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Water Saving in Rice Production– Dissemination, Adoption and Short Term Impacts of Alternate Wetting and Drying (AWD) in Bangladesh

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Photos	Left (woman with rice): Ema Jülich Right (kids and irrigation): Caroline Paul Right (rice): Ema Jülich

Für Jenny

mit der wir gelacht, getanzt & gesungen haben.

Danke für die gemeinsame Zeit.

Du fehlst.

Somewhere over the rainbow
Way up high,
There's a land that I heard of
Once in a lullaby.

Somewhere over the rainbow
Skies are blue,
And the dreams that you dare to dream
Really do come true.

Someday I'll wish upon a star
And wake up where the clouds are far
Behind me.
Where troubles melt like lemon drops
Away above the chimney tops
That's where you'll find me.

Foreword

The Postgraduate Studies on International Cooperation (SLE) at the Humboldt Universität zu Berlin has trained young professionals in the field of international development cooperation for more than 45 years.

Three-month consulting projects conducted on behalf of German and international cooperation organizations form part of the one-year postgraduate course. In multidisciplinary teams, young professionals carry out studies in innovative future-oriented topics and act as consultants. Including diverse local actors in the process is of great importance here. The outputs of this “applied research” are an immediate contribution to solving development problems.

Throughout the years, SLE has carried out over one hundred consulting projects in more than ninety countries, and regularly published its results in this series.

In 2010, SLE teams completed studies in Bangladesh, in the Dominican Republic, in Sierra Leone and Namibia.

The present study was commissioned and co-financed by the International Rice Research Institute (IRRI) and the Advisory Service on Agricultural Research for Development (BEAF) of GTZ. The study analyses the dissemination, adoption, and the early impacts of the Alternate Wetting and Drying (AWD) technology in irrigated rice in Bangladesh.

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Summary

Rice is the staple food of 164 million Bangladeshis, accounting for 77% of the total cropped area and two-thirds of the value-added of crop production, with an agrarian structure dominated by marginal and small farm holdings. During the past decades, rice production in Bangladesh experienced an impressive intensification. In the north and north-western divisions of Rajshahi and Rangpur, the increase in rice production is largely attributed to an unprecedented expansion of dry season cultivation, triggered by the liberalization policy for small-scale irrigation equipment.

The change to dry season rice, constituting about 60% of national rice production, was largely due to groundwater irrigation by shallow tube wells (STW) and deep tube wells (DTW). This practice led to the massive extraction of groundwater, an overexploitation of groundwater, locally manifested by declining groundwater tables in Rajshahi. Correspondingly to the expansion of irrigation, demand for energy increased, as electricity or fuel are needed to lift groundwater to the surface. This also touches on the chronically deficient energy situation of Bangladesh.

To address problems of water scarcity, researchers had been looking for ways to decrease water consumption of the rice crop. Alternate Wetting and Drying (AWD) is a technology developed by the International Rice Research Institute (IRRI). The technology is based on the knowledge that rice tolerates up to 30% reduced water supply during the main growing period compared to conventional irrigation. To determine the timing of irrigation, the water level in the soil is monitored by a perforated plastic tube, which is inserted into the rice field. AWD requires irrigation when the water level drops to 15 cm below the soil surface.

The introduction of AWD in Bangladesh started in 2004, with the IRRI playing a central role in promoting the technology. Since then public, private sector and non-governmental organizations introduced AWD into their programs, entering validation and pilots to disseminate the technology. As sound and reliable analysis of the outcomes and experiences of this process were lacking, the IRRI, in collaboration with the Advisory Service on Agricultural Research for Development (BEAF) of the German Technical Cooperation (GTZ), commissioned a study with the following objectives:

- To analyze the approaches and the organizational environment of dissemination;
- To assess constraining and enabling factors of adoption and short-term impacts;
- To draw general lessons learned with the AWD technology.

The study focuses on the Rajshahi and Rangpur Divisions and is based on a multi-level methodological concept at national, regional and local level involving a mixture of qualitative and quantitative sampling methods. A total of 67 semi-structured key informant interviews were conducted with stakeholders of national relevance and policy influencing actors, disseminating organizations and extension staff on the regional and local level. The field survey with farmers and pump owners as well as operators comprised 272 interviews. The sample was structured into farmers who either adopted or did not adopt AWD and farmers who did not receive training in AWD. Nine focus group discussions were organized with farmers and pump owners. Primary and secondary literature analysis as well as two stakeholder workshops complemented the empirical research.

Altogether, the findings of the study reveal that adoption and dissemination of AWD are still in their early stages, as organizations only started implementing programs to spread AWD from 2007 onwards.

The dissemination of AWD found high commitment by key organizations within their geographical mandate. However, a clear dynamic of the process at national level could not be observed. Many organizations had not gone far beyond piloting and validating the new technology.

One reason seemed to be a lack of ownership of the overall process, taking the lead to institutionalize the dissemination of AWD, which up until now, largely depended on the facilitation role of the IRRI, whereas the Bangladesh Rice Research Institute (BRRI) with its mandate for rice research, and the Department of Agricultural Extension (DAE), the main actor for disseminating agricultural innovations to farmers, stayed behind.

Initial steps have been taken to incorporate AWD into policies and structures at the national level. However, the National Irrigation Policy, which is currently being prepared, is the only explicit reference in this context. Whether these efforts will change the way irrigation is being organized remains to be seen.

At the same time, existing structures for agricultural technology development and extension did not take an active part, adding to a slacking process. In addition, cooperation and coordination between the organizations involved in disseminating AWD, including the sharing of experiences, tended to be insufficient and opportunities for developing a joint action or strategy were not being utilized.

To spread AWD at the local level, field staff who actually trains the farmers plays a critical role, as the survey showed. Field staff seemed to be limited in their resources for intensifying and scaling-out training activities to a greater number of farmers.

Considering that AWD is a knowledge-intensive technology, it appeared that most organizations were limited by the capacity and capability of well trained extension staff. This was partly attributed to inadequate training received from within their organizations. As a consequence, training of farmers was reported to lack quality and to insufficiently transfer the knowledge on AWD to farmers.

The approaches used by the different organizations, though often addressing groups of farmers, did not sufficiently address farmers from the same command area, or take into account the specific and varying features of the local irrigation systems.

The analysis of adoption of AWD by farmers confirmed that there is a substantial demand for AWD as a water- and energy saving technology for rice cultivation in the dry season. Actual adoption of AWD, however, is strongly determined by factors, either external or internal, which influence the local irrigation systems. Overall, the survey confirmed that the mass uptake of the technology has not (yet) occurred.

The chronically unreliable electricity supply has been found to negatively affect adoption, as it obstructs farmers from practicing in-time irrigation, a precondition of implementing AWD. It was concluded that farmers require a certain level of reliable and secure water and energy supply to be able to adopt AWD. The unreliable water supply has brought farmers to practice many variations of AWD, which mostly do not allow for the full exploitation of the potential for saving water and energy.

The largest water and energy saving potential benefits are expected with DTW and larger STW–based irrigation systems. All famers from a command area (mostly served by one tube) would be required to practice AWD and perform irrigation at the same time. This has not been observed in the field.

The conditions for practicing AWD are determined by the diverse features of STW and DTW-based irrigation systems, which vary significantly from one location to another. This includes, for example, regulations of payments, decision-making among users within a command area, the type of organizational arrangement, and the magnitude including the number of water users.

One of the most decisive factors influencing adoption was found to be the irrigation serial, which determines the sequence and schedule by which a block in the command area receives water. Currently, this serial irrigation limits a farmer’s ability to apply AWD irrigation. Farmers do not always receive water at the time of demand, since irrigation is executed by a pump operator or the pump owner. The greater the individual control over the timing of irrigation, as is the case with pump owners, the greater the practicality of implementing an AWD irrigation regime.

Another factor that is critical for the adoption of AWD by farmers is the role of the pump owners and operators on the stipulation of irrigation charges and the payment system. Fixed-rate arrangements discourage farmers to adopt AWD since charges for irrigation are by fixed amounts, which are settled prior to the season. Pump owners up until now mostly do not pass on the economic benefits, which occur due to savings of irrigation water and energy by farmers practicing AWD. This system emerged as the most common payment arrangement in STW and DTW-based irrigation schemes.

The current status of adoption and dissemination of AWD resulted in an analysis of the short-term impacts of the application of AWD.

Social changes at the level of the farmers, which may be attributed to the application of AWD, could not be observed yet. This seems related to the fact that wide-scale adoption of the technology has not happened so far. The assumption was that a reduction of excessive consumption of irrigation water ultimately contributes to the alleviation of conflicts over scarce water resources. However, successful irrigation management with AWD and sharing of benefits from water saving will only be achieved through collective action. This requires that medium, small-scale and marginal farmers within irrigation systems establish close collaboration. Adoption levels will then increase and this will enable to social changes to be measured.

Cultural changes in terms of beliefs and attitudes towards standing water could be detected. Farmers who apply AWD are mostly convinced that standing water is not needed at all the stages of rice growth, while the majority of rice farmers without training on AWD adhere to the belief that standing water is required to obtain a good yield. However, even these farmers seem to change their traditional beliefs that rice needs standing water, prompted by repeated dry spells which they have experienced over recent years.

The partial analysis of economic impacts showed that economic benefits in general by applying the technology were actually perceived by 81% of the farmers. The number of irrigations was reduced by 28% on average, while irrigation cost was nearly 20% less for the farmers who adopted AWD. Such a level of monetary profit, however, was observed only in cases where the payment system for irrigation is consumption-based compared to a fixed rate system. Weeds, however, were affected differently by the AWD regime, which often led to increased occurrence of weeds resulting in increased expenditure in hired labor for handweeding. Some farmers effectively managed the increased weed growth through the application of herbicides. Yields of rice increased by about 0.4 to 0.5t/ha, which is equivalent to about 10%. In addition, farmers often mentioned that rice crops under AWD look stronger and healthier, and develop more tillers and panicles.

The assessment of the dissemination and adoption of Alternate Wetting and Drying showed that the potential of the technology in Bangladesh has not been fully utilized up until now, given the high demand and potential that the technology offers for farmers to improve the irrigation of rice during dry (Boro) season. Utilizing this potential in the near future remains a challenging task. Since the further spread of AWD at this stage depends to a great extent on the actions taken and efforts made at the organizational level to improve and institutionalize the dissemination process in Bangladesh, recommendations address, in particular, the stakeholders at large and the key actors involved in disseminating AWD to farmers and pump owners.

Specific recommendations for changes and adaptations at national level:

1. The BRRI should assume ownership to facilitate the further process
2. The DAE should take the lead in disseminating AWD and to coordinate among the agencies involved in dissemination
3. Dissemination of AWD should become a priority issue on the agenda of the National Agricultural Technology Coordination Committee
4. Formulate a national strategy of AWD dissemination in Bangladesh
5. Develop strategic partnerships for disseminating AWD
6. Involve local government in the dissemination process

Specific recommendations to adjust approaches for AWD dissemination in order to meet context specific needs:

1. Adapt AWD dissemination approaches to local irrigation systems
2. Design training to fit AWD use in command areas of irrigation systems
3. Support farmers and pump-owners to develop a fair sharing of benefits
4. Strengthen the quality of training for farmers
5. Address possible adaptations of AWD during training of farmers
6. Improve monitoring and evaluation of AWD dissemination

General recommendations and lessons for disseminating natural resource management technologies based on experiences with AWD in Bangladesh:

1. Build on an overarching strategy to disseminate new technologies
2. Involve policymakers and ensure policy support early in a process
3. Establish a platform to coordinate research and dissemination activities
4. Involve extension agencies early on in technology dissemination
5. Encourage strategic partnerships between disseminating organizations
6. Emphasize on the benefits of a technology in promoting its dissemination
7. Integrate end-users from start in a process of developing technologies

Though impacts of a technology, as is the case with AWD, might have been demonstrated in one region, the compatibility of this technology with the local farming and resource management systems in another region needs to be re-evaluated.

This particularly applies when promoting an NRM-related technology, which may face many context-specific requirements.

Zusammenfassung

Reis ist das Grundnahrungsmittel für die 164 Millionen Einwohner von Bangladesch. Er wird auf 77% der gesamten landwirtschaftlichen Anbaufläche angebaut und generiert etwa zwei Drittel der Wertschöpfung in der Landwirtschaft, wobei Reis hauptsächlich von Bauern mit kleinen und kleinsten Anbauflächen produziert wird. In den letzten Jahrzehnten kam es zu einer zunehmenden Intensivierung des Reisanbaus in Bangladesch. In den nördlichen und nordwestlichen Provinzen (“divisions“) Rajshahi und Rangpur kann diese Intensivierung hauptsächlich der Ausweitung von Reisanbau in der Trockenzeit zugeordnet werden, begründet durch eine Liberalisierungspolitik zugunsten der landwirtschaftlichen Kleinbewässerung.

Inzwischen werden ca. 60% der gesamten nationalen Reisproduktion in der Trockenzeit produziert, wobei überwiegend mit Grundwasser bewässert wird. Dazu bedienen sich die Bauern Pumpen, die Grundwasser aus Tiefen von bis zu 30 m fördern können, sogenannte shallow tube wells (STW) und Pumpen, die aus bis zu 80 m fördern können, sogenannte deep tube wells (DTW). Durch die verstärkte Bewässerung kam es lokal schon zur Übernutzung der Grundwasserressourcen, mit der Folge von sinkenden Grundwasserständen, wie zum Beispiel in Rajshahi Division. Außerdem erhöht der zunehmende Energiebedarf der Pumpen den Druck auf die ohnehin schon knappe Energieversorgung in Bangladesch.

Um dieser Entwicklung entgegenzuwirken haben Wissenschaftler des International Rice Research Institute (IRRI) die Alternate Wetting and Drying (AWD) Technologie entwickelt. AWD ist eine wissensbasierte Technologie, die auf der Erkenntnis beruht, dass Reis mit bis zu 30% weniger Wasser angebaut werden kann als unter herkömmlichen Methoden des Nassreisanbaus. Dabei sind keine negativen Auswirkungen auf den Ernteertrag zu erwarten. Dazu wird ein perforiertes Rohr in das Reisfeld eingebracht, mit dem sich der Wasserstand unter der Bodenoberfläche messen lässt. Wenn das Wasser auf 15 cm im Boden absinkt, sollte wieder bewässert werden.

AWD wurde erstmals 2004 von IRRI in Bangladesch vorgestellt. IRRI nahm bei der Verbreitung der Technologie nach Bangladesch eine zentrale Rolle ein. Seitdem haben sich in Bangladesch mehrere öffentliche und private Organisationen sowie Nicht-Regierungsorganisationen der AWD Technologie angenommen. Sie haben die Technologie für sich validiert und damit begonnen, AWD im Land zu verbreiten. Zurzeit gibt es jedoch noch keine zuverlässigen Daten über die Erfahrungen und Ergebnisse der Verbreitung, so dass IRRI mit der Beratungsgruppe Entwicklungsorientierte Agrarforschung (BEAF) der Deutschen Gesellschaft für Technische Zusammenarbeit (GTZ) diese Studie mit den folgenden Zielen in Auftrag gegeben hat:

- Analyse der Verbreitungsansätze und der beteiligten Organisationen
- Einschätzung der fördernden und hindernden Faktoren für die Übernahme der Technologie sowie die Bewertung von kurzfristigen Wirkungen
- Ableitung genereller Schlussfolgerungen aus der Verbreitung der AWD Technologie in Bangladesch

Der Studie, mit dem Schwerpunkt auf die Regionen Rajshahi und Rangpur, liegt ein Mehr-Ebenen-Konzept zugrunde, das die Prozessbeteiligten auf nationaler, regionaler und lokaler Ebene berücksichtigt. Zur Erhebung der qualitativen und quantitativen Daten wurde ein Methodenmix eingesetzt. Insgesamt wurden 67 halbstrukturierte Experteninterviews mit relevanten Akteuren auf nationaler Ebene, Vertretern aus dem Management von Organisationen sowie entsprechenden landwirtschaftlichen Beratern auf regionaler und lokaler Ebene durchgeführt. Insgesamt wurden 272 standardisierte Interviews mit Bauern, Pumpenbesitzern sowie Pumpenbetreibern durchgeführt. Die Stichproben unterteilten sich in Bauern, die AWD anwenden, solchen die AWD trotz Training nicht anwenden und Bauern, die kein entsprechendes Training bekommen haben. Zusätzlich wurden neun Diskussionen mit Gruppen von Bauern und Pumpenbesitzern organisiert (fokus group discussions). Die empirischen Untersuchungen wurden ergänzt durch die Analyse von Primär- und Sekundärliteratur sowie zwei Workshops mit Entscheidungsträgern.

Die Ergebnisse zeigen, dass sich die Verbreitung und Annahme von AWD noch in einer Anfangsphase befinden. Erst seit 2007 wird AWD systematisch von Organisationen in Bangladesch verbreitet. Die beteiligten Organisationen sind sehr engagiert in der Verbreitung der Technologie. Trotzdem konnte auf nationaler Ebene kein dynamischer Prozess der Verbreitung beobachtet werden. Viele Organisationen haben die AWD Verbreitung noch nicht vollständig in ihre regulären Aufgaben integriert, d.h. sie stehen noch in einem Anfangsstadium der Validierung und Verbreitung der Technologie.

Ein Grund dafür scheint die vorrangige Rolle von IRRI im Verbreitungsprozess. Obwohl das Bangladeschische Reisforschungszentrum (BRRI) und die Landwirtschaftsbehörde (DAE) die nationalen Mandate für Reisforschung und die Verbreitung von landwirtschaftlichen Innovationen haben, hat keine dieser Einrichtungen bisher eine tragende Rolle (*ownership)* für den Prozess der Verbreitung der Technologie in Bangladesch übernommen. Insgesamt ist der Verbreitungsprozess bisher wenig institutionalisiert und im Wesentlichen von der Initiative des IRRI abhängig.

Es gab erste Schritte, die Verbreitung und Nutzung von AWD in die neue Nationale Bewässerungsverordnung aufzunehmen. Konkrete Ergebnisse dieser Policy, die sich derzeit noch in Vorbereitung befindet, hängen jedoch davon ab, inwieweit diese Verordnung dann auch umgesetzt wird und zu Veränderungen im Hinblick auf den Einsatz von AWD auf lokaler Ebene führt. Dies ist im Übrigen bisher die einzige explizite Verankerung von AWD auf Politikebene.

Gleichzeitig wurden bestehende Strukturen für die Entwicklung und Verbreitung landwirtschaftlicher Technologien bisher nur unzureichend genutzt. Kooperation und Koordinierung der an der Verbreitung beteiligten Organisationen sind in der Regel unzureichend, und Möglichkeiten, eine gemeinsame Strategie zu formulieren oder gezielt zu kooperieren, wurden nicht ausreichend genutzt. Auch wurden Erfahrungen mit der Verbreitung von AWD bisher kaum und wenig systematisch ausgetauscht.

Auf lokaler Ebene zeigte sich, dass die landwirtschaftlichen Berater der verbreitenden Organisationen eine zentrale Rolle bei der Technologieverbreitung einnehmen. Sie betreuen Bauern und Pumpenbetreiber und bilden diese aus. Die Mittel und Möglichkeiten der Berater, Trainingsaktivitäten zu intensivieren oder auszuweiten, schienen jedoch relativ begrenzt.

Obwohl AWD eine wissensbasierte Technologie ist, hatten die meisten der untersuchten Organisationen nicht genügend gut ausgebildete landwirtschaftliche Berater zur Verfügung, um dieses Wissen an die Bauern weiterzugeben. Ein Grund hierfür ist, dass die Berater oft selbst nur unzureichend in AWD ausgebildet wurden. Dies führte zu geringer Qualität der Trainings für Bauern und somit oft zu einer nicht ausreichenden Vermittlung des Wissens über die Anwendung von AWD.

Obwohl die von den verschiedenen Organisationen verwendeten Verbreitungsansätze oft Bauerngruppen einbezogen, wurde nicht berücksichtigt, dass Bewässerung meist im Einsatzbereich einer Pumpe bzw. Wasserquelle organisiert wird, wobei eine relativ große Zahl von Bauern von einer Pumpe abhängig sein kann. Statt die lokale Organisationsform explizit zu berücksichtigen, setzen sich Trainingsgruppen derzeit oft aus Bauern zusammen, die in unterschiedlichen Bewässerungssystemen wirtschaften. Auch die vielfältigen und stark variierenden Spezifika der lokalen Bewässerungssysteme werden oft nur unzureichend durch die Ansätze berücksichtigt.

Die Analyse der Technologieannahme durch Bauern bestätigte, dass es grundlegenden Bedarf für AWD als wasser- und energiesparende Technologie im Nassreisanbau während der Trockenzeit gibt. Jedoch ist die Anwendung stark von den Faktoren abhängig, die die Bewässerungssysteme beeinflussen. Insgesamt wurde festgestellt, dass es (noch) keine großflächige Übernahme von AWD gibt.

Die chronisch unzuverlässige Elektrizitätsversorgung hat einen negativen Einfluss auf die Anwendung von AWD, weil sie Bauern davon abhält, zu einem bestimmten Zeitpunkt ihre Felder verlässlich zu bewässern, was aber eine Grundvoraussetzung für die Anwendung von AWD ist. Es wurde festgestellt, dass Bauern eine gewisse

Sicherheit der Wasser- und Energieversorgung benötigen, um die Technologie anwenden zu können. Die unzuverlässige Versorgung mit Bewässerungswasser hat viele Bauern bereits dazu gebracht, verschiedene Wassersparmethoden anzuwenden. Damit lassen sich aber meist nicht die Einsparpotenziale für Wasser und Energie in vollem Umfang nutzen.

Die größten Einsparpotenziale von Wasser und Energie gibt es wahrscheinlich bei Bewässerungssystemen mit DTW und größeren STW. Um die vollen Möglichkeiten von AWD auszuschöpfen, ist es notwendig, dass alle Bauern in einem Bewässerungssystem, d.h. alle, die ihr Bewässerungswasser durch die gleiche Pumpe beziehen, gleichzeitig AWD anwenden. Dieser Fall wurde in der Praxis jedoch nicht beobachtet.

Faktoren, die die Anwendung von AWD beeinflussen, sind bedingt durch die Besonderheiten der jeweiligen DTW und STW Systeme, die sich von Ort zu Ort stark unterscheiden können. So können beispielsweise Zahlungsmodalitäten, Regeln zur Entscheidungsfindung zwischen den Nutzern eines Systems, die Art der Organisation der Bauern oder die Anzahl der Nutzer stark variieren.

Als einer der wichtigsten Einflussfaktoren für die Annahme von AWD wurde die Abfolge der Bewässerungsgaben in einem Bewässerungssystem identifiziert. Diese bestimmt, in welcher Reihenfolge und zu welchem Zeitpunkt einzelne Felder im System bewässert werden. Weil Bauern in vorherrschenden Bewässerungssystemen nicht immer nach Bedarf Wasser beziehen können, wirkt sich die vom Pumpenbesitzer oder Pumpenbetreiber ausgeführte Bewässerungsabfolge auf die Möglichkeit eines Bauern aus, sein Feld zu einem bestimmten Zeitpunkt zu bewässern. Je mehr Kontrolle Bauern über den Zeitpunkt der Bewässerung haben, desto wahrscheinlicher ist eine mögliche Annahme von AWD.

Pumpenbesitzer und –betreiber haben eine wichtige Rolle bei der Weitergabe von ökonomischen Vorteilen, die sich durch die Nutzung von AWD in ihrem Bewässerungssystem ergeben. Es hat sich gezeigt, dass hauptsächlich Pauschalzahlungen üblich sind. Diese fördern jedoch die Anwendung von AWD nicht, da sich die durch Bauern eingesparten Wassermengen und Energiekosten bei dieser Zahlungsform nicht in reduzierten Bewässerungsgebühren widerspiegeln.

Im Anschluss an die Analyse zur Verbreitung und Annahme von AWD wurden die kurzfristigen Wirkungen von AWD analysiert.

Wirkungen auf das soziale System der Bauern durch die Anwendung der Technologie konnten noch nicht festgestellt werden. Dies könnte mit der bisher geringen Verbreitung von AWD begründet werden. Es ist anzunehmen, dass die Reduktion des Wasserverbrauchs sich letztlich auf die Häufigkeit der Konflikte um die knappen Wasserressourcen auswirkt. Jedoch wird sich die erfolgreiche Organisation von Bewässerungssystemen und die Aufteilung der Einsparungsvorteile nur durch kollektive Handlungen bewirken lassen. Dazu müssen Bauern verschiedener Betriebsgrößen innerhalb eines Bewässerungssystems eng zusammenarbeiten. Dadurch kann sich die Annahmerate erhöhen und soziale Änderungen eintreten.

Kulturelle Änderungen beziehen sich vor allem auf Ansichten und Einstellungen zur Notwendigkeit stehenden Wassers im Reisfeld. Viele der befragten Bauern zeigten eine Änderung ihrer Auffassung, wobei Bauern, die AWD anwenden, meist überzeugt sind, dass sich ein reduzierter Wasserstand nicht negativ auf den Reis auswirkt. Bauern ohne Training meinen jedoch, dass stehendes Wasser im Reisfeld notwendig ist. Gleichzeitig scheint sich jedoch diese Ansicht auch bei Bauern zu ändern, die bisher kein Training bekamen, angestoßen durch zunehmende Trockenheit in den letzten Jahren.

Eine vereinfachte ökonomische Analyse der Technologie ergab, dass AWD für den Großteil der Bauern vorteilhaft ist. 81% der befragten Bauern, die AWD anwenden, profitieren durch höhere Einkommen von AWD. Die Ergebnisse zeigen, dass die Anzahl der Bewässerungsgaben pro Anbausaison um 28% sinkt, während die Bewässerungskosten 20% niedriger ausfallen im Vergleich zu konventionell bewässertem Reis. Von diesen Einsparungen profitieren jedoch nur Bauern, die Bewässerung nach tatsächlichem Verbrauch bezahlen. AWD führt andererseits zu erhöhtem Unkrautbesatz im Reisfeld, weshalb Produktionskosten durch zusätzliche Aufwendungen für das Unkrautjäten oder den Einsatz von Herbiziden ansteigen. Diese Kosten werden jedoch durch 0,4 bis 0,5t/ha höhere Ernteerträge kompensiert. Die Aussagen vieler weisen darauf hin, dass Reisbestände bei AWD einen gesünderen Gesamteindruck machen, stärkere Wurzeln, mehr Bestockungstriebe und mehr Rispen entwickeln.

Die Einschätzung der Verbreitung und Annahme der *Alternate Wetting and Drying* Technologie zeigt, dass das Potential der Technologie in Bangladesch bisher nicht völlig genutzt wird, obwohl es während der Trockenzeit großen Bedarf zum Wassersparen gibt und die Technologie dazu das Potenzial besitzt. Dieses Potenzial in der nahen Zukunft auszunutzen bleibt eine herausfordernde Aufgabe.

Zurzeit hängt die weitere Verbreitung von AWD stark von der Initiative der Verbreitungsorganisationen und der Unterstützung von relevanten Institutionen auf nationaler Ebene ab. Deshalb richten sich die Empfehlungen insbesondere an alle beteiligten Organisationen und Institutionen sowie die Schlüsselakteure zur Verbreitung von AWD hin zu Bauern und Pumpenbesitzern.

Spezifische Empfehlungen und Anpassungen auf nationaler Ebene:

1. BRRI sollte eine Führungsrolle in der Begleitung des Verbreitungsprozesses übernehmen
2. DAE sollte die Führung in der Verbreitung von AWD und Koordination der beteiligten Organisationen übernehmen
3. Die AWD Verbreitung sollte ein vorrangiges Thema auf der Tagesordnung des nationalen Koordinierungskomitees für landwirtschaftliche Technologien werden (NATCC)
4. Es sollte eine nationale Verbreitungsstrategie für AWD formuliert werden
5. Entwicklung von strategischen Partnerschaften zur AWD Verbreitung
6. Berücksichtigung lokaler Regierungsstellen im Verbreitungsprozess

Spezifische Empfehlungen zur Anpassung der Verbreitungsansätze an lokale Gegebenheiten:

1. Anpassung der Verbreitungsansätze an die Erfordernisse lokaler Bewässerungssysteme
2. Ausrichtung des Trainings an der Organisation von Bewässerungssystemen
3. Unterstützung von Bauern und Pumpenbesitzern zur Entwicklung von Modalitäten, die eine faire Verteilung der Vorteile zwischen beiden ermöglicht
4. Verbesserung der Qualität der AWD-Fortbildungen für Bauern
5. Bearbeitung möglicher Anpassungen der AWD-Technologie in Trainings
6. Verbesserung von Monitoring und Evaluierung der AWD-Verbreitung

Generelle Empfehlungen zur Verbreitung von Technologien zum Management natürlicher Ressourcen, basierend auf den Erfahrungen mit AWD in Bangladesch:

1. Entwicklung einer landesweiten Strategie zur Verbreitung neuer Technologien
2. Frühzeitige Einbindung von Entscheidungsträgern und Absicherung des Prozesses durch eine Unterstützung auf politischer Ebene
3. Etablierung einer Koordinationsplattform für Forschung und Verbreitung
4. Frühzeitige Einbindung landwirtschaftlicher Beratungsagenturen in den Prozess
5. Bildung strategischer Bündnisse zwischen den Verbreitungsorganisationen
6. Die Vorteile einer Technologie müssen vermittelt werden
7. Einbeziehung der Nutzer einer Technologie in den Prozess der Technologieentwicklung von Beginn an

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List of Abbreviations

AETEP	Agricultural Engineering Technology Project
AWD	Alternate Wetting and Drying
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BEAF	Advisory Service on Agricultural Research for Development of the German Technical Cooperation (GTZ)
BMDA	Barind Multipurpose Development Authority
BRRI	Bangladesh Rice Research Institute
DAE	Department of Agricultural Extension
DTW	Deep Tube-Well
FGD	Focus Group Discussion
GTZ	German Technical Cooperation
IPM	Integrated Pest Management
IRRC	Irrigated Rice Research Consortium
IRRI	International Rice Research Institute
MoA	Ministry of Agriculture
NATCC	National Agricultural Technical Coordination Committee
NATP	National Agricultural Technology Program
NGO	Non-governmental Organization
NRM	Natural Resource Management
RDA	Rural Development Academy
RDRS	Rangpur Dinajpur Rural Service
SAAO	Sub Assistant Agricultural Officer
SLE	Postgraduate Studies on International Cooperation, Humboldt University; Postgraduiertenstudium Internationale Zusammenarbeit, Humboldt-Universität zu Berlin
STW	Shallow Tube-Well
ToT	Training of Trainer

1 Introduction

Rice is the major staple food for more than 164 million Bangladeshis (UNESA – PD, 2008). About 54% of all households are involved in the agricultural sector, of which 89% cultivate lands smaller than 1.0 ha (equivalent to 2.5 acres). In fact, about 14% of households are landless share croppers (BRRI, 2008; BBS, 2008a). This fragmented agrarian structure is therefore deeply challenged to satisfy the ever rising food demand of the Bangladeshi people. This forebodes the pressures imposed on agricultural lands, whose cropping intensity[1] has consequently increased over the last decades to reach a nationwide average of 180% (BBS, 2007).

In Bangladesh, three rice growing seasons are differentiated: Aus (early monsoon rice), Aman (monsoon rice) and dry season Boro rice. The latter is sown in November-December and harvested in May and is fully irrigated. Boro rice production in the 2007-2008 season amounted to 17.8 million t (BBS, 2009), which is over 60% of the total annual rice production in Bangladesh (Hossain, 2009). Thus, the production of dry season irrigated rice has a predominant importance for national food security (Fujita, 2004).

Traditionally, lowland rice is cultivated in flooded fields. On the global average, 3400 liters of water are used to grow one kilogram of rice (Hoekstra, 2008), which makes rice a very water-intensive crop. Nevertheless, it has been proven that physiologically irrigated rice does not necessarily require this amount of water. From its research, the IRRI postulates significant scope for water-saving in rice irrigation based on the fact that it takes an average of 1,432 liters of evapotranspired water to produce 1 kg of rough rice (IRRI 2010)[2]

Although Bangladesh may be more commonly recognized as a country dominated by abundant water, some regions do experience water shortages. In particular, the north-western part of the country frequently suffers from physical water scarcity during Boro season. As groundwater presents the major water source for irrigated rice cultivation in the region, the ongoing intensification of rice production adds additional pressures to underground water resources.

In order to irrigate rice paddies, electricity or fuel is needed to bring water to the surface. However, the demand for energy grossly exceeds the available supply by far (Economist Intelligence Unit, 2008). Diesel is not always available in some rural

[1] The cropping intensity is commonly presented as the percentage of the ratio of “gross cropped area” divided by the “net sown area” during one agricultural year. A cropping intensity of 150% implies, for example, that a farmer grows one crop on all his arable land (=100%) and an additional second crop on half of his arable land (double-crop)

[2] IRRI (2010): accessed 15.11.2010 http://www.knowledgebank.irri.org/watermanagement/

areas and is expensive for poor rice farmers, while farmers connected to a public power grid are subject to frequent power cuts (CPD, 2010: 22). As a consequence, Bangladeshi rice farmers have to cope with unreliable irrigation water supply, either deriving from the physical unavailability of surface and groundwater resources, or caused by insufficient electricity and/or fuel supply for pumping. In order to address farmers' needs to save water, energy and fuel in irrigated rice, the International Rice Research Institute (IRRI) has developed the Alternate Wetting and Drying technology, which has been introduced in Bangladesh in 2004.

2 Relevance and Potential of AWD

2.1 Characteristics of Rajshahi and Rangpur Divisions

The divisions of Rajshahi and Rangpur receive a special focus in this study[3]. These divisions constitute the remote north-western and northern part of the country.

All in all, these divisions have a population of 29 million (BBS, 2001)[4] and stand out as the most poverty-stricken in the country. In 2005, 51% of the population of both districts was living under the poverty line (BBS, 2008b). Both divisions are unlikely to reach their Millennium Development Goals target of reducing the poverty level to 30% by 2015 (Planning Commission of the Government of Bangladesh, 2008: 13). In Rangpur Division, five districts regularly experience seasonal famine (seasonal food insecurity), the so called monga, during Aman season. Monga occurs as a consequence of the lack of seasonal employment opportunities after transplanting the rice and before the harvest of Aman (monsoon) rice and causes seasonal food insecurity. This has already become a unique feature of the greater Rangpur region (Neogi et al., 2009).

The agrarian structure of Rajshahi and Rangpur Divisions resembles the country's average. An outstandingly high number of marginal and small farm holdings dominate the study regions[5]. Marginal farmers with less than 0.2 ha of land and smallholders with up to 2.5 ha jointly comprise about 90% of all agricultural holdings in these regions. These include some 10% landless sharecroppers (BBS, 2007).

According to their physical geographical conditions, the central, northern and north-western parts of the country are favorable rice growing environments, in particular for flooded lowland rice. Eastern Bangladesh, due to its hilly topography, presents an ecologically unfavorable region for rice cultivation, while the southern (and partly southwestern) regions with their saline groundwater aquifers, (as a result of seawater intrusion and floods) also hamper rice production with the conventional high-yielding rice varieties. Situated in very flat and even lowlands, these regions are depicted by criss-crossed, abundant water courses, featuring alluvial soils with high amounts of clay (Shamshudduha et al., 2009).

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[3] Divisions are the largest administrative units in Bangladesh. Rajshahi and Rangpur are two of seven divisions in Bangladesh; Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur, Sylhet. Data on Rangpur and Rajshahi Divisions are aggregated, since the divisions were separated in January 2010 only.

[4] The last census was conducted in 2001. More recent reference data is not available

[5] Farm categories in terms of land area according to BBS (2005): Marginal farmers 0.02 to 0.19 ha (0.05 to 0.49 acres), small-scale farmer 0.2 to 1.0 ha (0.5 to 2.49 acres), mid-scale farmers 1.01 to 3.03 ha (2.5 to 7.49 acres) and large-scale farmers above 3.03 ha (7.5 acres).

A radical change of Boro rice production took place in the late 1980s when Bangladesh's government policy changed, favoring the liberalization in the acquisition and marketing of minor irrigation equipment, which had significant implications for the Rajshahi and Rangpur Divisions. The share of Boro rice in the national rice production increased from 9% in 1966-1967 to 60% in 2008. The 27%-share of farm households growing Boro rice in Rajshahi and Rangpur Divisions is clearly higher compared to the national average of 19%. Furthermore, it is not surprising that rice cultivation comprises the dominant source of income in these divisions (BBS, 2008a).

The increase of minor irrigation systems and their privatization, and the introduction of modern rice varieties also resulted in a substantial expansion of Boro rice cropping in the northern and northwestern parts of the country. Traditionally, the Boro rice crop had been limited to low-lying lands in the depressed basins of eastern and central Bangladesh.

Boro rice contributed substantially towards achieving food security, despite extreme population pressures, limited land resources, and an agrarian structure dominated by small-scale and tenant farmers; it comprised 90% of the production increase since 1988, with a constantly increase since the 1970s. It plays a central role in the agricultural sector's impressive response, doubling the country's agricultural production from 17.1 to an impressive 41.1 million t/a on a slightly increasing cultivation area (Hossain, 2009).

Despite the fact that the dissemination of Boro rice led to a broad adoption of Boro rice varieties by all categories of farmers, resulting in benefits from increased yields, gross returns and overall rice production, Boro rice is recognized as being a highly capital-intensive way of farming, which is fully dependent on irrigation and that has led to the overexploitation of groundwater resources as discussed by Hossain (2009).

Rajshahi and Rangpur Divisions also present physical limitations to irrigated rice production in the Boro season. The northwestern part of Bangladesh has one of the lowest rainfalls in Bangladesh ,going from 1400 mm in the west to over 4300 mm in the east of the country. While trend analysis showed a significant increase in the average annual rainfall of Bangladesh at a rate of 5.52 mm/year over the 1958–2007 time period, no significant changes to monsoon, post-monsoon, or winter rainfall were observed (Shahid, 2009).

The declining ground water tables and increasing water scarcity are even more critical issues for the north-central, north-western, and south-western areas of the country. Here, the decrease of groundwater levels, falling at the rate of 0.1–0.5m/yr, has been clearly linked to the intensive abstraction of groundwater due to dry season rice farming (Shamsudduha et al., 2009).

Shallow Tube Well (STW)	General characteristics	
	• Attains aquifers from 12 to a maximum of 15 meters • Access to STW by small-scale farmers has been growing since the 1980s. However, the distribution of ownership is still unequal. Only 6% of marginal farmers own STW, which constitutes 52% of farm households in Bangladesh • Emerging groundwater irrigation with STW contributed to the widespread and rapid agricultural and rural economic development • Individual use possible	
	Advantages	
	• Theoretically available to every land-owning farmer; flexible with a smaller number of farmers served by one STW • Less risk of breaking down than DTWs	
	Disadvantages	
	• Falling groundwater tables make the use of STWs increasingly difficult • May become locally dry in peak irrigation season • Increased risk of naturally-occurring arsenic that contaminates water • Irrigation fees for STWs are often higher than DTW fees • Repairs and spare parts pose a problem for pump owners	
Deep Tube Well (DTW)	General characteristics	
	• Taps aquifers up to 80 m deep (Rajshahi Division) • Mainly operates with electricity (seldom run by diesel engines) • Operated by pump operators who implement the irrigation schedule and payment arrangements	
	Advantages	
	• Electrically-operated irrigation equipment is less costly to operate compared to diesel engines • Good water quality (also less risk of arsenic contamination)	
	Disadvantages	
	• Higher investment costs • Managing large numbers of farmer groups for irrigation requires a more sophisticated organization of the irrigation management • More time needed for groundwater renewal since deep aquifers are narrow and are only replenished in the wet season • Frequent lack of sufficient technical knowledge • The percentage of equipment that breaks down increases every year Electrical engines require a continued supply of electricity during the winter season • Tail end conflicts Source: Hossain, 2009; Amin, 2010; Fujita, 2004; UNICEF, 2008; Shamsudduha et al., 2009	

Table 1: Characteristics of shallow and deep tube well systems for rice irrigation

The occurrence of physical water scarcity is more acute and pronounced in Rajshahi where Boro and sometimes even the Aman (monsoon) seasons are characterized by relatively severe water shortages. In the annual cycle, deep aquifers are refilled during the monsoon season, while the water table decreases during the dry season as water is extracted for irrigation. However, groundwater refill and water abstractions are no longer balanced. This means that, due to their hydrological connectivity with the deeper aquifers, shallower aquifers are becoming dry during the dry season (see Chapter 6.1).

The minor irrigation systems implemented in Rajshahi and Rangpur Divisions, which play a major role in supplying rice with irrigation water during the dry season, are largely based on Shallow Tube Wells (STW) and Deep Tube Wells (DTW), which are common in Bangladesh, in addition to low lift pumps. STW and DTW systems have unique features in supplying irrigation water and in managing irrigation (see Table 1).

The number of privately-owned STW rapidly increased with the privatization policy at the end of the 1980s. Farmers themselves invested in STW as the government did not provide subsidies. This led to the emergence of local “water markets” as pump owners started selling water to other farmers around their pump (Hossain 2009). Aside from increased private capital for irrigation infrastructure, liberalization led to enhanced competition on the water market with decreasing water fees and the development of a repair and maintenance sector.

Today, STW comprise the most significant means of minor irrigation for the majority of rice farmers in Bangladesh, increasing from 93,000 STW in 1982 to 1.3 million STW by 2008. This corresponds to 73% of all farms using STW for irrigation (Hossain, 2009). STW are also the primary source of irrigation in Rangpur Division.

Deep Tube Wells are particularly present in Rajshahi Division, but can also be found in less quantity in neighboring divisions. The northwestern part, in particular Rajshahi Division, shows lower ground water tables, whilst showing a higher variability of the ground water tables (Shamsudduha et al. 2009). These different hydro-geological conditions explain why DTWs comprise the dominant means for providing irrigation water in this area. The overall DTW figures, which now amount to 31,000, are much lower compared to STW. This is due to the investment costs, which are much higher than STW costs. DTWs have therefore been mainly introduced by governmental bodies in large infrastructure development programs (Hossain, 2009).

2.2 Alternate Wetting and Drying

“Alternate Wetting and Drying” (AWD) involves technology that tackles water scarcity in irrigated rice cultivation and has the potential to contribute to a more sustainable and effective water and energy use. By applying AWD, farmers or pump-owners are able to save 15 to 30% of their irrigation water. Water productivity, i.e. the volume of irrigation water required to produce a certain amount of rice, increases compared to conventional cultivation (Lampayan et al., 2009; Bouman et al., 2007). Savings in energy and fuel consumption represent another of AWD's significant advantages. Consequently, using AWD yields significant potential to reduce input costs for water, irrigation services, as well as energy and fuel.

"What is now called AWD is the result of a long research process that began in the 1980s by IRRI (R. Lampayan, IRRI, personal communication)."

In the search for an easy tool to signal the irrigation time, a perforated *field water tube* (Figure 1) was developed. The tube is inserted into the soil 10 to 15 days after transplanting and is used to visually monitor the water table in the field. It replaced earlier methods such as tensiometer measurements by scientists or the length of irrigation intervals used by farmers. These were not suitable for general use by farmers and were not adapted to different soil conditions. The tube may be made out of PVC, but locally available materials, e.g. perforated soda bottles or bamboo pipes, are also suitable to measure the water depth.

Figure 1: Perforated AWD-tube (Source: Own photo)

AWD is a knowledge-intensive technology as it is based on the insights gained by scientists at IRRI that rice – despite being a semi-aquatic plant – can tolerate reduced water supply without suffering any negative effects. As the water level drops below soil surface, the soil is still saturated. Water is still available for the rice plant. Hence, the water level in the rice field can drop down to 10 to 20 cm (or to 15 cm for so-called "safe" AWD) below the soil surface without significantly affecting yield. Intervals between re-irrigation can be extended for several days (Lampayan et al., 2009). This contradicts the traditional belief that standing water is necessary at all times during rice cultivation.

Continuous flooding of rice paddies is only required up to 15 days after transplanting[6] and during flowering. Reduced water supply at these growth stages would result in hampered plant growth and panicle development, which would result in yield losses. At the same time, expanding the aerobic conditions in the rice field two weeks after

[6] To apply AWD, standing water is recommended after transplanting in order to reduce water stress for the newly transplanted plants and to control weed growth.

transplanting until the flowering stage can cause the growth of more weeds. It is often suggested that AWD increases the labor costs for weeding or requires the use of herbicides to control the growth of weeds. However, extra costs may be offset by an additional yield of half a ton/ha.

2.3 Relevance of AWD for Bangladesh

In Bangladesh, out of the 8.4 million ha of total agricultural land, 4.8 million ha of arable land are currently irrigated. Furthermore, out of this area more than 70% is irrigated by underground water (Sattar et al., 2009). This presents a large potential area in which AWD could be implemented.

Farmers are currently paying an equivalent of 25 to 30% of their rice harvest for irrigation and these costs are tending to increase (Sattar et al., 2009). This presents another factor for the economic relevance of water-saving at the farm level. Experts state that on a national level, the implementation of AWD could save costs for irrigation of up to 56.4 million Euros[7] in electricity or 78.8 million Euros in fuel (30 liter diesel/ha) (Miah et al. 2009).

As irrigated rice systems serve as a large sink for atmospheric carbon dioxide and are a significant source of methane (Bouman et al., 2007) it is assumed that reducing the standing water in rice fields will have positive ecological implications.

Furthermore, the contamination of rice with arsenic, which is an acute problem in some regions of Bangladesh, is associated with an excessive withdrawal of underground water (Husain & Kabir in Sattar et al., 2009).

Therefore, introducing AWD could have major impacts at the farm level and be important throughout the country by reducing irrigation costs and reducing the excessive use of ground water, leading to a more sustainable use of natural resources.

[7]Values in Euro in this study are converted from the local currency, the Bangladeshi Taka; calculations based on the average currency rate of 2009: 100 Taka are equivalent to 1.063 Euros (Oanda, 2009)

3 Conceptual Framework and Objectives of Study

3.1 Research to Impact Pathway Concept

International agricultural research centers have been asked by international donors to provide more evidence of the impacts from their research. Consequently, the research centers have taken on a stronger impact orientation in their research approaches. Amongst others, the IRRI has chosen the concept of impact pathway analysis to monitor its work. The “impact-pathway” is a logic-based evaluation concept, which tries to explain the way research contributes to agricultural change. It identifies key links that connect stages along a pathway (Springer-Heinze et al., 2003). The conceptual framework of this study builds upon this established concept and on the partial or pre-impact assessment of the Impact Assessment Group of the Consultative Group on International Agricultural Research (CGIAR).

The red frame in Figure 2 indicates the scope of this study within the Research-to-Impact Pathway for AWD in Bangladesh. The research process of how AWD was developed by the IRRI in the Philippines was not included in the analysis as it was beyond the reach and scope of the study.

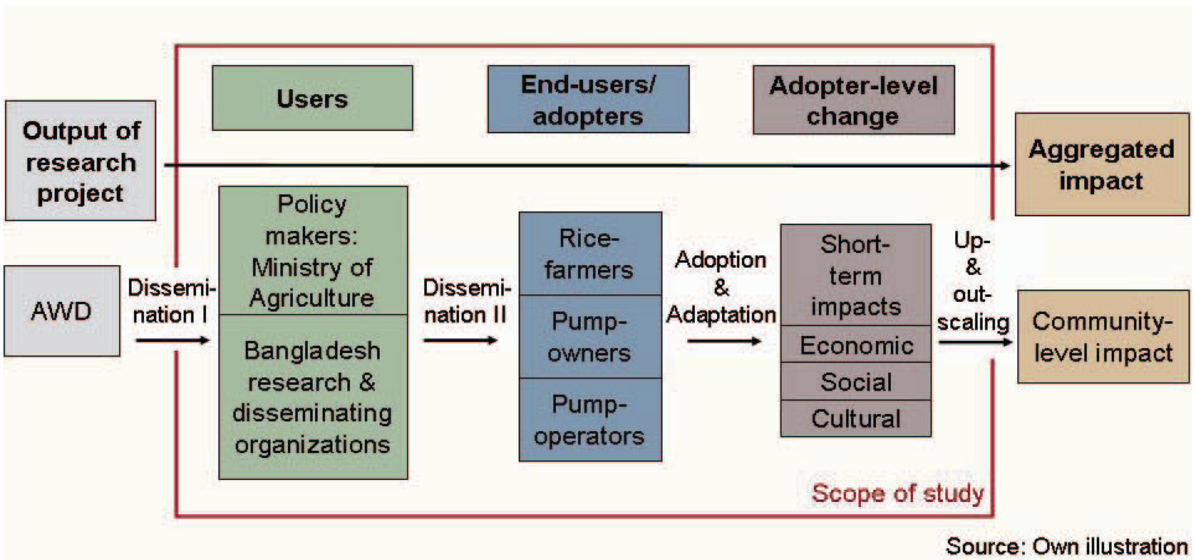

Figure 2: Focus of the study within the research-to impact pathway

The starting point of the pathway analysis for this study is the implementation of the AWD technology in Bangladesh on a national level. The aim is to describe and analyze the entire process of introducing the innovation in Bangladesh. Furthermore, this step contains a description of how Bangladeshi institutions and organizations have become involved in the process of promoting the new technology (Dissemination I in Figure 2, see Chapter 5). Along with the analysis of this process, the effects on the up- and out-scaling of AWD technology are looked at.

It is important to note that the term “innovation” as used in this study follows the definition by Rogers (2003:12). Innovation is an “idea, practice or object that is perceived as new by an individual or other unit of adoption”. The actual diffusion of an innovation refers to the “process by which an innovation is communicated through certain channels over time among members of a social system” (Rogers, 2003:5). Diffusion can be target-oriented, i.e. actively promoted or disseminated by an organization, or spontaneous, for example, through farmer-to-farmer diffusion. With this understanding in mind, dissemination is defined as the active spread of an innovation into a social system using a single approach or a set of dissemination approaches.

The analysis of the dissemination covers the active spread and the diffusion of the innovation AWD by the involved key stakeholders to the end-users, i.e. the rice farmers (Dissemination II in Figure 2, see Chapter 5) connected to the introduction of AWD. On the users' level, following the initial steps of introducing AWD in Bangladesh (“users”), the dissemination analysis contains an assessment of several key stakeholders, focusing on their specific contribution to the AWD dissemination process. The dissemination approaches employed, namely capacity building within the organization, inter-organizational communication and cooperation between the actors, as well as a closer look at monitoring and evaluation systems, are considered important elements to create a complete picture of the current dissemination status.

Adoption, defined as the second research area of this study, comes next in the impact pathway analysis and focuses on the adoption process, factors influencing it and the end-users' perspective regarding AWD. Again, Rogers (2003) delivers a practical definition for adoption, referring to adoption as an individual or collective multi-step decision-process of a potential end-user (or group of end-users) to implement an innovation, such as AWD, either continuously or discontinuously.

Following Rogers (2003) definition, adopters can be differentiated into adopter categories according to individual degrees of innovativeness and stages of decision making on innovations. The five adopter categories are: innovators (gatekeepers), early adopters, early majority, late majority, and laggards.

Key factors, which will lead to the adoption or a non-application of AWD by end-users, are analyzed comprehensively (see Chapter 6). Farmers' needs for a water- and energy-saving technology will be analyzed with respect to their specific context and logic of action. Understanding farmers' perception of AWD helps to identify “important constraints, desirable characteristics of the technology , and useful management practices” (IAEG, 2000).

The third research area of this study is the assessment of impacts, which are defined as changes evoked directly or indirectly, intended or unintended by an intervention (OECD DAC, 2009). Since the dissemination and adoption of AWD are still very recent in Bangladesh, the focus of this analysis will be on short-term impacts, as aggregated impacts cannot be measured at this point. The assessment includes economical, social and cultural impacts on the adopter level (see Chapter 7). Economical impacts relate to the changes that might occur after applying the new technology and can be assessed within an analysis of changes in input, outputs and productivity. Social and cultural impacts refer to the way AWD changes social interactions at the level of farmers and irrigation schemes, including aspects related to cultural beliefs.

3.2 Objectives of the Study

Up until now, no comprehensive studies of the Bangladesh ‘case’ of AWD have been conducted. At present, there is no reliable data of the experiences and of the outcomes of diffusion, adoption and impacts of AWD in Bangladesh. To close this gap, the IRRI commissioned and co-financed this study in collaboration with the Advisory Service on Agricultural Research for Development (BEAF) of GTZ.

The following objectives of the study were defined:

- Document and analyze the different dissemination approaches in Bangladesh and the organizational and institutional environment in which dissemination takes place;
- Assess constraining and enabling factors of adoption and of short-term impacts of AWD in the two defined study regions Rajshahi and Rangpur Divisions;
- Draw general lessons learned from the dissemination, adoption and impact resulting from AWD technology.

During the planning of the study, research activities were related to outputs, the use of these outputs and possible outcomes, thereby ensuring, as far as possible, the potential benefits and relevance of this study (Annex 1).

4 Methodology

4.1 Methodological Framework

A multi-level framework was defined to meet the broad methodological requirements of data collection. The research areas were systematically embedded within this geographical multi-level system (Rauch, 2009), differentiating stakeholders on three levels (see Figure 3): the national, regional and local level. Furthermore, the study is based on a mixture of methods varying throughout the different levels.

The national level includes players of national relevance and policy influencing actors, such as the Ministry of Agriculture (MoA), the Department of Agricultural Extension (DAE), Syngenta Bangladesh Ltd., the Bangladesh Rice Research Institute (BRRI) as well as the IRRI. On the regional level, players with regional relevance were analyzed such as the Barind Multipurpose Development Authority (BMDA) and Rangpur Dinajpur Rural Service (RDRS).

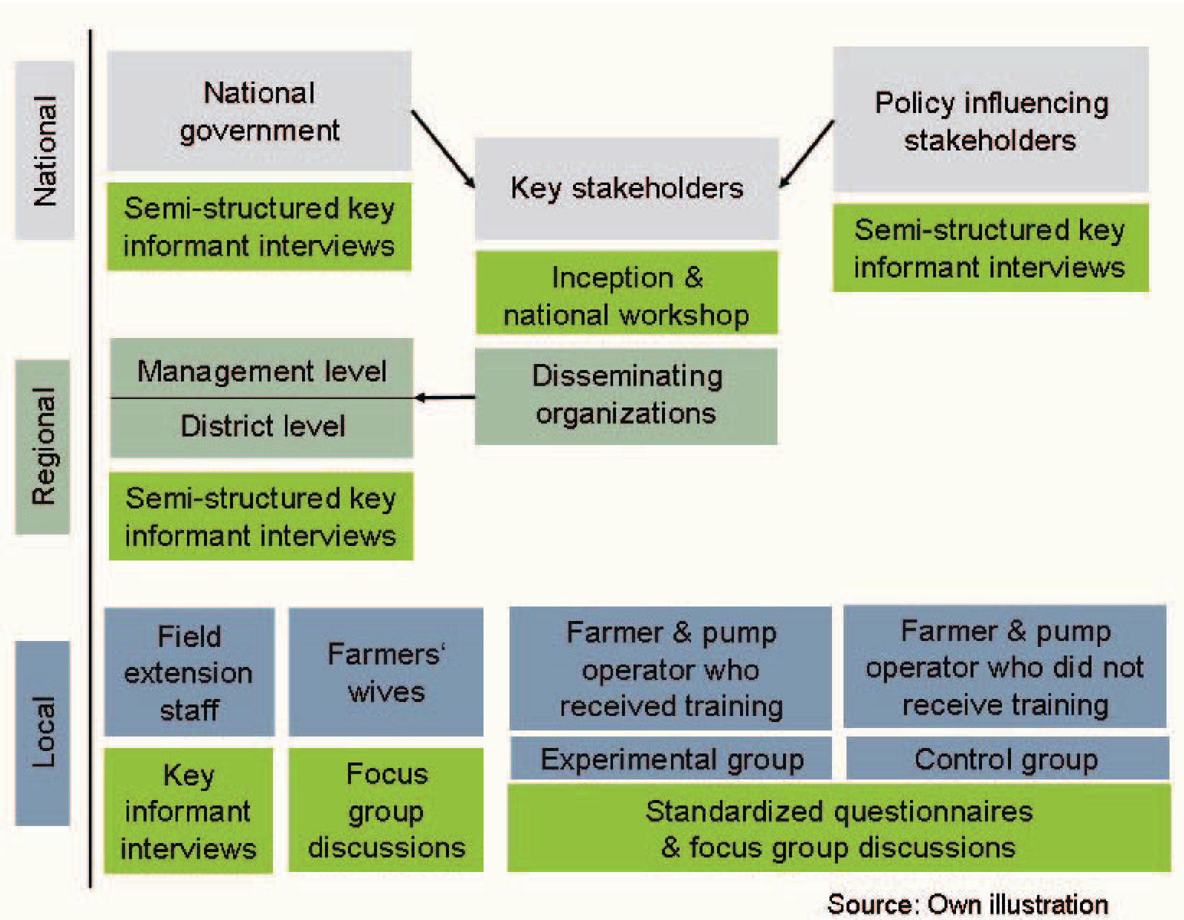

Figure 3: Methodological framework

The main method of gathering perspectives and opinions on the ongoing dissemination process of AWD on the regional and on the national level was by conducting semi-structured key informant interviews.

Furthermore, an inception and a national result workshop were held with policymakers and actors of national and regional relevance for AWD dissemination. The results from the workshops were employed in the study.

The local level includes players of local relevance and actors who are affected or potentially affected by AWD, such as farmers, pump owners and operators and the field extension staff of disseminating organizations. Standardized questionnaires, qualitative focus group discussions and qualitative interviews were conducted on this level. Surveys at farm level were complemented by key informant interviews with field extension staff and own observations.

In addition to the survey, primary and secondary literature was analyzed to complement the empirical research results.

4.2 Sampling

The data survey was preceded by a field test of the standardized questionnaires at the local level, which was conducted in the Bogra District of Rajshahi Division. Qualitative data gathered during the field test from key informants for DAE and Syngenta were included in the analysis of the study. Based on the field test, the following three categories were used throughout the study:

1. Farmers and pump owners/operators who have applied AWD-based irrigation at least once (AWD Adopter).
2. Farmers and pump owners/operators who have tried AWD-based irrigation at least once but did not continue to use it or who have not had the chance to apply it yet (AWD Non-Adopter).
3. Control group: Includes all farmers and pump owners from the same or neighboring village who have not received training on AWD.

Farmers and pump owners, respectively, were addressed with questionnaires tailored to their specific situation. With very few exceptions, all adopters and non-adopters of AWD either participated in an AWD training session or were formally involved in implementing AWD demonstration plots in cooperation with one of the disseminating organizations.

For the sampling of the quantitative interviews, lists of farmers and pump owners participating in demonstration or training activities were obtained from the organization. From these lists, the interviewees were chosen by random sampling. Given that not all of the organizations were able to provide these lists, in some cases extension staff had to gather trained farmers beforehand. The sampling intended to target interviewees with different sized farms (see Annex 2).

In each location a number of farmers who did not participate in the AWD demonstration or training and who did not use AWD was selected as a control group. In total, 272 interviews with farmers and pump owners/operators were conducted in Rajshahi and Rangpur Division. Local extension staff that provided the training to the farmers was interviewed if they were present whilst the survey was being carried out. In total, 35 interviews were held with field staff. Furthermore, nine focus group discussions were organized with farmers and pump owners (see Table 2).

The selected districts (zilas[8]) and subdistricts (upazilas) represent a purposive sample. On the regional and national levels, a total of 32 interviews were conducted, giving special emphasis to qualitative interviews with relevant stakeholders, extension staff, managers and decision makers of the respective organizations (see Annex 3 and Annex 4).

Rajshahi Division

The main emphasis of sampling in Rajshahi Division (see Figure 4) was given to surveying activities related to the BMDA, where three districts were sampled. The primary focus was given to Rajshahi District, including a larger number of sub-districts, i.e. five upazilas. As the lists of farmers participating in demonstration activities were not available for BMDA, two demonstration plots from different years were visited in each site where samples were taken. There, farmers involved in AWD demonstrations and farmers from the same or a nearby irrigation scheme (representing the control group), were interviewed.

To assess specific activities of the DAE, three districts were selected. In one of them, the DAE cooperates with the BMDA in setting up demonstration plots and does not have demonstration plots on its own. Since lists of trained farmers were not available, the sampling procedure was adapted as follows: After contacting the Agricultural Extension Officers or the DAE’s respective Sub-Assistant Agricultural Officers (SAAO), a meeting was set up with farmers. The interviewees were selected randomly from these farmers.

The adjacent Kushtia District of Khulna Division represents a special case. The main reason for including Kushtia into the sample was to assess the activities of BRRI, which operates one of its three AWD sites there. In Kushtia, the DAE was included in

[8] Administrative units in Bangladesh below divisions are districts, the so-called “zilas” and sub-districts, the so-called “upazilas”. Rangpur and Rajshahi Divisions are comprised of eight districts each.

the sampling as the identified settings were similar to other sites of the DAE that had been visited.

	Organi-zation	Districts sampled	Farm-level interviews	Key informant interviews (field staff)	Focus group discussions
Rangpur Division	DAE	Rangpur	61	7	-
		Dinajpur	41	3	-
	RDRS	Rangpur	31	1	2
		Lalmonirhat	10	1	1
		Kurigram	15	2	2
	BRRI	Rangpur	13	1	-
Rajshahi Division	BMDA	Rajshahi	48	6	3
		Chapai Nawabgonj	9	3	-
		Naogaon	11	2	-
	BRRI	Kushtia (Khulna Division)	13	1	-
	DAE	Rajshahi	11	2	1
		Natore	9	4	-
		Kushtia (Khulna Division)	-	2	-
Total		9	272	35	9

Table 2: Sampling on local level

Rangpur Division

Sampling in Rangpur (see Figure 4) focused on the activities of the DAE and RDRS as the major stakeholders in this division as well as on the BRRI. In Rangpur, the DAE mainly disseminates AWD through two programs, the National Agricultural Technology Program (NATP) and the Agricultural Engineering Technology Extension Project (AETEP). The sampling is focused mainly on farmers who received training through the NATP, as this is currently the main program. The AETEP was included in the sampling, since it addressed AWD one season prior to the NATP and had a broader scope. Specifically, the DAE sampling covered two districts. In both programs, lists of participating farmers were provided by the DAE.

In Rangpur Division, the BRRI operates an experimental station and conducts field tests at two nearby sites that were both sampled in Rangpur District through the lists provided.

Samples were collected in three districts with the RDRS. The sampling was conducted according to two different paths. Firstly, focus group discussions with six leader farmers who were invited by the RDRS were conducted in each district; subsequently farmers were interviewed individually.

Secondly, additional farmers who received training were randomly selected for interviews in the field. An overview of the sampled districts is presented in Table 2.

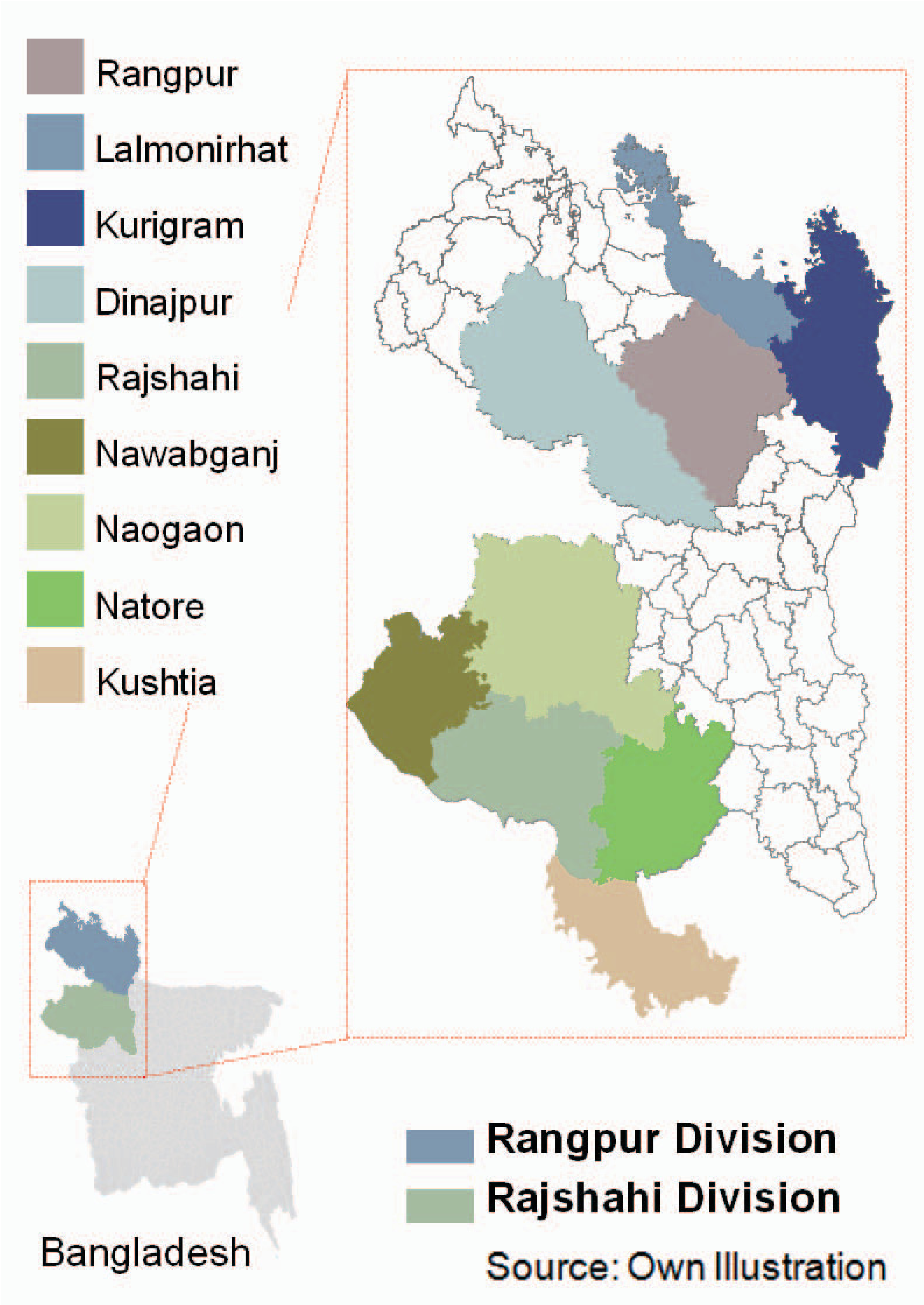

Figure 4: Rajshahi and Rangpur Divisions and the sampled districts

4.3 Limitations of Implementing this Study

General limitations are related to the time of year within which the study was implemented. Data collection was conducted mainly during the months of August and September, during Aman season (July to November), while AWD is largely relevant and implemented in the Boro season (December to May). This may imply that responses that could be obtained from farmers on the previous Boro season are limited and lack precision. Also, data collection coincided with the month of Ramadan, which posed a challenge in conducting interviews at local level, both in identifying farmers who were willing to be interviewed and who were sufficiently alert and focused to perform an intensive interview.

When conducting the first interviews on the farm level, it became evident from the early stages of adoption that sampling technology users, by applying a common definition of “adopters of technologies” (Rogers, 2003) would not be possible.

For this reason, farmers who received training or participated in an AWD demonstration and already tested the technology at least once were considered to be “adopters” for the purpose of sampling. Also, since “real” adopters were hard to find, it proved to be useful to assess the general situation of AWD in a more qualitative and descriptive way.

Another constraint of data collection relates to the fact that marginal farmers and sharecroppers who received training were difficult to find. This might be due to the focus of extension organizations, initially targeting mostly small-, medium and large-scale farmers for dissemination. Also, marginal farmers tended to be working in the field and were therefore hard to find during the day.

The random sampling based on the lists of trained farmers was also not always possible, as they were often unavailable, incomplete or not up-to-date. Another factor relates to the influence of local extension staff on the conduct and results of farmer interviews, which could not be excluded in all cases.

The diversity of measurement units in the study regions complicated the data collection and processing for analysis. As an example, the size of one of the standard measurement units for the land area, bigha, differed in some areas from one village to the other.

Finally, the survey was implemented with the support of local translators. This procedure may entail a loss of information during the translations while conducting interviews.

5 Dissemination

Developing innovations in agriculture is accompanied by manifold approaches and conceptual discussions related to different schools of thought. Some of these, including a wide-range of extension models, summarized by Hoffmann et al. (2009), are being discussed controversially, such as the linear transfer of technologies versus participatory technology development.

The focus of this study rests on analyzing the spread of AWD, taking into account that the technology was developed by IRRI as an international center, in one country (i.e. the Philippines) and introduced for dissemination in another country, namely Bangladesh, utilizing the prevailing research-extension-farmer linkages.

The process is analyzed in this chapter in three ways: the steps to introduce AWD to Bangladesh, aspects of disseminating AWD on a wider scale, in particular up-scaling and out-scaling, as well as ways and means of technology dissemination to farmers, pump owners and pump operators who are actually employing the technology.

5.1 Steps to Introduce AWD in Bangladesh

The entire period from 2004 until today can be considered to be the introductory phase for AWD in Bangladesh and is divided into three steps, which are largely consistent with respective time periods (Figure 5).

The boost for disseminating the technology in the country was made by IRRI scientists who presented research results and experiences of a successful application of the technology in irrigated rice in the Philippines to decision makers and scientists in Bangladesh. This led to the initiation of research activities by the BRRI, the national partner of the IRRI, as well as the Rural Development Academy (RDA)[9], an institution specialized in training and research (Miah et al., 2009).

The initial tests confirmed the potential benefits of the AWD technology when applied in irrigated rice during the dry season, the so-called *Boro* rice. The formal testing and validation[10] of the technology at different sites followed by the BRRI and by BADC[11], the Bangladesh Agricultural Development Corporation, which has a specific national-

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[9] Initial tests in 2005 in Bangladesh consisted mainly of researcher-led trials, which incorporated AWD in research as part of a seed testing project, funded by the Asian Development Bank.

[10] Validation in this study refers to the process of examining the effectiveness and the applicability of the AWD technology under different contexts, as AWD has been reported to be successfully applied and disseminated in the Philippines (Lampayan et al. 2009).

[11] BADC is a government owned corporation under the Ministry of Agriculture with the mandate to procure and supply inputs to the agricultural sector, in particular improved seeds, chemical fertilizers and irrigation equipment. Its main task is the multiplication, production and supply of seeds

level mandate in agricultural irrigation. The results of validation trials indicated that the time to run irrigation pumps and the fuel needed could be significantly reduced by AWD-managed irrigation (Miah, 2008)[12] and provided orientation and guidance for other agencies in practicing and adopting the technology (Miah et al., 2009)[13].

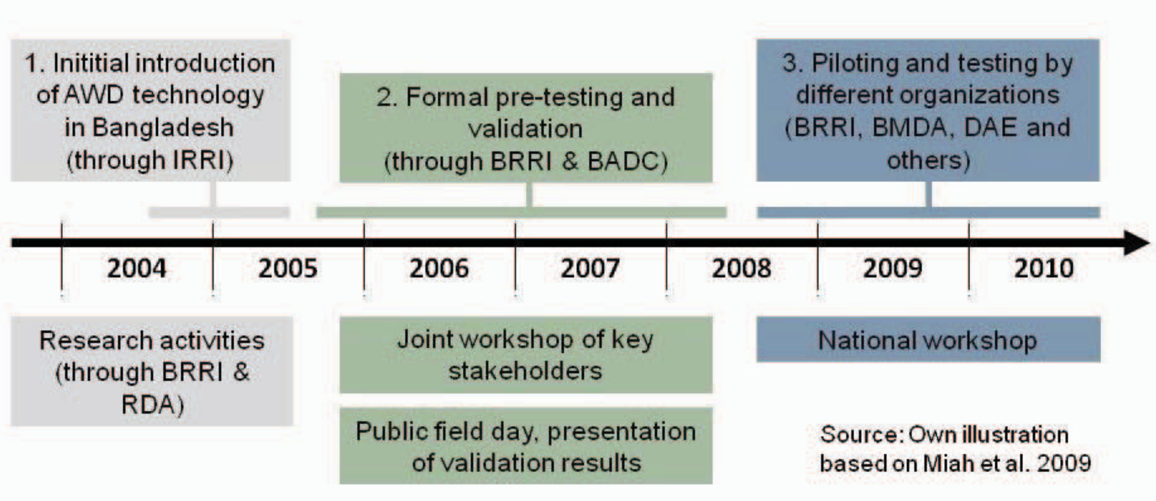

Figure 5: Steps to promote AWD in Bangladesh

The introductory phase was utilized to raise awareness about the potential of AWD technology among key stakeholders for agricultural extension as well as decision makers. For example, a workshop was conducted in 2006, involving the Secretary of Agriculture. Similarly, a field day and crop-cutting ceremony were conducted to present the AWD technology to a broader audience upon concluding the BADC validation trials in 2007. These activities led to a directive by the Secretary of Agriculture to include the Department of Agricultural Extension (DAE) and the Barindra Multipurpose Development Authority (BMDA), aside from the BRRI and BADC to validate and test AWD for dissemination on a wider scale.

The ultimate objective of this directive, which is getting key organizations of the agriculture sector to incorporate AWD in their programs and to link up in disseminating the technology, has been achieved only to a limited extent. During the 2009 *Boro* season, the BRRI, BMDA, and DAE actually started to implement separate pilot measures and demonstrations to disseminate AWD. In addition, private actors, such as Syngenta, a multinational agrochemical and seed company,

[12] BADC conducted validation trials during 2006 and 2007 *Boro* seasons to evaluate the effect of AWD on irrigation frequency and fuel consumption. Findings showed that a lowered irrigation frequency using AWD halved the time required for running irrigation pumps and the amount of fuel (Miah, 2008).

[13] BRRI conducted validation trials during the 2007 and 2008 *Boro* seasons (BRRI, 2008: 161) to provide orientation to other agencies in promoting AWD (Miah et. al., 2009), including research on water productivity, cost-benefit, varietal differences and responses of farmers to various aspects, for example, weeding. It was found that AWD eventually increased economic return (Alam et al., 2009).

as well as a number of NGO including the Rangpur Dinajpur Rural Service (RDRS) joined the process of disseminating AWD in Bangladesh, using their respective means and channels.

Another milestone in this process was marked by the first national workshop in 2009, which brought together the major stakeholders concerned with disseminating AWD (Sattar et al., 2009). This event was the first opportunity to review the dissemination process, to share results of three years of technology validation by different organizations, and to recommend further action for the ongoing process. While a number of key stakeholders were actively involved in disseminating AWD, the actual progress of spreading the technology to farmers on a broader scale remained in its provisional status. Basically, this review confirmed the potential of a more widespread applicability of the AWD technology in irrigated rice production during the Boro season.

The process of introducing AWD in Bangladesh, including the testing, validating and piloting of the technology and its dissemination, was mainly carried out by the IRRI. While the IRRI is competent in this subject, having actually developed the AWD and the experience to promote the dissemination of this technology in other countries, it lacks a national mandate in Bangladesh and the capacity for technology dissemination and agricultural extension. However, the IRRI has been instrumental in introducing AWD to the relevant stakeholders, in training trainers and managers at the national level and in providing technical advice and motivation to interested organizations and individuals.

IRRI's prominent role in this process may be attributed both to its recognition as an outstanding agricultural institution as well as to its strong links and partnership with the national agricultural system[14]. Without a "national champion" taking charge of promoting and facilitating the spread of this technology at different levels in Bangladesh, the IRRI moved towards supporting dissemination beyond a facilitation role fitting to its international mandate, and in fact led this process until now.

5.2 Large-Scale Dissemination of AWD in Bangladesh

Assuming that AWD has been successfully introduced and accepted by a significant number of innovative farmers to guide the irrigation of their rice crop during *Boro* season, there is still the issue of providing mechanisms for the continued spread of AWD on a larger scale, i.e. the up-scaling and out-scaling of the technology (Hoffmann et al., 2009: 119).

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[14] National Agricultural Research and Extension System (NARES), serving the agriculture sector

Up-scaling the spread of AWD refers to grounding the diffusion and active dissemination of the technology at institutional and policy levels, i.e. linking dissemination at local and farm-levels with organizational strategies and by involving policymakers at national level. These are being referred to as “vertical” processes or up-scaling. Up-scaling, accordingly, is intended to form an enabling institutional and policy environment for effective dissemination (see Figure 6).

Achieving an effective dissemination of AWD to large numbers of rice farmers in the country requires the horizontal diffusion of the technology. Such processes of spread, from one organization to another organization, for example, or from one farmer to another, are called out-scaling.

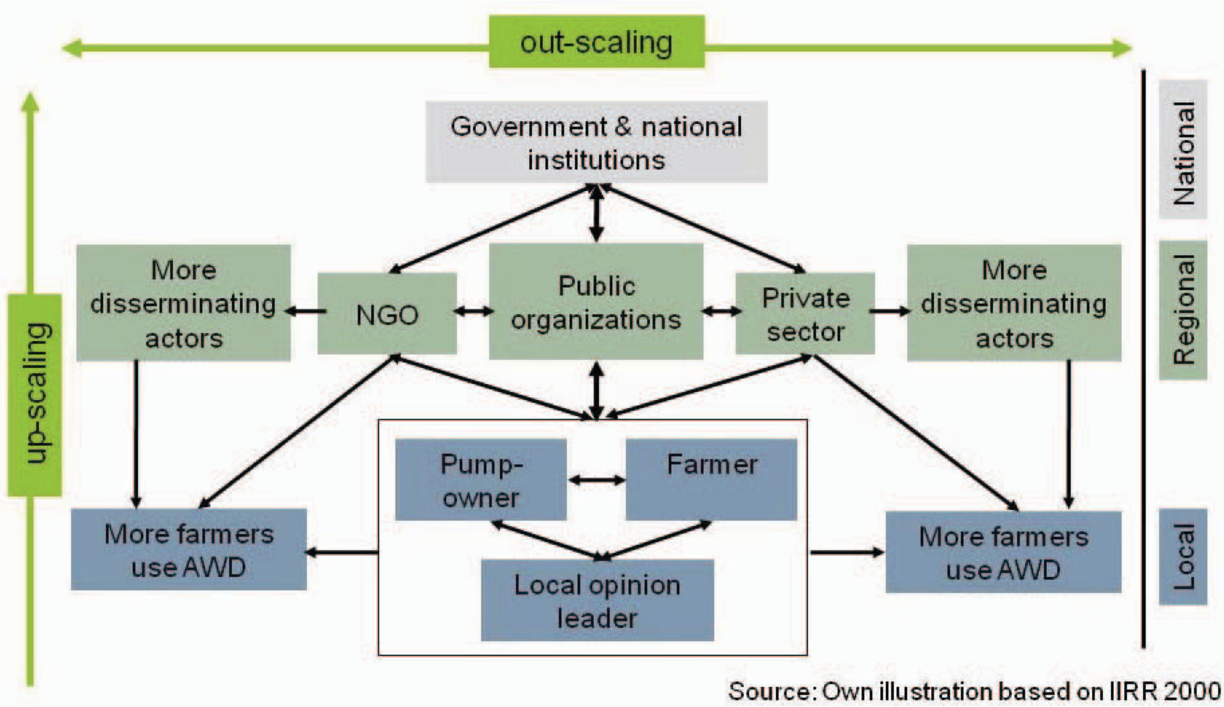

Figure 6: Up-scaling and out-scaling of AWD in Bangladesh

5.2.1 Up-scaling of the AWD Technology

At national level, the first steps towards initiating up-scaling were made by means of a series of workshops and awareness-raising events to promote AWD, by involving key-policymakers, such as the Secretary of Agriculture and the director generals of key agricultural service organizations (Miah, 2008). It is evident from the survey that these steps have shown only limited success so far. Initial directives of the Secretary of Agriculture to create a stronger and joint commitment to AWD between the stakeholders did not result in a project on nationwide AWD-dissemination in 2009 as the proposal by a consortium of the DAE, BMDA, BRRI and BARC failed to develop a coherent strategy. Consequently, AWD dissemination is currently still based on single programs and projects. Key informants repeatedly voiced that continuous government support, especially from the MoA, is needed to ensure and push AWD into mass dissemination. Otherwise the technology may perish, as has been the case with other useful technologies after projects come to an end.

Improving the legal framework conditions to promote water-saving technologies in agriculture in new policies is one of the ways to foster AWD dissemination and adoption. In fact, most key informants very enthusiastically mentioned that AWD was recently included in the draft of the First National Irrigation Policy for Bangladesh formulated under the leadership of the BADC (see box below).

Excursus: Incorporating AWD into Bangladesh's Draft National Irrigation Policy (BADC, 2010)

"To increase the efficiency of irrigation in rice cultivation, steps are needed on all levels to promote the use of AWD and other related technologies."

The National Irrigation Policy Draft forecasts a plan to create Upazila and District Irrigation Committees to facilitate a more effective implementation of irrigation schemes. The plan includes the formation of committees involving irrigation experts from relevant organizations and farmer representatives.

While the consideration of AWD in the first irrigation policy is just one example of grounding the technology at policy level, it remains to be seen whether the explicit inclusion of AWD in this policy, which is yet to be formally adopted and implemented, is actually effective in terms of facilitating a wide-scale uptake of the technology by organizations, leading to its subsequent adoption by farmers.

Based on the survey by the authors, policymakers see a limited scope for policies at the MoA level to guide the dialogue of farmers and pump owners in resolving conflicts of interest between these two groups.

Decision-making within irrigation schemes is considered to be a process by autonomous individuals based on rules and regulations defined by them. Whether there is scope for a common strategy for disseminating AWD in Bangladesh will be discussed in relation to the analysis of out-scaling and the role that cooperation and coordination structures have played until now at the national level (see Chapters 5.2.2 und 5.2.3).

5.2.2 Out-scaling of AWD Technology

Working on the assumption that the spread of AWD on a wider scale is driven by key stakeholders who are relevant for disseminating the technology in the respective regions, it is necessary to take a closer look at these stakeholders in terms of their status in establishing dissemination mechanisms for AWD within their own organization and in terms of their potential to support and to contribute to out-scaling the process to a wider range of actors.

Organizations from different sectors, including public, private organizations and NGOs, took up the dissemination of AWD or were invited to the process by the IRRI Bangladesh Office (Miah, 2008). While some organizations, such as the BADC and RDA, only participated for a certain amount of time and then discontinued their initial involvement in disseminating AWD, five organizations pursued AWD dissemination with the aim to incorporate AWD into their extension strategies and programs (see Table 3).

	BRRI	DAE	BMDA	RDRS	Syngenta
Sector	Public research	Governmental organization		NGO	Private
Core function	Rice research	Agricultural extension	Infrastructural projects & development	Rural development to reduce poverty	Supply of pesticide & seed inputs to the sector
Target group	Mostly small-scale farmers & some pump owners	Small & medium scale farmers 30% women / pump owners / operators depending on project	Innovative pump-operators, leader farmers, members of irrigation committees	Innovative medium scale farmers; 70% women	Innovative farmers at least 2 to 3 acres of own land; using Syngenta products
Scope in AWD dissemi-nation	Support of AWD dissemination in research, validation & training	Promoting AWD as part of improving irrigation management	Promoting AWD as part of improving Deep Tube Well-irrigation management	Promoting AWD as part of participatory development projects	Promoting AWD as a means to strengthening customer relationships
Geogra-phical focus on AWD	Selected sites in Rangpur, Rajshahi & Kushtia	Country-wide	Barind Tract, i.e. Rajshahi & Rangpur Divisions	Rangpur Division	Country-wide
Scope of dissemi-nation	3 field sites, each with 3 groups of 30 farmers (total of 90 plots) Since 2008 / 2009	528 demo-plots (NATP); 26880 trained pump owners (AETEP) Since 2008 / 2009	86 demo-plots, 25,000 trained farmers and pump owners Since 2007 / 2008	325 demo-plots through 13 partner NGOs Since 2009 / 2010	50,000 PVC (AWD) tubes distributed to farmers in 6 districts 2008/2009

Table 3: Profile of key organizations contributing to AWD dissemination

The BRRI, IRRI's formal counterpart, is an institute with a national mandate for rice research. This organization was one of the first to be involved in the introduction of AWD in Bangladesh. Through the involvement of major scientists over the years within its core functions, the institute laid down a solid base for disseminating AWD in Bangladesh. It conducted adaptive and farming systems research and analyzed the economics of introducing AWD into the irrigated rice farming system. With the BRRI's Irrigation and Water Management Division conducting research on increasing water productivity and, more specifically, on AWD, it also has competent experts in AWD technology. The role of the BRRI in promoting AWD in Bangladesh on a national level is considered important, considering that it hosted major workshops on AWD together with the IRRI as well as two training courses for trainers and managers, which were conducted at national level, building training capacity in the major organizations involved in AWD dissemination. Also, AWD was incorporated into all regular training programs for extension staff, which built on the knowledge and experience gained from research and validation. The focus and design of these courses[15] depend on the objectives and participants.

All in all, the BRRI played an important role in the research and on-farm validation of AWD, which provides an important basis for the lessons learned from case studies and dissemination piloting at selected sites. However, its mandate and capacity are not oriented towards disseminating the technology on a large, country-wide scale.

The second organization involved in diffusing AWD is the Department of Agricultural Extension (DAE). With its national mandate to disseminate agricultural technologies to farmers in Bangladesh, the DAE is considered the future key player in this process. It has incorporated AWD in most of its rice and irrigation management related extension activities[16]. Two specific projects, however, played a main role in disseminating AWD: the National Agricultural Technology Project (NATP)[17], including AWD as one of the project's main technologies for dissemination, and the Agricultural Engineering Technologies Extension Project (AETEP)[18], which recently ended. Since 2008-2009, pilots for disseminating AWD have been conducted in selected districts throughout the country and these pilots have increased year after year. To build in-house training capacity, DAE staff participated in training courses for national-level trainers. In addition to specific in-house training courses on AWD, extension staff is

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[15] The BRRI annually implements some 500 training courses. These are offered to extension staff of the DAE, in particular, to field staff, the SAAO, and the Agricultural Officers of the DAE at upazila level.

[16] The DAE incorporated extension on AWD in all projects related to rice production. To support its extension efforts, the DAE currently runs some 21 projects, which partially overlap at the field level.

[17] NATP (2010): The World Bank-funded NATP is a 15-yr national project with a large extension component. Started in July 2008, its objective is to improve agricultural productivity and farm income with a focus on small and marginal farmers (www.natpdae.gov.bd).

[18] The Agricultural Engineering Technologies Extension Project (AETEP) is a project that was reported to run from 2005 to 2007; and apparently continued until 2009 under the DAE. It was geared towards enhancing production and rural employment, to make agriculture more profitable economically.

being continuously trained in agricultural extension, through the BRRI and CERDI[19] for example, including the application of AWD as a new technology.

The BMDA is another governmental organization with an explicit mandate for the Barind region and a clear focus on infrastructure development including irrigation. Considering that Barind is a region that is particularly prone to water scarcity, the BMDA's role is highly relevant for the dissemination of AWD, as it addresses development issues for agricultural irrigation, in addition to irrigation development and the operation of a significant number of DTWs. In fact, as an autonomous organization under the Ministry of Agriculture (MoA), the BMDA has deployed resources for the dissemination of AWD from its own funding and has integrated it in its command area development and irrigation management project.

As a major NGO in the northern part of Bangladesh, the RDRS is engaged in rural development and empowering the rural poor with extensive experience in implementing and facilitating development processes with rural communities. However, it appears that efforts to improve rice cultivation were intensified only recently. For disseminating AWD, the RDRS uses its network of partners in the region. Although the RDRS's capacities are limited, it represents a major development actor in northern Bangladesh with respective project funding and competent staff in the field, contributing to the dissemination of AWD through its ongoing projects with farmers.

The private multinational company Syngenta, the major supplier of agrochemicals in Bangladesh, is the main private enterprise involved in AWD dissemination. It uses its own funds to provide AWD (PVC) tubes to its customers, in particular by means of associated retail sellers, contract farmers and by offering training as a part of formal meetings with farmers. Syngenta started to participate in disseminating AWD when its management realized that implementing this new technology is a win-win strategy for the company - it helps the customers to improve their rice production system and in return strengthens relationships with Syngenta.

Getting the different sectors, private-public-NGO and organizations with different profiles involved seemed to be beneficial and successful to establish a dissemination process for AWD in Bangladesh. This process benefited from the diverse backgrounds of these organizations, each with a different mandate and set of objectives. At least the major organizations involved have mainstreamed AWD dissemination in their activities and programs. However, it appears that these

[19] The Central Extension Resources Development Institute, or CERDI, is a training institute of the Department of Agriculture Extension (DAE) under the Ministry of Agriculture, located at Joydebpur, Gazipur, which specifically provides training for trainers and extension staff.

organizations have until now been more occupied with piloting and establishing AWD dissemination within their own systems and capacities, having hardly any impetus to providing a stimulus to other organizations in taking up AWD dissemination. This may not apply to the BRRI, which to a significant extent serves other service organizations through its research and training.

Overall, the number of organizations and actors significantly involved in AWD dissemination and the scope of AWD dissemination in these organizations is still limited. This is particularly the case as some actors, such as the BADC, a key national actor for developing the agriculture sector (including irrigation) has not played a significant role in advancing AWD dissemination beyond its initial involvement. Other actors, such as the seed production sector, represented by the private company Petrochem, which is a major entry point for farm innovations, have played a negligible role in disseminating AWD to date. In conclusion, it seems that out-scaling has in fact not yet reached a significant level. This process requires time, considering that AWD dissemination actually started mostly with the 2009 *Boro* season or even later, which is a very short period for initiating out-scaling processes. Also, taking into account the vast number of NGOs in Bangladesh involved in rural and agricultural development, there is an underutilized potential for future AWD dissemination.

5.2.3 Communication and Cooperation of Key Stakeholders

Good links between the organizations that disseminate AWD are essential for a successful spread of technology, especially at the beginning of the process, as new organizations join in or are about to gain experience in promoting the technology among farmers. Also, to promote successful out-scaling and up-scaling from a national or regional perspective, AWD dissemination requires effective communication and cooperation mechanisms among the stakeholders involved.

In Bangladesh, formal structures do exist to facilitate the development of new technologies and their dissemination in the agriculture sector under the Bangladesh Agricultural Research Council (BARC), which has the mandate under the MoA to coordinate the action of the stakeholders and agencies concerned (see Figure 7).

However, the BARC has not yet played an active role in this process. Also, the National Agricultural Technical Coordination Committee (NATCC), which is being chaired by the BARC[20], has apparently not been very effective so far in their support of AWD dissemination.

[20] The BARC, under the Ministry of Agriculture, assumes responsibility to develop future prospects and to prepare national the national agricultural research plan, which guides the planning and conduct

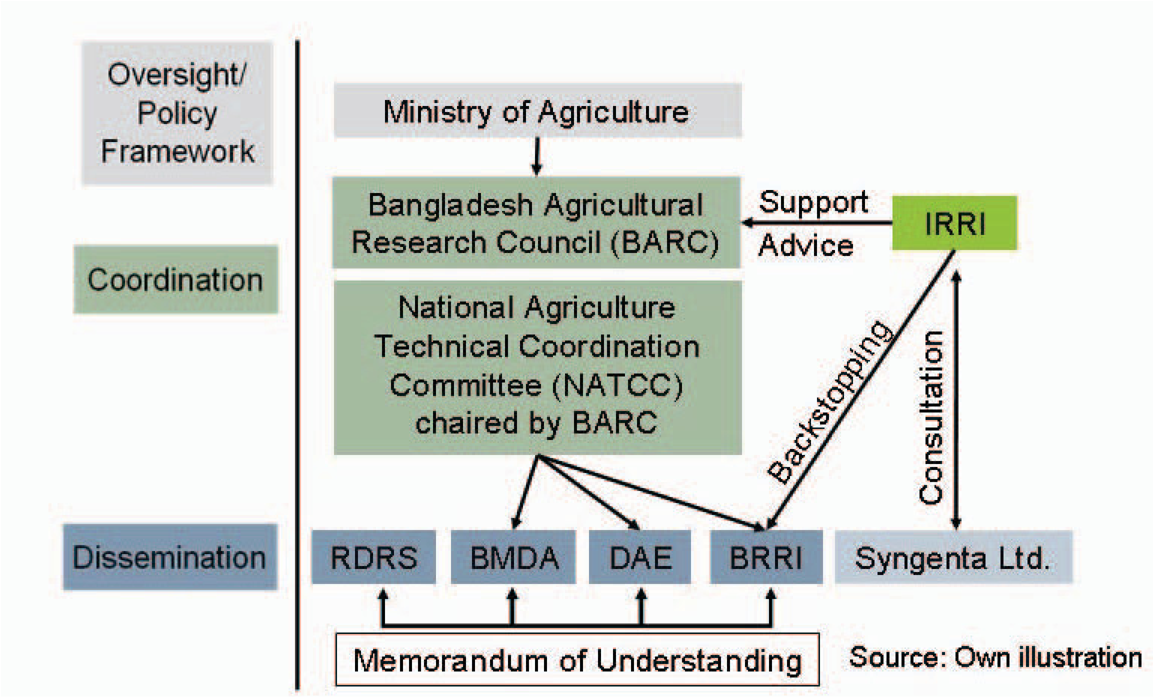

Figure 7: Coordination and cooperation mechanisms for AWD dissemination

This can also be seen from the fact that in 2007, the initial efforts of these organizations did not lead to the formulation of a joint AWD project, as requested by the Secretary of Agriculture. Coordinated action in disseminating AWD was therefore not pursued. That said, it does bring representatives of all the major national-level service organizations such as the DAE, BMDA,BRRI and experts to a meeting with the aim of reviewing and recommending the development of new technologies and to support, monitor and evaluate the contributions of extension (DAE, 1999) (see Chapter 5.2.1).

To date, the exchange of experiences in disseminating AWD has largely taken place through an informal platform, consisting mainly of workshops and meetings at national level, such as the 2009 and 2010 national AWD workshops facilitated by the IRRI (BRRI et al., 2009). While this kind of networking has been effective to support informal learning processes, it may not be effective in the long-term to establish respective ownership and commitment for AWD dissemination at national level.

In terms of making best use of the available resources and know-how, it would make sense for organizations to make better use of their complementary action in particular regions, such as the BMDA with RDRS or the BMDA with DAE, or by sharing responsibilities according to their comparative advantages, such as the specific

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of research according to national priorities. The BARC, through the NATCC and specific institutions, aims to coordinate research and inter-institutional collaboration (www.barc.gov.bd).

knowledge at BMDA of DTW-based local irrigation systems. While a number of formal agreements exist (see Figure 7) and specific collaborations actually take place in the field, the cooperation potential to disseminate AWD has not been fully utilized yet.

5.3 Ways and Means of Disseminating AWD to farmers

The dissemination of AWD to farmers is analyzed below according to the following criteria: the target group, the role of field staff from organizations, the training offered to the end-users, further methods for out-scaling at the local level, as well as the monitoring and evaluation of the dissemination process by the organizations.

5.3.1 Target Group

Until now, have the key organizations involved in AWD dissemination chosen suitable entry points to disseminate AWD at the level of farmers? Considering that 89% of the farmers in Bangladesh are small or marginal farmers (see Chapter 2.1), it turned out that the vast majority of farmers sampled for this study were small to medium-scale farmers[21]. In other words, marginal and small-scale farmers represented a much smaller share of the sample, as would be expected from the national distribution of farm sizes. This indicates a stronger involvement of farmers with medium and larger farms in the dissemination of AWD, given the prerequisite that samples were taken randomly.

The farmer category chosen by the different organizations as the target group for disseminating AWD seems to differ significantly based on the profile presented (see Table 3). However, when asking extension and field staff, it turned out that they foremost target educated and innovative, medium-scale farmers. High motivation and openness of farmers to try out new technologies are considered the main criteria for innovativeness by field staff.

The predominant concept of extension staff is based on the assumption that “medium-scale farmers will adopt first, i.e. those who have a considerable amount of land that they rely on and who are solvent enough to try it.” Medium and large-scale farmers are considered to rather follow economic principles and, therefore, “are always keen to try new technologies that are cost effective”. In the case of Syngenta, medium and large-scale size farmers are targeted as they are the main consumers of the company’s products. Certain types of larger farmers are not being directly

[21] The sample consisted of 6% marginal, 49% small, 35% medium and 10% large-scale farmers.

targeted by extension agents, because “they are not very keen to try AWD as they usually lease out their fields to others”.

Marginal farmers and share croppers were considered by extension staff as difficult to train, as they have very little time to invest, have less formal education and are very risk-averse. “All they want is to make sure that they can survive on the outcome”, as extension staff put it. Another constraining factor frequently voiced by field staff was the difficult access to this group. They may have to regularly shift rice cultivation from one plot to another, depending on the land owner’s decision. In addition, small-scale farmers often depend on others to obtain access to irrigation.

Pump owners and pump operators are the crucial actors for providing and managing irrigation. Therefore, most organizations focus on them as a target group for AWD dissemination. As Miah et al. (2009: 12) summarizes: “since pump owners are apparently first beneficiary, the approach of large scale-adoption may start with pump owners. All training and motivational work should start with them as the target”. AWD is often a component of training programs that address irrigation management, and which pump owners target with more emphasis.

Women are currently not a main focus of AWD dissemination. Their involvement in rice cultivation other than post-harvest activities is mostly rather limited. The RDRS is the only organization working with implementing target groups, 70% of them consisting of female leader farmers. Specifically in the northern parts of Rangpur Division, where farmers are in a particularly precarious social and economical situation, many agricultural activities are carried out by women. In fact, it turned out that some female leader farmers act as opinion leaders in their villages. This seems an important factor for dissemination, as these women can also convince their husbands to adopt the new technology. Whether targeting women will be successful for disseminating AWD cannot be concluded at this time and needs further evaluation. Though women are not actually implementing AWD, they still have to be considered as a relevant actor to spread knowledge about AWD locally.

5.3.2 Role of Field and Extension Staff

The organizations involved in extension and development activities deploy staff at local level. This field staff must be able to take on the responsibility of conveying the knowledge about AWD and to convince end-users to actually apply the new technology. The role of extension staff was also confirmed by the responses of farmers during the survey. When asked whose advice they trusted most, close to half of the farmers who did not receive training on AWD generally rely on extension staff when they have problems.

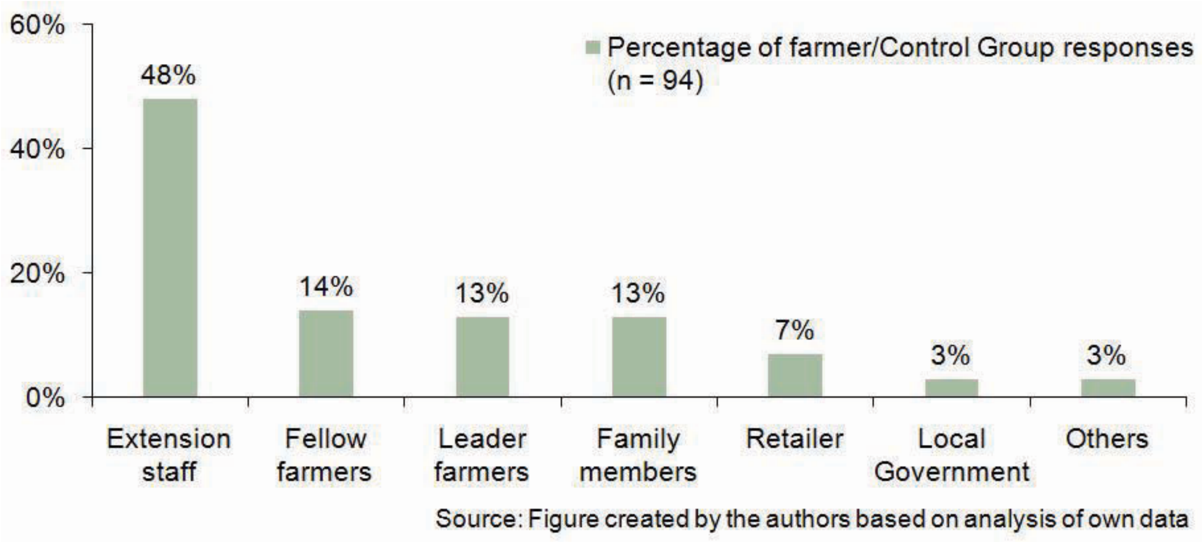

Figure 8: Farmers' responses to question: Whose advice do you trust most?

The role of field staff and their ability to provide effective training and support to farmers largely determine the effectiveness of the organizations' approaches in disseminating AWD. This mainly relates to three factors: Education and experience, the field staff's training in AWD and the general work environment.

Education and experience of staff

Professional background is important for the success of dissemination. Staff with sufficient background in agriculture effectively absorbed the principles of AWD and were able to train others, as interviews showed. However, it became evident that professional background and relevant work experience differed between different staff, ranging from a diploma in agriculture combined with extensive experience to other educational backgrounds with little work experience related to agriculture.

Extensive knowledge of the local conditions and of farmers' decision-making was essential to develop good access to farmers and for field staff to be able to help farmers to solve problems, as the survey showed. This includes the familiarity with customs, social issues, and local dialects. Building close relationships with farmers through dialogue appeared to be another important aspect. Extension staff originating from the same area or working with farmers for a longer period of time seemed to have clear advantages in gaining the trust of farmers.

The means of communication between field extension and farmers turned out to be another factor determining the success in disseminating AWD. From the interviews it appeared that extension was not able to reach different categories of farmers to a similar extent. On one hand, gaining access to farmers seemed to be closely related to the ability of field staff to use a language that farmers are familiar with. Some farmers complained that they did not understand what extension staff tried to tell them as it was "too complicated". On the other hand, extension officers often mentioned that they preferred to work with literate farmers who better understood extension issues.

Staff training on AWD

Organizations took different paths to train their respective extension and field staff. To some extent, at least for the DAE, a significant number of officers attended several-day training courses for trainers conducted by the BRRI. Also, the BRRI provided implementation training to extension and field staff within its regular training program[22]. In a few cases, initial training to an organization was provided directly by the IRRI. Subsequently, organizations usually trained their own staff to pass on know-how about AWD to field staff that would then be used to train farmers, i.e. the end-users.

It was found that extension staff who acquired a more comprehensive and focused training on AWD was better prepared to explain the technology and more confident to train farmers. In a number of cases, training sessions, in particular those offered within organizations, seemed to be inadequate to enable extension to effectively disseminate AWD. Also, the diversity in the length and quality of training sessions led to unequally trained staff within the same organization.

AWD was mostly added as one of many theoretical and practical components to one-day training courses. While content and length of training sessions varied substantially, even within the same organization or program, some staff did not receive training beyond a brief introduction to AWD, as indicated by the survey. This resulted in the response of interviewees, stating that they would not be able to effectively disseminate the technology due to an insufficient understanding of AWD. In exceptional cases, extension staff - when asked about AWD – asked farmers to explain the technology.

Work environment

Throughout the survey, extension support, especially from government organizations, was described as being somewhat erratic by a significant number of farmers. As one interviewee put it “he [the extension staff member] does not come here regularly, but his advice is useful”. High workload as a limitation for successful AWD dissemination and regular visits in the field was consistently given as a reason by local extension

[22] In addition to specific AWD training and training or trainers, AWD was incorporated in most of BRRI’s regular training courses. Training courses are offered to the DAE’s extension staff, in particular, DAE field extension staff (SAAO) and Agricultural Officers at upazila level. Some 500 courses are implemented annually. Focus and design depend on the respective objectives and participants.

staff. For example, one DAE field officer, the so-called SAAO[23], is responsible for one agricultural “block”, which comprises 2000 to 3000 farm households, a number, which has constantly increased[24] since the 1980s.

AWD dissemination to farmers is often perceived as an extra workload by DAE extension staff. Staff has to regularly oversee a number of implementation projects. This apparent limitation of staff also affects the quality of AWD training sessions, which are not planned and executed as desired, as indicated by the survey.

In some cases, high fluctuation and low motivation of staff due to the relatively low salaries of field extension staff seemed to have a substantial effect on the quality and efficiency of the extension work. In particular, the high fluctuation of staff affects ongoing extension processes, since new staff requires time to become familiar with local conditions and to establish a trustful relationship with the farmers. This was confirmed by some extension officers who worked in a particular area for just a few months. In addition, field staff mentioned a lack of adequate transportation that further hampers regular visits to farmers.

5.3.3 Training of the End-Users

Training sessions play a key role for successfully disseminating AWD to farmers and assuring later adoption. The analysis of non-adopters indicates that the duration and quality of the training pose major reasons for farmers not to try the technology. In total, 38% of the non-adopters in the study gave reasons related to training for their rejection of the technology (see Figure 9).

21% of farmers who did not adopt AWD explained that they did not receive adequate training or did not understand AWD. Chapter 5.3.2 reveals some of the reasons why field extension staff was not always capable of providing more adequate training to farmers. Farmers frequently complained about the duration of AWD training, on the one hand, which they often considered to be too short: “What can I understand in 15 minutes as I am not educated” or not able to understand the specifics of AWD: “only an introduction but no details”, as some other respondents highlighted. On the other hand, most training sessions took place only once. Even most field officers agreed that to really understand AWD, more sessions would be necessary. Another major factor for not adopting the technology is connected to the timing of the training. Of the farmers who did not adopt AWD, 17% criticized the training as coming too late in the season. When training was received in February or March, they were not able to effectively apply AWD anymore during that season.

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[23] The local DAE field extension staff is called SAAO or Sub-Assistant Agricultural Officers.

[24] The original number of households per SAAO was in between 800 to 1000 in 1980.

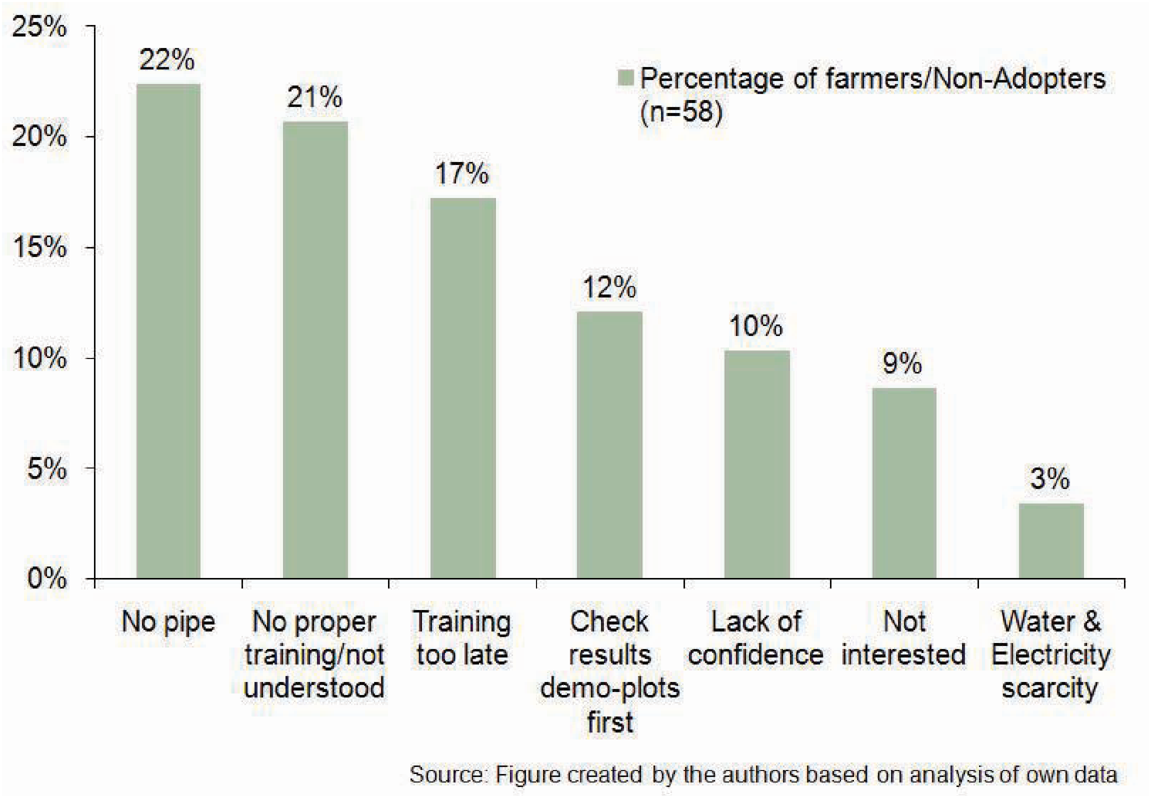

Figure 9: Reason for non-adoption of AWD

Therefore a BRRI scientist stressed the need to train farmers at the right time, i.e. before Boro season, as he concluded “the time between Boro seasons is long and the memory of the farmers is sometimes very short”.

Knowing about the importance of adequate training, all AWD disseminating organizations included in this study consider more extensive and participatory training programs as being more effective to pass on knowledge about AWD and to motivate farmers to try the new technology. Therefore, most organizations disseminated through a combination of demonstration plots and group approaches.

Dissemination through demonstration plots

For demonstration purposes, progressive leader farmers[25] usually implemented an AWD-plot alongside a conventionally irrigated plot. This enabled farmers to test AWD on a small plot and to directly compare respective costs and benefits. Table 3 shows the amount of demonstrations set up and farmers trained by each organization.

Demonstration plots were often set up during Farmer Field Days and ended by organizing local crop-cutting ceremonies during harvesting, inviting the farmers of the

[25] The prerequisites for the plot itself were that it had to be close to the road, easily accessible and near a pumping system.

area to join the AWD validation. Thus, the information on the results of the testing are passed on to a larger audience. The disseminating organizations usually supplied farmers with “demonstration packages”[26] that included different field inputs and AWD-pipes.

Several goals are pursued with the set up of demonstration plots according to regional level staff. Farmers can test the new technology through hands-on-experience and can learn how to use it. Also, using this “model-farmer” approach, most organizations assume that other, especially small-scale farmers would follow the lead farmers, having the benefit of observing the application of AWD and the results obtained with it for one season. Key interviews at a regional level assured that demonstration plots help to inform farmers, to start discussions about the technology and to help spread the news to other groups and villages.

Field extension staff confirmed that the approach with demonstration plots was very successful as it allowed farmers to acquire an understanding of the technology. However, extension staff mostly expressed doubts that AWD - as a knowledge intensive technology - will spread based on farmers’ observations only. The desired “snow-ball effect”, of neighboring farmers taking over the technology from the model farmers might not work as desired.

Dissemination through group approaches

All organizations interviewed use group-based approaches for training, such as Farmer Field Schools[27] (RDRS), formal meetings (Syngenta), Integrated Pest Management Clubs[28] or Common Interest Groups, so-called CIGs (DAE). Group extension work has several advantages over individual extension: A large number of farmers can be reached (time- and cost-effective) and farmers can participate in the process and exchange their problems, which can be more convincing than when the same content comes from the advisor (Hoffmann et al. 2009: 127). The extension officers considered the different group approaches to be successful as well. Farmers within the groups seem to be encouraged to share experiences with the new

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[26] Packages provided to farmers often consisted inputs such as seeds, fertilizers, pesticides and tools to measure the water level (AWD tube), depending on the resources of the organizations.

[27] Farmer Field Schools (FFS) emerged from IPM groups, focusing on the needs of farmers with the goal to make them experts and self-reliant in their decisions. FFS may vary in their focus but they all have the same core values: Learner-centered, participatory and relying on an experiential learning approach (Pontius et al., 2002). The rice field is used as the learning tool as it combines both learning sessions in the field and follow-up support (FAO, 2007:17ff).

[28] Integrated Pest Management (IPM) Clubs were introduced in Bangladesh in 1981 through the FAO to fight the abuse of highly toxic pesticides that were used in Asia during and after the green revolution (Dilts, R., 2001: 18).

technology and to pass on the acquired knowledge to other group members, which can lead to faster adoption compared to training individual farmers.

Figure 10: Training in group approaches (Source: Own photo)

But some field staff also expressed limitations in group extension, as training is restricted only to members. Despite the field staff's knowledge, the group approach does not seem to enable the inclusion of opinion leaders and other relevant farmers. Field extension staff expressed their desire for greater flexibility in gathering groups for training.

Another training approach that was found in the field was a one-off training session that was given to unorganized groups on several irrigation matters i.e. on field days. Despite the advantages of raising awareness of AWD quickly and cost effectively and among many farmers, this kind of training does not support experience-based learning. Field data showed that it does not necessarily increase adoption rates of AWD.

5.3.4 Methods for Out-scaling on a Local Level

A successful diffusion process at the local level is not only dependent on the extension system of the organizations and the adequate training of the end-user. For a broad diffusion, other factors such as integrating opinion leaders into the process, mass campaigns to promote AWD to a broad audience and farmer-to-farmer diffusion are essential.

Opinion leaders

Opinion leaders have a vital role in the dissemination process as they can act as role models in trying a new technology. Identifying and including them in the AWD extension activities might be favorable for dissemination. The study found that some opinion leaders were already included in the dissemination process, whilst others could still receive a stronger focus and comprehension.

Through interviews with the field extension staff, three different groups of local actors were identified to play a vital role: experienced and successful farmers, seed or agrichemical dealers and representatives of local governments.

The group of experienced and successful farmers usually included the older, better-off farmers of the village. 13% of the farmers not practicing AWD stated that they trusted the advice of experienced farmers (see Figure 8). Field extension staff noted that mostly small-scale farmers approach this group when they encounter problems. Some field staff expressed the need to involve local leader farmers more actively, e.g. for setting up a demonstration plot.

Secondly, retail sellers of seeds, fertilizers and pesticides might enable a more effective dissemination of AWD. These local dealers have not been included in the current dissemination approaches except in Syngenta's approach, which actually distributed AWD pipes through them. The dealers are frequently consulted by farmers when problems occur and the agrochemical dealers have developed relationships with their clients over the years. This channel could be an efficient platform to promote and pass on AWD to farmers in the future.

Thirdly, chairmen and representatives of local government (often being experienced farmers themselves) are considered to be important opinion leaders by farmers. Surprisingly, the local government is currently not systematically included in the dissemination process. Nevertheless, key informants found it important to involve the representatives to enhance AWD dissemination. One key informant even mentioned that the local government would be the most appropriate instrument to monitor and promote the dissemination process at the local level in cooperation with the DAE in the future.

The role of the media

The role of the mass media has been considered crucial to support the diffusion process of AWD in Bangladesh by a wide range of key informants at different levels. The use of electronic media, such as TV and radio, and printed media, are often cited to be indispensable for a massive spread of new technology and awareness-raising. 50% of the surveyed farmers state that electronic media is an effective way to inform farmers of new technology. The fact that only 10% of the farmers considered printed media to be appropriate for information sharing might originate from the high illiteracy rate found in the study regions.

From the very beginning of the process until now, television and almost a dozen English and Bangla newspapers engaged in raising awareness about AWD. Interviews with scientists were broadcast on Bangladesh Television and national workshops including policymakers received nationwide coverage in broadcast news and newspapers. A Bangladeshi television channel focusing on agricultural issues broadcast talk-shows with farmers and scientists and showed awareness-raising adverts (Miah, 2008).

Throughout the study, there were farmers who remembered having seen broadcasts on AWD. Nevertheless, suggestions for a broader media campaign, including appropriate methods to also reach illiterate farmers in the villages were brought up by a lot of key informants. To further disseminate AWD through the media, one expert suggested that the government should design a coordinated information campaign in cooperation with the MoA, the Ministry of Water and the Ministry of Information.

Farmer-to-farmer diffusion

As AWD trainings and implementation has happened only very recently in Bangladesh, the degree to which farmer-to-farmer diffusion takes place cannot sufficiently be assessed yet. Throughout the sampling, four farmers were found who were introduced to the technology without being trained by an organization, two of whom actually used AWD. Both of them were young (aged 21 to 30) and AWD was recommended to them by family members.

But when asked for their opinion on farmer-to-farmer diffusion, local staff mostly gave a negative outlook: “Without proper training it is really hard to disseminate the technology as most farmers are illiterate and poor. Farmer-to-farmer [diffusion] might not work that well – also because they really need to understand what they are doing” and another one said “farmer to farmer dissemination is hard and slow”.

Extension staff explained that this spontaneous way of diffusion is more likely to happen in well established groups (see Chapter 5.3.3) as farmers who are members of these groups come from a similar socio-economic background and are already used to exchanging ideas about agricultural issues. “Within the FFS news on AWD spread very well. So other FFS members will get to know about the technology and use it and then village people will also try it”. All in all it seems that farmer-to-farmer diffusion - if it occurs at all - is a very slow process.

5.3.5 Monitoring and Evaluation

All the organizations that were assessed in this study have incorporated AWD into their established monitoring and evaluation systems. This is working well in some cases and there is room for improvement in others.

A specific mechanism to monitor the dissemination of the technology has only been developed within the DAE’s NATP program, By means of a farmer-needs based approach within the NATP program, not only the profitability of AWD is monitored, but also conclusions of the dissemination process are assessed and passed on to the management. As an example, from the NATP program, the DAE has learned to change its approach from AWD demonstrations in single plots to entire irrigation blocks, as the adoption of AWD requires all actors in a command area to make decisions. Another lesson learned through the monitoring and evaluation is that the

DAE wants to help empower groups to own their own pumps so that potential conflicts between farmers and pump-owners may be resolved (DAE, 2010).

Also Syngenta must have assessed the dissemination process, as the company conducted adaptations to its strategy. An example of this is that Syngenta moved away from giving free AWD pipes towards promoting self-made pipes from plastic bottles, as PVC pipes were often stolen.

These examples show that feedback from field staff reaches the management level to redesign the dissemination approach in some cases. However, most organizations emphasize on monitoring the validation of the technology (i.e. collection of data about the number of irrigations, water and labor use etc. due to AWD). Thus all organizations could supply input/output analysis of AWD from their own validation. While such data are important, it seems more relevant to focus on monitoring the process related to the dissemination in order to be able to redesign the approach according to farmers' needs. The majority of organizations did not supervise this process, leading to difficulties in supplying lists of farmers who received training. This would be important in a second step to monitor whether farmers adopted the technology or not, to assess adoption rates and change strategies if necessary. All in all, there is significant potential to improve the monitoring of the dissemination process.

5.4 Conclusion

So far, key organizations from public, private and the non-governmental sector have shown high commitment in promoting AWD, taking up the new technology and disseminating it within ongoing projects and programs.

Yet, a clear dynamic of the process at national level could not be observed until now. Most organizations involved in AWD dissemination did not go far beyond the piloting and validating the new technology. This being said, the authors of this study found it difficult to pinpoint the general performance of the current dissemination process. However, relevant factors limiting AWD dissemination were identified as well as the potential for a more effective up- and out-scaling of AWD in Bangladesh.

One reason seemed to be a lack of ownership of the overall process, taking the lead to institutionalize the dissemination of AWD, which up until now, largely depended on the facilitation role of the IRRI, whereas the Bangladesh Rice Research Institute (BRRI) with its mandate for rice research, and the Department of Agricultural Extension (DAE), the main actor for disseminating agricultural innovations to farmers, stayed behind.

The national policy framework is another important factor that can promote or hinder the continued up and out-scaling of AWD. Initial steps have been taken to incorporate AWD into policies and structures at the national level. But the current policy framework does not sufficiently reflect yet the national relevance of AWD as a means to reduce resource consumption in agricultural production. The introduction of the first National Irrigation Policy might change this fact. However, the policy, which is currently being prepared, is the only explicit reference in this context. Whether the implementation of this policy, if approved in the near future, will actually result in effective support of the dissemination and mass-adoption of the technology by farmers remains to be seen.

Probably the biggest obstacle for effectively reaching millions of rice farmers is the lack of appropriate coordination, cooperation and knowledge-transfer of and between the stakeholders involved in AWD dissemination. Consequently, some extension projects seem to overlap unnecessarily in some regions or to utilize inappropriate, non-context specific approaches in other places.

At the same time, existing structures for agricultural technology development and extension, in particular the BARC and its related committee, the NATCC, which are well positioned to facilitate cooperation and coordination between the organizations involved in AWD dissemination, did not take an active part, thus adding to a slacking process.

Against this background, it seems important to overcome the currently insufficient coordination of the extension efforts and collaboration between relevant stakeholders. As most of the actors involved in this study voiced, the development a national dissemination strategy would be appropriate to institutionalize coordination and to allow for a systematic sharing of experiences and information.

When taking a closer look at the local level, field staff was found to play a key role in disseminating AWD to farmers. Moreover, AWD dissemination needs a more comprehensive process of extension as it is more of a knowledge-intensive technology than a capital intensive one. Thus, the capacity and capability of field staff plays a vital role in successfully passing on the details of implementing the technology.

The effective training and scaling-out of dissemination activities to a larger number of farmers by field staff seems to be restricted by the available financial resources, transport and other resources. Also, it appeared that most organizations were limited in their capacity of well-trained extension staff. At least in some cases, the capacity building received by extension staff seemed to be insufficient in order to successfully train farmers on AWD. This was explained to some extent by substantial variability of the content and length of training for field staff throughout the different programs and organizations. As a consequence, this sometimes led to farmer training of an insufficient quality and a number of farmers who did not properly understand the training.

When focusing on the way organizations pass on AWD knowledge, the study showed that most organizations spread the technology through a combination of demonstration of the technology in the field and training in groups. The learning processes of farmers implementing demonstration plots showed a positive effect, building hands-on practical experience and helping to understand the technology.

By using group extension approaches for disseminating AWD, a larger number of farmers are reached, whilst communication and knowledge transfer amongst them is facilitated. Whether farmer-to-farmer diffusion of AWD takes place outside the established training groups could not be analyzed at this point, but it should be looked into in the future. First findings support the assumption that knowledge is rather passed on through farmers with a similar socio-economic background. Last but not least, including local opinion leaders more strategically in the dissemination approach might be favorable for a wider spread of the technology. This means, for example, developing strategies to involve local governments and retail sellers with their established structures in dissemination approaches.

Finally, experiences of extending the technology to farmers needs to be continuously reviewed with an organization and important lessons learned need to be passed on in order to improve the effectiveness and efficiency of a dissemination approach. Although all organizations looked at by this study had established AWD monitoring and evaluation, they mostly concentrated on the technical performance of the technology. In most cases, the monitoring systems lacked a focus on the dissemination and adoption processes, which would allow an analysis of the limiting and success factors of dissemination and adoption, and of the specific needs and constraints of farmers (see Chapter 6).

6 Adoption

The adoption process of AWD in Bangladesh is still in its early stages as the study shows. Among the farmers and pump owners using AWD in the sample, 70% applied the technology for the first time in the 2010 *Boro* season. A large share of these first-time users are conducting AWD demonstrations instructed by one of the disseminating organizations (see Chapter 5). Farmers applying AWD since the 2009 *Boro* season made up just 26% and those applying the technology since 2008 made up just 4%. Most farmers have received training very recently.

Therefore, it is too early to make statements about adoption rates. Also, it does not make much sense at this point to comment on the sustainability of the farmers' practice of AWD. Similarly, it does not seem valid to extrapolate actual adoption levels by region or organization from the present adoption figures.

But what can be analyzed is the farmers' perspective about the relevance of this water saving technology, its benefits and compatibility with local agricultural systems. The findings outlined in this chapter, however, are a rough approximation of the factors that favor or hinder the adoption of AWD. Nevertheless, significant issues were identified that need to be considered generally to improve adoption at the farmers' level and that would eventually enable mass adoption.

6.1 Demand for AWD

A look at the context of the two study regions and the relevance of AWD for Bangladesh as described in Chapter 2 reveals that northern and north-western Bangladesh seasonally experiences water and energy problems. Therefore, farmers, pump owners and extension staff were asked about the consequences of water and energy problems for irrigation of their fields and about their perceptions of water and energy issues. The underlying hypothesis that there is a demand for a water and energy-saving technology such as AWD could be confirmed.

6.1.1 Water Scarcity

In the field survey, farmers were able to discern water scarcity as a problem during the *Boro* season in both study regions. Also, among the control group of farmers, 82% confirmed that water scarcity occurs during the *Boro* season.

The problem of water scarcity is particularly severe in Rajshahi Division, which can be seen in Figure 11 in the high number of interviewees (39%) who identified groundwater shortages as their main problem of irrigation.

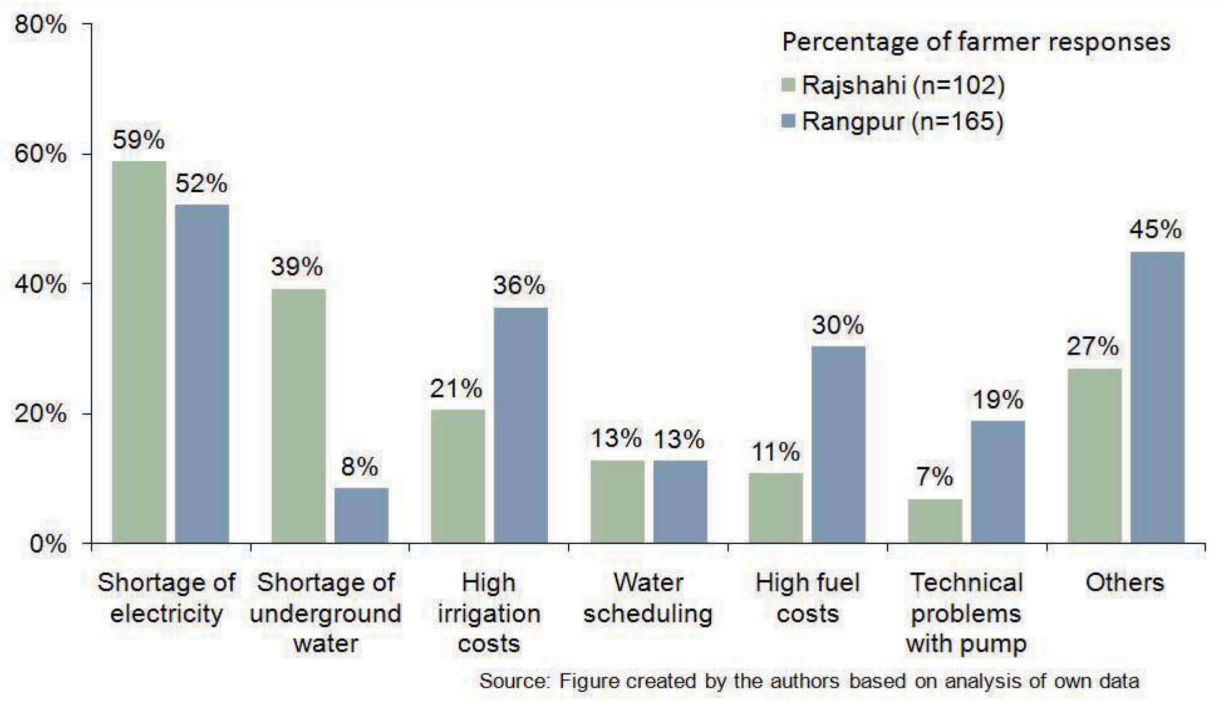

Figure 11: Irrigation problems as perceived by farmers

All key informant interviews with extension staff, focus group discussion, farmers comments and own observations during the survey confirmed the severity of physical water scarcity in this region also. While this study was conducted during the Aman season when the monsoon is expected to bring sufficient rainfall, an extension staff member in Rajshahi, as well as several experienced farmers, claimed that they “have not seen such a dry year in their lifetime”. Of the farmers in Rajshahi, 84% already picked up supplementary irrigation in this Aman season, which usually sees sufficient rainfall, while only 27% of the Rangpur farmers irrigated during Aman. In normal years, water scarcity does not occur until the onset of the dry *Boro* season in December.

Even though there is a physical water scarcity in Rangpur, water is rather considered to be an economically scarce resource in the division. Farmer Md. Aftab states that “...scarcity of water is not about the water source but about the cost of irrigation". 36% of sampled farmers and pump-owners consider that high irrigation prices are a problem for irrigation as indicated in Figure 11.

6.1.2 Energy Scarcity

The problem of water scarcity is intrinsically linked to the chronically deficient electricity supply in Bangladesh. Practically all DTWs and many STWs are run with electricity.

Bottlenecks in power supply therefore form a central obstacle for farmers in obtaining irrigation water in time. In Rajshahi, the delay of irrigation water has already led to serious harvest losses during the 2010 *Boro* season, as reported during the field survey. Depending on energy and water availability, rainfall, the number of farmers, the size of the command area and soil and pump capacity, each irrigation block in a DTW scheme (see Chapter 6.3) normally receives water every five to eight days. Due to the acute limitation of water and energy in Rajshahi, an extended irrigation interval of 10 to 17 days has been common practice in the 2010 *Boro* season. For some farmers the water situation is so drastic that they are considering to discontinue rice cultivation in the future.

Field extension staff in Rangpur confirmed that farmers have to cope with an erratic electricity supply. In the northern districts of Rangpur Division for example, continuous electricity supply sometimes lasts for just 10 minutes, while the overall electricity supply might last for only three hours each day. The lack of electricity is considered as the foremost problem of rice cultivation in both study regions by farmers and extension agents, as Figure 11 demonstrates.

It is often believed that solving the energy problem will automatically lead to solving the water problem as well. It appears that farmers and some extension officers do not necessarily relate water scarcity to an overexploitation of groundwater resources.

In contrast to electricity, whose supply depends on external factors and cannot be influenced by the famers, fuel presents a much more secure source of energy for irrigation. It is however also the more expensive option. 30% of farmers and pump owners consider the high fuel price in Rangpur as their main problem in irrigation. But in some remote Rangpur villages, fuel presents the only possible energy resource as the farmers in these regions have no access to the power grid. Farmers also explained that fuel is sometimes hard to come by as distances to markets are far and fuel is not always available.

Excursus: Farmers' view on water scarcity and Allah

"It is about Allah. Allah is angry with us. [...] 20 years ago there were no water problems during monsoon season. You could find water everywhere! But in the last 2 years there has been an extreme water scarcity as it has rained very little. And this year it is even worse. There has not been any drinking water in my tube well for over 4 days. […] If there is no rain then everything will be dry. When there is no water, the government cannot do anything. Not everything can be bought with money, in some cases we have to rely on nature. Allah is everything! If he wants to give us something, he will give it to us. We human beings cannot do anything against Allah. We must pray to him, so that we do not face any problems."

Abdul Aftab, Rajshahi Division, 04.09.2010

Surprisingly, about two thirds of all interviewees stated that they do not practice any kind of strategy to save water or energy. The strategies of the few interviewees that do perform a water or energy saving method (besides AWD) are indicated in Table 4.

Rajshahi (statements arranged according to frequency of responses)
• Repairing drains to keep water transmission losses low • Changing the cropping pattern: discontinuing Boro rice cultivation and shifting to crops with lower water requirements (pulses, wheat) • Irrigating at night when electricity is available • Less irrigation in general, e.g. irrigation for less than half an hour continuously • Closed irrigation tubes instead of open canals • Water storage: pumping groundwater into ponds when electricity is available, then irrigating by low-lift pumps • Using diesel pumps instead of electric pumps • Cultivating different crops every year on the same land
Rangpur
• Mulching with cow dung to preserve soil moisture • Using diesel pumps instead of electric pumps • Pump owner asks farmers to take care of their embankments on the side of the paddy in order to decrease water losses through leaching • Reduction of water losses by providing water to farmers that are furthest away from the irrigation point during the night (when evaporation is low) • Changing the location of the STW pump when the aquifer dries out temporarily

Table 4: Current strategies of farmers to save electricity, fuel and water

Peculiarly, farmers and pump-owners from Rajshahi Division practice a lot more strategies to cope with the two constraining factors. As described earlier, Rangpur farmers “merely” encounter the unreliable electricity supply as the major constraint. It appears that the combined pressures from the actual lack of electricity plus the physical irrigation water shortage affects Rajshahi farmers in a more substantial way.

The analysis of the current water and energy situation shows that the study regions suffer from a severe energy scarcity and consequent induced water scarcity, but also from a physical water scarcity that significantly constrains rice farming. The fact that some farmers are already using strategies to save water and energy similarly shows that there is a demand for water and energy saving strategies. These findings confirm the need for a water and energy saving technology such as AWD, which forms a good basis for the adoption of this new technology.

6.2 Farmers' Practice of AWD

The need for water and energy-saving technology does not necessarily mean that this technology is automatically adopted. In order to find out whether the previously described external pressures of limited water and energy supply influence the adoption of AWD, the AWD field practices were assessed and analyzed with respect to possible limitations and factors that have a positive influence on adoption.

Here, the practice of letting the water table drop to some extent below soil surface is regarded as an AWD practice. In this aspect, it was interesting to observe that even farmers in the control group (19%) are practicing some form of AWD without using the AWD-pipe. Moreover, 28% of the control group farmers exclaimed that decreasing the water level in the rice field to a certain threshold does not necessarily harm the rice crop. In these cases, farmers were deliberately utilizing the knowledge of AWD even without being trained. Moreover, extension officers (only in Rajshahi) confirmed that some farmers were more inclined to use this knowledge rather than the tool itself. These farmers simply dug a hole and used a stick to monitor the water level (see Excursus on AWD Adaptation below).

Moreover, it was found during the field survey that "unintended AWD", in which the farmer does not receive irrigation water at the agreed time and is therefore forced to let the water level drop below surface, is a common practice. This leads to unintended water savings. "Unintended" AWD can be further distinguished between "mild" and "forced"-AWD-practitioners. With "forced AWD", the water level in the field is much lower than in "mild AWD" and in extreme cases may even drop below the threshold of 15 cm below soil surface (compared to "safe AWD" in Chapter 2.3). "Mild"-AWD describes a form in which the water level may be at saturation or a few centimeters below the soil surface before re-irrigation. 24 % of the farmers who adopted AWD were forced by the delayed water allocation (usually induced by energy shortages) to practice a form of AWD (12% "mild" and 12% "forced" practitioners). The amount of adopters that use intended and unintended irrigation practices is indicated in Figure 12.

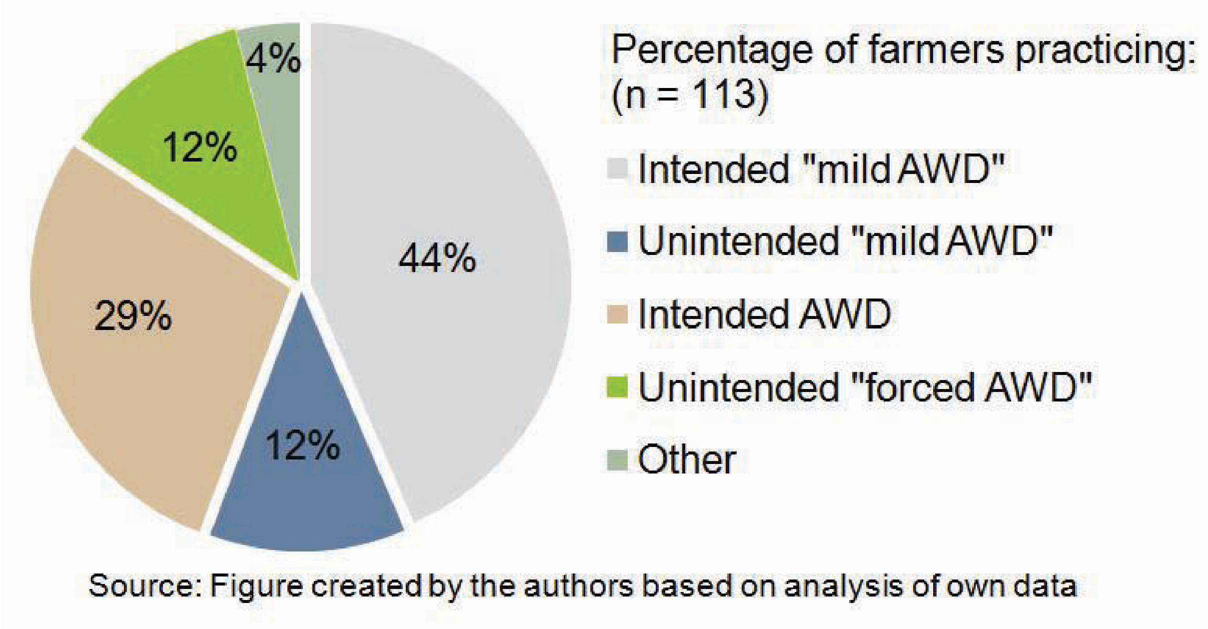

Figure 12: Adopters of intended and unintended irrigation practices

Being able to control the water influx to their paddies, farmers who received irrigation water at the agreed time were assumed to deliberately practice AWD, or a modified form of it, so they are using “intended” AWD. However, Figure 11 also shows that the majority of AWD practitioners (44%) performed “mild” AWD. 29% of all surveyed AWD adopters deliberately practiced AWD and stated to let their water table drop deeper than saturation, which may be regarded as a form close to “safe AWD”, although this could not be verified as water tables were not measured.

The ideal concept of “safe-AWD” is currently not the norm. Also, the high number of farmers practicing “mild-AWD” indicates that at present, water and energy saving potentials are not fully utilized yet. The reason for this may be found either in the perceived risk of a new technology or may result from structural problems in the irrigation systems in which farmers are incorporated (further explained in Chapter 6.4)

First-time users usually applied AWD on a very small share of their total cropping area and compared this plot to a conventional field (see Chapter 5.3.1). These farmers usually argued that they will expand the cropping area under AWD in the next Boro season, which also demonstrates the early status of AWD adoption in the study regions.

Excursus: Adaptations of AWD

At the present state, some adaptations have been found in the field that are practiced by AWD-trained farmers and organizations:

1. Monitoring the soil status:
- Digging a hole in the field to measure water level
- Measuring the water level with a stick

2. Adaptations of the pipe by farmers and organizations:
- 24% of adopters use self-made pipes; these are predominantly made out of plastic bottles or sometimes out of bamboo
- Syngenta adapted the pipe to ease the insertion into the ground
- Within the DAE programs NATP/AETEP, the pipe was simplified and shortened to 15 cm

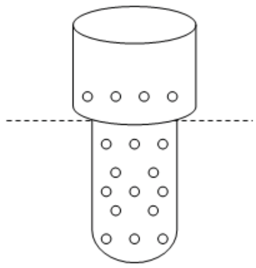

Figure 13: Adapted AWD-pipe by Syngenta

Source: Own

Adapting the AWD-pipe seems an easy and low budget option. It can be assumed that the potential for a wider adoption through the use of self-made adapted AWD-pipes is still considerable.

6.3 The Role of Energy and Water Reliability

The field survey demonstrated that AWD adopter farmers are in fact already practicing various methods of AWD, either deliberately or unintentionally, which often results from the limited availability of water and energy for irrigation. It was observed that the unreliable water and energy supply has a somewhat ambiguous influence on adoption, which needs to be differentiated depending on the local context.

For once, as explained in Chapter 6.2, electricity and water scarcity can have beneficial effects on increasing the awareness that less water does not harm the rice crop. However, this strongly depends on the seriousness of energy scarcity, as a severe and prolonged lack of water (beyond the 15 cm below ground threshold) does significantly increase the risk of yield losses.

On the other hand, in the case of an extremely unreliable water supply, AWD may pose an additional risk for farmers. As AWD prolongs irrigation intervals, the risk of crop losses is even larger when the electricity supply fails at the specific time when the rice crop needs water. As a consequence, it was observed that farmers tend to use more water than actually needed when electricity is available, as explained by local extension staff. Mr. Hossain, an experienced field staff, described this situation with the help of a simple metaphor: “If a man is well nourished, he will ration his food appropriately, but if a hungry man is given food, he will take more than he can digest at the time”. Some extension officers (only in Rajshahi Division) actually advised farmers not to wait until the water level drops to 15 cm below the surface, but to irrigate prior to this, as was confirmed by interviews. This also explains the high number of “mild-AWD” users in Figure 12. Hence, to practice AWD, a certain level of water and energy security is indispensible. The more reliable the water and energy supply is, the less risky the adoption of AWD becomes for farmers.

When asking about the advantages of AWD, it was interesting to observe that farmers and pump owners who practice AWD identified water savings as the primary advantage of AWD as indicated in Figure 14.

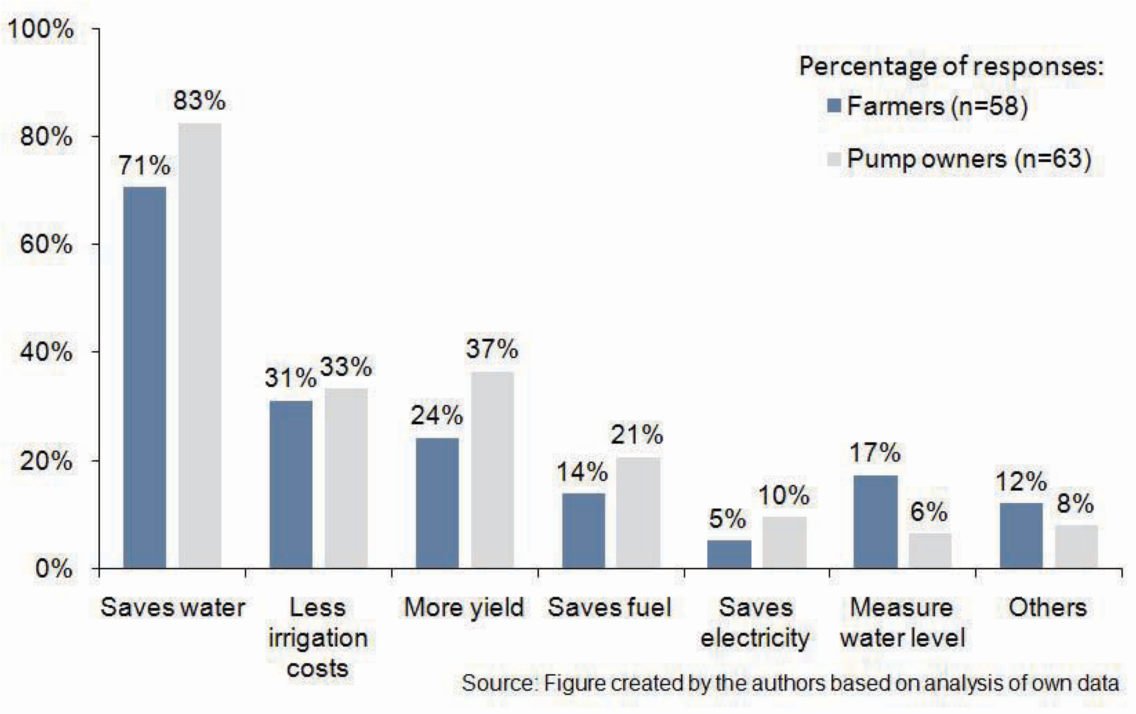

Figure 14: Advantages of AWD for adopter farmers and pump owners

Only a relatively small number of adopters regarded fuel or electricity savings as being advantageous. With respect to the severity with which energy constrains reliable irrigation, this result raises some questions. At this point it cannot be claimed with certainty why farmers seem to be less aware of the energy-saving potentials of AWD. Nevertheless, with regard to the demand for energy-saving in irrigation (as identified in Chapter 6.1), the energy-related benefits of AWD might be accentuated as a future potential that may lead to an increase in the adoption of the technology. However, in some cases, farmers might not even be able to monitor energy-saving as a result of AWD, as others in their irrigation system are in charge of managing the energy supply, which in these cases would explain this lack of awareness.

6.4 The Role of Local Irrigation Systems

In Chapter 6.1, external factors were described that influence the applicability and the feasibility of AWD, leading to AWD practices that do not always utilize the full energy-and water saving potential of AWD as discussed in Chapter 6.2. However, the field survey also revealed that a number of structural issues in the irrigation systems currently hinder or enable the adoption of AWD. Therefore, it was necessary to carry out more in-depth analysis on the operation of the two major irrigation systems found in the study regions - shallow and deep tube wells (see Table 1). Each irrigation system features a variety of different characteristics, in terms of the organization of water users, regulations, irrigation schedules and payment arrangements, for example. These features have been identified as crucial factors for adoption and will be discussed in the following section.

The two systems vary significantly in size and in the number of its members. The command area of one DTW, meaning the land area that can be supplied by one tube well, is much larger for DTWs (up to 25 ha) than STWs. Irrigation management for DTWs involves 100 to 200 farmers, and requires a lot more organization and coordination than in STW, which makes the adoption of AWD generally more complex as described in detail in Chapter 6.4.2.

In contrast to this, an STW command area is much smaller in size and may contain up to 30 farmers only. It was often observed that STWs supply water to just one individual pump owner, which generally increases the practicability of implementing AWD-irrigation. However, the larger the irrigation systems become, the more regulated the supply of irrigation water necessarily becomes.

6.4.1 Irrigation Serials and Block Irrigation

One DTW command area is normally divided into different irrigation blocks to help organize irrigation. This is demonstrated in Figure 15, where the DTW pump is situated in the center and supplies water to the four indicated irrigation blocks. Each block receives water according to a schedule, which is commonly called a “serial” by the farmers. In practice, one DTW scheme may constitute up to 15 blocks of 10 to 17 individual farmed plots each. The blocks are defined according to their topographical position in the field. One block is usually irrigated as a whole, which means that all farmers within this block receive water at the same time. Similarly to this, the irrigation schedule in one STW may function as one single block accordingly.

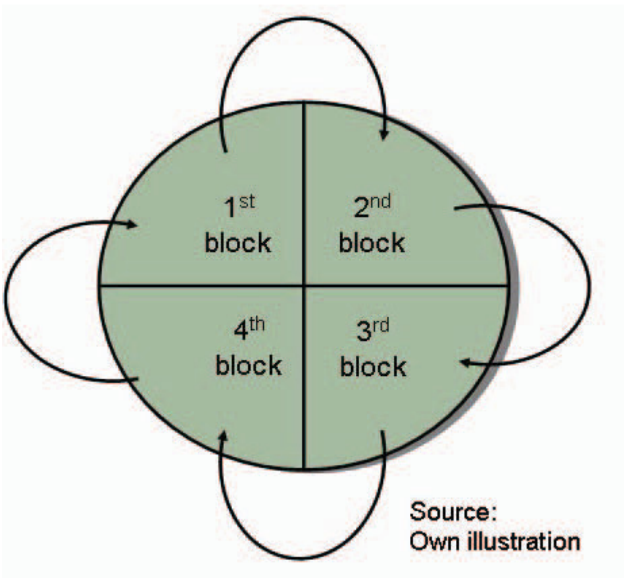

Figure 15: Block irrigation in DTWs (schematic)

It was observed that block-based irrigation currently hampers the adoption process. In this case, both with STWs or DTWs with fixed serials, single farmers are not able to control their supply of irrigation water. This limits their ability to implement an AWD-irrigation regime, which also leads to the different practices of AWD discussed in Chapter 6.2. Farmer Md. Mustafa explains that “individual decisions are not possible; we have to wait for the serial”. In Rajshahi for example, 57% of the farmers and pump-owners cannot decide on or influence the timing of irrigation as the irrigation serial is implemented by a pump operator in DTW and by the pump owner in STW systems. In case the pump operator or owner adjusts irrigation to energy availability, irrigation based on AWD might not be possible. As farmers are not able to govern their own water schedule, the possibilities of farmers applying AWD are limited.

Extension staff working in the context of DTW-based systems mentioned that AWD is only practical if the whole block implements the technology at once. This scenario has not however been found during the survey.

Farmers in larger STW systems may experience the same constraints regarding the applicability of AWD within a fixed irrigation serial. Nevertheless, the irrigation schedule can be organized in various ways; from the most distant to the nearest plots or from the nearest to most distant plots, serials can be fixed or more relaxed according to demand or on a system of who pays first gets water first. The latter arrangements particularly display a more flexible irrigation serial compared to DTWs. Consequently, AWD irrigation can be much more easily implemented in STW than in large DTW systems.

6.4.2 Organization of Irrigation

It has been shown above that implementing AWD requires a coordinated approach for water scheduling. The field survey revealed that irrigation is currently managed in many different ways. The forms of organization differ in the extent to which farmers can participate in decision-making processes, amongst other factors.

In most cases, farmers and the pump owners of STWs explained that they are not formally organized, in contrast to DTWs. While the pump owner often independently implements the entire irrigation schedule by himself, some cases have been found in which farmers in a command area are involved in decision-making processes. In these cases, farmers and the pump owner discuss the irrigation schedule and payment arrangement before the onset of the irrigation season. Thereafter, the farmer cannot choose to obtain water from another source nor can he negotiate the price.

The degree to which farmers really have an equal share in the decision-making processes, however, could not be assessed in the field. It is assumed, that the involvement of farmers in the decision-making process is also essential for the success of AWD. The greater farmers' needs and desires are considered, the more likely solutions will be provided to adjust the irrigation schedule for AWD. Often, the interviewed farmers did not articulate their precise water needs to their pump owners, which might also be due to the short time span in which AWD has been introduced at the field level.

On the other hand, it has been found that in STW systems, in which a single pump owner supplies water for his own fields, applying AWD is much easier than in command areas with more farmers. Holding total decision-power over irrigation water is beneficial for the practice of AWD (this has been the reason why many extension organizations have picked pump owners as demonstration farmers, as described in Chapter 5).

In DTWs, however, the management of irrigation is more complex. Within the study area, two models were found how DTW command areas are organized: the DTWs may either be state-owned by the BMDA or privately owned and managed by a committee of 15 to 45 farmers. In both ownership systems, a pump operator is appointed to organize the implementation of the irrigation schedule and to operate the pump[29]. In both cases, the irrigation schedule is arranged prior to the *Boro* season.

The general problem of adopting AWD that has been described above is the practicality of implementing an AWD irrigation regime in irrigation blocks. The field survey has revealed that merely a few farmers in each irrigation block have been trained on AWD. If they then wish to irrigate according to AWD, their influence may not be sufficient to change the irrigation schedule with their command area. In both irrigation systems, pump owners and pump operators play a decisive role in AWD. Thus if they are motivated to utilize AWD in their command area, considering their status, they may also be able to convince other farmers to adopt the technology.

6.4.3 Payment Systems

The diversity of irrigation systems with all their different features described above also results in a variety of payment systems, which are documented in Table 5. Similar to the specific irrigation modalities, payment arrangements vary from one village to another. The payment system plays a crucial role as it determines whether the economic benefits of AWD are transferred to the farmer or remain with the pump

[29] The pump operator usually contracts one or more line-men whose job is to maintain the irrigation drains and to take care of irrigating the fields. In some DTW, a "caretaker" guards electronic parts of the pump.

owner. It became evident that the two main payment forms outlined below - fixed (seasonal) and consumption-based rates - have decisive implications on sustainable adoption (Table 6).

Payment system			Costs [30]
Hourly rate according to consumption			
Pay-ment per hour	STW	STW pump is rented out to farmer on an hourly basis	No seasonal arrangement; hourly rate averaging 60 Taka/h (0.64 Euro/h), ranging from 40 – 100 Taka/h (0.43 - 0.94 Euro/h)
	DTW - BMDA	Pre-paid cards based on hourly consumption, often extra-charges by pump operator [31]	Only Rajshahi: seasonal average of 5301 Taka/ha (56 Euro/ha), ranging from 2470 - 10853 Taka/ha (26 - 115 Euro/ha) hourly rates of 75 - 120 Taka/h (0.8 - 1.3 Euro/h)
Seasonal fixed rate			
Pay-ment per season/ ha	STW	Seasonal payment arrangement per STW irrigation block, fuel provided by pump owner	Rangpur: average of 7358 Taka/ha (78 Euro/ha), ranging from 4490 - 10292 Taka/ha (48 - 109 Euro/ha)
	DTW - BMDA & Private	Fixed rates per season, rates previously decided in meeting	Rajshahi: average of 8325 Taka/ha (88 Euro/ha), ranging from 3930 - 14820 Taka/ha (42 - 158 Euro/ha) Rangpur: average of 5122 Taka/ha (54 Euro), ranging from 3861 - 8892 Taka/ha (41 - 95 Euro/ha)
Farmer buys own fuel	Only STW	Seasonal fixed rate, arranged by pump owner, farmer provides own fuel for irrigation	Rangpur: fixed rate, averaging 3748 Taka/ha (42 Euro/ha) ranging from 2245 - 6175 Taka/ha (25 - 69 Euro/ha); plus fuel per irrigation (ø 372 Taka/ha; 4 Euro/ha) or fuel per liter (ø 36 Taka/ha; 0.4 Euro/ha) or fuel per season (ø 1366 Taka/ha; 15 Euro/ha)
Seasonal fixed rate in kind			
Kind and fuel	STW	Fixed rate in kind for the season, farmer buys own fuel	Kushtia District: approx. 500kg rice/ha or 25% of yield plus fuel costs

Table 5: Payment systems and irrigation costs

[30] Values in Euro in this study are converted from the Bangladeshi Taka; calculations are based on the average currency rate of 2009: 100 Taka are equivalent to 1.063 Euros (Oanda, 2009)

[31] Furthermore, in BMDA-owned DTWs, payment with prepaid coupons still plays a role in the field. As this was found only very seldom during the survey, this system was not further analyzed in the study.

The majority of the payment arrangements are based on a seasonal fixed rate. Even the BMDA's more sophisticated, consumption-based payment system in DTW systems has been identified to actually function like a seasonal fixed rate system[32]. Indeed, the only true consumption-based payment systems found are "fixed rates plus fuel" (in these cases diesel has to be provided by the farmer according to demand) as well as "payment per hour" by renting out pumps for the time that farmers need to irrigate. Payments in kind were uncommon and found only a few times in Kushtia District.

Table 6 compares economic benefits for farmers and pump owners when adopting AWD according to the payment arrangement.

Payment form	Farmers' benefit	Pump owners' benefit
STW pump renting, hourly basis	**+**: saves fuel costs and pump lending fee	**-**: less income (unless renting out the pump to more farmers)
DTW prepaid, hourly basis	**+**: saves irrigation cost	**-**: pump operator receives less income
Fixed seasonal rate for STW or DTW	**-**: no direct benefits/savings	**+**: saves fuel/electricity, increases net return (selling less water at the same price)
Fixed rate plus own fuel for STW	**+**: saves fuel costs	**+**: unchanged income, but reduced usage of pump might decrease wear of equipment

Table 6: Economic benefits of AWD according to the payment form
+: beneficial; +/-: depends on situation; -: no benefits;
payments in kind were disregarded due to their rare occurrence

Using AWD in the consumption-based STW-system leads to direct benefits for the farmer, but can lower the profit of the pump owner who is renting the pump to AWD users on a less frequent basis. The pump owner can only make up for this loss by renting the pump to more farmers.

The innovative prepaid card system theoretically entails benefits for farmers. However, prepaid cards were introduced in a very limited number of DTW systems (of the BMDA) so far. More individual AWD farmers will only benefit if this system is successfully implemented on a large scale, as originally contemplated.

[32] The BMDA provides farmers with a prepaid card that is recharged according to the actual water needs of farmers. Many DTW command areas only possess one or two pre paid cards, which are owned by the pump operator or some better-off farmers. Hence, all farmers rely on these few cards to receive irrigation water. Prepaid card holders charge farmers with a fixed rate for the entire season instead of applying hourly-based consumption rates. Moreover, farmers explained that pump operators who hold a card retain a share of the irrigation charge in many cases for themselves.

The most frequently found system in blocks with irrigation serials, irrespective of tube well type, the fixed-rate payment forms, guarantee pump owners a secure and regular income. For farmers, however, this results in an unfair situation since adopters pay the same irrigation charge as non-adopters even though they use less water. The pump owner obtains extra benefits from a decreased water and energy consumption. In none of the reported cases did pump owners reduce the charges for AWD users upon their own initiative. Single AWD farmers often voiced their skepticism about receiving a reduced rate when being asked what would happen if they actually approached the pump owner on this issue.

Only the fixed-rate payment form, in which the farmer provides his own fuel along with a seasonal fixed rate for using the pump, is capable of entailing economic benefits and a fair water allocation to all involved parties. Farmers without training in AWD also expressed their enthusiasm to implement AWD in case they may be able to pay less for irrigation. Hence, the financial benefit arising from AWD has been identified as a key incentive for adoption. Nevertheless, the key role of the pump owner, and the pump operator respectively, can be confirmed again, as this person decides whether financial benefits from AWD are passed on to the users.

6.5 Other Key Factors for Adoption

One of the major underlying factors for early adoption proved to be the ability of a farmer to take the risk of trying new technology. This willingness to take a risk is intrinsically linked with the access to resources. Therefore, farmers with a bigger holding seem to be able to run the risk of losing some of their yield by trying AWD. Farmers who own a pump feature greater economical stability and are able to control irrigation as prescribed by AWD.

In contrast, many small and marginal farmers displayed a cautious and risk-averse behavior regarding AWD. Extension agents confirmed that the perceived risk is higher for this group of farmers, as a possible failure of the new technology would seriously threaten their livelihoods. Also, Scott (1976) elucidates that subsistence farmers' logic of action is based on avoiding economic disaster rather than on taking risks.

So called "AWD packages" (see Chapter 5.3.3) supplied to demonstration farmers by the organizations posed another factor affecting adoption. Receiving the AWD pipe for free for example, turned out to be a key incentive to try AWD. Farmers would have implemented AWD on some of their land if they had actually received a pipe. However, since they had not received one, they did not did not try AWD, as 22% of the non-adopters stated (see Figure 9).

Another decisive constraint for the implementation of AWD seems to be a physical factor. In several FGDs it was highlighted that AWD is more appropriate on highlands than on lowlands[33]. While the water level can easily be controlled in the highlands, the lowlands are often inherently waterlogged as the water from the highland drains into the lowlands. Furthermore, soils with a high sand content are less apt for AWD. The farmer Mahabul Islam explains “I could not achieve the proper impact of AWD because my land is sandy and cannot hold water for long”.

Overall, 79% of all adopters claimed there were no problems with AWD. Sporadically, farmers experienced it as problematic that “naughty kids steal the pani-pipe[34] from the field to buy sweets”.

6.6 Conclusion

Generally, the field survey has confirmed that mass uptake of AWD has not (yet) occurred and adoption is still in its early stages in Bangladesh.

On the one hand, it was found that water and energy saving is a highly relevant topic in the north-western region of Bangladesh, as a substantial demand for a water- and energy saving technology in rice cultivation exists. The demand for AWD and the fact that farmers already practice water and energy saving strategies support the adoption of the technology. Nevertheless, there seems to be scope to improve the knowledge among farmers that rice does not always have to stand in water as this facilitates the adoption process and acceptance of AWD.

On the other hand, the aggravated water and energy situation constrains adoption in those cases, where practicing AWD results in an additional risk of harvest losses for farmers. It is been therefore concluded that for long-term adoption, a certain level of water and particularly energy security is required. In this aspect, the chronically unreliable electricity supply affects adoption negatively as AWD requires farmers to receive irrigation water in time when crops are in need.

There seems to be a potential to increase the awareness of fuel and electricity saving that result from AWD among farmers. Despite the pressing energy problems, farmers mainly perceive water-saving as the predominant advantage of AWD. Creating greater awareness amongst farmers about potential energy savings and actively promoting AWD not just as a water-saving technology, but also as an energy-saving technology, could substantially support adoption. Together with focusing on the

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[33] Highlands and lowlands refer to only a slight difference of approximately one meter elevation with regard to the rice terrains.

[34] Pani pipe or chonga are farmers’ expressions for water tube; “pani” meaning water in Bangla language.

knowledge of AWD and not the pipe itself, would present a possible entry point for greater acceptance by farmers.

The unreliability of the two crucial resources of water and energy also leads farmers who adopted AWD to practice many different forms of the technology. While water scarcity (often induced by electricity shortages) forces some farmers to practice AWD, the majority of the farmers irrigate before the threshold of “safe-AWD” is reached. Consequently, potential water and energy saving are not yet widely taken best advantage of. This behaviour is to some extent likely to derive from farmer’s cautiousness with respect to adopting new technology, but it mainly stems from the structural features of the local irrigation systems that most farmers adhere to.

The irrigation serial, which is the norm in DTWs and many STWs, currently limits farmers’ ability to apply AWD irrigation on a broad scale, whereas individual water control supports the adoption of AWD. Pump owners supplying water only to their own lands and farmers renting out pumps from pump owners are able to irrigate in time for AWD. In contrast to DTWs, the irrigation schedule in individual or small STW systems has been identified as more flexible, simplifying adoption.

It has been shown that in order to practice AWD in DTWs and larger STWs in a way that entails the largest water and energy saving benefits, all famers in one irrigation block have to apply AWD irrigation at the same time. This, however, would require a coordinated approach on applying AWD and the group decision by farmers and particularly the pump owners or operators.

Pump operators and pump owners play decisive roles both in implementing an altered irrigation regime and in passing on the economic benefits to AWD practitioners in their command area. Mass adoption of AWD also requires that farmers receive a fair share of the water and energy saved in monetary terms. Fixed-rate arrangements as reported for the majority of the irrigation systems surveyed disable economic benefit-sharing. The way that payments for irrigation are currently carried out poses a systematic problem for AWD adoption that applies to both STWs and DTWs.

However, changing payment for irrigation towards more consumption-based forms is a process that requires a change in habits for the people in charge of STWs and DTWs. A participative negotiation process between farmers and the people in charge of irrigation management would likely support this change. The more empowered farmers actually are (see Chapter 7), the more likely the shift towards a larger utilization of consumption-based payment systems. This would create a more enabling environment for the large-scale adoption of AWD compared to now.

All of the key factors highlighted above (e.g. changes in attitudes, strengthening irrigation organization and the empowerment of farmers) describe processes that are unlikely to change in the short term. The realistic potential of how many users can be reached by AWD under the present conditions remains difficult to assess at this point (see Chapter 8). It is therefore concluded that AWD needs to be made more compatible with local level settings. The diversity of irrigation arrangements at the local level suggests that context-specific solutions have to be found to be able to promote adoption sustainably.

Success factors for adoption	
Demand for AWD	Farmers are already practicing various water and energy saving strategies. Farmers' awareness of water and energy scarcity and the deficient water and energy supply make AWD a relevant technology for the region.
Consumption-based payment systems	Farmers benefit directly from the water-saving and the corresponding fuel-saving.
"AWD Knowledge"	Farmers already use the knowledge that rice does not have to stand in water all the time (whether deliberately or unintentionally) in some regions. Spreading knowledge about AWD may be more promising than concentrating on the pipe.
Limiting factors for adoption	
Unreliability of irrigation water	Electricity, fuel and water shortages delay the irrigation schedule in STWs and DTWs and hinder control over water that is needed when practicing AWD.
Fixed rate payment systems	Savings in irrigation water are often not passed on to farmers, payments are arranged before the season and adaptations according to actual consumption are unusual; the participation of farmers in decision processes is limited.
Block or scheme irrigation	Individual decisions within an irrigation block are difficult or not possible; farmers depend on the serial irrigation schedule; coordination within block schemes becomes more complex with increasing number of members.
Power relationships within irrigation scheme	The pump owner makes the decision about rates in STW systems, the passing on of economic benefits depends on the pump owner.

Table 7: Success and limiting factors for adoption

7 Short-term Impacts

For various reasons discussed in the previous chapters, AWD adoption by farmers is still in its initial stage. Current adoption takes place in a scattered way by individual farmers rather than more broadly on a community or regional level. In fact, even the most innovative farmers interviewed for this study gained limited experience with AWD by applying the new technology in one to two seasons. Thus, the social, cultural and economic impacts on the community level cannot yet be assessed. This chapter presents the key findings on the first short-term impacts of AWD on farmers. Also, the results depicted below show trends that need to be re-assessed after adoption has gained a stronger momentum on a wider scale.

7.1 Social and Cultural Impacts

Adopting new technology requires a certain openness to change ones' traditional beliefs and attitudes. The decision to implement AWD means diverting from the traditional practice of growing rice in constantly flooded paddies. In order to assess farmers' attitude towards this practice, all farmers were asked whether less water on their fields could damage the plants' growth and yield.

Views on the need to keep the water table high in *Boro* rice clearly differ between farmers who adopted AWD, those who did not adopt and the control group that did not receive training in AWD (Figure 16). The majority (57%) of farmers not trained in AWD (control group) still considers standing water as essential for *Boro* rice cultivation. "Letting the soil get dry hampers the crop" is typical for the explanations given. This indicates that the traditional belief of farmers that rice always has to be kept in standing water throughout the growing season is still prevalent. By contrast, almost 90% of AWD-adopters do not believe that standing water is needed during all phases of rice cultivation. Also, these farmers were often able to correctly differentiate the changing water needs of the crop during the different growth stages. They explained that standing water is necessary for some time after transplanting and during the flowering stage, when the rice plant is particularly sensitive to water shortages.

However, it is somewhat unclear as to whether the answers given in the survey really reflect adopters' true beliefs, for many of them answered the question of why they believed standing water is not always necessary with the words "because I was trained so". Interestingly, 43% of the control group also acknowledged that occasional soil drying is not harmful to their crops. In fact, many farmers from the control group confirmed that they would let the soil dry during the tillering stage, which would help them to achieve a better yield. In Rajshahi, many farmers experience seasonal shortages of water and electricity that force them to let their fields dry out for some time during the *Boro* season. This "forced AWD" practice (see Chapter 6) has given them the chance to observe the effects of less water, which helps to explain the high percentage of Rajshahi farmers in favor of occasional soil drying.

The survey data reveals a clear change of beliefs about the need for standing water from traditional rice farmers and adopter farmers. One adopter even stated that "it is a mistaken concept among farmers that less water can damage the crop!" Although it is not clear to what extent changes in attitudes can be linked solely to AWD training and implementation; there is a high probability that training and practicing AWD has changed this traditional conviction of farmers. The study also indicates, however, that farmers without AWD knowledge have already started to re-think their traditional methods, especially when forced to practice a kind of AWD-based regime. Hence, infrastructural deficits might help future adoption of AWD-based irrigation, since farmers are already getting acquainted with the effects of occasional soil drying.

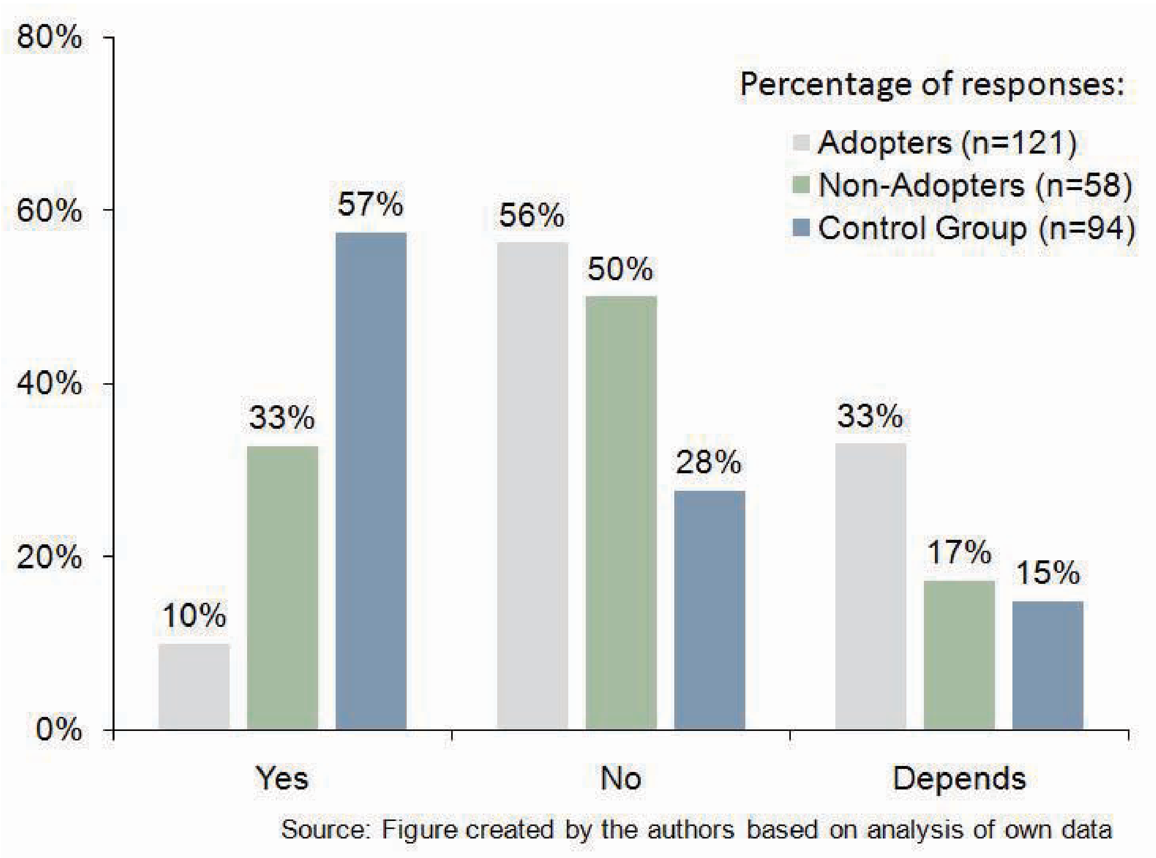

Figure 16: Farmers' perspective: "Can less water hurt the crop?"

The analysis of the social impacts of AWD on farmers' communities was based on two predominant hypotheses. On the one hand, "inter-communal conflicts over scarce water resources would decrease", and, on the other hand, "the bargaining power of AWD-practicing farmers with pump owners regarding water pricing would eventually increase."

Field interviews in many places, especially in some larger DTW schemes, confirmed ongoing conflicts during the Boro season as well as during the last two Aman seasons of 2009 and 2010, which were exceptionally dry. Various farmers expressed their discontent with irrigation services, referring to regular fights between the pump operator or the respective drain man/line man and farmers. Conflicts often occurred in cases where plots are relatively distant from pump outlets, since these farmers are more likely to suffer from a delayed or unfairly distributed irrigation service.

Conflicts over irrigation services heated up during the past Boro season when 400 to 500 angry farmers attacked the BMDA and the rural electrification offices in Mohonpur Upazila, Rajshahi, as reported during the survey. Here, farmers got very upset due to constant electricity shortages, which led to irrigation failures, exposing their fields to the risk of a complete harvest loss. It is assumed that especially in large DTW schemes, the number of conflicts over water-related issues can only decrease if enough farmers implement the new technology, reducing the overall water demand within the scheme.

With regard to the aim of reducing the price that farmers pay for irrigation, both pump owners and farmers acknowledge that they would only have enough power to attain a cost reduction from responsible authorities and/or local price setters (e.g. pump owners) if more farmers within one scheme would bargain together.

The first indications of a change in social power could be observed in Rangpur, where 40% of the farmers asked for a price reduction in irrigation. However, their success has been very limited. Payment systems as described in Chapter 6 have an influence on whether bargaining makes sense or not. In the cases of fixed rates where farmers are currently not profiting economically from irrigating less, it is necessary for farmers to bargain.

Thus, to achieve a sustainable adoption of AWD in larger schemes, the collective action of all farmers is required to facilitate the coordination of AWD irrigation and bargaining for better prices. Only then they will be able to achieve better results. If farmers work together, social capital within the irrigation schemes can be enhanced. Therefore, more farmers need to adopt AWD first, as one farmer summarizes the situation very well: “as AWD is still not widely spread there are no impacts yet”.

7.2 Economic Impacts

Several comprehensive benefit-cost analyses have already been undertaken by national research and extension institutions of Bangladesh, such as the BRRI, DAE, and BMDA, in order to validate the AWD technology at the farm-level[35,36,37]. By analyzing these studies, three major economical changes can be appreciated when an AWD regime is implemented:

1. The technology effectively reduces the amount of irrigation (i.e. number of irrigation measures) needed per season, thereby decreasing the labor and time input needed for the irrigation service. Consequently, AWD lowers farmers' cost for irrigation.
2. By applying AWD, farmers will experience higher input costs, especially to employ more hired labor or to buy extra agro-chemicals, such as herbicides, required to deal with the increased occurrence of weeds.
3. Changing from conventional to AWD irrigation leads to sturdier and healthier plants with more tillers and panicles, ultimately resulting in a higher yield per hectare. The yield gain increases the farmers' gross return from selling rice[38]. A higher yield also leads to increased revenue from selling more by-product (mainly straw) but it also raises post-harvest labor and input costs for harvesting, processing and transport.

With reference to these three hypotheses, the next three sub-chapters will present the respective findings. Overall benefits and costs of AWD will be discussed in the last sub-chapter supported by secondary data from other studies.

7.2.1 Effects of AWD on Irrigation Frequency and Irrigation Costs

AWD decreases the irrigation frequency, i.e. it helps to cut the number of irrigation measures per season, and consequently helps to reduce irrigation costs by using less water. This is expected to lessen the energy or fuel consumption through decreased pumping, and to reduce the need to hire labor for irrigation. Depending on the irrigation system, farmers may have to rent pumps less often.

In Rajshahi and Rangpur Divisions, frequency and cost of irrigation varied significantly between conventionally irrigated plots (non-AWD) and AWD managed plots. Field data (see Figure 17) showed that farmers irrigated more frequently in Rajshahi, applying 21 irrigation measures compared to Rangpur with 16, whereas the reduction in irrigation water due to AWD is in a similar order in both study regions,

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[35] E.g.: Alam et al. (2009); Husain and Kabir (2009).

[36] E.g.: Kabir (2009): Benefit-cost Analysis on demonstration on AWD Irrigation Method.

[37] E.g.: Hossain et al. (2009)

[38] That is, when the net return is compared between two plots in one year. When compared between two different years, it is necessary to consider changes in the price of rice.

amounting to a total saving of around 28%[39]. Higher water demand in Rajshahi results from higher temperatures and less rainfall in this area. In fact, Lalpur in Natore District, Rajshahi, is considered to be the driest and hottest location in all of Bangladesh.

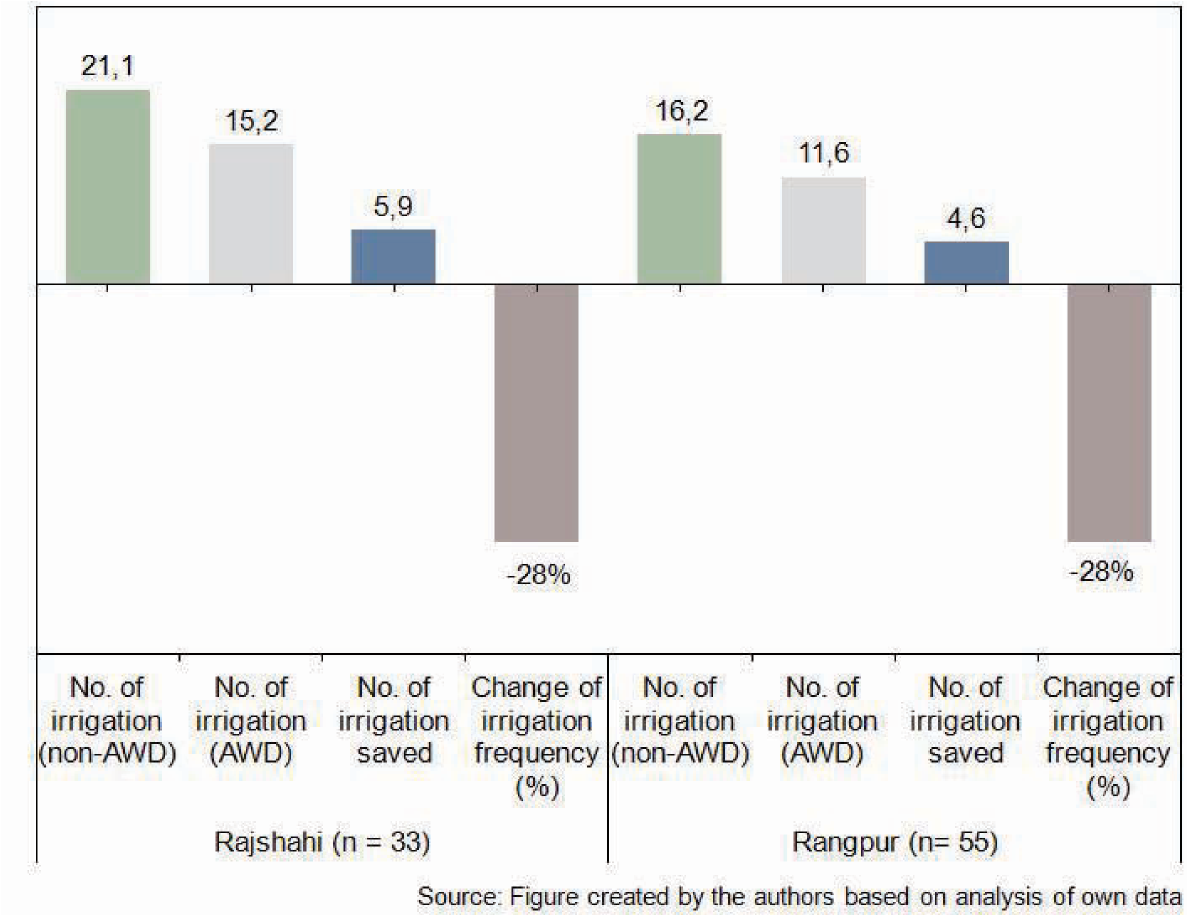

Figure 17: Changes in number of irrigations due to AWD

Thus, the higher demand of water in Rajshahi explains the generally higher irrigation costs in this region. While Rangpur farmers spend around 52.59 Euro/ha for their water supply per *Boro* season, Rajshahi farmers have to pay, on average, around 72.02 Euro/ha.

When looking at the effect that AWD-based irrigation has on irrigation costs, the survey data showed that, for both regions equally, around 18% of cost can be saved if AWD is applied. In monetary terms, a farmer saved on average 12.16 Euro/ha (see Figure 18) per season.

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[39] Relative saving of irrigation refers to the time AWD is applicable, i.e. around 15 days after transplanting until the flowering stage. When the whole irrigation period is considered, savings are less, typical values from literature are around 18 to 20% (Sattar et al., 2009).

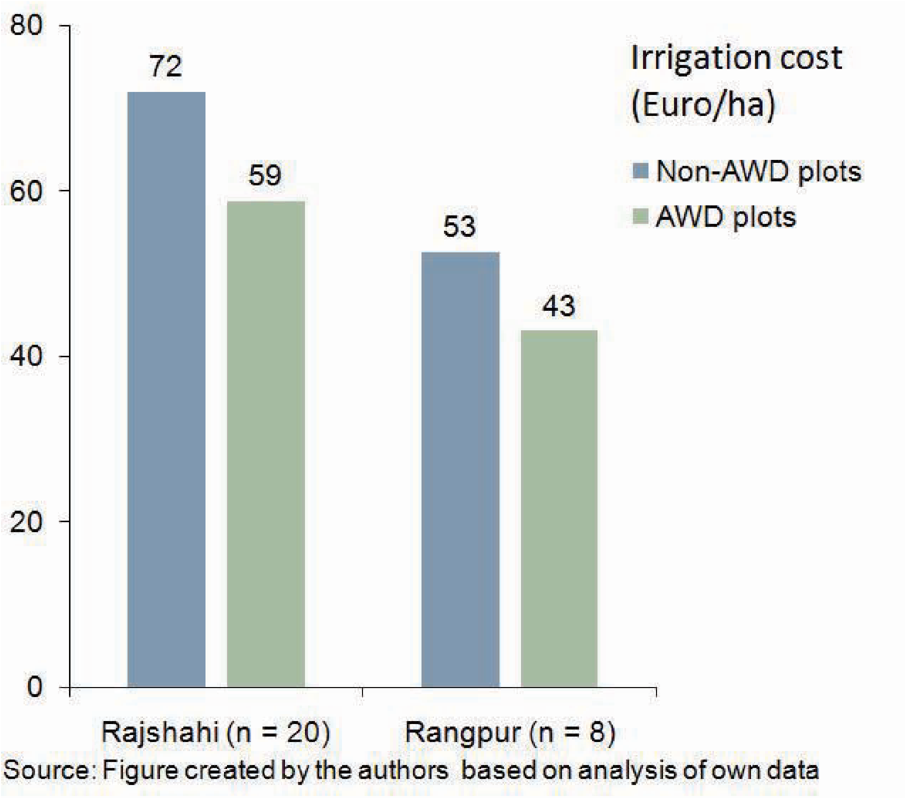

Figure 18: Irrigation cost reduction through AWD application

The AWD adopters interviewed for this study were mostly farmers and pump owners who irrigated their plots with either consumption-based payment arrangements, for example using DTW-systems with an individual prepaid card, or who directly control their own fuel consumption, through owning their own STW for example. Hence, this group was able to profit from using less pumping service with an economic advantage. Yet, the majority of interviewed farmers are not receiving a reduction in their irrigation costs by employing AWD, since the cost reduction is not transferred to them (see Chapter 7.2.3). Payment in these schemes are based on rates that are fixed for the whole season (flat rate) or for renting an STW including fuel and/or energy, whenever needed, which depends on a single pump owner who decides whether established prices can be reduced for using less water/energy/fuel. This however restricts the economic benefit for the farmer and often results in less motivation to apply the new technology in the first place or, after having tried it, to keep on utilizing it.

7.2.2 Effects of AWD on Weeding

Field data showed a significant difference between farmer observations regarding the effect of AWD on the occurrence of weeds. While almost two thirds of the farmers in Rajshahi reported an increase in weeds in AWD-managed plots, only one third of Rangpur farmers confirmed this observation. The reverse, somewhat contradicting finding of reduced weed occurrence in AWD-managed plots was observed by over 42% of Rangpur farmers, while only 16% of Rajshahi farmers said they noticed fewer weeds (see Figure 19).

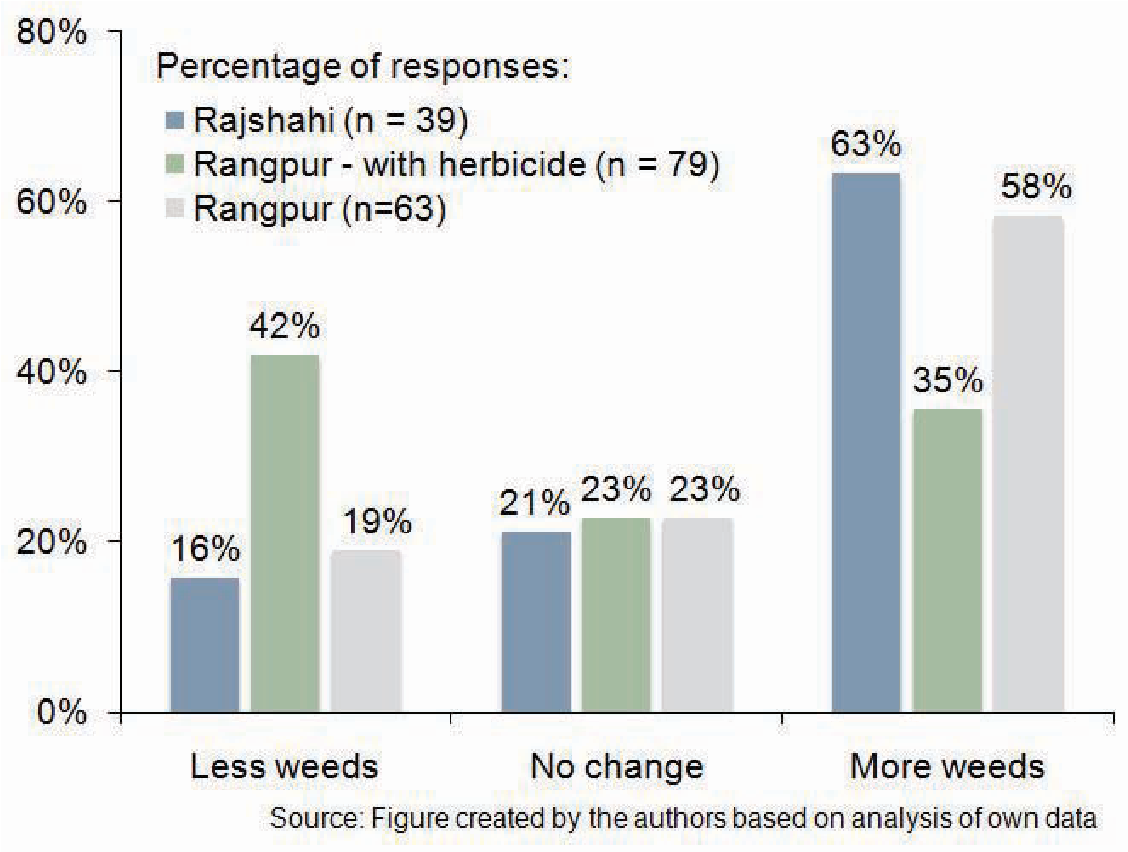

Figure 19: Farmers' perception of changing weed occurrence on AWD plots

A more consistent picture can be drawn from the effects of AWD on weeds, if the control of weeds by applying herbicides is included in this analysis. A share of the farmers in Rangpur who observed a decrease in weeds after implementing AWD also applied extra herbicide applications[40], which effectively prevented the occurrence of weeds. After including all the known herbicide effects[41] in the Rangpur region, almost two third of the farmers in both regions reported more weeds after employing an AWD regime, while about one third saw either no change or even noted a decrease in weed occurrence. However, it still remains uncertain how many of the farmers in this last group have applied extra herbicides and have therefore actively reduced the appearance of weeds, as many farmers in the survey have given no exact specifications on their herbicide input.

[40] In the case of Rangpur, operating RDRS farmers were advised to set up AWD plots with and without the use of herbicides for comparison.

[41] All cases in which farmers specifically stated that weeding had decreased or stayed the same due to an extra application of herbicides were included in the recalculation.

When looking at the additional expenses for manual weeding, the study results show that farmers employed on average two handweedings during *Boro* season, which corresponds to two days of labor input. Whereas, after applying the AWD regime, still close to 80% of the farmers in Rajshahi and Rangpur reported two handweedings, the number of hired labor increased on average by an extra one or two laborers per bigha[42] per handweeding, subsequently increasing expenditure between 12 and 32 Euro/ha per season[43]. However, the extra labor might not necessarily increase the pay-out costs in the full calculated amount, as part of the extra labor requirement might be covered by extra family labor that is normally not paid.

7.2.3 Effects of AWD-application on Yield and Gross Return

The great majority of AWD farmers in both study regions (81% average) said that their yield increased, though more overwhelmingly in Rajshahi, while only close to 10% of the farmers did not observe changes in yield. Decreasing yields after applying AWD were stated by only 5% of the interviewees in Rajshahi compared to 18% of the farmers in Rangpur (see Figure 20).

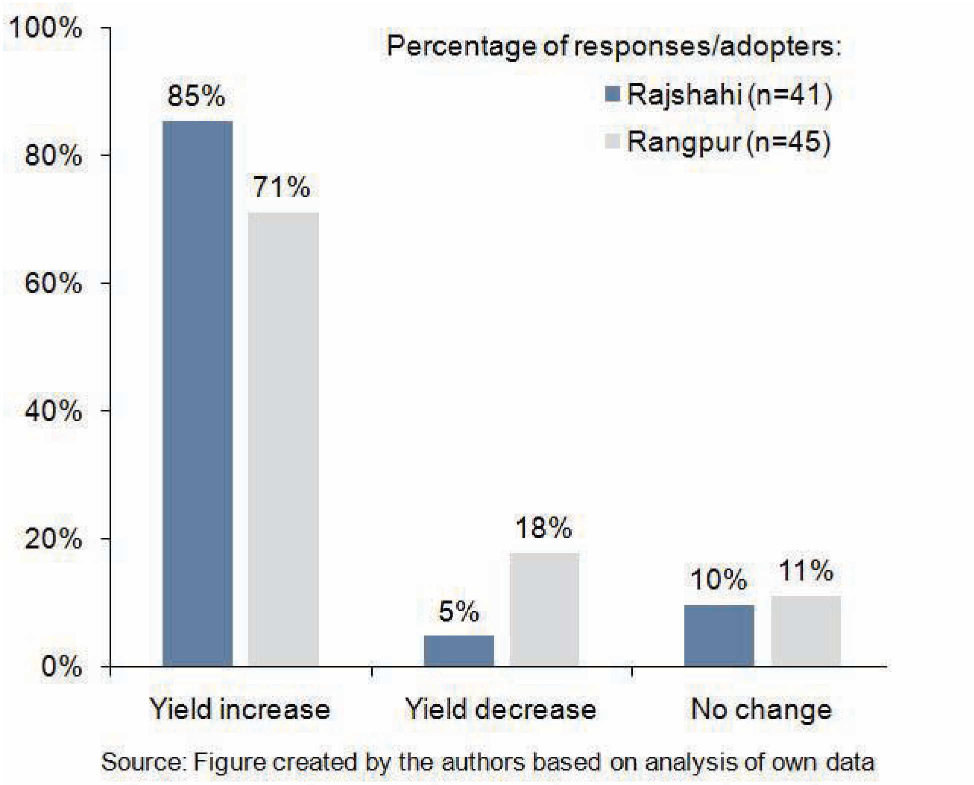

Figure 20: Effect of AWD on yield

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[42] The increase in the number of laborers by two per bigha corresponds to some 7 to 10 additional laborers per hectare.

[43] Commonly, local wages for agricultural labor such as handweeding range between 80 to 150 Taka (0.85 to 1.60 Euro) per day plus one or two meals.

However, the comparatively high number of farmers who experienced a reduction in yield might not be directly connected to the application of the AWD technology itself, but instead the results of an unusual cold weather period during transplanting at the start of the 2009-2010 *Boro* season. Moreover, most farmers, especially in Rangpur, used the AWD regime for the first time and applied it on very small plots, e.g. five decimal test plots. Since most farmers did not have an opportunity to measure the exact yield of each of their fields or did not exactly remember those, yield calculations on a per-hectare basis can only depict a general trend.

Comparing absolute yield figures of the *Boro* rice crop (see) and yield levels in conventionally-irrigated plots as indicated by farmers were similar in both regions, with 4.2t/ha in Rajshahi compared to 4.3t/ha in Rangpur.

Average yield increases due to the use of AWD as reported by farmers were also similar in both regions, with 0.39 t/ha in Rajshahi compared to 0,51t/ha in Rangpur. In summary, AWD farmers have experienced a rice yield increase by 0.45t/ha that corresponds to about 10%.

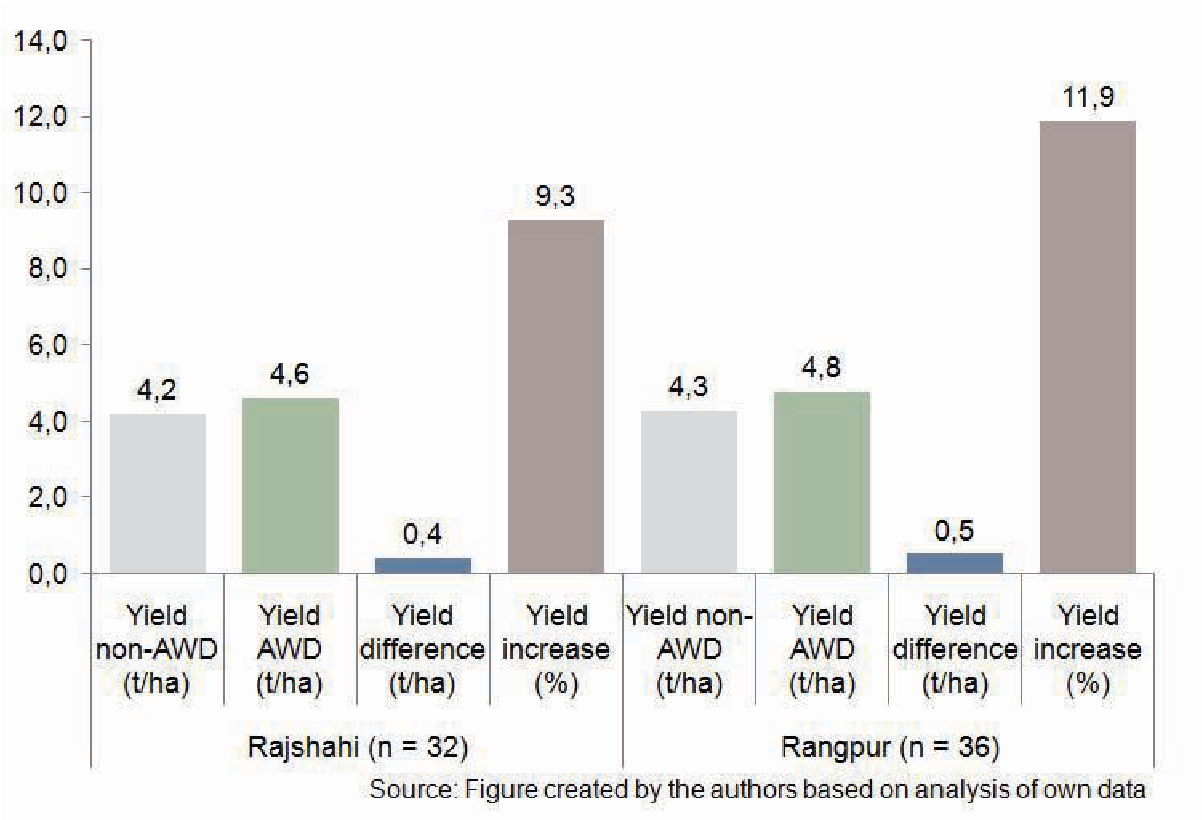

Figure 21: Yield change by AWD / non-AWD regime

This increase in yield is closely linked to farmers' observations about the changes in the visual appearance of their rice plants when applying AWD. An increased yield of plots following the AWD-based irrigation regime might arise from an increased number of tillers and panicles, which was observed by 20% of the farmers in Rajshahi and 29% in Rangpur. Furthermore, research done by CIRAD, a local NGO, indicates that AWD produces bolder grain, as the 1000-grain weight of BRRI dhan 29 was 21g in AWD-treated plots compared to 17g in conventional practice (Miah, 2010). Also, plants seemed to be sturdier, which was stated by 13% of the farmers in Rajshahi and 18% in Rangpur, which helps to prevent reductions in yield through a reduced lodging risk.

The good performance of the rice crop under AWD-regime could be also linked to a lower infection rate of diseases. About one third of AWD farmers, i.e. 34% in Rajshahi and 37% in Rangpur, said that plants looked greener, brighter and generally fresher and healthier under the AWD regime. Consequently, about one third of all interviewed farmers experienced a reduction in the occurrence of rice-related diseases while about two third of the farmers did not notice any significant change. When looking at pests, farmers' perception is less homogenous. While the majority of farmers, i.e. two thirds, did not perceive any change, 20% observed less pests after applying AWD, while 11% stated an increase in pest occurrence, especially from mice and rats.

However, whether and to what extent the increase in rice yield is influenced as well by (additional) fertilizer use cannot be answered by this study. Although at least some of the demo-farmers received package deals by the organizations including fertilizer, none of the adopters seemed to increase the number of fertilizer applications in their AWD plots, usually ranging from one to three. Yet, the survey data cannot answer the question if the interviewed farmers had changed the rate of standard fertilizer products (e.g. NKP) or used different amounts of fertilizer upon each application.

Economically, a higher yield results in a higher gross return. Using a market price from 2009[44], the extra revenue from selling rice can be calculated at about 67.5 Euro. The overall return further increases as farmers receive more by-product, i.e. straw. Unfortunately, most farmers remembered neither the amount nor the price for straw as many do not sell the by-product and rather use it for their own means.

7.2.4 Assessment of Cost-Benefit-Effects for AWD

Does the decrease in irrigation costs, on the one hand, and the increase of revenue through higher yield, on the other hand, fully compensate extra input costs for weeding and pre- and post-harvest activities? Since the field data does not allow for a detailed analysis of all production expenses and total returns, complementary data has been taken from Kabir (2009), Miah and Sattar (2009) and Hossain et al. (2009) to illustrate the overall economic impact of AWD in Bangladesh.

[44] 14 Taka/kg rice corresponds to 0.15 Euro /kg taken from Sattar et al. (2009:11)

A farmer receives economic profits from cultivating rice when his total revenue (or gross return) from selling rice and its related by-products, i.e. straw, exceed the total production costs. The total production costs for growing rice, however, are made up of fixed costs, i.e. the rent for the land, interest on loans, or interest of capital, and variable costs, i.e. expenses that change in proportion to the level of activity of a rice farmer. These variable costs include several input and labor costs, such as fertilizer, herbicide or fungicide inputs, expenses for water and energy, and labor.

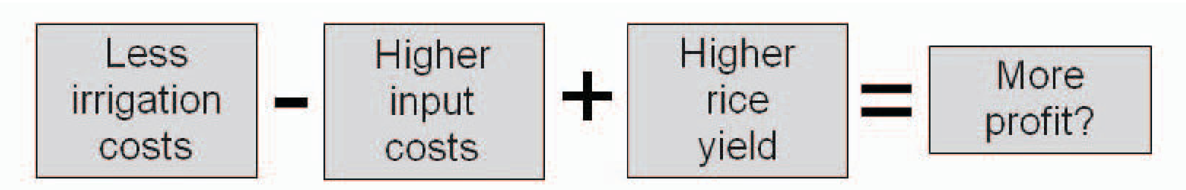

Figure 22: Concept for analyzing cost-benefit with AWD

As seen in Chapter 7.2.1 and 7.2.2 AWD-based irrigation has an impact on variable costs as the technology reduces irrigation costs but also leads to higher inputs, such as weeding labor or pesticide use, extra labor for the preparation of the rice paddy and extra labor requirements caused by extra yield, i.e. post-harvest labor such as threshing, winnowing, packing, or transport. The degree to which these costs are influenced by AWD greatly depends on site-specific factors such as soil type[45], water and/or energy availability and costs, climate[46], local wages for agricultural labor and local input prices for fertilizer and other agro-chemicals.

On the understanding that there is a great variability in total production costs and total revenue in Bangladesh, the question of whether AWD helps farmers to attain more profit needs to be assessed rather on an individual basis considering local production factors than on a macroeconomic scale. However, some trends and general ranges of costs and benefits can be highlighted with the help of complimentary data.

The total production costs for the *Boro* season for conventionally irrigated rice ranged in Bangladesh in 2009 from 475 Euros in Rajshahi (Hossain et al, 2009:39) to 1010 Euros in Comilla (Kabir, 2009:31). Of these total costs between 12% (Chittagong) and 27% (Rajshahi) were irrigation costs, ranging in 2009 between 54 Euros/ha (Hossain et al, 2009:39) and 226 Euros/ha (Kabir, 2009:31).

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[45] More water is needed in sandy soils than in loamy ones, thus generally requiring higher labor and water costs in sandy soils.

[46] Rajshahi, for example, is hotter and dryer than Chittagong and therefore more irrigation water is needed in this region, hence increasing total irrigation costs.

Through implementing AWD-based irrigation between 15 Euros/ha (Hossain et al., 2009:39) and 112 Euros/ha (Kabir 2009:31) could be theoretically saved, i.e. if water and energy savings were transferred to the farmer. Irrigation savings calculated in this study of around 12 Euro/ha (see Chapter 7.2.1) were just below the minimum savings found in other studies, as these also included savings in labor and time that were not calculated in this study. AWD-based irrigation also increased costs for weeding and weeding-related inputs, fertilizer inputs and additional labor for pre- and post-harvest related activities. Of all the changes, weeding expenses are seen as the major disadvantage. Weeding costs in conventional plots were about 52 Euros/ha in 2009 (Hossain et al., 2009:39), but were raised between 3 Euros/ha (Hossain et al., 2009:39) and up to 32 Euros/ha, as the highest value calculated in this study. Extra labor costs for pre- and post-harvest related activities are difficult to specify and depend mainly on the land type and the amount of extra-yield. Miah and Sattar (2009:8) gives an overall increase of the pre-and post-harvest costs of about 20 Euros/ha for a single site in Kushtia (see Table 8 with a yield increase of 0.38t/ha on the AWD plot).

In conclusion, some 23 to 52 Euros/ha for extra input costs (of pre- and post-harvest and weeding) have to be matched with an irrigation savings potential between 15 and 112 Euro/ha.

Nevertheless, changes in total production costs need to be compared to additional revenue by increasing rice yield. In the national comparison done by Kabir (2009), yield has increased between 0.35 t/ha (Barisal) to 1.00 t/ha (Comilla). Taking an average rice price of 14,000 Taka/t or 150 Euros/t, this increases revenue from 53 to 150 Euro (Kabir, 2009:26), not including extra revenue for additional by-product.

Considering the overall economical impact of AWD for farmers, the data presented above suggests an improved benefit-cost ratio over conventional irrigation. On average, the total variable input costs will decrease due to savings from irrigation costs when using AWD. In some cases, the total variable costs might increase due to higher weeding costs and extra pre- and post-harvest labor, especially when irrigation prices are low or if benefits from water savings are not transferred to the farmer. Depending on the price of the rice, farmers will profit economically from AWD even if yield surplus is lower than the average 0.5 t/ha.

Raising the question of whether farmers profited economically from applying AWD in this study, 81% of interviewed farmers confirmed that they had received more profit, whereas only 19% did not. Of these 19% most farmers argued that they did not see a monetary profit since benefits from water-saving were not transferred to them (fixed payment per season) and the yield increase was comparable to the extra weeding costs.

Cost and return item[47]	AWD-based irrigation Euro / ha	Conventional irrigation Euro / ha	Difference Euro /ha
Total production costs	798	772	+ 26
Total fixed cost[48]	205	205	0
Total variable cost	593	567	+ 26
• Pre-harvest labor cost[49]	124	116	+ 8
• Irrigation cost[50]	131	160	- 29
• Post-harvest labor cost[51]	121	109	+ 12
• Other input cost[52]	217	182	+ 34
Gross return[53]	1213	1072	+141
Profit[54]	415	300	+115
Source: Own calculation based on data reported for Kushtia by Miah & Sattar (2009:8)			

Table 8: Exemplary cost and returns for Boro rice under AWD

As one farmer put it "as I irrigate less I buy less fuel but I need to pay extra labor for weeding". In some cases, possible yield effects did not materialize due to storms and periods of cold weather during seedling growth. Yet, some farmers stated, that although "no monetary impact" materialized after using AWD, they were quite content with the technology, as it helped to grow "better plants and higher quality rice".

7.3 Conclusions

With AWD adoption still in an initial stage, only some short-term impacts on social, cultural and economical level were assessable.

On a cultural level, some changes in beliefs and attitudes towards standing water were traceable between farmers with conventional irrigation and those who implemented an AWD-based irrigation regime. Adopters were mostly convinced that standing water is not needed at all stages for crop growth during the *Boro* season.

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[47] 1 Euro is equivalent to 94 Taka (Oanda, 2009)

[48] Fixed cost include the rent of land, interest on loans, interest on capital

[49] Pre-harvest cost comprises land preparation that is generally more expensive in AWD irrigation systems due to extra labor to level the paddy

[50] Includes labor cost as well as payment for irrigation services (water/energy/pump owner share)

[51] Post-harvest labor increases in AWD due to extra rice yield and higher labor requirements for threshing, winnowing and transport

[52] Includes cost for weeding, fertilizer, herbicides, and pesticides

[53] Gross Return = revenue of rice yield and by-product (straw): AWD 5.63 t/ha, conventional 5.25 t/ha

[54] Profit = Gross Return – Total Production Cost

However, the majority of rice farmers who have not been exposed to AWD still believe that standing water is required to obtain a good yield. At the same time, traditional beliefs that rice needs standing water seem to change even among these farmers, favored by experiencing repeated dry spells over the last years. Many farmers seemed to have gained the understanding that the harvest of their *Boro* rice does not necessarily have to be decreased, even though the supply of irrigation water was reduced substantially.

Looking at the social impact, implementing an AWD-regime in *Boro* rice may contribute towards reducing potential conflicts over water issues in larger irrigation schemes. In order to achieve a comprehensive implementation within the larger irrigation schemes, including a passing-on of profits from water saving to all farmers, tackling major structural problems, mainly the energy shortages and groundwater depletion, as well as social power asymmetries, i.e. between the pump operator and farmers, and between richer and poorer farmers, need to be addressed. Future adoption will therefore depend to a significant extent on a stronger collaboration and coordination between medium-, small-scale and marginal farmers in an increased number of schemes. Only through collective action will they be able to implement and manage AWD successfully in a larger scheme and to ensure benefits in terms of water saving and economic return.

The partial economical impact analysis has shown that AWD is, after all, a beneficial technology for farmers. If an AWD-based irrigation regime is employed, famers were able to decrease the total number of irrigation by 28%. Hence, irrigation costs were decreased by nearly 20% in the study regions. However, a monetary profit from a reduced irrigation number was only observed in cases where payment and irrigation systems worked on a consumption basis. The implementation of the AWD technology fosters the occurrence of weeds, especially when an insufficient water level is maintained after transplanting. This increased expenditure in hired labor for handweeding. However, field data from Rangpur region also showed that weeds can effectively be managed through the application of herbicides. In cases were herbicides were applied on AWD plots, farmers observed no increase in the occurrence of weeds and they did not have to apply extra handweeding. As for the changes in yield, the analysis showed that the application of the AWD method leads to stronger and healthier plants that develop more tillers and panicles. This helped farmers to close the gap between locally attained yields and the maximum yield a variety can theoretically produce. Yield increases were similar in both regions and reached 0.4 to 0.5t/ha. In summary, 81% of asked farmers stated that they profited economically from AWD implementation. However, the total number of farmers who received economic benefits from AWD can still be increased in the future, if savings in irrigation costs are finally transferred to all AWD-practicing farmers.

8 Assessment of Potential Wide-scale Adoption and Dissemination

The findings of this study on the short-term impacts, adoption, and dissemination of AWD as a water-saving technology for irrigated rice provide a comprehensive view of the current status and the benefits resulting from the introduction, initial spread and further dissemination of the technology in Bangladesh, and in particular the north and north-west of the country.

Based on the results achieved so far at national, regional and local levels, the national relevance of the technology and its applicability for farmers will be assessed, together with the effectiveness of specific dissemination approaches and perspectives for a process of up-scaling and out-scaling. Along with it a view on the future of AWD will be presented as a water-saving technology in irrigated rice production in Bangladesh.

8.1 Is AWD a Relevant Technology for Bangladesh?

The unsustainable use of water and energy resources in Bangladesh increasingly threatens the livelihoods of farmers, in particular if they depend on irrigating their rice crop with groundwater using shallow and deep tube wells. As a consequence, this may have implications on national food security in the long run.

The urgent need to implement measures to better target rice irrigation is evident from the aggravating scarcity of ground-water resources, increasing costs for irrigation and the continued energy crisis, manifested in the often unreliable electricity supply as well as limited accessibility and the disproportionately high prices of diesel fuel, particularly in rural areas.

Saving irrigation water to reduce the pressure on groundwater resources is particularly an issue in the north-west of the country where rainfall is insufficient to replenish groundwater reservoirs, leading to declining ground water tables. In addition, the judicious use of irrigation water is increasingly an issue in major rice growing areas as climate change is increasingly forcing farmers to irrigate their Aman rice, as the monsoon fails to provide sufficient rainfall for a rainfed crop.

Therefore, AWD has the potential to contribute to significant savings at the national level, both in the consumption of ground water and respective energy for irrigation, as farmers are consistently able to save up to one third of the irrigation water required between transplanting and flowering. Scientists estimated savings of between 56.4 and 78.8 million Euros due to wide-scale adoption of AWD.

The relevance of AWD can be also confirmed for the farm level, since there is significant potential of farmers to experience advantages by applying the technology, which has been confirmed by 81% of the farmers during the survey.

Advantages of AWD at the field level, however, can only occur if farmers are able to actually implement the technology properly within their farm. One external factor poses a significant constraint for farmers to implement the technology, which is namely the availability of electricity and fuel. Ongoing shortages of fuel and electricity make it difficult for farmers to carry out “in-time irrigation”, which is considered a prerequisite for implementing AWD.

Thus farmers’ choices to better target irrigation are not expected to change in the near future as they do not have reliable and adequate supplies of electricity or fuel at their disposal. Ongoing energy shortages will have to be remedied first to counter prevailing perceptions of farmers such as “How can [we] save energy when there is none!” In addition, several structural issues inherent to irrigation systems have to be overcome to pave the way for a wide–scale adoption of AWD in Bangladesh.

8.2 Issues Influencing the Applicability of AWD by Farmers

Raising production costs and failures in energy supply actually encourage farmers to deliberately apply water saving strategies in the irrigation of their rice crop or “force” farmers to do so. Some farmers are even implementing their own forms and adaptations of “Alternate Wetting and Drying”. Facilitating farmers to gain knowledge and experience in water-saving contributes to a favorable environment in which farmers will more easily accept and understand AWD.

If farmers are to be encouraged to adopt the technology at a faster pace and on a larger scale, it is necessary to solve or to overcome the following structural issues of local irrigation systems, which currently pose a major obstacle to adoption:

- Payment systems prevent the users of a command area from experiencing the benefits of reduced irrigation costs due to AWD, unless charges are based on consumption or related directly to the magnitude of the irrigation operation.
- Individual farmers within an irrigation command area are excluded from receiving the economic benefits and incentives that result from applying AWD, unless the pump owner or operator are willing to pass on a fair share of the savings in cost.
- Arrangements in a command area squeeze farmers into fixed irrigation schedules with individual farmers having little flexibility to change irrigation practice. There seems to be a very limited scope for implementing AWD unless the pump owner or operator are willing to consider AWD when arranging the irrigation schedule,

for example, allowing localized in-time irrigation, or when AWD is adopted by a group or by all the farmers in the command area, leading to “collective” adoption.

8.3 Issues Influencing the Effectiveness of Dissemination

The key organizations contributing to the spread of AWD within their geographical mandate showed high commitment to take up AWD as part of their established approaches of technology dissemination. The following issues, however, need to be addressed to make the current dissemination approaches more effective:

- Approaches focusing on routine training sessions and demonstrations of the technology appeared to be common among the different organizations that do not pay enough attention to the specific and varying features of the local context. These features determine the prevailing factors that enable or hinder farmers to adopt and to practice AWD in their irrigation systems.
- Target groups of organizations mostly center around leader farmers who are looked upon as innovators in their communities. While this proved to be efficient and effective to establish a nucleus to spread AWD, until now smaller and marginal farmers, who represent the majority of farmers, are neglected by the approaches, limiting a broadened adoption process in farming communities.
- Training and demonstration approaches in the field are often based on involving individual leader farmers and pump owners who do not seem to sufficiently trigger adoption in their respective command areas so far. Therefore, focusing extension on the use of AWD within command areas is considered to be a factor that would be very much required to enhance the quality and success of the approaches.
- In addition to training sessions on AWD provided by field staff, it seems that farmer groups have to be supported to enter negotiation processes with pump owners or operators to facilitate the adaptation of irrigation schedules or payment forms to fit the requirements of implementing AWD as a water-saving strategy.
- Considering that the success of AWD largely depends on putting the knowledge of the technology into practice, i.e. the know-how of when to irrigate and how to measure the water level in the field, enabling a sufficient number of well trained trainers and field staff is of great importance.
- In addition to the issue of training field staff, the capacity and productivity of extension or field staff depends on a number of prerequisites, such as financial resources for training sessions and transport, and if properly fulfilled affect the performance and motivation of field staff.

8.4 Prospects of Up-scaling and Out-scaling AWD

While looking at the prospects of a process for broadening the dissemination of AWD as a water-saving technology for irrigated rice in Bangladesh, it turned out that important players in agricultural extension and development have already developed their own views on such a process.

Although some of the key organizations have shown definite commitment to disseminating the technology on their own, as indicated by their validation and piloting activities, a sweeping dynamic at national level is still missing.

A reason for this might be that the initiation and advancement of this process largely depended on a facilitation role assumed by the IRRI as an international center. In other words, the process lacked ownership in taking the lead to institutionalize AWD dissemination at the national level by national organizations, in particular the BRRI with its mandate for rice research, and the DAE, as the main actor for agricultural extension.

In addition, it seems that insufficient cooperation and coordination between organizations that are involved in disseminating AWD seemed to add to a slacking process. This was observed when a national project proposal for coordinated dissemination by the involved key organizations was not convincingly elaborated and was consequently dismissed by the MoA. However, a coherent national strategy for the future up- and out-scaling of AWD dissemination is still politically desired. At the national AWD workshop in 2010, the MoA expressed that "money [for dissemination of AWD] is not a problem", if the organizations come up with sound program proposals.

The availability of sufficient funds specifically targeted to disseminate AWD on a large scale was considered essential by key informants. Despite the existing commitment of individual organizations, capabilities and manpower in terms of field staff to train farmers seems to still be very limited, considering that agricultural extension and development actors have multiple objectives and carry out a wide range of different activities in the field.

Introducing AWD on an institutional and policy-level is considered to be an important step in creating an enabling environment to better disseminate AWD. Early involvement of policymakers and engagement in policy dialogue is considered to be crucial to successfully spread a new technology (Guendel et al., 2001).

With regard to the role of policy support, the IRRI liaison scientist Dr. Miah stressed: "My shouting has no strength, but the secretaries' [of the Ministry of Agriculture] has". Consequently, a stronger involvement of policymakers was aspired to. Initial progress seems to have been achieved with an increasingly stronger voice of the

MoA, for example, by insisting on requesting a joint national project of key disseminating organizations, and is now reflecting this change. With the MoA's facilitation the desired formal commitment of organizations such as the DAE or BADC, whose involvement in the beginning did not trigger a substantial impact on advancing the dissemination process at the national level, seems more likely now.

In terms of incorporating AWD in policies and structures, the first steps have been taken after initial shortcomings at the national level. While the incorporation of AWD in the National Irrigation Policy, which is currently being prepared, has the potential to contribute towards promoting this technology, it is still the only explicit reference in this context. Whether these efforts, including a plan to establish local irrigation committees, will actually change the way that irrigation is being organized and help foster AWD adoption rates at the farm level, remains to be seen.

More importantly, a maintained focus is required to trigger a paradigm shift in the minds of key actors to move towards recognizing the importance of implementing a water-saving technology in irrigated rice in response to the increasing scarcity of water and energy and to sustain the level of rice production.

While the contributions of organizations to spread AWD further in Bangladesh will vary, a forecast adoption of the technology of at least 5 to 10% by all farmers within the next five years seems reasonable, as suggested by experiences in the private sector. While findings indicate that adoption levels will differ from one place to another, rates are expected to be higher in places where farmers and pump owners reach an agreement in adjusting their irrigation systems to benefit from the use of AWD.

In order to realize the potential benefits of AWD as a water-saving technology in irrigated rice, substantial changes and adjustments are required in the design and implementation of the dissemination process and approaches to speed up the spread of the technology. Unless the dissemination of Alternate Wetting and Drying quickly outgrows its infancy by leading to wide acceptance and adoption, the technology may end up on the shelves of scientists and extension and development workers.

9 Recommendations

The assessment of dissemination and adoption of the Alternate Wetting and Drying technology showed that the full potential of AWD in Bangladesh has not been utilized up until now, given the high demand and potential that the technology offers farmers to improve irrigation of rice during the dry (Boro) season.

In order to achieve a large-scale spread and adoption of AWD, at least in regions where water scarcity poses a threat to sustain and further improve rice production, a number of constraints and issues at national, regional and local levels have to be overcome as suggested by the findings.

Since the further spread of AWD at this stage depends to a great extent on the actions taken and efforts made at the organizational level to improve and institutionalize the dissemination process in Bangladesh, recommendations, therefore, address in particular, both the stakeholders at large and the key actors involved in disseminating AWD to farmers and pump owners.

Lastly, the study offers some general recommendations and lessons for disseminating natural resource management technologies, based on experiences in Bangladesh, which are specific to the dissemination of AWD technology.

9.1 Changes and Adaptations at National Level

1. **The BRRI should assume ownership to facilitate the furthering of the process**

It is essential that a national institution assumes ownership for advancing and further developing the process of AWD dissemination in the country. While initiating and up-scaling of AWD dissemination to date very much depends on the IRRI, a sustainable strategy requires the transfer of responsibilities from the IRRI to the BRRI. It is, therefore, recommended that the BRRI assumes full ownership to facilitate the further process and to provide the technical support to disseminate AWD.

2. **The DAE should take the lead in disseminating AWD and to coordinate among the agencies involved in dissemination**

While the BRRI should assume ownership of facilitation and technical support of the future process, effective dissemination also requires the coordination of the different organizations involved in the actual dissemination. Having the national mandate to disseminate agricultural innovations in Bangladesh, it is recommended that the DAE, the national agricultural extension agency, takes the lead in disseminating AWD in Bangladesh and to coordinate among the agencies involved in dissemination.

3. AWD dissemination should become a priority issue on the agenda of the National Agricultural Technology Coordination Committee (NATCC)

The National Agricultural Technology Coordination Committee (NATCC) is the national coordination platform for agricultural research and extension. Therefore, it is the appropriate forum to exchange experiences and to decide on strategies to further implement AWD in Bangladesh. However, the committee is not making use of its potential in guiding the AWD process. The DAE and BRRI should take a lead in making AWD dissemination a priority issue on the agenda of the NATCC.

4. Formulate a national strategy of AWD dissemination in Bangladesh

Considering that Boro rice is a water- and energy-intensive cropping system and given its significance for the national rice production, the dissemination of Alternate Wetting warrants a national approach. A national strategy of AWD dissemination could be formulated based on experiences exchanged at the NATCC. This could provide an appropriate forum to start such a process. While all relevant actors need to be involved and have their share in formulating a strategy, the DAE should take the lead.

5. Develop strategic partnerships for disseminating AWD

Organizations involved in disseminating AWD have different strengths, such as in reaching target groups or in facilitating irrigation schemes, as well as having physical presence and capacities at local level. In order to make dissemination more efficient, strategic partnerships could be used to make the dissemination of individual actors and efforts more effective in certain locations, adding to the existing formal memoranda of bilateral agreement. This would also help to avoid overlaps of field activities, such as double training sessions offered at the same location, thereby contributing towards the better use of financial and human resources.

6. Involve local government in the dissemination process

Local government representatives are looked upon as opinion leaders by farmers. Being elected members of their constituencies, they play an important role for the farmers and the development of rural communities in their respective area of authority. Including local government representatives in local processes of AWD dissemination will help to further promote the technology among farmers. In particular, a closer cooperation between the local government and the DAE is considered important.

9.2 Adjusting Approaches to Context-specific Needs

1. Adapt AWD dissemination approaches to local irrigation systems

The adoption of AWD is strongly affected by a variety of specifics that constitute an irrigation system, including the organization of its users, scheduling of irrigation and payment arrangements. While these characteristics can vary from one village to the other, it was evident from the analysis that overcoming such structural obstacles will be a prerequisite for the further spread of the technology. It is essential that the approach of the disseminating organization takes the specific characteristics of an irrigation system into account as it promotes AWD to farmers in a certain location.

2. Design training to fit AWD use in command areas of irrigation systems

Irrigation is a collective activity involving pump owners, pump operators and farmers as well as other local actors. Training single farmers often entails difficulties as farmers try to implement AWD in their plots, whereas scheduling or payment arrangements are interrelated with the entire irrigation scheme. For AWD dissemination to be effective, the involvement of all members of an irrigation block needs to be addressed early on to facilitate decision making on changes in the irrigation schedule or payment arrangements, for example. It is recommended that disseminating organizations center trainings on command areas.

Encourage local stakeholders, especially farmers and pump owners, to share the economic benefits of AWD application While AWD has generally proven to be beneficial for farmers, economic benefits are received only if a farmer owns a pump, or if the payment arrangement allows the sharing of cost saving between the pump owner and farmer. It was often the pump-owner who benefited from the savings, while irrigation charges for the dependent farmers remained unchanged even though they reduced irrigation frequency by applying AWD. In order to boost AWD dissemination, it is crucial that extension emphasizes related issues on cost savings, by encouraging local stakeholders within a command area to find ways of a fair sharing of benefits, for example. It would be worthwhile to explore whether legal framework conditions could be changed in order to promote a fair distribution of benefits between the pump owners and farmers, in particular small-scale farmers.

3. Strengthen the quality of training for farmers

Considering that AWD is a knowledge-intensive technology, it is essential that field staff of the disseminating organizations is able to effectively pass on the technology to farmers. It turned out that quality of the training was often a limiting factor for its success. Training sessions were often too short or unsuitable for farmers to acquire adequate knowledge to be able to translate AWD into irrigation practice. Therefore it seems essential that AWD training is organized with suitable group sizes, timing, using suitable language and training methodologies, thereby ensuring that all the farmers are able to comprehend the essentials of the technology.

4. Address possible adaptations of AWD during training sessions

The study showed that AWD often needs some adaptation to fit local conditions. Training sessions should therefore systematically address possible adaptations of the technology to make it easier for farmers to handle AWD and adapt it to their specific setting. This should include information on the production of AWD pipes with local material. Also, alternative methods that are already used by farmers to systematically measure the soil water level in the field, should be assessed by extension and included in the farmers' training.

5. Improve monitoring and evaluation of AWD dissemination

To enhance the efficiency of extension work, we recommend that the disseminating organizations comprehensively assess the knowledge and experience gained by local field staff working with AWD. The monitoring and evaluation the progress in disseminating the technology to farmers should place a much greater focus on the adoption process under local conditions, i.e. the positive factors as well as the factors constraining the adoption by farmers, rather than continuing to address the technical performance of the technology.

9.3 General Recommendations for Disseminating NRM Technologies

1. Build on an overarching strategy to disseminate new technologies

In order to effectively introduce and disseminate new technology on a large scale, a consolidated countrywide approach could entail significant advantages and dynamics, such as the ownership and commitment of key national-level stakeholders. Therefore, to implement a comprehensive process of technology dissemination, a national strategy should be developed and implemented under the leadership of a strong national institution, which is equipped with a countrywide mandate and adequate resources.

2. Involve policymakers and ensure policy support early in a process

Policy support often seems essential to effectively up-scale and out-scale any NRM technology at national level. In order to create an enabling legal framework, policymakers and policy influencing actors need to be involved early on in the process of introducing and disseminating new NRM technology in a country.

3. Establish a platform to coordinate research and dissemination activities

Technology dissemination involving a range of organizations from science, adaptive research, extension to development, requires effective coordination. A national platform or leader needs to be identified that is able to involve a wide range of stakeholders at the national level. Also, such a formal mechanism is required to structure and guide a process of technology dissemination by encouraging individual organizations to systematically reflect results themselves and to provide a forum for a regular review of the progress in dissemination and to exchange experiences.

4. Involve extension agencies early on in technology dissemination

National agencies that are mandated and experienced with agricultural extension are key players in disseminating innovations in the agriculture sector. Therefore, extension agencies should be involved as early as possible in a process of technology development and dissemination. Their early involvement will help to create greater ownership of the technology and for its promotion at the national level.

5. Encourage strategic partnerships between disseminating organizations

Organizations involved in NRM innovations have different strengths and capacities in reaching farming communities. The involvement of partners with various backgrounds, from the government, private or non-governmental sector, should be encouraged to complement the action of the government in promoting the dissemination of innovations, and to build fitting partnerships.

6. Emphasize on the benefits of a technology in promoting its dissemination

Spreading a technology successfully requires the users to be able to both discern the potential benefits of the technology and develop a clear understanding of how to actually cash the benefits. Training sessions and information campaigns therefore need to emphasize the benefits for farmers when introducing a new technology.

7. Integrate end-users from start in a process of developing technologies

Users of a technology are deemed to have the best knowledge of their local context and environment and the potential and limitations of their farming systems. Therefore, end-users or local practitioners of a technology should be integrated from the start when developing a new NRM technology. This applies also to the validation and adaptation of an innovation to ensure its compatibility with local practices, beliefs and systems.

Even though impacts might have been demonstrated in one region, the compatibility of a technology with the local farming and resource management systems in another region needs to be re-evaluated early on, especially when promoting an NRM-related technology, which may face many context-specific requirements. This includes the question of whether the user actually harnesses the benefits when adopting a technology. In order to appraise the feasibility of integrating a new technology into a specific local farming context, extension organizations, social scientists and development practitioners should conduct compatibility studies.

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11 Annex

Annex 1: Result chain of study

Level		Description
Inputs		SLE-Team; translators/interviewers; Dr.Sikder (resource person); financial resources GTZ, IRRI and SLE; methodologies, material & equipment; support by IRRI Bangladesh Office
Activities		Inception and national workshop; training of field team; conducting field survey and additional interviews; reporting; presentations
Results	Output	• Description and analysis of dissemination pathways utilized by organizations disseminating AWD technology.* • Description and analysis of adoption processes, including their limiting and success factors for selected farming systems. • Assessment of short term impacts (economical, social & cultural) for end-users applying AWD. • To provide lessons learned in dissemination, adoption and impacts.
	Use of output	• Organizations involved in technology dissemination in Bangladesh are using the results of the study to review their approaches with AWD. • IRRI uses the results of the study to improve its backstopping.
	Outcome/ direct benefit	• Improved dissemination approaches lead to better out-and up-scaling of AWD in Bangladesh. • Through improved backstopping on AWD dissemination, IRRI promotes the out- and up-scaling of AWD in Bangladesh. • IRRI facilitates the diffusion of AWD to other countries through IRRC.
	Attribution gap**	
	Impact /indirect benefit	• Higher adoption rates of farmers using AWD lead to reduced water and energy consumption on an aggregated level. • Through higher adoption rates of AWD, more farmers benefit from improved cost-benefit ratios through water and energy savings. • Agricultural service organizations in other countries utilize the insights gained in Bangladesh to introduce/improve the dissemination of AWD.
	Highly aggre-gated impact	• The higher adoption rates of AWD result in more sustainable water and energy use by farmers and pump-owners. • National agricultural service organizations in Bangladesh and other countries use the experience from AWD to disseminate other NRM technology.

* exemplified by analyzing experiences of BMDA, BRRI, DAE, RDRS, and Syngenta in Rajshahi and Rangpur Division.

** Indirect benefits and impacts that may result from the study on the long-term are beyond the study's reach, i.e. they cannot directly be attributed to the outcome of this study ("attribution gap").

Annex 2: Sampling structure at local and regional level *

		Sub-sampling unit	Study region (division)	
			Rajshahi	Rangpur
End-user interviews	By admin. Level	District	5	4
		Upazila	13	8
		Union	18	19
	By disseminating organization	BMDA	33	0
		BRRI	9	13
		DAE	6	76
		Syngenta	5	-
		RDRS	-	37
	By sampling/response category	Adopter farmers**	26	32
		Adopter pump owners **	15	48
		Non-adopter farmers ***	11	26
		Non-adopter pump owners ***	1	20
		Control group farmers ****	49	45
		Focus Group Discussions (FGD)	4 (~64 participants)	5 (~30 participants)
Key informant interviews	Regional level / extension staff	BMDA	2	-
		BRRI (Scientific Officer)	1	-
		DAE	2	3
		RDRS	-	1
		Practical Action	-	1

* no of interviews conducted

** Farmers and pump owners, respectively, who received training on AWD by one of the dissemination organizations or who decided to adopt AWD without receiving training.

*** Farmers and pump owners who received training on AWD, but did not yet adopt AWD and did not conduct AWD demonstrations.

**** Farmers and pump owners who did not receive training on AWD but are from the same or neighboring village as the adopter and non-adopter sample

Annex 3: Sampling structure by tube well system and farm size

a. Sample of end-users by DTW and STW systems*

	DTW	STW		
	Electric-powered	Total	Electric-powered	Diesel-run
Rajshahi Division	94	45	5	40
Rangpur Division	28	188	76	112
Total	122	233	81	152

*no. of samples

b. Complete sample of end-users by farm size

	Marginal 0.05 – 0.49 acre	Small 0.5-2.49 acre	Medium 2.5-7.49 acre	Large 7.5 acre plus
Rajshahi Division	5	46	40	9
Rangpur Division	15	89	52	13
Total	20	135	92	22

* The definition “marginal, small, medium and large" farm, originally based on the agricultural report of 2005, has been adapted to the conditions of the study. The land area considered to be the total area of cultivated land, whether it is owned or leased.

c. Sample of adopters by farm size

	Marginal 0.05 – 0.49 acre	Small 0.5-2.49 acre	Medium 2.5-7.49 acre	Large 7.5-above acre
Absolute figures	11	86	61	18
Percentage	6.3	48.9	34.7	10.2

Annex 4: List of key informant interviews at national level

Organization	Interviewee	Date of interview
BRRI	Dr. Md Abdur Rachid, Chief Scientific Officer and Head Irrigation and Water Management Division	14.09.2010
	Dr. Nazmul Hassan, Senior Scientific Officer, Irrigation and Water Management Division, Manager of the AWD project	14.09.2010
	Dr. M. Shahe Alam, Head Agriculture, Economics Division	14.09.2010
	Dr. Md. Abdul Mannan, Director General	14.09.2010
	Dr. Md. Hazrat Ali, Head Rice Farming Systems Division	14.09.2010
	Dr. Md. Humayun Kabir, Head Adaptive Research Division	14.09.2010
	Dr. Md. Islamuddin Molla, Head Training	14.09.2010
DAE	Dr. Nurul Islam, Director of PIU/NATP	8.08.2010
	Mr. Khan, Director of Field Service Wing	8.08.2010
	MD Mizanur Rahman, Monitoring and Evalutaion Officer	8.08. and 16.09.2010
	Zakia Begum, Additional Deputy Director	16.09.2010
	Mustafizur Rahman, Monitoring and Evaluation Specialist	16.09.2010
IRRI	Dr. Abedin, IRRI Representative, Bangladesh Office	2.08.2010
	Dr. Hamid Miah, Liaison Scientist, Bangladesh Office	Several: 3.08.; 13.09.; 19.10.2010
MoA	CQK Mustaq Ahmed, Secretary	20.09.2010
Petrochem	Md. Shahjahan Ali, Advisor	13.09.010
RDA	A. K. M. Zakaria, Joint Director	17.08.2010
	M. A. Matin, Director CIWM	17.08.2010
Syngenta	Ahmed Sarwar, Managing Director Bangladesh	9.08.2010
	Nazmul Kabir, Business Manager/Project Manager AWD accompanied by Head of Sales and Head of Marketing	9.08.2010

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