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**

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# 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.<br>Simple but powerful sanitation technology to reduce groundwater contamination, needs for fuelwood, and indoor air pollution caused by fuelwood burning.<br>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.<br>The demand for support of medium / large scale biogas farms and plants is increasing.<br>The excess biogas from the bunkers is not used up.<br>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.<br>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;<br>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.<br>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.<br>Source: MONRE (2015). *"INDC Technical report Viet Nam's Intended Nationally Determined Contribution"* |
| | **Existing Policy & Measures** | Decision No. 3119/QĐ-BNN-KHCN (2011)<br>Decision No. 543/QĐ-BNN-KHCN (2011)<br>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.<br>+ 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.<br>+ Spread compost: is a method that can provide decomposed organic matter without heaping.<br>+ 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.<br>+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.<br>- Rarely applied for large production<br>- Hard to collect<br>- Increased consumption of chemical fertilizer |
| | **Implementing agencies** | Ministry of Agriculture and Rural development |
| | **Target of Reduction measure** | - Reduce organic waste<br>- Reduce consumption of chemical fertilizer<br>- Decrease burning and air pollution.<br>- Increase the use of organic fertilizer, raising soil fertility and productivity<br>- Increase crop yield<br>- Avoiding soil degradation<br>- Reduce GHG emission from crop residues burning |
| | **Implementation level** | Nation |
| | **Target of GHG reduction** | Reduce 1,07 $x10^{-4}$ kgCO2e/ha/year<br>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)<br>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%<br>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<br>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<br>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.<br>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<br>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.<br>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.<br>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.<br>Save and optimize fertilizer, reduce $N_2O$ emissions due to excessive or unreasonable fertilizer application.<br>The scale is 1 million ha |
| | **Implementing agencies** | MARD |
| | **Target of Reduction measure** | Save water, fertilizer, reduce seeds<br>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)<br>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<br>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,<br>Sheet composting: is a method which can provide organic material without building a composting pile<br><br>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).<br>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 x$10^3$ $kgCO_2eq$ / ha / year by 2030<br>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)<br>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.<br>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.<br>The marginal abatement cost (MAC) curve demonstrated in the INDC indicates that feeding Lysine for pigs/chickens is financially attractive.<br>Initial cost is 3.6 USD/kg of linseed oil (1USD=110 JPY) and 2.15 USD/kg of Lysine (2012)<br>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<br>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<br>1 t of Life-cycle-CO2/2.4 kg of added Lysine |
| | **Relevant policies or actions** | Decision No. 3119/QD-BNN-KHCN (2011)<br>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<br>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)<br>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<br>Initial cost is 1,125 USD/ton (initial cost is subject to the scale of the plant system, etc.)<br>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)<br>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<br>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 $CO_2$eq |
| | **Relevant policies or actions** | Decision No. 3119/QĐ-BNN-KHCN (2011)<br>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 $CO_2$eq<br>Source: MONRE (2015). *"INDC Technical report Viet Nam's Intended Nationally Determined Contribution"* |
| | **Relevant policies or actions** | Decision No. 3119/QĐ-BNN-KHCN (2011)<br>Decision No. 543/QĐ-BNN-KHCN (2011)<br>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*

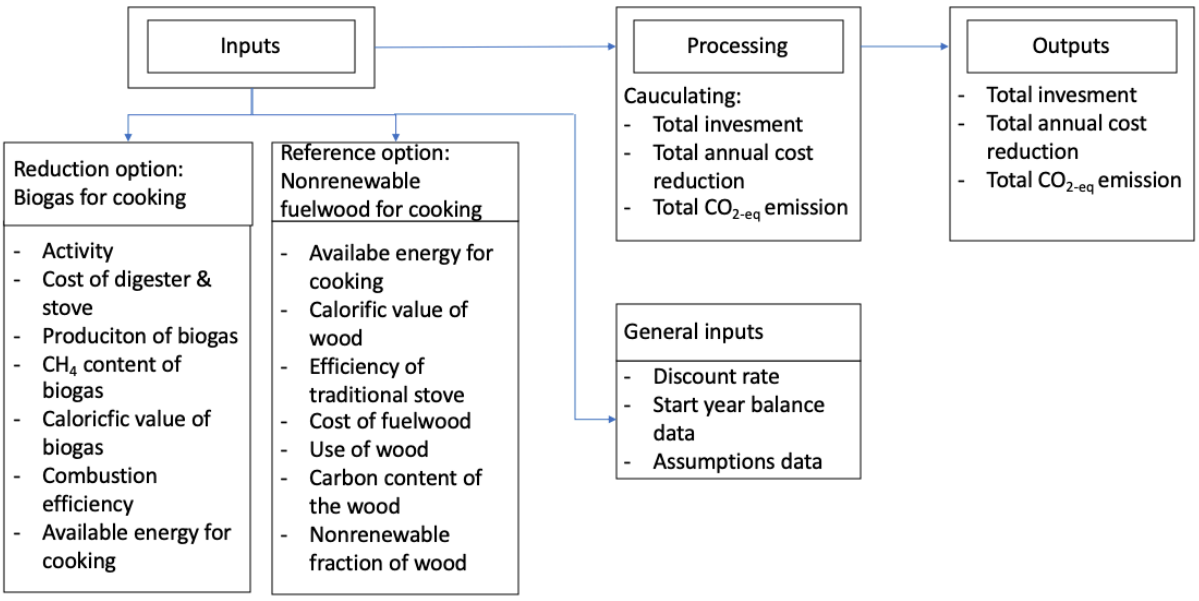
| | | |
|---|---|---|
| Country: | VIETNAM | |
| Start year (latest inventory): | 2014 | |
| Currency: | VND | |
| Exchange rate used:<br>1 US$= | 23,000 | VND |
| Discount rate = | 10.0% | |

*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 |

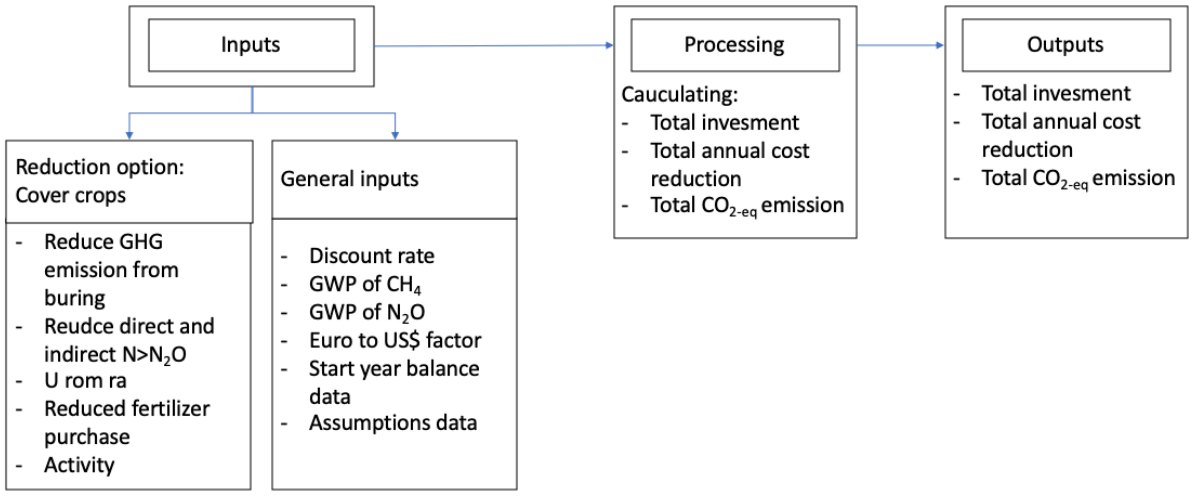
The model has more than 100 emission reduction options sorted by sectors with the goal of determining the total CO2 emissions for each emission reduction option. However, with 15 options for reducing emissions in agriculture, only 10 options are presented in the form of the chart below:

### a/ Option A1: Increased use of biogas

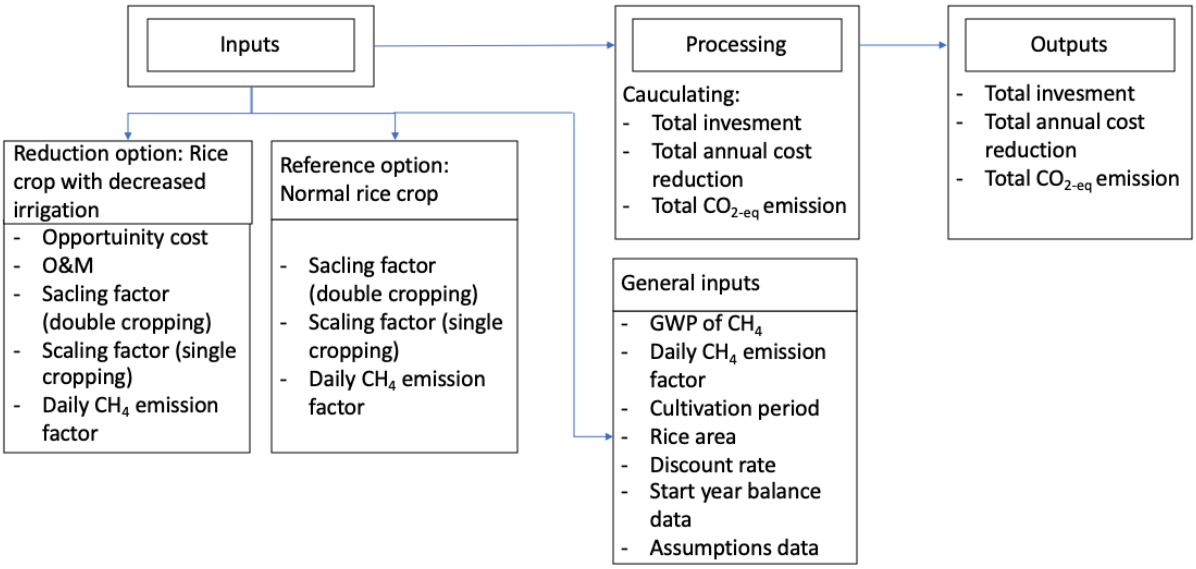



### b/ Group II (A2, A3, A5, A9): Reduction options on rice cultivation (Package option):

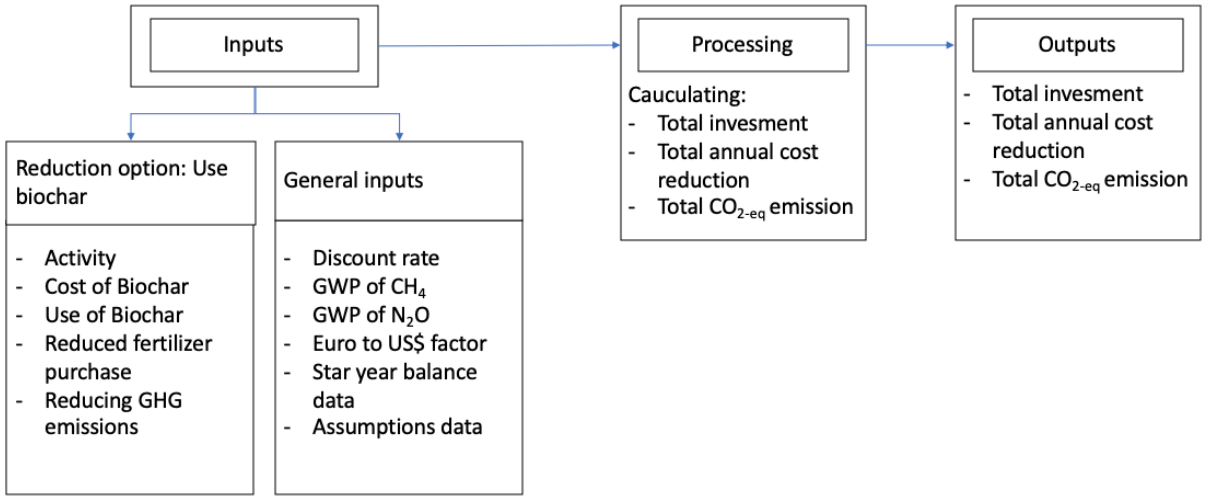
- Option A2: Reuse of agricultural residue as organic fertilizer



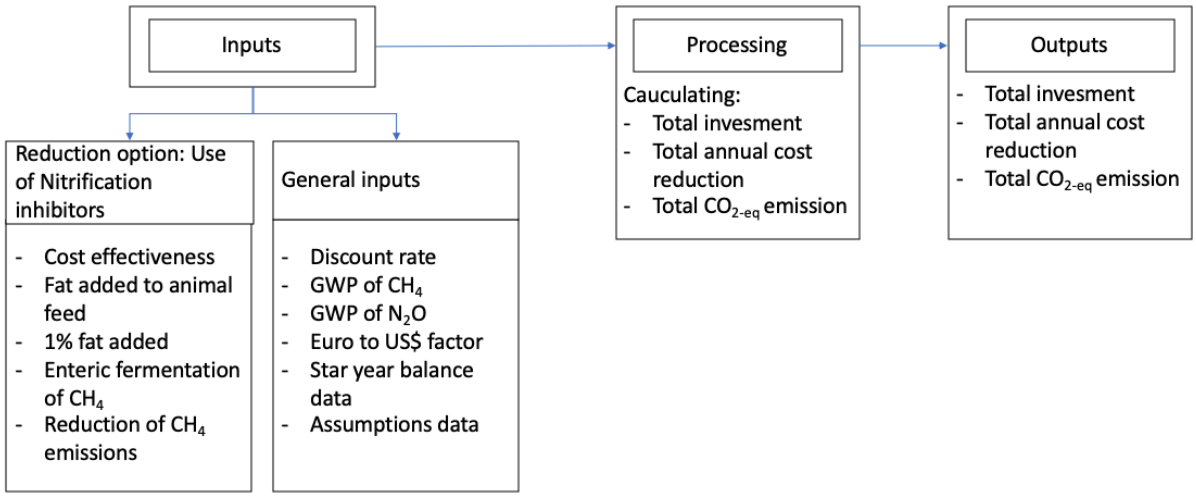

- Options A3, A5, A9:




**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 | | | | | | |
| Lev. investment | 33,123,614 | | 33,123,614 | | **Reduction option: Biogas for cooking** | | |
| Annual O&M | | | 0 | | Activity | 500,000 | biogas plant |
| Annual fuelcost | | 3,692,726 | -3,692,726 | | Cost of digester & stove | 564 | US$ |
| Total annual cost | 33,123,614 | 3,692,726 | **29,430,888** | | Production of biogas | 14 | m3/day |
| | | | | | CH4 content of biogas | 60% | |
| Annual emissions (tons) | Tons | Tons | Reduction | | Calorific value of biogas | 23.4 | MJ/m3 |
| Fuel CO2-eq. emission | 0 | 4,352,142 | 4,352,142 | | Combustion efficiency | 60% | |
| Other | | | | | Available energy for cooking | 197 | MJ/day |
| Total CO2-eq. emission | 0 | 4,352,142 | **4,352,142** | | | | |
| | | | | | **Reference option: Nonrenewable fuelwood for cooking** | | |
| **US$/ton CO2-eq.** | | | **6.8** | | Available energy for cooking | 197 | MJ/day |
| | | | | | Calorific value of wood | 136 | MJ/kg |
| | | | | | Efficiency of traditional Stove | 10% | |
| Notes: | | | | | Cost of fuelwood | 1 | US$/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.) | General inputs: | | |
| Total investment | | | 0 | Discount rate | 10% | |
| Project life | | | | GWP of CH4 = | 25 | Ton CO2 |
| Lev. investment | | | 0 | GWP of N20 = | 298 | Ton CO2 |
| Annual O&M | 62420000 | 0 | 62420000 | 1 Euro= | 1.15 | US$ |
| Annual fuelcost | | | 0 | Reduction option: Cover crops | | |
| Total annual cost | 62420000 | 0 | **62420000** | Activity | 200000 | ha |
| | | | | Cost of Biochar | 0.58 | US$/kg |
| Annual emissions (tons) | Tons | Tons | Reduction | Use of Biochar | 1.7 | ton/ha |
| Fuel CO2-eq. emission | | | 0 | Reduced fertiliser purchase | -673.9 | US$/ha/yr |
| Other | | 745000 | 745000 | Reducing GHG emissions | 12.5 | kgN2O/ha |
| Total CO2-eq. emission | 0 | 745000 | **745000** | | | |
| | | | | Reference option: Normal crops | | |
| **US$/ton CO2-eq.** | | | **83.785** | | | |

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.) | General inputs: | | |
| Total investment | 12335 | | 12335 | Discount rate | 10% | |
| Project life | | | | GWP of CH4 = | 25 | Ton CO2 |
| Lev. investment | | | 0 | GWP of N20 = | 298 | Ton CO2 |
| Annual O&M | 12335 | | 12335 | 1 Euro= | 1 | US$ |
| Annual fuelcost | | | 0 | Reduction option: Use of Nitrification inhibitors | | |
| Total annual cost | 12335 | 0 | **12335** | Cost effectivenes | 23.63 | US$/tCO2-eq |
| | | | | Fat added to animal feed | 3 | %DM fat added |
| Annual emissions (tons) | Tons | Tons | Reduction | 1% fat added | 3.8% | Reduction in CH4 |
| Fuel CO2-eq. emission | | | 0 | Enteric fermentation of CH4 | 13736.7989 | ktCO2-eq. |
| Other | | 522 | 522 | Reduction of CH4 emissions | 522.0 | ktCO2-eq. |
| Total CO2-eq. emission | 0 | 522 | **522** | | 91960% | 24200000 |
| | | | | Reference option: Normal crops | | |
| **US$/ton CO2-eq.** | | | **23.6** | | 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 $CO_2$eq / equipment / year, the cost for reducing 1 ton of $CO_2$eq 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 $CO_2$eq / year and the cost to reduce 1 ton of $CO_2$eq 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 $CO_2$eq / 1000 ha / year, the straw incubation cost is 416 US$ / ha / year, therefore with 1 ton $CO_2$eq 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 $CO_2$eq on a scale of 2 million hectares, equivalent to 1.6 tons $CO_2$eq / ha / year, the cost of reducing 1 ton of $CO_2$eq 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 $CO_2$eq / 1000ha / year and the cost to reduce 1 tonne of $CO_2$eq 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 $CO_2$eq per % of fat added to dry matter and the cost to reduce 1 ton of $CO_2$eq 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 $CO_2$eq) | 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 $CO_2$eq) | 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 $CO_2$eq) | 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 $CO_2$eq / ha / year while reusing by-products, ICM integrated farming management to reduce emissions of 0.38 ton $CO_2$eq / ha / year
+ The option is to increase the use of biogas reduces of 8.7 ton of $CO_2$eq /unit/ year
+ The package option applied to the management of upland integrated crop management for emission reductions of 0.74 ton $CO_2$eq / ha / year
+ The option is to improve animal diets to reduce emissions of 522 tons $CO_2$eq /% 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 $CO_2$eq / ha / year. Options to improve technology in aquaculture and waste treatment

in aquaculture to reduce emissions of 1.21 ton $CO_2$eq / ha / year. The option to improve the irrigation system for coffee has a reduction of 5.3 tons of $CO_2$eq / ha / year. The option to improve processing technology and waste treatment of agro-forestry and aquatic products with emissions reduction of 0.16 ton $CO_2$eq / ha / year.

## V. REFERENCE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