Technical Bulletin
2013 No. 17

Alternate wetting and drying in Philippine rice production: feasibility study for a Clean Development Mechanism

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IRRI

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The work described here was undertaken as part of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS; www.ccafs.cgiar.org), which is a strategic partnership of CGIAR and Future Earth. The views expressed in this document cannot be taken to reflect the official opinions of CGIAR or Future Earth.

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Suggested citation:
Siopongco JDLC, Wassmann R, Sander BO. 2013. Alternate wetting and drying in Philippine rice production: feasibility study for a clean development mechanism. IRRI Technical Bulletin No. 17. Los Baños (Philippines): International Rice Research Institute. 14 p.

ISSN 0074-7807

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Acronyms and abbreviations

AMRIS	Angat Maasim River Irrigation System
AO	administrative order
BIIS	Bohol Integrated Irrigation System
BLM	baseline methodology (BLM)
CCAFS	Climate Change, Agriculture and Food Security
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CF	continuous flooding
COP	Conference of the Parties of the UNFCCC
DA	Department of Agriculture (Philippines)
DNA	Designated National Authority
DOE	Designated Operating Entity
ENSO	El Niño/Southern Oscillation
FUSA	firmed-up service area
GHG	greenhouse gases
IA	irrigators' association
INWEPF	International Network for Water and Ecosystem in Paddy Fields
IPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institute
JICA	Japan International Cooperation Agency
KP	Kyoto Protocol
MRV	monitoring, reporting, verification
NIA	National Irrigation Authority
NIS	National Irrigation System
NPC or Napocor	National Power Corporation
PhilRice	Philippine Rice Research Institute
SD	sustainable development
TSA	turnout service area
UNFCCC	United Nations Framework Convention on Climate Change
UPRIIS	Upper Pampanga River Integrated Irrigation System

Summary

Water-saving technologies such as alternate wetting and drying (AWD) provide a way to change practices to improve the livelihoods of many rice farmers and AWD is regarded as one of the more important rice cultivation methods that can dramatically save freshwater irrigation in this century. AWD not only conserves water but also mitigates greenhouse gas emissions. The global climate influence of gases, particularly methane, and resulting reduction in methane emissions by adjusted water management practice through AWD may provide the means for rice to adapt to water scarcity and at the same time mitigate greenhouse gas emissions. With these associated benefits, AWD technology could be harnessed for a Clean Development Mechanism (CDM). This paper will discuss the merits of AWD and explore the possibility of being a CDM for areas affected by water shortage in the Angat dam and reservoir.

This document has three parts:

- A literature review of AWD and CDM
- An in-depth assessment of possible AWD dissemination in Angat reservoir
- Appendices comprising documents that will be needed in the process of application and registration of an envisaged CDM project in Angat reservoir

Introduction

Agriculture in developing countries must undergo a significant transformation in order to meet the related challenges of food security and climate change. Recent and increasing anthropological activities have influenced global weather extremes. Water and greenhouse gases are two prime factors that affect climate that are used indiscriminately and produced abundantly, respectively. The wanton disregard for water conservation through watershed misuse has left this commodity wanting in many agricultural areas and has caused drought-induced decreases in crop yield. On the other hand, greenhouse gases such as methane are being pumped into the atmosphere at increasing rates in industrialized countries but may be offset through rice cultivation technology for reduced emissions in developing countries. The effects of climate change have never been as obvious and intense as in recent years. Global elevated temperatures, increasing greenhouse gases, and erratic weather conditions have countries coming up with various means of mitigating these adverse factors brought about mostly by human activities. The harmful impacts of climate change help explain why sustainable development may often be unsuccessful in developing countries (Lasco et al 2007). Because of limited resources, the Philippines, like other developing countries, is among the hardest hit in Southeast Asia in terms of climate change and sustainability development.

Water scarcity is a crucial confounding factor limiting agricultural productivity. In rice, for example, water needed for irrigated areas is fast dwindling. Reservoirs, such as Angat dam (14°52′15″N 121°8′30″E), have been experiencing decreasing output for irrigation purposes, especially during the dry seasons. Rice farming in the region serviced by the local National Irrigation Administration (NIA) system, specifically the Angat Maasim River Irrigation System (AMRIS), had on several occasions been disrupted. Especially with El Niño/Southern Oscillation (ENSO) events in this decade, particularly in 2004 and 2010, dry-season rice yields declined markedly.

The effect of a lack of water was so alarming that the Department of Agriculture (DA) issued an administrative order (AO 25) in 2009 on "Guidelines for the adoption of water-saving technologies (WST) in irrigated rice production systems in the Philippines." This was an opportunity for the International Rice Research Institute (IRRI) and its local counterparts in PhilRice (Philippine Rice Research Institute) and NIA to widely disseminate rice cultivation using alternate wetting and drying (AWD) technology. In this practice, the crop is intermittently submerged and dried from 20 days after sowing until 2 weeks before flowering, that is, fields are allowed to drain until water below the surface reaches down to 15 cm before re-flooding. In this controlled drainage setup, the crop is still spared from the debilitating effects of drought. Water savings in AWD compared with conventional flooding could be as much as 25%, thus resulting in a reallocation of saved water to nearby fields or other purposes such as household use.

Although farmers were reportedly practicing alternate wetting and drying in the AMRIS region as early as 2006, this is "forced" AWD, in which re-flooding is not controlled or triggered by a set subsurface water level (AMRIS-JICA 2007). Forced AWD or default AWD is the farmers' practice, as distinguished from the 15-cm subsurface water level threshold for reflooding called "safe AWD" (Lampayan et al 2009).

Aside from water savings, another component of AWD that is beneficial arises from its contribution, or lack of, to greenhouse gases. Among the different rice ecosystems (rainfed, upland, irrigated, deepwater, etc.), the irrigated lowland rice ecosystem is one of the major contributors to methane. Methane (CH_4) is a greenhouse gas that remains in the atmosphere for 9–15 years. Methane is over 20 times more effective in trapping heat in the atmosphere than carbon dioxide (CO_2) over a 100-year period and is emitted from a variety of natural and human-influenced sources).[1] However, through the practice of AWD, methane has been found to decline dramatically. Multiple field aeration by AWD potentially reduced methane emissions by 48% compared with continuous flooding of rice fields.

In this regard, AWD is proposed to be adopted as a Clean Development Mechanism (CDM), which is stipulated in the Kyoto Protocol (KP) of 1998. This would mean careful measurement, reporting, and verification (MRV) on carbon emissions of rice fields during the growing season. Presently, for one rice crop with a growing season of 100 days, the default value translates to 4.5 t CO_2eq ha^{-1}. If we further assume a per ha price of US$5 to $10 per CO_2eq as an example, though this is

[1] www.epa.gov/methane/.

difficult to predict,[2] then the additional return would be \$23 to \$45 ha^{-1}. Thus, such an AWD project can earn salable Certified Emission Reductions (CERs) credits benefiting the proponents and the environment as well.

This paper consists of two parts: the first part is on alternate wetting and drying: the principle and mechanism behind it, its technology transfer to farmers, and its practice by farmers. Part two discusses the CDM on AWD as to how it could be implemented in a local setting, particularly the Angat reservoir, and AWD's effect on greenhouse gas mitigation. This study therefore aims to assess the potential and constraints of AWD for mitigating methane emissions in rice farming of the Philippines and to assist in crop management decisions and review AWD programs in the Philippines, (1) focusing on current partners and areas of active dissemination or involvement, and (2) coming up with priority areas for implementation.

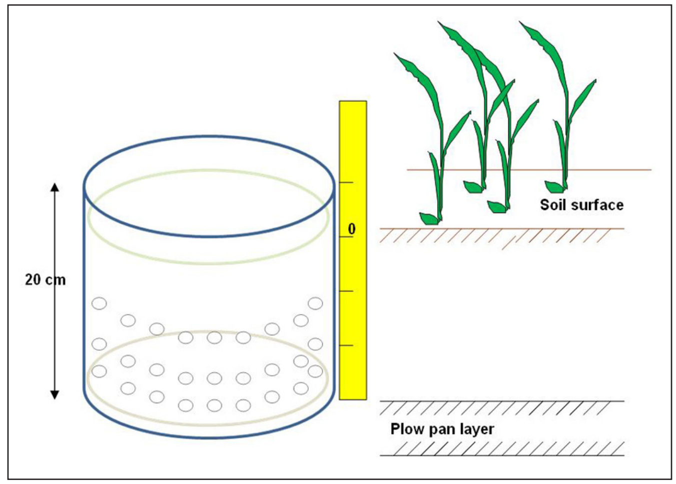

Fig. 1. Observation or perched tube well embedded at 15-cm depth. Illustrations are not drawn to scale.

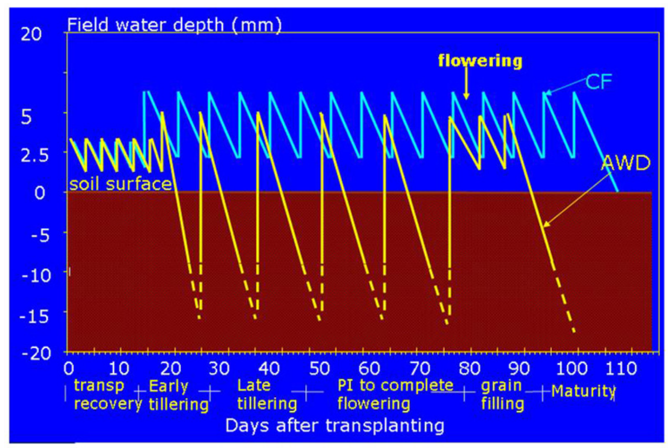

Fig. 2. Water table and ponded water depth measurements for AWD and CF showing periods of flooding and drainage during the various growth stages of rice.

Principles of AWD and CDM

Alternate wetting and drying

Water savings and greenhouse gas emissions. With the advent of the 21st century, IRRI developed a water-saving technology for farmers in irrigated lowlands. The term AWD is also known as controlled irrigation (CI) or intermittent irrigation, distinct from farmers' conventional practice of continuous flooding (CF). The number of days of nonflooded soils can vary from 1 to more than 10. In this technology, the farmers are taught to monitor the depth of the water table in the field using a perforated water tube. The practice, which commences at 1 to 2 weeks after transplanting, involves draining the field until the water level reaches 15 cm below the soil surface (Fig. 1). Immediately, the field is re-flooded to a ponded depth of around 5 cm before re-draining. This irrigation scheme is followed throughout the cropping season except from 1 week before and 1 week after flowering (Fig. 2). The threshold of water at 15 cm below the soil surface is called "safe AWD," as this will not cause any yield decline because the roots of the rice plant will still be able to capture water from the saturated soil (Lampayan et al 2009).

AWD technology can reduce the number of irrigations significantly compared with the farmers' practice, thereby lowering irrigation water consumption by 25% and, in some cases, reducing fuel consumption for pumping water by 30 liters per hectare.

Moreover, AWD technology has been proven to mitigate methane emissions. The greenhouse gas (GHG) methane is produced anaerobically by methanogenic bacteria that thrive well in paddy rice fields. Hence, flooded rice fields are a large source of methane emissions (in fact, the second largest anthropogenic source after ruminant livestock). Because periodic aeration of the soil inhibits methane-producing bacteria, AWD can reduce methane emissions by up to 50% (Sander, pers. comm.).

In fact, this notion has also been reflected in the IPCC methodology (IPCC 2006), which is used for computing GHG emissions in the National Communications submitted by countries to the UNFCCC. In the revised IPCC methodology (IPCC 2006), "multiple aeration," to which AWD corresponds, is presumed to reduce methane emissions by 48% compared with continuous flooding of rice fields (UN FAO 2010). Other studies showed that AWD technology can reduce methane production by about 60% (Uprety et al 2012). The cost of AWD was found to be \$20 per t CO_2eq saved in Haryana, India, whereas, in Ilocos Norte, Philippines, and Zhejiang, China, this cost surpassed \$45 per t CO_2eq saved (Wassmann and Pathak 2007).

However, AWD also influences the emission of nitrous oxide (N_2O), another potent greenhouse gas. In fact, N_2O has a global warming potential (GWP) of 298, which means that it is 298 times more effective in trapping heat in the Earth's atmosphere than CO_2, while CH_4 has a GWP of 21.[3] Nitrous

[2] www.co2prices.eu/.

[3] GWP = 21 according to IPCC 2006 guidelines used for CDM projects, but GWP = 25 according to new IPCC Report 2011.

oxide emissions are generally low in rice production and negligible in continuously flooded systems. According to the IPCC guidelines for National Inventories, 0.3 % of the N fertilizer applied to flooded rice fields is emitted in the form of N_2O. The corresponding emission factor for nonflooded cropland is 1%.

Under water-saving strategies, N_2O emissions tend to increase because of increased nitrification and denitrification activities, with soil conditions constantly changing between anaerobic and aerobic, and related changes in redox potential. However, data on N_2O emissions under different water management regimes are limited to a few field studies that vary dramatically (Sander et al 2013). In view of this uncertainty, the approved UNFCCC methodology requires that N_2O emissions either be measured or that N fertilizer be dosed based on actual N requirements. The latter can be accomplished with site-specific nutrient management that increases N-use efficiency and avoids a buildup of excessive N pools in the soil. Alternate wetting and drying therefore generates multiple benefits related to reducing water use (adaptation where water is scarce), reducing methane emissions (mitigation), increasing productivity, and increasing food security (Bouman et al 2007).

Adoption. Dissemination of AWD to farmers in the Philippines as well as in Asian countries such as Vietnam, Indonesia, Bangladesh, and China proved the benefits of this technology. Although the response may vary from that of those who practiced AWD in the Philippines, for example, in Canarem, Tarlac, the majority of the farmer-cooperators gave positive feedback about the effectiveness of AWD as a water-saving technology as follows: (1) no yield difference from the farmers' practice of continuous flooding;. (2) saves water; (3) saves time and labor and thus is less expensive; (4) heavier and bigger grains, and good shape; (5) more tillers; and (6) fewer insect pests and diseases (Palis et al 2004).

A recent visit to one of the adopters of AWD had no observed yield penalty although the varieties changed as PhilRice released new and improved lines over the years. The use of tube wells has been dispensed with, too, with a comparable visual observation of water in soil cracks or levee canals.

Another example of AWD practiced in the Philippines was on Bohol Island, which is one of the biggest rice-growing areas in the Philippines' Visayas region. In the face of declining rice production, because of insufficient water and unequal water distribution, the NIA-Bohol Integrated Irrigation System (BIIS) planned (1) the construction of a new dam (Bayongan Dam) and (2) the implementation of AWD. The adoption of AWD facilitated an optimum use of irrigation water, so that cropping intensity increased from approximately 119% to about 160% (related to the maximum of 200% in these double-cropping systems; UN FAO 2010).

With the development and improvement of irrigation canals by NIA as part of its nationwide medium-term plan, the use of pumps could soon become obsolete in many locations. This could have drastic consequences for AWD; thus, policies from the local government units on water savings must bolster the practice of AWD. Also the adoption of meter-based (volumetric consumption-based) water rates instead of fixed area-based rates currently employed by most NIA-serviced areas would be a welcome motivation.

Among irrigated farmers, those under a volumetric water-pricing system (as opposed to an area-based flat-rate system) contribute slightly more to public good. Thus, volumetric pricing of irrigation water should induce an incentive for better collective action toward saving water resources than does area-based pricing, in which the marginal cost of using water is zero (Tsusaka et al 2012).

The Bohol AWD experience. Malinao Dam or Bohol Irrigation Phase 1 was built in 1995 through a loan fund from Japan's Official Development Assistance (ODA), amounting to Php 1.4 billion. During the construction phase, 1,363 farmer-landowners entered into a loan agreement with their parcels of land as collateral for the loan, to be able to convert their agricultural land into rice paddies. The irrigation staff of the NIA as a policy campaigned for land leveling and promised that the dam project would "uplift the economic status of the farmer-beneficiaries."[4] The dam project started its operation in 1998 with a target to irrigate 4,960 hectares. Since 2005, after seven years of operation, complaints from the beneficiaries have surfaced that the dam performance is inadequate. The farm areas serviced by the Malinao Dam were beset with the following problems: (1) declining water supply, (2) inefficient water use, (3) asynchronous farming activities, (4) poorly managed irrigation facilities, (5) conflict among farmers, and (6) a decline in rice production in the province.

The construction of a new dam, Bayongan Dam, funded by a loan from the Japan Bank for International Cooperation, coupled with the implementation of AWD facilitated an optimum use of irrigation water, thereby increasing cropping intensity from one crop to a double-cropping system (Bouman et al 2007).

In 2006, the NIA introduced an irrigation schedule for the BIIS enforcing AWD. The schedule has evolved over the years to become viable and effective for as many farmers as possible. Now, the rotation of water is divided between upstream and downstream. Downstream farmers receive water first so they can plant ahead by about a month. This was regarded as an excellent water-saving strategy because downstream IAs had a more reliable water supply, meaning that a larger area was cultivated. Both downstream and upstream farmers are on an every-other-week schedule, which effectively enforces AWD because each farmer has irrigation water for 3 days, then none for the next 10–12 days. In order to receive water at all, each IA must collect 60% of the irrigation service fees (ISF). Although AWD demonstration fields have been established in Bohol, and NIA has led information campaigns and farmers' field days, not all farmers have participated and thus some still have no awareness of AWD (Shapiro 2011). Overall, this was a prime example of sustainable AWD adoption through fine tuning.

Long-term implementation. Current estimates show widespread adoption of AWD. Lampayan (2013) estimated a total

[4] www.takagifund.org/e/archives/08/83005_WDC.html#03.

area of 100,000 ha under AWD in the Philippines. However, some farmers revert to continuous flooding, especially those who obtain irrigation water through gravity rather than a pump. One of the reasons given is the lack of "encouragement," in the form of incentives or policies. Farmers, especially those from the Upper Pampanga River Integrated Irrigation System (UPRIIS)-serviced areas, who save water from AWD have more than enough water to use—there is no shortage of water to begin with.

Deep-well pumps have also proven to be costly in the long run for early adopters of AWD. Pumps used to run this system cost a lot to maintain and they use too much fuel (despite savings through AWD), especially for small farmer groups that split the cost among a few participants. Hence, farmers tend to use shallow tube-well pumps if this is a feasible option for AWD.

Thus, AMRIS-serviced areas have greater potential of AWD being widely adopted because of (1) water scarcity during the dry season (having no guarantee of obtaining enough water to maintain a continuously flooded crop) and (2) AWD (i.e., "safe AWD") represents a genuinely new idea for these farmers, as it hasn't been tested in this area before.

Potential and constraints. In the perception of farmers, AWD meant inadequate soil-water during the drying period, thus carrying a risk of drought stress to the crop. However, thoroughly implemented AWD, specifically "safe AWD," dispelled this notion. AWD allows draining up to 15-cm maximum depth of the water table when the roots can still capture the moisture-laden water in the root zone. Flooding of soils over many years triggers the development of a hardpan at 15- to 20-cm depth, which acts as a mechanical barrier for roots and water. Although this sealing may not be complete in terms of percolation losses, penetrable roots are dependent on the perched water above the hardpan. It is difficult to convince farmers that observing no standing water does not automatically imply an absence of soil water. Thus, the perforated tube served a dual purpose of not only measuring the water table but also acting as a visual assurance to farmers that the roots still had access to water at the subsurface.

On the positive side, however, farmers claim that practicing AWD not only saves water but also increases rice yields. This observation may be the exception rather than the rule, though, and it should be followed up to further improve the attractiveness of AWD. Several potential traits have been reported as a means to increase yields under AWD but they need further investigation:

- Lodging-resistant culms
- Profuse tillering
- Less susceptibility to pests and diseases

On the other hand, AWD may reduce grain yield but, in most field studies, yield losses were insignificant. Moreover, economic yield tends to be higher in AWD, that is, the cost of irrigation decreases, especially for pump users. The visible successes of AWD on demonstration farms, as well as specific training programs for farmers, were able to dispel the widely held perception of possible yield losses from nonflooded rice fields (UN FAO 2010).

Moreover, AWD significantly decreases methane emissions. Because public discussion on climate change generally equates mitigation with lower CO_2 emissions, the potential contribution of decreasing CH_4 emissions is often overlooked. Cultivated wetland rice soils emit significant quantities of methane (Smith et al 2008). Methane in many soils can be consumed by methane-oxidizing bacteria (methanotrophs). This microbial process generates CO_2 and thus concludes the carbon cycling that has started with primary production and avoids the formation of the powerful GHG methane. The fact is, from the methane perspective, CO_2 equivalent from methane emissions is considerable, for example, if a 100-d rice crop discharges 1,800 kg of CH_4, the equivalent CO_2 is 4.5 tons CO_2 eq ha^{-1}.

Lessons learned. Consolidating various lessons learned from different authors (Palis et al 2004, Sibayan et al 2010) as well as our own perceptions yields the following:

- Increased funding for AWD outscaling. Despite the concerted efforts of various agencies and institutes in promoting AWD, funds are lacking for proper technology transfer logistics and implementation. There is a need for local government funds, national government funds, the private sector, and international donors to contribute to this project.
- Co-ownership. The technology and responsibility may not be shared among the stakeholders, perhaps because of misunderstanding and information gaps. The fear of disastrous consequences of improper implementation may distract and discourage stakeholders from further adopting the system. AWD needs to get buy-in not just from farmers but more importantly from irrigation system administrators and managers to implement the technology.
- Feasibility pending on irrigation settings. When farmers have incentive, AWD can be quickly promoted. AWD is more likely to be adopted in pump systems in which the farmers pay for diesel or electricity as opposed to gravity irrigation systems. However, this incentive for AWD adoption is eradicated in places where they use highly subsidized electricity.
- Need for champions. Widespread adoption will depend on the existence of local "champions." The immediate contact and visible example of one of their peers are by far the most promising approach to convince fellow farmers. By the same token, the champions approach can also be applied at other scales, namely, for irrigation agencies, local government units, etc. On the other hand, this may also entail problems because of high reliance on individuals once the champions are no longer supportive or in other functions.
- Thriving for good agricultural practice. Involvement of partners in AWD adoption enhances their capacity, that is knowledge, skills, and resources. AWD represents one component of best management practices for natural resource management such as AWD. It facilitates reaching more farmers more quickly; from a deep-well system to a national irrigation system.
- Overcoming reluctance. Farmers' attitude resulting in resistance to change. Farmers are reluctant to change any of their "practices," but, once they are convinced about benefits, they can be very good agents for promoting a technology that they adopted. Thus, the support and cooperation of farmers and the linkage between NIA officials and farmers

through the IA are especially important in the initial stage as a means to foster farmers' adoption and capitalizing on the multiplier effect derived from early adopters.

- Compensation for eventual losses. Farmers are of course more inclined to adopt a new technology as long as they will be compensated for whatever losses they incur. This is especially relevant in cases of irrigation water coming from a larger irrigation scheme (and not through pumping), which is out of the farmers' control. Thus, the engagement of both parties, namely, water suppliers and users, is important in order to bring the technology to the individual farmers' level and later scale it out with needed support from NIA management.
- Information flow. The adoption and practice of AWD paved the way for an intensified information exchange and eventually close working relationship among different water users at the lateral level as well as among water users and irrigation agencies.
- Vested interests. Implementation programs will have to take into account specific interest groups within a given irrigation service area. Although farmers at the top end of the irrigation scheme may not have direct benefits form AWD, the situation is very different for farmers at the tail end. For this group of farmers, AWD reduces farming costs stemming from lower pumping needs and, in turn, improves their prospects for sustained income, which will also translate into easier access to loans. These regionally diverging interests are a challenge for any technology program, but could also be seen as a strategic asset by highlighting the group-specific benefits:
  - (i) mobilizing this group with a vested interest in AWD to express its opinion in relevant fora such as barangay meetings,
  - (ii) forging alliances with local politicians concerned about votes,
  - (iii) stressing links to poverty alleviation programs (e.g., Conditional Cash Transfer programs) as tail-end farmers will almost certainly have deficient incomes, and
  - (iv) aiming to make the broader public (including farmers from the upper areas) aware of the plight of tail-end farmers.

Clean Development Mechanism

Definition and criteria. The CDM is one of the flexibility mechanisms introduced by the Kyoto Protocol (KP) in 1997. This is a project-based mechanism of emissions trading and is the only mechanism involving non-Annex 1 parties (developing countries) that does not have any stipulated obligation to reduce GHG emissions. The idea behind the cooperative mechanism is that 1 ton less GHG emissions will slow climate change—irrespective of the location of the savings. Economic principles would suggest that developing countries are generally beset by inefficient use of energy and natural resources and thus offer many win-win options for climate and sustainable development. Annex 1 (industrialized) countries can take advantage of mitigation through a CDM project implemented in a developing country by purchasing CERs to meet their targets or emission caps (Fig. 3). This mechanism adds more choices and flexibility to comply with the targets and offers economically sound solutions. The non-Annex 1 countries in turn receive capital for investments in projects and clean technologies to reduce their emissions and enhance socioeconomic well-being.

Thus, the CDM has two key goals: (1) to promote sustainable development (SD) objectives in the host country (i.e., non-Annex 1 countries) and (2) to help Annex 1 parties to meet their GHG reduction targets. A CDM project activity in a non-Annex 1 country produces CERs that can be used toward partial compliance with its emission reduction targets.

However, the eligibility of projects reducing *in situ* emissions from land use such as methane emissions from rice remains complex (Wassmann 2010). Nevertheless, with the positive feedback and continued improvements and revisions to the methodology on GHG measurements in rice, the current proposal looks promising.[5]

According to Section 12.5 of the KP, a CDM project has to satisfy the following criteria: (1) the parties involved in the project activity take part voluntarily and both approve the project; (2) the project must produce real, measurable, and long-term benefits for the mitigation of climate change; and (3) the emission reductions should be additional to any that would occur without the project activity (commonly known as the "additionality" criterion).

Moreover, article 12.2 of the KP states that the purpose of the CDM is to assist non-Annex 1 parties in achieving SD. This is interpreted to suggest that the project activities should be compatible with the SD requirements of the host country.

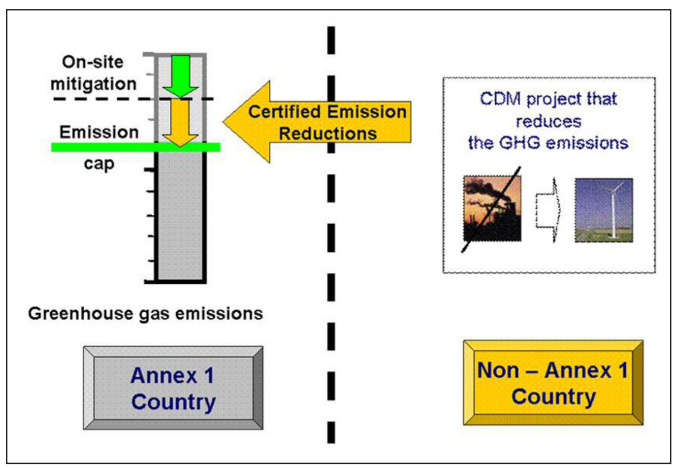

Fig. 3. Flow chart showing how non-Annex 1 countries, by reducing GHG emission through the CDM project, earn carbon credits to compensate for excess GHG emission of Annex 1 countries.

[5] http://cdm.unfccc.int/methodologies/DB/D6MRRHNNU5RUHJXWKHN87IUXW5F5N0

However, neither the KP nor the subsequent Conference of Parties (COPs) have provided guidance on defining sustainability, leaving the decision to host countries. COP 7 in Marrakech in 2001 stipulated that all participating countries have to establish a "Designated National Authority" (DNA) to assess whether any CDM proposal complies with their own sustainability criteria (Bhattacharyya 2011).

The Bohol case is an example of water savings coming from new technologies that increase the income of poor farmers while decreasing GHG emissions. Yet, it is not eligible for a CDM because of missing additionality, that is, AWD was introduced for the purpose of saving water and not as a means of mitigation.

CDM pipeline and monitoring, reporting, and verification guidelines. The procedure for getting approval of a CDM project and—finally—for obtaining carbon credits in the form of CERs is very long and in many cases cumbersome (Fig. 4). In the initial step, a potential project developer has to submit a proposal to the DNA, which is in most countries an office within the Ministry of Environment (called Department of Natural Resources, or DENR, in the Philippines). Apart from project specifics (such as location, site, etc.), the proposal also has to specify an approved CDM baseline methodology (BLM) to be used for computing CERs. In the case of AWD, there was no approved BLM up to 2011, so it was technically impossible to apply for any CDM project using AWD before that. In the meantime, however, the CDM Executive Board has approved the small-scale methodology "AMS-III.AU" (Methane emission reduction by adjusted water management practice in rice cultivation).[6] In Version 3.0, this methodology allows using default values for assessing mitigation effects by shifting from continuous flooding to intermittent flooding: "For regions/countries where double cropping is practiced, the default values are as follows":

- 1.5 kg CH_4/ha/day for the shift to intermittent flooding (single aeration).
- 1.8 kg CH_4/ha/day for the shift to intermittent flooding (multiple aeration).

With this BLM in place, potential project developers can submit a proposal to the Designated National Authority of the respective non-Annex 1 country. If the DNA has no objections, the project developer can elaborate a project design document that has to include a detailed MRV plan. The consistency of all measures described in this document will be assessed by an independent Designated Operating Entity (DOE). The findings of the DOE are submitted (in form of a validation report) to the DNAs of both the non-Annex 1 country (i.e., host country where the CDM will be implemented) and the Annex 1 country (i.e., country where the prospective buyer of CERs is based). The project registration by the CDM board completes the project design phase, followed by project implementation and monitoring. This phase involves another DOE that has to be different from the first DOE involved in the design phase (Fig. 5). This second DOE receives a monitoring report from the project developer and submits a verification report to the CDM board. As long as these reports comply with the CDM standards, the board will issue CERs that can be used by an Annex 1 Buyer once the agreed-upon payment has been made to the project developer.

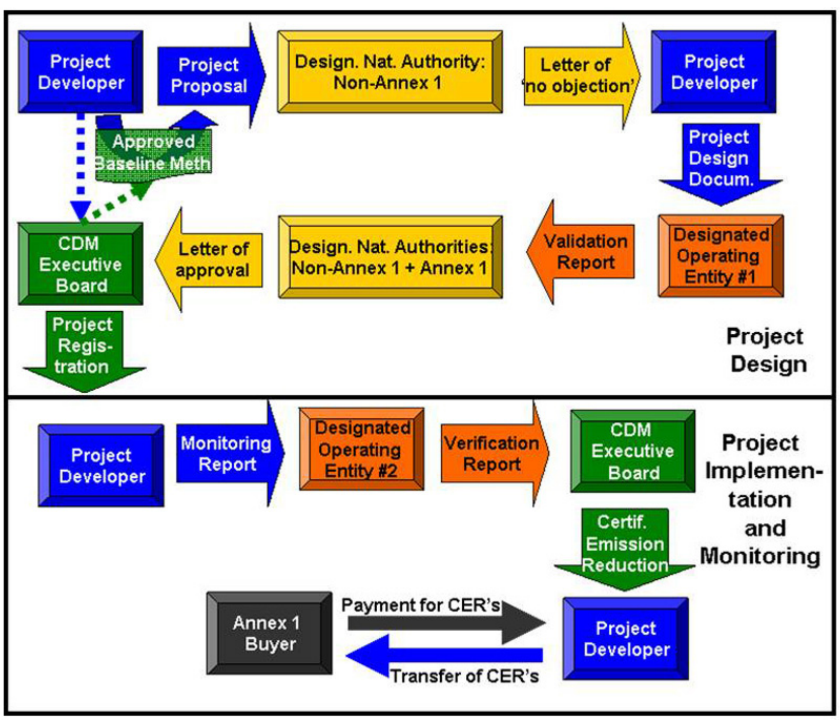

Fig. 4. Schematic presentation of CDM pipeline

[6] http://cdm.unfccc.int/methodologies/DB/D6MRRHNNU5RUHJXWKHN871UXW5F5N0.

Generating accurate, consistent, and internationally comparable data on greenhouse gas emissions of any given CDM project is vital to monitoring progress in reducing emissions as well as ensuring that the funds are used efficiently in terms of mitigation targets. Given the diversity of CDM projects in different sectors, no universal stipulations exist on MRV for the CDM projects. MRV guidelines have to be specified in the "baseline ,methodology," which has to be approved by the UNFCCC before any are implemented. From these MRV principles, three requirements for the specific MRV procedures in AWD projects can be derived:

Monitoring—Infrastructure or materials must be set up to facilitate the faithful practice of AWD in farmers' fields (gravity irrigation, pump irrigation, or diversion). This may require on-the-ground partner-personnel (TSAs, NIA staff, farmer-cooperators). However, there may be a need to hire on-site or local people for logistics purposes, that is, for prompt and up-to-date data collection. These people may handle the recording of daily measurements, such as water table depths.

Reporting—Faithful transcription of raw data onto spreadsheets and transmission of the same in the least possible time are critical. There is a need to present data in a consistent format and have wide coverage to ensure that they are sufficient and correct.

Verification—From the reports, a formal review is needed. This may be likened to an audit of the report furnished. International reporting rules require that accurate inventories be prepared in accordance with the principles of transparency, completeness, consistency, and comparability and that proper quality control and quality assurance procedures be implemented and documented to facilitate third-party review.

Documents to support the MRV are included in Appendices 1, 2, and 3. In brief, these documents contain (1) the rationale and justification for AWD as a CDM, (2) methodology for field establishment of AWD, and (3) a log book and data sheet for AWD field research and accompanying measurements.

Lessons learned from CDM in agriculture. The Clean Development Mechanism has proven to be effective on biogas and rice husk projects. A CDM works well in these areas because (1) there is a steady supply of materials and (2) there is clear ownership of these materials. To elucidate further, in a milling scnenario, rice millers that have a vested interest in husks would get them free from farmers who view the husks as waste material that they can do without. In turn, the miller transforms these husks into biochar to earn CER.

Biochar is charcoal created by pyrolysis (burning with minimal oxygen) of biomass (e.g., agricultural and forest wastes) and it is the most effective way to remove CO_2 from the atmosphere. Biochar is an almost pure carbon; at least 50% of the CO_2 a plant or tree absorbed from the atmosphere during its lifetime is trapped through the charring process. For every 1 kilogram of pure carbon produced, 3.67 kg of carbon dioxide are taken out from the atmosphere.

In some cases, two CERs can be attained for biochar production: the first batch would be for burning and the second would be for power or electricity. In contrast, for AWD, the methane emission reduction is solely for an avoidance mechanism.

Although current reports indicate that, in the Philippines, about half of the CDM projects are on methane avoidance, which are mostly on manure, but none are on rice-based GHG emission reduction.[7]

Recommendations and target areas of AWD. As with any groundbreaking technology, AWD has not been spared from skepticism. Rice, a hydrophyllic plant, has always been thought to grow efficiently in flooded conditions and that drought stress during its growing period would mean yield loss.

Despite this, a decade of research on AWD and its dissemination has produced countless opportunities for fine-tuning the safe AWD technology, for example, going from 20-cm to a shallower 15-cm subsurface water threshold for re-flooding to avoid adverse effects of drought stress.

On inception, AWD was promoted as a water-saving tool in the face of the water crisis. Recently, however, reductions in GHG emissions from AWD are receiving more attention.

One of the primary goals of this project is to choose an area with heightened potential for AWD, such as (1) the presence of irrigation water control and availability of water when needed; (2) partners (institutes, government agencies, and farmer associations) exist who are receptive to the technology; and (3) the dry-season crop in the area selected historically experiences water shortage.

By earning CER credits through CDM, farmers could potentially be encouraged to practice AWD. However, most rice farmers cultivate only a small land area (often less than 1 ha), so that the possible gains through CDM will inherently be small for an individual farmer. Moreover, such a direct money transfer to farmers would entail high transaction costs given the relatively small amount of CERs per farmer, so that the viability of this CDM model for AWD is questionable. The situation might be better for higher irrigation units, such as irrigators' associations and irrigation offices that could aggregate sufficient rice land to compensate for such costs. It should be noted in this context that the CDM Executive Board has recently approved a provision for "bundled" CDM projects. "Bundle" is defined as "bringing together of several small-scale CDM project activities, to form a single CDM project activity or portfolio without the loss of the distinctive characteristics of each project activity." In the case of AWD technology, several irrigation schemes could be combined as "subbundles" within one project.

This CDM model based on higher irrigation units would be especially fitting in a situation where the current irrigation infrastructure is insufficient for a controlled supply of irrigation water—one of the prerequisites for AWD. Improvement of the infrastructure will require investment, but funds generated from

[7] www.cdmpipeline.org/.

the CDM project could amortize this investment within a relatively short time. This model is similar to commonly practiced CDM projects with biogas technology, that is, the construction of a biogas plant in expectation of steady revenue from CERs, and this avoids any conflict with the "additionality" criteria stipulated for CDM projects.

Although farmers are not the direct recepients of funds, they still benefit in terms of better access to irrigation water. In a broader perspective, the CDM will be used for rural development—something that fits squarely to the original intention of this mechanism. This incentive may be seen as an avenue to change the attitude of farmers, who, in a communal irrigation area, especially one close to the source of irrigation or in the upstream that inherently has the advantage of plentiful water, are anxious about the consequence of re-appropriating the water saved from AWD. These farmers may be the the hardest to convince to practice AWD because of the "what's in it for me" attitude. Reallocating saved water to downstream areas may be farthest from their minds (Sibayan et al 2010)

Up to now. AWD has widely been seen as an adaptation to water scarcity and has been widely studied in terms of water savings for nearly a decade. The recognition of GHG mitigation as a trade-off may provide an additional stimulus for a wider promotion of AWD. it is imperative that target stakeholders be equipped with the knowledge and accompanying awareness of the importance of practicing AWD as prescribed by research institutes such as IRRI and PhilRice.

Case study on AMRIS

The Angat dam (14°52′15″N, 121°8′30″E) reservoir is located on the Angat River in Norzagaray, Bulacan, in Central Luzon (Fig. 5). It is operated by the National Power Corporation (NPC or NAPOCOR). The NFC can cut off irrigation releases when the dam's water level is below 180 cm.

Angat dam became operational in 1968 with the following multipurpose functions: (1) to provide irrigation to about 31,000 ha of paddy and vegetable farms in 20 municipalities in the provinces of Pampanga and Bulacan, (2) to supply the municipal and industrial water requirements of Metro Manila residents, (3) to generate hydroelectric power to feed the Luzon Grid, and (4) to serve as flood control storage to protect areas downstream of the dam site (Pascua 2007).

From Angat dam, the water traverses a fixed-type river weir without gates, the Angat Afterbay Regulator Dam (AARD), also known as Bustos Dam (14°57′25″N, 120°57′15″E), which is a 79-meter rubber dam serving nearby cities.[8]

This afterbay dam, under control of the Angat Maasim River Irrigation System (AMRIS), discharges water into two zones: North and South (Fig. 5).

AMRIS covers 26,791 ha of paddy and vegetable farms in 20 municipalities in Bulacan and Pampanga provinces in Central Luzon and serves 23,708 farmers. It is a reservoir system using water coming from the Angat reservoir. Wet-season cropping is from June to November and the dry season from November to April. Yield averages 2.5 t/ha^{-1} during the wet season and 5.0 t/ha^{-1} during the dry season, with estimated production of 185,000 t annually. AMRIS is just one of 204 national irrigation agencies managed by the NIA, a government-owned and -controlled corporation mandated to develop and manage water resources for irrigation.

Potential of a CDM project at Angat

The proposal to have the AMRIS-serviced (Angat dam) farms implementing AWD starting in 2013 would be very timely given that the irrigated area, historically, has an irrigation water shortfall (Table 1). This lack of water drastically failed to meet the yearly crop water requirements, especially during the dry season (November to April). In fact, the irrigation surplus (actual water supply less irrigation diversion requirement [IDR]) has been

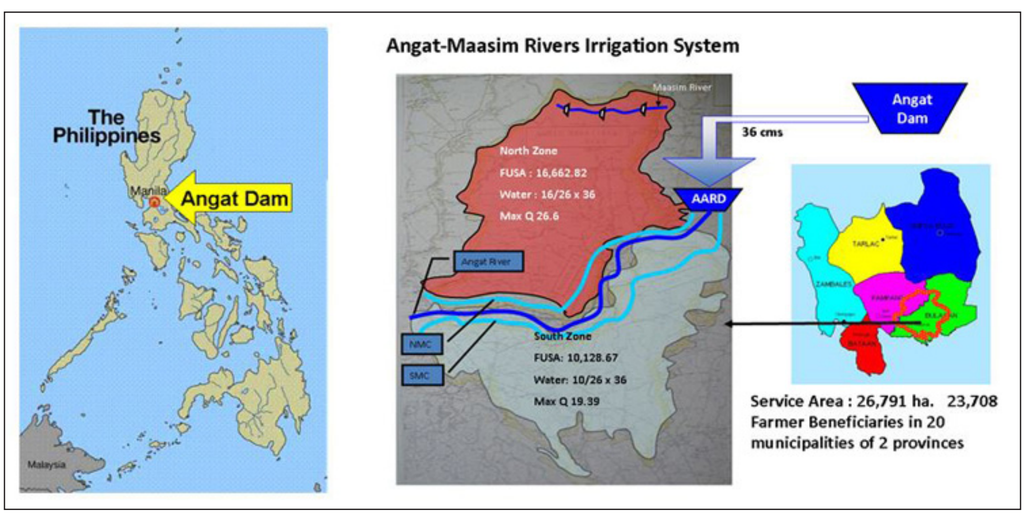

Fig. 5. Water flow of Angat Dam through the AARD to NIA-serviced irrigation zones (North and South). AMRIS, 2012. Note: firmed up service area (FUSA).

[8] http://en.wikipedia.org/wiki/Angat_Dam.

Table. 1. Angat Dam monthly irrigation surplus (m3 s^{-1}) computed as actual supply less irrigation diversion requirement from 2001 to 2011. AMRIS, 2012.[a]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2001	3.8	1.5	6.1	11.5	11.4	−12.8	−11.5	−10.4	7.2	−0.2	1.1	2.0	0.8
2002	0.5	−5.1	1.7	11.3	1.4	−19.9	−16.9	−11.9	−8.7	3.8	2.7	−0.9	−3.5
2003	-5.2	−6.4	−1.1	3.0	3.1	−22.2	−1.8	−4.3	−2.3	13.5	0.0	4.2	−1.6
2004	−5.3	−12.6	−10.9	−1.0	n.a.	n.a.	n.a.	n.a.	−20.0	−8.5	−12.2	38.4	−9.4
2005	−11.8	−13.3	−2.9	0.8	n.a.	n.a.	−32.1	−14.0	−7.6	−6.0	14.8	42.3	−5.2
2006	19.0	36.2	−6.6	−1.1	24.3	−9.8	−8.7	−6.9	−7.3	0.8	−18.3	−10.8	0.9
2007	−8.0	−9.5	−6.9	9.1	−5.0	−10.2	−11.3	−22.6	−9.3	−8.4	19.4	17.9	−4.6
2008	−3.8	−6.1	3.8	1.8	24.5	5.7	1.6	3.5	6.3	10.2	21.9	0.0	5.8
2009	3.2	0.6	−4.8	2.1	0.6	7.2	−2.6	0.1	8.5	49.7	19.8	−7.6	3.6
2010	−9.7	−10.7	−13.1	−8.5	−5.1	−36.0	−31.3	−32.9	−34.4	−11.5	−38.1	−13.9	−20.4
2011	−12.3	−9.8	−6.7	−4.3	−4.5	−30.1	−6.0	2.5	16.0	55.7	47.1	31.0	6.5
Average	−2.7	−3.2	−3.8	2.3	5.6	−14.2	−12.0	−9.7	−4.7	9.0	5.3	9.3	6.5

[a]Negative values indicate irrigation shortfall. Years 2004 and 2010 are El Niño years. n.a. = no data.

decreasing in the last decade (Fig. 6). Likewise, data showed that agricultural distribution of water follows a downward trend compared with an upward trend of nonagricultural distribution of water from Angat reservoir during a 30-year period (Fig. 7). Needless to say, the sharpest discrepancy (the largest drop for agricultural water) occurred during the ENSO of 1998. Under normal conditions, NPC and NIA-AMRIS maintain that the 60:40 water allocation for "Manila's municipal:AMRIS irrigation" use is followed although there was a case when water was suspended for irrigation in 1998, for example, at the height of ENSO. However, to the irrigators' consternation, the Water Code of the Philippines (1976) guarantees water for household use over irrigation and power generation. To wit, under article 10, the purposes of water use are as follows: domestic, municipal, irrigation, power generation, fisheries, livestock raising, industrial, recreational, and other. In times of scarcity, domestic and municipal use will have more right over all other uses (Raby 1997).

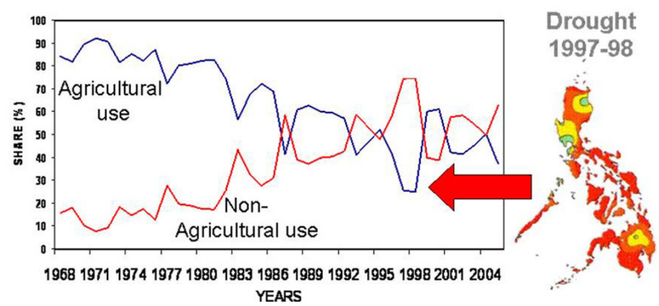

Fig. 7. Agricultural and non-agricultural distribution of water from Angat.

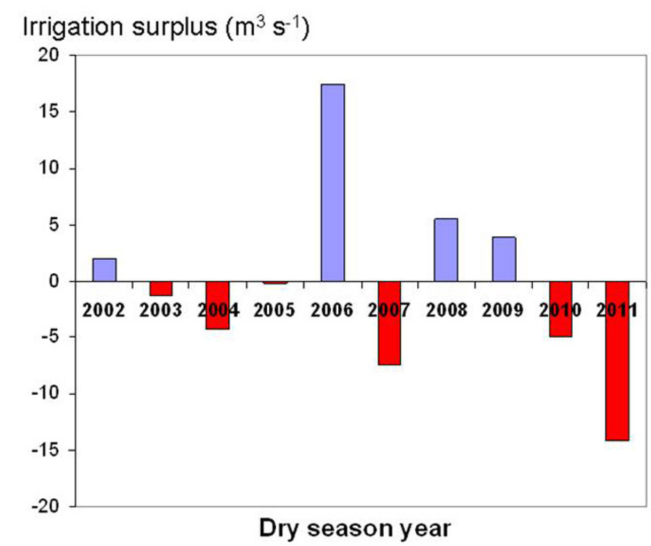

Fig. 6. Irrigation surplus at AMRIS-serviced areas from 2002 to 2011 dry season. AMRIS, 2012.

The expected ENSO in 2013 would make matters worse as NIA expects a 20% reduction in irrigation water supply, that is, more priority will be given to Manila's household use. The scenario would be similar to 1997 and 1998 when an ENSO-influenced water shortage forced farmers in the AMRIS-serviced area to forego dry-season cropping.

The Angat dam water scarcity scenario is not unique. In the news recently, the San Roque dam in Pangasinan is facing a water shortage as well. The San Roque Dam irrigates 12,000 hectares of rice land in 18 eastern and central Pangasinan towns. The province has more than 70,000 ha of irrigated rice land, which is more than half of its total rice production area of 130,000 ha. Because of the impending El Niño, NPC and NIA representatives stated that the dam would stop releasing water for irrigation in April 2013 (http://newsinfo.inquirer.net/319109/farmers-to-get-less-irrigation-water-from-dam).

Thus, the technology of AWD as a water-saving initiative could not come at a better time. The worsening shortage of water for irrigation in dams, particularly Angat, coupled with the worsening greenhouse gas accumulation in the atmosphere put greater emphasis on the adoption of AWD for an efficient use of water and mitigation of greenhouse gas emissions.

Therefore, the objective of this study is to use AWD technology as a CDM project for mitigating methane emissions of AMRIS-serviced rice-farming areas.

Project preparation phase

Groundwork. Appreciation seminars, technology transfer briefs, and meetings involving IRRI, NIA-AMRIS,and PhilRice were held at NIA-AMRIS, San Rafael, Bulacan, during the last quarter of 2012, to inform the irrigators' association (IA) officers, turnout service area (TSA) staff, researchers, and farmers about the merits and protocol for safe AWD in water-scarce areas and AWD's accompanying reduction in GHG emissions. Aside from awareness, one of the more important outputs in these series of meetings was the selection of farmers' fields as demoplots for AWD. A minimum of 150 ha will be used from selected TSAs. These plots must represent, in principle, pump-and gravity-driven irrigation.

As a prerequisite for a CDM, there is a need now to put in place protocols to conduct proper MRV. Monitoring would involve, among other things, strict compliance with accurate perched-water-level measurements before re-flooding. Personnel from AMRIS and/or PhilRice will be actively involved as they will not only regulate water input (into the field) but make sure that water is available when the perched water level of 15 cm below the soil surface is reached. PhilRice, as the agency responsible for improved local rice farming and production, will take the lead in cultural management of the demonstration plots.

*Selection of partners***.** Currently (as of this writing), NIA-AMRIS and PhilRice have shown great interest in AWD being implemented in AMRIS-serviced areas in compliance with the criteria mentioned for CDM accreditation, such as "parties involved in the project activity do so voluntarily and both approve the project" and that, with the adoption of AWD, it is assumed that all measures be taken to ensure "the project must produce real, measurable, and long-term benefits for the mitigation of climate change."

This AMRIS AWD project sets it apart from the BIIS AWD project because the latter has no additionality (i.e., "The emission reductions should be additional to any that would occur without the project activity"). To expound further, AWD is already the "existing" water management (enforced) in BIIS, thus, there is no "additionality." However, this enforcement of AWD must continue because the situation calls for it even with no CDM.

The possible inclusion of the National Power Corporation (NPC) as an involved party arises from the fact that it is the agency that manages the watershed. Currently, all water emanating from the Angat reservoir is under the NPC's jurisdiction.

The CER credits derived from a CDM are an excellent incentive for AWD adoption. It should be emphasized down to the hierarchy of partners, for example, AMRIS-serviced area farmers, that "individually, they may not directly benefit; on the other hand, the region or area as a whole would be the beneficiary."

Required documentation. The proposed project design document in Appendix 1 outlines the important information required for the proposed CDM. However, AWD establishment requires a detailed protocol that is described in Appendix 2. As part of this protocol, two demo sites are chosen as representing gravity and pump irrigation rice environments—each site consisting of adjacent plots with continuous flooding and AWD, respectively. Rice would be cultivated through the usual farmers' practice, that is, fertilization and weed management However, irrigation in designated AWD plots will be monitored using tube wells and water inflow in the fields will be regulated. Drainage will also be monitored and controlled. Basically, the AWD plots will be compared with continuously flooded plots on crop performance and yield. Parameters for sampling and measuring methane gas are described, and data on crop growth and development will be monitored and entered in the fieldbook.

Conclusions

Benefits

Studies showed that the practice of AWD produces no significant yield penalty despite the 15% to 35% reduction in irrigation. Consequently, farming costs decrease not only in terms of water but also fuel and labor. Also, under AWD, there is a faster turnaround time between croppings. This is especially important for rice farmers who more often than not subsist below the poverty line.

As a result of intermittent irrigation and drainage, better soil conditions are achieved during harvest so that mechanization can be considered. Equipment and machinery for harvest can easily enter the field because of the firmer ground resulting from several wetting and drying cycles of the soil.

In the community and as a social concern, the relationship among water users improved, especially within an irrigation unit, because water had become available not only upstream but also downstream. Without AWD, farmers in the tailend may not have enough water for a bountiful harvest.

Challenges

Rice production also demonstrates the potential pitfalls of allocating CERs in the land-use sector. Water-saving techniques can reduce GHG emissions in a given area of rice land, but, in most cases, the water saved will then be used to irrigate more rice land or new crops in future seasons. Subsequently, emission savings are offset by emissions created on newly irrigated land. Ironically, if the water saved were channeled to other users, for example, in residential areas, one could rightfully claim CERs because of a net reduction in global warming potential (Wassmann 2010).

Although AWD has been widely adopted in different areas for a variety of compelling reasons, its sustainability remains a concern wherein the development and improvement of infrastructure and mechanisms that make irrigation convenient and readily available diminish the eagerness of farmers to continuously implement AWD.

The AWD irrigation technique would likely be most beneficial and applicable for rice-producing areas where pump irrigation is used because farmers have incentives to adopt the technology (i.e., reduced marginal fuel costs). For rice farmers using gravity flow irrigation systems, these incentives may be less (i.e., irrigation water is paid for at a flat rate).

The shift from fixed area-based irrigation service fees currently employed by NIA-AMRIS to volumetric consumption-based water rates instead may be a viable mechanism for pricing to be shared fairly among farmers. This would be an incentive for farmers on gravity-irrigated farms.

Extension programs that provide general irrigation information and specific information regarding AWD can encourage further adoption of this irrigation technique. Benefits from water conservation as well as reduced GHG emissions can be realized if local government agencies (e.g., PhilRice and NIA) as well as international agencies (e.g., IRRI) continue to provide education and training about the latest research on AWD to local extension personnel, field technicians, IAs, and farmers (Rejesus et al 2010).

In the long run, the prospects for (1) conserving water and (2) reducing greenhouse gas emissions for the greater good must be instilled in the mind-set of stakeholders to make AWD sustainable.

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Appendices

APPENDIX I:

Possible project design document for AWD in the AMRIS

I. Project identification

– Project title: Dissemination of Alternate Wetting and Drying in the Angat Irrigation Scheme (AMRIS)

– Project purpose and objectives: To assess the potential of and constraints to alternate wetting and drying (AWD) technology for mitigating methane emissions in rice farming of the Philippines and to assist in crop management decisions and review AWD programs in the Philippines, (1) focusing on current partners and areas of active dissemination or involvement, and (2) coming up with priority areas for implementation.

– Project location: National Irrigation Administration-Angat Maasim River Irrigation System (NIA-AMRIS), San Rafael, Bulacan.

II. Project contact information

- Project proponents: International Rice Research Institute (IRRI), Philippine Rice Research Institute (PhilRice), NIA-AMRIS
- Other parties with a material interest: National Power Corporation (NPC)
- Roles and responsibilities: PhilRice and NIA are mandated by the government of the Philippines through the Department of Agriculture to undertake projects, as joint partners, on water-saving technologies. This is specifically stated in Administrative Order 25 of 2009 titled “Guidelines for the adoption of water-saving technologies (WST) in irrigated rice production systems in the Philippines.”
- IRRI, through the International Rice Research Consortium (IRRC) and other funding units, may provide some financial support in the (1) research on greenhouse gas emissions and (2) dissemination of the AWD project.

III. Project description

- AMRIS has no AWD implemented by either IRRI or PhilRice. Although in 2006, under the auspices of JICA, some farms practiced controlled irrigation, this was “default” AWD, in which irrigation and drying did not follow the researchers’ protocol for safe AWD. The Clean Development Mechanism will be undertaking safe AWD, in which the risks of crop yield decline or failure decline drastically as backed up by 10 years of research.
- Through alternate wetting and drying, rice fields’ emissions of methane can be decreased to about 50% compared with crop management under continuous flooding, as commonly practiced by farmers of the region.
- Through careful monitoring, of otherwise already documented methane reductions (http://cdm.unfccc.int/methodologies/DB/D6MRRHNNU5RUHJXWKHN87IUXW5F5N0), CER credits can be traded.

IV. Project details

- AWD technology falls under the agricultural land use category in which reductions in methane emissions are governed by the principle of reduced activity of methane-producing organisms. The periods of drying or drainage enhance aeration of the soils, thus inhibiting proliferation of methane-producing bacteria.
- Irrigated lowland rice is the specific type of area to be implemented with AWD.
- With NIA-AMRIS as the sole irrigation governing body, the project is bounded by the areas it services. Although AMRIS extends to 100,000 ha, preliminary or pilot plots for AWD will comprise at least 150 ha (per locality) of a formerly continuously flooded site. The sites will be under two modes of irrigation system: pump and gravity-driven.
- Inventory of sources: Methane emission levels from specific sources can vary significantly, depending on factors such as climate, industrial and agricultural production characteristics, energy types and usage, and waste management practices. Because both temperature and moisture have a significant effect on the anaerobic digestion process, the alternating aerobic and anaerobic conditions plus levels of water play an important factor in AWD.
- Project baseline: Default factors for reduced emissions have already been identified (1.8 kg ha−1 d−1) in the case of multiple aerations.
- Methane emission measurement has already been documented under the INFCCC CDM protocol: (http://cdm.unfccc.int/methodologies/DB/D6MRRHNNU5RUHJXWKHN87IUXW5F5N0), and, as of this writing, is titled “AMS-III.AU: Methane emission reduction by adjusted water management practice in rice cultivation—Version 3.0”
- As stipulated in an accompanying protocol for AWD technology, field personnel under the supervision of the project’s main proponents will be trained and tasked to closely monitor field water measurements as well as crop data.
- Quality control and assurance will be strictly adhered to, especially that one of the implementing bodies, PhilRice, has received the following certifications: ISO 9001:2008 (Quality Management), ISO 14001:2004 (Environmental Management), and OHSAS 18001:2007 (Occupational Health and Safety Assessment Series). Likewise, IRRI, through its service component, the Analytical Services Laboratory (ASL), was awarded an ISO 17025 accreditation by the Philippine Accreditation Office.
- Fieldbooks will be developed for the project. The data collected will be audited and backed up on a regular basis.
- AWD will be set up in 2013, with January as the start of planting for the dry season. It is planned and expected

that twice–monthly reporting will be done within the proponent agencies: NIA-AMRIS, PhilRice, and IRRI.

- As this is the first initiative for a CDM project in rice, there are no existing links to other registries or programs in the realm of CDM.
- Because this project will rely on irrigation water impounded in the Angat reservoir and coursed through NIA, with the expected ENSO forecast to affect the hydrology of the watershed in 2013, water would be the main limiting factor. However, with careful forecasting and planning, an unreliable water supply will be minimized. In fact, NIA, in its readiness, has taken into account the projected 20% irrigation supply reduction for 2013 and appropriate remedial measures are in place.
- This project no obvious environmental threats. On the other hand, the conservation of water at the same time as an expected reduction in methane emissions can only mean an environment-friendly advantage.
- In the course of this project, several meetings within proponent agencies and appreciation seminars with stakeholders are being held, with minutes of the meetings and highlights carefully documented.

APPENDIX II:

Alternate wetting and drying field establishment protocol

Alternate wetting and drying aims to reduce water use in irrigated lowland rice fields through intermittent irrigation. However, as opposed to "imposed" AWD, "safe AWD" involves water-table depth monitoring before re-irrigation of a drained field.

Land preparation and crop establishment for an AWD field follows the conventional way of irrigated lowland rice (www.knowledgebank.irri.org/bmp/pre-planting-phase/land-preparation.html). However, as distinguished from conventional flooding, drainage commences when rice seedlings reach the 2-week stage. Previously installed polyvinyl chloride (PVC) pipes with perforated sides are monitored for depth to available water (for the plant). A detailed online course, can be accessed at http://irri.org/index.php?option=com_k2&view=item&id=7446:e-water-management-course&lang=en.

About 20 days after crop establishment (direct seeding or transplanting), the fields are drained until the water table goes down to 15 cm below the soil surface and then re-irrigation to a flooded depth of 5 cm follows. After which the field is re-drained to a 15-cm subsurface water level and then re-irrigated to 5-cm ponded water depth. This cycle of irrigation, drainage, and re-irrigation continues until 2 weeks before and 2 weeks after flowering. In this timing and irrigation-drainage cycle, the rice crop continues to grow and develop normally, unaffected by the periods of dry soil.

Preparation of tube wells

The tube wells are 20-cm-diameter PVC pipes that have holes drilled on their side for water to pass through (Fig. 1). These pipes are embedded to 15-cm depth with 5 cm protruding from the ground during field preparation or at sowing/transplanting.

Depending on availability, the PVC pipes can be replaced by bamboo, a bottomless metal can, or plastic tubes with sides perforated, as long as access to observing the water inside is not hampered.

Measurement of water level

In principle, two levels of water are monitored in safe AWD: (1) the ponded water depth (water above the soil surface) and (2) subsurface water during field drying. The water level from the soil surface is monitored daily inside the pipes. When the water level reaches the bottom (15-cm depth), this is the threshold for field drainage. At the same time, the soil moisture level is still adequate for plant roots to extract water at the same time, a signal for re-irrigation.

Validation

Coordinates of the field will be plotted with the aid of a GPS for proper location mapping. Plot IDs will be assigned per area or parcel. The parcels may be irregular depending on the area enclosed by the bunds. The proximity of each tube well to the GPS coordinates should be noted. The tube wells are installed with the frequency of a minimum of 3 units per hectare positioned to follow the gradient of the field. However, when farm sizes are small, at least one observation well per bund-enclosed parcel of land will suffice. Digital cameras will be provided, at least one for each locality, and will be entrusted to the technician for periodic snapshots (twice a week) of actual field conditions, especially the water level (1) in the field and (2) inside the tube, if possible.

Fieldbooks

Data sheets in the form of ruled paper with pagination similar to the following will be furnished for monitoring and data entry (see Fieldbook in Appendix).

Date	Plot ID	Water level (cm)	Remarks

On-site personnel (technicians) will be hired for the measurements. Collaborating agency staff (NIA-AMRIS, PhilRice, or IRRI) will regularly check the veracity of the measurements.

Methane measurements

Sampling for methane gas will be done at least twice a month with removable chambers. IRRI and PhilRice personnel will take the lead for this task.

The procedure for methane gas emission measurement is discussed in Appendix 1 of "AMS-III.AU: Methane emission reduction by adjusted water management practice in rice cultivation," downloadable as a pdf or Word file from http://cdm.unfccc.int/methodologies/DB/D6MRRHNNU5RUHJXWKHN87IUXW5F5N0.

Field data

Phenology, location, toposequence, weather data, and other information (Annex 2) will be incorporated in the fieldbooks. Each locality will be provided with a fieldbook, kept by the person in charge of monitoring the water level. This fieldbook will be periodically checked by staff from IRRI, PhilRice, and/or NIA-AMRIS. At each visit, data will be copied in a duplicate fieldbook. Picture files from the camera will also be copied to a flash drive or downloaded to a computer or suitable device (laptop, smartphone, or tablet). This duplicate fieldbook will be kept at NIA-AMRIS headquarters in San Rafael, Bulacan, for safekeeping and transcription to spreadsheets.

Crop and other data

Seedbed sowing, transplanting, flowering (when 50% of the plants have reached this stage), and harvest dates will be recorded at each locality. If the crop is directed-seeded, then sowing date will be used. Incidence of diseases, weeds, and pests as well as method of control or prophylactic treatment must be recorded under "Remarks." Rates, time of application, and amount of fertilizer and other amendments should be noted. Weather data will be gathered from the nearest agrometeorological station. Yield and yield components will be taken from a 5-m2 area.

Water flow data

Where available, a staff gauge (NIA-administered) will be used to compute flow of water in the canals. The staff gauge is used for a quick visual indication of the surface level in rivers, streams, irrigation channels, and wherever accuracy and readability are important. Water meters or flowmeters, if available, will be monitored in irrigation pumps. Consumption of electricity and fuel (when applicable) for running the pumps, will also be noted.