Final Technical Report Component 2.4

Innovation for Climate Adapatation and Resilience

Name of Organization	Curtin University
Title of Project	Innovating Non-monetary Interventions for Climate-smart Agriculture: An ADOPT Model for Technology Diffusion
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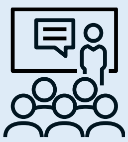
Executive Summary

This final technical report on the Climate Innovation Challenge project on Innovating Non-monetary Interventions for Climate-smart Agriculture: An ADOPT Model for Technology Diffusion, discusses the brief of the innovation, methods of innovation analysis, the key findings and way forward. This project provides a solution-based process of "Advocating available climate-smart technologies, Demonstrating the most appropriate technology, Omitting misinformation about climate-smart technology, and Putting peer pressure for Technology adoption"- ADOPT is a process-based mix of nudging tools to tweak farmers' perceptions about adopting climate-smart technologies.

The ADOPT Model components and hypotheses



ADVOCACY

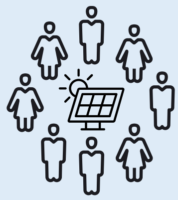
Referrals are preferable to solar farmers.

DEMONSTRATION

Seeing is believing.

OMITTING MISINFORMATION

Solar irrigation is sustainable and cost-effective.



PEER PRESSURE

Farmers go for solar *collectively* and not *individually*.

Methods and Study Region

The ADOPT Model pilot project in Bangladesh introduced an innovative behavioral instrument to induce low-carbon CSA technology adoption; and popularized a nonmonetary approach to making climate-smart village by scaling up its adoption.

In this project, 2800 farming households (1400 solar user-farmers and 1400 non-solar user-farmers) are surveyed (face-to-face interviews) in 28 districts with solar irrigation networks in Bangladesh. This field survey and the data analysis collected from the survey followed the methodological approach of a natural experiment. To test the ADOPT model, its four nudging components are compared for solar irrigation adopters and non-adopters.

Key Findings

Advocacy increases solar irrigation adoption by **14.3%**.

Demonstration on solar irrigation increases its adoption by **30.8%.**

Omitting misinformation increases solar irrigation adoption by **9.5%**.

Peer pressure increases its solar adoption by **37%.**

Using **any of the ADOPT components** increases solar irrigation adoption by **37.28%** .

Using **all of the ADOPT components** increases solar irrigation adoption by **30.5%** .

Takeaways

Non-monetary interventions exclusively/inclusively are effective in adopting solar irrigation

The ADOPT model is scalable for solar irrigation.

The ADOPT model showed an improved interaction between solar users and its providers.

The ADOPT model can be used as an intervention for any climate-smart agricultural technology.

Background to Pilot

Pilot solution

In the spirit of the “Nudge Theory”, the Curtin University team has devised the ADOPT model of incentivizing farmers in adopting climate-smart technologies in irrigation system. The ADOPT stands for “Advocating available climate-smart technologies, Demonstrating the most appropriate technology, Omitting misinformation about climate-smart technology, and Putting peer pressure for Technology adoption” in agriculture. This product is a process-based solution, identifying nonmonetary approach to tweak farmers’ perception in adopting climate-smart technologies through multiple nudging components. These components include advocacy, demonstration, peer influence and peer pressure.

Given the nonmonetary nature of this model, this innovative project is unique in terms of cost-effectiveness, scalability, sustainability and market-orientation. Firstly, the ADOPT model is highly cost-effective, because it uses resources at the community level and farming population size is of little importance on budgetary requirements. Next, marginal cost of this model application is nearly zero which is convincing for policy-makers. Hence we can scale up at country level with institutional assistance. Regarding sustainability, this model or solution directly addresses SDG 7 and SDG 13, with relevance to climate action and renewable resource-use. In addition, this solution will facilitate SDG 12 and SDG 16, by i) replacing nonrenewable diesel and coal energy with renewable solar energy in agriculture and ii) promoting inclusive and participatory decision-making at multiplayer levels among farmers, local influential persons and local agricultural institutions. Finally, this solution is suitable for market environment where technology users (e.g., farmers) and providers (e.g., solar companies) can interact simultaneously. This unique market-based feature is efficient to promote behavioral change towards low-carbon usage.

Goals and objectives

Long-term goals:

Reduce carbon emissions from agriculture in South Asia;

Increase agricultural resilience in the changing climate; and

Install new norms for climate-smart agriculture.

Objectives:

To **introduce** an innovative behavioural instrument to induce low-carbon CSA technology adoption; and

To **popularize** a nonmonetary approach to making climate-smart village by scaling up its adoption.

Contribution of this pilot solution

Promoting climate-smart technology in agriculture is a crucial challenge in South Asia due to its cropping pattern and high farm heterogeneity. Together, agriculture is the most climate-sensitive sector in this region. The ever-growing practice of extensive cropping, livestock rearing, and unplanned high carbon input use (e.g., chemical inputs, diesel irrigation systems) caused a substantial increase in greenhouse gas (GHG) emissions (Sapkota et al., 2021). Nieto et al. (2018) projected that in the absence of effective mitigation, GHG emissions would increase by 95.7% globally and even 37.8% at the country level, resulting in 4°C warming by 2030. This alarming scenario calls for immediate actions in reducing the use of nonrenewable energies and accelerating the transition to CSA (climate-smart agriculture). In response, multiple CSA technologies have been evolving in the last two decades including climate-stress tolerant cropping, water-efficient irrigation, and various agri-environmental land and input management practices. While there are a plethora of technological breakthroughs in the clean energy-based irrigation system, farmers tend to ignore embracing them in their agriculture practices. Such negligence in adopting new technologies is not due to their financial affordability only, rather it may be humans' innate reluctance to change (Kumar et al. 2020), indicating complexity and uncertainty in the decision-making process. To demonstrate, the failure of identifying "humans' innate nature of resistance to change" as the true cause of the technology adoption rate, increases the difficulty in expanding horizontal and vertical coverage of CSA technologies (Vernooy and Bouroncle, 2019). Apart from this, the ongoing policy efforts to increase the CSA adoption rate is excessively centered on boosting farmers' financial affordability. For this reason, despite input subsidies and extension services, CSA could progress towards neither scaling up the emerging technologies nor adopting newer ones. Therefore, a decision-making approach of the ADOPT model which is instant, reciprocal and local resource-based, could be more effective to encourage a CSA technology adoption.

Target groups and beneficiaries

Agriculture remains the largest source of GHG emissions in the country because of intensive rice cultivation and extensive irrigation network. Irrigation mostly uses groundwater sources (79%) and diesel power pumps (90%) (Salem et al., 2018). Extensive irrigation itself and water-energy resources used for irrigation have serious implications for the carbon footprint. Nevertheless, the country has abundant solar exposure and sunshine, hence there is an enormous potential for solar energy use. However, its 10% target of renewable energy generation (REN21, 2019) could hardly utilize and increase the solar capacity factor. Sustainable irrigation approach in the country merely addressed water use efficiency, while energy-efficiency received less attention and inadequate finance. Institutional referral programmes followed the same outline for any climate adaptation and mitigation measure.

The ADOPT model uses four nudging components or tools to observe and encourage farmers' solar irrigation technology adoption behavior. This pilot solution identifies either the most appropriate tool or a mix of tools that motivate farmers in adopting solar irrigation technology in the context of Bangladesh. The target population includes farming households and 2800 (1400 solar users and 1400 non solar users) farming households are surveyed. This project is implemented for 56 solar irrigation systems in 28 districts in Bangladesh (Fig 1). The sampling frame enlists and selects both low and high solar capacity areas in 6 (out of 8) divisional headquarters in the country. A structured questionnaire is used to conduct one-on-one survey of farmers.

Key metrics and the intended impacts

Following the global agenda of greenhouse gas emission reduction and de-carbonisation, Curtin University established a consortium by collaborating with the Government of Bangladesh along with other national and international stakeholders in piloting the ADOPT model. The overall purpose of this project is to facilitate low-carbon CSA technology and support green public policy initiatives. While this project uses the ADOPT model in addressing the adoption of solar irrigation technology, the outcomes of this project can be utilized to diffuse other CSA technologies. The following Fig 1 depicts the hypotheses of the ADOPT components in this pilot initiative and the intended impacts on the targeted farming population.

ADVOCACY	DEMONSTRATION	OMITTING MISINFORMATION	PEER PRESSURE
Referrals are preferable to solar farmers.	Seeing is believing.	Solar irrigation is sustainable and cost-effective.	Farmers go for solar *collectively* and not *individually*.
• Increase in institutional access • Accuracy in solar irrigation knowledge • Follow-up	• Improved knowledge and experience about solar irrigation • Motivated to use solar irrigation	• Correct information about solar irrigation benefits • Understand the comparative evaluation so solar and other energy sources	• Improvement in collective pro-environmental attitude • Improved trust and social capital

Fig 1: The ADOPT model hypotheses and the intended impacts

Innovator's profile

The innovator Curtin team of researchers has a wealth of experience conducting research on environment and climate change in Asia. Dr Habib Rahman is the Team Leader in delivering and implementing this project. He has a long history working with several international development partners in Asia and the Pacific regions over the past 15 years. In 2008-09, he has worked as a Project Manager at ADPC. During his tenure, he implemented a regional programme to estimate the impact of climate-induced disasters in South and Southeast Asian countries. Dr Rahman, along with Professor Ruhul Salim (one of the Chief Investigators of this project, ranked within the top two percent of researchers in the world), is now leading an international climate change engagement programme in 14 countries (including Bangladesh) under the Department of Foreign Affairs and Trade (DFAT) of the Commonwealth Government of Australia. They are jointly supervising Associate Professor Zeenatul Islam, University of Rajshahi, to conduct her PhD research in the field of climate-smart agriculture in Bangladesh. Ms Islam assisted in designing the survey instrument, field survey, data analysis, and document preparation in this project.

The Curtin University team established strategic collaborations with Dr Shuddha Rafiq (climate-smart energy expert) of Deakin University, Associate Professor Shamsuddin Shahid (one of the top two percent of researchers in the world) of Universiti Teknologi Malaysia, Professor Maksud Kamal (the Pro Vice-Chancellor) of the University of Dhaka, and Professor Jahangir Alam (Leading Agricultural Economist) of Bangladesh Agricultural University to harness multi-disciplinary capacities and local experiences when implementing this project. All of the participating universities have a strong track record of engaging with industries in the field of applied energy, environment and climate change research. The field level implementation process has been coordinated by Dr Mahfuz Kabir of BIISS in Bangladesh, on behalf of the Ministry of Agriculture of the Government of Bangladesh. Advisors and end-users of this pilot initiative include the Ministry of Agriculture, the Ministry of Environment, Forest and Climate Change, and the Sustainable and Renewable Energy Development Authority of the Government of Bangladesh.

Process, Progress and Results

Project implementation

The operational and implementation plan in this project includes the survey design for introducing, testing the ADOPT model and analyzing the survey data. The tasks are planned in five broad phases, namely

- Selection of the study regions and develop the survey instrument;
- Building survey tool and training survey teams;
- Conducting pilot and final surveys;
- Preparing database and analytical plan; and
- Data analysis and documentation.

This project has used data from secondary and primary sources for implementation. The study regions include all major administrative areas with solar irrigation network in Bangladesh recorded until June 2021. Thus, the ADOPT model is tested in 28 districts in the country (Fig 2). Two solar systems are randomly selected in each district and thus 56 solar irrigation systems are selected for the survey (Fig 3). A multi-stage clustered random sampling method is employed to select both solar systems and farming households (solar and non-solar users) in the study area. The SREDA database and GIS mapping are used to select solar systems in the selected study regions. To select 2800 solar and non-solar farming households, farmers' list provided by AED (Agricultural Extension Department), are utilized. From each solar plant 25 solar users are randomly selected and 25 non-solar users are randomly selected in the 500 meter radius of the solar plant under consideration. In three districts, namely Chattogram, Khagrachhari and Kurigram, sample size at district level is lower due to lower population size of solar users. In such cases, nearby sample size is adjusted by pulling more than 50 farmers from the nearest solar plant area. In the field survey, quantitative and qualitative information are collected on household and farm characteristics, and the ADOPT modules using a structured questionnaire.

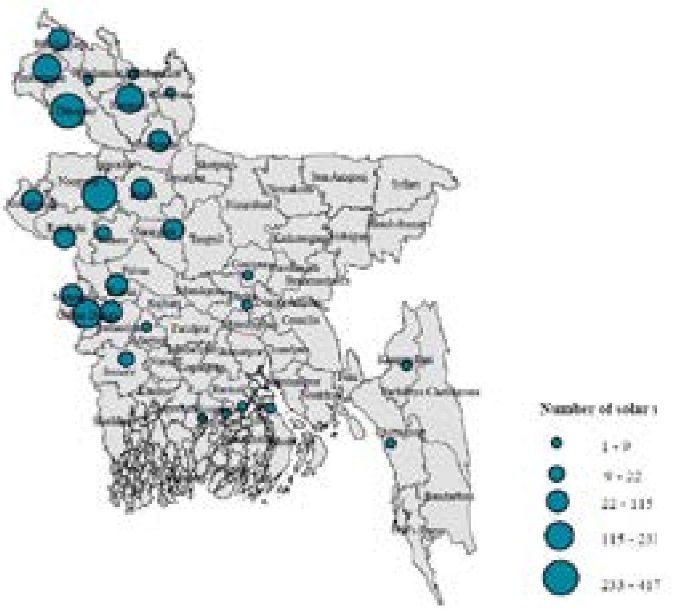


Fig 2: The distribution of solar irrigation systems in Bangladesh

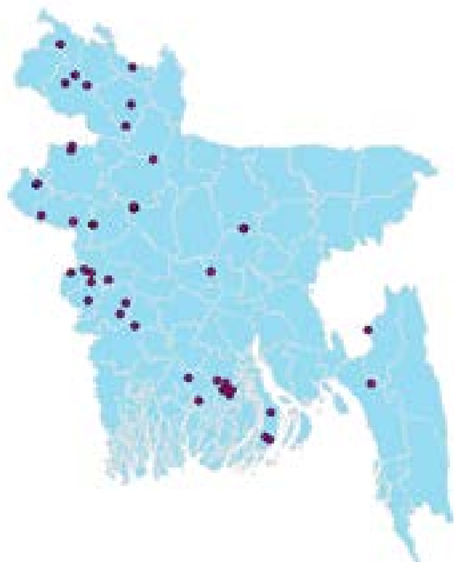


Fig 3: Solar plants in the survey locations

Irrigation systems in Bangladesh

50%
area under irrigation

2666
solar systems

51.979 MWp
total plant capacity

(source: SREDA database)

Field survey

Key outcomes and major achievements

In the full sample, there is no difference between adopters and non-adopters in means of household size, distance of drinking water source from household, tin/brick-made houses, number of rooms, land amount owned and/or cultivated, farming experience, years of schooling and monthly income of farmers, kharif 1/2 cultivation, clay/clay-loamy/sandy-loamy soil-type and land productivity.

Years of schooling
6

HH size
5

Distance to drinking water source
14.37 meters

Tin/brick house
88.65%

No. of rooms
4

Monthly income
14,810.66 BDT

Land amount
141.24 decimals

Farming experience
25 years

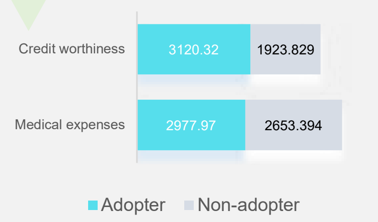
Kharif1 33.60%
Kharif2 87.02%

Clay type 62.82 **decimals**
Clay-loamy 51.80 **decimals**
Sandy-loamy 12.97 **decimals**

26.24 kilo
per decimal

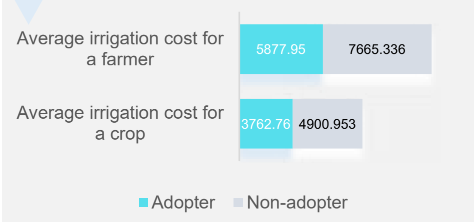
Significant differences are observed between adopters and non-adopters for the following characteristics. They include land-to-pump distance, number of users of a single pump, pump capacity, amounts of medium and high land, amounts of loamy and sandy soil type land, average irrigation cost for a crop and for a farmer, credit worthiness of a farmer and household's medical expenses. The following sections describe the differences in detail.

Adopters have more credit worthiness and incur larger medical expenses. This shows a higher standard of living for adopters. The difference between the creditworthiness and medical expenses of adopters and non-adopters amount to BDT1196.50 and BDT324.57.

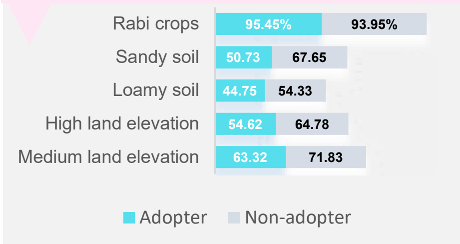


Farmers mostly grow irrigated crops including grain crops, vegetables, and lentils. The difference in irrigation fees is observed as highly significant in the study regions.

For irrigation fees, adopters pay BDT1200 less for a single crop and BDT1800 in the entire crop season annually than non-adopters.

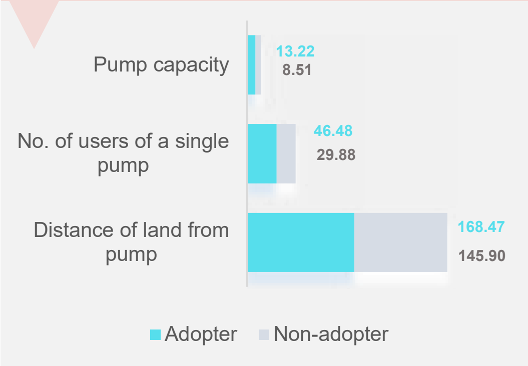


Bangladesh has three distinguished crop seasons, namely Kharif 1 (Mid March-Mid July), Kharif 2 (Mid July-Mid November), and Rabi (Mid November-Mid March). Rabi crops are winter-season crops. The percentage of adopters is higher than non-adopters during the winter season. For non-adopters, land elevations are high and medium and soli types are sandy and loamy.

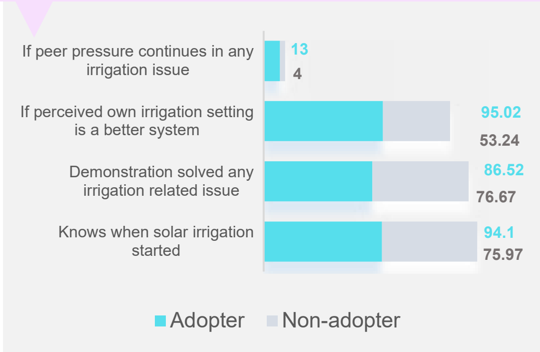


Key outcomes and major achievements

Higher pump capacity, a larger group of irrigation users for a single pump, and a larger distance of land from the pump are significant irrigation features for adopters. These features explain the technical efficiency of solar irrigation.

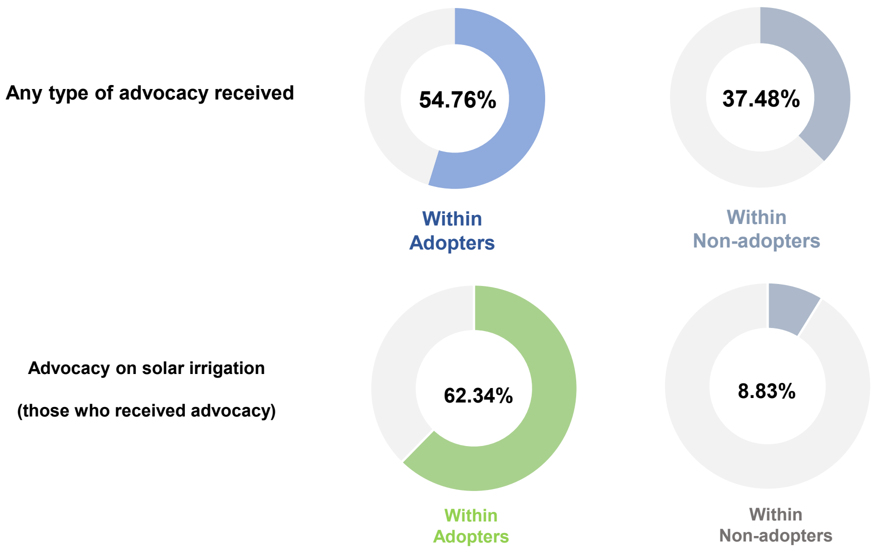


Within adopters, a higher percentage of farmers know solar installation dates in their villages. Most adopters reported that demonstration sources solved irrigation-related issues and peer pressure would continue in irrigation management. Adopters are also more confident about their irrigation systems.



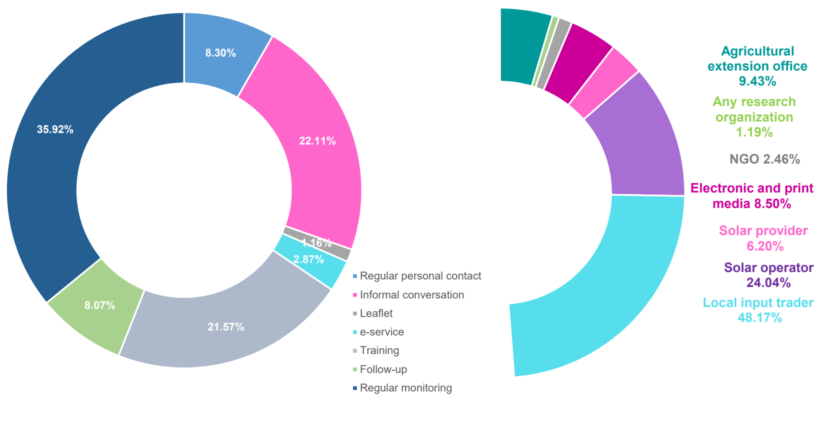
Pictures are taken during the field survey. There are two types of solar plants installed in Bangladesh, plants with small panels (maximum 136 panels) and big panels (minimum 2 panels). The average capacity of a solar pump in all study regions is 14.28 kWh. On average a solar pump daily lifts approximately 2.2 million L in summer, 0.8 million L in monsoon, and 1.7 million L of water in winter. Agricultural Extension Department, the Government of Bangladesh and IDCOL (Infrastructure Development Company Limited) are the main solar providers in the country.

Strategy 1: Advocacy



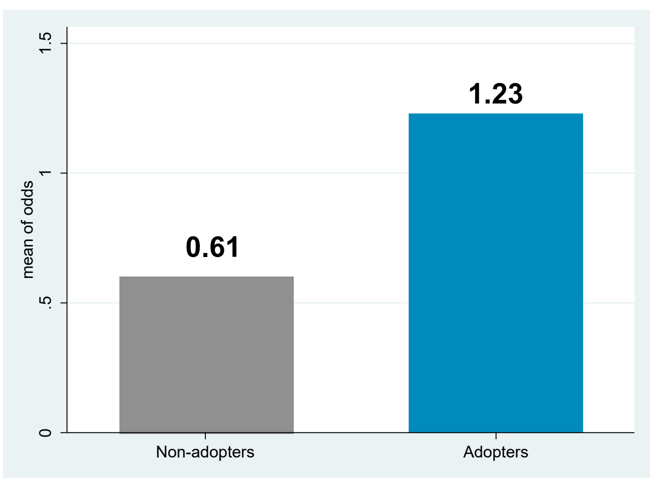
Approximately, 55% of adopters and 38% of non-adopters received any type of institutional advocacy. Advocacy on solar irrigation through training was received by 62.34% of adopters and 8.83% of non-adopters.

Advocacy sources include agricultural extension offices, research organizations, NGOs, electronic and print media, solar providers, solar operators, and local agricultural input traders. Three most important advocacy media are regular monitoring (35.92%), Informal conversation (22.11%) and training (21.57%).



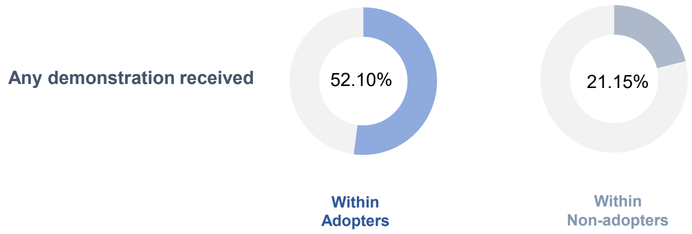
Advocacy media

Advocacy sources



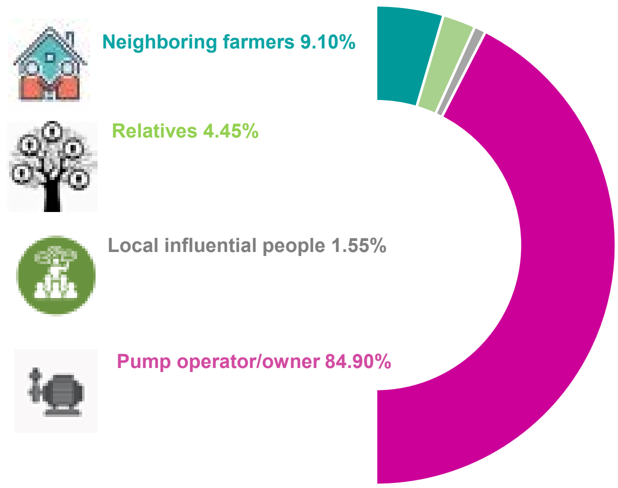
From the means of odds for both groups, 1.23/0.61=2.02, it implies that receiving advocacy for adopters is 2 times as large as the same for the non-adopters.

Strategy 2: Demonstration

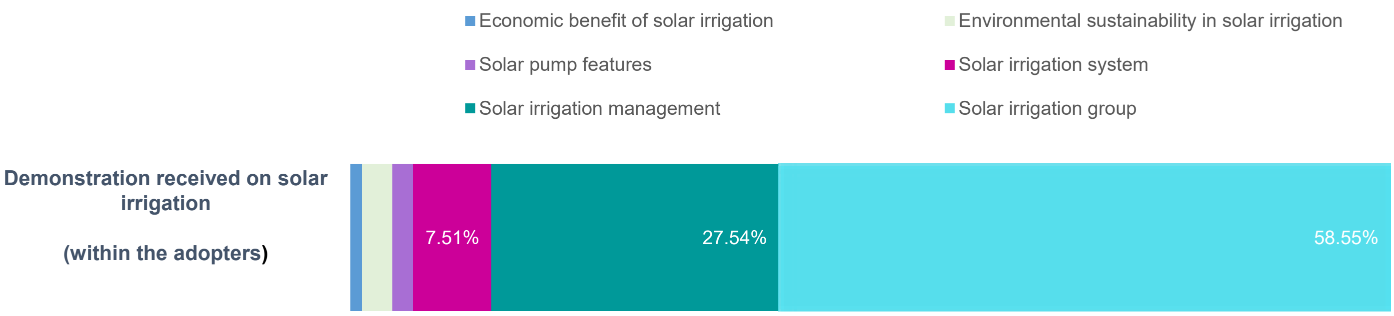


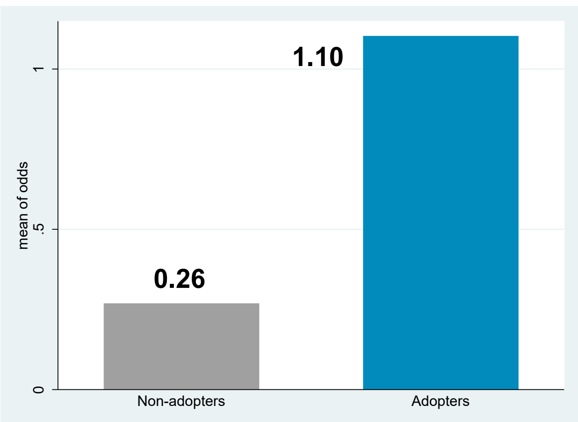
Approximately, 52% of adopters and 21% of non-adopters received any demonstration on solar irrigation.

Demonstration sources include neighboring farmers, relatives, local influential people and pump operators/owners. Most demonstrations are given by pump owners/operators (84.90%). For solar irrigation adopters, most demonstrations are given on the irrigation group features followed by irrigation management and its system.



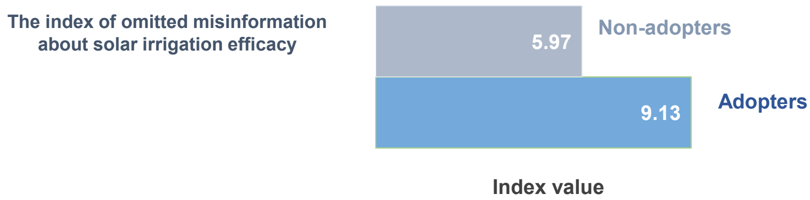
Demonstration sources



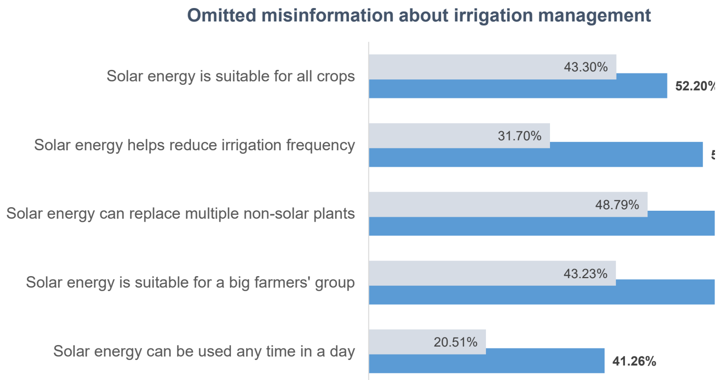


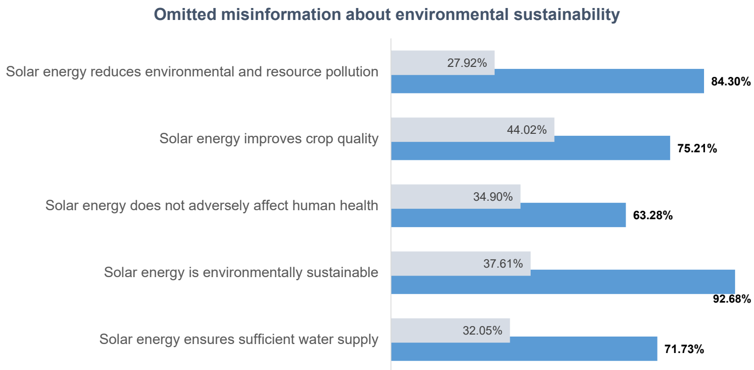
From the means of odds for both groups, 1.10/0.26=4.23, it implies that receiving demonstration for adopters is 4.23 times as large as the same for the non-adopters.

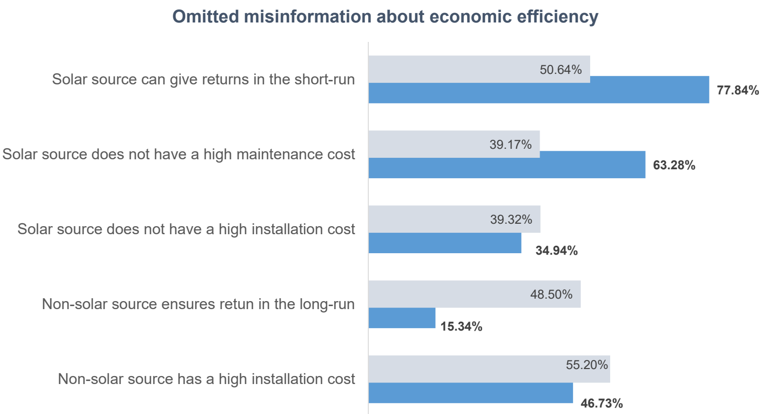
Strategy 3: Omitting misinformation



Three types of omitted misinformation were identified, namely, i) solar irrigation management (5 indicators), ii) economic benefit of solar irrigation (5 indicators, and iii) environmental sustainability of solar irrigation (5 indicators). The index of omitted misinformation for adopters is 9.13, while this number for non-adopters is 5.97. Adopters at least have omitted 3 types of misinformation about solar irrigation compared to non-adopters.

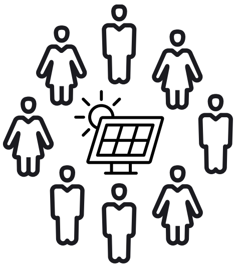






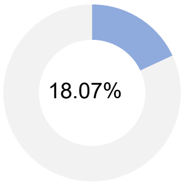
Omitting misinformation about irrigation management for adopters is 6 times as large as the same for the non-adopters.

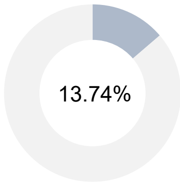
Omitting misinformation about environmental sustainability for adopters is 17.62 times as large as the same for the non-adopters.



Strategy 4: Peer pressure

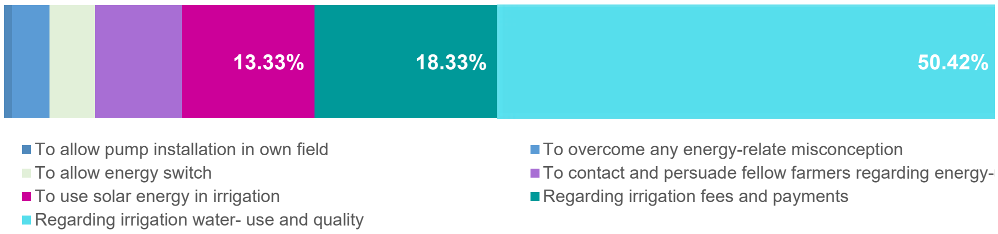
Experienced any peer pressure for solar irrigation

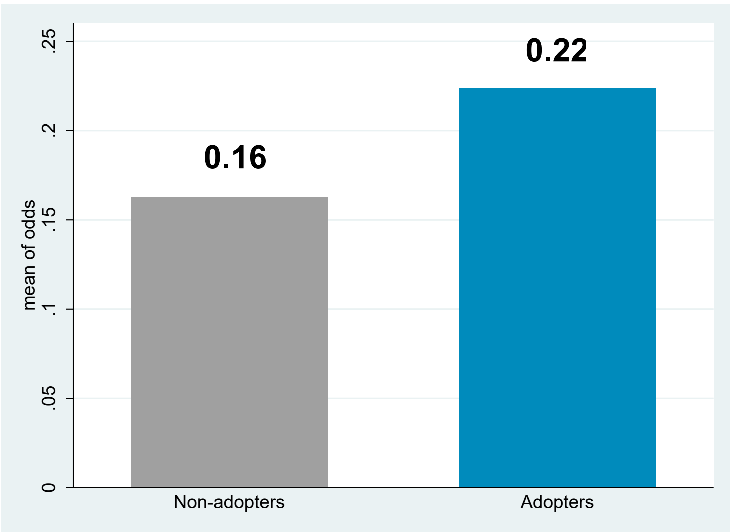




Only 18.07% of adopters and 13.74% of non-adopters experienced peer pressure to use solar irrigation in the full sample.

Peer pressure is experienced from neighboring farmers, relatives, local influential people and pump operators/owners. Main reasons for experiencing peer pressure include regarding irrigation water-use and water quality, followed by irrigation charge and payment system and persuading farmers to use solar irrigation.





From the means of odds for both groups, 0.22/0.16=1.38, it implies that experiencing peer pressure for adopters is 1.4 times as large as the same for the non-adopters.

The efficacy of the ADOPT Model: Empirical analysis

In the empirical analysis, four separate models are estimated for the ADOPT components. The outcome variable is the energy source of irrigation and it is estimated on advocacy (Model 1), demonstration (Model 2), omitting misinformation (Model 3), and peer pressure (Model 4). It is also observed if solar irrigation adoption depends on any of the ADOPT components considering all four components as mutually exclusive. Finally, solar adoption is estimated on the ADOPT model considering all four components inclusive. For controlled variables, farmers' schooling years and pump capacity have significant positive impacts on solar irrigation adoption in all four models (Table 1). Apart from this, solar adopters are more aware of the plant installation dates, and are able to solve any irrigation related conflicts or issues from demonstration. Solar adopters are also confident about their irrigation as a better system. The models' main outcomes are mentioned below.

Advocacy increases solar irrigation adoption by **14.3%**.

Demonstration on solar irrigation increases its adoption by **30.8%**.

Omitting misinformation increases solar irrigation adoption by **9.5%**.

Peer pressure increases its solar adoption by **37%**.

Variables	Model 1 Advocacy	Model 2 Demonstration	Model 3 Omitting misinformation	Model 4 Peer pressure
If advocacy received	0.143***			
If demonstration received		0.308***		
If omitted misinformation			0.095***	
If peer pressure experienced				0.370***
Farmer's schooling years	0.005**	-0.002	0.005**	0.004*
Household size	-0.009	0.006	-.009	-.009
Pump capacity	0.023***	0.027***	0.020***	0.023***
If knows solar irrigation start year	0.359***			
If the demonstration solved any conflict/issue		0.202**		
If own irrigation is perceived better			0.450***	
If peer pressure continues for solar irrigation				-0.171***
Sample size	**2800**	**2800**	**2800**	**2800**

Note: ***p< 0.01, **p<0.05, *p< 0.10

Source: Field survey and authors' calculations

The efficacy of the ADOPT Model: Empirical analysis

Using **any of the ADOPT components** increases solar irrigation adoption by **37.28%** .

Using **all of the ADOPT components** increases solar irrigation adoption by **30.5%** .

Challenges and Mitigation Measures

There were no issues of scalability and sustainability of the ADOPT model initiative. However, this project perceived the possible challenges in its implementation. Precisely, three sets of challenges were experienced in this pilot initiative, namely the dynamism of the consortium, internal and technical management, external environmental uncertainties. The following sections explain the challenges and the mitigation measures taken to solve the issues in this project.

The dynamism of consortium: This pilot initiative is managed by multiple parties from different public and private sectors across the world. Thus, it was plausible to experience the dynamic changes in communication and management, field survey coordination and monitoring the progress.

In order to tackle this challenge, the core objectives were solidified while preparing the survey instrument and analyzing the survey data. For coordination and management, every party of the consortium had one lead coordinator and a team to manage each responsibility. The implementation phase was planned in multiple stages with a structured division of responsibilities for each team.

Internal and technical management: This project uses a structured questionnaire for field survey of 2800 farming households in 28 districts in Bangladesh. Thus, there were challenges related to the validity of survey instrument, training the surveyors, data collection tool development and analytical plan framework.

The survey instrument was validated after a pilot test in two study regions. Necessary changes in the questions were made after piloting. Along with on-spot monitoring, several training sessions were organized to train the surveyors and improve their competence. Data collection tool was carefully designed by skilled technical team and the analytical framework was designed based on the ADOPT expected outcomes. The analytical framework was finalized after pilot test.

External environment uncertainties: This set challenges include health risks during Covid-19, location confirmation of solar irrigation plants due to a mismatch of coordinates collected from the online database, farmers' availability to complete face-to-face survey and on-spot survey management.

Health safety measures were provided to surveyors and farmers. All surveyors are confirmed to be at least double vaccinated (Covid-19). The location coordinates of a solar plant were recorded in real-time in each sub-district. Regarding the availability of farmers to complete the face-to-face survey, a second list of farmers (i.e. who are not primarily selected) after randomization was used. Field supervisors managed local communications and tackled any complexity during survey.

Lessons Learned and Recommendations

Potential impacts at a glance

	Queries and Answers
1	Q. What is the value added by ADOPT? (i.e., what could not have happened without ADOPT in Bangladesh)?
	A. Our findings suggest that non-monetary nudges in the ADOPT model, separately and comprehensively change human behavior to maximize the adoption rate of solar irrigation. This tool is useful in expanding the coverage of the existing climate-smart technologies. At the same time, this is a tool through which we can enable the potential users to actually use new technologies, e.g., solar power tiller, water-efficient irrigation, hydropower-based agricultural technology, and carbon farming practices.
2	Q. What are we learning from the pilot solution – for example, what approaches work, what works less well?
	A. Advocacy, demonstration, and omitting information gaps work quite well except for the peer pressure when it comes to incentivizing solar irrigation users in Bangladesh. Most advocacy in terms of training is given by the respective technology providers. Important community sources disseminating demonstrations and exerting peer pressure include pump owners/ operators, neighboring farmers, relatives, and local input traders. The efficiency of the ADOPT tool illustrates that nudging components are useful in linking solar providers and their users.
3	Q. What are the incentives/factors that determine whether the pilots will be taken up by governments?
	A. We have received verbal commitments from several ministries in Bangladesh including the Ministry of Agriculture, the Government of Bangladesh that they would like to scale up ADOPT given the financial support from the international development organizations. In this respect, this report includes both short- and long-term recommendations and a way forward in the following sections. We expect to convey our recommendations to scale up and institutionalize the ADOPT tools for any climate-smart agricultural technology.
4	Q. What is the real difference ADOPT is expected to make (now that they have been implemented)?
	A. ADOPT sensitizes policymakers in that inventing technologies is meaningless unless we guide human behavior to scale up such technologies through non-monetary interventions. An important finding in this project is that the ADOPT is more efficient for pumps with a large capacity. This indicates that a climate-smart pump can serve a large group of farmers, implying less resource use and more technical efficiency. Therefore, non-monetary nudges are able to increase economic benefits along with environmental sustainability.
5	Q. Has the ADOPT been accepted, endorsed, or adopted by the government? Do you have any indication of the end user that has any commitment to further scale-up, continue to implement, etc?
	A. We have worked with four ministries to complete our pilot project. We are now in the process of obtaining their endorsement letters to support our next scale-up phase.
6	Q. Is there data on the population (numbers of people, disaggregated) covered by your pilot (which are going to continue/ be scaled up)?
	A. In this pilot project, we have surveyed 28 districts covering 2800 farmers. We randomly chose two solar plants and 50 solar irrigation users in each district. We also randomly selected 50 non-solar (electricity or diesel) users within a 500-meter radius of the solar plants. Recently, solar irrigation coverage has been extended to 22 districts in the country. We intend to develop an ADOPT module to estimate the impact of non-monetary nudges on the solar irrigation adoption rate in all 50 districts in Bangladesh. We intend to compare the institutionalized and non-institutionalized non-monetary nudges in i) high and low adopted areas and ii) old and newly adopted areas.
7	Q. Any other human stories of benefits/change?
	A. Yes, we will add some comments (e.g., case studies) of the farmers.
8	Q. Have any partnerships with national and local governments and their agencies progressed?
	A. We have worked with the field-level Agriculture Extension Departments of the Ministry of Agriculture as well as local irrigation cooperatives. We also consulted local and regional level officers at Barendra Multipurpose Development Authority.
9	Q. Any thoughts on how your organization's support has helped to build the capacity of end users to take this innovation approach to scale (for future)?
	A. We have made a technological breakthrough to convert diesel power tiller into solar power tiller in associated with one local university in Bangladesh. We believe that scaling up such technologies will substantially reduce carbon emissions in the agriculture sector. The Secretary of the Min of Environment, Forest, and Climate Change has endorsed this intervention already.
10	Q. Please list and share any videos and pictures that showcase the impact on the ground.
	A. We have included photographs in annex 3 of the report.

Key lessons learned

1	**Non-monetary** interventions exclusively/inclusively are effective in adopting solar irrigation.
2	The ADOPT model is **scalable** for solar irrigation.
3	The ADOPT model showed an **improved interaction** between solar users and its providers.
4	The ADOPT model can be used as an **intervention** for any **climate-smart** agricultural technology.

Recommendations

Based on the survey observations and analysis, this project has several short-term and long-term policy suggestions. They are mentioned as follows.

Short-term recommendations:

- Local monitoring and regular follow-up of institutions should mobilize local/community resources including influential people and experienced users of any CSA technology.
- Improvised methods of demonstration should be used to explain the services of a CSA technology and the disservices of non-CSA technologies.
- The benefits of using CSA technologies should be disseminated by showing actual adoption scenarios and experiences.
- The responsibility of a CSA management and circulating the benefits of CSA technologies can be shared among the user groups.

Long-term recommendations:

- The integration of public and private institutions and local resources is required.
- Non-monetary interventions of the ADOPT model should be institutionalized by public and private institutions both separately, in partnership, and without overlapping.
- CSA intervention and awareness programmes should be undertaken on a need basis prioritizing the climate conditions and the existing adoption scenario.
- CSA providers can announce non-monetary rewards and incentives (e.g. sharing a CSA user's experience, using community examples, making a CSA user train others, shared responsibility in a community) to promote CSA adoption.

Conclusion and Way Forward

This final technical report gives a background of the project including project objectives and the consortium's profile that managed the ADOPT model pilot initiative. The specific objectives of this project are to introduce an innovative behavioural instrument to induce low-carbon CSA technology adoption; and to popularize a nonmonetary approach to making a climate-smart village by scaling up its adoption. This report also describes the major outcomes and lessons learned from the field observations and survey data analysis. All the ADOPT model components, namely advocacy, demonstration, omitting misinformation, and peer pressure are separately and inclusively effective in increasing solar irrigation use in Bangladesh. Thus, the ADOPT model is found effective and efficient in improving CSA technology adoption scenarios. Based on this pilot initiative's findings, short-term and long-term policy recommendations are suggested in this report.

Way Forward

Four key institutions of the Government of Bangladesh, viz. Ministry of Agriculture; Ministry of Environment, Forest and Climate Change; Sustainable and Renewable Energy Development Authority (SREDA), Ministry of Power, Energy, and Mineral Resources are the end-users of this project. The strategic partnership with the end-users will be useful for **scaling up the ADOPT model**; by promoting the ADOPT components, mobilizing local resources, increasing partnership with private institutions, generating awareness, and providing non-monetary incentives. Evidence of this pilot initiative ensures **the applicability of the ADOPT model** to induce any CSA technology adoption behavior in no, low, and high adoption areas. The ADOPT model components are effective both separately and inclusively, thus **the ADOPT model is adaptable** to any context. Non-monetary interventions of the ADOPT model are effective in large groups of solar irrigation users and high solar capacity plants, which ensures **the sustainability of the ADOPT model**. The success factors of the ADOPT pilot project, i.e. non-monetary nudging components add value to the CSA technology market by facilitating and improving the adoption scenario. Therefore, this project allows us to uptake the following steps ahead.

- Developing a module of ADOPT components and institutionalizing the interventions for a CSA technology;
- Integration and collaboration among multiple stakeholders including CSA providers and users; and
- Exploring the opportunities of linking multiple CSA technologies with non-monetary incentives.

References

Nieto, J., Carpintero, 6.,& Miguel, L. J. (2018). Less than 2 C? An economic-environmental evaluation of the Paris Agreement. Ecological Economics, 146, 69-84.

Salem, G. S. A., Kazama, S., Shahid, S., & Dey, N. C. (2018). Groundwater-dependent irrigation costs and benefits for adaptation to global change. Mitigation and Adaptation Strategies for Global Change, 23(6), 953-979.

Sapkota, T. B., Khanam, F., Mathivanan, G. P., Vetter, S., Hussain, S. G., Pilat, A. L., ... & Krupnik, T. J. (2021). Quantifying opportunities for greenhouse gas emissions mitigation using big data from smallholder crop and livestock farmers across Bangladesh. Science of the Total Environment, 786, 147344.

Kumar, V., Syan, A. S., Kaur, A., & Hundal, B. S. (2020). Determinants of farmers' decision to adopt solar powered pumps. International Journal of Energy Sector Management, 14(4), 707-727.

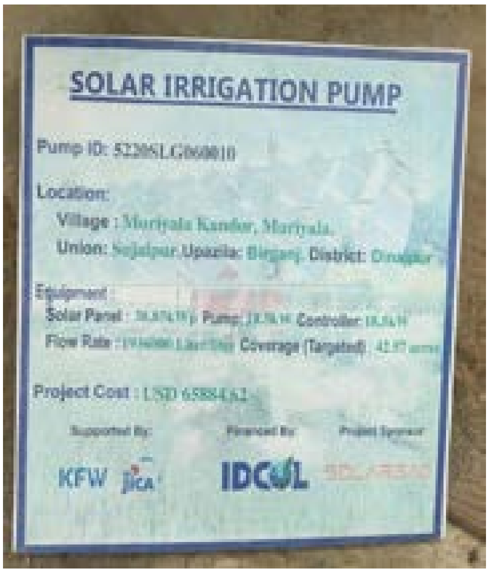
SREDA (Sustainable Renewable Energy Development Authority) 2019, Annual Report 2018-19, Ministry of Power, Energy and Mineral Resources, Dhaka. http://www.renewableenergy.gov.bd/

Thaler, R.H., & Sunstein, C.R. (2008). Nudge: Improving Decisions About Health, Wealth, and Happiness, New Haven & London: Yale University Press.

Annex 3a: The list of surveyors

Anika Samma	E.M. Talid Khan	Kamrun Nahar
Faruki Fahim	Abdullah Ar Rakin Azad	Mrinal Roy
Momtahina Mitu	Anika Tabassum	Fatema Niha
Aishia Fyruz	Md. Kamruzzaman	Anika Bushra Arty
Alvi Akon Sourav	Mahfuja Khandaker	Mehedi Hasan
Sukta Dey	Iffat Jahan Shammee	Sujana Afroz
Tasnim Jabin Jui	Tamanna Haque Mim	Saima Nurjahan
Nazmul Hasan Shovon	Tanzil Hossain	Redwan Saleh Chowdhury
Ashiqur Rahaman Shumon	Sabiha Anjum Dibby	Asif Ahmed
Naimul Huda Shohan	Akram Hossain	Malik Al Hasan Shuvo
Ashraful Uzzal	Aysha Akter Nila	Muhaimin Tafakkurun
Abu Jafor Salim	Habiba Azad	Mubassir Billah
Ayesha Fiza	Asim Abrar	Hasib Ahmed
Moin Hasan	Sanjida Sultana	Menhajul Alam
Nusrat Jahan Nilima	Md. Akiuzzaman Koel	Soaib Ahmed
Abdullah-all-Sakib	Sumaiya Siddiqa	Ismat Mahmood
Afsana Sultana Shorna	Md. Hasan Shahriar	Jeba Sultana Setu
Md. Mehedi Hasan	Naharin Zannat	Usama hasan
Md. Anwarul Haque	Romana Ibrahim	Jubayer Plabon
Md. Julfikar Ali Shakil	Md. Mahfuzar Rahman	Ziaul Haque
Md. Abdur Rakib-ul-Hasan	Tonmay Kumar Barman	Sagor Hossain
Mahbuba Hasnat Swa	Adib Zawad	Mostafa Aninda Zaman
Faiza Waziha	Mahina Yusuf Tarana	Srabanti Mazumder
Md. Ali Ahammed	Samiha Saleha	Shamsuddin Sarker Chonchol
Md. Kamruzzaman Konok	Md. Shahoriar Sarker	B D Rayhan
Md. Walid Hossen Tamim	Noshin Nower	Subeya Taieba Swarna
Sabrina Rubaiyat Kheya	Mahfuza Anzum Tamanna	Fatima Tuj Johra Juthi
Ishaq Sorkar	Shaheen Reza	Nazmul Shad
Masuda Afrin	Nayeem Samad	Shamiul Islam

Annex 3b: Photographs of the field survey



Photos taken during survey by the team of Bangladesh Agricultural University

Photos taken during survey by the team of University of Rajshahi, Bangladesh

Photos taken during survey by the team of Dhaka University, Bangladesh

Annex 3c: List of the participants of the research dissemination worsk-

Name	Designation and Institution	Name	Designation and Institution
Dr. Md. Enamur Rahman	MP, State Minister, MoDMR	**Tammana Haque Mim**	DSCR, DU
Pro. A. S. M. Maksud Kamal	Pro-VC, University of Dhaka	**Sabiha Anjum Dibby**	DSCR, DU
MD Ruhul Amin Talukder	Additional Secretary, Ministry of Agriculture	**Anika Tabassum**	DSCR, DU
Ms Munira Sultana	Chairman, SREDA	**Md. Kaium Hossain**	Assistant Professor, United International University
Kate Sangster	Australian High Commission, Bangladesh	**Partha Roy**	Video Journalist
Profesor John Evans	Curtin University Australia	**Selim Hossain**	Director, MoDMR
Dr Min Teah	Curtin University Australia	**Rishan Nasrullah**	Bangla Vision
Mr Hans Guttman	ADPC	**E. M. Talid Khan**	DU
Dr. Siddique Hossain	AIUB	**Sohel Ahmed**	Video Journalist
Dr. Mohammad Jahangir Alam	BAU	**S.M. Kamrul Hassan**	Assistant Professor, DSCR, DU
Dr Tauhidul Islam Tanin	Monash University Australia	**Golam Kadir Robu**	ATN News
Dr Ishtiaque Selim	Monash University Australia	**Noyan Islam**	MoDMR State Minister's Personal Photographer
Mr Saso Martinov	FAO Bangladesh	**Habiba Azad**	DSCR, DU
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Prof. Dr. Zillur Rahman	Professor		
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Annex 3d: Photographs of the research dissemination worskhop







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