the net profit crop-wise. Adding up the profit for all crops cultivated by the farmer throughout the year we get the net yearly agricultural income. This is then divided by the total cropped area of the farmer to get the net yearly income per hectare from agriculture. We used the same procedure to calculate the per-hectare net yearly income from agriculture in the pre-ADMI period. The prices and costs have been inflation adjusted for the pre and post-ADMI years (2012-2013 and 2018-2019).

We use the following formula in our calculations:

Net Yearly Agricultural Income per ha = (Σ[(Total production*Total price) crop i - Total cost of crop i]) /(Total Cultivated Area)

The average yearly net income from cultivation for sampled farmers under WBADMI scheme[16] comes to Rs. 64,547 per hectare. Figure 20 gives the average yearly net income per hectare across different scheme types for WUA Members, which shows that it was highest for TW (Rs. 77,454) schemes; and Creek (Rs. 19,182) and WDS (Rs. 32,054) schemes had the lowest net income per hectare in our sample.

But to understand how much the agricultural income increased since the ADMI intervention, we also estimate the increase in net income per hectare from agriculture between pre-ADMI and post-ADMI years. Here the purpose is to show how the income of WUA Members have changed over time. We do a more systemic comparison of this change with that of non-WUA Members, later in this section using a regression model. However, this is to emphasise the point, that the changes in Figure 19 between 2018-2019 and pre-ADMI are likely to be confounded by other factors that changed over time. So the purpose is to demonstrate how the agricultural income per hectare changed over time, for the WUA beneficiaries and **not ascertain causation.** Also, in this analysis, the pre-ADMI period has no specific year as the reference point, so theoretically it is likely to be different for different farmers as different schemes began in different years. However, we ask this question in a way to know the average production, and costs in a pre-intervention normal year.

16 In total there were 444 WUA Members in the sample. Since we are interested in the change in income between pre-ADMI and post-ADMI periods, we restrict our sample to WUA Members who had agricultural income both pre and post-ADMI periods. For 44 farmers the pre-ADMI values are missing, either because they did not do cultivation or the data is missing, these farmers are not included. Additionally, we exclude 17 farmers with outlier values for income (net income per hectare is 5 standard deviations away from the mean). So, we were left with 382 WUA Members, 148 non-WUA Members.

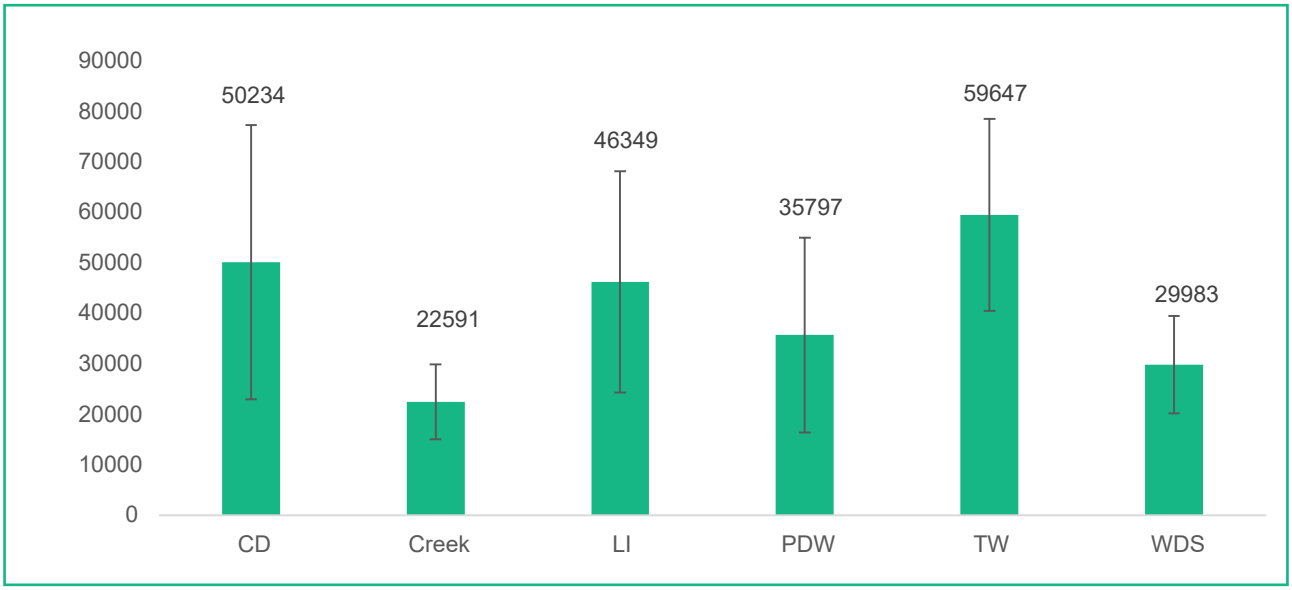


Figure 21 - Post-ADMI Increase in Net Income Per Hectare Scheme-Wise (in INR)

Figure 19 presents the increase in net yearly agricultural income across scheme types for WUA Members. The overall average increase since the pre-ADMI period has been Rs. 50,029 per hectare. The graph shows that per hectare incremental income is highest for Tube Well schemes (Rs. 59,647), followed by Check Dam (Rs. 50,234) and LI schemes (Rs. 46,349). WDS and Creek schemes have the lowest values of incremental incomes per hectare post-ADMI, with the increase in TW schemes being 164% higher than the Creek schemes. This matches with the fact that the cropping intensity is low for these schemes, but it also reflects the fact that, these schemes are often not new but rejuvenated. Even before the project, it acted as a source of limited irrigation, and the impact of rejuvenation on income, is therefore comparatively less.

Table 23, gives the average change in net income per hectare, for the five Agro-Ecological Zones, and for each year of scheme hand-over. The Terai Teesta and Hilly Zones have the highest increase in net income in 2018-2019 at Rs. 92,860 and Rs. 85,047 respectively. However, the increase has not been this substantial in the other zones. Both the Red Lateritic and Saline Coastal Zones have yielded an incremental net yearly agricultural income of less than Rs. 30,000. This reveals that certain zones cover less prosperous districts. For instance, the Red Lateritic Zone spans over the Western Districts of Birbhum, Bankura, Purulia, Paschim-Midnapore and Jhargram which had mostly small surface water schemes and consequently had lower cropping intensity, diversification and yield, thereby culminating in lower earnings from agriculture. However, this additional income plays a vital role

Table 23 - Post-ADMI Increase in Net Income Per Hectare by Agro-Ecological Zone and Year of Scheme Handover (in INR)

Agro-Ecological Zone	Change in Net In-come Per Hectare	Year	Change in Net Income Per Hectare
Alluvial (Vindhya & Gangetic)	52982	2013	81538
Hilly	85047	2014	58892
Red Lateritic Semi-Arid Zone	28167	2015	57373
Saline Coastal Zone	22218	2016	48623
Terai Teesta	92860	2017	56350
		2018	31124
		2019	30848

in uplifting highly impoverished farmers in these regions to take up cultivation beyond subsistence farming and sell their crops in the market. In the richer districts or regions, the incremental income could encourage expansion of cultivated area, using high yielding varieties and adopting more efficient agricultural equipment or technologies. Going by the year of implementation, we can observe that the 'older' schemes, introduced between 2013-2015, have on an average, larger increases in the net yearly income per hectare. This is an encouraging sign, which brings us to acknowledge, that the impact of the ADMI project in the newer schemes could potentially increase over time. The 'newer' schemes implemented from 2017 onwards have had only 1 to 2 years of exposure to the project and have comparatively lower increases in net income per hectare which is expected. Thus, the duration of scheme implementation is positively associated with increases in the net income per hectare. However, in our regression later, we check if the correlation is sustained once controlling for other confounding factors.

3.3.2 Change in Income from Fishery

Around 13% of the WUA farmers in our sample are Members of Fishery Interest Groups (FIGs), and most of these fishery activities are concentrated in the Western Lateritic Zone with many WDS schemes in Bankura, Birbhum, Jhargram and Purulia. They are also prominent in the Creek schemes of South 24 Parganas, Cooch Behar and Dakshin-Dinajpur districts. The mean net income from fishery activities for our sample farmers is Rs. 9,432 per year, if they are cultivating fish with only ADMI support, while it is Rs. 17,312 per year if the Members are cultivating fish privately in addition to ADMI support. This is a testimonial to the immense aid provided by ADMI schemes in enabling farmers to earn adequately from fisheries and reduce dependence solely on agricultural activities.

3.3.3 Impact on Food Intake

The project has provided strong agricultural support services to WUA farmers to encourage them to cultivate more vegetable crops and reduce reliance on paddy, along with the promotion of fishery interest groups in the project areas. As a result, this has not only increased their income, but also improved their domestic consumption of vegetables and fish. The additional income is also expected to be spent for larger quantities of food of better quality. In our sample, more than 70% of WUA farmers responded, that they have increased their consumption across all food groups, i.e. vegetables, meat and fish. Around 1% reported decline in consumption of these food items in post-ADMI years and the rest responded that there was no change in consumption. Thus, the project appears to have contributed in improved nutritional intake and well-being for farmers and their families as reported by them. This is a positive sign but we should also be careful that these are the perceptions of farmers.

3.3.4 Change in Average Monthly Per Capita Income (PCI)

Income from crop cultivation is not the only income source for farmers. Some farmers rely on cultivating fruits and vegetables, engaging in fishery activities and other non-farm employment for their yearly income (housework, animal husbandry, migrant

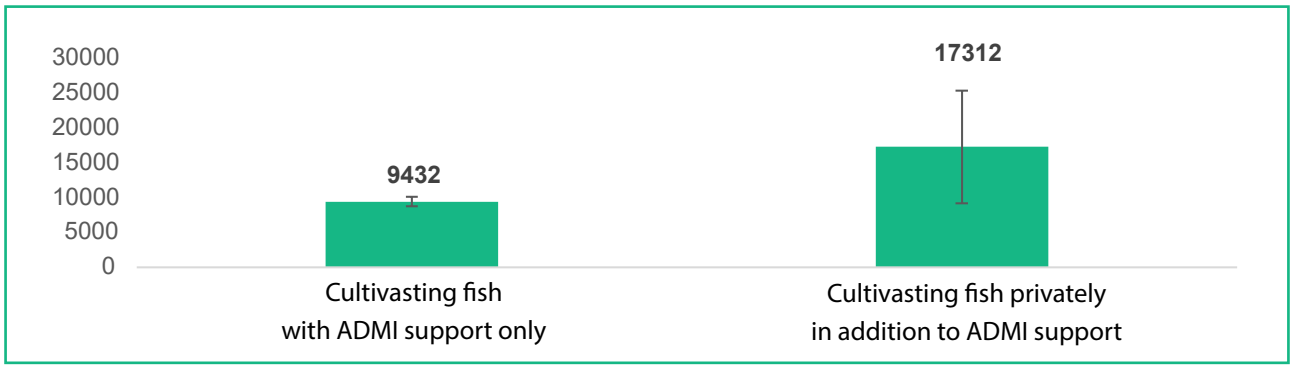


Figure 22 - Mean Net Income from Fisheries (in INR)

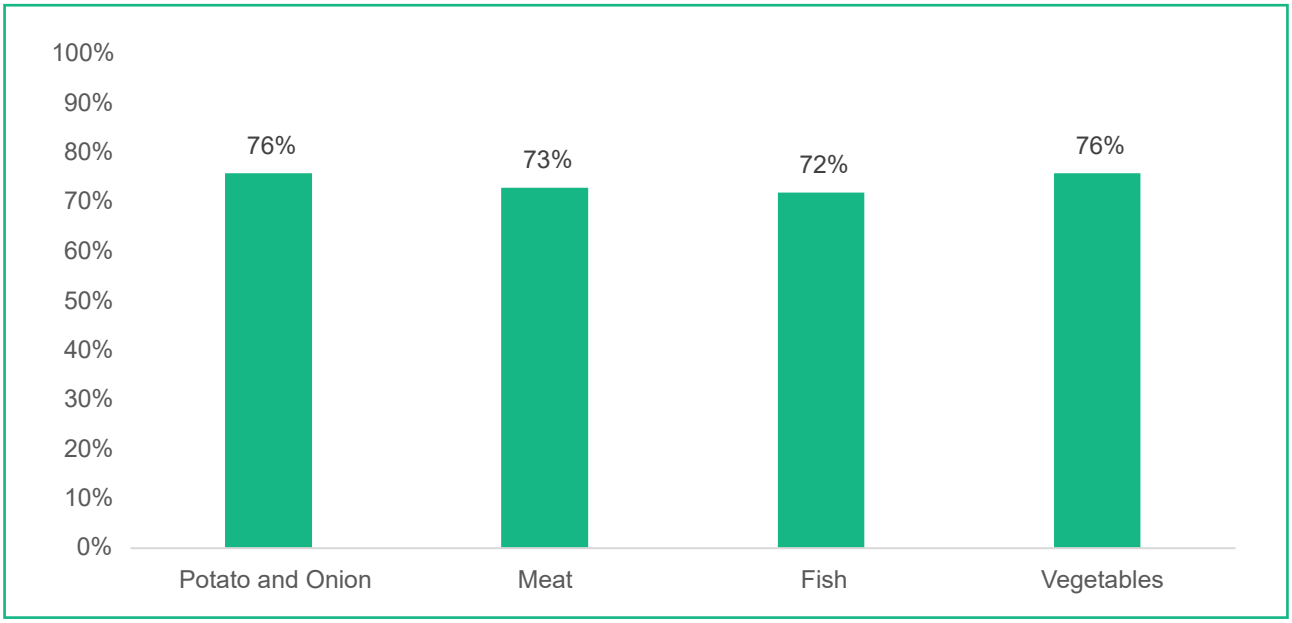


Figure 23 - Percentage of WUA Farmers Reporting Increase in Essential Food Item Consumption since WUA Handover

work, etc). For an overwhelming majority of farmers (80%), agriculture is the only source of income. Around 13% farmers are engaged in agriculture, horticulture and other income generating activities, while 5% practice agriculture and fisheries. Figure 24 presents the average annual income from each source and the average share of income source at endline (2018-2019). Mean yearly income in the case of those farmers engaged in agriculture alone is at Rs. 39,274 per year per capita. Engaging in agriculture, horticulture and fisheries is associated with the highest income on average, at Rs. 1,49,000 per year per capita. Combining crops with horticulture and/or fisheries is also very profitable as evident from the figure. This reveals that ADMI's approach of having an integrated farming approach

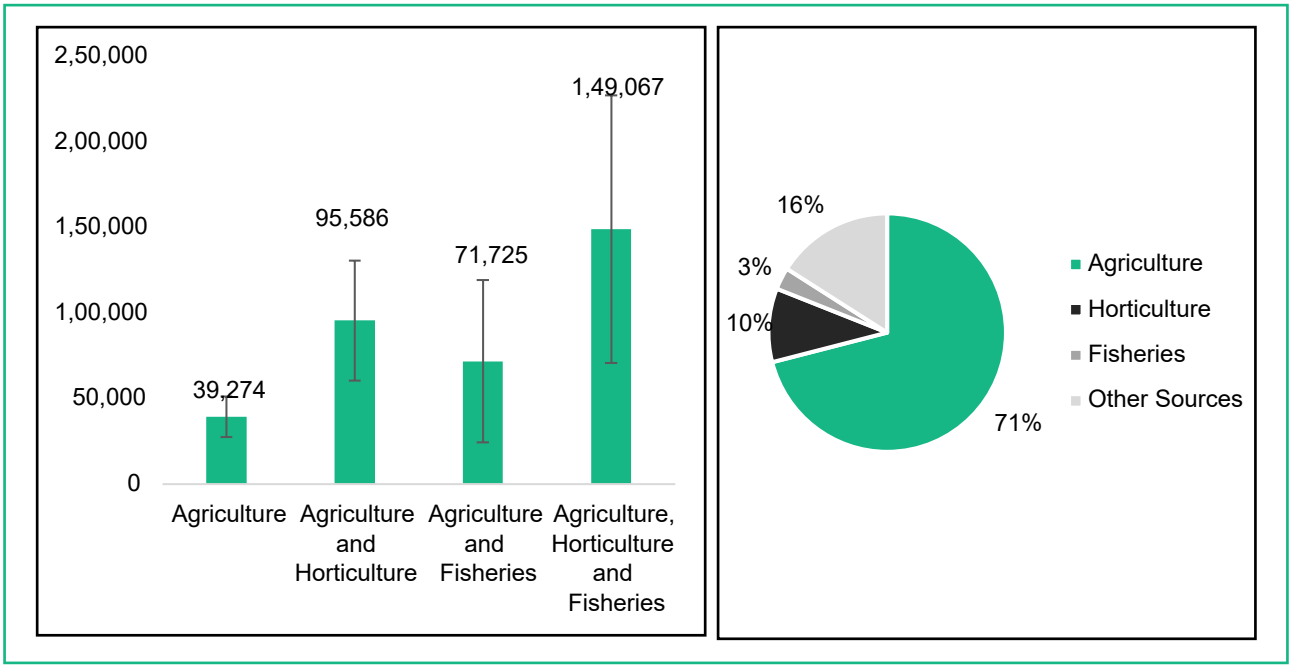


Figure 24 - Average Yearly Income Across Various Sources (in INR) and Distribution of Income (in %) in 2018-2019

Table 24 - Average Monthly Per Capita Income Across Membership Status (in INR)[17]

*95% Confidence intervals in bracket

	Overall	WUA Members	Non-WUA Farmers	Sig.
Pre-ADMI	459 [313.0-606.0]	400 [325.9-474.2]	462 [309.1-615.8]	0.07
Post-ADMI	1009 [756.9-1260.6]	1398 [1070.0-1726.1]	990 [727.3-1252.6]	0.1

involving crops, fisheries and horticulture can be the key to reducing poverty. Looking at the average contribution of different income sources on the total yearly income, we see that agriculture accounts for 71% of total annual income in 2018-2019, followed by other sources which include non-farm related employment (16%) and horticulture (10%). Farmers continue to rely on agriculture as their primary activity but have begun to supplement this with additional sources.

To measure how total income and poverty levels have changed for WUA and non-WUA Members, we also estimated the average of monthly per capita income by summing up the total yearly income from agricultural and non-agricultural activities to arrive at the total yearly income for each farmer household in our sample. This was then divided by their family size and further divided by 12 to derive the monthly per capita income for each household.

From Table 24 it is evident that the mean monthly per capita income of WUA farmers has increased substantially after the project implementation, with the average increase being higher than that of the non-WUA farmers. Before the scheme handover, the average income of WUA Members (Rs. 400) was significantly lower than that of non-WUA farmers (Rs. 462) in our sample. This could be the case since the project specifically targeted the poorest sections of rural West Bengal.[18] The reason for this could also arise from selection of scheme location within a village to maximize targeting of the poor and marginalised farmers. However, in the post project years, the income of WUA Members who benefitted from the ADMI project, increased at a higher rate than non-WUA farmers, from Rs. 400 to Rs. 1398 (~250% increase), as compared to (Rs. 462 to 990 – a 114% increase). In interpreting the numbers, we should also be careful because the data on income is generally very noisy (evident from the wide confidence intervals for our income estimates in Table 24. Also, there could be a high tendency to under-report the actual income in a farmer survey. Hence, the focus here is to assess the direction of change in the income for WUA Members compared to non-WUA farmers, rather than the absolute value. Also in the regression below we look at this relation more carefully.

In Table 25 below, we run a regression to estimate the change in total annual income and change in monthly per capita income of WUA Members, both with and without covariates. We control for individual level characteristics such as the age of the farmer, gender, caste, religion, participation in training, educational attainment etc. We used district and scheme type fixed effects for this regression and clustered standard errors robust at the district level. We find that the coefficient on WUA Membership is positive and significant – change in yearly income for WUA Members is Rs. 25,192 higher than non-WUA Members and the change in monthly per capita income is Rs. 718 higher than that of the non-WUA Members. This indicates that the project is correlated with increasing farmers' income effectively. This would in turn have a positive impact on outcomes such as nutrition and expenditure on their children's education.

17 Rather than calculating monthly per capita income for each household in our sample, we can also sum up the total income for all households, divided by total family size summed up, for all households and then divide it by 12 to get the average monthly per capita income. It gives very similar estimates - the overall average monthly per capita income in the pre-ADMI period is Rs. 406 and Rs. 1,155 in the post-ADMI period. For WUA Members only, this increased from Rs. 393 to Rs. 1,219. Non-WUA Members had a mean monthly per capita income of Rs. 447 before the scheme handover, which rose to Rs. 973.

18 However, within the villages, such large differences in per capita income between the WUA and Non-WUA Members may not be due to targeting alone.

Table 25 – Regression Estimates of the Impact of WUA Membership on Total Income and Change in MPCI

*** p<.01, ** p<.05, * p<.1. Standard errors clustered robust at district level.

	Change in Annual Income (1)	Change in Annual Income (2)	Change in Monthly Per Capita Income (3)	Change in Monthly Per Capita Income (4)
WUA Membership	**17079.6*** **	**25192.1** **	**345.3*** **	**718.0** **
Age		237.2		5.2
Male		-8601.6		265.8
General Caste		-13603.8		-334.8*
Hindu		-1732.1		61.3
Class 10 or Above Education		-13732.8**		-392.9***
Participation in Training		4513.6		-176.5
Constant	6213.6*	8240.5	162.6	3237.2
Scheme Type Fixed Effects	✔	✔	✔	✔
District Level Fixed Effects	✔	✔	✔	✔
R Squared	0.183	0.336	0.165	0.377
Number of Observations	**530**	**524**	**530**	**524**

3.3.5 Poverty Rate Estimates

As we discussed above, the WUA schemes have a positive effect on the change in farmer's income and this is also reflected in the reduction in poverty rate for the WUA farmers in our sample. The poverty line (adjusted for inflation) for rural areas in West Bengal has been defined at Rs. 942 per capita per month (2013: pre-ADMI) and Rs. 1,224 (2018: post-ADMI).[19] At baseline, 87% of WUA Members were below the poverty line as compared to 86% of non-WUA Members. Such a high poverty rate for the sample farmers is because the project has targeted specifically the most marginalised regions of the state for the introduction of the scheme. The slightly higher average income for non-WUA Members at baseline (Table 24) also suggest selection bias at the farmer level in our sample, due to the project's focus on marginalised farmers. Also, there could be a high tendency to under-report the actual amount of income. However, the focus is on the direction of change and we see that, after the project implementation, there has been a significant reduction in the number of people below the poverty line by 17 percentage points for WUA Members. For non-WUA Members on the other hand, the decline in the proportion of people below poverty line is lower at 11 percentage points. Although we should be careful in attributing these results to the scheme, in the presence of these potential selection issues and the absence of a proper baseline, these results do indicate that the situation of WUA farmers has improved more than that of the non-WUA farmers in our sample, and there has been substantial improvement in the lives of these very poor farmers in these extremely marginalised regions.

Table 26 - Percentage of WUA and Non-WUA Farmers Below Poverty Line

	WUA Members (N=382)	Non-WUA Members (N=146)
Pre-ADMI	87%	86%
Post-ADMI	70%	75%
Change (in pp)	17%	11%

19 The poverty line was last updated for the year 2011-12. The Planning Commission released the poverty estimates in July 2013 (Press Note on Poverty Estimates, 2011 - 12, Planning Commission). These were based on the consumer expenditure surveys conducted by the National Sample Survey Office (NSSO) of the Ministry of Statistics and Programme Implementation.

4. VERIFICATION OF KEY INDICATORS FROM PHONE SURVEY

We conducted a primary survey through telephonic interview of a sample of schemes, to verify certain key agricultural and institutional indicators, estimated from DPMU data and to supplement the analysis of secondary data. The agricultural indicators have been computed at the scheme level for the phone survey data which we refer to as 'primary data'. This primary data sample comprises of a total of 65 schemes. We calculate our estimates of indicators for all 65 schemes and compare with the 65 schemes for which data has been collected by the ADMI project officials. This data collected by project officials which we have analysed in the previous section has been referred to as 'secondary data' in this section. For this comparison we have used the same 65 schemes for our analysis that were selected for telephonic survey, to estimate the extent to which our 'primary survey' data differs from 'secondary data' collected by ADMI. The primary aim here is to show the estimates of various indicators based on our data and test how similar these results are to the secondary data source.

4.1 Changes in Total Cultivated Area

Based on our primary data we can see that the average gross cropped area (GCA) for the schemes selected for our telephonic survey increased from 26.1 hectares in pre-ADMI years to 44.7 hectares post-ADMI, registering an increase of 71%. The GCA estimate for the same schemes from secondary data shows very similar trend – an increase of 75% in average GCA from 31.1 hectares to 54.5 hectares after scheme implementation. The increase in the average Net Sown Area (NSA) is more modest, as it increased by 17.7% from 19.2 hectares to 22.6 hectares. In the secondary data, the estimates of average Net Sown Area are slightly higher and the increase in Net Sown Area is

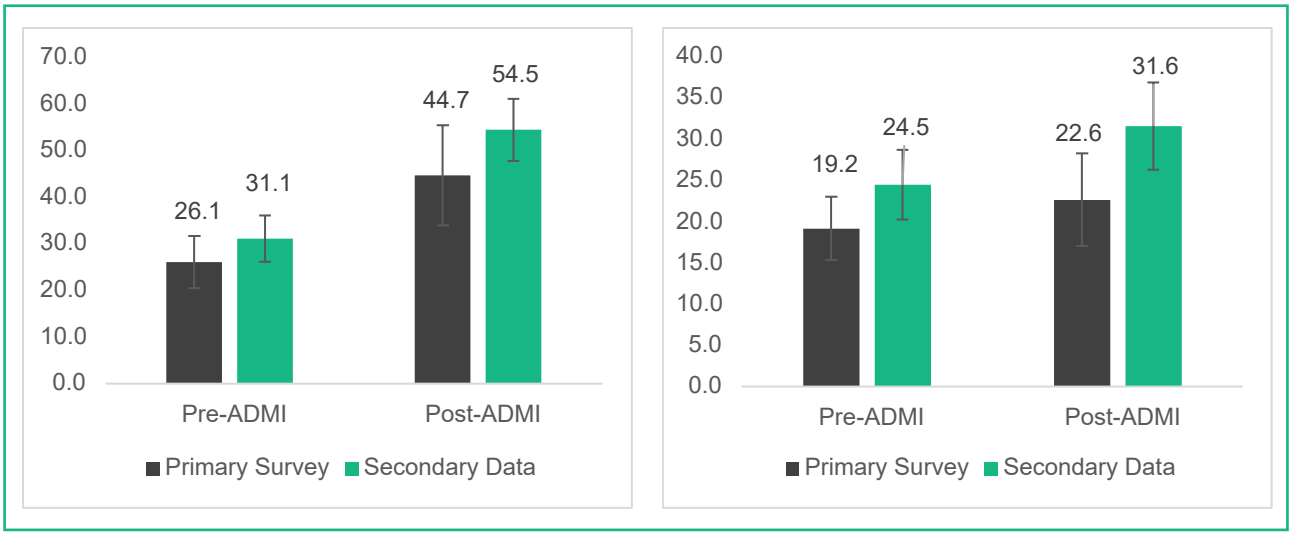


Figure 25 - Average GCA and NSA Estimates from Primary and Secondary Data Sources

Table 27 – Season-Wise Average Cultivated Area Per Scheme from Primary and Secondary Data

	Primary Data		Secondary Data	
	Pre-ADMI	Post-ADMI	Pre-ADMI	Post-ADMI
Kharif Area	19.1	22.3	17.1	20.4
Rabi Area	3.0	13.5	8.0	23.3
Pre-Kharif Area	2.6	8.8	6.0	10.8

also at 29.0%. Although the estimates for secondary data are slightly higher, but both data sources yield very consistent estimates for the change in gross cropped area and Net Sown Area.

This is consistent with what we discussed in the previous section, that the average *Kharif* area increased by around 20%, as the project brought more area under cultivation even during *Kharif* season. This has increased the Net Sown Area. But the major change is in the area cultivated during *Rabi* and *Pre-Kharif* season. Table 27, shows that according to our primary data, *Kharif* area marginally increased by 3.2 hectares, from 19.1 hectares to 22.3 hectares. This is similar to the increase in cultivated area in *Kharif* for the secondary data (3.3 hectares).

4.2 Changes in Cropping Intensity

Increased cultivation during non-monsoon season is reflected in the rise in cropping intensity. Figure 26 shows that cropping intensity increased by 48.4 percentage points from 134.5% in pre-ADMI years to 182.9% post scheme implementation, according to primary data. This estimate from phone survey is very close to our secondary data estimates, which increased from 130.2% to 185.2% - an increase of 55 percentage points, slightly higher than the phone survey estimates.

If we look at how the cropping intensity has changed across scheme type, according to our telephone survey, the least progress has been made in PDW schemes (13.7 percentage points). The highest increase is for TW (63.5 percentage points) and Creek schemes (61.5 percentage points), followed by LI schemes. LI schemes have very high cropping intensity in Post–ADMI period, but they also had a higher pre-ADMI cropping intensity at 165%. The scheme-wise estimates from secondary data gives a different picture – the increase in cropping intensity for WDS schemes is higher (53.5 percentage points) and also much higher for LI schemes (99.4 percentage points). However, it is important to remember that for each scheme type, number of observations are very small as the total sample size is 65, and consequently make the estimates quite imprecise at scheme level.

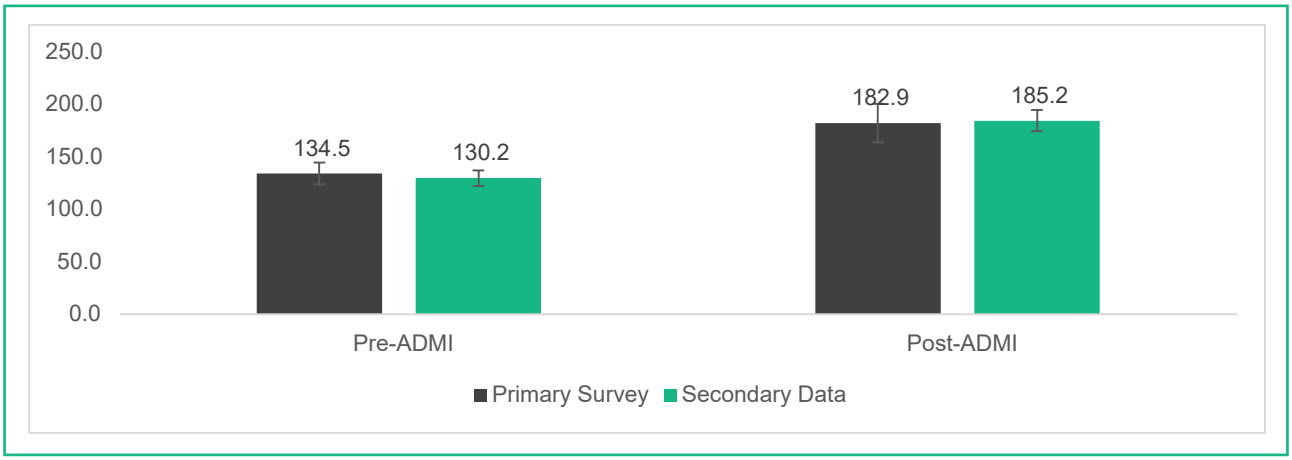


Figure 26 - Average Change in Cropping Intensity from Primary and Secondary Data Sources

Table 28 - Scheme-Wise Change in Cropping Intensity from Primary and Secondary Data Sources

Scheme	Primary Data		Secondary Data	
	Pre-ADMI	Post-ADMI	Pre-ADMI	Post-ADMI
CD	103.80%	136.10%	108.50%	138.60%
Creek	106.30%	167.80%	104.30%	167.40%
LI	165.00%	201.50%	120.20%	219.60%
PDW	118.90%	132.60%	158.20%	164.90%
TW	139.40%	202.90%	133.10%	189.10%
WDS	100.00%	116.70%	100.00%	153.50%

4.3 Changes in Crop Diversification

Both primary data and secondary data for the 65 schemes in our sample indicate that the Crop Diversification Index (CDI) has increased substantially as a result of scheme introduction. Our estimate from the telephone survey show a growth in CDI from 0.22 to 0.57, while the secondary data gives an estimate of CDI growth from 0.26 to 0.51. Again, the estimates are quite consistent and tell a story of increased cultivation of other crops like vegetables, mustard, etc.

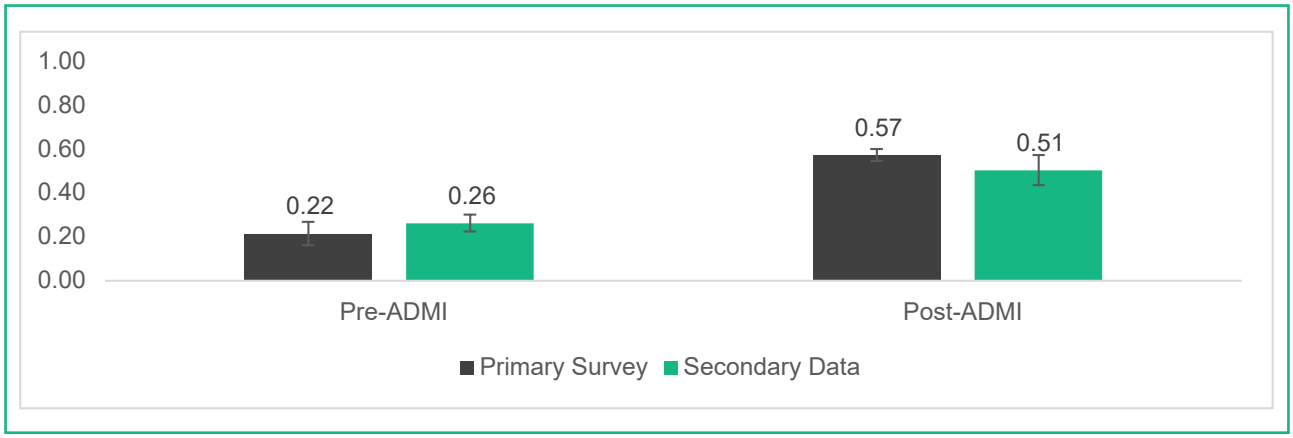


Figure 27 - Average Change in Crop Diversity Index from Primary and Secondary Data Sources

Table 29 - Average Change in Crop Yield from Primary and Secondary Data Sources

Crop	Primary Survey		Secondary Data	
	Baseline	Endline	Baseline	Endline
Aman Paddy	3.5	4.6	3.0	4.2
Boro Paddy	3.9	6.6	4.9	5.7
Potato	17.1	27.1	17.3	26.3
Mustard	1.0	1.3	1.0	1.3

4.4 Change in Average Crop Yield

Table 29 gives the average yield for key crops in tonnes/ha. Our telephonic survey data estimates Aman paddy increase in yield by 1.1 tonnes/ha, from 3.5 tonnes/ha to 4.6 tonnes/ha. Although the secondary data has lower yield, it predicts almost similar increase in paddy yield by 1.2 tonnes/ha after the scheme.

For Boro paddy our telephonic survey in fact estimates a larger growth in yield as compared to the secondary data. The yield gain is substantial by 2.7 tonnes/ha according to the telephonic survey, while the secondary data shows a more modest jump by 0.8 tonnes/ha. Since most of the schemes did not cultivate Boro in the pre-ADMI years, the yield estimate for baseline is quite imprecise. In the case of potato and mustard, the telephonic survey estimates match very well with the secondary data. Both datasets estimate that potato yield increased from around 17 tonnes/ha to 26-27 tonnes/ha – a jump of almost 10 tonnes/ha. Mustard yield on the other hand was estimated to increase by just 0.3 tonnes/ha.

4.5 WUA Membership

One important aspect of WUA as an institution is to look at the composition of WUA Members and assess whether it is inclusive of marginalised groups. We again use the telephonic survey to compare with the ADMI 'Ground-Truthing' dataset. Indicators on Membership in WUA, representation, institutional functioning have been presented to show the insights drawn from the primary data analysis as well as to check the extent of convergence of the results with that of the secondary data.

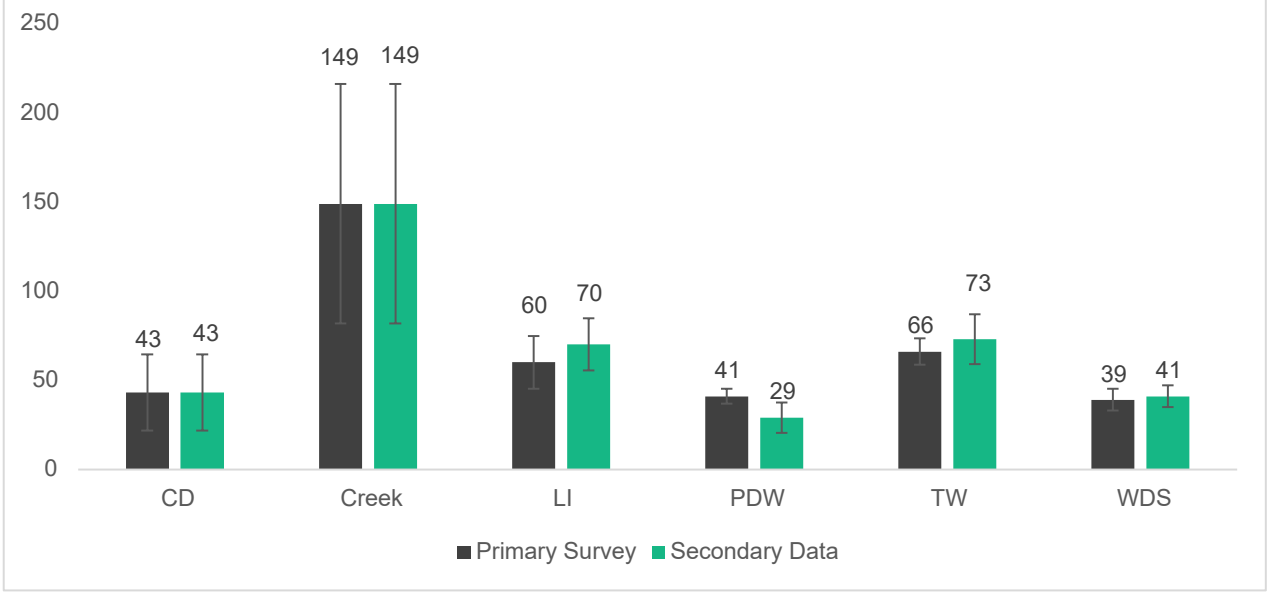


Figure 28 - Average Number of Members in Each WUA Across Scheme Types

Table 30 - Female Membership Across Scheme Types

	Average Proportion of Females within WUA		Average Proportion of Female within Governing Body/Executive Committee	
	Primary	Secondary	Primary	Secondary
CD	7%	8%	25%	25%
Creek	8%	6%	34%	29%
LI	14%	10%	30%	26%
PDW	24%	46%	45%	63%
TW	12%	11%	28%	29%
WDS	85%	100%	100%	100%
Total	**15%**	**19%**	**32%**	**36%**

The average number of Members per WUA across scheme type matches quite closely between the two datasets. Check Dam, Pump Dug Well and Water Detention Structures have the least number of Members per WUA, while the WUA size for Creek is the highest, followed by Tube Well and LI schemes. The proportion of female WUA Members is estimated to be 15% according to telephone survey, which is less than the estimate from secondary data which estimates that 19% of the WUA Members are female. In terms of female Members in WUA Executive Committee, we find the overall mean proportion to be more than 30% across both telephone survey and primary data estimates. Telephone survey estimates are slightly lower, but it matches quite closely across scheme types. We can see in our sample, that female Membership is comparatively lower in TW schemes and Check Dam schemes, and highest in WDS schemes. This is consistent with what we have discussed previously that female Membership is comparatively lower for schemes that are larger and have higher financial transactions (typically WDS[20] schemes have low revenue, since mostly the farmers use their own pump to irrigate). Also, most of the WDS schemes are located in the Western Lateritic Zone, where tribal population density is high and involvement of women in these activities are much higher.

In terms of caste categories of WUA Members, we find that for the sample schemes the estimates matches closely between our primary telephone survey data and secondary data from ADMI. On an average, 65% of WUA Members hail from marginalised backgrounds (45% Scheduled Caste and 20% Scheduled Tribes). This reflects the presence of a high proportion of marginalised farmers as WUA Members.

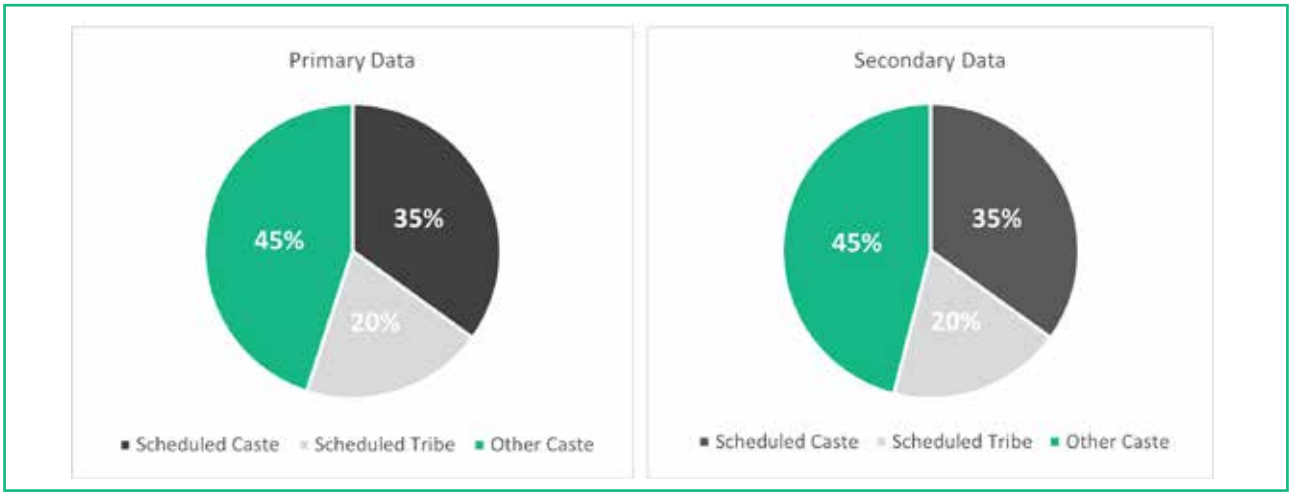


Figure 29 - Average Proportion of WUA Members by Caste Categories

20 The WDS schemes in our sample of 65 schemes were all female WDS schemes.

Table 31 - Proportion of WUAs Where Findings of Last Audit Report was Shared with All Members

Scheme	Primary Data			Secondary Data		
	Yes	Don't Know	No	Yes	Don't Know	No
CD	100%	-	-	100%	-	-
Creek	100%	-	-	100%	-	-
LI	100%	-	-	72%	2%	26%
PDW	97%		3%	71%		29%
TW	94%		6%	79%	3%	18%
WDS	0%	-	100%	0%	-	-

4.6 WUA Institutional Accountability

For proper WUA functioning it is important that, it functions in a democratic manner and it is accountable to its Members. We look at various indicators to assess from our telephone survey, how the WUAs are performing as an institution in this respect.

Among the 65 schemes in our telephone survey, 95% had mentioned that the last audit report findings were shared with all WUA Members in AGM from the primary data. This is higher than what is reported in secondary data where there are also some 'Don't Know' responses. None of the WDS schemes had their audit reports shared with the Members from both primary and secondary estimates. This is also reflective of the fact that fee collection in WDS schemes are often lower, and institutional strength is much lower for such schemes. CD and Creek schemes have been the most transparent, with all WUAs responding that audit findings have been shared. In the secondary data, 26% LI schemes and 29% PDW schemes have not shared the audit report with WUA Members, which is in contrast to the primary data.

The WUAs also keep a track of different aspects of their functioning in the form of registers. This enables effective planning, provides a record for lessons learned and a progress check from past cropping and water management activities. The four main types of registers are 'Crop Planning and Actual Cropping', 'Irrigation Schedule', 'Pump Log Book' and 'Water Distribution'. In the primary data, we can observe that all Creek schemes have maintained all four of their registers. CD schemes have performed well with respect to three registers but no scheme under this scheme type maintains the pump log book register. This is because the schemes do not have pumps of their own and the farmers use their own pumps. WDS schemes in our sample only maintain Crop Planning books,

Table 32 - Percentage of WUAs that Maintain Different Types of Registers

Scheme	Primary				Secondary			
	Crop Planning	Irrigation Schedule	Pump Log Book	Water Dis-stribution	Crop Planning	Irrigation Schedule	Pump Log Book	Water Dis-stribution
CD	100%	100%	0%	100%	100%	100%	0%	50%
Creek	100%	100%	100%	100%	100%	75%	0%	100%
LI	100%	95%	89%	100%	77%	77%	71%	27%
PDW	97%	100%	77%	77%	100%	36%	29%	36%
TW	94%	75%	97%	87%	83%	80%	91%	71%
WDS	100%	0%	0%	0%	67%	0%	0%	0%

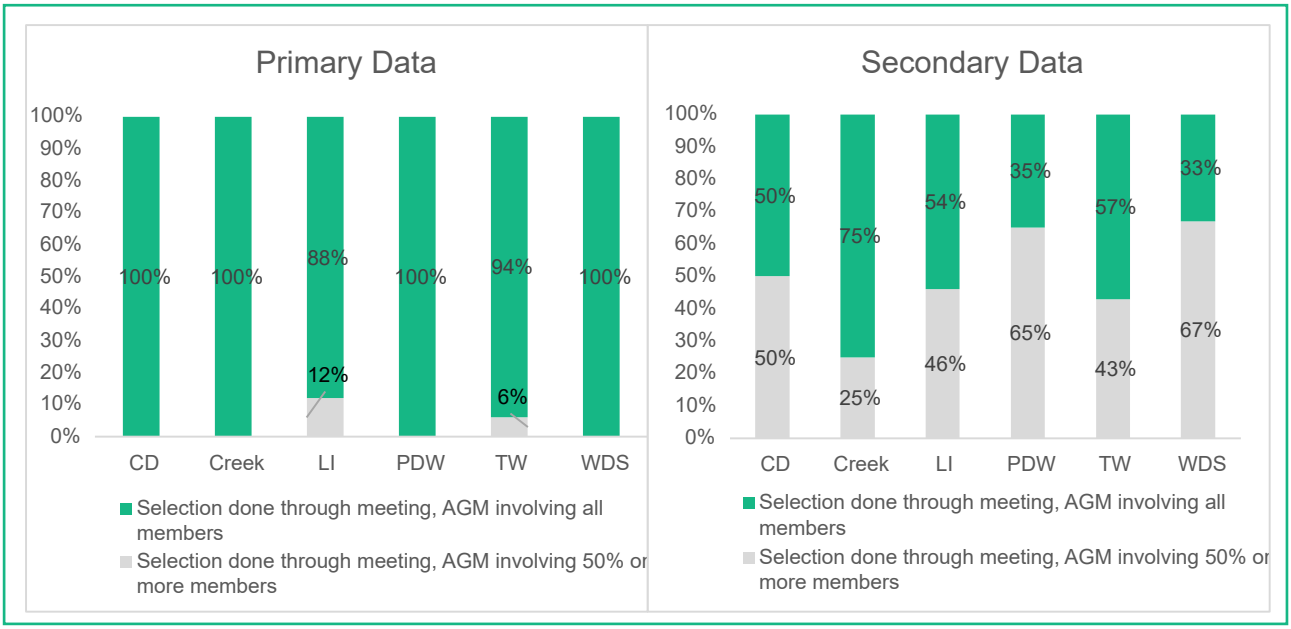


Figure 30 - Selection of Executive Committee Scheme-Wise for Primary and Secondary Data

but none of the other registers. This is same for both primary and secondary data. LI, TW and PDW schemes have more consistent maintenance of all registers. Overall, WUAs have performed quite well in systematically and transparently maintaining these key sources of information that facilitate their smooth operation.

Both primary and secondary data tell us that in none of the schemes, the Executive Committee selection was done without an AGM. Where it differs is that, overall, 96% schemes according to telephone survey has done the selection involving all Members, while the secondary data gives the estimate at 51%. It is clear from Figure 30 that the Primary data results have higher percentage of schemes reporting selection by all Members. However even if the selection was done with all Members, what we found from our survey was that in almost all the schemes, no change in Executive Committee happened after the initial selection. In most of the cases the Executive Members selected initially are replaced very rarely due to some incident, but not as a general process of change. One likely reason is that the skill and time required to maintain the books and finance etc., would exclude many people to contest for these positions.

If we look at the composition of the top 3 positions within the Executive Committee i.e. Chairman, Secretary and Treasurer, we find that more than 90% are male, although more than 30% of Executive Committee Members are female. In terms of caste composition, between 25 -30% of the top 3 positions are occupied by general category individuals, which is slightly more but close to the proportion of general category farmers within WUA (around 20%). This is primarily because of the schemes in tribal regions in Purulia, Jhargram and Birbhum, where most of these positions are filled with farmers belonging to ST category. Also in North Bengal in Cooch Behar and Jalpaiguri, with high density of farmers from SC category, these positions are filled by that group. So the project has been successful in targeting regions with vulnerable population and prioritizing them. However, in terms of female engagement in decision making positions, it is still lacking.

4.7 WUA Financial Accountability

The main income of WUAs are the water charges collected from the Members using irrigation facilities. For the sustainability of the project it is important to collect enough funds and have surplus, that can be used for maintenance in future. The number of defaulters in water fee payment is

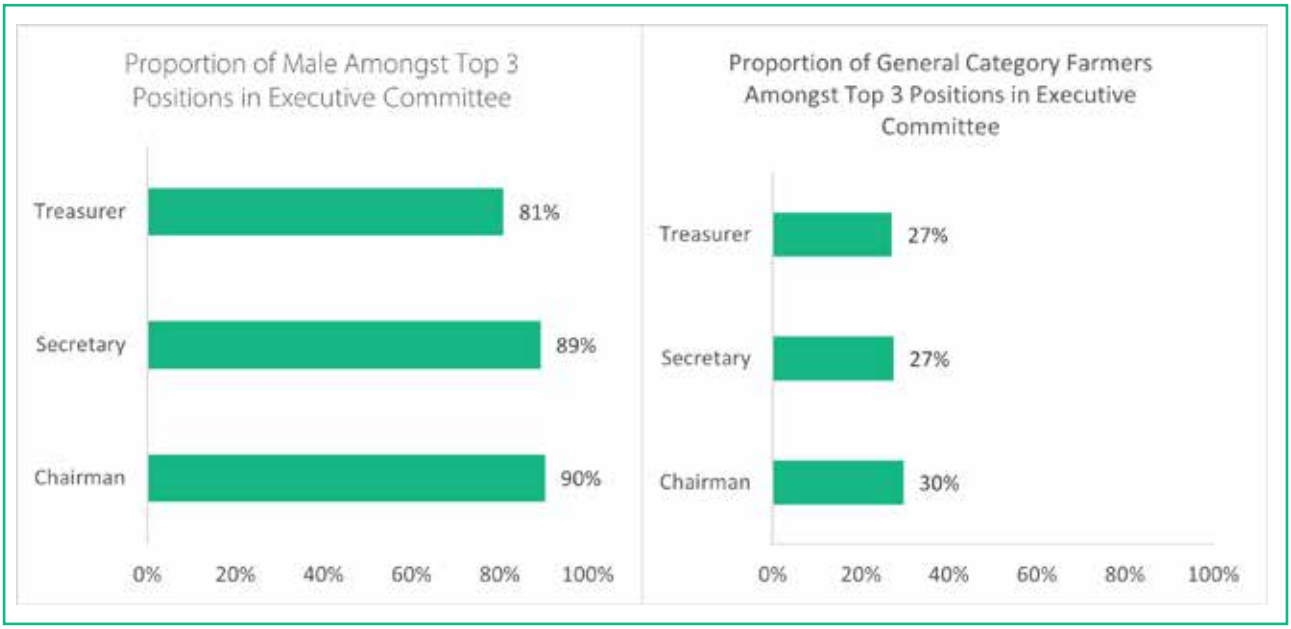


Figure 31 - Composition of Top 3 Positions in Executive Committee

substantially lower for every season in the primary data relative to the secondary data. However, this is due to the fact that the primary data is for the financial year 2019-20; while secondary ADMI data is for the period 2018-19. In 2019-20, many farmers have been unable to pay their dues as a result of the COVID 19 pandemic and the Amphan Cyclone. The actual cases of pending payments are high this year, but these WUA Members are not being recorded under the defaulters list. They have stated that they are willing to repay the amount in the next growing season. In the secondary data, the number of defaulters is highest in the *Rabi* season. The high rates of water charges during this period could be the primary reason behind more farmers being unable to pay the full amount.

To understand the financial liquidity of the WUAs we look into total cash holdings of WUAs for our 65 schemes. The total cash holdings of WUAs comprise of both cash in hand and cash at bank. The primary dataset contains this information till March 2020. On the other hand, the secondary data covers this for the year ending 30th June 2019. Overall, the primary data reveals 65% of cash is kept at the bank and the remaining 35% is in hand as of March 2020. In the secondary data, we find that 51% of cash is in hand in 2019. This indicates that WUA Members have shifted to depositing with banks and retaining less liquid cash which will increase their savings and earnings. From Table 34 we can see that Creek and TW schemes are the most well-endowed financially. Creek has been the only scheme type to have experienced a decline in cash holdings by about 5%. Cash reserves in WDS schemes have remained consistently the lowest and Creek schemes have been the highest. In most scheme types, the estimates from primary data are much higher than the secondary data estimates.

Table 33 - Total Number of Defaulters Season-Wise

	Primary			Secondary		
	Kharif **19**	*Rabi* **19**	*Pre-Kharif* **20**	*Kharif* **18**	*Rabi* **18**	*Pre-Kharif* **19**
Number of Defaulters Reported	2	130	58	117	603	298

Table 34 - Average Cash Holding with WUAs Across Scheme Types

Scheme Type	Primary Data (April 2019-March 2020)	Secondary Data (till 30th June 2019)
CD	35,840	16,859
Creek	89,530	94,620
LI	41,150	33,999
PDW	44,632	11,642
TW	69,603	40,260
WDS	2,800	245

For the financial sustainability of the schemes it is also important to look at how much surplus it can generate in a year after spending on electric bill, maintenance, and other operational expenses. The surplus generated can be used if there are requirements for maintenance in the future. Table 35 gives the average surplus for WUAs by scheme type for 2018 and 2019. Surplus has been calculated as the difference between total income and total expenditure in a financial year. In 2018, on average, WDS schemes had no surplus reserves. The major difference is seen in CD schemes with primary data showing a mean surplus of Rs. 105 and secondary data showing a deficit of Rs. 1,195. For TW schemes, the secondary data surplus amount is almost double that of the primary data estimates. Only PDW schemes have the most similar surplus values (difference of Rs. 609). The average difference between primary and secondary data results for the rest of the scheme types is approximately Rs. 2,694. In 2019, WDS schemes continue to have a zero surplus. Again, we notice that PDW schemes show the most consistent estimates. A common finding from both 2018 and 2019 data is that the secondary data amounts are greater, with the exception of the deficit for the CD schemes in 2018. But more importantly the data shows that overall, there has been a substantial growth in the surplus from 2018 to 2019 for all schemes. On average across the three years, the highest savings are for Creek and TW schemes. TW schemes charge higher prices for water because of the energy payment that needs to be paid, but their surplus amount is also necessary because many schemes that we interviewed reported that their pumps get burned or leakages in delivery pipes etc., that require surplus money with the WUAs. Another observation from our focus group discussions has been that many TWs or RLIs that are using electric pumps faced the common problem of very high electric charges. In a few cases, the connection had to be cut because of non-payment. Electricity prices in West Bengal are comparatively higher and often, farmers with no previous experience with electric connections are unaware of how much electric cost is entailed in running the pumps. Thus the WUA can often be surprised with a very large electricity bill that makes them unable to pay back the money.

Table 35 - Average Surplus of WUAs Scheme-Wise

Scheme Type	2018		2019		2020
	Primary	Secondary	Primary	Secondary	Primary
CD	105	-1195	4851	9611	53075
Creek	11892	15674	39591	59653	20264
LI	1964	6279	6279	17080	27874
PDW	1702	2311	1449	4475	1202
TW	5822	11177	23399	44474	30538
WDS	0	0	0	0	2360

Table 36 - Average Change in Per Capita Income from Primary and Secondary Data Sources

	Primary Data				Secondary Data			
	Overall	WUA	Non-WUA	Sig	Overall	WUA	Non-WUA	Sig
Baseline	336	338	333	0.27	466	395	468	0.04
		[224.9 - 450.6]	[203.8 - 462.7]		[221.4 - 710.8]	[317.4 - 473.7]	[216.7 - 719.1]	
Endline	808	824	793	0.16	1082	1399	1073	0.01
		[689.7 - 958.1]	[587.3 - 998.1]		[466.3 - 1697.1]	[1006.0 - 1793.0]	[441.2 - 1705.9]	
Change (%)	140%	144%	138%		131%	254%	129%	

4.8 Change in Income

The average yearly per capita income has been calculated from the telephone survey data in the same way as described in previous section for secondary data. The overall estimates show that average monthly per capita income increased by 140% according to telephone survey data, while it increased by 131% according to secondary data estimates. In the secondary data, for WUA Members average monthly per capita income increased by a large amount i.e. 254%. But in comparison the primary survey data shows only 144% increase in monthly per capita income for WUA Members. This is because, the endline values for baseline secondary data are much larger. This could be arising due to the higher variation in the larger secondary sample in terms of a wider income range among the farmers. Non-WUA Members on the other hand, had a 138% increase in their income in the primary telephone survey data and by 129% in secondary data. As a result, the telephone survey data tells that both non-WUA and WUA Members had very similar growth in income after scheme implementation and there is no statistically significant difference in their income. But the secondary data tells us that per capita increase in income for WUA farmers are much larger compared to non-WUA farmers. The likely reason for this is the way the non-WUA Members were selected in the telephone survey. Since we did not have the list of non-WUA Members we had to rely on local field partners and WUA Members to give us names of non-WUA Members, which would result in selection bias.

We also examine in our primary survey data how the incidence of poverty changed after ADMI scheme implementation. The threshold poverty line has been defined as earning a per capita monthly income of less than Rs. 924 pre-ADMI and Rs. 1,224 for post-ADMI. In the primary data, we find that 93% farmers were poor at baseline and it significantly reduced by 19 percentage points at endline with around 202 farmers (74%) falling under this category. Almost equal proportions of WUA and non-WUA Members were below the poverty line before and after the handover. This again illustrates

Table 37 - Percentage of Farmers Below the Poverty Line

	Primary Data			Secondary Data		
	Overall	WUA Members	Non-WUA Members	Overall	WUA Members	Non-WUA Members
Baseline	93%	95%	91%	84%	84%	82%
Endline	74%	74%	74%	73%	71%	77%
Change in Percentage Points	19pp	21pp	17pp	11pp	13pp	5pp

the point that according to the telephone survey interview estimates, there was an increase in income and reduction in poverty, but both WUA and non-WUA Members had similar changes. In the secondary data however, there has been a notable improvement for WUA farmers with a reduction in poverty count by 13 percentage points. Non-WUA Members do not demonstrate this extent of decrease (5pp). Hence, the percentage point change in movement from below the poverty line is much higher for WUA Members in the secondary data. As mentioned before, this could be due to the selection bias in non-WUA Members in the primary data and given the restrictions of telephone survey, the secondary data samples should be more reliable for non-WUA Members.

5. CONCLUSION

The ADMI scheme has been successful in developing irrigation infrastructure, creating Water Users' Association for community management of assets created, and providing crucial agricultural support services for enhancing agricultural production. The project has heavily focused on small and marginal farmers and tribal farmers and rightly so, in deciding the target locations for the project.

The success of the project can be understood from the impact it has created by bringing previously fallow land under cultivation through enhancement in water availability, especially during the non-monsoon season i.e. *Rabi* and *Pre-Kharif* season. Not only more area has been brought under cultivation but more types of crops are being cultivated, clearly signaling crop diversification and thus diversifying farmer's income and domestic consumption. The distinctive feature of this project is the integration of agricultural support services with improved irrigation access, in order to maximize the beneficial potential of minor irrigation schemes. This has been made possible through the development of community based irrigation management by the Water Users' Associations, created through this project. These are the two distinctive features of this project which differentiate it from other similar micro-irrigation schemes of the government. The WUAs as an institution are not only responsible for the operation and management of the scheme, but they help nurture community leaders and bring together farmers into an association which can be used for easy dissemination of technical knowledge and improved agricultural practices by other government departments. The farmers can also make use of these associations to create a larger federation for marketing of their products and generating new livelihood opportunities.

Our assessment has been done on the last year of this phase of the project, but there is still active support from the government officials to the project farmers. The results of this study have highlighted significant improvement. However, the ultimate success of the project will be judged on how these WUAs will function and whether the irrigation infrastructures will be maintained properly after withdrawal of the ADMI project. This has to be looked into in the future, but below we present some of the key learnings and suggestions that can be useful for the future sustainability of these schemes under the project.

i. **Convergence with other government development schemes:** The project has spent considerable resources to help create these association of farmers and build their capacity through training in many villages across the state. This provides a considerable scope for convergence with other developmental schemes of the state and central government including MGNREGA, RKVY, PMKSY, NRLM, KUSUM and others.

   There have been some very good examples in the project where WUAs farmers have successfully mobilized resources from other government departments – for example plantation of trees with Forest Department or the Agricultural Technology Management Agency (ATMA), pond re-excavation though MGNREGA, field channels through Department of Agriculture, pisciculture with support from Fishery Department, using Central Finance Commission (CFC) & State Finance Commission (4th SFC) grants etc. Despite these success stories, this aspect of convergence is largely missing. One way to institutionalize this convergence procedure would be to create District Level Implementation Committees, with the District Collector as the chairman. Such convergence with existing institutions could be crucial in long term sustainability of the assets created through this project.

ii. **Collective marketing for farmer produce:** The potential benefits of developing a viable business model of collective marketing of farmer's produce is evident from the shining example of the Farmer Producer Company (FPC) named 'Bangabhumi Farmers Producer

Company Limited' formed with the participation of several Water Users' Associations (WUAs). The FPC is a registered company but it acts as a block-level 'federation of WUAs' for the marketing of crops cultivated by WUA farmers. It provides direct market linkage for WUA farmers and maximizes their profit. The FPC is Member of a state level FPC named 'Samiyog Agro-Farmers' Producer Company Ltd.' – a collective of 10 such FPCs all over the state. Their goal is to make the FPC as a branded product that can spread business across the country. Such collective marketing in a cluster based approach can be a very good option for increasing WUA farmer's profitability. This would also provide strength for aggregating input requirement, as well as aggregating producers' outputs for better marketing and bargaining capacity. The existence of WUAs make such an approach a very practical option for development.

iii. **Capacity building to prevent electricity payment default:** During our focus group discussions, we observed quite a few cases where electric tube wells have been disconnected from the electric connection by the Utility due to non-payment of bills. The WUA farmers informed that the billings were sometimes irregular and they suddenly got very high bills, which the farmers do not have capacity to pay. West Bengal has a comparatively high electricity tariff and if bills are irregular then farmers can be unaware of how much electricity is being consumed and what is the charge that has accumulated. This is further complicated by the fact that complex time of the day tariff and the fact that many farmers with different land characteristics will spend different energy to irrigate the same amount of land. All of this makes it very difficult to estimate what could be potential bills and how to set the water fee. Given this uncertainty, there is scope of more cases of non-payment in future for electric tube wells under the scheme. In this context, it can be helpful to give training to WUA farmers to understand the tariff structure and how the water fees should be determined. In some cases, it can also be useful to shift to solar pumps (the Tube Well and distribution infrastructure is already there) via convergence with existing government programme on solar irrigation. There are also successful models of Solar Cooperatives to incentivise farmers for saving energy by evacuating and selling the unused solar energy to grid and thereby also help conserve groundwater.

iv. **Need for water demand management:** The ADMI project's core objective has been to expand irrigation access, and its focus on demand side management has been sporadic. Lack of on-farm water management is specifically crucial for small size irrigation schemes like WDS and PDW, with limited storage capacity. Emphasizing on farm water management practices would help bring more area under irrigation, achieve the targeted command area and enhance water productivity. Also in groundwater schemes, over-abstraction leading to long term risk of groundwater depletion can be avoided through effective water demand management. There is need to promote water management interventions like AWD, DSR, soil moisture sensor based irrigation, promotion of drip, sprinkler and rain gun; land levelling, channel to field irrigation, and better irrigation scheduling. For this purpose, convergence with relevant schemes and programmes could also be explored.

v. **Prevent capture of WUA by local elite:** Our interaction with farmers reflect mostly positive evaluation of the WUA as an inclusive institution with high participation of marginal farmers and representation from farmers belonging to SC and ST categories. Also more than 30% of WUA Executive Members are female farmers. The selection of Executive Committee is also done by voting of all Members. But our interactions also indicate some worrying signs in terms of the actual power enjoyed by all Members of the WUA. It was observed that in many schemes, female Members of WUA are only for the sake of formality to achieve project target. This is also evident from the fact that most of the top Members of the Executive Committee i.e. Chairman, Secretary and Treasurer are

overwhelmingly male. Also in many schemes, no explicit voting is done for reselection of Executive Committee Members at the end of year, and previous committee gets re-elected. The committee from the start rarely gets changed. Over the long term, this could result in elite capture of WUA, alienating marginalised Members. There should be some sort of restriction of the length of WUA leadership and capacity building exercises should be done to train more people for leadership activities.

vi. **Success of integrated farming system model:** In our case studies and interviews, we have seen some very successful examples of integrated farming system models around the ponds/ water bodies incorporating crop-horticulture-livestock-fishery; to encourage multiple use of water, increase economic water productivity and ensure steady income. Plantation with inter-cropping is one such example where till the plants are matured, crop is cultivated in the land in between the plants and then farmers can get regular income from the orchard. Fishery in the water body has already attracted many farmers into Fishery Interest Groups. In fishery groups, low cost cat fish hatchery should be promoted as an alternative. Once again efforts should be put to promote such integrated farming models, with the help from relevant government schemes and departments. The fact that this hand-holding support is provided even after the project completion, through government extension network is crucial.

vii. **Training local technicians for maintenance and repair:** One serious threat to these kind of projects is the long term sustainability of scheme infrastructure after handing over. Capacity development is required to train local people who can provide support for all non-major repair and maintenance. Often with no nearby facilities for such services and no local mechanic, the infrastructure can quickly become damaged and unusable, well before its useful life.

The long term sustainability of this project is dependent on a successful exit strategy including creating linkages for sourcing funds required for major repairs through convergence with other government development schemes, value chain development through collective marketing for farmer produce, capacity building of WUA farmers on repair and maintenance of scheme infrastructure and associated equipment, encourage on farm water management among other things.

With these potential future threats and opportunities for this model, it is required to develop a comprehensive exit protocol that will focus among other things - capacity building of WUA farmers, repair and maintenance of scheme infrastructure and associated equipment; create linkages for sourcing funds required for major repairs, encourage on farm water management, promote convergence, develop models for marketing farmer produce etc. The long term sustainability is dependent on a successful exit strategy for this project.

CASE STUDIES

i. Federation of WUAs: Naskarpur Ghantipara Mini RLI, Hooghly

A transformative case of WUA agglomeration under a Farmer Producer Company to increase farmer's profitability

The Naskarpur Ghantipara Mini RLI Water Users' Association was formed in 2012 under the ADMI project at Naskarpur village on the bank of Damodar River in Hooghly district. The association initially started with only 20 beneficiaries, but it increased over time to include 136 farmers. Creation of this river lift irrigation infrastructure has resulted in increased cropping intensity, where most of the farmers are now cultivating 3 to 4 crops in a year. Earlier most of the area was mono-cropped, with some potato cultivation during *Rabi* season. Farmers are now able to grow sesame and vegetables in the *Pre-Kharif* season. Groundnut has also become very popular. Earlier the *Kharif* paddy had to be transplanted late nearer to monsoon season due to lack of irrigation and it used to get damaged by the yearly monsoon flooding of the Damodar river, that happened right after transplantation. With the establishment of LI, it is now possible to sow paddy early without waiting for monsoon and as a result even if floods occur in the months of August and September, it does not cause damage, because the paddy is in full bloom stage. Early paddy harvest, also enables farmers to grow leafy vegetables during the gap period of one and half month between *Kharif* paddy harvesting and potato cultivation.

The increase in cropping intensity and productivity is impressive, but the really unique aspect of Naskarpur Ghantipara Mini RLI WUA is that it is part of a Farmer Producer Company (FPC) named 'Bangabhumi Farmers Producer Company Limited'. This was formed in 2019 with the participation of several Water Users' Associations (WUAs) and some other farmers, for proper marketing of farm produce. Though the FPC was formed under the Company Act, it acts as federation of WUAs in the block for the marketing of crops cultivated by WUA farmers. This is a unique model that provides direct market linkage for WUA farmers to maximize their profits. This FPC itself is Member of a state level FPC named 'Samiyog Agro-Farmers' Producer Company Ltd'. that was formed taking 10 such FPCs from all over West Bengal. Their target is to make a brand name of the FPC product and to spread the business across the country. WUA farmers are Members of the FPC and they get a portion of its profit, according to their respective shares in the FPC.

The FPC is not just marketing and profit sharing, but it is also disseminating new agricultural technologies like seed treatment with biological agent, discriminate use of fertilizers, production technology of leafy and other vegetables etc. at doorstep of the farmers for better production. For example, the female farmers have been provided training on vermicompost production which can be used in their own cultivation and also sold in the market. The FPC also provides its' Members with agricultural inputs at a lower rate for example potato seed, fertilizers, etc. The organization has encouraged Member farmers to use daily home consumable materials from FPC to make it more profitable.

Linking up of WUA Members to a new marketing channel by forming a farmer producer company through a federation of WUA's like the Bangabhumi Farmers' Producer Company Limited has achieved enormous popularity within few years. The simple concept is that Members of WUAs are cultivating crops, which is being marketed by FPC for profit maximization. But it has immense positive impact for the Member beneficiaries in terms of receiving agricultural inputs at lower price, selling of farm produce at premium price, direct benefit from company's profit etc.

Formation of WUA is a compulsory component in the ADMI project area for maintenance and smooth operation of micro-irrigation infrastructure. But in this case linking up of WUAs Members to a new marketing channel through formation of FPC and providing added benefit to its Members in terms of

technological and financial aspects has made this a role model in the block as well as in the district. This 'federation of WUAs' under Bangabhumi Farmers' Producer Company Limited has achieved enormous popularity within few years. The simple concept is that Members of WUAs are cultivating crops, which is being marketed by FPC for profit maximization. But it has immense positive impact for the Member beneficiaries in terms of receiving agricultural inputs at lower price, selling of farm produce at premium price, direct benefit from company's profit etc. The FPC opens up other possibilities also, for example if capacity building programme can be organized for female Members to produce homemade materials, then these can also be marketed through the FPC.

The farmers of Naskarpur Ghantipara Mini RLI WUA reported that as a result of the increased productivity and better marketing of their produce, their income has doubled. Also in terms of food security the farmers are now growing leafy and other vegetables in their own land for home consumption. Practical vision and mission, coupled with trustworthiness and honesty of Members, motivation, good teamwork, transparency in activity, regular meetings etc. are the key factors identified by the Members for the success of the FPC model. The ADMI personnel, ACESS Development (organization for FPC formation), local ADA etc. have also provided their continuous support for the FPC's success. This model has the potential to be replicated in other areas also to unlock the full potential of the productivity gains from improved irrigation access under the ADMI project.

ii. Orchard Development by Amtore Mini RLI, Purulia

A representative model of agri-horticultural system as a sustainable land management strategy

The Amtore Mini RLI Water Users' Association was formed in June 2017 to look after the operation and maintenance of the River Lift Irrigation system installed under the ADMI project in Amtore village in Raghunathpur – I block, Purulia. It is situated in the catchment area of Panchet dam and provides

irrigation to 20 hectare of land benefitting more than 42 families, mostly tribal. During 2018-19, the WUA has established an orchard in the community owned waste land, planting fruit species like Mango, Mousambi, Citrus and Jackfruit. The village had a vast area of cultivable waste land covered by bushes and natural vegetation and the idea of implementing a mixed fruit orchard as an alternate land management strategy on such a community property within command area was inspired through an exposure visit to another orchard developed by PRADAN at Matha (Bagmundi).

The orchard in Amtore is developed over an area of 1.8 hectares involving twelve WUA Members, all of whom belong to the Scheduled Tribe category. Farmers are also using the interspaces in the orchard area, to grow vegetables year round with irrigation from the RLI. Plantation details are as follows, which show, that the survival rate of plants is quite satisfactory at 97.4% (overall survival rate).

The orchard is in its second year of establishment and therefore economic returns from fruit plants have not yet been received as it has been directed to sacrifice the fruits at least for the first four years for optimum long term economic return from the plantation. But based on the plantation visit and its current status and land management facilities, an annual net return of at least Rs. 1.5 lakh per year can be expected from the fifth year onwards.

However, from the very initiation of this plantation, farmers are growing vegetables in the space between the orchard trees and have realized sizable economic returns from the cultivation of brinjal, tomato, chili, cabbage, cauliflower, beans, bottle-gourd, pumpkin and radish. Selling these

Name of Saplings	Mango	Mousambi	Citrus	Jackfruit	Total
Saplings Supplied	400	60	40	30	530
Mortality Number	4	5	2	3	14
Survival Rate	99.0%	91.7%	95.0%	90.0%	97.4%

vegetables, the 12 farmers have earned around more than 1 lakh rupees as a whole which amounts to more than 8,000 rupees of additional income per household in a year.

Breaking the poverty trap:

One farmer from Amtore mini RLI WUA described how a small amount of extra income made possible by the scheme, can help overcome persistent poverty through productive investments. The farmer got a net return of Rs. 32,000 by cultivating chili over an area of 0.025 ha within the said orchard. He invested Rs. 17,500 to purchase a milch cow, capable of giving 2.5 litres/day milk. He now sells 1.5 litres of milk every day to earn around 60 rupees per day. The remaining milk is used for home consumption making the family healthy. From this enterprise he purchased a 4G mobile and enrolled his daughter in graduation course in a college apart from making regular savings.

Another female farmer reported that vegetable cultivation within the orchard area, helped her to earn an additional income of Rs. 42,000, which she could invest to procure 10 ducks and 2 pigs to earn additional income.

The orchard developed in the Amtore village has shown its efficacy in managing cultivable waste lands in a sustainable way where regular field crops could not be taken as an economic enterprise.

Farmers are already earning through vegetable cultivation in the interspaces between fruit trees. It is expected that the fruit trees would be under economic bearing stage from 2022 onwards with an expected net return of at least Rs. 2 lakhs per annum. From 2022 onwards, when the canopy of the fruit species will cover the interspaces, then it will be required to help the WUA by providing planting materials of shade loving/tolerant crop species like elephant foot yam, colocasia, turmeric, ginger etc. The additional income truly has the potential to put these poor farmers on a transition path, out of poverty. Farmers mentioned, that now they can afford to send their children for higher education and provide them with private tuition.

Our interactions also highlighted other positive social impacts this enterprise has brought into the village. The establishment of this agri-horticultural system has created employment opportunities in the village that has reduced migration for work outside, according to farmers. According to our interviews, the WUA has also been effective in empowerment of female farmers by fostering female leadership and has contributed in resolving many social issues like early marriage. In particular female farmers of this village took over the charge from their male counterparts to sell their produce particularly vegetables by visiting adjoining local *hats* periodically. This exposure has created awareness among them about 'at what time', 'what vegetable to grow', 'which variety they should grow' etc. to become good marketing managers and confident with their decision making in farm planning.

It was clear from this case study that for successful implementation of any such system it would require formation of a group that is democratic in nature. Addressing equity issues increases the involvement of marginalised people and their ownership in the Project; which in turn support the democratic functioning of the association and its transparency,

accountability and sustainability. The support organization and DPMU have played a crucial role as facilitators to make this happen. This agri-horticultural system has now become a source of inspiration for large scale adoption of a sustainable model of alternate land use system, not only in Purulia but also in adjoining areas of Chotanagpur Plateau. Already in 2019, this WUA has taken up another 1 acre of land in the same village to grow mousambi and mango. Exposure visits to this orchard by Members of fifty different WUAs have already been organized, that has resulted in the generation of proposals for similar agri-horticultural system in more than 12 hectares of area, pending for COVID-19 regulations and associated official bindings.

iii. Kumirmari WUA, South 24 Parganas: Lighthouse in a Lone Island

Women led integrated development in an island of Sundarbans

The Kumirmari Water Users' Association was formed in June 2019, for the management of the Water detention structure that was excavated to store sweet rain water during the monsoons, that can be used for irrigation throughout the year. It is in an island in the Kumirmari Gram Panchayat of Gosaba block, South 24 Parganas, fully surrounded with Indian Sundarbans. Most of the WUA Members are small and marginal farmers, but it is also an association of mostly female farmers. Out of the seventy Members of Kumirmari WUA, sixty-five are female and forty-six Members belong to the SC category, and fourteen are ST. All eleven Members of the WUA's Executive Committee are women.

Before the excavation of the WDS, it was only possible to cultivate during the rainy season, and most of the areas used to remain fallow for the rest of the year. But utilizing the sweet water stored in the WDS during *Rabi* season, for the first time in their life time, farmers are now able to cultivate two crops in a year - paddy and vegetables. Some cultivation has been made possible during the *Pre-Kharif* season also. The command area has been

Plantation at Kumirmari, WUA

demarcated as hundred meters on both sides of the canal structure being used for water detention. The owners of the agricultural land which are lying under this demarcated area are Members of the WUA.

To improve the livelihood of farmers in this region, the ADMI project officials have emphasized an integrated approach from the start that focused on agriculture, horticulture and fisheries. While access to irrigation made it possible to cultivate multiple crops, the project introduced new varieties of paddy seeds along with capacity building on low/no cost technologies like seed selection, seed treatment, skip row and adoption of bird percher etc.; with the objective of improving agricultural production. High value vegetable crops like capsicum and hybrid tomato have been introduced in the command area to increase farmer's profitability. Vermicomposting pits have been constructed for spreading the awareness of using manure instead

Paddy Crop Field Visit with WUA President

Vegetable Seed Field with Vermicomposting Unit

Pond Net Operation by a Fisher-Women

of chemical fertilizers. Mixed fruit horticulture plantation (i.e. mango, blackberry, guava, betel nut, jackfruit etc.) has also been introduced on an area of 500 meters on the embankment of the WDS, so that the WUA Members can earn some extra income. A FIG group with fifteen female Members was also formed in 2019-2020 and they were provided with 8250 numbers of IMC and 1650 kgs of fish feed to start fishery as an activity. They have successfully produced around 415 kgs of fishes and earned Rs. 35,800 after selling it in local markets by themselves, out of which 10% has been deposited in the WUA corpus fund. During 2020-2021 ten new FIG Members have started spawn to fingerling scheme under this project. This integrated approach of increasing farmer's profitability has been successful, as they are able to earn extra income for their family from the vegetable crops during *Rabi* season, from the fruit trees and from selling fishes. Farmers during the interaction have also mentioned about reduced rate of migration as they are now engaged in their own land throughout the year.

From our field visits we also identified certain areas which can be further improved to have better outcomes from this scheme. These include formation of a farmer producer organization that can provide better market linkages for these farmers and increase their profitability further. Also mass scaling of vermicomposting and seed production of paddy and pulses should be encouraged to further increase productivity and profitability. In fishery establishment of low cost, cat fish hatchery should be promoted as an alternative.

The Members of Kumirmari WUA have set an example of how female farmers working together with cooperation and cohesiveness can overcome various challenges and bring about socio-economic development in the community. But it has not been an easy process for them to become leaders of the community. Our interactions with the female Members revealed that they faced hurdles from both within their family and from other villagers, who created obstacles or discouraged them from participation in WUA activities. It is especially hard for them to spend time for the daily activities of the committee after finishing all household work. But they have shown their determination to do something for the betterment of their own family as well as for the village. As they started earning a little bit from fishery and agriculture during *Rabi* season they could make their family Members realize that if they run the WUA well it will be economically beneficial for the families. Seeing their proactive involvement in the community's betterment especially during the pandemic, other villagers have also slowly come forward to help them in various group activities. The trainings organized under the project on institutional strengthening, agriculture, horticulture and fisheries activities have been crucial for this WUA's success along with the hand-holding support received from the project staff in terms of register maintenance, financial matters and nurturing of demonstration centers of agriculture, horticulture and fisheries. It can be expected that the lessons from this women-led WUA can help build many more such groups beyond Kumirmari.

Community leadership by the female WUA Members during times of crisis:

Forming this women-led WUA and strengthening it institutionally through various capacity building trainings have resulted in transforming its female Members as strong proactive leaders of the local community. This gets reflected in how these female farmers have stepped up during the recent COVID crisis. The WUA Members decided to make a programme on awareness generation to allay villagers' misconceptions regarding lockdown protocol, and organized a rally on their own to spread real information by reaching out to every door of the village. They have also distributed dry ration and eighteen kgs of fish from the WDS to the poorest of the poor families in the village for ensuring their daily ration during the pandemic. Thus they have emerged as true leaders of the community.

iv. Kailashnagar WDS WUA, South 24 Parganas: A Journey Towards Sustainable Development

Successful fishery management to increase income and improve health, food-security and livelihood

Kailashnagar Water Detention Structure is located at Kultali block under South 24 Parganas. It was formed on December 2017 and it currently comprises of 98 Member farmers. Before excavation of the WDS, major portion was single cropped area (*Kharif* paddy only). During that time, water logging was the major problem during rainy season, that caused damage to the standing paddy crop and thus immense economic loss for the farmers. To cope up with the intense poverty, people used to migrate out of the village. Now irrigation from the WDS structure has converted the single cropped area into double cropped area and during *Rabi* season apart from paddy, intercropping such as spinach, brinjal, knolkhol, potato, tomato, chilies are taking place. Water logging problem during the rainy season has also been solved, as through the inlets, the extra storage water gets drained into the WDS.

Vermicompost Pit at Kailashnagar

But what is truly unique for this WUA is that it has demonstrated how fish cultivation by WUAs can be immensely profitable for their Members if managed properly. In Kailashnagar fishery has currently become the main source of income for the WUA Members. Fisheries activities has started here with forty-eight Members in four different FIGs. But as it became very profitable, more farmers wanted to join and the WUA Executive Committee decided that other Members will be involved in fisheries activities on a rotational basis. At the starting in FY 2018-19, the FIGs were provided with 16,000 pcs of IMC, 17,500 pcs of Pangus, 15,000 pcs of Monosex Tilapia and 2,010 kgs of fish feed from the ADMI Project. They also released 14,200 pcs of giant prawn and 45 kgs of other carps into the WDS on their

Kailashnagar WDS

own initiative. Next year in 2019-20, supported by ADMI Project, another 5,640 pcs of Chital and 3,008 pcs of Bhetki, 140 kgs of Brood Tilapia and 136 kgs of fish feed and 137 kgs of lime for better fish culture were put into the WDS. Besides that, FIG Members released another 90 kgs of IMC by themselves.

Combining the last two years, the WUA FIG Members have invested nearly Rs. 48,000 of their own money for seed, feed, fertilizers etc. Additionally, they have made a long term investment of Rs. 84,280 (Rs. 1,720 from 49 farmers each) to construct three thatched houses as storage and guarding room, and to grow orchard plants on the embankments and to prepare four partitions within the WDS for better fish culture. Already they have produced around 852 kgs of fishes and got one lakh two thousand rupees (Rs. 1,02,000) after selling in local markets on their own initiative, despite problems in fish selling, that they faced this year due to the pandemic. They have a plan to sell larger sized fish in the future for better profitability. Currently, they have deposited Rs. 10, 000 from fisheries in the corpus fund of the WUA and plan to deposit more after harvesting of fish in the future.

The WUA has established convergence with Forest Department and local Gram Panchayat for plantation of various trees on the embankment of the WDS. Mixed fruit horticulture plantation of coconut, drumstick and papaya have been completed on 3000 meters of embankment of the WDS, so that the WUA Members can earn some extra income. Also, the farmers in the WUA have started cultivating vegetables on the embankment during *Rabi* season. It has contributed in their food security as these are grown mostly for own consumption and some excess quantity being sold to the local market. Introduction of high value vegetables and salt tolerant crops like beetroot, spinach and hybrid-okra in the command (especially on the embankment) area has been introduced. Apart from that twelve vermicomposting pits have been constructed and production of manure has already been started for spreading out the awareness of using organic manure instead of chemical fertilizer. The WUA has also got machineries like power tiller, paddy transplanter, drum seeder and two portable solar pump sets from the project, which are used on rental basis among the WUA Members. Despite this stellar performance from the WUA, there is still scope for improvement in terms of market linkages. Presently the Members sell their paddy, vegetables and fish in the local market at low prices. Marketing is a major problem, which has become more severe during the pandemic and resultant lockdown. If they can be connected with Sufal Bangla, BENFISH, Govt. of WB, then they would be able to earn more from their produce and get better income.

Overall this WUA has proved to be a shining example of integrating various project activities to become a sustainable farmers' organization and develop a vibrant and profitable fishery venture with their diligence, accountability and sincerity. In fact, recognizing their achievement, World Bank has awarded them two mementos for best performing WUA and best WUA in fisheries activities (Best FIG) respectively. The WUA is also socially responsible, as during this current pandemic they have organized awareness programme on COVID protocol and distributed dry ration and vegetables from their corpus fund, for 65 economically backward families in their village.

President of the FIG described the positive impact of this FIG through a poem in vernacular language that says "Because of the ADMI Project, green revolution has come in their village, and their water bodies are filled with silver fishes. Farmers are now happy as there is no need to migrate now to other places for work, as there is food in everybody's home"

সবুজ বিপ্লব এলোরে ভাই
আদমি প্রকল্পের জন্য তাই,
জলে রুপালি শষ্য খেলা করে
তাই আনন্দ দেখ চাষীর ঘরে।
দূরদেশে আর দিতে হয় না পাড়ি

By Shri Sudhir Gayen, The President of the FIG

v. Balichak Thakuranichak Sprinkler WUA, Howrah: Polyhouse Vegetable Farming

High value vegetable cultivation to increase farmer's profitability

Balichak Thakuranichak Water Users' Association is situated at Balichak village in block Amta-1, Howrah. The scheme has 5 pump houses, with sprinklers installed to irrigate a command area of 9 hectares. Totally 63 farmers are Members of the Water Users' Association. There are also two Polyhouses developed in the command area under this project and each of that covers 500 sq. m area.

Polyhouse at Balichak Thakuranichak Water Users' Association

Before implementation of the project farmers in this region used to mostly cultivate Aman paddy during *Kharif* and few seasonal vegetables, depending on rainfall. In general, there was not much opportunity to grow crops during the *Rabi* and *Pre-Kharif* season due to lack of irrigation. After implementation of ADMI project however, the WUA Members got the scope to cultivate different types of high value vegetables like broccoli, cucumber as well as off-season vegetables like spinach, radish, tomato, chili, cauliflower, cabbage etc. with sprinkler and drip irrigation systems both under protected conditions (i.e. Polyhouse) and open field conditions. They got extensive training from a specialist from Howrah DPMU regarding these modern technologies and water management systems. As a result of this intervention, income of the farmers has increased substantially.

In these two Polyhouses currently high value crops like coloured capsicum, mini cucumber; off season vegetable like spinach, coriander, seedless brinjal, cherry tomato, cabbage etc. are being cultivated. The farmers have got training regarding protected cultivation under Polyhouse from Punjab (Ludhiana & Jalandhar) with support of Riwkzwan Company. They also visited the Centre of Excellence of Vegetable Cultivation at Jalandhar, Punjab. The Polyhouse was formally handed over in 2018, and they have since, maintained the Polyhouse properly. The system is equipped with drip irrigation system and farmers here are following the fertilizer chart given by DPMU Howrah to apply appropriate amount of fertilizer to their crops. They are also producing vegetable seedlings on plug tray. Regarding plant protection measures they follow IPM practices like use of yellow trap, Trichoderma sp., Pseudomonas, neem cake & neem oil and other bio-pesticides as well as chemical pesticides on need basis. The farmers reported that they earned yearly net profit of around 18 lakh rupees per hectare from the Polyhouse which is 2 to 3 times more than their traditional cultivation in open field.

Our field visit identified certain improvements in infrastructure and management of this Polyhouse to make it more beneficial for the system, including:

a) Currently the locking wire of Polyhouse is not anti-rust. So it is resulting in rust on the wire and damaging the poly film. It will be better to use poly-coated locking wire for this purpose.

b) The insect proof net on side curtain should be flexible for proper aeration as required.

c) Bottom of the side curtain poly is very low (approx. 1-1.5ft). It needs to be increased for proper CO_2 accumulation. Also, the centre height of the Polyhouse should be increased.

d) Greater awareness is required about the discharge rate of the sprinklers, drippers etc.

Overall the establishment of the Polyhouse has diversified farmer' cropping choice to include high value vegetable crops and increase their income, which has piqued the interest of other farmers in the village, who also want to grow vegetables under protected conditions. However, it is also crucial to create a proper value chain for these crops before the model can be scaled up. Although production and quality is good in the Polyhouses, currently farmers are selling mostly in local market getting lower prices. Their profit can increase substantially with proper market linkages. This is absolutely essential if more farmers are going to grow these high value vegetables. One way to solve this, would be to connect these farmers with larger private retail chains.

vi. Floriculture - A Lucrative Business in Kalimpong Hills

High value flower farming in Polyhouses to increase farmer's profitability

Kalimpong Hills are the natural abode for countless flora and fauna. The region has the right climatic conditions that are appropriate in growing a wide variety of high value, quick returning flowers like Gladiolus, Carnation, Gerbera, Rose, Alstromeria, Lilium, Anthurium and Marigold. Using this opportunity, a regular alternative source of income for farmers in this region was developed by setting up protected cultivation of high value cut flowers – Gerbera and Carnation, under the ADMI project.

Cultivation of Gerbera and Carnation in Kalimpong Hills

Estimated Earnings from Gerbera (within 9 years) and Carnation (within 6 years) Cultivation

Crop	Expected Returns
Gerbera (3 years/crop cycle)	1st crop cycle 2,16,000
	2nd crop cycle 2,40,000
	3rd crop cycle 2,88,000
Carnation (2 years/crop cycle)	1st crop cycle 2,88,000
	2nd crop cycle 3,36,000
	3rd crop cycle 3,84,000

Accordingly, twenty-four Polyhouse, each of 96 sq. m area, were setup for floriculture in late 2019 at Kagay, Sakyong and Paiyong Gram Panchayats under Kalimpong District. These Polyhouses have been set up in villages in Kalimpong where HYDRAM schemes were installed under the ADMI project and handed over to the WUA. The project was constructed with the objective of ensuring proper utilization of water and each of these Polyhouses are equipped with drip system, fogger, GENAP water tank, electric pump & rain water harvesting system for effective use of water.

Out of the twenty-four, fourteen Polyhouses were at Benda and Paiyong villages for growing different Gerbera varieties like Ankur and Stanza (Red colour), Intense (Pink), Dana Ellen (Yellow), Shimmer (Bicolour), while the other ten Polyhouses at Mul Sakyong and Bich Kagay villages were for cultivating Carnation varieties like Master and Mango (Red), Liberty (White), Star (Orange), Kino (Yellow), and Seventus (Pink). All twenty-four Polyhouses had female beneficiaries targeting small and marginal farmers. In Benda village, six female farmers from Benda Krishak Bandhu WUA and in Paiyong village, eight female farmers from Paiyong Ghantay Jhora WUA, were beneficiaries of the fourteen Polyhouses for Gerbera cultivation. Similarly, six female farmers from Mul Sakyong WUA and four female farmers from Bich Kagay Tulsi WUA, were beneficiaries of the ten Polyhouses for Carnation cultivation.

Total investment costs for setting up each unit of Gerbera and Carnation Polyhouse (96 sq. m area) are reported to be Rs. 4,99,723 and Rs. 6,27,651 respectively. The costs include installation charges with drip irrigation system and fogger fitting, labour charges, cost of planting materials, nutrients and packaging materials for cut flowers etc. Earnings on the other hand are estimated to be approximately Rs. 7.5 lakhs for Gerbera cultivation within 9 years and around 10 lakhs from Carnation plants within 6 years as above.

The harvesting of flower stick has already started and till now the total earnings from cut flowers between June-July 2020 for Gerbera and Carnation are Rs. 68,617 and Rs. 1,39,805 respectively. Thus the project provides a tremendous scope of income generation for the farmers. To ensure that the system is financially sustainable, the profit is reinvested into the scheme. Specifically, only 60% of the profit is given to the individual farmers of the Polyhouse, while the remaining 40% is shared in the following way - 10% given to WUA, 10% for crop insurance and the remaining 20% is used for the purchase of further planting materials and maintenance of Polyhouse.

Setting up these Polyhouses with drip irrigation technology for cut flower production has created a highly profitable income source for farmers doing flower cultivation and generated new livelihood opportunities in the villages. If excess water could be made available, then even Strawberry and Lilium cultivation would be possible in open field for other nearby farmers under the HYDRAM schemes.

The project has been particularly successful in capacity building of the farmers, especially in terms of user friendly technologies to enhance horticulture production and effective use of water through HYDRAM systems. These floriculture Polyhouses could be set up and managed successfully because of the co-ordinated approach of the three key actors namely WBADMI project officials, WUA farmers and

the service providers. The main functions of the project officials have been the selection of farmers, overseeing the project as per norms and time frame, providing finance for the units and fixing the price mechanism for the flowers. The WUA farmers are cultivating the flowers and they are the landowners where these Polyhouses have been set up. The service provider's functions are to supply the inputs, and installation of Polyhouses, plant management and transfer of technology, collection, packing and marketing, providing hand-holding technical support for three years and maintain the service stations. Crucially the project has a buy back agreement signed by District Magistrate in the presence of farmers, ADMI staff and the Director of North Bengal Floratech (TSA), Siliguri, to ensure that farmers have assured return from flower cultivation.

Planning from the grass roots with emphasis on capacity building has ensured in proper understanding and execution of the project. Also regular monitoring at every stage has helped to enhance quality and achieve the goal on time. The project makes efficient utilization of land, labour and capital and has generated a lot of interest among other farmers. There is ample scope of registering many more WUAs under this project and 150 more Polyhouses are expected to be completed in the next financial year.

vii. Durlavpur MDTW WUA, North 24 Parganas

Successful case of agricultural support services targeted towards marginal farmers for intensive vegetable cultivation

Durlavpur Medium Duty Tube Well Water Users' Association is situated in Amdanga block of North 24 Parganas district. The Water Users' Association (WUA) was formed and registered during 2012-13 and currently it has 94 Members out of which 21 are female farmers. This MDTW scheme irrigates a command area of approximately 18 hectares, covering 430 plots of the beneficiaries. Most of the farmers under this scheme have very small and fragmented plots, with landholding between 0.07 hectare to maximum 0.40 hectare.

Along with assured irrigation from the MDTW system, the project focused on capacity building and training farmers on latest agricultural technologies and improved practices like System of Rice Intensification (SRI), organic farming, kitchen gardening, pulse intensification, mulching, two and three tier cultivation, crop rotation, intercropping and orchard plantation. To promote judicious use of water, farmers in this WUA were trained in giving irrigation only after proper inspection of soil moisture content using tensiometer and scientifically follow its pH by using a pH meter. Although it is often difficult to get the soil testing reports from concerned departments, farmers reported that this has made their cost of cultivation lower. Different farm implements like power tiller, sprayer, solar trap, marker for SRI, paddy thrasher, kono weeder etc. were also made available through custom hiring system. The project in this village also promoted organic farming and farmers developed their own vermicompost unit to meet the demand of organic fertilizer. Institutionally also, this project has facilitated credit linkages for farmers with relevant government departments. Also the farmers mentioned that key factor for their success has been the unity and cohesiveness among the WUA Members, which has strengthened through various social programmes organized by the WUA – these include awareness programmes on health and hygiene, empowerment of women, gender equality, natural resource conservation and environment, plantation of trees, plastic usages, sports day, Independence Day etc.

These concerted efforts are reflected in the increased income of the farmers after formation of this WUA by 75-80% as area of paddy cultivation was shifted to high value crops like vegetables, pulses and oil seeds, which fetched good price in market. To facilitate better marketing of their organic products, the produce is graded and this year even with the pandemic, farmers were able to sell their products to big retail chains like Reliance, Spencer's, Big Bazaar, Aditya Birla fetching good rates. Farmers in the command area are cultivating 57 different vegetable crops across the year (21 in *Rabi*, 20 in *Pre-Kharif* and 16 in *Kharif*). This level of crop diversification and off season production of

Furrow Irrigation in a Brinjal Field

Vermicompost Unit

vegetables and kitchen gardening with backyard animal husbandry has contributed significantly in increasing food security of the WUA Members. Secretary of the WUA mentioned 'after maintaining family expenditures we are saving double of what we used to save earlier'. Due to the increased income, villagers are now having *pukka* houses with toilets, and are able to send their children to school.

This is an inspiring story and this model can be further improved through proper convergence with different allied departmental schemes and integrating fishery and animal husbandry component to enhance farmer's income with help from animal and fishery departments of the state. But future scope for scalability of this model, lies in the formation of vegetable cold storages and promoting Polyhouses with drip and sprinkler irrigation facilities. Facilitating the development of marginal and small entrepreneurs in the region who could do value addition to the agricultural produce, would also bring a lot more value to the farmers.

viii. A Women Institutional Case Study of Arrorah Mini RLI WUA, Bankura

Towards successful participatory irrigation management

Arrorah-II Mini RLI Water Users' Association was formed during 2012-13 under the ADMI project in Simlapal block, Bankura. The scheme had set up 2 electric pumps (each of 7.5 hp) with 10 spouts to irrigate an area of 20 hectares with around 80 beneficiaries. Under this scheme a women's group of 15 farmers were formed that is involved in farming and spawn production under District Fishery Department. The women's group got registration from the government in 2014. With the support of the irrigation infrastructure created under this scheme, this group of female farmers are now successfully producing aromatic rice, high yielding variety paddy, fish fingerlings and table fish. Government agencies like WRIDP (Agri-mechanical), ADA and District Fishery Department are continuously helping the group by providing different technological advisories. The Members of the women's group received functional training on field crop production and fishery activities for 4 and 2 days respectively through this project. This Arrorah-II women Water Users' Association is playing a significant role in participatory water management. Their activities are distinct from other conventional groups as they are also taking initiative on sustainable ecological management.

This group is cultivating paddy (Gobindobhog, HY GB-1, BB-11, MTU-7029) during *Kharif*, vegetables like potato, mustard, cabbage and cauliflower during *Rabi*, and sesame, cucumber and pumpkin during *Pre-Kharif* season. They are also practicing

inter-cropping of sesame and green gram. In terms of fishery the women's group is mostly doing spawn production under District Fishery Department. Through these activities, the group Members said that, their monthly savings increased from around 500 rupees per month to around 3,000 rupees. The productivity of the field crop also increased by almost double after the project. As women of the group are earning a higher income now, they can support their family too. Our interactions with the group Members revealed however, that the most important aspect of this project was the empowerment of female farmers. As we can see in the table below that among the group of female Members whom we interviewed, more than 85% were taking part in decisions regarding finance, child's education, institution etc. and from their increased income they are supporting their household expenses and started savings.

90% women take financial decisions

85% women take the decision on their child's education

80% women undertake institution related research

98% women started saving

85% support their male counterparts

75% women were trained

70% women have access to other government institutions

75% women bought new material for their homes

This has set an example on how participatory water use and gender empowerment can go hand in hand even in a remote block like Simlapal of Bankura District. Their product has a huge demand in local as well as outside market which has drawn the attention of private investors too. With better market linkage and access to potato storage, the group's income can increase further substantially. The group is already planning for the future to set up MIDI RLI from the current MINI RLI system, construct embankment in the river and build a community centre.

ix. Jamirdiha Atu Utnao WUA, Bankura: Community Orchard with Solar Pumps

Under the ADMI project a wide-scale publicity on solar pump installation and subsidy was carried out during 2018-19 and a group of farmers from Jamirdiha village of Simlapal block, Bankura came to know about this project from local BDO and ADA offices. In their village there was 24 hectares of land that was not suitable for cultivation with no irrigation sources. So a group of 15 farmers, with land ownership of that 24 hectares of barren land submitted a proposal for orchard plantation with support from the ADMI project. Accordingly, a mixed fruit orchard was set up in their village during 2018-2019 with these 15 farmers (10 male and 5 female farmers). Under the project there was construction of four big water detention structures equipped with two solar pumps of 5hp capacity each, for irrigation purposes in the orchard. The farmers' group using the water detention structures for irrigation, formed the Jamirdiha Atu Utnao Water Users' Association. In the first year of the plantation, there was a severe drought in the region, where this solar irrigation system proved to be crucial and helped in reducing the sapling mortality rate substantially. Over time with visible success other villagers also got interested and another 70 farmers joined that group, taking the total number of group Members to 85.

This orchard has many diverse type of plants as described in the table below:

Type of Tree	Number of Trees	Varieties
Mango	1920	Amrapali, Mallika, Himsagar, Baramasi
Cashew nut	7220	VR4
Guava	120	Baruipur, L-49
Jackfruit	340	Cyclone Jack
Citrus	200	Lemon, Sathgudi Sweet Orange
Pineapple	1000	Giant Kew

From our interview with the farmers we found that on average the monthly income of group Members increased by Rs. 500 - Rs. 1,000 from the orchard. This increase in income has contributed to their food security. The project also contributed towards empowerment of women as they participated more in the operation and management of the orchard activities. The group Members received functional training of 1 to 2 days on layering, grafting, budding activities which had a great impact on management of the orchard. Marketing is being done through commission agents and currently there is no storage facility for their products. The farmers and local extension agents also mentioned that the water harvesting structures have contributed in groundwater recharge and increased the ground water table. Consequently, it now takes less time to irrigate per unit, farm land area.

Impact of orchard as mentioned by group Members:

"Before it was a barren land but now it is full of greenery with water harvesting structure seems the village has got its life back…"

One female farmer of the orchard commented "Before we were only housewife but now are earning as skilled labour in the orchard"

Almost all the group Members of this orchard are from Scheduled Caste or Scheduled Tribe category and belonging to BPL families. This orchard has proved to be a ray of hope for them and for the surrounding area. In future, the group is planning for cashew nut processing unit that will contribute

Mixed Fruit Plantation at Jamirdiha

in value addition and substantially increase income from the orchard. They are also planning to construct larger sized water detention structures and larger number of smaller water harvesting structures, to bring more area under plantation. There are plans of setting up an animal husbandry (cow, poultry, goat rearing) unit and a fishery unit for pisciculture in the WDS structures. With the establishment of the plantation it has become possible for the farmers to be more ambitious and become active agents of change.

x. Kartickdanga Kalimata WUA, Birbhum: Integrated Approach for Enhancing Income from Orchard and Intercropping with Add-On Income from Fishery

The Kartickdanga Kalimata Water Users' Association under the ADMI Project is located in Kartickdanga village of Bolpur-Sriniketan block, Birbhum. The

Key Factors Behind the Success and Challenges for the Project

Success Factors	Challenges
Availability of large area in one un-fragmented holding	More farmer training is required as the scenario in horticultural industry is changing rapidly
Continuous support from local field level extension agent, WBADIMP officials and local irrigation department	No soil testing was performed before setting up the orchard
Purchase of certified varieties of sapling from recognized institutions both public as well as private	No proper storage facility for the harvested products
Hard work and initiative of the farmers' group	Lack of proper knowledge on the usage of various farm implements

WUA was formed after several rounds of visits by ADMI project officials in Kartickdanga village and numerous rounds of informal and formal meetings with the villagers. Several rounds of meetings culminated into the formation of the Water Users' Association involving 26 Members who have voluntarily come forward to be a part of the proposed association and devote time and efforts for the initiative in the end of February, 2019. Out of the 26 Members, 22 are male farmers and 4 are female. The WUA was officially registered in April 2019. Initially a seed fund of Rs. 6 lakhs was provided from ADMI for starting this project in Kartickdanga. The main focus of the association was to establish an orchard with different types of fruit trees and plants in an undulating and previously unutilized land covered by wild bushes with an area of about 3.1 hectares. The orchard was using water from nearby water bodies, that were rehabilitated under the project. The water bodies are 20 in numbers with a gross area of 5.33 hectares. The Association has leased in both the land and the water bodies for a period of 25 years through a lease agreement executed in April, 2019. The group Members also started doing fisheries in the water bodies and intercropping practices in the orchard field.

The ADMI officials were actively involved since February, 2019 in organizing the group and getting it registered, technological back-stopping and hand-holding through organising knowledge and skill development training programmes, information and knowledge support in different critical aspects of the project. Specifically, four training programmes were organised for the group Members. The main focus areas of the trainings were procedures of orchard layout and planning, proper management practices for the orchard and the inter-crops, methods of pond preparation, selection of fish species for composite fish culture, proper management practices of fish fingerlings production and composite fish culture, fish feed management etc. The ADMI project also provided the initial stock of Fish Feed.

The orchard comprises of mango (660 nos.), guava (200 nos.), mousambi (150 nos.), pomegranate (100 nos.), jackfruit (100 nos.), lime (150 nos.),

Orchard of the Kartickdanga Kalimata WUA Adjacent to a WDS Structure

banana (200 nos.), coconut (80 nos.) and papaya (250 nos.). Through convergence with Agricultural Technology Management Agency (ATMA), Birbhum, the association has also planted 100 saplings of dragon fruit plants. The orchard is still in its nascent stage and only the banana plants has started to produce yields amounting to 350 to 440 pcs per month with an average net return of Rs. 627 per month. Although income from the orchard will only materialise once the plants start producing, the association farmers are already cultivating various seasonal vegetables as inter-crops in the orchard field (as the fruit trees are still in initial stage). These

Fishery in the Leased-In Water Bodies

include brinjal, pointed gourd, ridge gourd, lady's finger, chili, pumpkin during *Pre-Kharif* season; and beet, carrot, cabbage, peas and cauliflower in winter season; and green papaya throughout the year. Till the fruit trees are in initial stage, inter-cropping of vegetables has made it possible for the farmers to earn income by selling their produce (almost 80% of it) in the nearest wholesale market for vegetables. The sale of vegetable produce gives an average monthly net income in the range of Rs. 4,000 to Rs. 7,000 per Member.

The WUA Members are also rearing fish species of rohu, catla, mrighel, silver carps, American grass carps and Japanese-punti through composite fish culture practices in the water bodies it has leased in. The average yearly fish production is 50 – 60 quintals, 75 per cent of which are sold in the wholesale fish market of Bolpur Town once in 2 or 3 weeks. The association is earning a net income of Rs. 2 - Rs. 3.5 lakhs per year from fishery. From all these above mentioned economic activities each group Member is earning a monthly net income in the range of Rs. 6,000 – Rs. 10,000. Also the association has already created a corpus fund of Rs. 2 lakhs through savings from the sale of vegetables, fruits, fishes, fish fingerlings etc.

Along with the increased income from these activities, the project has also contributed in food security for the Member villagers. The high quality green vegetables produced as inter-crops and the fish from the water bodies are also used for self-consumption by the farmer's family and providing a rich source of vitamins, minerals and animal protein, essential for proper nutrition.

Key Factors Behind the Successes of the Kartickdanga Kalimata WUA are:

i. Hand-holding and support from ADMI officials.

ii. Access to the wholesale market nearby.

iii. Proper planning and management. For example, the association has divided its Members into groups of 8 – 10 and entrusted them with specific jobs such as selection, planting, management of mango saplings etc.

iv. Homogeneous and close knit group, with less conflict among Members.

During the COVID-19 lockdown, the association had also taken up a leadership role in the community to help 150 villagers in need by providing each of them with 2 kgs of rice and 2 kgs of potato. The overall success of the Kartickdanga Kalimata WUA has motivated other practicing farmers and farm women of the village, to be involved and actively engaged in similar type of group formation, for promoting the unutilized lands (nearly 40 hectares in that location) and derelict water bodies (50 hectares in area) of the village to be renovated, and utilized in a productive way for their socio-economic development.

ANNEXURE:

Annexure 1: Selected Schemes for Telephone Survey

Scheme ID	Scheme Name	District	Block	Scheme Type
02-03-039-06-043	Purbatati - I	Bardhaman	Ausgram - I	LI
02-03-133-12-052	Tilata - I	Bardhaman	Ausgram - I	TW
02-03-026-16-074	Mirsha - I	Bardhaman	Ausgram - I	TW
02-03-063-16-081	Hargaria - I	Bardhaman	Ausgram - I	TW
04-01-172-16-058	Ramprasad TW	Dakshin-Dinajpur	Balurghat	TW
04-01-169-16-064	Keotsar	Dakshin-Dinajpur	Balurghat	TW
04-01-173-16-057	Chand Pukuria TW	Dakshin-Dinajpur	Balurghat	TW
04-07-188-03-007	Bhaior	Dakshin-Dinajpur	Tapan	LI
07-08-004-16-016	Agai TW	Hooghly	Goghat - II	TW
06-03-009-03-005	Paschim Bainan - I MIDI RLI	Howrah	Bagnan - I	LI
06-10-102-01-001	Baral South West MINI RLI	Howrah	Shyampur - I	LI
08-03-023-01-041	Uttar Dangapara	Jalpaiguri	Dhupguri	LI
08-03-062-10-026	Niranjanpat	Jalpaiguri	Dhupguri	TW
08-09-022-14-186	Mathachulka - I PDW (III)	Jalpaiguri	Mal	PDW
08-09-090-16-130	Adabari - II	Jalpaiguri	Mal	TW
08-09-076-16-091	Jhar Majgram IV TW	Jalpaiguri	Mal	TW
08-09-051-16-171	Nipuchapur - III TW	Jalpaiguri	Mal	TW
08-09-107-16-125	Basusuba - I	Jalpaiguri	Mal	TW
08-09-107-16-127	Basusuba - III	Jalpaiguri	Mal	TW
08-09-047-16-179	Hai Hai Pathar - I TW	Jalpaiguri	Mal	TW
08-09-051-16-169	Nipuchapur - I TW	Jalpaiguri	Mal	TW
08-09-105-16-134	Dakshin Matiali - II	Jalpaiguri	Mal	TW
08-10-021-15-072	Salbari - III Solar PDW	Jalpaiguri	Matiali	PDW
08-10-021-15-067	Salbari - VIII Solar PDW	Jalpaiguri	Matiali	PDW
08-11-082-13-007	Bhangarhat	Jalpaiguri	Maynaguri	TW
08-11-016-16-156	Kumarpara - II (III)	Jalpaiguri	Maynaguri	TW
09-01-119-13-016	Dawaguri - I	Cooch Behar	Cooch Behar - I	TW
09-02-016-01-014	Kaljani - I	Cooch Behar	Cooch Behar - II	LI
09-01-110-10-026	Khapaidanga	Cooch Behar	Cooch Behar - II	TW
09-06-086-16-058	Ashok Bari - I	Cooch Behar	Mathabhanga - I	TW
09-06-188-16-066	Sarkardanga	Cooch Behar	Mathabhanga - I	TW
09-07-078-01-047	Purba Bhojaner Chhara	Cooch Behar	Mathabhanga - II	LI
09-07-182-06-089	Baraibari - I	Cooch Behar	Mathabhanga - II	LI
09-10-006-16-070	Nalgram	Cooch Behar	Sitalkuchi	TW

Scheme_ID	Scheme_Name	District	Block	Scheme Type
09-10-121-16-074	Khater Bari	Cooch Behar	Sitalkuchi	TW
10-03-192-03-014	Hossainpur - VI	Malda	Chanchal - II	LI
10-05-288-16-042	Adhna TW	Malda	Gazole	TW
10-05-012-12-030	Muriakundu	Malda	Gazole	TW
11-19-131-16-016	Mirjapur TW	Murshidabad	Raghunathganj - I	TW
11-23-154-06-028	Diar Balagachi Li	Murshidabad	Sagardighi	LI
12-07-021-03-004	Narayanpur Barikpara	Nadia	Karimpur - II	LI
12-12-087-06-014	Birpur Charer Math Li	Nadia	Nakashipara	LI
12-12-064-01-010	Chandanpur Deepar Math - I	Nadia	Nakashipara	LI
13-01-061-13-009	Khundasarkara	North 24 Parganas	Amdanga	TW
13-14-035-12-010	Mana	North 24 Parganas	Habra - II	TW
17-01-094-05-063	Beledahari WDS	South 24 Parganas	Baruipur	Creek
17-01-190-05-012	Ronia WDS	South 24 Parganas	Canning - I	Creek
17-09-089-05-015	Purba Bhaleya WDS	South 24 Parganas	Canning - I	Creek
17-24-32-05-003	Heria Ratna WDS	South 24 Parganas	Mograhat - II	Creek
18-02-036-10-039	Mahua	Uttar-Dinajpur	Goalpokher - I	TW
18-02-102-10-055	Tapsa	Uttar-Dinajpur	Goalpokher - I	TW
18-04-015-13-007	Birgram	Uttar-Dinajpur	Hemtabad	TW
03-14-003-14-033	Madarpur - I PDW	Birbhum	Raj Nagar	PDW
03-14-090-17-061	Chandrapur Check Dam	Birbhum	Raj Nagar	CD
03-14-177-17-129	Bhabanandapur - I CD	Birbhum	Raj Nagar	CD
03-03-122-13-001	Aamkhoy (Chowpahari Jangal) MDTW	Birbhum	Illam Bazar	TW
05-10-104-14-014	Sabhita - I PDW	Darjeeling	Naxalbari	PDW
05-11-096-16-025	Uttar Bansgaon - I	Darjeeling	Phansidewa	TW
05-09-006-16-006	Barachanga - I Organic Farm	Darjeeling	Mirik	TW
07-18-090-13-013	Panchgachhiya	Hooghly	Tarakeswar	TW
07-02-120-12-004	Gournai Panchpara	Hooghly	Balagarh	TW
08-01-032-10-032	Pakuritala - 2 (E)	Jalpaiguri	Alipurduar - I	TW
11-19-125-16-027	Katnai West TW	Murshidabad	Raghunathganj - I	TW
14-01-687-14-107	Benageria PDW (E)	Paschim-Midnapore	Binpur - I	PDW
23-233-024-05-355	Amlasole-Amjharna WDS IV (PAS6PMWS08)	Paschim-Midnapore	Binpur - II	WDS
23-233-164-05-712	Sitapur WDS 102 (PASMWS13)	Paschim-Midnapore	Binpur - II	WDS
14-09-136-01-015	Kathnimaro	Paschim-Midnapore	Sankrail	LI
18-06-27-12-013	Dharanda-Kukrakunda-Sadapur	Uttar-Dinajpur	Itahar	TW
18-06-012-12-008	Bohuti	Uttar-Dinajpur	Itahar	TW

Annexure 2: District-Wise Key Indicators

Cropping Intensity

Table 38 - Cropping Intensity Across Districts at Baseline and Endline

District	Pre-ADMI	2018-19	Percentage Point Changes
Bankura	106.1%	180.4%	74.3
Bardhaman	113.3%	175.7%	62.4
Birbhum	113.8%	167.6%	53.8
Dakshin-Dinajpur	145.2%	205.7%	60.5
Darjeeling	134.6%	211.2%	76.6
Hooghly	105.5%	157.6%	52.1
Howrah	142.3%	108.0%	-34.3
Jalpaiguri	141.7%	182.3%	40.6
Jhargram	117.5%	182.8%	65.3
Cooch Behar	141.7%	221.9%	80.2
Malda	122.4%	174.6%	52.2
Murshidabad	166.6%	211.9%	45.3
Nadia	238.9%	228.2%	-10.7
North 24 Parganas	158.7%	187.4%	28.7
Paschim-Midnapore	117.6%	191.8%	74.2
Purba-Midnapore	167.5%	167.1%	-0.4
Purulia	111.1%	136.8%	25.7
South 24 Parganas	102.7%	157.0%	54.3
Uttar-Dinajpur	154.7%	184.9%	30.2

Crop Diversification Index

Table 39 - Crop Diversity Index Across Districts at Baseline and Endline

District	Pre-ADMI	2018-19	CDI Changes
Bankura	0.07	0.56	0.49
Bardhaman	0.15	0.40	0.25
Birbhum	0.15	0.49	0.34
Dakshin-Dinajpur	0.31	0.45	0.14
Darjeeling	0.21	0.51	0.31
Hooghly	0.19	0.30	0.10
Howrah	0.73	0.51	-0.22
Jalpaiguri	0.31	0.49	0.18
Jhargram	0.14	0.46	0.32
Cooch Behar	0.20	0.42	0.22
Malda	0.22	0.45	0.23
Murshidabad	0.51	0.72	0.21
Nadia	0.67	0.68	0.01
North 24 Parganas	0.45	0.65	0.20
Paschim-Midnapore	0.08	0.24	0.16
Purba-Midnapore	0.10	0.01	-0.10
Purulia	0.07	0.40	0.33
South 24 Parganas	0.02	0.16	0.14
Uttar-Dinajpur	0.32	0.51	0.18

Aman Paddy Yield

Table 40 - Aman Paddy Yield Across Districts at Baseline and Endline[21]

District	Pre-ADMI	2018-19	Change in Yield
Bankura	3.2	4.3	1.1
Bardhaman	4.3	5.2	0.9
Birbhum	3.7	5.2	1.5
Dakshin-Dinajpur	3.5	4.1	0.6
Darjeeling	3.3	5.5	2.0
Hooghly	4.5	5.5	1.0
Jalpaiguri	2.8	4.1	1.3
Jhargram	2.9	4.3	1.4
Cooch Behar	2.8	4.7	1.9
Malda	2.8	3.6	0.8
Murshidabad	3.8	5.9	2.1
Nadia	3.9	4.5	0.6
North 24 Parganas	3.2	5.0	1.8
Paschim-Midnapore	2.9	4.6	1.7
Purba-Midnapore	4.0	5.2	1.2
Purulia	2.8	3.8	1.0
South 24 Parganas	1.9	3.1	1.2
Uttar-Dinajpur	3.2	4.8	1.6

21 Howrah is not included since only one scheme is growing paddy.

Boro Paddy Yield

Table 41 - Boro Paddy Yield Across Districts at Baseline and Endline

District	Pre-ADMI	2018-19	Change in Yield
Bankura	-	-	-
Bardhaman	-	6.0	-
Birbhum	-	-	-
Dakshin-Dinajpur	-	-	-
Darjeeling	-	8.9	-
Hooghly	-	6.5	-
Jalpaiguri	5.4	5.0	-0.4
Jhargram	4.1	5.2	1.1
Cooch Behar	4.6	8.2	3.6
Malda	3.7	5.6	1.9
Murshidabad	-	6.6	6.6
Nadia	4.7	5.1	0.4
North 24 Parganas	5.3	6.9	1.6
Paschim-Midnapore	-	5.8	5.8
Purba-Midnapore	4.9	6.8	1.9
Purulia	-	-	-
South 24 Parganas	4.2	5.8	1.6
Uttar-Dinajpur	6.0	-	-

Potato Yield

Table 42 - Potato Yield Across Districts at Baseline and Endline

District	Pre-ADMI	2018-19	Change in Yield
Bankura	16.8	25.1	8.3
Bardhaman	27.3	30.5	3.2
Birbhum	20.0	26.6	6.6
Dakshin-Dinajpur	17.1	21.6	4.5
Darjeeling	11.9	17.9	6.0
Hooghly	22.5	25.1	2.6
Howrah	22.5	-	-
Jalpaiguri	15.3	23.7	8.4
Jhargram	22.5	28.5	6.0
Cooch Behar	15.9	25.5	9.6
Malda	22.5	25.8	3.3
Murshidabad	17.8	23.4	5.6
Nadia	-	-	-
North 24 Parganas	-	25.5	-
Paschim-Midnapore	-	-	-
Purba-Midnapore	-	-	-
Purulia	-	27.7	-
South 24 Parganas	-	-	-
Uttar-Dinajpur	23.7	32.3	8.6

Mustard Yield

Table 43 - Mustard Yield Across Districts at Baseline and Endline

District	Pre-ADMI	2018-19	Change in Yield
Bankura	0.9	1.2	0.3
Bardhaman	0.9	1.2	0.3
Birbhum	0.9	1.4	0.5
Dakshin-Dinajpur	0.9	2.1	1.2
Darjeeling	-	-	-
Hooghly	-	1.5	-
Howrah	-	-	-
Jalpaiguri	0.7	0.8	0.1
Jhargram	0.7	1.1	0.4
Cooch Behar	0.9	1.2	0.3
Malda	0.8	1.2	0.4
Murshidabad	0.9	1.4	0.5
Nadia	1.2	1.3	0.1
North 24 Parganas	0.9	1.9	1.0
Paschim-Midnapore	0.7	1.2	0.5
Purba-Midnapore	-	-	-
Purulia	0.8	1.1	0.3
South 24 Parganas	-	0.9	-
Uttar-Dinajpur	0.9	1.3	0.4

Support to Agricultural Activities

Table 44 - Improved Agricultural Practices Across Districts at Post-ADMI

	Seed Treatment	Seed Preser-vation	Farm Mechan-isation	High Value Crops	Pest Manage-ment	Vermi-compost	Organic Farming
Bankura	37%	3%	8%	2%	3%	0%	0%
Bardhaman	28%	18%	10%	0%	23%	9%	9%
Birbhum	18%	19%	30%	2%	1%	1%	1%
Dakshin-Dinajpur	71%	70%	12%	31%	36%	2%	2%
Darjeeling	55%	52%	0%	1%	4%	52%	52%
Hooghly	61%	61%	63%	63%	61%	60%	63%
Howrah	2%	0%	2%	2%	1%	2%	0%
Jalpaiguri	42%	36%	15%	18%	30%	17%	9%
Jhargram	18%	18%	21%	16%	21%	17%	17%
Cooch Behar	28%	7%	31%	23%	24%	0%	4%
Malda	2%	2%	0%	0%	2%	0%	0%
Murshidabad	14%	14%	2%	7%	14%	7%	14%
Nadia	4%	48%	3%	1%	3%	35%	4%
North 24 Parganas	7%	7%	7%	7%	7%	7%	7%
Paschim-Midnapore	1%	1%	0%	0%	2%	1%	1%
Purba-Midnapore	9%	0%	2%	0%	3%	93%	0%
Purulia	19%	35%	9%	0%	43%	0%	30%
South 24 Parganas	56%	38%	56%	1%	56%	1%	1%
Uttar-Dinajpur	0%	0%	0%	0%	0%	0%	0%

WUA Membership

Table 45 – District-Wise Average Proportion of Female Members in WUA and Executive Committee

District	Average Proportion of Female Members in WUA	Average Proportion of Female Members in Governing Body
Bankura	7%	32%
Bardhaman	9%	27%
Birbhum	14%	31%
Dakshin-Dinajpur	12%	31%
Darjeeling	23%	21%
Hooghly	4%	21%
Howrah	15%	38%
Jalpaiguri	12%	28%
Jhargram	45%	56%
Cooch Behar	16%	26%
Malda	17%	26%
Murshidabad	6%	35%
Nadia	18%	34%
North 24 Parganas	23%	29%
Paschim-Midnapore	7%	30%
Purba-Midnapore	7%	5%
Purulia	23%	39%
South 24 Parganas	8%	30%
Uttar-Dinajpur	6%	16%

Table 46 - Average Proportion of SC and ST Members in WUA Across Districts

District	Average Proportion of SC Members in WUA	Average Proportion of ST Members in WUA
Bankura	7%	38%
Bardhaman	13%	5%
Birbhum	27%	24%
Dakshin-Dinajpur	36%	33%
Darjeeling	27%	11%
Hooghly	43%	6%
Howrah	8%	1%
Jalpaiguri	55%	14%
Jhargram	5%	56%
Cooch Behar	73%	0.2%
Malda	44%	33%
Murshidabad	61%	-
Nadia	11%	-
North 24 Parganas	-	1%
Paschim-Midnapore	7%	33%
Purba-Midnapore	13%	-
Purulia	18%	54%
South 24 Parganas	48%	8%
Uttar-Dinajpur	9%	2%

Remote Sensing Comparison

Table 47 – District-Wise Comparison of Cropping Intensity Between Survey Data Estimates and RS Analysis

District	Cropping Intensity (%) Survey	Cropping Intensity (%) RS	Number of Schemes
Bankura	194.6	228.2	9.0
Bardhaman	174.4	222.7	17.0
Birbhum	171.9	153.2	21.0
Cooch Behar	220.8	262.8	20.0
Dakshin Dinajpur	205.6	243.6	13.0
Darjeeling	210.0	203.8	8.0
Hooghly	152.9	251.3	3.0
Howrah	108.0	298.6	1.0
Jalpaiguri	184.1	219.6	33.0
Jhargram	184.5	230.1	28.0
Malda	171.0	244.1	9.0
Murshidabad	207.1	245.6	7.0
Nadia	229.4	263.7	8.0
North 24 Parganas	189.9	256.9	4.0
Paschim-Midnapore	194.5	232.7	7.0
Purba-Midnapore	167.1	220.2	2.0
Purulia	140.4	133.0	12.0
South 24 Parganas	157.0	173.0	8.0
Uttar Dinajpur	179.8	248.5	6.0

Annexure 3 - Summarised Indicators

Impact Assessment [Corresponding Indicators]				Matching PDO Indicators
Indicator	Unit	Pre (2013-14)	Post (2018-19)	
PDO Indicators				
Net increase in yearly agricultural income per hectare	Rs./ hectare	NA	50,029	PDO Indicator 1: Relative change in value of outputs measured as ratio between post to pre-project values
Total number of WUA Members[22]	number	NA	91338	PDO Indicator 2: Water users provided with new/improved irrigation and drainage services
Female farmers Membership in WUA	%	NA	16.9%	PDO Indicator 3: Water users provided with irrigation and drainage services - female
Schemes with good or very good infrastructure condition[23]	%	NA	94%	PDO Indicator 4: Operational Water Users' Associations created and/or strengthened*
Schemes with crop planning & cropping register	%	NA	88%	
Percentage of WUAs where Executive Committee was elected through an AGM	%	NA	98	
Crop yield				PDO Indicator 5: Increase in production of major outputs: (Rice, oil seed, vegetable) (Metric tonnes/year, Custom Supplement)
(i) Paddy (*Kharif*)	Tonnes/ha	3.3	4.6	
(ii) Potato (*Rabi*)	Tonnes/ha	14.3	28.2	
(iii) Mustard (*Rabi*)	Tonnes/ha	1.2	1.5	
Marginal farmers Membership in WUA	%	NA	98.7	PDO Indicator 6: Water users provided with new/improved irrigation and drainage services: small and marginal farmers
Tribal farmers Membership in WUA	%	NA	22.7	PDO Indicator 7: Water users provided with new/improved irrigation and drainage services: tribal farmers
Impact Assessment [Corresponding Indicators]				Matching PDO Indicators

22 Average number of WUA Members estimated from a representative sample (62.56 Members per WUA) multiplied by number of active schemes in 2020 i.e. 1460.

23 Based on rating given as good or very good by key informant interviews.

Impact Assessment [Corresponding Indicators]				Matching PDO Indicators
Indicator	Unit	Pre (2013-14)	Post (2018-19)	
Generating O&M: Water Users' Association that are generating at least 5% of total capital cost[24]	%	NA	17	PDO Indicator 8: Water Users' Association that are generating at least 80% of resources required to manage, operate and maintain the developed schemes
Intermediate Results Indicators				
Season-wise average area cultivated per scheme[25]				Intermediate Results Indicators 9 and 10: Area provided with new/improved irrigation or drainage services (Hectare)
(i) *Kharif*	hectare	16.2	19.5	
(ii) *Rabi*	hectare	3.6	15.2	
(iii) *Pre-Kharif*	hectare	2.7	9	
Crop diversification	Crop Diversity Index[26]	0.21	0.45	Intermediate Results Indicators 12: Area diversified to less water intensive cash crops
Percentage of gross cropped area under pulses, oil seeds and vegetables	%	12	25	
Change in cropping intensity in areas provided with new/improved irrigation services	%	129.3	183.1	Intermediate Results Indicators 13: Change in cropping intensity in areas provided with new/improved irrigation services

24 Total collection in 2018-19 as proportion of total project cost contract amount (collected from WBADMI project website).
25 Total area cultivated in each season by all 215 schemes/number of schemes (i.e.215).
26 Crop Diversity Index = – ∑pi*logpi; where pi is the proportion of area under crop i in a particular scheme.

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