Opportunities for Agricultural Water Management interventions in the Jaldhaka watershed in Koch Bihar, West Bengal, India

Key Findings

- Agricultural production and development in the watershed is not restricted by availability of water resources which is plentiful, but by land area per smallholder household (0.8 ha per household) and limited opportunity to intensify water use through access to appropriate irrigation. The pumps needed to access groundwater are limited in availability, affecting the opportunity for optimal irrigation scheduling, thereby decreasing yields.
- Groundwater provides roughly 80% of irrigation water in the watershed (equalling roughly 145 mm/year, or less than 5% of annual rainfall), compared to about 20%, which comes from the river. Despite high level of groundwater use, the exploitation is less than groundwater recharge (570 mm/year), indicating there is room for increased outtake of irrigation for summer-season rice production.
- The cropping intensity in the watershed is high (163% in Maynaguri Block and 192% in Mathabhanga Block), with up to 3 crop cycles per year, depending on access to irrigation. Further increasing intensification of crop production on diminishing land parcels is needed to reduce poverty and raise income. Yet, due to the difficulties in increasing income from the traditional cropping patterns, those farmers in the upper part of the watershed who have the appropriate land type and enough finances to wait the initial two years before the first harvest have shifted to producing tea as their sole cash crop.
- The potential for electrification is very important to smallholders in the watershed. The overall realistic impact of electrification may be small on the water resources of the Jaldhaka watershed, while it may enable smallholders to produce 13% to 25% additional rice, equivalent to approx 61,000 to 116,000 additional tons per year.
- Since each household depends on and manages its own resources, and there are few community initiatives related to livelihood improvement, the landless, and farmers with particularly small parcels, are very vulnerable.
- Decreasing numbers of animals (and thus manure) due to mechanization and increased crop intensification have led to an increase in use of agro-chemical inputs such as fertilizers and pesticides. This has caused an increase in health problems, especially for farm and tea plantation laborers.
- Knowledge on soil fertility and soil health is limited. Thus, soil fertility may be another limiting factor for improving yields on smallholder plots. Further knowledge is needed to ensure investments in irrigation are realised through good soil health and nutrient management.

What are Agricultural Water Management interventions?

Agricultural water management (AWM) interventions are increasingly being promoted as a first step to enable positive development, alleviating food insecurity and poverty in the smallholder farming systems that dominate rural South Asia and sub-Sahara Africa. These AWMs range from in-situ soil and water management improvements (conservation tillage, terraces, pitting) to supplemental and full irrigation systems, drawing water from a wide variety of sources in the landscape. However, re-allocation of water can potentially undermine other uses of the same water, for other livelihood purposes or, indirectly, by reducing availability for support of different ecosystem services. This case study, in the Jaldhaka watershed in West Bengal, India, aimed to create a baseline of resource-based livelihoods and to assess the potential for ad-

Figure 1 A tea grower transporting the irrigation pipes to the next tea field

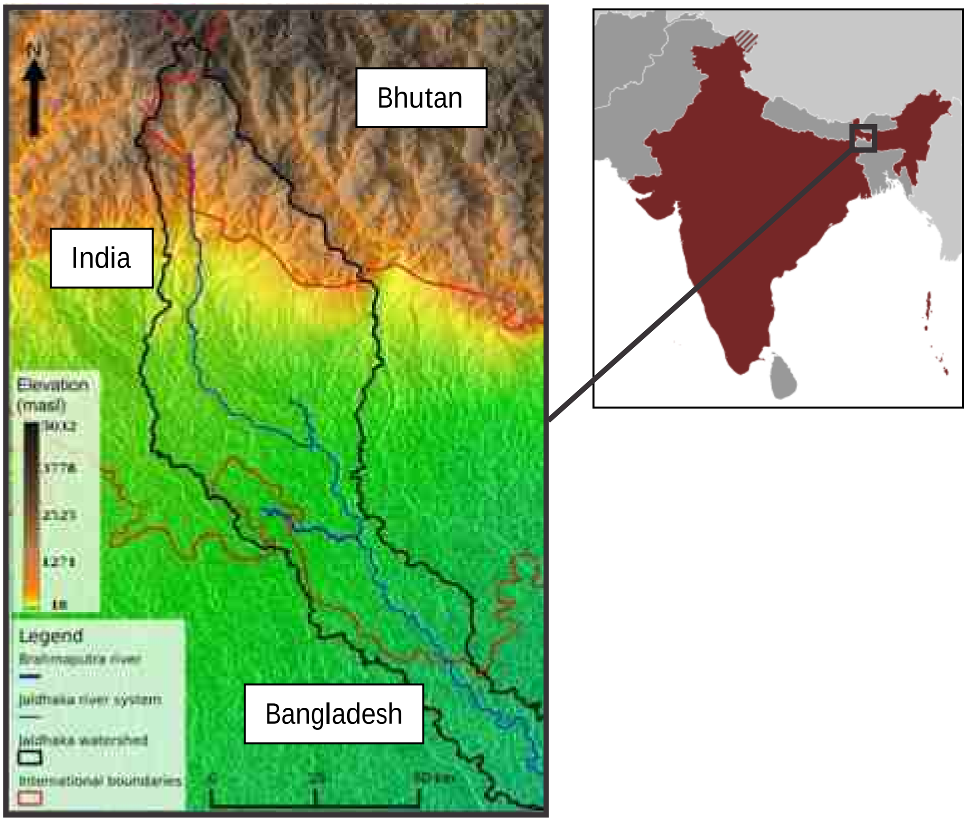


Figure 2: Delineation of the Jaldhaka watershed and the river tributaries

ditional development of AWM interventions in relation to the local hydrology.

Water and land for agriculture in Jaldhaka

The river Jaldhaka is a tributary of the Brahmaputra River and flows through Bhutan, India and Bangladesh (Figure 2). The total area of the Jaldhaka watershed is 6,140 km^2, mainly located in India (66%) and the rest almost equally in Bangladesh (18%) and Bhutan (16%). Jaldhaka basin has a contrasted topography that can be characterized by three regions: a mountainous upstream, a piedmont upstream, and a flat middle and downstream. The watershed experiences high rainfall with an average of 3,180 mm y^{-1}, 80% of which falls during the rainy season, June-September. The ratio of rainfall to evapotranspiration is high at 2.5. Near 75% of rainfall is diverted to streamflow and about 25% is evapotranspiration of crops and other vegetation. The shallow groundwater recharge equals 13% of the rainfall and contributes to streamflow through groundwater baseflow. The Jaldhaka River is perennial but has high seasonal variation. There is a wealth of shallow groundwater in the area with average groundwater level at 2-4 meters deep.

What are the main livelihood strategies in the watershed?

The three main livelihood systems of the India section of Jaldhaka watershed were identified as farmers with multi-crop agriculture, farmers dependent on off-farm income, and independent tea-producing farmers. Independent tea producers do better financially than those with multi-crop agriculture, who are still more secure than those dependent on off-farm or non-farm income. The population density is high in this area. Figures for West Bengal show that in rural areas an average 676 persons live on one km^2. In Cooch Behar about 65% of the rural population fall into the Indian ‘below poverty line’ category. A striking feature of the livelihoods in the Jaldhaka watershed is the strong sense of individuality: each household

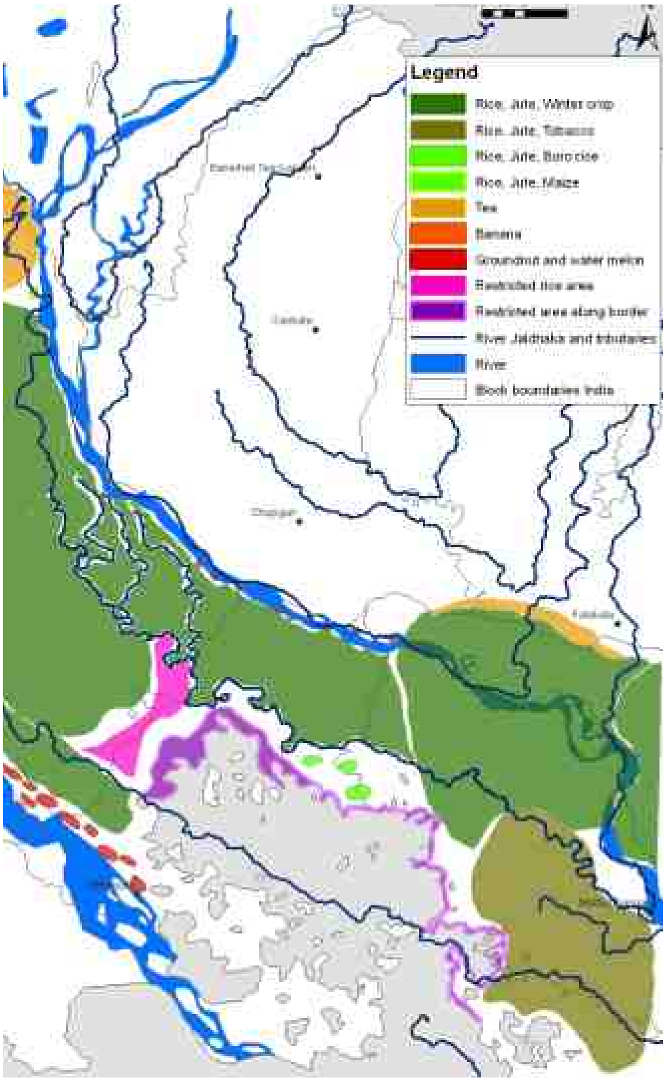


Figure 3: land use map relating to the three livelihood strategies identified.

depends on and manages its own resources (land, trees, and groundwater), and there are few community initiatives related to livelihood strategies and farming. Those without land, or with particularly small parcels, are very vulnerable.

Farmers practicing multi-crop agriculture have small parcels with a high intensity of production (163% in Maynaguri District and 192% in Coochbehar District), growing up to 3 crops per year. The main cropping patterns are jute - kharif or aman rice - winter crop (potatoes, and/or vegetables) and jute - kharif or aman rice - tobacco (Figure 3). Rice is the staple crop and is predominantly for household consumption. Farmers with access to regular irrigation from groundwater in the lower part of the watershed grow summer-season rice (*boro* rice, as it is called) as a cash crop. The most common method of irrigation is diesel pumps, followed by electric pumps, and then treadle and hand pumps. Along the smaller rivers farmers use canals, ponds and river lift irrigation. A few farmers in each village own a diesel or electric pump and rent them out to the others. However, pump rental is often prohibitively expensive or unavailable at the necessary time of irrigation due to high demand. The tea growers largely use flood irrigation by pumping groundwater with a diesel or electric pump.

Some households in the watershed rely heavily on off-farm income for their livelihoods, either to supplement their insufficient farm production, or as their sole earning activity. Most households in this category cultivate crops on their own land or on leased land, using off-farm income to supplement food supply; others buy all their food.

Smallholder farmers in the upper part of the watershed who have the appropriate land type and enough finances to wait the initial two years before the first harvest, have started their own small tea gardens. A few Self Help Groups have been established to help the independent producers to better access markets. Others have chosen to be 'out-growers', where they sell their land to a tea company, continue producing tea on the same plot, and the company purchases all of the produce.

Cattle are important to all three livelihood groups, providing financial security in addition to milk, dung for fertilizer, and labour for ploughing. Due to mechanization, the number of cattle has been declining while intensification has been rising, resulting in the use of heavy amounts of fertilizers and pesticides. This is leading to increased health problems in the watershed.

What potential impacts could AWM interventions have?

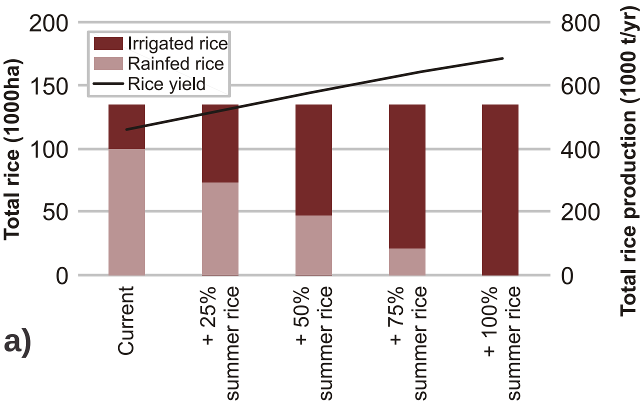
Lack of electricity is a major constraint for smallholders. Affordable electricity would enable cheaper irrigation (switching from diesel to electric pumps) as well as other benefits such as light for their children to study at night. In a consultation with watershed experts, a scenario for complete electrification of the watershed was reviewed. In the scenario, farmers would be able to switch from diesel to electric pumps, allowing for increased irrigation. With increased irrigation, farmers would likely irrigate their current rice crop and also grow an additional rice crop during the dry season for sale. In addition, potatoes could be further expanded if extra post harvest storage facilities could be developed. Farmers would be able to use pumps at the optimal time, increasing yields and thereby income. However, increased irrigation in the dry season

Figure 4: Farmer in the Jaldhaka watershed using a treadle pump

would require in increase in purchase of inputs, which would somewhat reduce the rise in income. The entire chain of input shops, cold storage, processing and packaging units, marketing, and transport would benefit from the increased production. For tea growers, electricity would allow the use of improved technologies such as sprinkler irrigation and power sprayers for pesticide application. By improving roads and increasing facilities (such as cold storage), the benefits of increased production would be even greater.

Electricity access would enable additional improvements for government and civil society organizations supporting smallholders. Government training could improve through the use of computers, making farming clubs the portal for market information. Civil society institutions could improve their external connections through computers, and ultimately raise their budgets, enabling them to further assist smallholders.

This scenario of full electrification was also assessed for potential water resource impacts through hydrological modeling. Four sub-scenarios were tested: increasing intensification by shifting one season rainfed rice production to two irrigated rice crops per year on 25%, 50%, 75%, and 100% of the current rainfed rice area. This analysis showed that with withdrawals increasing to 400 mm y^{-1} (100% sub-scenario) from 145 mm y^{-1} (current situation), river flows could decrease in the dry season, and groundwater could decrease annually (see Figure 5 a and b). An increase of 50% irrigated area or higher may disturb the current sustainable exploitation of groundwater. At 100%, downstream groundwater levels would decrease by up to 8 meters. Throughout the watershed, groundwater baseflow would reduce by 15% in the 50% sub-scenario and by 30% in the 100% sub-scenario. Although there is a small reduction of streamflow noticeable during the dry season, the overall impact on the annual flow of the Jaldhaka River is small. The gains in increased electrification may enable smallholders to



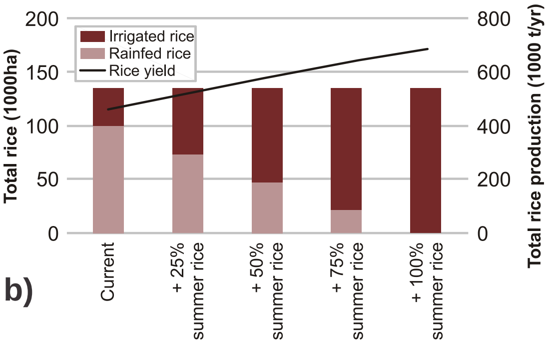


Figure 5: Current state and hydrological impacts of electrification scenario, a: crop area change (ha) and associated total rice production (t y^{-1}) and b: impacts on surface annual and low flow surface and groundwater resources (as % deviation from current state) for increasing irrigated (summer) rice.

produce 13% (in the 25% sub-scenario) or even 25% (in the 50% sub-scenario) additional rice (Fig 5b). Exploiting surface water resources is generally more energy efficient and could be done through storage and/or diversion of a fraction of the sudden high river flows for distribution through a network of canals later during the dry season. However, storage would be very difficult in the parts of the watershed located in India and Bangladesh, where the terrain is very flat and most land is already under cultivation.

There are a few cascading concerns with this scenario. First, not all smallholders will be able to afford electricity limiting their ability to improve their livelihoods. Government subsidies could make a difference, but still not everyone would be able to afford it. Second, increased irrigation would likely lead to increased use of pesticides and fertilizers, which could potentially negatively impact livelihoods and health in the long-term. The local environment and the health of residents are already affected by inappropriate use of agro-chemicals. Third, the soil health and fertility depletion associated with continuous cropping in the Jaldhaka may become a barrier to further intensification. This could be mitigated through training on techniques to maintain soil health. Overall, electrification will have positive impacts on livelihoods in the watershed if steps are taken to ensure equity of access and mitigate potential negative side effects. Further knowledge and efforts to ensure sustainability are needed to successfully realize the potential of adoption of AWM technologies in the Jaldhaka watershed.

Figure 6: Women participating in a baseline livelihood assessment in Jaldhaka

Further information available on demand:

De Condappa, D., J. Barron, S. K. Tomer and M. Sekhar 2011. 'Application of SWAT and a groundwater model for impact assessment of agricultural water management interventions in Jaldhaka watershed, West Bengal: Modelled water balances for current landuse and scenario of agricultural development.'

De Bruin, A., M. Mikhail, A. Brahmachari, 2010. 'Assessment of impacts of AWM interventions on resource-based livelihoods: Agriculture Water Management Scenarios in the Jaldhaka Watershed, West Bengal, India'.

De Bruin, A., M. Mikhail, 2010. 'Assessment of impacts of AWM interventions on resource-based livelihoods: Baseline Assessment of Current Livelihood Strategies in Jaldhaka Watershed, West Bengal, India.

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Published by:
Stockholm Environment Institute
Kräftriket 2B
SE -106 91 Stockholm
Sweden
+46 8 6747070

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Authors: Monique Mikhail, Annemarieke de Bruin
(annemarieke.debruin@sei-international.org)
Devaraj de Condappa
SEI Head of Communications
Robert Watt +46 73 707 85 89
robert.watt@sei-international.org