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Research article

A multi-stakeholder partnership for the dissemination of alternate wetting and drying water-saving technology for rice farmers in the Philippines

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Abstract: To address issues of water scarcity and food security for sustainable rice farming and increasing production, a water-saving technology called alternate wetting and drying (AWD) was disseminated in the Philippines. This study assessed the impact of facilitating a network of stakeholders on disseminating AWD in irrigated rice systems in the Philippines. It used both qualitative and quantitative data collected from 2002 to 2012 in study sites in the country. Engaging multi-stakeholders in adaptive research, training, and dissemination facilitated the process of more interaction by partners. All partners joined a knowledge and dissemination alliance for scaling out AWD activities. This in turn effected a policy outcome, and the synergetic interactions of each partner within and outside the current network fast-tracked the dissemination process and adoption of AWD by farmers. The AWD practice resulted in an increase in irrigated rice area but not necessarily in rice production and farmers' income. It also reduced labor and fuel consumption, especially in deep-well irrigation systems.

Keywords: rice production; alternate wetting and drying; water-saving technology; Philippines; multi-stakeholder partnership

1. Introduction

Rice is the staple food of more than half the world's population and the common source of livelihood for many, most of them located in Asia [1,2]. Thus, maintaining a sufficient supply of rice is crucial. However, sustaining the rice supply is threatened by global water scarcity due to competing demands of the growing population for water (agriculture, industry, and domestic uses) and climate change [3,4].

Around 75% of the world's rice supply is grown in the irrigated ecosystem. And for irrigated rice, it takes 3000−5000 liters of water to produce one kg of rice, which is two or three times more compared with what other cereals need. Inadequate supply of water at specific stages of rice growth generally reduces yield significantly, whereas oversupply of water is a waste and an avoidable cost [3,5]. Diminishing water resources that could be used for rice production globally will ultimately affect the supply of rice for all consumers.

To address water scarcity and to sustain rice production for food security and poverty reduction, scientists from the International Rice Research Institute (IRRI) developed and promoted a water-saving irrigation technology called alternate wetting and drying (AWD). A departure from the common practice of farmers, AWD introduces periods of dry (aerobic) soil conditions. It entails an irrigation schedule where: (i) water is applied to the field for a number of days after the disappearance of ponded water (as opposed to continuous flooding); (ii) water is maintained at 2−5 cm depth during irrigation (instead of fully flooding the paddy field, normally at 5−10 cm) [6,7].

To effectively address the crucial issues of water and rice, farmer adoption of AWD on a wider scale over time and space should happen. But a confounding challenge is the slow adoption of most agricultural technologies [8], more so with knowledge-intensive technologies (KIT) such as AWD because they are presented as knowledge and not in tangible form or as physical product [9]. AWD is a technique to fine-tune farmer water management practices, enabling farmers to make decisions that translate into sound agronomic practices.

This study aims to illustrate how multi-stakeholder partnership and engagement of partners can efficiently disseminate a technology, such as AWD, in the Philippines and facilitate wider farmer adoption to achieve impacts. It is hypothesized that, in the dissemination of AWD, engaging partners in a multi-stakeholder partnership creates an enabling environment for learning, allowing incorporation of farmer knowledge for technology adaptation, and facilitation in harmonizing extension efforts of partners for scaling up and scaling out of AWD.

- *Multi-stakeholder partnerships to drive innovation and innovation diffusion*

Technology has been viewed most often as a tool or a physical product that is developed and then distributed. Most natural resource management technologies however like alternate wetting and drying (AWD) are argued to be knowledge intensive technologies or KIT, because they are in the form of knowledge and information, which are made accessible to the end user in a less tangible form than physical products such as seed or machinery [9]. Technology is further argued as a socio-technical hybrid, which is composed of tools and practices as well as the human actors and their relationships [10].

While the profitability of an innovation is a very important factor, it is not the only aspect that matters in adoption because innovation adoption is both a social and cultural process [11]. Adoption by farmers is a deliberate decision made after considering a wide range of issues, and done within a social and cultural context where different individuals may interact and influence the decision. Hence, to influence wider technology adoption, it is not enough to merely provide a tool or knowledge about a new practice to one group of people, or stakeholders. It will require a "collective process that involves the contextual re-ordering of relations in multiple social networks" [12]. Varied stakeholders, often linked to one another as a network, would be needed to orchestrate change especially because it involves complex interdependencies, interactions that may have synergistic outcomes, and negotiated dynamics among groups with different interests [12-14].

This study used the innovation system framework and the theory of social capital in illustrating the effectiveness of multi-stakeholder partnerships in achieving wider technology adoption. The innovation system framework stresses the evolving system of actors and actor involvement in the production, dissemination, and use of knowledge [15-17]. Innovation such as alternate wetting and drying (AWD) is a complex process, often requiring technical, social, and institutional changes and involving interaction of organizations across conventional producers and users of knowledge [15]. Learning and the role of institutions are critical components because it is not possible to understand learning without referencing its institutional and cultural contexts. Learning is an interactive and socially embedded process that will affect into social learning to various actors and members in respective organizational networks [17,18].

Social capital refers to "features of social organization such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit" [19]. Through the engagement of partners in the innovation system, within a multi-stakeholder partnership platform, social capital has been developed and facilitation of the process of learning and adoption of the innovation has increased. Networks and individuals involved in the partnership have diverse perspectives and experiences, which are questioned, affirmed, or re-shaped in the interaction with others in a process that contributes toward learning collectively. Thus, as partners interact with each other in many different activities throughout the project, trust building has been developed or enhanced, and experiential learning (learning by doing) is further facilitated. Furthermore, the actors involved in the partnership have their own networks, creating synergy in the dissemination process resulting in wider adoption of the innovation such as the AWD. Consequently, the social capital built and enhanced in the MSP can facilitate natural capital (such as food), financial capital (higher economic returns), human or cultural capital (knowledge and learning), and physical capital (tools for need-based irrigation).

2. Materials and Methods

2.1. Forming the partnership for AWD dissemination

The partners in multi-stakeholder partnership (MSP) AWD research and extension platform was formed through the Technology Transfer for Water Savings (TTWS) project, which was an interagency collaboration between the International Rice Research Institute (IRRI) through the Irrigated Rice Research Consortium (IRRC), National Irrigation Administration (NIA) in Tarlac province, and the Philippine Rice Research Institute (PhilRice) [4]. The MSP was established based on a number of criteria: resource profile; culture fit such as shared vision and goals; partner reputation; and partnership experience [12]. In the TTWS implementation, a memorandum of agreement, where responsibilities were outlined, was drafted and signed by the partners.

The TTWS project, and the created MSP, aimed to validate and disseminate AWD water-saving irrigation technology in rice production through a farmer participatory approach, where farmers and researchers and members of the MSP worked together. The pilot site for AWD was in P-38, one deep-well system in Canarem, Victoria, Tarlac, a province of Central Luzon Region. Central Luzon is the rice granary of the Philippines. On top of the above-mentioned three collaborating agencies, the initial MSP included a farmer group, the P-38 Irrigators' Service Cooperative (ISC), and individuals who were 'local champions' of the technology. The MSP was established through a stakeholder workshop organized by IRRC, followed by a technology training of stakeholders.

The most common irrigation system used for irrigated rice in the Philippines is the gravity system, where water comes from an open source into farm canals and pipelines such as irrigation dams. For other irrigated rice areas where gravity system is absent, and mostly in the rainfed and upland ecosystems, an irrigation deep-well system is used. It utilizes a pump to provide pressure for conveying and/or applying irrigation water. Electric motors and internal combustion engines are normally used as power for pumps using diesel or gasoline as fuels.

2.1.1. The IRRC at IRRI

The IRRC scientists worked with actors from the national agricultural research and extension system to validate the AWD technology in farmers' fields. The IRRC, serving as the facilitator of the MSP, had a platform for partners to disseminate promising technologies through the IRRC Country Outreach Program or ICOP. ICOP involved key national partners with shared goals and visions for scaling up and scaling out rice technologies to effect higher income and rice production for farmers involving several Asian countries including the Philippines. Most of the key partners in the AWD MSP research and extension in the Philippines already had previous engagement experience with IRRC and other local partners in the country.

2.1.2. PhilRice

The PhilRice, a research institution of the Department of Agriculture (DA), is mandated to lead in attaining and sustaining rice self-sufficiency, as well as implement research, technology promotion, and policy advocacy in the Philippines. It has six branch stations all over the country and strong partnerships with various international and national research institutions. With its national mandate, it has a great stake in the MSP to achieve success of the project.

2.1.3. NIA

The NIA is a government-owned-and-controlled corporation responsible for the development and operation of irrigation systems in the Philippines. It is mandated to develop a 3-million-hectare area nationwide that has potential for irrigation. It organizes irrigators' associations (IAs) or irrigators' service cooperatives (ISCs) and strengthens them through training activities to make them more effective partners in irrigation development and management. NIA's motivation in the MSP is beyond question since irrigation water supply and management have already been a problem to the agency as well as to the IAs and ISCs.

2.1.4. P-38 Irrigator Service Cooperative

The farmer group was represented by the P-38 ISC in Canarem, Victoria, Tarlac province. It has 50 farmer-users of the P38 deep-well pump. Originally, the operation of the P38 deep-well pump system was through a loan granted by NIA to farmers for operation and maintenance. Through time, the cooperative paid off the loan and its share in pump construction. Consequently, the operation and maintenance of the pump were handled independently by the cooperative, with individual members shouldering the operation costs. Considering the expensive irrigation expense in pump system, due to increasing cost of fuel for the pump, the P-38 ISC and especially its officers were so enthusiastic in implementing the project and being a key partner in the AWD MSP.

2.1.5. Local champions

The local champions primarily refer to the chairman and officers of P-38, farmers who joined the AWD experiments, and local leaders (the village captain and officials of Canarem as well as the mayor of the municipality of Victoria, Tarlac). To address water stealing of irrigation water, and other related problems in irrigation water scheduling and management, the P-38 officers and local leaders perceived AWD as a positive solution.

2.2. Engaging varied stakeholders in the AWD validation and dissemination

2.2.1. Farmer participatory AWD experimentation

Farmers from P-38 ISC and IRRI-IRRC and PhilRice researchers, including irrigation engineers and extension staff from NIA, jointly established the adaptive AWD experiments. These included 12 farmer-cooperators in the 2002 dry season (DS) and 15 in the 2003 DS, all members of the P-38 deep-well system of Canarem [6]. Each farmer-cooperator managed two different plots: in one, standard farmers' practice (FP) was used; in the other, AWD was used. Each plot had an area of 500−1000 m^2. Monitoring and recording of specific observations were done by farmers together with scientists and NIA staff. In this initial phase, all partners focused on testing the technology to see if it worked, considering local farm conditions.

Irrigation water input in both plots was measured using trapezoidal weirs. Plastic perched tubes were installed to monitor daily ponded and perched water depth in the plots as shown in Figure 1. This perched tube served as a decision tool: when water is 15 cm below the surface, the farmer needs to irrigate the AWD plot. AWD also requires a 3−5 cm depth only, in contrast to the common practice of gauging 10−12 cm depths when farmers irrigate their rice fields. Grain yields in AWD and FP were measured; an input-output survey was carried out using semi-structured questionnaires at the end of each harvest [6].

Figure 1. Perched plastic tube and steel tape.
Source: IRRI

2.2.2. Training of and information dissemination among farmers

IRRI implemented a series of trainings on AWD to researchers and extension staff of partner agencies to disseminate the technology. In particular, IRRI conducted several training courses participated in by NIA technical staff around the country. These efforts targeted NIA staff and their farmer-cooperators through the agency's *Lakbay-aral* or study tour program.

During the training, participants were brought out to the field to see what the farmers were doing. The farmer-cooperators in the participatory experiments served as resource persons who explained the AWD experiment, their experiences in testing the AWD, and the results they found in their fields. Also, at the end of the farmer experiment season, field days/harvest festivals were held. These activities gathered farmers, local officials, and other guests to see the results of the experiments. The farmers themselves helped organize the activity.

2.2.3. Continuous updating among partners

Working closely together and continuous updating between and among partners were done through workshops and meetings. Through these venues, needs and gaps were identified for further action of the different partners to speed up AWD dissemination. Strategic actions were then decided upon.

2.3. Data collection and analysis

The study used both qualitative and quantitative methods and analyses. Data from 2002 to 2012 were collected and analyzed. Focus group discussions and key informant interviews were utilized in collecting qualitative data. Discussions and interviews were done with farmer partners, members of the partnership, and other farmers in the sites where AWD was introduced. The main focus of the discussions and the interviews was the documentation of the context, processes and mechanisms used, outcomes, and impacts. Outcomes were measured in terms of adoption and diffusion of AWD and impacts in terms of the consequences of AWD adoption.

Four survey data sets complemented the on-farm experimental data from farmer participatory research in 2002 and 2003. The first survey was conducted in 2004 to monitor initial adoption in the participating trial site. This involved 63 farmers within the P-38 deep-well IA, including cooperators in the participatory trials.

Since AWD was implemented on a wider scale through the initiative of NIA, a second survey was done in 2006−2007 to assess farmer adoption and impacts among 319 farmers from the 25 deep-well pump systems in Tarlac province. The third and fourth surveys were done in 2006 and 2011, respectively, to assess the changes in area cultivated, yield, and mean net income of rice farmers in the Bohol Irrigation System (BIS) 1 in Bohol Province. AWD was implemented in 2006 in BIS 1, which was a gravity irrigation system with an irrigable area of more than 4000 ha.

Descriptive statistics such as frequency counts, percentages, means, and standard deviations were used to determine the proportion of rice farmer-respondents who adopted AWD as a result of the dissemination activities and to compare the effects of AWD adoption on area cultivated, average yield, and net income of rice farmers. As to the impact of the AWD technology, the "with and without program" and "before and after" analyses were employed in Tarlac and Bohol, respectively. Results of the impact assessment of AWD were published for the Tarlac data and for the Bohol data, but these will also be briefly discussed and cited in this paper [20,21].

3. Results and Discussion

3.1 AWD learning through joint experimentation

3.1.1. Farmer learning about AWD

Through joint experimentation by farmers and scientists, farmers were able to observe and see the differences between the plots using FP and those using AWD. They observed that there was no yield difference between FP and AWD plots, and that AWD plots saved a lot of water, time, and labor and fuel costs in irrigation. They also noticed more tillers in the AWD plots. However, they got lower yields when water rotation took a long time.

Empirical evidence jointly measured by researchers and farmers corroborated farmers' observations regarding AWD (Table 1). The on-farm experiment had shown that AWD indeed saved water significantly by 21–26%, irrigation labor by 9–11%, fuel consumption by 41–44%, and irrigation cost by 35–39% in the 2002 DS and 2003 DS [22]. Also, there was no significant yield difference between AWD and FP plots in both years.

Table 1. Mean and per cent difference between farmers' practice (FP) and AWD plots for selected variables, 2002 DS and 2003 DS farmer participatory experiments

	2002			2003		
	FP	AWD	% mean[1] difference	FP	AWD	% mean difference
Water used (mm/ha)	743[a]	587[b]	21	714[a]	525[b]	26
Total fuel consumption (li/ha)	356[a]	199[b]	44	430[a]	255[b]	41
Costs for fuel and oil (real cost, US $/ha, base year = 2002)	99.07[a]	60.39[b]	39	119.54[a]	77.32[b]	35
Labor for irrigation (man days/ha)	12.12[a]	9.1[b]	25	14.12[a]	11.12[b]	21
Yield (tons/ha)	5.4[a]	5.4[a]	0	6.2[a]	6.1[a]	1.6
Net returns[2] (real cost, US $/ha, base year = 2002)	524.38[a]	542.74[a]	+0.03	655.73[a]	622.22[a]	−0.05

% mean difference = ((FP-AWD)/FP) * 100

For details of cost and return analyses [22]

The yields and net returns of AWD were not significant in both 2002 DS and 2003 DS. However, AWD had added benefits such as water savings, less labor and time allotted by farmers for irrigation, and lower fuel consumption and costs. The reduction in irrigation labor implies either less fatigue for farmers or additional potential income from opportunity costs.

Similar results were also observed [23,24]: AWD as a rice management practice reduced water use by up to 30% and could save farmers money on irrigation and pumping costs. Likewise, AWD did not reduce rice yields [21,22,24,25]. Considering the high volatility of the prices of fuel and the aforementioned benefits of AWD over common farmers' irrigation practices, AWD would still be a better alternative irrigation scheme.

3.1.2. Adoption and adaptation of AWD by P-38 ISC rice farmers

(1) Negotiating for implementation in an ISC: Adoption process of AWD

Shortly before the start of AWD implementation in the P-38 ISC, there was tension arising from water use because of the increase in membership and service area, which lengthened the water delivery intervals. The implementation of AWD increased the tension because farmers were apprehensive to see dry rice fields with cracked soil [22]. Although AWD implementation in P-38 ISC was a collective decision influenced by results of the participatory experiments and actual observations made by other members of the P-38 ISC, still many farmers had doubts about getting the same yields. For this reason, some farmers stole water by placing holes underneath paddy dikes, hidden from other farmers' eyes. Conflicts increased but these were resolved through the intercession of village officials, particularly the village security officers.

Another decision of the ISC was to stop availing itself of the NIA loan for fuel and oil, which was part of the ISC operation scheme. To cover costs for fuel and maintenance, the ISC policy to access irrigation changed from using NIA-provided fuel and oil to individually-provided ones because many farmers did not pay their fees. Each farmer needed to bring his own fuel and oil to the pump to irrigate his field. This solved the occurrence of free riders. There was a remarkable 40%-decrease in the total amount of fuel and oil used, consistent with the experimental findings in Table 1. This was much expected because, when the cooperative was using fuel provided by NIA, farmers were so lavish in their use of fuel. When it was individually provided, they became very prudent in its use. Since AWD reduced water consumption, the technology became a significant factor in solving their operational problems and motivated farmers to cooperate. At the end of the second year of participatory experimentation (2003 DS), social capital was enhanced through deepened mutual trust within P-38 members and between partners, resulting in the practice of AWD at the system level.

(2) Farmer adaptation of AWD by P-38 ISC rice farmers

During the conduct of the experiment in 2002 DS, the farmers used the suggested perched plastic tube in monitoring the water level below the surface. However, after a season-long implementation, farmers replaced the perched plastic tube with a perched bamboo tube, and the steel tape measure with a meter stick [26]. At the same time, instead of monitoring the irrigation water and measuring the 5-cm water depth requirement for AWD, they just maintained it by reducing a certain portion of the paddy bunds [26]. So, they no longer measured the 5-cm water depth in their respective farms because the water automatically flowed to the next paddy after one was fully irrigated. After one year of AWD implementation, the farmers just stomped on the soil to see if irrigation was needed instead of using a perched tube.

This farmer adaptation and adoption of AWD illustrated the importance of experiments jointly participated in by partners, especially the farmers, in the development and utilization of knowledge through the experiential learning process. Here, local knowledge emerged through sequential reflection and corresponding actions by the members in the network and partnership. This local knowledge was utilized by actors in the multi-stakeholder partnership for research planning and AWD out-scaling [26]. Farmers themselves served as resource persons during field days, sharing their hands-on experience and AWD adaptation.

3.2. Partners' capacity building and dissemination efforts

The engagement of partners in the MSP for AWD dissemination brought out each partner's core competence and experience about the theory and application of AWD. It has also increased the capacity of partners and has built synergies to co-create something new (e.g., new projects from independent funding), in this case, for AWD dissemination [27,28]. The partners' institutional learning capacity has expanded through in-house training and other innovative activities for extensive dissemination efforts. Altogether, the capacity building and disseminating efforts have continuously built-up the social capital in the MSP.

3.2.1. NIA

Following the positive results in P-38 ISC, "water savings" became a banner program for ISC and IA strengthening at the national level [27]. Large-scale dissemination in the deep-well system was done through the ISCs and the IAs took care of spreading it among gravity system users. For one, in Tarlac province, AWD was promoted in 72 deep-well systems covering 3,354.7 ha of land for 2,256 farmer members through the Tarlac Groundwater Irrigation Systems Reactivation Project (TGISRP) [24]. The AWD was introduced in a number of national irrigation systems in the country, such as the Bohol Irrigation System 1 (BIS 1) in 2005 and Upper Pampanga River Integrated Irrigation System (UPRIIS) in 2007. AWD was implemented in BIS 1, covering more than 4000 ha with around 4000 farmers [21]. The AWD promotion in UPRIIS was a collaborative effort by NIA and PhilRice.

With a slogan, "More crop per drop," NIA promoted water-saving in its projects such as the Irrigators' Association Strengthening Support Technical Cooperation Project to counter problems of low cropping intensity and cycle-of-irrigation-related problems: involving unstable water supply; unstable or decreasing crop production; decrease in farmers' income; decrease in irrigation service fee (ISF) collection; and deterioration of irrigation management [27]. Empowering farmers with knowledge on efficient water use was seen by NIA as a solution to the aforementioned water management problems. Several training and dissemination activities were conducted, e.g., techno-demonstrations on AWD managed by the farmers themselves (Table 2).

There was widespread awareness of water-saving technologies in the different NIA offices through the *Lakbay-aral* (Study tour) program. Large-scale dissemination of AWD technology was undertaken by various NIA provincial offices countrywide.

Table 2. Training and dissemination activities, 2005−2006 and 2009−2011

Activity	Years	Participants
Training (3 batches)	2005−2006	450 farmers
Training (12 batches)	2009−2011	447 farmers, government agency staff, students
Cross-visits/study tours		30 IA leaders, 3 NIA staff

Source: Data came from interviews with NIA officers and farmers.

3.2.2. Bureau of Soil and Water Management (BSWM)

The Bureau of Soil and Water Management is another agency under the Department of Agriculture of the Philippines. It was not originally a partner agency but it became a new partner, through NIA, as the different activities moved forward. The agency has the mandate to develop shallow groundwater and small impounding systems throughout the country. It is likewise mandated to coordinate the implementation of small-scale irrigation projects that have been proven effective in mitigating the impacts of El Nino events in the country. The BSWM was engaged through another collaboration project and through its relations with NIA; it also got interested in managing smaller irrigation systems.

The water-saving technologies of AWD and aerobic rice were used by the BSWM in training farmers in shallow water impounding project (SWIP), small gravity irrigation systems, and shallow tube wells (STW). Since the start of the partnership, the BSWM has incorporated AWD in its training activities for its farmer clients. From 2005 to 2007, a total of 327 extension staff and farmers participated in the different training activities of BSWM.

3.2.3. PhilRice

The water-saving technologies were used in three of the four programs of PhilRice: Favorable Environment; Unfavorable Environment; and Knowledge Management. Research on AWD has been continuous since the partnership started with the TTWS Project. From AWD, PhilRice has expanded the technology to "controlled irrigation," which it used to mean water savings in rice production from land preparation to harvest, as opposed to alternate wetting and drying from planting to harvest.

The UPRIIS project initiated by PhilRice in collaboration with NIA in 2006 implemented a pilot area of 293 ha and 200 farmers [28]. The goal was to achieve equitable distribution of water within the UPRIIS, thereby increasing ISF collection. Following the successful pilot project, AWD implementation was targeted to 20% (16,000 out of 82,000 ha) of the UPRIIS service area. One motivation was that the water saved could be sold for use in hydroelectric power generation, thereby having additional income for the agency. The water was sold at 30 centavos per cubic meter. Research findings on AWD have been incorporated into many of its research information dissemination activities, specifically addressing conditions of water scarcity such as what happened during dry spells in August 2007 onward. Furthermore, PhilRice has conducted seven trainings of trainors (ToTs) on water saving from 2005 to 2007 to speed up AWD dissemination. There were 256 participants, mostly technicians and farmers, who served as "trainors" in their respective localities.

3.3. Impacts of using AWD at different levels: Implications for food security

This study aimed at exploring the partnerships and drivers toward the implementation of a water-saving technology at various levels. This section discusses the impacts of these partnerships and drivers, particularly on what these imply for issues around food security.

3.3.1. Farm-level economic impacts

With the implementation of AWD at the P-38 deep-well system, farm-level economic impacts were observed. On a per-hectare basis, there was a significant increase in yield but this result was not conclusive (Table 3). The increase in production of 11.5% may be attributed to better management practices introduced along with the practice of AWD, such as the right kind, timing, and amount of fertilizer used. Some findings though have shown that AWD could increase rice yield [28-30]. However, others found no effect on yield for the pump system [20,22,24].

The implementation of AWD at the P-38 deep-well system level did not significantly increase net returns (Table 3). Although there was a significant decrease in production cost due to less fuel use from

AWD practice (Tables 3 and 4), still the nominal increase of net returns was not significant because of the high fertilizer prices in 2005. Similar findings were also noted in another study [31].

Table 3. Average yield, cost, and returns of P-38 users in 2003 and 2005

ITEM	2003 (n = 63)	2005 (n = 33)
RETURNS		
Yield (kg/ha)	4550	5,191.38
Gross returns (P/ha)	857.92	967.88
COSTS (P/Ha)		
Material		
Seed	21.61	11.18
Fertilizers	71.99	97.30
Pesticides	7.55	9.70
Fuel consumption for irrigation	92.94	44.53
Food	19.73	17.19
Tractor rent	8.14	6.97
Others	27.87	24.16
Total material cost	249.84	211.03
Labor		
Seedbed preparation	3.63	3.11
Land preparation	10.85	7.76
Transplanting	41.90	39.49
Fertilizer application	0.53	0.44
Pesticide application	0.33	0.35
Hand weeding	0.32	0.00
Post-harvest	133.49	112.39
Permanent labor	29.80	30.49
Total labor cost	222.84	194.03
Total production cost	470.68	405.06
NET RETURNS (P/ha)	391.42	393.48

Table 4. Fuel consumption, number of irrigation, and hours per irrigation of P-38 users in the 2003 and 2005 dry seasons

Parameter	2003 DS	2005 DS	% change
Total number of irrigation	10	10	0
Mean hours/irrigation	7.6	3.96	−48
Total fuel consumption (li/ha)	323.7	193.7	−40

The water use reduction among P38 farmers can be inferred from the number of hours spent for irrigating one's field and irrigation fuel consumption (Tables 3 and 4). While irrigation frequency was generally the same, irrigation time for every application was reduced by 48%, from 7.6 hour to 4.0 hour. This reduction was due to the shift from the traditional practice of fully flooding the field to fulfilling the 5-cm water depth requirement under AWD. With farmer adaptation of reducing paddy bunds, farmers strategized their irrigation scheme in such a way that, even if only some portions were irrigated, they stopped using pumps because they calculated that water would flow to the rest of the paddies after a few hours. The significant reduction in labor spent for irrigation allowed farmers to spend a substantial portion of their time doing other things.

Further analysis done in 25 ISCs from 25 deep-well systems in Tarlac province revealed that AWD effectively reduced the hours of irrigation use by about 38%, without a significant reduction in yield and profit [20]. These findings are consistent with those seen for the pump system [30]. Although AWD did not have a significant increase in yield, water productivity in rice was observed to be higher with the use of AWD because the decline in water input was larger than the decrease in yield [31].

For the gravity system, a study in Bohol further confirmed that AWD might have had a significant contribution to changes in profit but not in yield [21]. These findings are consistent with results of other studies [28,32] that showed no yield penalty with AWD. However, the implementation of AWD in BIS 1 in Bohol resulted in an increase in rice cultivated area, particularly those downstream: an average increase of 0.20 ha cultivated by each farmer during the dry and wet seasons [21,33]. This increase can be attributed to the equitable distribution and reliability of irrigation water brought about by the implementation of AWD [34]. The certainty of water supply also resulted in the closing of the yield gap between upstream and downstream farmers [21]. Considering that, in the Philippines, about 90% of irrigated rice area is using gravity systems and approximately one-third of the irrigated area is downstream, more farmers will benefit from the effect of AWD and this will be mostly felt in the dry season [35].

Availability, access, and efficiency of using fresh water for irrigation have been identified as key issues that affect food security at a global scale [36,37]. These findings on the impact of AWD, whether in deep well systems or larger gravity irrigation systems, imply that use of AWD at system level leads to expansion of the number of farmers who could access scarce water resources for rice farming, and expansion of rice cultivated areas.

As in the P-38 experience of AWD, its service area has increased from 50 to 70 ha because the farmers need not use the pump often, allowing others to avail themselves of its use [22]. And in the BIS 1 experience, the total area cultivated increased by 41.30 ha in the dry season and by 42.31 ha in the wet season. This illustrates that limiting the water being used by farmers through AWD can still sustain the yields for farmers. The same amount of rice could be produced using less water, and ensuring that more farmers could access irrigation water. An increase in irrigated area at the system level, both deep-well and gravity systems [20-22,35], can lead to higher rice production, both at the farmer and country levels. Moreover, AWD was projected to be potentially adopted on the 20 million hectares of irrigated rice land in the world that are estimated to be under water scarcity by 2025 [34]. Hence, AWD can benefit many poor rice farmers in Asia through maintaining and improving the economic and environmental sustainability of their livelihoods. As a result, this allows them to further contribute to local, national, and global food security.

3.3.2. Sociocultural impacts

Socio-cultural impacts were measured in terms of changes in farmers' perceptions and beliefs about the utilization of water in rice production. Also included were the changes in people's lives including women and children as observed and validated through narratives by people in the community.

Farmers in the P-38 irrigators' cooperative have become more confident that the practice of allowing the field to be without standing water is not harmful to the plants. Around 79.4% thought that less water would not hurt the crop and 77.2% believed that more water was not necessarily better for the plants.

This change in perception and attitude toward water use in rice cultivation was translated into adoption of AWD and resulted in greater community cohesion [22,33]. Similar scenarios on adoption of technology and community cohesion were evident, with resulting changes of perceptions about ecologically based rodent pest management [38,39].

Despite the minimal length of time each farmer was allowed to use the pump, farmers who have adopted AWD were no longer anxious about their crop. They were already satisfied with their irrigation schedule (94.3%) using AWD principles. This was in contrast to the tension arising from pump sharing as people got into conflict over the use of the pump. This situation was also earlier experienced by the P-38 farmers with the introduction of AWD, but the conflict was resolved because farmers have achieved equitable use of the pump [22].

Less use of water has also increased the domestic water supply in the village. In the past, people in the village, usually the women and children, had to walk long distances to fetch water from a common well prior to the establishment of the P-38 deep well. After the pump became operational, the members coordinated with the local government unit to have a water tank installed for domestic water use. With the implementation of AWD in the P-38 deep-well system, farmers were not using the pump as much, allowing more time for the pump to store up water for domestic consumption. As a result of using the pump less, more domestic water became available to the village. In the past, the tank was only filled once in the morning and once in the afternoon. After the implementation of AWD, the pump was used even in the middle of the day to fill up the overhead tank for domestic consumption, ensuring that there was water in the homes for most of the day. Women and children were freed from the task of fetching or storing water for household use.

The balance between competing stakeholders who need to access water is an issue inherent to addressing global food security. On one hand, food production is important, but there are various stakeholders who require access to the same resource. In this case, the perspective of innovation systems points to negotiations among different groups in a community as being necessary to scheduling users, implementing rules, and creating new, workable arrangements for different groups. Such changes on the social side go hand in hand with the technological changes as farmers and managers of the irrigation system implement AWD.

3.3.3. Policy impact

Policy changes are required for some innovations to be embedded in systems [40]. In the case of AWD, the supportive policy frameworks, which have developed over time through the efforts of various actors, were critical factors for the extensive AWD dissemination. On one hand, it was an outcome of the strategies implemented by the stakeholders who were supportive of AWD implementation; at the same time, it also created synergies required to scale out the implementation. This highlights the interrelatedness of various dimensions of change required to address food security.

The Philippine national government issued a policy through Administrative Order (AO) 25 of the Department of Agriculture in December 2009 on "Guidelines for the adoption of water-saving technologies (WST) in irrigated rice production systems in the Philippines" [41]. This DA-AO 25 was the policy support for the nationwide adoption of AWD in the country.

The successful adoption of AWD in TGIS, UPRIIS, and BIS became the basis of the formulation of Administrative Order (AO) 25. In March 2008, the Water Saving Workgroup of IRRC in the Philippines met at IRRI to form a team to come up with policy support to effect nationwide dissemination and adoption of AWD. In April 2008, a technical working group (TWG) was created by the DA Secretary through Special Order (SO) 266 to formulate implementing guidelines in the adoption of water-saving technologies for rice in the Philippines (DA 2008). After several meetings, the TWG drafted the guidelines and did public consultations regarding the guidelines throughout the country. Four island-wide consultation meetings were conducted from June to August 2009, which were participated in by NIA personnel in the regional and system levels, officials of confederated IAs, regional and provincial agriculture officials, representatives from the state colleges and universities, and NGOs. In November 2009, the Department of Agriculture (DA) Administrative Order (AO) 25 was issued by the DA Secretary; it provides the guidelines for the adoption of Water-Saving Technologies (WST) in irrigated rice production systems in the Philippines (41). After the issuance of the order, a series of technical briefings were carried out in different regional irrigation offices in the country for effective implementation of the technology.

With the associated funding from the AO 25, AWD implementation of NIA all over the country was further accelerated. Likewise, collaborative research activities of PhilRice on AWD have increased, enhancing and refining AWD applications in different agroecological and climatic farming conditions. Moreover, the Philippine government included it in the country's adaptation and mitigation initiative for implementing climate smart agriculture [42].

3.4. The partnership and lessons learned: building and strengthening linkages

Critical to the success of the partnership is the recognition of shared interest, commitment to common goals, and partners having a stake in the outcomes [12,43]. All the partners in the AWD MSP have varied but complementary stakes. In the case of NIA, the need for efficient water use in water-scarce areas and for sustaining irrigation infrastructure despite rising fuel costs was motivation enough to introduce the technology in deep-well systems. For PhilRice, the mandate of leading in attaining and sustaining rice self-sufficiency was a prime motivation to disseminate it for sustainable rice production amidst water scarcity. For the P-38 ISC, the motivation of spending less in fuel cost for pump irrigation and attaining higher income was a key driver to validate the AWD in their respective farms. Thus, at the beginning of this partnership and within the background of the TTWS implementation, a memorandum of agreement with outlined responsibilities of partners was in place. This was the framework within which the partners patterned their respective courses of action and their expectations of one another. This way, overlaps and gaps in functions were identified and properly addressed.

The existing social relations, developed through past collaborative engagements between and among the members of the AWD MSP, had facilitated the MSP process resulting in wide-scale dissemination of the AWD technology. IRRI and IRRC through ICOP, had a network of national research and extension institutions such as PhilRice and NIA. NIA, on the other hand, had been working with farmer officers and members of IAs and ISCs in the whole country. At the same time, NIA and PhilRice had been working together for the rice self-sufficiency program of the country. Altogether, it resulted in an effective facilitation role of IRRI and IRRC in the MSP process and in the implementation of the project.

The partnership with farmers, as brought about by the participatory experiment approach of the TTWS, engaged end-users in the development and validation of the technology. This allowed partners to learn about the necessary conditions in which groups of users, such as in an irrigators' service area, should organize themselves to enable better access to scarce water resources. The dynamic negotiations between farmers who use irrigation, and those who access pumped water for domestic use, show a balance wherein collective understanding, norms, and rules supported the change in practice of farmers. The frequent interaction of partners including farmers and the farmer group has generated more trust among themselves in the MSP.

There were challenges though in the implementation of AWD at the P-38 system level. For the rice farmers, water is life because rice production is their common source of livelihood and source of food security. At the initial AWD implementation, there was tension because farmers were apprehensive of seeing dry rice fields with cracked soil. This resulted in stealing of water by some farmers, who punched holes underneath their paddy dikes next to the paddies with irrigation, hidden from other farmers' eyes. Conflicts were resolved through the mediation of village officials, particularly the village security officers. The trust and confidence of farmers, and the experiential learning of partners individually and collectively, were built-up within and among partners in the MSP through the project implementation process.

The policy outcome of AO 25, which facilitated the speedy dissemination process of AWD, illustrated that choosing the right representative from each partner group was also necessary in strategic partnership [12,44]. If the chosen representatives are in decision-making positions within their agencies, necessary authority in policy changes, for example, can be easily obtained. In this AWD MSP, the representatives were those in power and position to influence the higher authority to modify processes or negotiate policy changes [43]. Also, the chosen participant farmers and leaders of the cooperative were actually instrumental in making the necessary policy changes in the P-38 ISC, which enforced the implementation of AWD in the P-38 deep-well system.

Strengthening of linkages has been an area for learning in partnerships. A strong linkage will foster more linkages because of continuous assessment of gaps within the linkage [45]. This means constant communication between partners and consistent involvement of all partners through all the activities. Between 2009 and 2011 alone, there were 22 activities on AWD conducted for partners. These linkage activities were mostly trainings, but they also included some workshops and meetings for furthering the activities of the alliance thereby increasing trust and confidence for each partner member in the AWD MSP.

The strengthening of linkages in the MSP has improved the learning and extension capabilities among partners [45]. The research capacity of both NIA and PhilRice was enhanced through the project, resulting in two major publications and presentations in national and international conferences. PhilRice has continued to do research on efficient irrigation management by its own, even after the TTWS, such as the transformation of AWD into controlled irrigation or CI. The agency has disseminated the technology in different areas of the country considering respective agro-ecological conditions. NIA also disseminated the technology in other deep-well and gravity irrigation systems, making AWD its banner program nationwide. It has generated its own innovations in local implementations and within its own networks such as the BSWM. Consequently, the social learning among research and extension partners of the AWD MSP and member networks happened.

Strengthening of linkages also means continuous assessment of aspects in the partnership that need to be addressed. While there is no single formula in making sustainable linkages, FAO research pointed out the need for careful analysis of constraints and opportunities that are present in the specific situation of each partner [46].

In the case of AWD in Tarlac, Philippines, water is pumped from the ground; the pump itself is a common property resource managed by an association of irrigators. The farmers follow a specific schedule that they have been using for years. The pattern for water use is governed by rules set around the common property resource. With the introduction of a water-saving technology through the partnership, these farmers had to reassess the best use of the common property. As farmers changed their actions when they adopted AWD, they slowly made changes in the use of the pump, which resulted in a revised schedule for all other users, and consequently the adoption of the AWD pattern of irrigation for the rest of the farmers in the group. As the partner agencies found positive effects based on farmer feedback, they were able to create innovative ways of engaging with other farmer groups in the country across types of irrigation systems, effectively disseminating the technology to more farmers.

Another important point is the role of learning among partners in the MSP in the effective scaling out of AWD. A common extension tool is the transfer of technology approach, which is in the title of the initial project, TTWS. However, the partnership actually used a participatory approach in introducing AWD. From this approach the partners obtained more than just the linear benefit of getting new knowledge. For one, IRRI and PhilRice as research institutions were able to learn from the experience of farmers, enough to validate the technology. The NIA found that the AWD technology was viable for use in irrigation systems for more efficient and equitable use of water. The farmers learned about a technology that could minimize their water use, which could in turn translate into lower fuel expenditure. The partners were getting benefits for their own use while they were also contributing to one another; eventually they were able to bring it out to a larger number of farmers through the synergy of their respective networks.

The participatory approach stands on the systems paradigm where innovation (technical and institutional) comes from multiple sources, including farmers [47]. In addition, the agricultural knowledge and information system in extension literature involves all stakeholders as information sources in the goal of creating systems that assist in the generation and dissemination of knowledge [48]. The systems paradigm emphasizes the importance of learning as a means of evolving new arrangements that are suited to local contexts. Hence, partnership between different agencies and actors is required. Innovation is not research-driven but it is a process of generating, accessing, and putting knowledge into use, making the interactions of different people, the ideas that they have, and the social setting of these interactions an important part of extension [49,50]. In the innovation system, this strengthening of linkages, partnerships, or strategies of inclusion, are actually illustrations of the building-up and enrichment of social capital [19,50-52].

Lastly, because of this paradigm, the assessment of performance does not stop at adoption of technologies, which is a common pitfall in extension efforts [49]. The measure of effectiveness of the partnership is in the impacts that are experienced by the farmers and farming communities such as economic impacts at the farm level and sociocultural impacts. Thus, the social capital built up and enhanced in the MSP has generated: (a) natural capital through more food availability to farmers and community with the increase in yield, though this is not consistent across type of irrigation system; (b) financial capital through reduction in the amount of fuel use and time spent in irrigation which opens up opportunity cost for other sources of income, and possible increase in net returns from rice farming; (c) cultural capital through increase in knowledge about AWD from experiential learning resulting in farmer adaptation; (d) physical capital in the form of local materials developed as tools for need-based irrigation. To this end, the contribution of the adoption of AWD to addressing food security has to be anchored on the impacts at a broader level, although much of the work is in coordination and negotiation among various actors in an innovation system.

4. Conclusion

The adoption of AWD by farmers within the irrigation system in the Philippines was facilitated by the partnership and the policy changes at different levels. It started with the establishment and fostering of a multi-stakeholder partnership, followed by securing the commitment and engagement of various key stakeholders. The involvement of all partners in experimentation and better interactions, instead of a top-down passing of knowledge, facilitated experiential learning, reflection, and further actions. With experiential learning and interaction, there was more opportunity for different organizations to learn from one another. For example, BSWM could implement similar strategies as NIA.

For the partnership to happen, mutual benefits should first be established. The partners must first see the need to be in this partnership and appreciate the effect that the partnership will have on them later on. As they work closely together, partners build trust through which they collectively work toward a common goal. It is then important to see how each partner plays a role in the partnership, then later on identify new partners who could be part of the alliance.

Once the partners are empowered with knowledge that they actively produced and skills to implement activities for dissemination, they can work outside the partnership and bring these to their other networks so that wider dissemination occurs. This way, the spread of technologies and obtaining policy support are achieved as in the case of AWD. This has led to various impacts such as more equitable distribution of irrigation water, or expanding access to cover not only farmers but also household water users. At the same time, the adoption of AWD by farmers has not reduced their yields. Thus, it has implications on food security through addressing issues around water, while sustaining food production.

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Conflict of interest

The authors declare no conflict of interest in publishing this paper.

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