Science and technology as a key solution to adapt to climate change in the Mekong Delta

Case studies from the JIRCAS-CTU project

Japan International Research Center for Agricultural Sciences

Taro Izumi, Project Leader

College of Environment & Natural Resources, Can Tho University

Dr. Nguyen Van Cong

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   - Adapting to climate change through science and technology -

1. History of the joint research between JIRCAS and CTU

Period	Project
1991 - 1993	Poverty reduction and rural settlement
1994 - 2004	Integrated farming system
2008 - 2010	Validation Study of Rural Development based on CDM in Mekong Delta
2011 - 2015	Development of agricultural technologies in Mekong Delta to respond to climate change
2016 - 2020	Development of agricultural technologies for reducing greenhouse gas emissions from the Mekong Delta
2021 - 2025	Development of comprehensive agricultural technologies for climate change mitigation and adaptation in the Mekong Delta

Prof. Ha Thanh Toan
Rector
Can Tho University, Viet Nam

To commemorate the 50th Anniversary of the Japan International Research Center for Agricultural Sciences (JIRCAS), Can Tho University (CTU)would like to send warm congratulations. We deeply appreciate the great contribution of JIRCAS, the Japanese Government and the Japanese people.

CTU has collaborated with JIRCAS for the past several decades. CTU and JIRCAS have conducted researches through interdisciplinary cooperation in the fields of agriculture, fisheries, and environment, and have contributed directly in solving the problems in the Mekong Delta for several decades. The first project, "Poverty reduction and rural settlement", was in the period of 1991 to 1993. Though this project, the livelihood of farmers was dramatically improved. The second project, "Integrated farming system", was implemented in the period of 1994 to 1997, changing the traditional rice production (mono-cropping) into an integrated farming system. Through the project, farmer's income per area increased, which guaranteed food security. The other significant project entitled "Validation Study of Rural Development based on CDM in Mekong Delta" was implemented from 2008 to 2011. This was the first biogas CDM project towards the direct benefit of low-income households as well as the environment in Viet Nam. The issuance of carbon credits by CDM-EB was approved. From 2012 to present, the project entitled "Development of agriculture technologies for reducing greenhouse gas emissions from the Mekong Delta" has been conducted towards agricultural production with low greenhouse gas emissions under climate change situation. These projects helped transform the traditional method of rice production from the continuous flooding technology to the water-saving technology (alternate wetting-drying irrigation). The studies on reduction of greenhouse gas emission from livestock and use of agricultural by-products for biogas systems have been carried out under the project. The project has demonstrated a model of agricultural production with low greenhouse gas emission in Viet Nam.

On the occasion of the 50th year since JIRCAS was first established, I hope that JIRCAS will constantly develop to contribute for sustainable agriculture in developing countries and regions, and continue having tighter collaborations in the future especially with CTU in solving the problems in the Mekong Delta and Vietnam.

I wish the 50th Anniversary of JIRCAS to be greatly successful.

Congratulatory Message from Rector of CTU at JIRCAS 50th Anniversary in 2020

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Multiple drainage can deliver higher rice yields and lower methane emission in paddy fields in the An Giang Province

To evaluate the effects of a simplified form of Alternate wetting and drying (MD) on rice yield and emissions of CH_4 and N_2O in An Giang Province, we carried out 2-year field experiments at three remote sites. We compared MD and continuous flooding (CF) at each site under conventional agronomic practices through six consecutive rice growing seasons. MD was achieved with varying degrees of success at each site. Rice yield was significantly increased (by 22%) in MD plots relative to CF plots. Seasonal total CH_4 emissions were significantly reduced (by 35%) in MD plots, but no difference was found in N_2O emissions. These results indicate that MD, if adequately implemented, can increase rice yield and decrease CH_4 emissions.

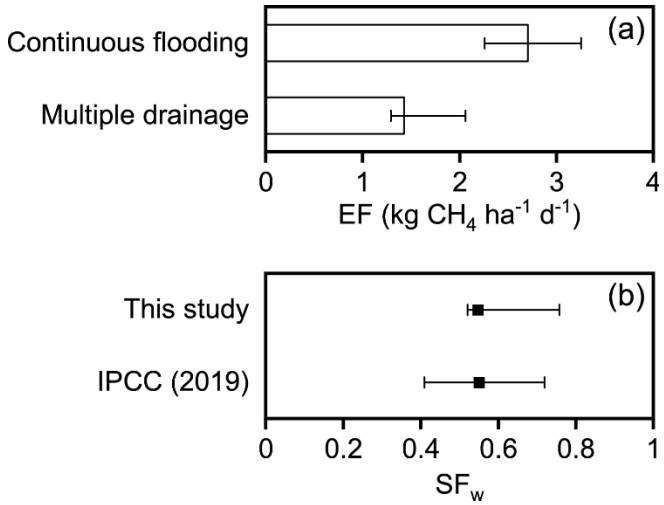


Fig. (a) Emission factors (EF) of CH_4 emissions for continuous flooding (CF) and multiple drainage (MD) and (b) the scaling factor for MD relative to CF (SFw). The horizontal bar indicates the 95% bootstrapped confidence interval (CI). The bar for IPCC (2019) in b indicates the 95% CI

"Suggestions for mitigating greenhouse gas emissions from rice cultivation in the Mekong Delta, Vietnam," was held in An Giang Province on February 28, 2019

Details：https://www.jircas.go.jp/en/program/20190523

Potential mitigation of life cycle greenhouse gas emissions from rice cultivation by alternate wetting and drying (AWD)

Alternate wetting and drying (AWD) has been introduced in Vietnam's Mekong delta. This study showed that AWD farmers lowered the use of nitrogen fertilizer and operation hours of irrigation pumps, etc. without reducing yields (Fig. 1). Despite an increase in N_2O emissions by 17%, life cycle greenhouse gas (LC-GHG) emissions were reduced by 41% (Fig. 2). LC-GHG emissions were estimated to be 9.82 for AWD and 16.6t CO_2-eq ha-1 for non-AWD farmers. Unlike water management, straw management had little influence on the CH4 emissions difference between groups, as >75% of farmers irrespective of the water management carried out on-site burning as straw management. (Fig. 3).

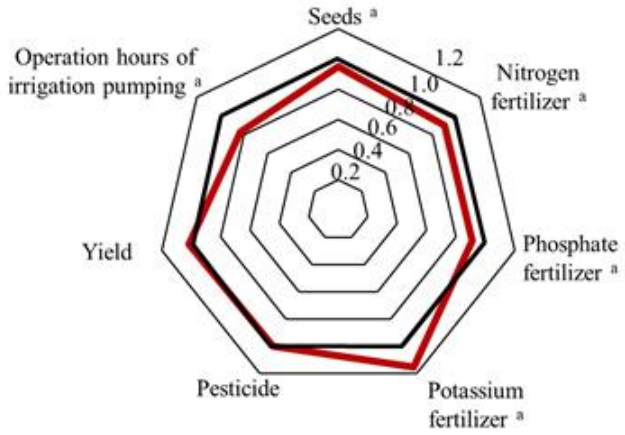


Fig.1. Ratios of AWD farmers to non-AWD farmers in the use of seeds, nitrogen, phosphate, potassium fertilizers, pesticide, yield, and operation hours of irrigation pumping, in early wet season 2019

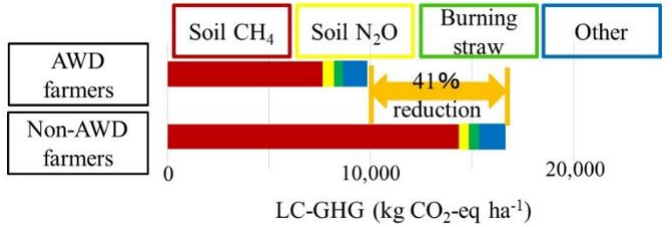


Fig.2. Comparing GHG emissions between AWD farmers and non-AWD farmers, in early wet season 2019

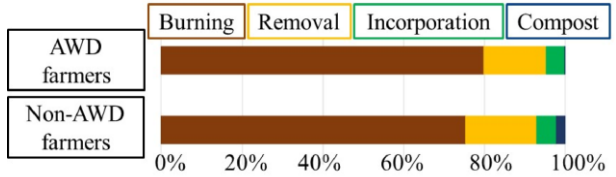
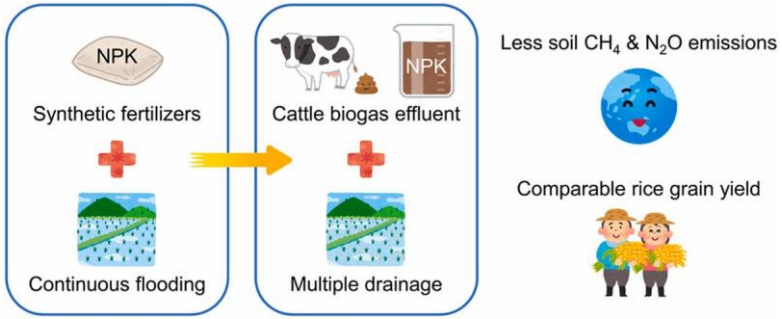


Fig. 3. Rice straw management between AWD farmers and non-AWD farmers, in early wet season 2019

Details：https://www.jircas.go.jp/en/publication/research_results/2020_a02

Multiple drainage can cancel out the enhancement of methane emissions by biogas effluent application in a rice paddy

In a triple-rice cropping system in the Mekong Delta, Vietnam, the application of cattle biogas effluent as fertilizer increased CH_4 emission by 19% relative to synthetic fertilizer application (Fig. 1). Combining multiple drainage with the biogas effluent reduced CH_4 emission by 11–13% and N_2O emission by 35–54%, without loss of rice yields, relative to the conventional practice with synthetic fertilizer and continuous flooding (Fig. 2). As a result, the Global Warming Potential (GWP), CO_2 - equivalent of combined CH_4 and N_2O emissions, and grain-yield-scaled GWP were also reduced by the proposed combination practices.



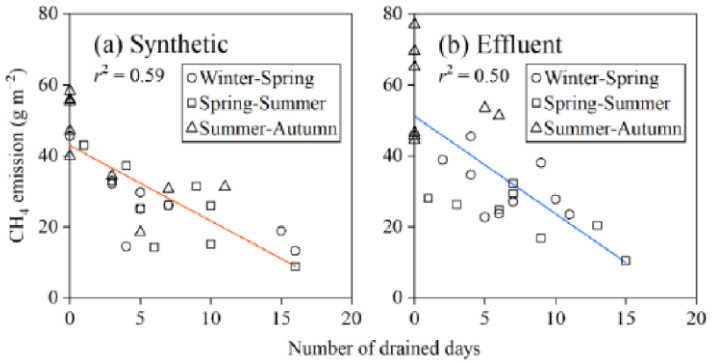


Fig.1. Relationships between CH4 emission and the number of drained days between crop establishment and final drainage in each rice season for (a) synthetic fertilizer application and (b) biogas effluent application

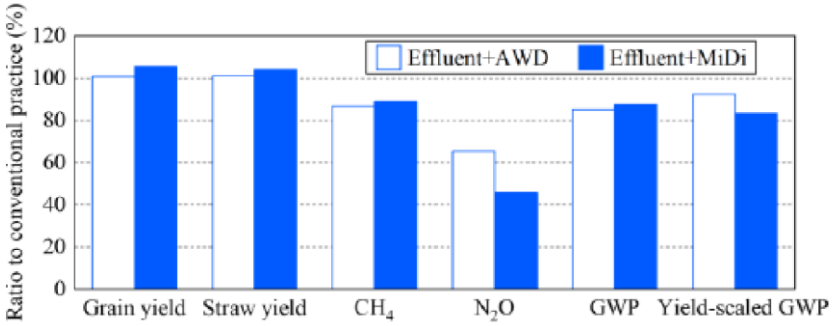


Fig.2. Comparisons between the proposed combination practices, biogas effluent application with AWD or MiDi, and the conventional practice with synthetic fertilizer application and continuous flooding

Details：https://www.jircas.go.jp/en/publication/research_results/2021_a01

Mitigation of methane emissions from Vietnamese local cattle (Lai Sind) by cashew nut shell liquid (CNSL) feeding

The effects of cashew nut shell liquid (CNSL) feeding on methane (CH_4) emissions and the ruminal microbiome of Lai Sind beef cattle were investigated. CNSL feeding mitigated 20.2%–23.4% of CH_4 emissions in vivo without apparent adverse effects on feed intake and feed digestibility. The relative abundance of methanogen decreased significantly. The predicted function of the rumen microbiome indicated that carbohydrate and lipid metabolisms were upregulated. Our findings demonstrate that CNSL feeding can mitigate CH_4 emissions from local cattle production systems in Vietnam.

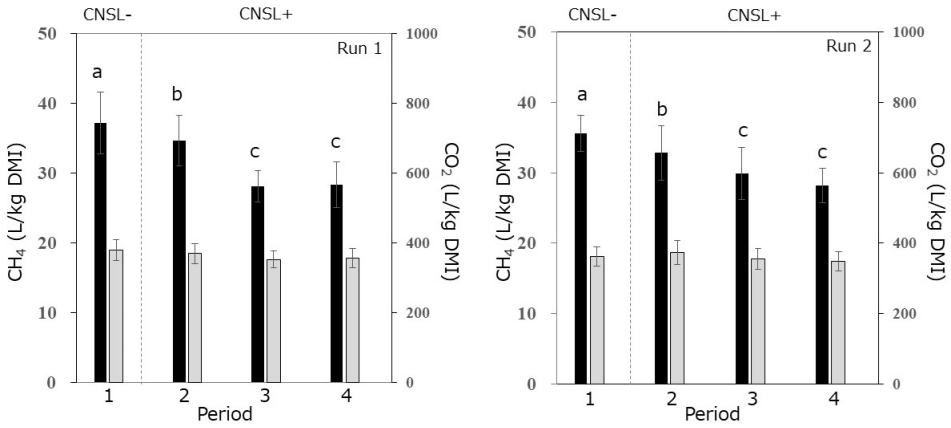


Fig.1. Enteric CH_4 (black) and CO_2 (grey) emissions per kg dry matter intake (DMI) from Lai Sind cattle, with (periods 2–4) and without (period 1) CNSL feeding (n=4), Ave. of 5 days

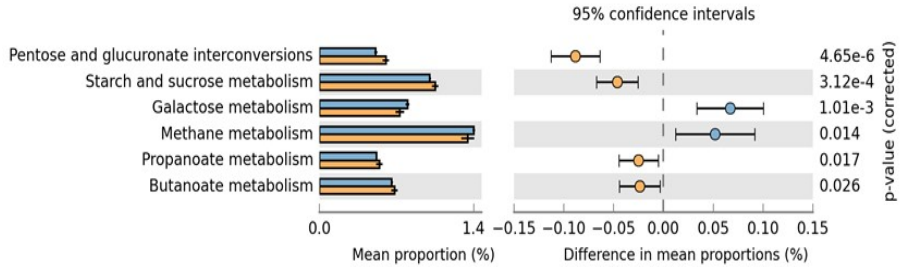


Fig.2. Effect of CNSL feeding on the function of the rumen microbiome. Orange: CNSL+, Blue: CNSL-

Details：https://www.jircas.go.jp/en/publication/research_results/2020_a01

Biogas digesters (BDs) reduce greenhouse gas emissions and provide benefits to households

The Clean Development Mechanism is an important instrument for reducing greenhouse gas (GHG) emissions in developing countries. However, this system is not working well due to the low price of carbon credits and so on. Thus, for the mitigation technology to be disseminated widely, it should be beneficial to households. In Mekong Delta, Vietnam, the installation of domestic biogas digesters (BDs) is one of the mitigation actions taken to reduce GHG emissions. This research, therefore, aims to clarify 1) whether BD is a measurable, reportable, and verifiable mitigation technology, and 2) whether BD realizes both mitigation and household benefits.

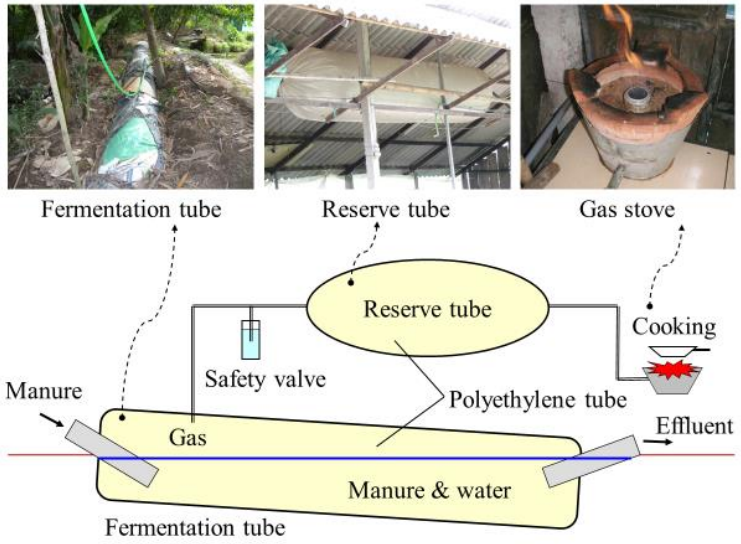


Fig. 1. Plastic biogas digester (BD) system

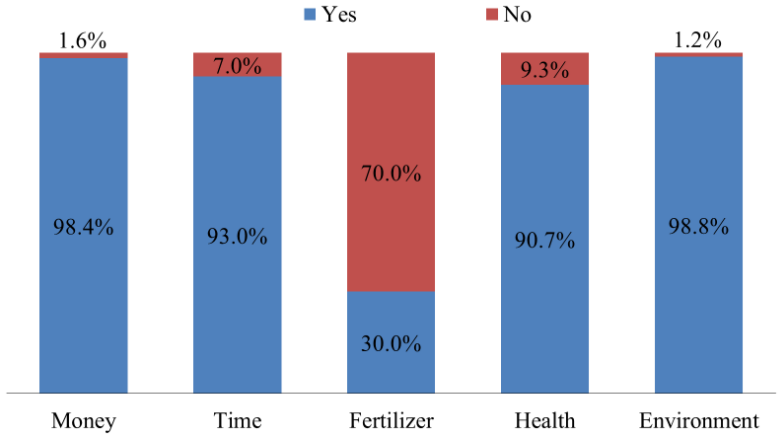


Fig. 2. Perceptions of participating households regarding the effects of BD installation

Note 1. Number of surveyed households: 257
Note 2. Money = cost savings on cooking fuel; Time = time savings associated with reduced time spent on firewood collection and cooking; Fertilizer = use of BD effluent as fertilizer for gardens and ponds; Health = health benefits from avoiding smoke and soot generated from cooking by firewood; Environment = Environmental enhancement by reducing malodors and overcoming poor water quality issues.

Details：https://www.jircas.go.jp/en/publication/research_results/2016_a01

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   - To adapt to climate change by science and technology -

Outline of the biogas CDM project

- Title: Farm Household Biogas Project Contributing to Rural Development in Can Tho City
- Duration: 7 years. Monitoring period started on 1 June 2013
- Location: 3 districts in Can Tho City, Vietnam
- Activity: Introducing around 1,000 units of biogas digester (BD) system to replace the use of firewood and LP gas with biogas. The estimated total GHG emission reduction is around 1,200 $tCO_2 \cdot year^{-1}$
- Remarks: Registered on 15 August 2012 with the UNFCCC CDM-EB. First biogas CDM project to directly benefit low-income households as well as the environment in Vietnam.

Registration of the CDM project

- Preparation of Project Design Document (PDD)
- Validation of CDM project
- Registration in UNFCCC CDM-EB

Issuance of carbon credit

- Implementation of the project
- Monitoring activities
- Verification
- Approval for issuance of credit by CDM-EB
- Issuance of credit

2008 -
Formulation of project by JIRCAS
Application of CDM methodology

Validation: on 18 - 20 Jan. 2011

- Approval of Gov. of Japan: 12 Sep. 2011
- Approval of Gov. of Viet Nam: 15 Feb. 2012

Registration of the project in UNFCCC CDM Executive Board (CDM-EB) on 15 Aug. 2012

Installation of BD

Monitoring of GHG emission reduction
(1st monitoring: 1 Jun. 2013 - 31 May 2014)

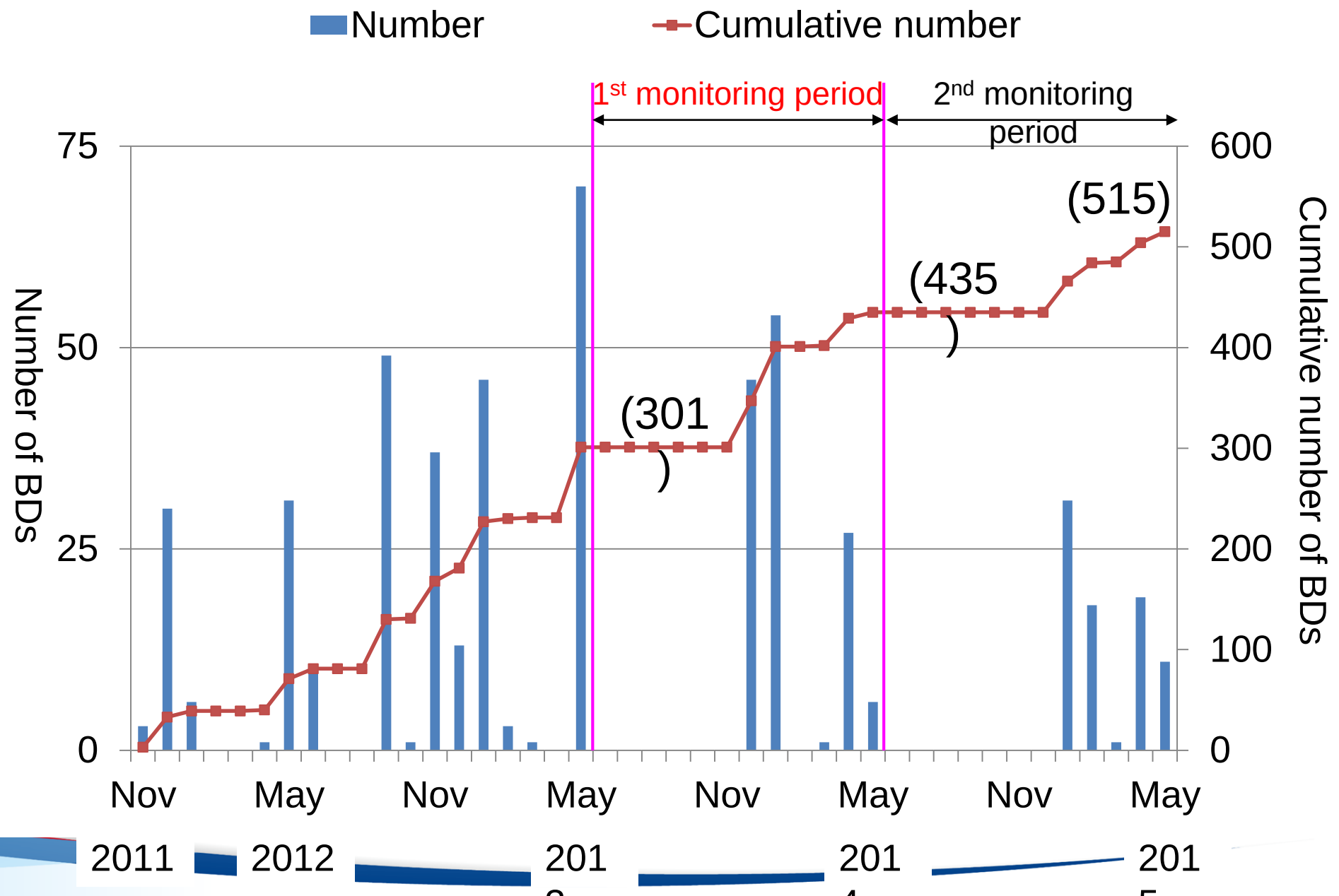
Verification by Designated Operational Entity: on 30 Sep. - 2 Oct. 2014

19 June 2015

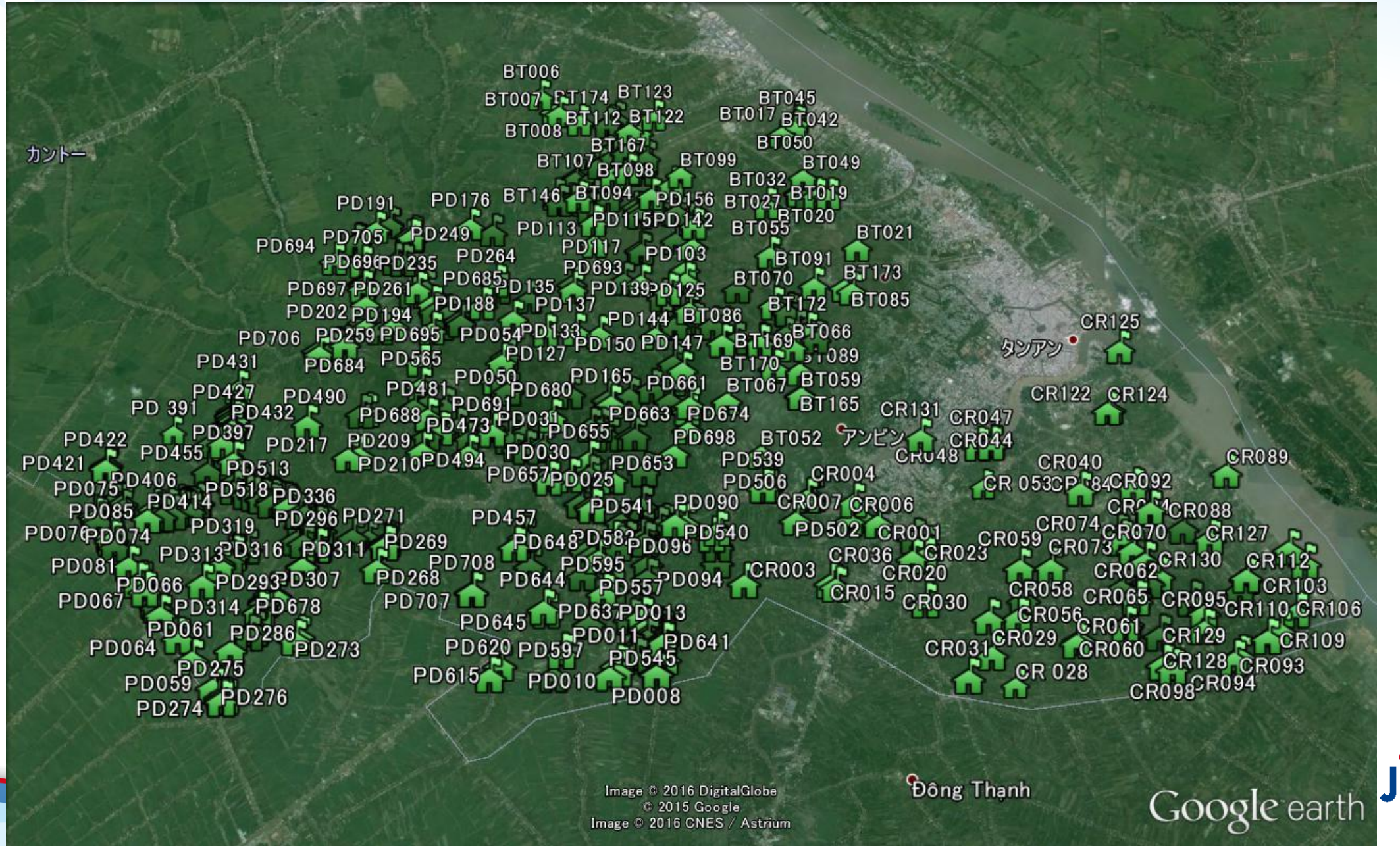
Training of Key Farmers (KFs) and implementation of the biogas CDM project

- Trained Number of KFs: 26
- Installed Number of BDs: 515

Progress of BDs installation



Distribution map of installed BDs



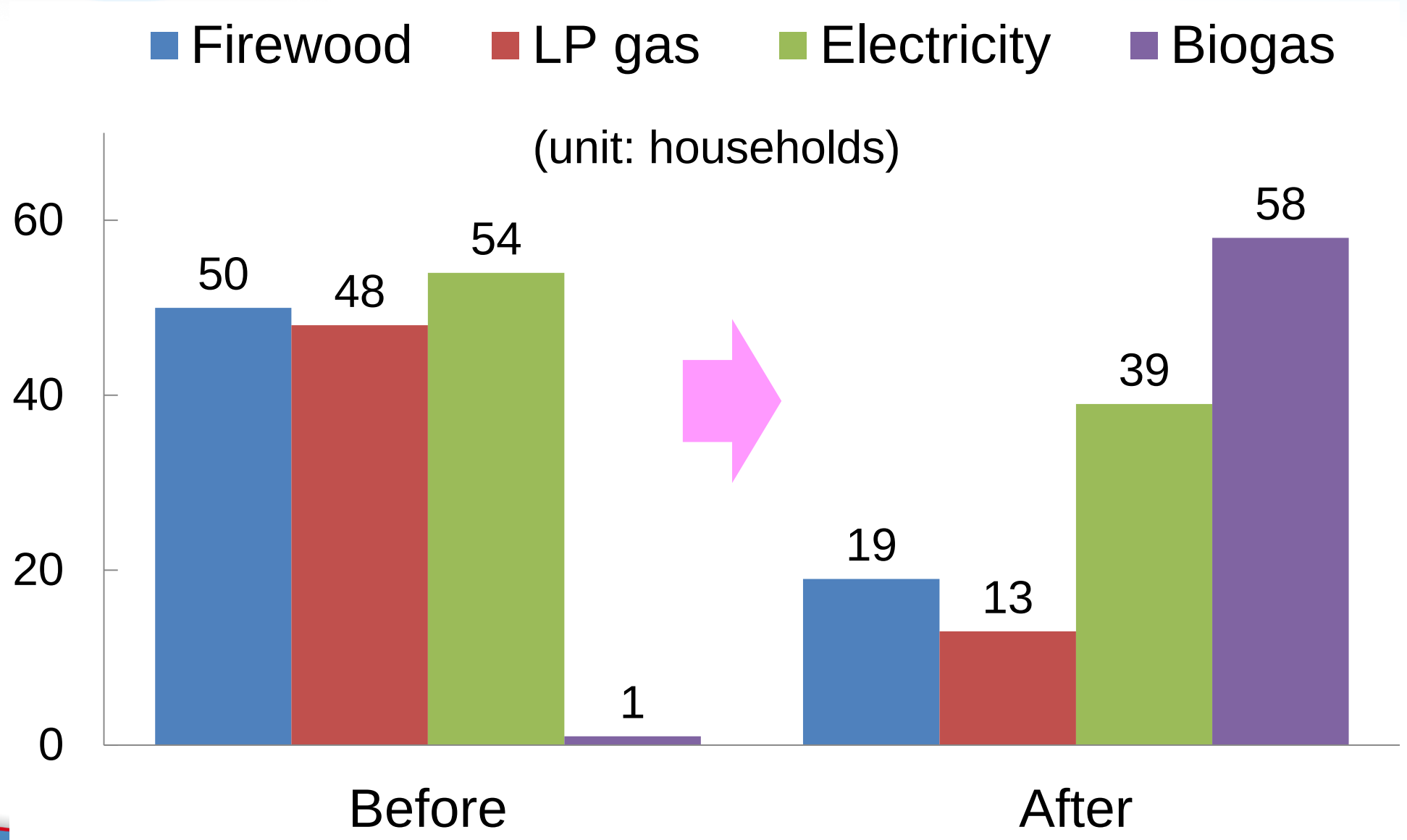
Monitoring of the CDM project

Time of biogas usage (435 households, June 2013 to May 2014)

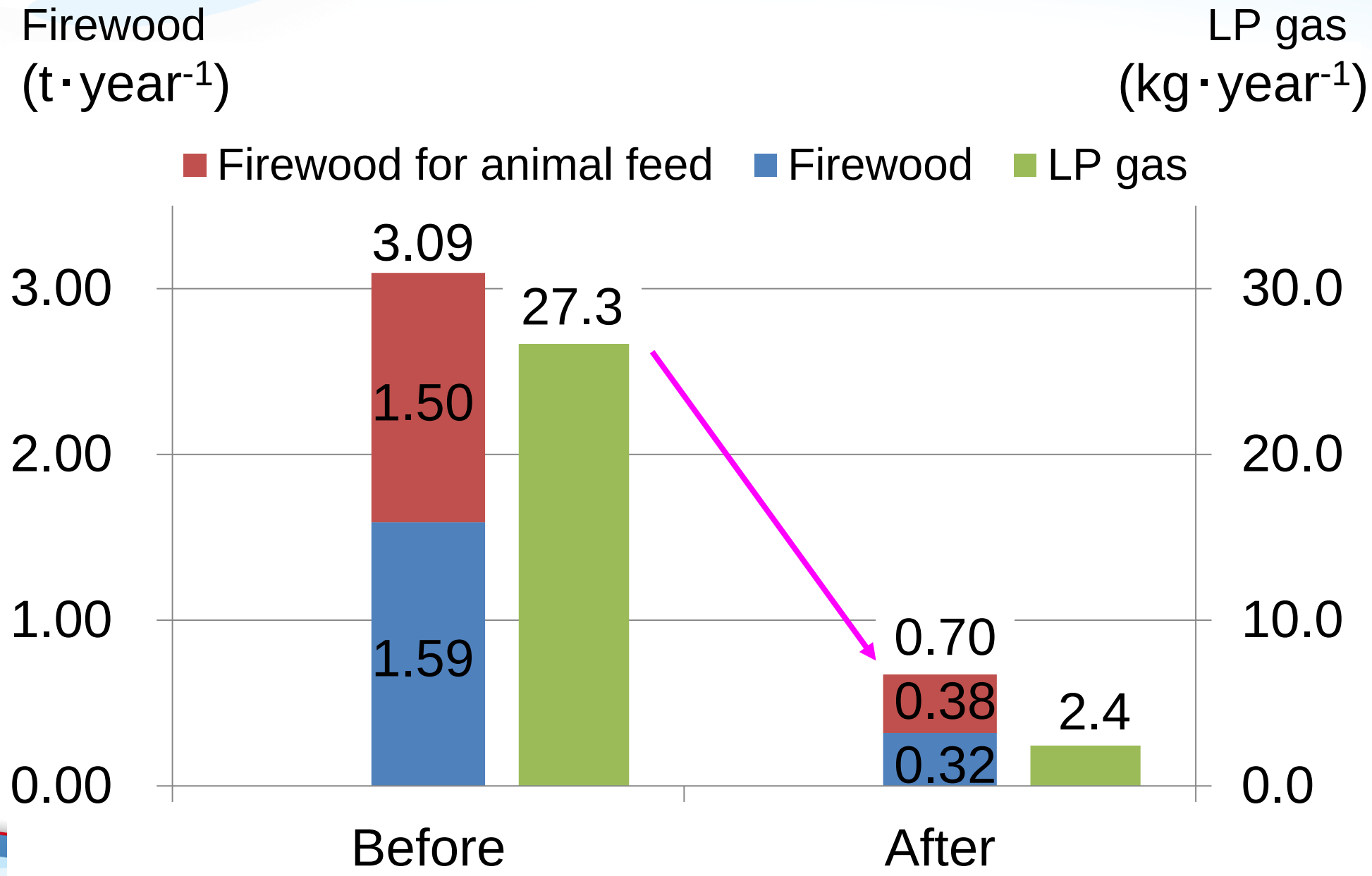
Time (h)	0	0-2	2-4	4+	Total
Days	5,234	15,469	67,605	33,988	122,296
(%)	4.3	12.6	55.3	27.8	100.0

Total operational days: 117,062 (95.7%)

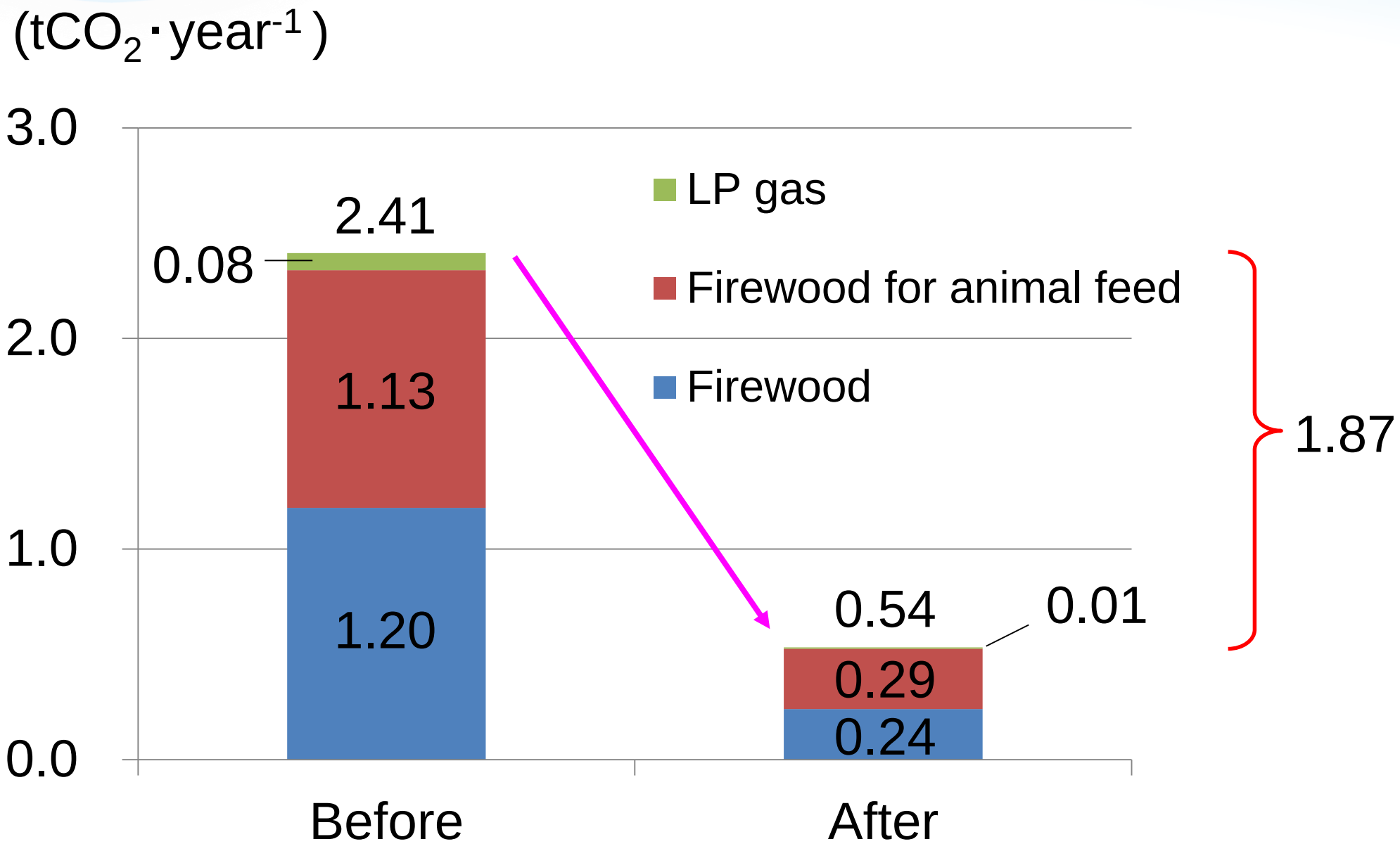
Changes in Cooking Fuel Usage



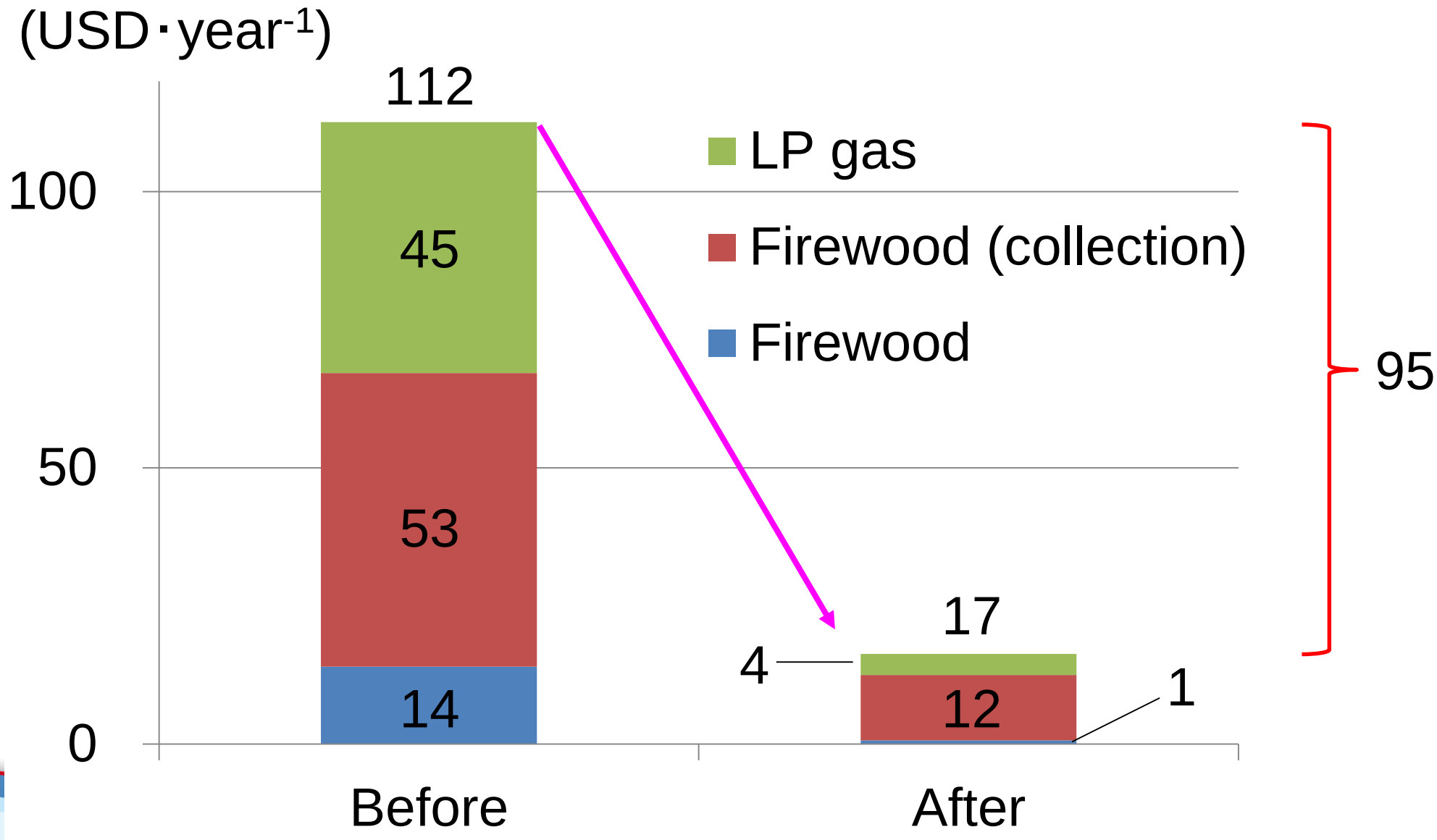
Ave. cooking fuel consumption per household



Ave. GHG emissions from cooking fuel per household



Ave. expenses for cooking fuel per household



Changes caused by introduction of BD per household (Ave. of 66 households)

Item			Before	After	Difference
Amount of cooking fuel used	Firewood ($t \cdot year^{-1}$)	Cooking	1.59	0.32	-1.27
		Animal feed	1.50	0.38	-1.12
		Total	3.09	0.70	-2.39
	LP gas ($kg \cdot year^{-1}$)		27.3	2.4	-24.9
GHG emission ($tCO_2 \cdot year^{-1}$)	Firewood	Cooking	1.20	0.24	-0.96
		Animal feed	1.13	0.29	-0.84
		Total	2.33	0.53	-1.80
	LP gas		0.08	0.01	-0.07
	Total		2.41	0.54	-1.87
Expenses for cooking fuel (USD·year^{-1})	Firewood (purchase)		14	1	-13
	Firewood (collection)		53	12	-41
	LP gas		45	4	-41
	Total		112	17	-95

Cost-benefit cash flow

1)Initial cost: material cost, labor cost, technical service by KF
2)Maintenance cost: Technical service by KF (twice a year)
3)Saved fuel cost: 95 USD・year^{-1} (sampling survey)
4)Discount rate: 6.0% (official interest rate of Vietnam)

(USD)

Year	Cost			Benefit	Cash Flow
	Initial	Maintenance	Total		
1	180	10	190	47.5	-142.5
2		20	20	95	75
3		20	20	95	75
4		20	20	95	75
5		20	20	95	75
6		20	20	95	75
7		20	20	95	75
Total	180	130	310	617.5	307.5

NPV USD 214

4. Future of biogas research in Mekong Delta
- Adapting to climate change through science and technology -

- Currently, the world is facing global warming concerns and the problem of rising prices of energy and chemical fertilizers.
- BDs can contribute to reduced GHG emission, pollution and supply energy and fertilizers by effectively utilizing the abundant local resources in the Mekong Delta.
- In particular, the Mekong Delta is a major rice production area in Vietnam, and it is hoped that the energy and fertilizers supplied by BDs will be utilized for rice production.
- However, in order to establish this system, various issues remain (ex. Application of biogas effluent to a farmer's field in practice), and JIRCAS and Can Tho University will continue joint research to solve these issues.

Thank you for your attention!