INTRODUCING WATER-EFFICIENT TECHNOLOGIES INTO BANGLADESH

ALTERNATE WETTING AND DRYING FOR PADDY RICE

PROJECT SNAPSHOT

In northwestern Bangladesh, continuous irrigation of paddy rice has led to ‘groundwater mining’ and rapid depletion of aquifers.

This is particularly the case during the winter season from December to May. Most rice farmers practice traditional irrigation, drawing groundwater through either shallow or deep tube wells. On average, farmers irrigate each paddy plot about 15 times per season. Each irrigation cycle requires 300,000-500,000 liters of water per acre. However, the main financial cost of rice cultivation is labor; land leases and fertilizer are also expensive.

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PROJECT DESIGN

A promising way to reduce this water consumption is AWD, alternate wetting and drying of paddy rice. AWD applies controlled intermittent irrigation.

Instead of continuous standing water in the crop, farmers allow their fields to dry for a few days before re-irrigating. By slowing, or ideally halting, the depletion of groundwater, this new practice enables farming communities to cope better with more erratic water availability. The project described here also involves a second water-saving intervention. AWD is accompanied by a shift from paddy rice to higher-value, less water-intensive crops. Vegetables and fruit provide attractive rotation options here.

Alternate wetting and drying (AWD) is a method of controlled and intermittent irrigation, to cultivate irrigated rice with much less water than the usual system of maintaining continuous standing water in the crop. A periodic drying and re-flooding irrigation approach is followed in which the fields are allowed to dry for a few days before re-irrigation.

PROBLEM DEFINITION

- **Groundwater levels are declining**; continuous groundwater extraction reduces farmers' productivity and resilience
- **Irrigation efficiency in Bangladesh is the lowest in South Asia.** High production costs make agricultural produce uncompetitive
- Traditional rice production is a key agricultural **contributor to greenhouse gas emissions** (field flooding causes high methane production)

OBJECTIVES

- **Reduce groundwater extraction to avoid further depletion of groundwater levels**
- **Improve the resilience** of rice farmers

ACTIVITIES

1. Introduction of paddy cultivation using Alternate Wetting & Drying (AWD) techniques
2. Introduction of vegetables and fruits alongside paddy as high-value rotation options.

THE CLIMATE CHANGE CHALLENGE

Bangladesh has heavy rain during the June-September monsoon. The rest of the year is very dry. Outside the monsoon season, farmers irrigate their crops with groundwater. Most of them use inefficient methods such as flood irrigation. Heavy extraction has lowered groundwater levels, notably in northwestern Bangladesh's Barind Tract. This depletion is aggravated by increasingly erratic rainfall. In recent decades, both dry spells and flooding have become more frequent in the region.

HOW THE PROJECT IS **CURRENTLY** CLIMATE-SMART

The project's 'climate-smartness' is visible in all three pillars of CSRA: profitability, mitigation and resilience.

	PROFITABILITY	MITIGATION	RESILIENCE
AWD	+ Reduced costs of irrigation (-23%) + Minimal investment cost	+ Reduced water usage (-40%) + Lower GHG emissions than traditional rice production	+ Reduces water usage (-40%) + Increased resilience to erratic water availability
Crop diversification	+ Increased revenue from higher yields and prices of vegetables and fruit	+ Reduced water usage (-90%) + Reduced GHG emissions	+ Reduced water usage (-90%) + Income diversification + Increased resilience to erratic water availability

PILLAR 1: PROFITABILITY

- **Lower input costs**: **AWD** only very slightly increases yields. However, farmers' profitability improves thanks to the **lower pump costs** of less frequent irrigation. The required investment is only $0.50 to purchase a pipe. It should, however, be noted that many smallholders in Bangladesh grow rice for family food security, even if it generates a financial loss.

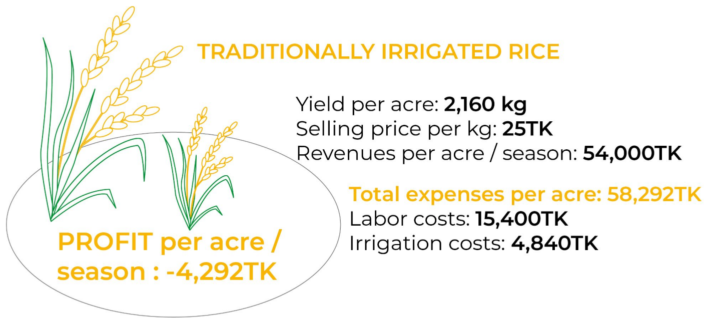
	Traditional irrigation	AWD	% Change
Rice yield per acre	2,160 kg	2,280 kg	+5%
Revenues per acre	54,000TK	57,000TK	+5%
Total expenses per acre	**58,292TK**	**57,172TK**	**-2%**
o/w irrigation expenses	*4,840TK (8,3%)*	*3,720TK(6,5%)*	*-23%*
o/w land lease expenses	*18,000TK (30,9%)*	*18,000TK(31,5%)*	
o/w land preparation expenses	*3,600TK (6,2%)*	*3,600TK (6,2%)*	
o/w fertilizer expenses	*10,452TH(17,9%)*	*10,452TH(17,9%)*	
o/w pesticide expenses	*6,000TK(10,3%)*	*6,000TK(10,3%)*	
o/w labor expenses	*15,400TK(26,4%)*	*15,400TK(26,4%)*	
Profit per acre	**-4,292TK**	**-172TK**	

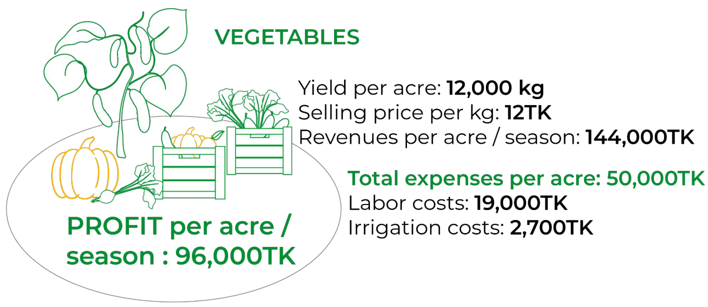
- Pricing influences the motivation to save water. There are currently two water pricing schemes for Barind Tract rice growers. Traditionally, access to water pumps has been priced on a contractual basis per acre. Here, farmers have no financial incentive to adopt AWD, as water charges do not depend on the amount used. The Barind Multipurpose Development Authority (BMDA) is now introducing volumetric payment systems. Making farmers pay for the water they actually use leads to savings for those farming in favorable locations.

- The introduction of AWD needs strongly coordinated change across communities farming in the same watershed.

- **Higher revenues and profit**: By diversifying – e.g. replacing irrigated rice with vegetables – farmers increase their revenues by up to 167% per acre. Total expenses for vegetable production are similar to those for rice, but earnings are much higher. Farmers making a loss with rice can earn handsome profits with vegetables. Our table illustrates a leap from a 4,292TK deficit per acre to a 96,000TK profit.

  The additional income can help support rice production which, despite limited profit, is very important for subsistence





PILLAR 2: MITIGATION

REDUCED **GREENHOUSE GAS EMISSIONS**

- In **AWD** fields, shorter flooding periods reduce methane (CH_4) production in comparison to traditional irrigation. Overall, AWD can decrease emitted gases' Global Warming Potential (see below*) by 35%[1].

Table. Effects of different irrigation techniques on greenhouse gas emission of rice fields in Bangladesh (based on CH_4 and N_2O emission measurements).

Water use	Traditional irrigation	AWD	% Improvement
Global Warming Potential (kg CO_2 equivalent/ha)	5,819.4	3,736.5	36%
Greenhouse Gas Intensity (kg CO_2 equivalent/kg grain yield)	1.01	0.67	34%

* Global Warming Potential: the capacity of greenhouse gases to absorb heat over 100 years, in relation to that of CO_2.

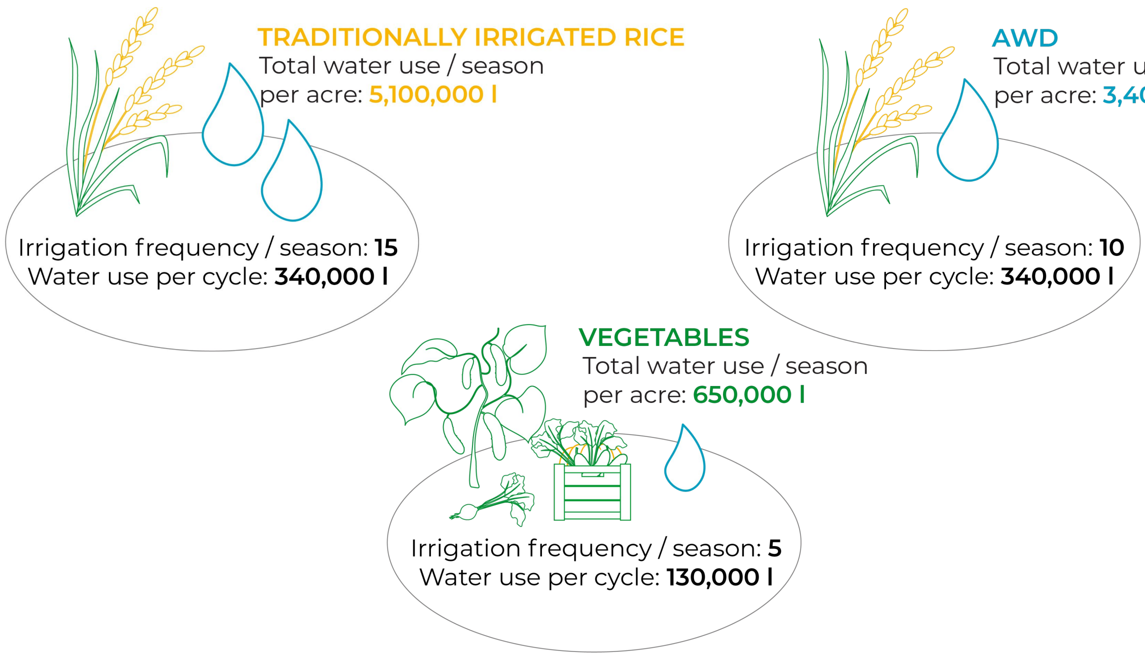
Greenhouse Gas Intensity: level of GHG emission per unit of economic activity (here: kg of grain yield). Data adapted from: S. M. Mofijul Islam et al., *'Effects of water management on greenhouse gas emissions from farmers' rice fields in Bangladesh'*, 2020

- Crop diversification. Compared to vegetables, rice has very high greenhouse gas emission rates, as flooded paddy fields produce high amounts of methane[2]. Alongside transitioning to AWD, growing vegetables on some of the land or as a rotation crop can further reduce emissions[3].

1. S. M. Mofijul Islam et al., '*Effects of water management on greenhouse gas emissions from farmers' rice fields in Bangladesh*', Science of the Total Environment, 2020
2. J. Poore and T. Nemecek, *'Reducing food's environmental impacts through producers and consumers'*, Science, 2018
3. Md Mozammel Haque, et al., *'Greenhouse Gas Emissions from Selected Cropping Patterns and Adaptation Strategies in Bangladesh'*, International Journal of Development Research, 2017.

WATER USE

- **AWD** reduces water use by 33%; irrigation frequency drops from 15 to 10 cycles per season. Total consumption per acre falls from 5,1 million liters per season to 3,4 million, for equal yields.
- **Crop diversification:** Substituting irrigated rice with vegetable crops reduces total water consumption by 87% (from 5,1 million liters to 650,000 liters). Vegetables need to be irrigated less frequently and consume less water per irrigation cycle.



PILLAR 3: RESILIENCE

The project enhances farmers' resilience in 3 ways:

- **Reduced water use:** The introduction of AWD helps farmers to be more resilient by ensuring the same yield with less water. It also avoids further depletion of groundwater, supporting the future resilience of farming systems.
- **Increased resource independence:** Reduced water demand makes farmers less dependent on declining aquifers and incidental power loss in the pumping facilities.
- **Increased diversification:** Through the introduction of vegetables, farmers diversify their revenue sources, while also spreading their income across seasons.

RESULTS TO DATE

In the first three years of the project, **7,200 farmers were trained** on AWD; 3475 (48%) have adopted the practice. A slightly higher number of farmers have adopted crop diversification, replacing part of their irrigated rice with vegetables.

# Farmers	2018	2019	2020	Total
Farmers trained	800	2,400	4,000	7,200
Farmers adopting AWD	206	1,200	2,069	3,475
Adoption rate AWD	*26%*	*50%*	*51%*	*48%*
Farmers adopting crop diversification	0	1,138	2,445	3,583
Adoption rate crop diversification	0%	47%	61%	49%
Land surface dedicated to vegetables (from paddy)	0	250	538	788

The main barrier to the adoption of AWD is that there is **limited financial gain**. The method does not increase productivity, and lower water use does not decrease costs when water is priced by area of farmed land. This issue is already partially addressed due to the local authorities (BMDA) gradually introducing the volumetric water payment system. Hence, we focus on the combination of **water cost savings** and **minimal investment** required. AWD is promoted in combination with crop diversification to ensure higher revenues and profits. However, farmers also adopt AWD because they experience **water scarcity** in their farming and household use.

CSRA IN A NUTSHELL

Our objective: To help smallholders grow profits (**profitability**) while increasing their capacity to deal with shocks (**resilience**) and reducing their negative impact on the environment (**mitigation**).

5 CSRA DESIGN PRINCIPLES	DESCRIPTION
Adapt CSRA as starting point	- Identify most important climate challenge - Formulate objectives across the 3 CSRA pillars
Become expert on target audience	- Define and prioritise various customer groups/ target audiences - Identify drivers and barriers to the adoption of promoted behaviour - Integrate behavioural change lens into project design

Clarify SFSAs role	- Clearly define SFSA's role:
	  - R&D
	  - Testing to drive initial adoption, demonstrate to partners
	  - Scaling / hand-over to partners

Deliver on farmer profitability & accessibility	- Conduct P&L analysis to understand the impact on short- and long term profits - Understand cash flow implications and potential financing need - Ensure financial sustainability after project subsidies end
Ensure coherent project design	- Demonstrate how activities contribute to the achievement of objectives - Ensure that activities are adapted to the target audience (e.g. purchasing power) - Set indicators that are aligned with the objectives and SFSA's role - Make conscious trade-offs to ensure farmer adoption

REFLECTIONS

DESIGN PRINCIPLES	LEARNING
Adapt CSRA as starting point	+ Groundwater depletion key climate change challenge in Barind Tract + Objectives defined across 3 CSRA pillars: profitability, resilience and mitigation
Become expert on target audience	+ Baseline conducted on rice farming - Adoption rate can potentially be improved by clearer customer segmentation and behavioral change lens
Clarify SFSAs role	+ SFSA's role clearly defined: testing to drive initial adoption and demonstrating to partners
Deliver on farmer profitability & accessibility	+ Detailed data available on cost structure of rice farming + Activities are financially sustainable: - Minimal investment the costs required - Crop diversification ensures short-term profit gain for farmers + Make sure that farmers are connected to offtake markets when recommending a full business case on the transition to vegetables, i.e., careful selection of the new crop, considering (i) perishability and (ii) strength of existing value chains, or investments required in developing new value chains + To drive farmer adoption, consider creating a stronger financial incentive through policy changes that would switch the water pricing systems from payment by land surface to payment by volume of water used.
Ensure coherent project design	+ Activities contribute to achievement of objectives + Activities are adapted to target audience as minimal up-front investment costs + Bundling with crop diversification ensures mitigation and profitability benefits

OUTLOOK ON SAVING WATER IN THE BARIND TRACT

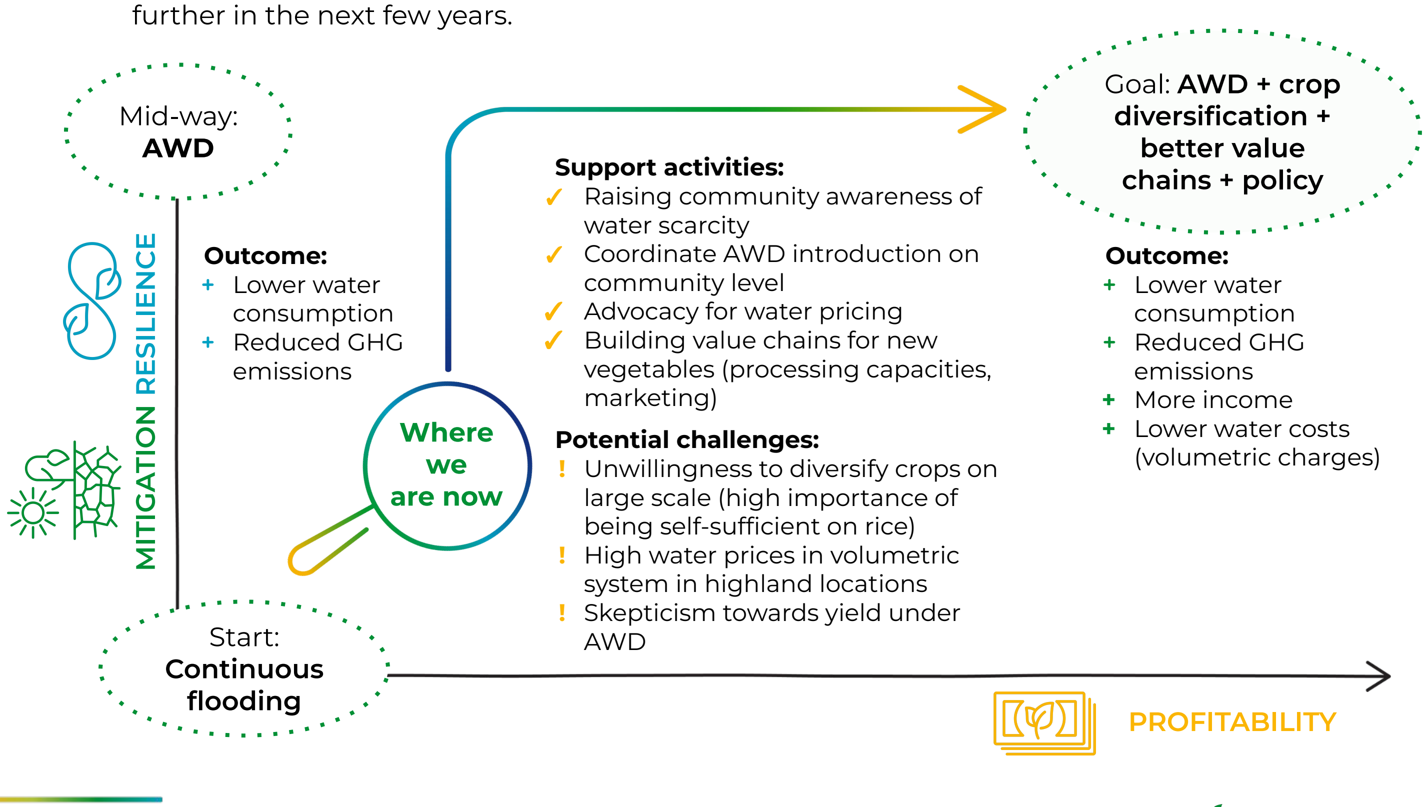
Water pricing changes are already underway in the Barind Tract

The BMDA is introducing volumetric water distribution systems (pre-paid pumps) for rice fields throughout the region. Compared to the previous contractual system (fixed price per acre per season), this will reduce water costs at least for farmers in the lowlands, where groundwater is widely available and little irrigation is necessary. The water payment change will be especially noticeable in the highlands, where groundwater declines very quickly, and water costs are still higher in the volumetric payment system than in the contractual payment system. These farmers will have the strongest incentive to introduce AWD in their fields. This discrepancy shows that there is still room for improvement in terms of the financial regulation of water usage in rice farming. While adjusting water pricing systems is very important, it is not the only component of the problem. In general, irrigation constitutes less than 10% of rice-growing expenses. Growing environmental awareness in the community is therefore also essential.

Vegetable production has a different water pricing scheme than rice production as it requires significantly lower amounts of water per season. Therefore, water prices are not an important factor in the profitability of vegetable growing.

Community awareness is an important factor in the region-wide success of AWD adoption

Farmers want to see for themselves that introducing AWD does not reduce yield. Once they have seen this in their own or neighbors' fields, they have no reason to continue using the traditional system. Gradual awareness-building in the community, coupled with the introduction of volumetric payment water pumps, is expected to raise AWD adoption rates further in the next few years.



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