Initiative for Climate Action Transparency - ICAT -

PRELIMINARY RESULTS FROM APPLICATION OF THE GACMO MODEL TO ACCESS GHG MITIGATION POTENTIAL IN AGRICULTURE SECTOR OF VIETNAM

Hanoi, July 2020

Initiative for Climate Action Transparency - ICAT -

Application of GACMO model to access GHG mitigation potential for Agriculture Sector of Vietnam

Deliverable: D2.1.A

Date of the deliverable: June 2020

AUTHORS

Mai Van Trinh[1], Bui Thi Phuong Loan[1], Dao Thi Thu Hang[1], Duong Linh Phuong[1], Vu Thi Hang[1], Nguyen Quang Chien[1], Ha Quang Anh[2], Nguyen Hung Minh[2]

[1]Institute for Agriculture Environment, the Ministry for Agriculture and Rural Development of the Socialist Republic of Vietnam;

[2]Center for Ozone layer protection and Low-carbon Economy Development of the Department of Climate Change, Ministry of Natural Resources and Environment of the Socialist Republic of Vietnam

DISCLAIMER

PUBLISHED BY

- Institute for Agriculture Environment, Ministry for Agriculture and Rural Development (Vietnam)

- Center for Ozone Protection and Low-carbon Economy Development/ Department for Climate Change/ Ministry of Natural Resources and Environment, Vietnam;

PREPARED UNDER

Initiative for Climate Action Transparency (ICAT) project supported by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the Children's Investment Fund Foundation (CIFF), the Italian Ministry of Ecological Transition (IMET) and ClimateWorks.

The ICAT project is managed by the United Nations Office for Project Services (UNOPS)

ACKNOWLEDGEMENT

We would like to acknowledge and express gratitude to Karen Holm Olsen and Gerardo Sanchez Martinez at UNEP-DTU; Emanuele Peschi, Federico Brocchieri, Marina Vitullo, Daniela Romano and Eleonora Di Cristofaro at ISPRA; colleagues at CCOZONE for insightful discussions and kind support to this report.

Contents

I. OVERVIEW OF REDUCTION MEASURES IN AGRICULTURAL SECTOR IN VIETNAM

1.1. Agricultural Reduction measures

The agricultural sector has identified 15 reduction measures, of which 11 options have been prioritized and included in the implementation plan of the Paris Agreement. These measures are in line with the action plan put in place to respond to climate change in the agriculture and rural development sector over the 2011-2015 period, with a vision to 2050 and a decision approving the greenhouse gas (GHG) emission mitigation program in agriculture and rural development to 2020. However, in order to carry out the impact assessment effectively, it is necessary to have an understanding and a detailed description of the plan to be assessed. The following table provides a checklist of the recommended information that should be included in the description of the reduction actions to allow an effective assessment.

Table 1. Description of agricultural reduction measures

No.	Information	Description
1	**Reduction measures**	**A1. Increased Use of Biogas**
	Policy tool	Research, development and deployment
	Summary of Technology	Biogas digester is a technology which captures the gas from the anaerobic fermentation of biomass from animal dung and night soil. A small-scale basic biogas digester is consisted of a tank in which the organic material is digested and combined with a system to collect and store the biogas produced. Simple but powerful sanitation technology to reduce groundwater contamination, needs for fuelwood, and indoor air pollution caused by fuelwood burning. Eliminates methane emissions created during fermentation of openly-discharged sewage.
	Current State of mitigation plans	From 1991 to 2011, with the development of the husbandry and rural sanitation sector, biotechnology developed rapidly. The demand for support of medium / large scale biogas farms and plants is increasing. The excess biogas from the bunkers is not used up. As of July 2011, 107,000 biogas plants were built in 48 provinces.

No.	Information	Description
		MARD has been implementing the project "Biogas Program for the Animal Husbandry Sector of Viet Nam" to exploit effectively biogas technology and develop a commercially viable biogas sector in Viet Nam. Produced biogas is mainly used for kitchen use at rural households. Approx. 500,000 small scale biogas digesters (< 50 m^3) have been installed.
	Implementing agencies	Priority will be given to key animal husbandry areas in the RRD, the Northern Midlands and Mountains, the North Central and Central Coast regions, and some provinces in the Mekong River Delta; Forming a national biogas project led by the Department of Livestock Production in coordination with related units
	Target of Reduction measure	Reducing odors and improving landscapes, creating a green and clean environment for livestock households due to waste being concentrated and loaded into biogas tanks
	Implementation level	Nation
	Target of the sector	Helps to produce clean and renewable energy sources: 1 m3 of biogas is equivalent to 0.6 m^3 of natural gas, 1.5 kg of firewood and 1 litter of diesel oil. From 1 m3biogas we can produce 1.5-2.2 kWh of electricity, 2.8-4.1 kWh of heat. Therefore, biogas contains methane which is a valuable gas that can be used to produce energy in cars or power plants. Objective: By 2030, reach 300,000 biogas digesters
	Target of GHG reduction	The average emissions of small-scale biogas plants (8-10m3) are 6.8 tons of CO_2 / project / year, the total emission reduction is 3.18 million tons of CO2 equivalent / year. Source: MONRE (2015). *"INDC Technical report Viet Nam's Intended Nationally Determined Contribution"*
	Existing Policy & Measures	Decision No. 3119/QĐ-BNN-KHCN (2011) Decision No. 543/QĐ-BNN-KHCN (2011) Decision No. 24/2014/QĐ-TTg
2	**Reduction measure**	**A2. Agricultural residue as organic fertilizer**
	Policy tool	Research, development and deployment
	Summary of Technology	+ Produce organic fertilizer from agricultural residue by using microorganism and composting. This is decomposition of organic matter involved with

No.	Information	Description
		microorganism activities to release degradable organic matter. + Farmers can produce micro-organic fertilizer from wastes such as human, cattle and poultry wastes; straw, corn stalks, beans, peanuts, sugarcane; green manure is composted with probiotics used to fertilize the soil to increase fertility, reduce environmental pollution. + Spread compost: is a method that can provide decomposed organic matter without heaping. + Pile composting: an affordable method to produce a large amount of micro-organic fertilizer from dry biomass by pile composting in a relatively shorter time than other methods. +Aerated static pile composting: produce compost relatively quickly (within 3 to 6 months). This method is suitable for a mixture of many types of organic waste except abattoir or fat from the food processing industry.
	Status	- Cattle reduction leads to reduced input materials for organic fertilizers. - Rarely applied for large production - Hard to collect - Increased consumption of chemical fertilizer
	Implementing agencies	Ministry of Agriculture and Rural development
	Target of Reduction measure	- Reduce organic waste - Reduce consumption of chemical fertilizer - Decrease burning and air pollution. - Increase the use of organic fertilizer, raising soil fertility and productivity - Increase crop yield - Avoiding soil degradation - Reduce GHG emission from crop residues burning
	Implementation level	Nation
	Target of GHG reduction	Reduce 1,07 $x10^{-4}$ kgCO2e/ha/year Source: *"Ministry of Natural Resources and Environment, Viet Nam, (2015). INDC Technical report Viet Nam's Intended Nationally Determined Contribution"*
	Relevant policies or actions	Decision No 3119/QĐ-BNN-KHCN (2011) Decision No 543/QĐ-BNN-KHCN (2011)

No.	Information	Description
		Circular No 108/2017/NĐ-CP
3	**Reduction measure**	**A3. AWD, System of rice intensification**
	Policy tool	Research, development and deployment
	Summary of Technology	Under the alternating wet-dry method, the rice fields are periodically drained to enhance soil aeration, preventing methane-producing bacteria, thus reducing methane emissions. After the rice is tillering, the field is drained to the ground about 15cm. After that, the field is irrigated again with a depth of about 5cm compared to before draining. This process is repeated throughout the crop except for a week before and after the flowering of the rice.
	Status	Rarely used in Vietnam, but there is a growing trend recently with regional differences
	Implementing agencies	Department of crop production - Ministry of Agriculture and rural development
	Target of Reduction measure	Remarkably reducing irrigation, decrease water consumption by 30% Decrease CH_4 GHG emission
	Implementation level	Nation
	Target of the sector	Development of irrigation canals and the use of high-efficiency pumps to deal with flooding in the rainy season
	Target of GHG reduction	1,46 tCO2e/ha/ Spring season- 2,93 tCO2e/ha/ Summer season Decrease CH_4 emission by 48% (IPCC method)
	Relevant policies or actions	Decision No 3119/QĐ-BNN-KHCN (2011) issued on December 16th 2011 about Approval of plan on GHG emission reduction in Agriculture and Rural area till 2020 Decision No 543/QĐ-BNN-KHCN (2011) issue on 23/3/2011 issuing action plan to response with climate change of agriculture and rural development sector in the period of 2011-2015 and vision to 2050
4	**Reduction measure**	**A5. Integrated crop management in rice cultivation**
	Policy tool	Research, development and deployment

No.	Information	Description
	Summary of Technology	ICM was developed based on a number of crop management practices. The main components of ICM include: seed and location selection, seed quality, rotation, soil and nutrition management, crop protection, landscape management and Natural surroundings, and energy efficiency. ICM implementation can contribute to GHG emission reduction through energy saving in rice cultivation. High efficiency water pump can reduce a total energy usage and save cost and maximum irrigation and drainage capacity and unit which satisfy the idea of ICM in energy usage, especially fossil fuels
	Status	Integration of measures to save input sources such as 3 decreases 3 increases, saves and optimizes fertilizers, reduces N_2O emissions due to excessive or unreasonable fertilizer application. The scale of ICM application is 1 million ha
	Implementing agencies	Ministry of Agriculture and Rural development
	Target of Reduction measure	Water and fertilizer saving Pesticide saving
	Implementation level	Ministry of Agriculture and Rural development
	Target of the sector	5,2 tCO_2e/unit/year
	Relevant policies or actions	Decision No 3119/QĐ-BNN-KHCN (2011) issued on December 16th 2011 about Approval of plan on GHG emission reduction in Agriculture and Rural area till 2020. Decision No 543/QĐ-BNN-KHCN (2011) issue on 23/3/2011 issuing action plan to response with climate change of agriculture and rural development sector in the period of 2011-2015 and vision to 2050.
5	**Reduction measure**	**A6- Integrated Crop Management on the annual upland crop**
	Policy tool	Research, development and deployment
	Summary of Technology	(ICM): ICM was developed based on several crop management practices. Major Components of ICM includes: Site and variety selection, Seed quality and health, Site, Crop Rotation and Varietal Choice, Soil Management and Crop Nutrition, Crop Protection,

No.	Information	Description
		Wildlife and Landscape Management, and Energy efficiency. ICM practice can contribute to promote GHG reduction by focusing on energy efficiency in crop cultivation.
	Status	ICM measures have been applied on crops such as corn, soybean, melons, vegetables, coffee, etc. to help improve crop yields and increase product quality. Save and optimize fertilizer, reduce N_2O emissions due to excessive or unreasonable fertilizer application. The scale is 1 million ha
	Implementing agencies	MARD
	Target of Reduction measure	Save water, fertilizer, reduce seeds Reduce plant protection drugs, and save energy
	Implementation level	MARD
	Target of the sector	Reaching the scale of 1 million hectares. Which gives priority to coffee and maize
	Target of GHG reduction	GHG reduction potential in 2030 is 0.32 tons CO_2e / year)
	Relevant policies or actions	Decision No. 3119/QĐ-BNN-KHCN (2011) Decision No. 543/QĐ-BNN-KHCN (2011
6	**Reduction measure**	**A7: Applying SA (Sulphate Ammon $(NH_4)_2SO_4$) instead of Urea**
	Policy tool	Research, development and deployment
	Summary of Technology	As part of the fertilizer factory, the following equipment can save energy: high-pressure steam pipes insulated with calcium silicate (0.78 GJ / t), CO-type conversion tanks thermal (0.418 GJ / t), installation of speed control devices for cooling tower fans (2.77 kWh / ton), and Steam Trap Management (0,0003 GJ / t).
	Status	GHG emissions from urea fertilizer production from coal account for 83% of urea fertilizer production. Ammoni Sulphate fertilizer is used sparingly because of its low nitrogen content and higher transfer costs and high import reliance.
	Implementing agencies	Ministry of Agriculture and Rural Development

No.	Information	Description
	Target of Reduction measure	Applying SA fertilizer instead of urea in scale of 2 million ha to reduce N_2O
	Relevant policies or actions	Law No 50/2010/QH12 on economical and efficient use of energy Decision No. 1621 / QD-TTg (2013) approving the planning for development of Vietnam's chemical industry by 2020 with a vision to 2030
7	**Reduction measure**	**A8- Reuse of upland crops Residues**
	Policy tool	Research, development and deployment
	Summary of Technology	Annual crop residues will be collected and processed (composted) for agricultural production with 25% of annual crop residues, Sheet composting: is a method which can provide organic material without building a composting pile Static pile composting: can produce compost relatively quickly (within 3 to 6 months). This method is suitable for a relatively homogenous mix of organic waste except animal by-products or grease from food processing industry.
	Status	Sugar cane, banana, pineapple, coffee, sugar, cassava are the main upland crops and they are grown on a small scale on upland.
	Implementing agencies	Priority should be given to areas with large areas of dry crops in the North Central Coast, Central Highlands, Southeast and Northern mountainous areas (maize). Department of Crop Production is the focal point, in collaboration with agencies of the Ministry (Department of Science, Technology and Environment, OCCA Office), National Agricultural Extension Center and localities.
	Target of Reduction measure	The scale of implementation is 2.8 million hectares of annual crops in 2030
	Implementation level	Nation

No.	Information	Description
	Target of the sector	Reduce the amount of chemical fertilizer, increase the use of organic fertilizer in agriculture, reduce GHG emissions
	Target of GHG reduction	3-30 USD / m^2 (Sheet composting) with the potential of reducing emissions of 0.29 $x10^3$ $kgCO_2eq$ / ha / year by 2030 Source: MONRE (2015). *"INDC Technical report Viet Nam's Intended Nationally Determined Contribution"*
	Existing Policy & Measures	Decision No.3119/QĐ-BNN-KHC 16 /12/2011) Decision No.543/QĐ-BNN-KHCN 23/ 3/2011
8	**Reduction measure**	**A11. Improvement of livestock diets**
	Policy tool	Research, development and deployment
	Summary of Technology	Large portions of enteric methane and nitrous oxide comes from fermentation processes in ruminants. Cattles emit 60 to 160 kg CH_4/yr, depending on their size and DMI (Dry Matters Intake). Although, long-term effect still need to be confirmed, dietary lipids (e.g. fatty acids, medium to long chain) are reported to suppress CH_4 production. For monogastric farm animals, adding Lysine in feed is effective in reducing the total volume of CO_2 produced in the process from manufacture of raw materials to production (life cycle) as well as excretion of nitrogen.
	Status	In Viet Nam ruminant production is based on small households; there are few large commercial units. The marginal abatement cost (MAC) curve demonstrated in the INDC indicates that feeding Lysine for pigs/chickens is financially attractive. Initial cost is 3.6 USD/kg of linseed oil (1USD=110 JPY) and 2.15 USD/kg of Lysine (2012) This measure does not affect other ruminal parameters and safe to the animals (Lipid supplement) and amino acid balance and efficiency of feeds can be improved, resulting in reduction of the amount of animal waste and methane gas
	Implementing agencies	Ministry of Agriculture and Rural Development

No.	Information	Description
	Target of Reduction measure	Reducing GHG from animal husbandry through improved animal diets
	Implementation level	National
	Target of the sector	Add fat (lipid) to ruminant animals Using Amino Acid (Lysine) food for pigs and chickens
	Target of GHG reduction	Mean decrease in CH_4 of 3.8% with each 1% addition of supplemental fatty acid 1 t of Life-cycle-CO2/2.4 kg of added Lysine
	Relevant policies or actions	Decision No. 3119/QD-BNN-KHCN (2011) Decision No. 543/QD-BNN-KHCN (2011)
9	**Reduction measure**	**A12. Improvement of quality and services available for aquaculture such as inputs and foodstuff**
	Policy tool	Research, development and deployment
	Summary of Technology	Purification, aerobic treatment, microbe fermentation, up-flow anaerobic blanket process and rotating biological contactor are the series of methods to reduce/remove impurities in wastewater generated from the livestock production, food and aquaculture processing. It can also recover methane gas for power generation
	Status	The technology can quick and high efficiency processing can be implemented resulting in reduced fuel cost and other production cost 108,208 USD/unit (for biogas co-generation system of 25 kW) and 324,624 USD/unit (for Up-flow anaerobic sludge blanket (UASB))
	Implementing agencies	Ministry of Agriculture and Rural Development
	Target of Reduction measure	Improve the quality and services of breeds, feed and supplies for aquaculture
	Implementation level	National
	Target of the sector	Wastewater treatment with backflow biological treatment tank through anaerobic sludge (UASB) and biological rotary disc type wastewater treatment equipment (RBC)

No.	Information	Description
		Methification process by wet fermentation biological method
	Target of GHG reduction	7.739 tCO2eq/system/year
	Relevant policies or actions	Decision No. 3119/QĐ-BNN-KHCN (2011) Decision No. 543/QĐ-BNN-KHCN (2011)
10	**Reduction measure**	**A13. Improvement of technologies in aquaculture and waste treatment in aquaculture**
	Policy tool	Research, development and deployment
	Summary of Technology	Biogas plant can capture the methane gas that results from the anaerobic fermentation of biomass from aquaculture waste. An industrial scale of basic biogas digester usually consists of five equipment: 1) Pretreatment system; 2) Sterilization system; 3) Methane Fermentation system; 4) Gas Utilization system; and 5) Post-Treatment system.
	Status	Current technology is anaerobic/Open Lagoon Treatment Initial cost is 1,125 USD/ton (initial cost is subject to the scale of the plant system, etc.) Technical advantages are quick and high efficiency process and Energy saving
	Implementing agencies	Ministry of Agriculture and Rural Development
	Target of Reduction measure	Reducing GHG through technology improvement in aquaculture and waste treatment in aquaculture
	Implementation level	National
	Target of the sector	Methane and power generation from aquaculture waste treatment
	Target of GHG reduction	22,806 tCO_2eq/year (from the plant: one anaerobic digester with biogas production of 3,000 m^3 /day, and one 500 kW biogas generator with power generation of 3,285 MWh/year)
	Relevant policies or actions	Decision No. 3119/QĐ-BNN-KHCN (2011) Decision No. 543/QĐ-BNN-KHCN (2011)

No.	Information	Description
11	**Reduction measure**	**A14. Improved irrigation for coffee**
	Policy tool	Research, development and deployment
	Summary of Technology	Change the amount of water for coffee to increase the effectiveness of reducing irrigation from 600 litters / tree to 400 litters / tree, 640,000 hectares of coffee
	Status	Farmers are watering the traditional method of surface watering The technical advantage is that higher irrigation efficiency leads to reduced water consumption and reduced fuel costs and other production costs.
	Implementing agencies	Ministry of Agriculture and Rural Development
	Target of Reduction measure	Change the technology and process of irrigation for coffee to increase efficiency and reduce GHG emissions
	Implementation level	National
	Target of the sector	Improving irrigation technology for 640,000ha coffee trees nationwide
	Target of GHG reduction	Reducing GHG emissions by 3.39 million tons CO_2eq
	Relevant policies or actions	Decision No. 3119/QĐ-BNN-KHCN (2011) Decision No. 543/QĐ-BNN-KHCN (2011)
12	**Reduction measure**	**A15. Improved technologies in food processing and waste treatment in agriculture, forestry and aquaculture**
	Policy tool	Research, development and deployment
	Summary of Technology	Reform technology for processing and processing of agricultural, forestry and fishery wastes on a national scale
	Status	Processing seafood using low efficiency cooling
	Implementing agencies	Ministry of Agriculture and Rural Development
	Target of Reduction measure	Reduction of GHG by improving technologies in food processing and waste treatment in agriculture, forestry and aquaculture

No.	Information	Description
	Implementation level	National
	Target of the sector	Improving technologies in food processing and waste treatment in agriculture, forestry and aquaculture with 21 million tons of products scale
	Target of GHG reduction	Reducing GHG emissions by 3.36 million tons CO_2eq Source: MONRE (2015). *"INDC Technical report Viet Nam's Intended Nationally Determined Contribution"*
	Relevant policies or actions	Decision No. 3119/QĐ-BNN-KHCN (2011) Decision No. 543/QĐ-BNN-KHCN (2011) Decision No. 24/2014/QĐ-TTg (2014)

1.2. Classification of the reduction measures

The Reduction measures can be independent of each other or they can interact with each other. The Reduction measures interact if they affect the same GHG source or carbon pool, therefore the policy makers can access according to policies individually or a package. By reviewing the evaluation objectives, the feasibility we have classified the impact assessment individually or in the form of packages. Table 2 below categorizes mitigation options and the interaction between policies.

Table 2. Classification of the reduction measures

No.	Reduction measures	Individual	Package	Name of options
1	A1	x		Increased Use of Biogas
2	A2, A3, A5, A7, A9		x	GHG mitigation in paddy rice cultivation
3	A6, A8		x	Integrated cultivation of upland crops
4	A11	x		Improvement of livestock diets
5	A12, A13		x	Improvement of quality and services available for aquaculture, such as inputs and foodstuff
6	A14	x		Improved irrigation for coffee
7	A15		x	Improved technologies in food processing and waste treatment in agriculture, forestry and aquaculture

II. METHODOLOGY FOR ASSESSMENT OF MITIGATION POTENTIAL

2.1. Database

The data used in this report are secondary data collected from reliable and transparent documents.

We use in Vietnam's biennial update report for the United Nations Framework Convention on Climate Change for baseline and growth data.

The data used for calculating emissions for each of the emission reduction options is used from the report: "Low carbon technology assessment facilitates Viet Nam's nationally determined Contribution", however, there is some data referenced from previous studies, published information and implemented projects.

2.2. GACMO model

GACMO is a spreadsheet model that can calculate the amount of GHG reduction and cost for mitigation options compared to the technology used in BAU (Business as usual).

GACMO allows creating other mitigation options and to provide an overview of the total mitigation effort. The model starts from a baseline year with emission and energy balance. In this report, we use 2014 as the start year balance for calculation.

In agriculture, the following criteria are used for the input of the base year: intestinal fermentation in animal husbandry, livestock waste, rice farming, N20 emissions in agricultural land, burning waste agricultural and forestry by-products, solid and liquid wastes.

Table 4: GHG emissions (Unit: kt-CO_{2eq})

Total Agriculture	**88,353**
Enteric fermentation	9,468
Manure management	8,560
Rice cultivation	44,614
N2O from agricultural soils	23,812
Burning of agricultural residues	1,899
Forestry	-22,544
Waste - solid	6,908
Waste - liquid	8,444

Once the model has been calibrated on the start year, the sheet “Growth” has to be filled with data on the expected evolution of GDP and population, as well as on energy consumption with the same level of detail used in the balance and emissions for non-

energy sectors. These data are needed for forecasting purposes in the BAU scenario. In this report, we consider the growth in 3 periods: 2014 - 2020, 2020 - 2025, 2025 - 2030.

Table 5: Growth in 3 periods

Start year	**2014**		
Emission source	**% Annual change in GHG emissions in each period**		
	2014 – 2020	**2020 – 2025**	**2025 - 2030**
Livestock emissions	6.4%	1.8%	1.8%
Rice emissions	-2.0%	0.2%	0.2%
N2O from agricultural soils	0.0%	0.0%	0.0%
Biomass burning	5.3%	0.7%	0.7%
Forestry emission	0.0%	-20.6%	0.6%
Solid waste emissions	12.6%	14.1%	14.1%
Liquid waste emissions	6.6%	2.9%	2.9%

Besides, several parameters are assumed to request information include: Exchange rate with US dollars; Discount rate; Prices of oil, coal, natural gas, liquefied natural gas, oil products, electricity and heat distribution.

Table 6:Information of some parameters

Assumptions and Country settings

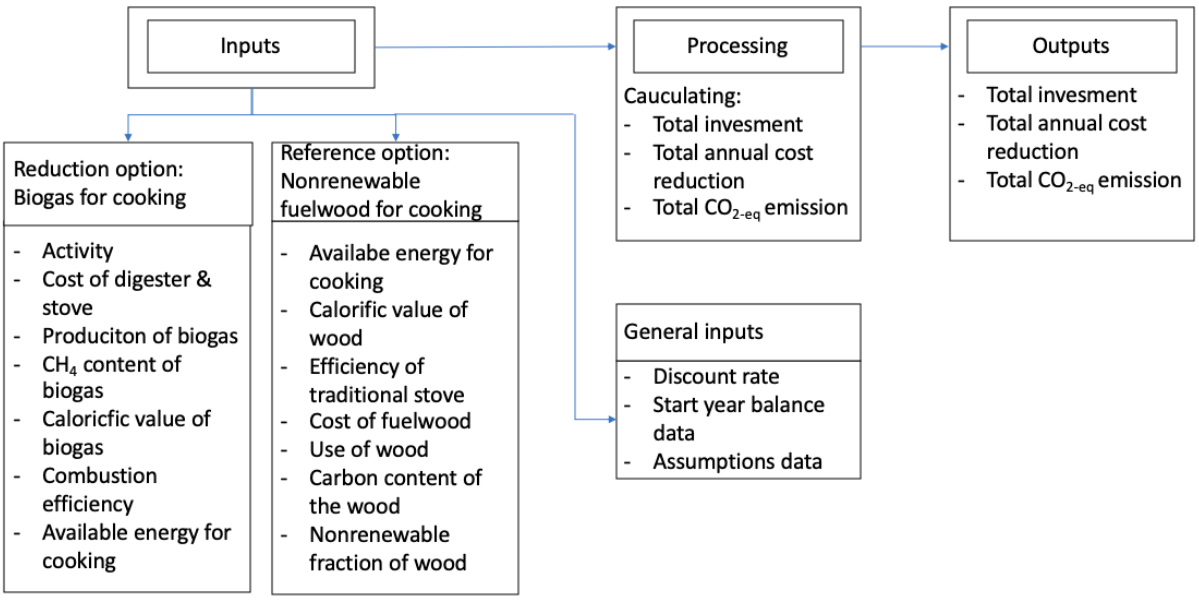
Country:	VIETNAM	
Start year (latest inventory):	2014	
Currency:	VND	
Exchange rate used: 1 US$=	23,000	VND
Discount rate =	10.0%	

Energy prices used for the whole period:

Crude oil	51.5	US$/bbl
Crude oil	0.32	US$/litre
LNG	4.4	US$/MBTU
Natural gas	4.2	US$/GJ
Coal	60	US$/ton

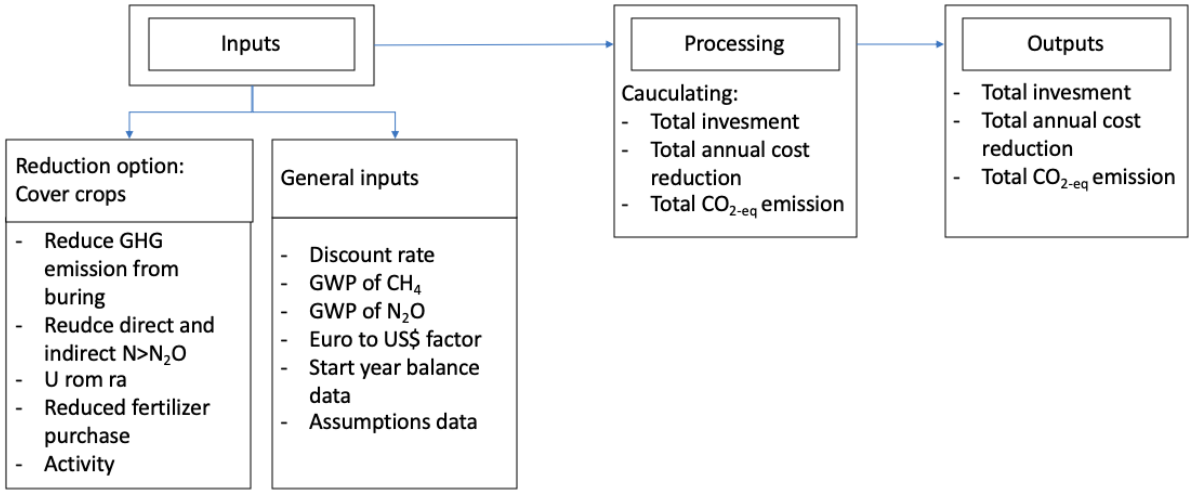
The model has more than 100 emission reduction options sorted by sectors with the goal of determining the total CO2 emissions for each emission reduction option. However, with 15 options for reducing emissions in agriculture, only 10 options are presented in the form of the chart below:

a/ Option A1: Increased use of biogas

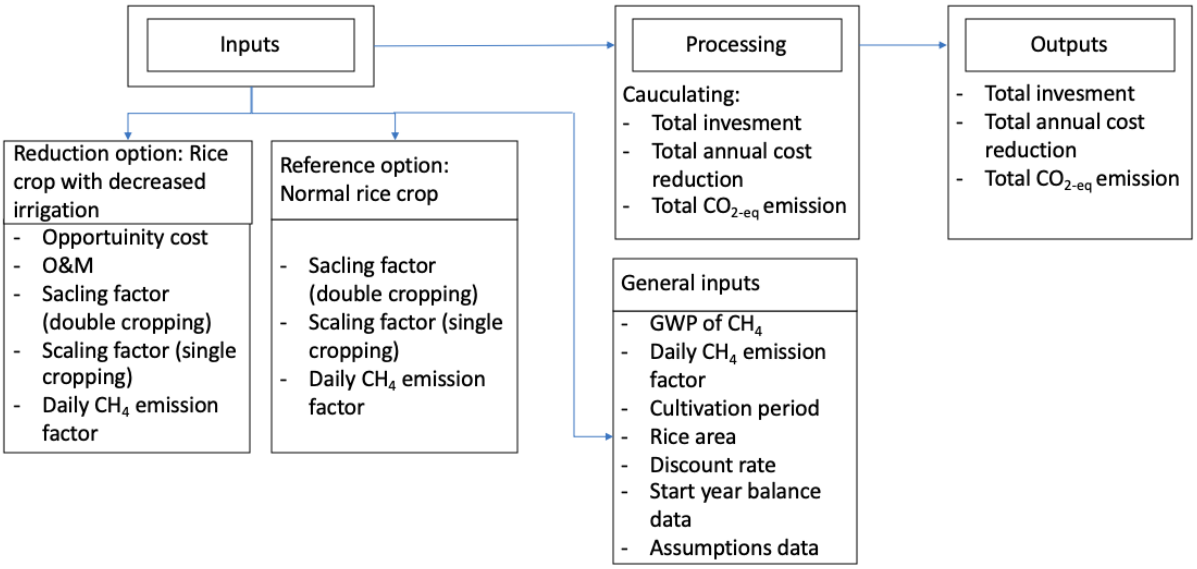


b/ Group II (A2, A3, A5, A9): Reduction options on rice cultivation (Package option):

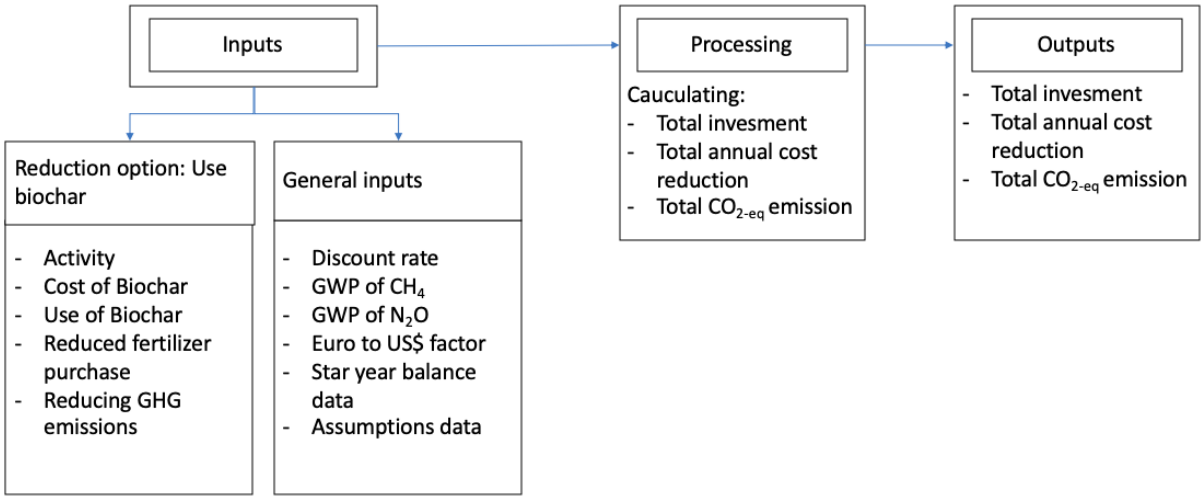
- Option A2: Reuse of agricultural residue as organic fertilizer



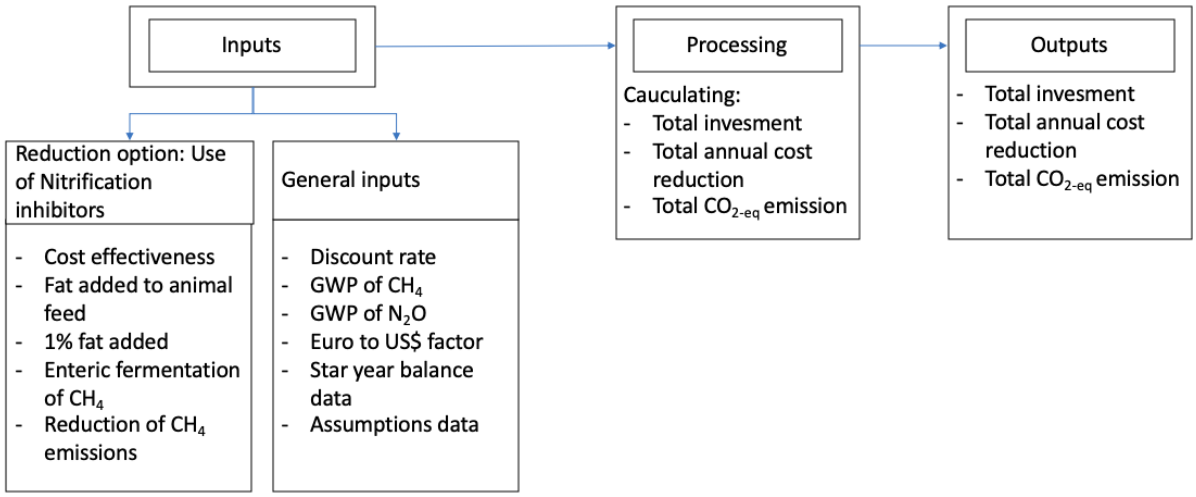
- Options A3, A5, A9:



c/ Package: Integrated crop management (ICM) in annual upland crop cultivation



d/ Option A11: Improvement of livestock diets



III. RESULTS AND DISCUSSION

3.1. Data arrangement for operation of GACMO

Option A1: Increased use of biogas

A1							
Costs in US$	Reduction Option	Reference Option	Increase (Red.-Ref.)		**General inputs:**		
Total investment	282,000,000				Discount rate	10%	
Project life	20				**Reduction option: Biogas for cooking**		
Lev. investment	33,123,614		33,123,614		Activity	500,000	biogas plant
Annual O&M			0		Cost of digester & stove	564	US$
Annual fuelcost		3,692,726	-3,692,726		Production of biogas	14	m3/day
Total annual cost	33,123,614	3,692,726	**29,430,888**		CH4 content of biogas	60%	
					Calorific value of biogas	23.4	MJ/m3
Annual emissions (tons)	Tons	Tons	Reduction		Combustion efficiency	60%	
Fuel CO2-eq. emission	0	4,352,142	4,352,142		Available energy for cooking	197	MJ/day
Other							
Total CO2-eq. emission	0	4,352,142	**4,352,142**		**Reference option: Nonrenewable fuelwood for cooking**		
					Available energy for cooking	197	MJ/day
US$/ton CO2-eq.			**6.8**		Calorific value of wood	136	MJ/kg
					Efficiency of traditional Stove	10%	
Notes:					Cost of fuelwood	1	US$/kg
2 m3 biogas plant feed with cattle dung and other organic waste produce biogas for cooking purpose and heating of hot water.					Use of wood	14.5	kg/day
Data from the CDM project (ref=3541): Social Education and Development Society (SEDS) Biogas CDM project for the rural poor (in India)					Use of wood	5.3	t wood/yr
					Carbon content of the wood	2.6	t C/year
					Nonrenewable fraction of wood	90%	

3.1.1. Package A2, A3, A5, A7, A9: Reduction options in rice cultivation

Option A2

A2							
Costs in US$	Reduction Option	Reference Option	Increase (Red.-Ref.)		General inputs:		
Total investment	0		0		Discount rate	10%	
Project life	20				GWP of CH4 =	25	Ton CO2
Lev. investment	0		0		GWP of N20 =	298	Ton CO2
Annual O&M	20942		20942		1 Euro=	1	US$
Annual fuelcost			0		Reduction option: Cover crops		
Total annual cost	20942		20942		reduce GHG emission from burnir	0.38745636	tCO2e/ha/yr
					Reduce direct and indirect N>N2O		tCO2e/ha/yr
Annual emissions (tons)	Tons	Tons	Reduction		Ủ rơm rạ	24.1043478	US$/ha/yr
Fuel CO2-eq. emission		387	387				
Other			0		Reduced fertiliser purchase	-3.16252174	US/ha/yr
Total CO2-eq. emission	0	387	387		Activity	1000	ha/year
					Reference option: Normal crops		
US$/ton CO2-eq.			54.0				

Options A3, A5, A9

A3, A5, A9							
Costs in US$	Reduction Option	Reference Option	Increase (Red.-Ref.)		General inputs:		
Total investment	2,609	ADB3772-VIE, bộ KH và Đầu tư,2003			Discount rate	10%	
Project life	20				GWP of CH4	21	
Lev. investment	306	0	306		Daily CH4 emission factor	1.3	kgCH4/ha/day
Annual O&M	835	965	- 130		Cultivation period	200	days/year
Annual fuelcost			-		Rice area	1000	ha
Total annual cost	1,141	965	176				
					Reduction option: Rice crop with decreased irrigation		
Annual emissions (tons)	Tons	Tons	Reduction		Opportunity cost	1.2	US$/ton CO2e
Fuel CO2-eq. emission			0		O&M		
Emission of CH4	1	5			Scaling factor (double cropping)	1.73	Single aeration
Total CO2-eq. emission	1	5	4		Scaling factor (double cropping)	0.20	Multiple aeration
					Scaling factor (single cropping)	**0.69**	Single aeration
					Scaling factor (single cropping)	0.60	Multiple aeration
					Daily CH4 emission factor	0.3	kgCH4/ha/day
US$/ton CO2-eq.			40.3		Remember to choose the correct scaling factor		
Notes:					Reference option: Nomal rice crop		
Irrigated, flooded fields for an extended period during the growing season. EF (BL,c)=1.30 (kgCH4/ha/day) from IPCC 2006, volume 4, chapter 5.5, Table 5.11.					Scaling factor (double cropping)	1.00	
The daily emission factors are multiplied by the scaling factor Scaling factors from AMS-III.AU.					Scaling factor (single cropping)	**1.16**	
Ha/days from the CPA: "Methane avoidance in rice cultivation in SJB: 001" No data available for costs/savings .					Daily CH4 emission factor	1.3	kgCH4/ha/day
G. C. Nelson et al., *India Greenhouse Gas Mitigation: Issues for Indian Agriculture*, IFPRI Discussion Paper: Opportunity cost is 1.2$/tCO2e					Remember to choose the correct scaling factor		

Option A4

A4						
Costs in US$	Reductic Option	Reference Option	Increase (Red.-Ref.)	General inputs:		
Total investment	0		0	Discount rate	10%	
Project life	20			GWP of CH4 =	25	Ton CO2
Lev. investment	0		0	GWP of N20 =	298	Ton CO2
Annual O&M	261		261	1 Euro=	1	US$
Annual fuelcost			0	Reduction option: Cover crops		
Total annual cost	261		261	Increased soil C	0	tCO2e/ha/yr
				Reduce direct and indirect N>N2O	0.39	tCO2e/ha/yr
				Stove	261	US$
Annual emissions (tons)	Tons	Tons	Reduction			US$
Fuel CO2-eq. emission		0.39	0.39	Reduced fertiliser purchase		US/ha/yr
Other			-	Activity	1000	ha/year
Total CO2-eq. emission	0	0.39	0.39	Reference option: Normal crops		
US$/ton CO2-eq.			673.6			

3.1.2. Package A6, A8 – Integrated crop management (ICM) in annual upland crop cultivation

ICM CÂY TRỒNG CẠN (A6,A8,A10)						
Costs in US$	Reduction Option	Reference Option	Increase (Red.-Ref.)			
Total investment			0	General inputs:		
Project life				Discount rate	10%	
Lev. investment			0	GWP of CH4 =	25	Ton CO2
Annual O&M	62420000	0	62420000	GWP of N20 =	298	Ton CO2
Annual fuelcost			0	1 Euro=	1.15	US$
Total annual cost	62420000	0	**62420000**	**Reduction option: Cover crops**		
				Activity	200000	ha
Annual emissions (tons)	Tons	Tons	Reduction	Cost of Biochar	0.58	US$/kg
Fuel CO2-eq. emission			0	Use of Biochar	1.7	ton/ha
Other		745000	745000	Reduced fertiliser purchase	-673.9	US$/ha/yr
Total CO2-eq. emission	0	745000	**745000**	Reducing GHG emissions	12.5	kgN2O/ha
US$/ton CO2-eq.			**83.785**	**Reference option: Normal crops**		

Notes: OECD Food paper no. 89 p 23: Grown for the purpose of absorbing surplus N remaining after harvest of the main crop. Iincreasing soil organic carbon content by decreasing soil carbon loss due to erosion during the fallow period; reduction in N leaching (and subsequent N2O emissions) and by reducing the amount of N that needs to be applied to the following crop (reducing synthetic fertiliser use).

3.1.3. Option A11 – Improvement of livestock diets

A11 - 2020						
Costs in US$	Reduction Option	Reference Option	Increase (Red.-Ref.)			
Total investment	12335		12335	General inputs:		
Project life				Discount rate	10%	
Lev. investment			0	GWP of CH4 =	25	Ton CO2
Annual O&M	12335		12335	GWP of N20 =	298	Ton CO2
Annual fuelcost			0	1 Euro=	1	US$
Total annual cost	12335	0	**12335**	**Reduction option: Use of Nitrification inhibitors**		
				Cost effectivenes	23.63	US$/tCO2-eq
Annual emissions (tons)	Tons	Tons	Reduction	Fat added to animal feed	3	%DM fat added
Fuel CO2-eq. emission			0	1% fat added	3.8%	Reduction in CH4
Other		522	522	Enteric fermentation of CH4	13736.7989	ktCO2-eq.
Total CO2-eq. emission	0	522	**522**	Reduction of CH4 emissions	522.0	ktCO2-eq.
					91960%	24200000
US$/ton CO2-eq.			**23.6**	**Reference option: Normal crops**		
					919600.00	

Notes: OECD Food paper no. 89 p 31: A traditional ruminant diet, contains 1.5-3 **dry matter % (DM%) fat**. The CH4 reduction is proportional to the fat content, but, due to potential health issues and practical aspects, a limit of 5-6 DM% total fat content is necessary. Various supplementary fat sources exist: whole seeds (e.g. rapeseed, linseed, soybean), plant oils (e.g. sunflower oil, rapeseed oil, palm oil, coconut oil).
With every 1% fat added CH4 emissions are reduced by approximately 4% across all ruminants.
In most cases farmers are likely to incur increased feeding costs, On the positive side, the additional fat can increase the growth rate and the milk

3.2. Total GHG emissions per unit used for emission reduction options

3.2.1. Option A1: Increased use of biogas

GACMO model can be used for calculating reduction potential for biogas to replace traditional methods using non-renewable energy. Due to the small scale to handle cattle and poultry manure, a gas stove is assumed to need an invest of about US$ 43 and the cost for a biogas pit is about US$ 521 for the generate 14 m^3/day. With the

traditional option, the investment cost is considered as zero and the efficiency is 10%. Hence, this option helps to mitigate the total CO_2 emission reduction amount is 8.7 tons CO_2eq / equipment / year, the cost for reducing 1 ton of CO_2eq is 6.8US$.

3.2.2. Package A2, A3, A5, A7, A9: Reduction options in rice cultivation

The package of GHG emission reduction options in rice cultivation is divided into two calculation methods in the GACMO model. Options A3, A5 and A9 are advanced irrigation techniques and integrated crop management (ICM) techniques to enhance soil aeration and prevent bacteria from producing CH_4. Options A2, A4 and A7 are methods of using rice residues to provide biodegradable organic matter such as biochar, replacing Urea with SA fertilizer (Sulfate Amon).

The investment costs for this package of CH_4 emission reduction in rice cultivation include upgrading the construction of gravity structures and the construction of new electric pumping stations for water. The model is calculated with 2 rice season crop: spring-summer crop and summer-autumn crop. So with the A3, A5, A9 packages, 1 hectare of rice reduces 4 tons of CO_2eq / year and the cost to reduce 1 ton of CO_2eq is US$ 40.3.

Option A2 reuse of agricultural residue as organic fertilizer is a method that is implemented at the production sites and low cost. Comparing with the traditional method of burning, the A2 reduction method has reduced both CH_4 and NO_2 by 387 tons CO_2eq / 1000 ha / year, the straw incubation cost is 416 US$ / ha / year, therefore with 1 ton CO_2eq reduction for this option would cost US$ 54

Option A7 is substitution of urea with SA fertilizeran (Sulfate Amon fertilizer, $(NH_4)_2SO_4$) to save energy consumption, but the input data for this option is not adequate, so we use alternatively, the data of "Nationally defined contribution report of agriculture and rural development sector". This option helps to reduce emissions of 3.2 million tons CO_2eq on a scale of 2 million hectares, equivalent to 1.6 tons CO_2eq / ha / year, the cost of reducing 1 ton of CO_2eq is 30 US$.

3.2.3. Package A6, A8 – Integrated crop management (ICM) in annual upland crop cultivation

Integrated crop management is a combination of measures to save input resources such as the practice namely "3-Reducing & 3-Increasing" (reducing seedling, fertilizers and pesticides; increasing production, quality and effectiveness). This practice can save money and reduce N_2O emissions by reducing unreasonable fertilizer application. Annual crop residues will be collected and processed (composted) for agricultural production with 25% of annual crop residues in 2.8 million ha of annual

upland crop. This technology requires residue collection fee and processing, so the GACMO model calculate the total emission reduction is 745 tons CO_2eq / 1000ha / year and the cost to reduce 1 tonne of CO_2eq is 84 US$.

3.2.4. Option A11 – Improvement of livestock diets

This option improve feed ration for 22 million ruminant cattle (The Intended Nationally Determined Contribution for Agriculture and Rural Development) to reduce methane emissions due to rumen fermentation. The option is to change the diet by adding lipid fat to ruminant animals feed to prevent CH_4 production. Without changing the diet, goats and sheep produce 10-16 kg CH_4 / year and cattle produce 60 - 160 kg CH_4 / year depending on cattle weight and dry matter consumption. Therefore, the diet modification plan has reduced emissions of 522 tons CO_2eq per % of fat added to dry matter and the cost to reduce 1 ton of CO_2eq in this option is US$ 23.6.

3.2.5. Evaluation for reduction measures

Table 7 below shows details of figures for the total investment, annual cost and the total emission reduction for each measure.

Table 7: Total investment, annual cost and the total emission reduction for each measure

No.	**Reduction measures**	**Scale capacity (compared to BAU)**	**Emission reduction in 2030 (tCO_2/unit)**	**Investment**	**Annual costs**	**Cost reduction (USD/Ton CO_2eq)**	**Total of emission reductions per unit of capacity**
		unit		**(Millions USD)**	**Mill. USD/yr**		
1	A1. Increased use of biogas	500,000	8.70	126.50	-93.37	-6.80	4,350,000
2	A2. Reuse of agricultural residue as organic fertilizer	3,500,000	0.39	98.72	73.30	-54.00	1,350,000
3	A3. Alternate wetting and drying, and improved rice cultivation system (small scale)	200,000	4.00	521.74	35.20	-40.30	800,000
4	A5. Integrated Crop Management	1,000,000	4.00	521.74	35.20	-40.30	4,000,000

No.	Reduction measures	Scale capacity (compared to BAU)	Emission reduction in 2030 (tCO_2/unit)	Investment	Annual costs	Cost reduction (USD/Ton CO_2eq)	Total of emission reductions per unit of capacity
		unit		(Millions USD)	Mill. USD/yr		
	(ICM) in rice cultivation						
5	A6. Integrated Crop management (ICM) in upland annual crop cultivation	1,000,000	0.75	1.03	0.01	-84.00	750,000
6	A7. Substitution of urea with SA fertilizer (Sulfate Amon)	2,000,000	1.60	10.26	0.03	-30.00	3,200,000
7	A8. Reuse of upland agricultural residues	2,800,000	0.75	78.98	0.04	-84.00	2,090,000
8	A9. Dry-wet alternative watering and advanced cultivation system	1,500,000	4.00	3,913.04	263.97	-40.30	6,000,000
9	A11. Improvement of livestock diets	22,000,000	0.04	338.48	21.73	-23.60	920,000
10	A12. Improvement of quality and services available for aquaculture, such as inputs and foodstuff	1,000,000	0.41	2,564.23		-90.00	410,000
11	A13. Improvement of technologies in aquaculture and waste treatment in aquaculture	1,000,000	1.21	2,564.23		-95.00	1,210,000
12	A14. Improved irrigation for coffee	21,000,000	0.16	1,025.69		-94.00	3,360,000
13	A15. Improved technology in food processing	640,000	5.30	9.85		-0.46	3,390,000

No.	Reduction measures	Scale capacity (compared to BAU)	Emission reduction in 2030 (tCO_2/unit)	Investment	Annual costs	Cost reduction (USD/Ton CO_2eq)	Total of emission reductions per unit of capacity
		unit		(Millions USD)	Mill. USD/yr		
	and waste treatment in agriculture, forestry and aquaculture						

3.3. Compare GACMO results with the result of The Nationally Determined Contribution Report of Agriculture and Rural Development (NDC)

The Agriculture and Rural Development component of Viet Nam's Nationally Determined Contribution is made by the Ministry of Agriculture and Rural Development and supported by many research experts. This report also estimated the mitigation potential for each solution and estimates the costs for mitigation options.

Table 8: Comparison of the mitigation potential between NDC and GACMO

Reduction options	Scale	Mitigation Potential	
		GACMO	INDC
A1. Increased use of biogas	500,000 unit	8.7 ton CO2eq/unit	6.34 ton CO2eq/unit
A2. Reuse of agricultural residue as organic fertilizer	3,500,000 ha	0.39 ton CO2eq/ha	0.1 ton CO2eq/ha
A3. Alternate wetting and drying, and improved rice cultivation system (small scale)	200,000 ha	4 ton CO2eq/ha	4.7 ton CO2eq/ha
A5. Integrated Crop Management (ICM) in rice cultivation	1,000,000 ha	4 ton CO2eq/ha	0.5 ton CO2eq/ha
A6. Integrated Crop management (ICM) in upland annual crop cultivation	1,000,000 ha	0.75 ton CO2eq/ha	0.32 ton CO2eq/ha
A7. Substitution of urea with SA fertilizer (Sulfate Amon)	2,000,000 ha	X	1.6 ton CO2eq/ha
A8. Reuse of upland agricultural residues	2,800,000 ha	0.75 ton CO2eq/ha	0.1 ton CO2eq/ha

A9. Dry-wet alternative watering and advanced cultivation system	1,500,000 ha	4 ton CO2eq/ha	4.68 ton CO2eq/ha
A11. Improvement of livestock diets	22,000,000 ha	522 ton CO2eq/% DM fat added	0.08 ton CO2eq/ha
A12. Improvement of quality and services available for aquaculture, such as inputs and foodstuff	1,000,000 ha	x	0.41 ton CO2eq/ha
A13. Improvement of technologies in aquaculture and waste treatment in aquaculture	1,000,000 ha	x	1.21 ton CO2eq/ha
A14. Improved irrigation for coffee	21,000,000 tons	x	0.16 tons CO2eq/ha
A15. Improved technology in food processing and waste treatment in agriculture, forestry and aquaculture	640,000 ha	x	5.3 tons CO2eq/ha

IV. CONCLUSION AND RECOMMENDATION

These 15 emission reduction options have the potential to lead to high emissions reductions for specific agricultural sectors:

+ The package option applied in rice cultivation including: alternating wet and dry irrigation for reduction of 4 tons of CO_2eq / ha / year while reusing by-products, ICM integrated farming management to reduce emissions of 0.38 ton CO_2eq / ha / year
+ The option is to increase the use of biogas reduces of 8.7 ton of CO_2eq /unit/ year
+ The package option applied to the management of upland integrated crop management for emission reductions of 0.74 ton CO_2eq / ha / year
+ The option is to improve animal diets to reduce emissions of 522 tons CO_2eq /% of fat added to dry matter / year

The remaining options are due to the lack of data and there is no calculation option in the GACMO model, so we propose to use the emission reduction data from the report: "Intended Nationally Determined Contribution Report of Agriculture and Rural Development (INDC)". The report shows the results of the reduction of emissions for the option to improve the quality and services available for aquaculture to reduce 0.41 ton CO_2eq / ha / year. Options to improve technology in aquaculture and waste treatment

in aquaculture to reduce emissions of 1.21 ton CO_2eq / ha / year. The option to improve the irrigation system for coffee has a reduction of 5.3 tons of CO_2eq / ha / year. The option to improve processing technology and waste treatment of agro-forestry and aquatic products with emissions reduction of 0.16 ton CO_2eq / ha / year.

V. REFERENCE

Mai Van Trinh, Ly Viet Hung, Intended Nationally Determined Contribution Report of Agriculture and Rural Development (INDC), published by Deutsche Gesellschaft für, Internationale Zusammenarbeit (GIZ) GmbH;

Low carbon technology assessment facilitates Viet Nam's nationally determined Contributions, 2018, published by Ministry of Natural Resources and Environment;

Productive Biogas, current and future development, 2014, published by SNV

ICAT Agriculture guidance, 2018, published by Initiative for climate action transparency;