インドネシアの水田から発生するメタンガス放出制御のためのCDM事業の実行可能性

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●Article

Financial Viability and Its Analysis of CDM Projects for Mitigation of Methane Emissions from Paddy Fields in Indonesia: A Cost-Benefit Simulation Study

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Abstract

The study aims to demonstrate financial viability of model Clean Development Mechanism (CDM) projects to mitigate methane emissions from paddy fields in rural parts of Indonesia and to identify issues in developing CDM projects. The projects were designed to phase the implementation into three stages over 10 years adopting a step-by-step process to ensure that implementing entities gradually gain confidence and later embark on a much wider and thorough application. The internal rate of return (IRR) of the projects starting with an irrigation block, a water user's association (WUA) and a WUA Federation were -1.8, 19 and 52 %, respectively for Bantimurung Irrigation Area. The risks associated with recurrent El Niño were judged as primary challenges to the project. Unlike major CDM projects in the country such as methane avoidance from wastewater treatment systems and biogas utilization types, an intrinsic nature of the project is its use of an annual plant so that the project benefit is more susceptible to short-term climatic variability. The wage increase at an annual 8 % pushed the IRR of the project starting with one WUA down to 7.7 % from 19 %. Bottlenecks in scaling up the project were transaction costs including those for negotiating with the participating farmers, as it increases proportionally to the number of farmers. The project is further designed to provide incentive to the farmers by sharing the revenue generated by sales of the carbon credit. The analysis indicated that 1) the provision of 50 and 10 USD/ha/year to a head of irrigation block and an ordinary farmer respectively functioned as an incentive motivation to the farmers to undertake intermittent drainage; 2) a head of block is more motivated to undertake intermittent drainage with the proportional remuneration; and 3) the incentives were robust against climatic variability under said assumption.

Key words: Indonesia, Paddy Field, Methane, CDM, Financial Analysis

I. Introduction

Rice is the lifeline in Asia and the Pacific where 56 % of the world's population resides including nearly 70 % of the world's 1.3 billion poor people (Cantrell and Hettel 2004). Ninety two (92) % of the world's rice is produced and consumed in the region. Indonesia, with a population over 230 million positioned in the heart of the region, regards rice as the most important grain since it is the staple food and a major source of income of the nation.

Rice fields have drawn considerable attention among climatologists since the 1980's as growing evidence indicated that it could be a major source of atmospheric methane (CH_4), a greenhouse gas with the second-largest radiative forcing after carbon dioxide, contributing 4-19 % of its entire emission (Ramaswamy 2001). Present atmospheric levels of CH_4 are unprecedented in at least the last 650 kyr (Spahni *et al.* 2005). In 2005, the global average abundance of CH_4 measured at a network of 40 surface air flask sampling sites operated by NOAA/GMD in both hemispheres was 1,774.62 ± 1.22 ppb (IPCC 2007).

Methane emitted from rice field is generated by the anaerobic decomposition of soil organic matter and is dependent on two principal resource management factors: water and organic matter. Intermittent drainage, alternate flooding and draining, is a conventional water management practice in Japan and other countries in North Asia to provide short periods without standing water in the rice field and thus generate oxidative soil environment resulting to promotion of rice yield through controlled tillering and minimized occurrence of sulfide toxicity. Intermittent drainage is viewed as a promising option for mitigating CH_4 emission from paddy fields as it has concomitant mitigative effects on CH_4 generation through accelerating aerobic microbiological decomposition of soil organic matter (Inubushi *et al.* 1992).

Diffusing the practice in major rice growing countries is now imperative for mitigating CH_4 emission from rice fields. However, limited incentive to farmers to undertake intermittent drainage poses a challenge to apply the option to a broad geographical area. In addition, a recent study in South Sulawesi and South Kalimantan indicated no discernible impacts of intermittent drainage on rice yield (Jumadi *et al.* 2007).

The Clean Development Mechanism has created an enabling environment for reducing Greenhouse Gas (GHGs) emissions by allowing developed counties and economies in transition to implement their commitment to developing countries as an alternative to what is generally considered more costly in their own countries. Indonesia, one of the largest contributors of GHGs emissions having significant mitigation potential, is a party to the United Nations Framework on Climate Change Conventions and the Kyoto Protocol. In this context, field studies were conducted in Indonesia to design and assess model CDM projects to contribute to mitigation of CH_4 emission from paddy fields.

II. Objectives

The objectives of the study are to demonstrate the financial viability of model CDM projects for mitigation of methane emissions from paddy fields by applying intermittent drainage in rural parts of Indonesia and to identify issues in developing the CDM projects.

III. Methodology of the study

Field surveys were undertaken in Banjar of South Kalimantan in 2005 and Maros of South Sulawesi in 2006 (Figure 1, Table 1). The villages were chosen considering the readiness and preparedness of its local universities for such initiative as CDM projects. The survey in 2005 focused in Riam Kanan Irrigation Area located within Banjar, where four farmers in two sub-districts, Sungai Tabut and Martapura, were chosen for a two-day farm household interview. The Riam Kanan Irrigation Area was originally designed to provide water over an area of 26,000 ha in three stages starting with sub-area B with around 6,203 ha of land area. The survey in 2006 was, on the other hand, conducted in Bantimurung Irrigation Area in Maros to have a two-day interview on five farm households in Bantimurung and Lau sub-districts. Bantimurung Irrigation Area spreads over 6 sub-districts along Bantimurung Primary Canal with a total land area of 6,513 ha.

The surveyed villages in both years were purposively selected as representative of the irrigation areas and farming systems present in the areas. The author led and separately organized the survey teams for each area both comprising of university staffs with 3 to 4 members each consisting of a soil scientist and a biologist or a hydrologist. The interview identified the current farming practice and water management practices in relation to organizational structures of WUA.

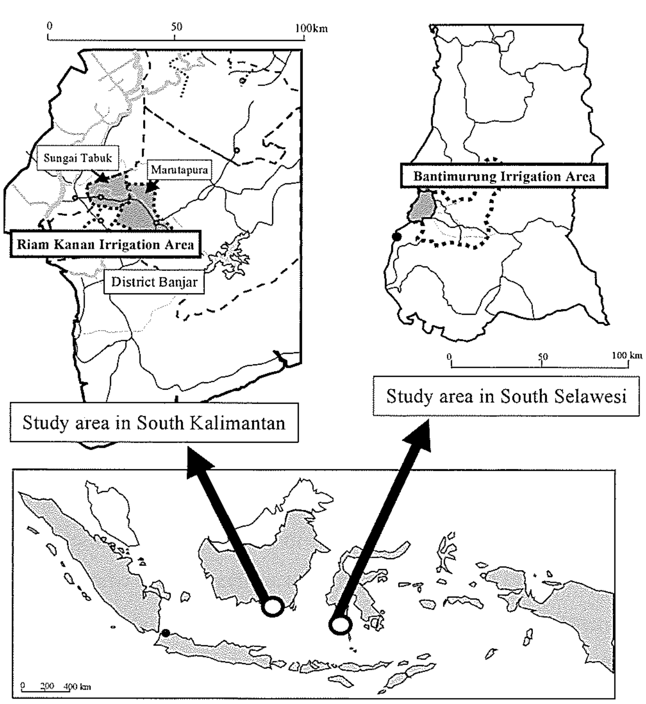

Fig. 1 Study Area

Table 1 Maros and Banjar

Province	South Sulawesi	South Kalimantan
Studied Regency	Maros	Banjar
Total Land Area (km^2)	1,881	4,711
Rice field (ha)	25,919	425,732
Distance to the Capital of Province (km)	30	40
Population in 2005	296,336	454,998
Population Growth 2005	2.12	1.72*
Population Density (per km^2)	183	97
Regional Minimum Wage 2006 (Rp)	612,000	629,000

Source: Profile of Regency of Maros [1]
Profile of Regency of Banjar[2]

IV. National and Regional Context

National and Sectoral Context:

Indonesia is the 15th largest greenhouse gas emitter in the world in 2000, emitting an equivalent of 503 million tons of carbon dioxide per year and contributing 1.5 percent of the world's total emission of the year (Baumert *et al.* 2005). Indonesia is at the same time a victim of global warming through threatened food security, inundated productive coastal zones and reduced farming and coastal livelihoods as a result of sea level rise. The commitment of the country to Climatic Change was codified in Law No.6/1994 that ratified the United Nations Framework on Climate Change Conventions. The National Commission on Climate Change was created under the Ministry of Environment through Ministerial Decree No.35/MENKLH/1992. Indonesia signed the Kyoto Protocol in 1997 and ratified it in 2004 through Law No.17/2004 (PEACE 2007).

The agricultural sector of the country is the 7th largest contributor to the global agricultural GHGs emissions (Baumert *et al.* 2005). The sector is the main source of national methane emissions contributing 59 percent. Paddy fields are estimated to emit 70 percent of CH_4 (PEACE 2007).

Regional Context

Double rice cropping is the major cropping pattern over the surveyed areas. Hybrid varieties are grown in the rainy season mostly from December to March, which is followed by local rice varieties in the dry season from April to September. The farmers in the surveyed area drain surface water for the purpose of applying fertilizer 10 days after rice planting and before the heading stage of hybrid rice. This demonstrates that 1) the farms are already oriented to allow intermittent drainage in the area where hybrid rice are grown; and 2) farmers have fundamental water management skills needed for intermittent drainage. Nonetheless, the farmers in the areas do not undertake intermittent drainage largely due to negligible incremental impact on rice yield as evidenced at nearby experimental stations (Jumadi *et al.* 2007). The current irrigation schedule is therefore designed solely for fertilizer application, which is thereby unfit for CH_4 emission mitigation.

The majority of the interviewed farmers, however, responded positively on the introduction of intermittent drainage emphasizing their capability to do it. This is presumably due to their exposure to the news on the recent global climatic change and the significant damages caused by a series of devastating tsunami triggered by the 2004 Indian Ocean earthquake. On the other hand, they frequently cited severe drought years as a potential obstacle in performing intermittent drainage that may be intensified during El Niño.

The irrigation system in Bantimurung Irrigation Area is operated by a dual-purpose irrigation-drainage field ditch having rather randomly shaped farm plots scattered throughout the command area. The organizations pertaining to water management are formed into three tiers i.e. 1) an irrigation block, 2) a WUA and 3) a WUA federation. The smallest unit of water management structure is an irrigation block that is organized at the quarterly channel level. Although the size of each irrigation block varies according to the number of belonging farmers, the land area of each block is about 0.3 km^2. The irrigation blocks in the areas adopt the cascade method of water supply whereby the irrigation water is supplied to the highest field by gravity, and then allowed to flow to subsequent fields until the lowest field is flooded. The earthen intake of block is then closed when supply of irrigation water is abundant. WUA is the organization for controlling, managing and maintaining irrigation facilities at the tertiary level. Each WUA comprises of two to four irrigation blocks in the villages interviewed. Water is supplied from a secondary canal to each WUA through a tertiary canal installed with division boxes. Water distribution within a WUA is administered by an ulu-ulu (water masters), who opens and closes division boxes as necessary. The gate connected to the secondary canal is operated by the officers of the Ministry of Public Work. WUA federation manages irrigation system at the secondary channel. A WUA federation at a nearby area consists of four WUAs having a total land area of 4 km^2.

In contrast, each strip of farmland is provided with an irrigation canal and a separate drainage system in Riam Kanan Irrigation Area. The farm plots with an average land area of 1-1.5 ha are arranged in a geometric grid that determines the layout of irrigation and drainage systems. Increased accessibility to irrigation service allows the users of the land in the area to govern their irrigation schedule according to cropping plans. Therefore, said surface drainage for fertilization is performed individually by operating the inlet and outlet of each farm plot. Unlike the WUAs in Bantimurung Irrigation Area, the majority of WUAs in the area is accordingly unfunctional as a collective entity for managing water delivery service and thus is unable to perform systematic water management.

V. Analytical Framework

The analysis was performed for model CDM projects designed to mitigate CH_4 emission by intermittent drainage. Irrigation blocks along with WUAs are assumed to function as the primary entity for implementing the projects in the analysis. This is to leverage their innate capacity in managing irrigation water and group cohesiveness in undertaking a project. Further, a model WUA was structured over three irrigation blocks with a land area of 0.3 km^2 each in double cropping areas with the assumption that each participating farmer holds 0.01 km^2 of paddy field.

Project scenarios were designed to phase the implementation into three stages over 10 years adopting a step-by-step process 1) to ensure implementing entities gradually gain confidence, and later embark on a much wider and thorough application and 2) to minimize the initial transaction cost associated with preparing project document relative to the likely return on investments.

Table 2 presents the number of participating irrigation blocks for each of the project stage. Scenario 1, for instance, starts with one irrigation block (0.3 km^2) for 3 years, followed by duplication over additional two irrigation blocks with a total land area of 0.9 km^2 for the subsequent three years, and over additional two WUAs with a total land area of 2.7 km^2 for the rest of the project life. Scenario 2 is to model a case starting with one WUA . The third one is to start with one WUA federation.

Although the WUAs in Riam Kanan Irrigation Area are not func-

Table 2 Number of Participating Blocks of Each scenario

Scenarios	Number of Blocks		
	Stage 1 (Year 1 to 3) b_1	Stage 2 (Year 4 to 6) b_2	Stage 3 (Year 7 to 10) b_3
Scenario 1	1	3	9
Scenario 2	3	9	27
Scenario 3	12	36	108

Note: "b" denotes the number of participating blocks for each project stage.

tioning, unlike Bantimurung Irrigation Area, the same model was adopted for the purpose of analysis.

Under the Kyoto Protocol, agriculture projects reducing not greater than 60,000 tons of tCO_2^e/year fall under Type III of small-scale projects. The procedures of the project adopted those for the small-scale project as the projects meet said criteria. A single 10-year crediting period was selected.

The internal rate of return (IRR) was estimated for each scenario based on the net present value (NPV) of the project's benefit and cost. Mitigation of CH_4 and associated carbon credit is the sole source of project cash inflow as no changes were detected in emission of carbon dioxide (CO_2) and nitrous oxide (N_2O) with intermittent drainage at the nearby experimental stations (Jumadi *et al.* 2007). The present value of the project's benefit is given by the following formula (1).

$$B=\sum_{n=1}^{3} Kb_1/(1+r)^{n-1}+\sum_{n=4}^{6} Kb_2/(1+r)^{n-1}+\sum_{n=7}^{10} Kb_3/(1+r)^{n-1} \cdots (1)$$

Where:

B = Present value of the project benefit

K = (Md+Mr) × P_C

Md = CH_4 emission reduction in dry season

Mr = CH_4 emission reduction in rainy season

Pc = Prevailing market price of CO_2^e

b_1= Number of participating irrigation blocks from Year 1 to 3

b_2= Number of participating irrigation blocks from Year 4 to 6

b_3= Number of participating irrigation blocks from Year 7 to 10

r = Interest rate (%)

The value of CH_4 emission mitigation (Table 3) by intermittent drainage relied on a recent pilot study (Murakami *et al.* 2005, Jumadi *et al.* 2007) at nearby experimental stations established by the local university in cooperation with Chiba University.

The price of CO_2^e adopted the weighted average prices for primary Certified Emission Reduction (CER) for the first 3 quarters in 2006 at 10.5 USD/tCO_2^e (Karan and Ambrosi 2006).

Table 3 Methane Emission Mitigation by Intermittent Drainage

Irrigation area	Season	Mitigation of CH_4 (tCO_2e/km^2)
Bantimurung	Dry	531.3
	Rainy	1,129.8
Riam Kanan	Dry	448.0
	Rainy	229.6

The project cost consists of 1) carbon finance cost, 2) physical investment cost, 3) incremental cost for gate operation, 4) instruction cost conducted by Farmers' Field School (FFS), 5) recurrent FFS cost and 6) monitoring cost. The present value of the project's cost (Ct) is given by the following formula (2).

$$Ct=Ccf+Pi+G+Fi+Fr+Mi+Mr \cdots (2)$$

Ccf = Carbon finance cost comprising of 1) C_i= project documentation at 110,000 USD in the Year 1, 2) C_v= initial verification at 3,000 USD in the Year 2 and 3) C_r= recurrent cost for verification and certification at 4,000 USD. The cost was converted to the present value.

Pi = Summation of physical investment cost in present value at Year 1, 4 and 7 is expressed as follows:

$$Pi=p\times b_1+p\times(b_2-b_1)/(1+r)^3+p\times(b_3-b_2)/(1+r)^6$$

Where: p is the unit cost of a concrete gate installed at the inlet of each irrigation block (56.3 USD).

G = Incremental cost for gate operation in present value is expressed as follows:

$$G=\sum_{n=1}^{3}(g\times b_1)/(1+r)^{n-1}+\sum_{n=4}^{6}(g\times b_2)/(1+r)^{n-1}+\sum_{n=7}^{10}(g\times b_3)/(1+r)^{n-1}$$

Where: g is the annual incremental labor cost for gate operation at 28.6 USD.

Fi = Initial instruction cost for FFS in present value is expressed as follows:

$$Fi=f\times b_1+f\times(b_2-b_1)/(1+r)^3+(b_3-b_2)/(1+r)^6$$

where : f is the unit cost of FFS for one irrigation block estimated at 801 USD.

Fr = Recurrent cost for follow-up FFS in present value is expressed as follows:

$$Fr=\sum_{n=1}^{3}(ff\times b_1)/(1+r)^{n-1}+\sum_{n=4}^{6}(ff\times b_2)/(1+r)^{n-1}+\sum_{n=7}^{10}(ff\times b_3)/(1+r)^{n-1}$$

Where: ff is the unit cost of a follow-up FFS at 226 USD/ one irrigation block.

Mi = The initial investment cost for monitoring estimated at 500 USD.

Mr = Recurrent monitoring cost in present value is as follows:

$$Mr=\sum_{n=1}^{3}(m\times b_1)/(1+r)^{n-1}+\sum_{n=4}^{6}(m\times b_2)/(1+r)^{n-1}+\sum_{n=7}^{10}(m\times b_3)/(1+r)^{n-1}$$

Where: m is the unit cost of monitoring estimated at 1,960 USD for one irrigation block.

The project carbon finance cost was quantified on the basis of generic costs for small-scale projects (World Bank 2003) as follows: The cash outflow in the initial year for initial project documentation (Table 4) was estimated at 110,000 USD including 1) preparation and review of the Project, 2) preparation of a Simplified Project Design Document, 3) validation and 4) project appraisal and negotiation. The cost for the initial verification incurred in the second year was estimated at 3,000 USD. The recurrent cost for verification and certification was estimated at 4,000 USD incurred for the rest of the project life.

Recognizing that the inlet operators, heads of block, reiterate digging and filling earthen inlet passage to control irrigation water, the project was designed to install one concrete-built gate with an approximate di-

Table 4 Breakdown of Carbon Finance Cost in the Year 1

Stage	Activity	Cost (USD)
Preparation and review of the Project	Upstream due diligence, carbon risk assessment and documentation	20,000
Simplified Project Design Document	Baseline assessment	10,000
	Monitoring	5,000
Validation	Contract, Processing and Documentation	20,000
Project Appraisal and Negotiation	Consultation and Project Appraisal	35,000
	Negotiation and Legal Documentation	20,000
Total Initial Cost		110,000

Source: World Bank (2003)

mension of 30×50×15cm for each irrigation block to avoid physical collapse of inlet and farmers' unwillingness to undertake cumbersome earthworks resulting from repeated gate operation needed for intermittent drainage. The installation cost of a gate (p) was estimated at 56 USD inclusive of 1 day construction supervision at 50USD/Man-day (MD) and 2 MD employing mason at 2.9 USD/MD; and the material cost at 0.62USD estimated by prevailing market price of stone, sand and cement. The investment cost incurred at the first year of each stage, the 1st, 4th and 7th year, for additional participating blocks.

The incremental cost for gate operation was estimated as the product of the prevailing labor cost at 2.86 USD/MD and estimated incremental labor for one block at an annual 10 MD for operation of gate needed for intermittent drainage. It was further multiplied for the number of participating blocks for each corresponding project stage.

The farmers in the area are able to undertake intermittent drainage, however, the current schedule of water management is unfit for CH_4 emission mitigation. It necessitates dissemination of information on intermittent drainage including its rationale and appropriate flooding/drainage schedule, in addition to the basics on cash/treasury management. The Farmer Field School (FFS), born in Indonesia to promote Integrated Pest Management, is a group-based learning process. Dissemination of hands-on management skills for CH_4 emission control may be undertaken through FFS approach in collaboration with facilitators employed for the project with an estimated total cost of 801 USD for one irrigation block. The costing of FFS for one irrigation block was made on the basis of: 1) 2 MD of soil scientist for planning with 50 USD daily compensation and 33 USD as the cost for preparing teaching materials; 2) 6 MD of soil scientist (2 soil scientists for 3 days) at 50 USD/MD for convening FFS assisted by 6 MD facilitators costing at 30 USD/MD each; 3) a 3 day vehicle operation at 46 USD/day during the 3 school days and 4) 1 MD of soil scientist for post FFS reporting. The scale of FFS was designed on the basis of the first FFS[3] established in 1989 in Central Java during a pilot season, wherein two hundred FFSs were established with 5000 farmers participating. The cost for FFS accrues at the initial year of each project stage (the 1st, 4th and 7th year) for additionally participating blocks.

The recurrent cost for follow-up FFS is to avoid potential failure resulting from incompliance with the designated water management schedule through time passage. The annual cost is estimated at 226 USD for one block. This follow-up is one-day FFS undertaken by one soil scientist. A soil scientist at 50 USD/MD is mobilized for one-day planning, a one-day implementation and one-day reporting with an assistance of 1 MD facilitator at 30 USD/MD plus one-day vehicle operation at 46 USD/day. It was further multiplied for the number of participating blocks for each of the corresponding project stage.

Compliance monitoring is performed by measuring soil redox potential with a portable pH/Eh meter accompanied by a joint walk-through of the command area with the respective head of an irrigation block. To do this, a pH/Eh meter would be purchased at the onset of the project at 500 USD.

The recurrent annual monitoring cost is estimated at 1,960 USD for one irrigation block. A total 3 MD would be needed for one irrigation block at the unit rate of 50 USD/MD for pre-monitoring planning, actual measurement of redox potential and report writing. A vehicle would be operated at a unit cost of 46 USD for one-day field measurement. One round of monitoring, thus, would cost 196 USD, which would be undertaken 5 times to capture the changes of soil redox potential over a cropping season with a total annual cost of 1,960 USD in the double cropping area.

IV. Results and Discussion

The internal rate of return (IRR) of the projects starting with an irrigation block, a water user's association (WUA) and a WUA Federation were -1.8, 19 and 52 %, respectively for Bantimurung Irrigation Area. The NPVs with a discount rate at 10 % of each scenario are also presented in Table 5. The project scenario starting with one irrigation block was judged financially infeasible. As for Riam Kanan Irrigation Area, the IRRs of the three scenarios were incalcurable. This is due to smaller return on investments generated from sales of credit because the annual mitigation of CH_4 emission was merely 41% of the Bantimurung Irrigation Area case.

Table 5 IRR and NPV of Base Scenarios (Bantimurung Irrigation Area)

Scenarios	IRR	NPV (1000 USD) at 10 %
Scenario 1	−1.8 %	−62
Scenario 2	19 %	77
Scenario 3	52 %	708

Potential Impacts of El Niño: Indonesia is recurrently struck by severe droughts as a result of El Niño-Southern Oscillation (ENSO; commonly referred to as El Niño). It typically causes a delay in the onset of the monsoon by 1 to 2 months, postponing the main rice harvest. For the period in which rice production data are available for Java and Bali (1983–2004), the probability of a 30-day delay in monsoon onset was 18.2 % for West/Central Java (Naylor *et al.* 2007).

Weather variability, more specifically drought, is a potential risk for the project. In drought years, the farmers more likely keep a higher water level to cope with revenue shortfalls particularly for the hybrid rice growing season as it is more susceptible to water scarcity. This would take place at irrigation blocks located at the periphery of the irrigation command areas where its topographic setting is disadvantageous to access irrigation water. Table 6 presents IRRs of the Bantimurung Irrigation Area project wherein: 1) half of the farmers temporarily withdrew from the project during the rainy season in the 3rd and 8th years; 2) half of the farmers temporarily withdrew from the project during the two consecutive seasons in the 3rd and 8th years; 3) all the farmers temporarily withdrew from the project during the rainy seasons in the 3rd and 8th years; and 4) all the farmers temporarily withdrew from the project during the two consecutive seasons in the 3rd and 8th years. The project scenario starting with one WUA is susceptible to such recurrent drought that may take place as a result of ENSO and thus its IRR dropped to 8.8 % in the fourth case. The risks associated with adverse regional weather conditions are judged as the primary challenges to the project. Unlike other CDM projects in the country such as methane avoidance and biogas utilization types (IGES 2008), an intrinsic nature of the project is its use of an annual plant so that project benefit is more susceptible to short-term climatic variability.

Wage Increase: Wage rise in Indonesia also impacts the profitability of the projects. In Bantimurung Irrigation Area, geographical proximity to the provincial capital and resource endowment such as coal, granite and limestone would provide non-agricultural employment opportunity. Such increase in employment opportunity may push up wage rate in the agricultural sector. The minimum wage for agricultural workers in Indonesia rose at an annual rate of 8.4 % during the period 1990 to 2003 (Prijono 2007). The minimum wage for other sectors such as the industry, electricity, construction and mining sectors rose at higher rates in the same period. An analysis was performed for the case where the costs for agricultural and skilled labors rose by 1.4 times the base case from the 4th to the 6th year; and by 1.8 times from the 7th to the 10th year to model the wage increase at an annual 8 %. Table 7 presents the result of the analysis. The IRR of scenario 2 starting with one WUA dropped to 7.7 % from 19 % of the base case. Meanwhile, the IRR of scenario 3 was kept at 39 %.

Table 6 IRR of the Project with El Niño Cases (Bantimurung Irrigation Area)

Scenarios	Case 1		Case 2		Case 3		Case 4	
	Rainy 50 %	Dry 0 %	Rainy 50 %	Dry 50 %	Rainy 100 %	Dry 0 %	Rainy 100 %	Dry 100 %
Scenario 1	−4.3 %		−5.6 %		−7.2 %		−10 %	
Scenario 2	16 %		15 %		13 %		8.8 %	
Scenario 3	48 %		46 %		43 %		37 %	

Table 7 Changes in IRR and NPV with Wage Increase (Bantimurung Irrigation Area)

	IRR	NPV (1000 USD) at 10%
Scenario 1	−	−93
Scenario 2	7.7 %	−14
Scenario 3	39 %	340

Note: The IRR for Scenario 1 was incalculable.

Bottleneck in scaling up: The carbon finance cost in the initial year is the largest component in terms of its present value. It was at 35,000 USD based on the generic cost for Small-Scale Project including: 1) preparation and review of the project; and 2) preparation of Simplified Project Design Document. During the period, negotiation and contract with the participating irrigation blocks needs to be accomplished, which is a potential bottleneck in scaling up the project. To estimate the number of irrigation blocks, assumptions were made that 1) a local consultant is able to prioritize and choose the irrigation blocks in 0.5 month and negotiate/contract with two blocks per week for the rest of the period with a monthly fee of 3,000 USD, 2) an international consultant for project administration and documentation is mobilized for 1 month with a monthly fee of 15,000 USD, 3) international and domestic flights cost 1,500 USD, and 4) a vehicle is operated for the entire period of the local consultant' s mobilization (20 days/month) at 46 USD/day. The estimated man-months that could be allocated for negotiation/contract are 4.2 MM. With the assumption that a local consultant is able to contract with two irrigation blocks in one week, the estimated total number of irrigation blocks under the project is limited to 33 with the generic cost. Bottlenecks in scaling up the project were therefore judged as the transaction costs including those for negotiating with the participating farmers, as it increases proportionally to the number of farmers.

Farm income analysis: Incentive to the participating farmers would be provided by sharing the dividend from the revenue generated by the sales of the carbon credit. In the analysis, assumptions were made that a head of the irrigation block is provided annually with 50, 45 or 40 USD/ha/year, as remuneration for their engagement to be incurred from Years 2 to 10. On the other hand, each ordinary member of the irrigation block was assumed to annually have 15, 10 or 5 USD/ha/year.

Table 8 Gross Production of Model Farmers

	Unit	Rainy	Dry
		Hybrid	Local Rice
Yield	ton/ha	4.2	3.0
Price	Rp/kg	0.12	0.173
Gross Production	USD/ha	512	519
		1,031	

Table 9 Farm Income Analysis

		Remuneration	Net Present Value (USD) at 10% discount rate		
		USD/ha/Year	Normal Case	Drought Case 1	Drought Case 2
Without discount	Head of block	50 (4.8%)*	37	26	16
		45 (4.4%)	8	1	−6
		40 (3.9%)	−21	−25	−28
	Ordinary member	15 (1.5%)	59	49	38
		10 (1.0%)	30	23	16
		5 (0.5%)	1	−2	−6
With discount	Head of block	50 (4.8%)	54	43	29
		45 (4.4%)	25	18	11
		40 (3.9%)	−4	−8	−15
	Ordinary member	15 (1.5%)	75	65	52
		10 (1.0%)	47	40	30
		5 (0.5%)	18	15	8

* The values in the parenthesis indicate a percentage of remuneration against the gross production.

Each corresponds to 4.8, 4.4 and 3.9 % of the annual gross production for a head of the irrigation block and 1.5, 1.0 and 0.5 % for an ordinary member (Table 8). The cost to be incurred by a head of block include those for gate operation at 5 MD for one crop season, attending the three-day initial instruction in Year 1, recurrent cost for attending a one-day FFS annually and one-day monitoring activity for each cropping season. On the other hand, cost to be incurred by an ordinary member include attending the three-day initial instruction in Year 1 and the recurrent cost for participating to the one-day FFS arising from Year 1 up to 10. Further, a discount arrangement for the irrigation water charge was incorporated into the analysis. Although the farmers in the area have not been privileged to have a water charge discount; the area has been confronted with a temporal shortage of irrigation water resource during the dry season; and therefore undertakes rotational irrigation water management. Growing scarcity of water resources is also a likely impact of global warming. In this context, water saving could be a favored orientation. In Bantimurung Irrigation Area, a water charge, IPAIR (IURAN Relayanan Air Irrigasi), is collected for water delivery during the dry season at a rate of 3 to 6 \$/ha/year. Recognizing that water management at the experimental station in Bantimurung Irrigation Area was performed by keeping surface water levels at an average of 3 cm throughout the growing seasons as compared with 6 cm or above for the control plot (Jumadi *et al.* 2007), the analysis was conducted to model the case where farmers are privileged to have discounted water charge at 2.5 \$/ha/year for the engagement during the dry season as against an average of 5 \$/ha/year for those who are not participating in the project.

Table 9 presents the results of the analysis. NPV at a discount rate of 10 % is used to enable easy comparison with the gross production of the farmers. The table compares the normal case with the climatic variation cases where the corresponding irrigation blocks withdrew from the project 1) during the rainy season and 2) during the rainy and dry seasons in the 3rd and 8th years due to drought. In the climatic variation case, the block was assumed not to comply with the designated irrigation schedule. Therefore, 1) the cash income does not arise from the sales of carbon credit for the corresponding cropping season for both the head of the block and ordinary members; 2) incremental cost to the head of the block is saved for gate operation for the corresponding season; 3) the cost for one-day attendance of a monitoring activity of the block head was also saved for the corresponding season; and 4) an irrigation charge at 2.5 \$/ha/year was not deducted for the dry season during the drought years.

As the incremental impact on rice yield resulting from undertaking intermittent drainage *per se* was negligible at nearby experimental station, the incentive to farmers is generated solely from carbon credit. In the case where no discount of water delivery charge was incorporated into the analysis, it indicated that 1) the provision of 50 and 10 USD/ha/year to a head of irrigation block and an ordinary farmer respectively functioned as an incentive motivation to the farmers to undertake intermittent drainage, 2) a head of block is more motivated to undertake intermittent drainage with the proportional remuneration; and 3) the incentives were robust against climatic variability under said assumption. With the arrangement for irrigation water charge discount, the participating farmers would concede a lower rate of remuneration. However, 5 USD/ha/year for an ordinary farmer may weaken incentives to ordinary members of WUA as it corresponds to merely 0.5 % of the gross production.

Other aspects:

The areas where each farm plot is provided with an irrigation canal and a separate drainage system, like Riam Kanan Irrigation Area, were assumed to be capable of undertaking the project. However, the farmlands with rather rudimentary facilities but with functioning WUAs operating dual-purpose field ditches were deemed more suited to the application of such projects because 1) the farmers were organized for collective actions to manage irrigation water, and 2) they are already exposed to the basics of cash and treasury management needed for participation to such projects.

Since emission of methane has significant local variations depending on soil organic matter, ferric substances and other soil variables, establishment of baseline and monitoring methodologies remains a challenge to diffuse the practice in major rice growing countries.

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インドネシアの水田から発生するメタンガス放出制御のためのCDM事業の実行可能性―費用便益分析を用いたシミュレーション分析―

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インドネシアにおける水田起源のメタンガス放出制御を目的とし，間断灌漑を適用したクリーン開発メカニズム（CDM）の事業を案出し，その財務的実行可能性を評価した。事業は，事業期間を10年とし，小面積から３段階で次第に拡大していくことにより，事業実施者の経験蓄積が可能となるよう配慮した。灌漑ブロック一つ，水利組合一つおよび水利組合連合会一つからそれぞれ事業を開始する３つのケースについて，内部収益率（IRR）は-1.8，19 および52 %とそれぞれ算出された。但し，インドネシアでは５年に１度くらいの周期でエルニーノに伴う旱魃が発生しており，これが事業最大のリスク要因の一つとなると考えられた。汚水処理施設からのメタン回収，バイオガス利用などインドネシアで提案されている主要なCDM事業と対比すると，本事業では１年生作物が事業活動の中心になっているため，短期的な天候変動のリスクにより曝されやすい。また年率８％の賃金上昇を仮定したところ，水利組合一つから開始する事業のIRRは，上述の19 %から7.7 %に押し下げられた。事業策定段階で参加する農家と契約協議が必要であり，そのコストは相対的に大きく事業規模が大きくなればなるほど拡大するため，事業規模拡大の阻害要因となると判断された。間断灌漑を行う動機付けが重要な課題であったが，事業に参加する農家に対して，得られた収益の一部から水管理者に対しては年間50 USD，水利組合に属する一般農家に対しては年間10 USDを配当すると仮定したところ，天候変動のリスクを考慮しても充分な動機付けとして機能すると判断された。

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