Asia-Pacific
Economic Cooperation

Scientific Workshop on measurement and mitigation of greenhouse gases in livestock systems for green production and environment of APEC members

2-4 December 2014

Pullman Bangkok Hotel
Thailand

APEC Project: ATC 01 2013A

For
Asia-Pacific Economic Cooperation Secretariat
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This report was prepared by Kalaya Boonyanuwat with the help and information provided by all speakers and participants in the Scientific Workshop on Measurement and Mitigation of Greenhouse Gases in Livestock Systems for Green Production and Environment of APEC members that took place in Bangkok (Thailand) during 2-4 December 2014.

All responsibility for any errors or omissions rests with the authors.

Contents

Executive Summary

Background

Globally, the agricultural sector accounts for 14% of the total greenhouse gas emissions. Agriculture is an essential activity because it is about food production. However, agriculture also has impacts on the environment and people's health and well being.

A Scientific Workshop on measurement and mitigation of greenhouse gases in livestock systemsfor green production and environment of APEC memberswas proposed to be organized by the Department of Livestock Development, Thailand. This workshop took place in Bangkok between 2 and 4 December 2014. It included oral presentations of APEC delegations, discussion on relevant topics, and site visits, the presentations were related to themes focusing on measurement and mitigation of greenhouse gases in livestock systems. The workshop contributed to the understanding of the diversity of livestock management systems in APEC member economies, the greenhouse gas emissions and the special characteristics of those systems. A key goal of the workshop was to identify opportunities for future collaboration and coordinated capacity building activities in livestock mitigation research across member economies.

In most developed countries, enteric methane measurements for cattle have been conducted using respiration chambers, masks and hoods. These methods allow comparison between treatments, but interfere with normal animal behaviour and are highly restrictive. Measurements of emissions under production situations would allow a more realistic evaluation of enteric methane emissions. For example, barns have been equipped to estimate methane emissions. Micrometeorological methods are also employed to determine methane emissions without restricting the activity of cattle. At present, in many countries, the SF_6tracer method is also employed to determine methane emission from free-ranging ruminants. Methane emission measurement development is very important to set the right inventories of GHG emission from livestock. This workshop was aimed to 1) establish the network and cooperation and coordinated capacity building activities in livestock mitigation research across member economies, and 2) be a platform for exchanging, discussing and sharing experience on measurement and mitigation of greenhouse gases in livestock systems between APEC members in order to increase capability on livestock production for food security and green environment of the member officers and scientists.

Workshop Findings

Participants at the workshop agreed that:

- CH_4 emissions differ between sub-categories of animals. So in each economy should develop own emission factors for each sub-category
- To develop own emission factors for each sub-category, each economy should develop and establish GHG measurement methods.
- There are many methods proposed for mitigationof emissions of methane, such as: feeding improvement, genetic improvement, farm management, and manure management.
- About feeding management, each economy can use feed suplement, feed additives, feed processing, local feed, high quality feed. The technologies implied should be not only accessible, but also of low cost and even better if an improvement in animal production is associated.
- We may be able to use knowledge of rumen microorganism genetics to produce methanogen inhibitor vaccines or feed additives.
- There are many agriculture by-products such as: mangosteen peel, Leucaena leaf with potential for reduction of emissions of methane.

- Animal genetics tools may be useful in adaptation to climate change as well as a mitigation method. For mitigation practice, animal genetics can be used to incorporate traits or indicators related to feed efficiency (e.g., residual feed intake) and low CH4 emission. Improvement of forages by genetic means also will contribute to reduce livestock emission intensities.
- Genetic selection and targeted breeding could reduce methane emissions per unit ofproduct through selecting genetic traits that increase the general efficiency of production (e.g., milk yield and reproductive efficiency per animal)
- About farm management, they can improve for cooling house, good ventilation house.
- About manure management, they can produce biogas and compost fertilizer.
- It is very important that livestock production is important for food security. So in term of mitigation, we can reduce GHG emission per unit of animal product.
- To reduce GHG emission per unit of animal product, we need to improve efficiency of the whole production unit/system.
- About GHG measurement method, especially enteric methane, we use respiration chamber and SF6 tracer technique.
- It is very important to organize hands-on training courses on GHG measurement methods, supported by APEC.
- There is great value in establishing and maintain a network in the research area of mitigation. To combine database and exchange knowledge about climate change in livestock sector among APEC economy is very important.
- It is very important to arrange the workshop once per year. This will enable renewing collaboration and accelerating knowledge gain.
- Members were generally in agreement is devising/exploring strategies of adaptation to climate change in livestock sector. This may have a rapid impact.

Agreed Priority Issues and action arising from the Workshop

The workshop agreed on the following priority issues and actions, subject to APEC member economies being able to secure necessary funding to deliver on these action points.

1 The establishment of an international scientific network aimed at adaptation and mitigation through improved animal production by using feeding, farming, manure management, and genetic improvement. APEC economies scientists would take primary responsibility for the establishment and management of the Network. While this network will initially involve scientists working in the area of mitigating methane emissions intensity and adaptation, the option of including research around other greenhouse gases as the network progresses, is open

2 The establishment of a common database for the storage of GHG emission in area of adaptation and mitigation. These data would be available for use in wide association studies.

3 Continue discussions on defining which co-benefit between mitigation and adaptation should be targeted and how these will be incorporated into objectives.

4 Develop a set of common protocols to guide the search for the rapid measurement of CH_4 and feed intake when repeated measurements on large numbers of animals are required.

Scientific Workshop on measurement and mitigation of greenhouse gases in livestock systemsfor green production and environment of APEC members

2-4 December 2014
Pullman Bangkok Hotel. Bangkok. Thailand

Background

Introduction

Greenhouse gas emission from agricultural sector of the world is around 14% of total emissions. In the main idea, agriculture is important because it is food production for the world consumption. But green environment is also important because it has impacts on people health in every economy members of APEC.

The Ministry of Agriculture and Cooperatives of Thailand makes the action plan of climate change in agriculture sector during 2013-2016, considered to National Economic and Social Development Plan No. 11 (2012-2016) as green development and food security which operated under strategic development for product capabilities, balanced agricultural resources effectively and sustainable. These strategies are related APEC strategy. The Department of Livestock Development is the organization within the Ministry of Agriculture and Cooperatives, and works on aspects of livestock production in Thailand. Livestock production is very important for food security and also has implications on climate change and suffers effects of it. The first thing that is very important to work about climate change in livestock sector is greenhouse gas inventory system. Measurement and mitigation of greenhouse gases in livestock systems is the important part of inventory system.

Scientific Workshop on measurement and mitigation of greenhouse gases in livestock systemsfor green production and environment of APEC members was proposed to be organized by Department of Livestock Development, Thailand. This workshop included oral presentations of APEC delegations, discussion on relevant topics, and site visits which all activities will not be affiliated to all members. The presentations were related to these themes focusing on measurement and mitigation of greenhouse gases in livestock systems. The workshop aimed at improving the understanding of the diversity of livestock management systems in APEC member economies, the greenhouse gas emissions and the special characteristics of those systems. A key goal of the workshop was to identify opportunities for future collaboration and coordinated capacity building activities in livestock mitigation research across member economies.

GHG emitted from the livestock sector accounts for 27.27% of all agricultural greenhouse gas (GHG) emissions in Thailand (ONEP, 2000). Understanding the relationship of diet to enteric methane production is essential to reduce uncertainty in GHG emission inventories and to identify viable GHG reduction strategies. The major GHG from livestock are methane, nitrous oxide, and carbon dioxide.

Most enteric methane measurements for cattle have been conducted using respiration chambers, masks and hoods (Kelley *et al.* 1994; Boadi *et al.* 2002; Amon *et al.* 2001; Moss 2002). Masks, hoods and chambers allow comparison between treatments but interfere with activity of cattle. Measurements made under production situations would allow a more realistic evaluation of enteric methane. For example, barns have been equipped to estimate methane emissions (Kinsman *et al.* 1995; Jungbluth *et al.* 2001). Micrometeorological methods are also employed to determine methane emissions without restricting the activity of cattle (Harper *et al.* 1999). Now in many countries, the SF6 method is also employed to determine methane emission from free ranging animals. Methane emission measurement development is very important to set the right inventories of GHG emission from livestock.

Objectives

1. To establish the network and cooperation and coordinated capacity building activities in livestock mitigation research across APEC member economies.

2. To be a platform for exchanging, discussing and sharing experiences on measurement and mitigation of greenhouse gases in livestock systems between APEC members in order to increase capability on livestock production for food security and green environment of the member officers and scientists.

Venue

Pullman Bangkok Hotel. Bangkok. Thailand

Duration

2-4 December 2014

Participants

1.	Speakers	6	persons
2.	APEC economy	11	persons from 7 economies
3.	Thai participants	24	persons

Project overseer

Dr. Kalaya Boonyanuwat
Biodiversity Research Sector.
Bureau of Animal Husbandry and Genetic Improvement.
Department of Livestock Development.

Program

PROGRAMME

Scientific Workshop on Measurement and Mitigation of Greenhouse Gases in Livestock Systems for Green Production and Environment of APEC Members

Day 1 December 2, 2014	
08.30 - 09.00	Registration Pullman Bangkok Hotel
Morning Session Pullman Bangkok Hotel	
09.00 - 10.00	**Opening Program** MC: **Mrs. PRAPAWAN SAWASDEE**
	Welcome Remarks **Mr. THANIT ANEKWIT** Deputy Director Department of Livestock Development

	Introduction of Participants and Speakers **Dr. KALAYA BOONYANUWAT** Biodiversity Research Sector. Bureau of Animal Husbandry and Genetic Improvement. Department of Livestock Development. Project Overseer- ATC 01 2013A
	Group Photo
10.00 – 10.30	Coffee Break and Networking
Workshop Proper Pullman Bangkok Hotel **Moderator:** Thailand	
10.30 – 10.40	**Workshop Overview, Objectives, Expected Output and Administrative Arrangements** **Dr. KALAYA BOONYANUWAT** Biodiversity Research Sector. Bureau of Animal Husbandry and Genetic Improvement. Department of Livestock Development. Project Overseer- ATC 01 2013A
10.40 – 11.10	Paper 1**: Livestock in a changing climate: benefits from increased productivity for mitigation** **Mr. Peter Ettema** Position Manager, Resource Information & Analysis Organization Ministry of Primary Industry New Zealand • Commonly adopted climate change adaptation strategies and criteria/rationale for selecting these strategies • Impact of these strategies to yield/productivity, animal health and food safety • Which of these strategies have mitigation potential, and to what extent (level of significance of mitigating effect) • Prospects and constraints for widespread adoption of adaptation strategies with mitigation potential • Policy and institutional requirements to promote widespread adoption of adaptation strategies with mitigation potential
11.10 – 11.40	Paper 2: **Methodological aspects of environmental assessment of livestock production by LCA (Life Cycle Assessment)** **Assoc. Prof. Dr. Krittapol Sommart** Position Associated Professor Organization Khon Kaen University. Khonkaen

	Province. Thailand. • Definitions of LCA • Uses and types of LCA • The structure of LCA • The functional unit • System boundaries and allocation • Carbon footprint • Carbon footprint of livestock products • Uncertainties in the carbon footprint of livestock products • Sustainable livestock systems • Life cycle sustainability assessment (LCSA) • Limitations with LCA, SLCA and LCC
11.40 – 12.10	**Paper 3: Emissions inventory of greenhouse gases from livestock and manure management** **Assoc.Prof. Dr. Amnat Chidthaisong** Position Associated Professor Organization King Mongkut's University of Technology Thonburi (KMUTT) Thailand • Definition of emissions inventory • Method used to measure methane conversion factors (MCF) • Methane emission factors (MEF) • Livestock categorization • Methane emission from manure management • Confidence level of the coefficients, quality assurance and quality control • Methane emission levels • Emission inventory guides • Livestock buildings and emissions inventory • Paradigms of national emissions inventories • Emissions abatement techniques
12.10-12.30	Synthesis and Open Forum
12.30 – 13.30	Lunch Break and Networking

Afternoon Session

Pullman Bangkok Hotel

Moderator: Indonesia

Economy reports shall address the following:

- Particular climate change vulnerabilities of economy and how these affect livestock productivity and food security
- Climate change adaptation strategies most widely used and how/why these have been selected

• Which of these strategies have been proven to have mitigation potential, and benefits obtained from these strategies • Greenhouse gasses measurement method using in each economy • Financing options	
13.30 – 13.50	**Economy Report :** Chinese Taipei
13.50 – 14.10	**Economy Report** :Thailand
14.10 – 14.30	**Economy Report :** Philippines
14.30 – 14.50	**Economy Report :** Viet Nam
14.50 – 15.10	Coffee Break and Networking
15.10 – 15.40	Synthesis and Open Forum
18.30 – 20.00	Welcome Dinner Pullman Bangkok Hotel **Host: Thailand, Department of Livestock Development**
Day 2 December 3, 2014	
Morning Session Pullman Bangkok Hotel **Moderator:** Philippines	
0900 – 0940	Paper 4: **GHG Emissions from Pig House** **Dr Arux Chaiyakul** Position Senior Veterinarian Organization Department of Livestock Development. Bangkok. Thailand • **Sources of ammonia, nitrous oxide and methane from pig houses** • **Influencing factors** • **Climatic conditions** • **Floor type, pen design and manure management**
09.40 – 10.20	Paper 5: **Nutritional Implications of Ruminant Methane Emissions and Measurement Methods** **Dr. Cesar Pinares Patino** Position Research Scientist Organization CSIRO. Australia Agriculture Flagship, Integrated Agricultural Systems GPO Box 1600. Canberra ACT 2601 AUSTRALIA • Measurement of methane by open circuit chambers • Measuring methane with the SF6 tracer technique
10.20– 11.00	Paper 6:**Mitigating Farm Livestock Greenhouse Gas Emissions**

	Dr. Kalaya Boonyanuwat Position Senior Animal Scientist Organization Department of Livestock Development. Bangkok Thailand. • Improved productivity through breeding • Lifetime management of beef cattle • Replacing roughage with concentrate • Improving forages / legume inclusion • Feeding plant oils • Feeding propionate precursors • Policy considered separately • Factors to account for whencalculating emissions reductionpotential of any measure
11.00 -12.00	Synthesis and Open Forum
12.00 – 13.00	Lunch Break and Networking
Afternoon Session Pullman Bangkok Hotel **Moderator:** Viet Nam	
13.00 – 13.20	**Economy Report :** Indonesia
13.20 – 13.40	**Economy Report :** Mexico
13.40 – 14.00	**Economy Report :** The United States
14.00 – 14.30	Synthesis and Open Forum
14.30 – 14.50	Coffee Break and Networking
14.50 – 16.30	Synthesis Report
16.30 – 17.30	**Closing Program** MC: **Mrs. PRAPAWAN SAWASDEE**
	Presentation of Draft Report **Dr. KALAYA BOONYANUWAT** Biodiversity Research Sector. Bureau of Animal Husbandry and Genetic Improvement. Department of Livestock Development. Project Overseer- ATC 01 2013A
	Closing Address **Mr. THANIT ANEKWIT** Deputy Director Department of Livestock Development
18.30 – 20.00	Farewell Dinner Pullman Bangkok Hotel Host: Thailand, Department of Livestock Development
Day 3 December 4, 2014	
8.00 – 17.30	Field trip Biogas and Manure Management in Pig Farm in Chonburi Province.

Organization

Biodiversity Research and Development Sector. Bureau of Animal Husbandry and Genetic Improvement. Department of Livestock Development. Bangkok. Thailand. Email: kalayabo@gmail.com

Methodology

1. Presentation
   1.1. Livestock in a changing climate: benefits from increased productivity for mitigation
   Mr. Peter Ettema. Manager, Resource Information &Analysis. Ministry of Primary Industry. New Zealand
   1.2. Methodological aspects of environmental assessment of livestock production by LCA (Life Cycle Assessment)
   Assoc. Prof. Dr. Krittapol Sommart. Khon Kaen University. Khonkaen Province. Thailand.
   1.3. Emissions inventory of greenhouse gases from livestock and manure management
   Assoc.Prof. Dr. Amnat Chidthaisong. King Mongkut's University of Technology Thonburi (KMUTT). Thailand
   1.4. GHG Emissions from Pig House
   Dr Arux Chaiyakul. Senior Veterinarian. Department of Livestock. Development. Bangkok. Thailand
   1.5. Nutritional Implications of Ruminant Methane Emissions and Measurement Methods
   Cesar Pinares Patino. Research Scientist. CSIRO. Australia Agriculture Flagship, Integrated Agricultural Systems. GPO Box 1600. Canberra ACT 2601. Australia.
   1.6. Mitigating Farm Livestock Greenhouse Gas Emissions
   Dr. Kalaya Boonyanuwat Senior Animal Scientist. Department of Livestock Development. Bangkok Thailand.
2. Economy report
   There are 6 reports from six economies, Chinese Taipei, Thailand, Philippines, Viet Nam, Indonesia, and Mexico.
3. Field trip
   Biogas and Manure Management in Pig Farm in Chonburi Province (Santirath Agricultural Farm)

Discussion

Presentation

1. **Livestock in a changing climate: benefits from increased productivity for mitigation**

   Mr. Peter Ettema. Manager, Resource Information & Analysis. Ministry of Primary Industry. New Zealand.

The presentation included four sections: 1) New Zealand economy, 2)New Zealand's greenhouse gas emissions profile, 3) Direct and indirect approaches to reducing emissions, and 4) Government's role in supporting adaptation.

Agriculture, fisheries and forestry in New Zealand contribute 11.1% of GDP for year ending June 2013.They represent over 11.6% of employment. Around 90% of New Zealand's agricultural produce is exported. It comprises 76% merchandise exports.

Emissions intensity of NZ agriculture has declined consistently by about 1% per year since 1990. Examples are 10kg CO_2e/kg milk solids and 30kg CO_2e/kg lamb meat. Nevertheless, absolute emissions of GHG have increased by 14.9% since 1990. Increasing absolute emissions result from livestock production (mostly dairy) rising faster than emissions intensity is declining.

From 1990 to 2012, GHG emission increases 25.4% of total emission. In agriculture sector, it increases 14.9%. In 2012, GHG emission from agriculture is 46.0% of total emission. In livestock sector, GHG emission is decrease in term of emission per production unit by increasing of production efficiency.

Four approaches are used to reduce GHG emission. They are 1) Direct (mitigation technologies), 2) Indirect(increase in efficiency using current technologies), 3) Adaptation(research and information for farmers), 4) Measuring and reporting(country specific data). It can reduced emissions intensity & absolute emissions.

Indirect approaches, they can improve efficiency that provide the best immediate mitigation option. They can do by improving better genotypes, more efficient use of fertilisers & legumes, improved feeding, improved animal health, better management, reducing emissions per unit of product, may reduce absolute emissions.

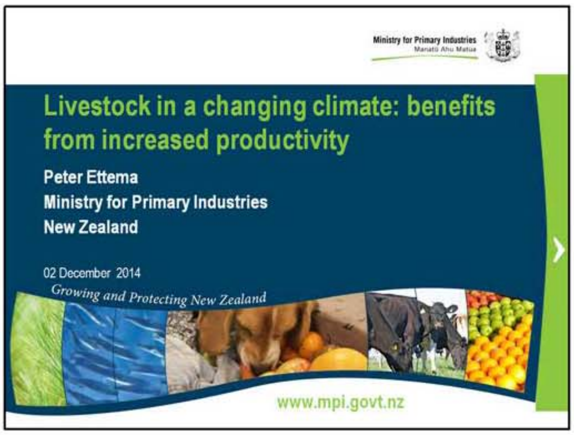
Indirect approaches are challenged. Intensity gains will plateau out eventually – but no indication that this will happen soon. Intensity gains strongly linked to intensification: other environmental constraints (water quality /quantity)and perception/reality of what NZ farming is about. Challenging is to monitor, report, verify (MRV). Takes time; bringing up worst performers also helps, but cannot be achieved by push of a button.

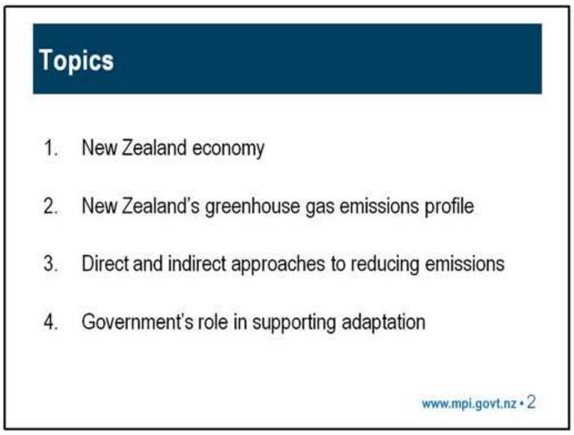
Direct approaches are challenged. Urease inhibitors (now) and nitrification inhibitors are used. Methanogen vaccine or inhibitor are researched (proof of concept by 2015). Animal selection and breedingare researched (proof of concept now). Novel/change in foragesare researched (anecdotal evidence; cost, trade-offs). Novel management practices are researched and applied (anecdotal now – upscaling, MRV). The consideration are: technical difficulty, market acceptability, and cost, practicality and uptake.

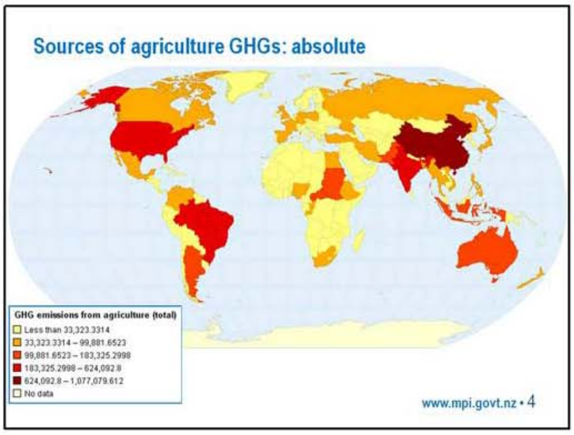
Supporting adaptation is the role of the Ministry for Primary Industry. It Work with sector organisations, local government and Māori to ensure that farmers, growers and foresters have the information and tools they need to be prepared for a changing climate. The Ministry's key initiatives are: investment in research – inventory and farm-level, an adaptation toolbox, case studies and fact sheets by sector and by topic, supporting rural professionals, and co-benefits with actions focussing on water.

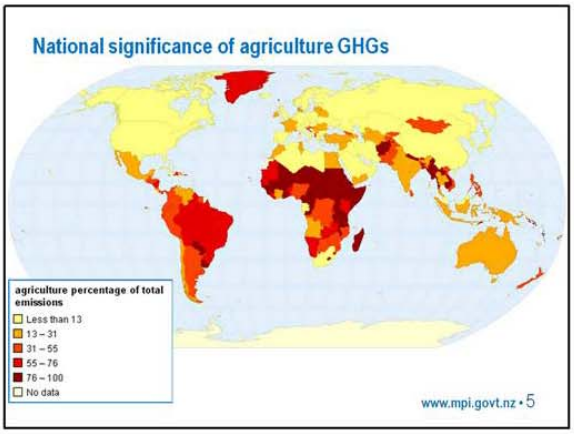
The summaries are:

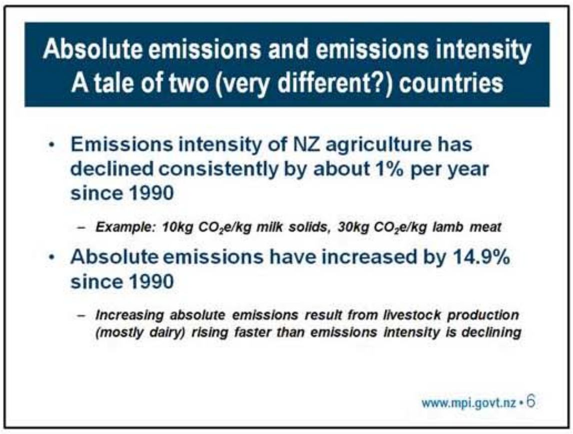
- Changes in production efficiency are, and will continue to, happen.
- Positive implications from an emissions intensity perspective.
- An inventory/ reporting system that can reflect these changes – positive step forward.











New Zealand's GHG profile

Sector	1990 (Mt CO_2-e/year)	2012 (Mt CO_2-e/year)	% change
Energy	23.5	32.1	36.3
Industrial Processes	3.3	5.3	61.8
Agriculture	30.5	35.0	14.9
Waste	3.3	3.6	8.8
Total	60.6	76.0	25.4
Agriculture %	51.5	46.0	

Methane represents 32% New Zealand's total CO_2-e emissions and 68% of agricultural emissions

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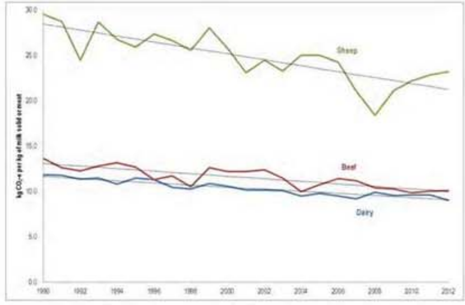
Agricultural emissions intensity for dairy, beef and sheep (1990-2012)



Note: Excludes dairy cull for beef, and emissions for wool are not included.

3

Focus on improving productivity

	Unit	1990	2012
Lambing	%	95	121
Lamb carcass weight	kg	13.7	18.7
Milk solids per cow	kg	256	364
Cows per hectare	# / ha	2.4	2.8
Milk solids / hectare	kg / ha	614	1019
Steer weight	kg	282	314
Heifer weight	kg	204	242
Urea	tonnes	19,000	501,000
PKE	tonnes	0	1.3 million

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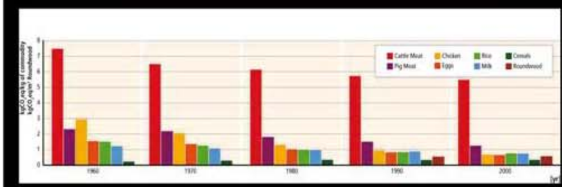
Reducing emissions per unit of product - worldwide trend



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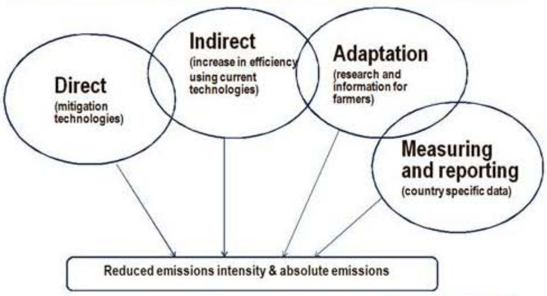
Mix of approaches to meet overall aim of emissions reduction and increase productivity



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Indirect approaches - improved efficiency provides the best immediate mitigation option

- Better genotypes
- More efficient use of fertilisers & legumes
- Improved feeding
- Improved animal health
- Better management
- *NB Will reduce emissions per unit of product, may reduce absolute emissions*

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Challenges: Indirect Approaches

- Intensity gains will plateau out eventually – but no indication that this will happen soon
- Intensity gains strongly linked to intensification:
  - other environmental constraints (water quality /quantity)
  - perception/reality of what NZ farming is about
- Challenging to monitor, report, verify (MRV)
- Takes time; bringing up worst performers also helps – but cannot be achieved by push of a button

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Challenges: Direct Approaches

- Urease inhibitors *(now)* / nitrification inhibitors
- Methanogen vaccine/inhibitor (proof of concept by 2015)
- Animal selection and breeding (proof of concept now)
- Novel/change in forages (anecdotal evidence; cost, trade-offs)
- Novel management practices (anecdotal now – upscaling, MRV)

- Technical difficulty
- Market acceptability
- Cost, practicality and uptake

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Supporting adaptation: the role of the Ministry for Primary Industries

- Work with sector organisations, local government and Māori to ensure that farmers, growers and foresters have the information and tools they need to be prepared for a changing climate.
- The Ministry's key initiatives are:
  - Investment in research – Inventory and farm-level
  - An adaptation toolbox
  - Case studies and fact sheets by sector and by topic
  - Supporting rural professionals
  - Co-benefits with actions focussing on water

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Summary

- Changes in production efficiency are, and will continue to, happen
- Positive implications from an emissions intensity perspective
- An inventory/ reporting system that can reflect these changes – positive step forward

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New Zealand's Primary Industries: A Snapshot

Pastoral farming dominates
- Sheep: 31.1 million
- Beef cattle: 3.9 million
- Dairy cattle: 6.2 million (4.7 mil in calf or milk)
- Deer: 1.1 million

Horticulture is increasingly important
- Wine grapes: 311 000 tonnes
- Wine: 190 million litres

Arable farming
- Barley: 65,700 hectares
- Wheat: 54,800 hectares

Fisheries
- Commercial fish catch: 418,307 tonnes

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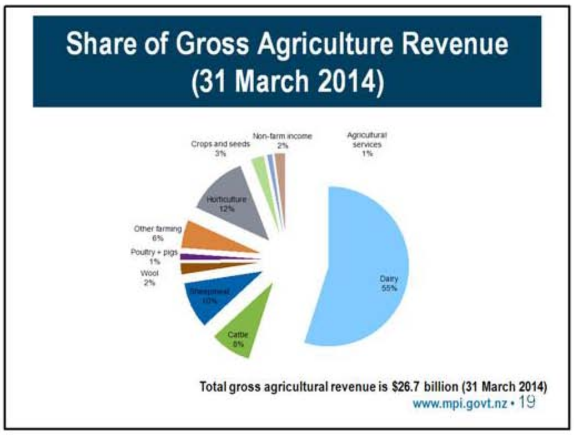

New Zealand's GHG profile (by gas)

Direct GHG emissions	1990 (Mt CO_2-e/year)	2012 (Mt CO_2-e/year)	% change
CO_2	24.9	34.3	37.5
CH_4	26.8	29.0	8.2
N_2O	8.2	10.9	32.0
HFCs/ PFCs/ SF_6	0.6	1.9	-
Total	60.6	76.0	25.4

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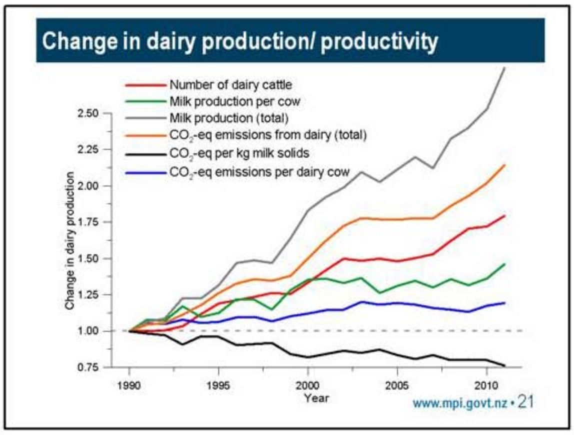
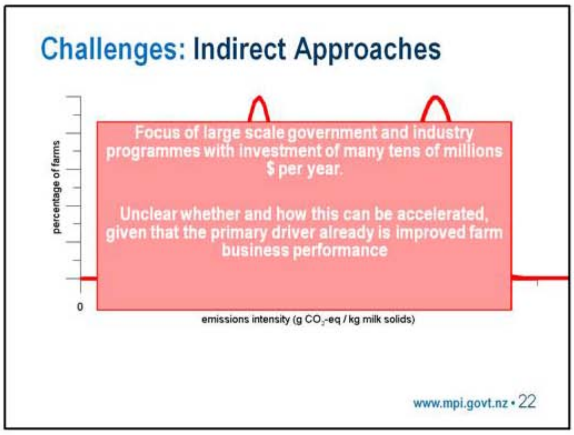




2. Methodological aspects of environmental assessment of livestock production by LCA (Life Cycle Assessment)

Assoc. Prof. Dr. Krittapol Sommart. Khon Kaen University. Khonkaen Province. Thailand.

About this topic, it is separated into 3 parts: background, summary and methodology of general LCA, application of LCA to beef production.

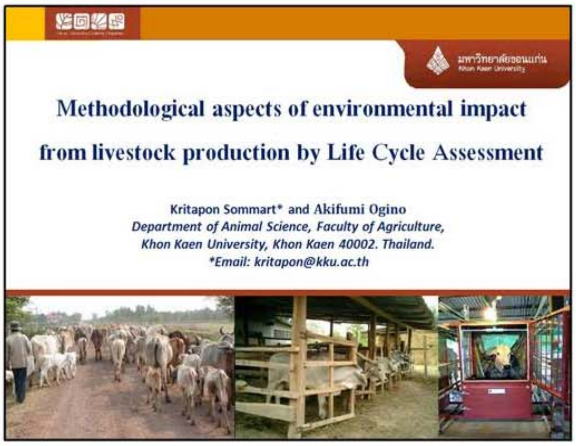
Increasing GHG concerns about environment. We should do to reduce impacts of GHG emission.

Carbon footprint and other eco- labeling shows environmental impacts, especially consumers. Now in Japan, they calculate carbon footprint in food and agriculture products. The most carbon footprint in 1 kg carcass weight of beef is from enteric methane, followed by feed production. Carbon footprint is calculated by life cycle assessment (LCA). They use carbon emission from supply chain, life cycle of animal in farm, transportation, and slaughter house.

Concepts and definitions of LCA are 1) “Cradle-to-grave” approach for assessing industrial system. Begins with the gathering of raw materials from the earth to create the product and ends at the point when all materials are returned to the earth. 2) By including the impacts throughout the product life cycle, LCA provides a comprehensive view of the environmental aspects of the product or process and a more accurate picture of the true environmental trade-offs in product and process selection. 3. The environmental impact is expressed by impact categories. The impact categories can be defined at different level; mid-point effect (acidification, neutrophication, global warming, ozone depletion etc) or end-point effects (lessen biodiversity or shorter length of life of humans).

In this topic also talked about LCA history and ISO system. LCA is compost of system boundary and functional units. Functional units mean carbon emission from 1 production unit. Boundary systems are compost of raw material supply, production, use, and disposal.

In this topic also talked about 1) GHG emission from composting of manure management, 2) measurement of enteric methane using ventilated head-hood respiratory analysis system, 3) measurement of GHG emission from soil. The speaker gave example of life cycle assessment of Thai beef fattening cattle.


Methodological aspects of environmental impact
from livestock production by Life Cycle Assessment
Kritapon Sommart* and Akifumi Ogino
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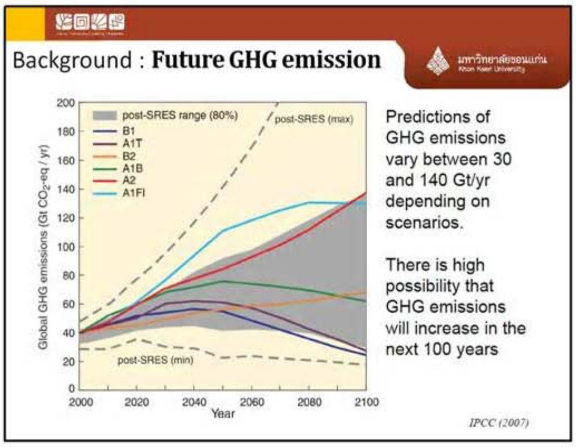
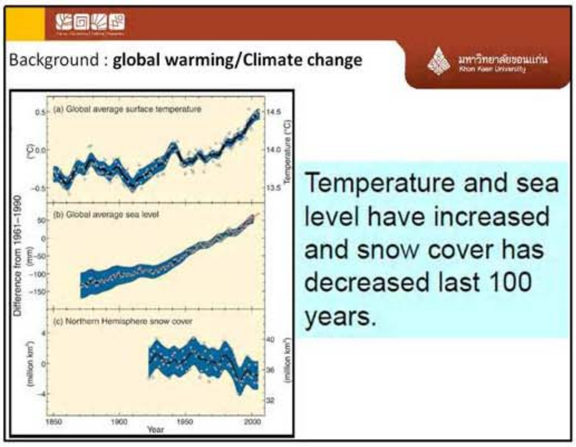
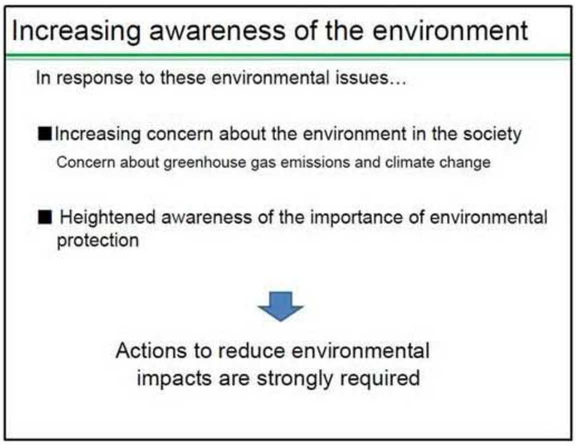
Contents
• Background
• Summary and methodology of general LCA
• Application of LCA to beef production

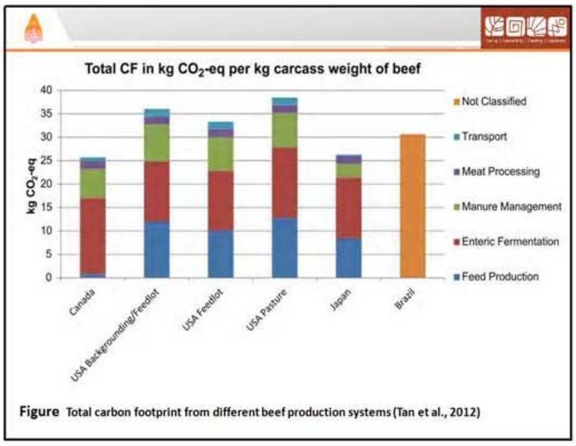

Background : Future GHG emission
post-SRES range (80%)
post-SRES (max)
B1
A1T
B2
A1B
A2
A1FI
post-SRES (min)
Global GHG emissions (Gt CO2-eq / yr)
Year
Predictions of GHG emissions vary between 30 and 140 Gt/yr depending on scenarios.
There is high possibility that GHG emissions will increase in the next 100 years
IPCC (2007)

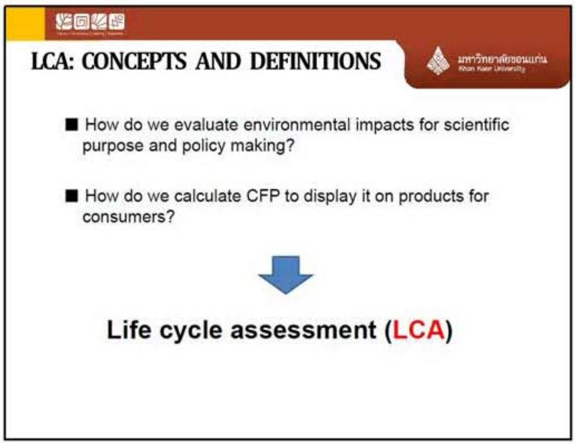

Background : global warming/Climate change
(a) Global average surface temperature
(b) Global average sea level
(c) Northern Hemisphere snow cover
Difference from 1961–1990
Year
Temperature and sea level have increased and snow cover has decreased last 100 years.

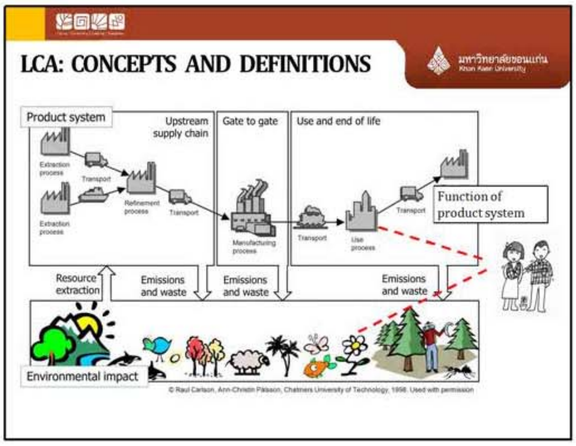

Increasing awareness of the environment
In response to these environmental issues…
■Increasing concern about the environment in the society
Concern about greenhouse gas emissions and climate change
■ Heightened awareness of the importance of environmental protection
Actions to reduce environmental impacts are strongly required

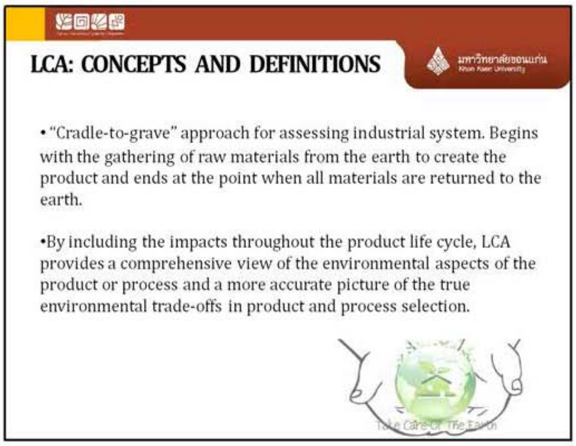

Carbon footprint
■ Carbon footprint (CFP) and other eco-labeling
-Visualization of environmental impacts, especially for consumers
123g
CO2
Advertisement with carbon footprint
Continental Clothing Company (UK)
CFP display on orange juice
TESCO (UK)
CFP mark in Japan

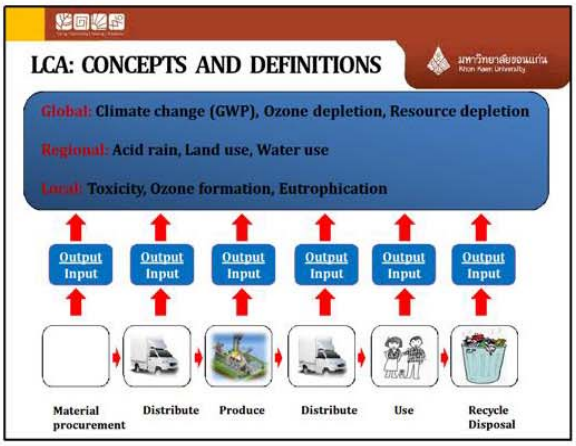

Carbon footprint
■ Carbon footprint (CFP) are calculated and displayed for increasing number of products in Japan.
■ In particular, food is primary target for CFP display, because food is purchased very frequently.
7730g
CO_2
5kg rice
Production
Distribution
Use and disposal
(Aeon Co., Ltd.)

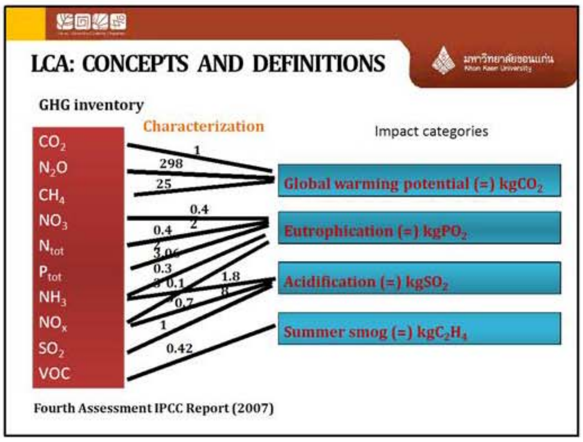

Total CF in kg CO_2-eq per kg carcass weight of beef
kg CO_2-eq
40
35
30
25
20
15
10
5
0
Canada
USA Backgrounding/Feedlot
USA Feedlot
USA Pasture
Japan
Brazil
Not Classified
Transport
Meat Processing
Manure Management
Enteric Fermentation
Feed Production
Figure Total carbon footprint from different beef production systems (Tan et al., 2012)

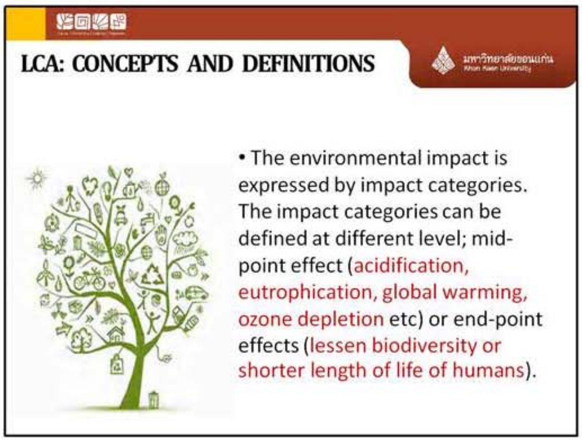

LCA: CONCEPTS AND DEFINITIONS
■ How do we evaluate environmental impacts for scientific purpose and policy making?
■ How do we calculate CFP to display it on products for consumers?
Life cycle assessment (LCA)

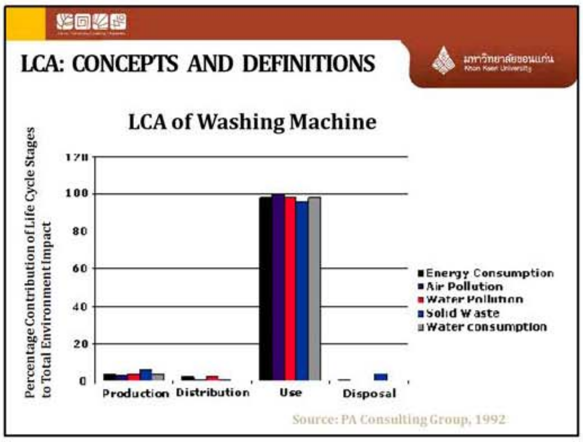

LCA: CONCEPTS AND DEFINITIONS
Product system
Upstream supply chain
Gate to gate
Use and end of life
Extraction process
Transport
Refinement process
Manufacturing process
Use process
Function of product system
Resource extraction
Emissions and waste
Emissions and waste
Emissions and waste
Environmental impact

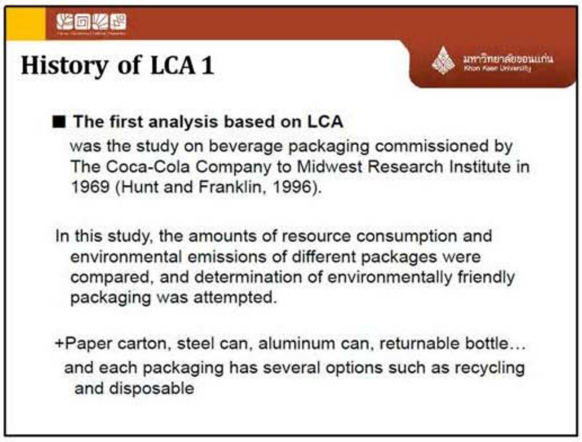

LCA: CONCEPTS AND DEFINITIONS
• "Cradle-to-grave" approach for assessing industrial system. Begins with the gathering of raw materials from the earth to create the product and ends at the point when all materials are returned to the earth.
•By including the impacts throughout the product life cycle, LCA provides a comprehensive view of the environmental aspects of the product or process and a more accurate picture of the true environmental trade-offs in product and process selection.
Take Care of The Earth


LCA: CONCEPTS AND DEFINITIONS
Global: Climate change (GWP), Ozone depletion, Resource depletion
Regional: Acid rain, Land use, Water use
Local: Toxicity, Ozone formation, Eutrophication
Output Input
Output Input
Output Input
Output Input
Output Input
Output Input
Material procurement
Distribute
Produce
Distribute
Use
Recycle Disposal

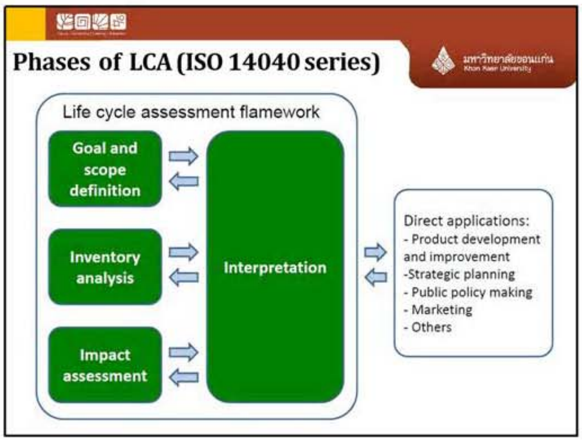

LCA: CONCEPTS AND DEFINITIONS
GHG inventory
Characterization
Impact categories
CO_2
N_2O
CH_4
NO_3
N_{tot}
P_{tot}
NH_3
NO_x
SO_2
VOC
Global warming potential (=) $kgCO_2$
Eutrophication (=) $kgPO_4$
Acidification (=) $kgSO_2$
Summer smog (=) kgC_2H_4
Fourth Assessment IPCC Report (2007)

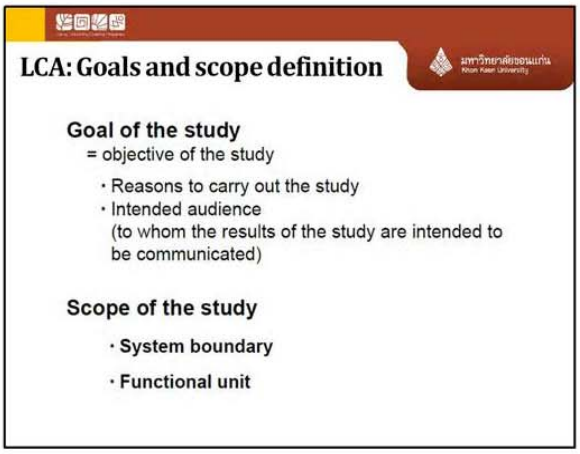

LCA: CONCEPTS AND DEFINITIONS
• The environmental impact is expressed by impact categories. The impact categories can be defined at different level; mid-point effect (acidification, eutrophication, global warming, ozone depletion etc) or end-point effects (lessen biodiversity or shorter length of life of humans).

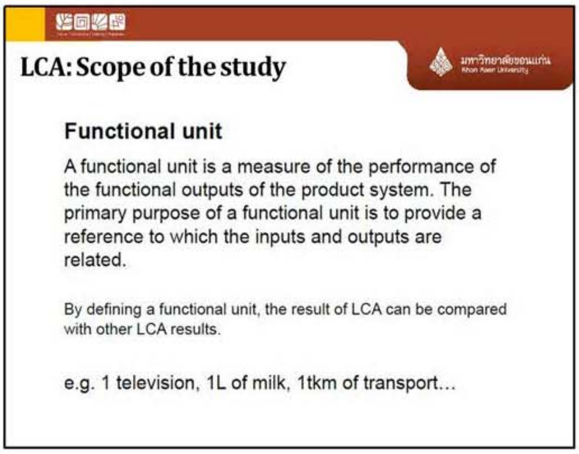

LCA: CONCEPTS AND DEFINITIONS
LCA of Washing Machine
Percentage Contribution of Life Cycle Stages to Total Environment Impact
Production
Distribution
Use
Disposal
Energy Consumption
Air Pollution
Water Pollution
Solid Waste
Water consumption
Source: PA Consulting Group, 1992

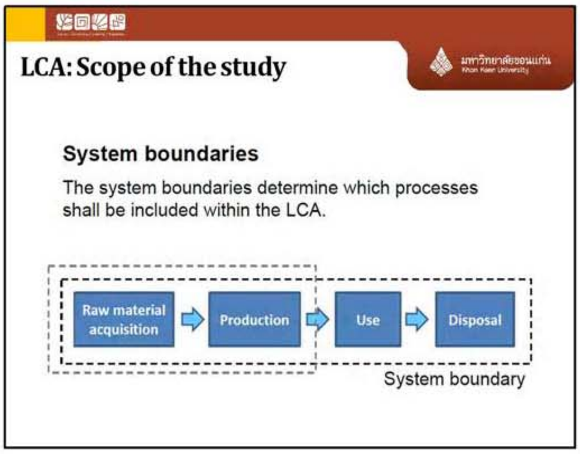

History of LCA 1
The first analysis based on LCA
was the study on beverage packaging commissioned by The Coca-Cola Company to Midwest Research Institute in 1969 (Hunt and Franklin, 1996).
In this study, the amounts of resource consumption and environmental emissions of different packages were compared, and determination of environmentally friendly packaging was attempted.
+Paper carton, steel can, aluminum can, returnable bottle…
and each packaging has several options such as recycling and disposable

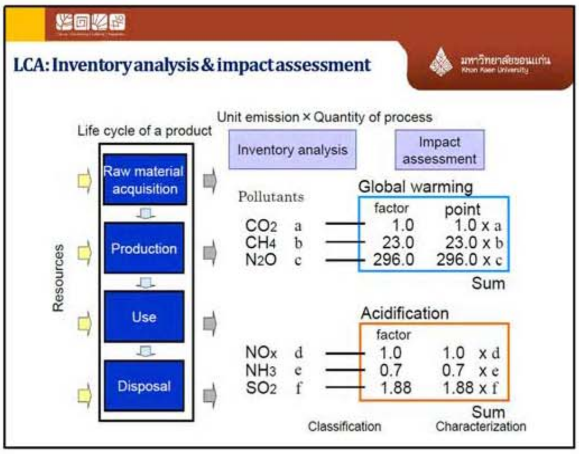

History of LCA 2
ISO 14040 series
In the last two decades, LCA has been internationally standardized by the International Organization for Standardization (ISO) as ISO 14040-43
(ISO 14040, 1997; ISO 14041, 1998; ISO 14042, 2000; ISO 14043, 2000).
Rules have been set for LCA
*ISO 14000 series: The international standards about environmental management system

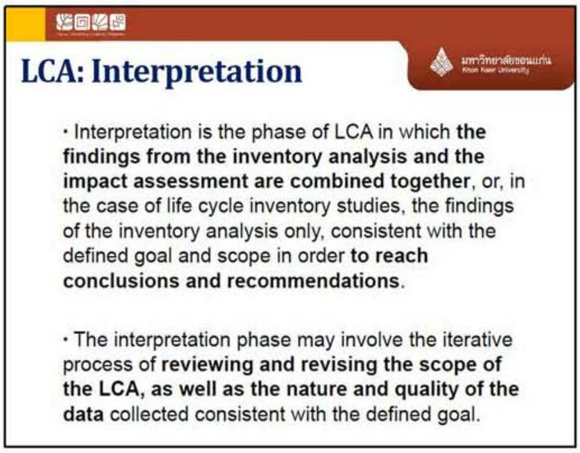

Phases of LCA (ISO 14040 series)
Life cycle assessment flamework
Goal and scope definition
Inventory analysis
Impact assessment
Interpretation
Direct applications:
- Product development and improvement
-Strategic planning
- Public policy making
- Marketing
- Others


LCA: Goals and scope definition
Goal of the study
= objective of the study
· Reasons to carry out the study
· Intended audience
(to whom the results of the study are intended to be communicated)
Scope of the study
· System boundary
· Functional unit

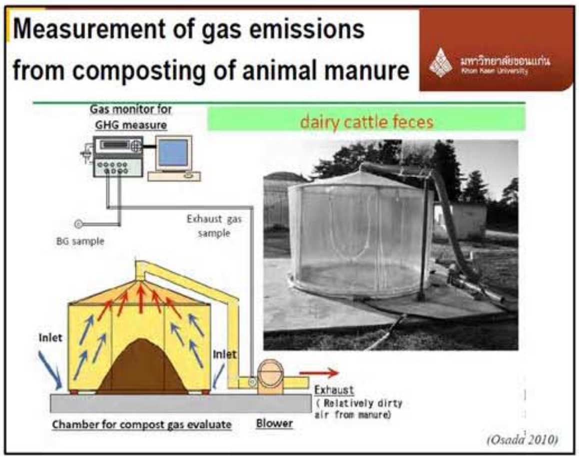

LCA: Scope of the study
Functional unit
A functional unit is a measure of the performance of the functional outputs of the product system. The primary purpose of a functional unit is to provide a reference to which the inputs and outputs are related.
By defining a functional unit, the result of LCA can be compared with other LCA results.
e.g. 1 television, 1L of milk, 1tkm of transport…


LCA: Scope of the study
System boundaries
The system boundaries determine which processes shall be included within the LCA.
Raw material acquisition
Production
Use
Disposal
System boundary

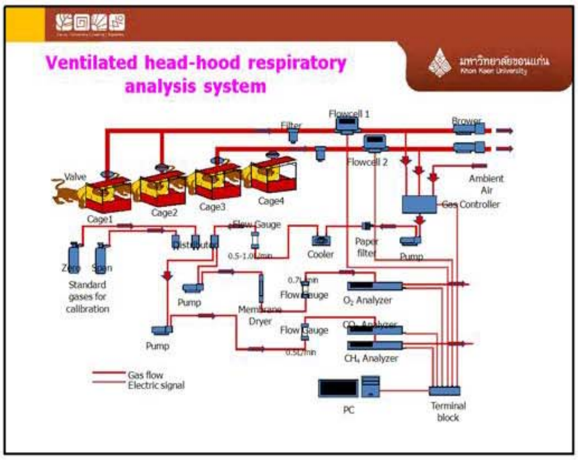

LCA: Inventory analysis & impact assessment
Unit emission × Quantity of process
Life cycle of a product
Inventory analysis
Impact assessment
Raw material acquisition
Production
Use
Disposal
Resources
Pollutants
CO2 a
CH4 b
N2O c
Global warming
factor
point
1.0
1.0 x a
23.0
23.0 x b
296.0
296.0 x c
Sum
Acidification
factor
NOx d
NH3 e
SO2 f
1.0
1.0 x d
0.7
0.7 x e
1.88
1.88 x f
Sum
Classification
Characterization

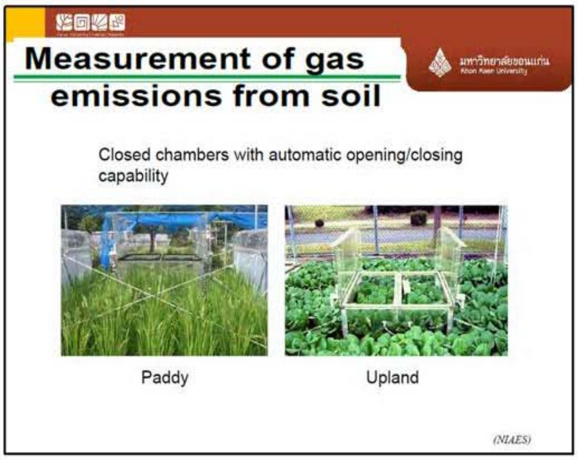

LCA: Interpretation
· Interpretation is the phase of LCA in which the findings from the inventory analysis and the impact assessment are combined together, or, in the case of life cycle inventory studies, the findings of the inventory analysis only, consistent with the defined goal and scope in order to reach conclusions and recommendations.
· The interpretation phase may involve the iterative process of reviewing and revising the scope of the LCA, as well as the nature and quality of the data collected consistent with the defined goal.

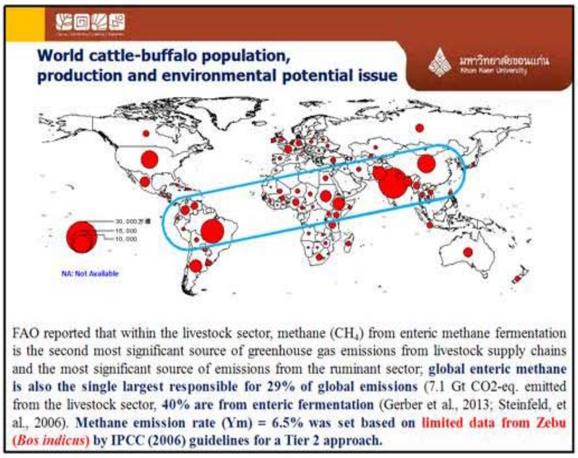

Intergovernmental Panel on Climate Change
2006 IPCC Guidelines for National Greenhouse Gas Inventories
Volume 4
Agriculture, Forestry and Other Land Use
For estimation of CH4 and N2O emissions from agricultural practices

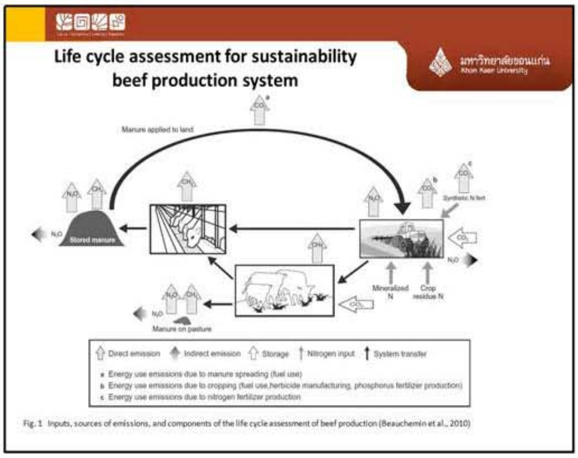

Measurement of gas emissions
from composting of animal manure
Gas monitor for
GHG measure
dairy cattle feces
BG sample
Exhaust gas
sample
Inlet
Inlet
Exhaust
(Relatively dirty
air from manure)
Chamber for compost gas evaluate
Blower
(Osada 2010)


Measurement of enteric methane using Ventilated
head-hood respiratory analysis system


Ventilated head-hood respiratory
analysis system
Flowcell 1
Filter
Brower
Flowcell 2
Valve
Ambient
Air
Gas Controller
Cage1
Cage2
Cage3
Cage4
Flow Gauge
Cooler
Paper
filter
Pump
Standard
gases for
calibration
Pump
O₂ Analyzer
Dryer
Flow Gauge
CH₄ Analyzer
Pump
Gas flow
Electric signal
PC
Terminal
block


Measurement of gas
emissions from soil
Closed chambers with automatic opening/closing
capability
Paddy
Upland
(NIAES)


World cattle-buffalo population,
production and environmental potential issue
NA: Not Available
FAO reported that within the livestock sector, methane (CH4) from enteric methane fermentation is the second most significant source of greenhouse gas emissions from livestock supply chains and the most significant source of emissions from the ruminant sector; global enteric methane is also the single largest responsible for 29% of global emissions (7.1 Gt CO2-eq. emitted from the livestock sector, 40% are from enteric fermentation (Gerber et al., 2013; Steinfeld, et al., 2006). Methane emission rate (Ym) = 6.5% was set based on limited data from Zebu (Bos indicus) by IPCC (2006) guidelines for a Tier 2 approach.


Life cycle assessment for sustainability
beef production system
Manure applied to land
Stored manure
Manure on pasture
Mineralized N
Crop residue N
Synthetic N fert
Direct emission
Indirect emission
Storage
Nitrogen input
System transfer
Fig. 1 Inputs, sources of emissions, and components of the life cycle assessment of beef production (Beauchemin et al., 2010)

LCA of beef production

Life cycle assessment of Thai beef fattening systems

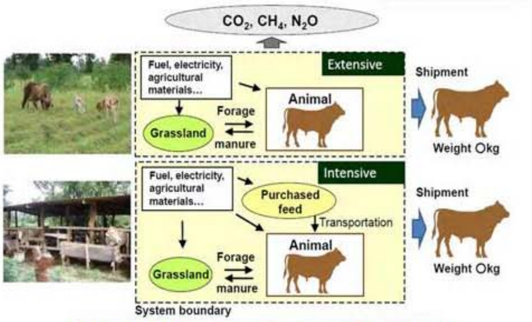
Introduction

Livestock is a major emitter of greenhouse gases (GHG) worldwide. Livestock sector is growing in Southeast Asia, and thus reduction of GHG emissions is required.

One of the measures for GHG reduction per product is increase of productivity.

LCA model for Thai beef production systems was developed, and GHG emissions from extensive and intensive beef production systems in northeastern Thailand were compared in this study.

Thai beef systems compared



Evaluation of GHG emissions per unit product

Summary of two beef production systems

Location: Khon Kaen, Sakon Nakhon, and Nakhon Phanom Provinces, Thailand

	Extensive	Intensive
No. of cattle in farm	9.4	13.2*
Average shipping age, mo	54.5	36.3
Average shipping weight, kg	375.5	653.3
Breed	Thai native-Brahman crossbred	Brahman-Charolais crossbred
Grazing/Housing	Grazing (daytime)	Grazing/Housing
Diet	Grass (grazed), rice straw	Purchased concentrate, molasses, grass, rice straw*
Manure management	No treatment and applied to grassland from housing	No treatment and applied to grassland from housing

*Fattening only

Methods for extensive farming

- No purchased feed is used

- GEI was calculated from ME requirements obtained using the equation for Brahman in WTSR (2010) based on the growth curve estimated from weight and age of cattle and GE/ME ratio of the feed.
- CPI was calculated from ME requirements obtained above and CP/ME ratio of the feed.

- Enteric CH_4 emission was estimated using Chaokaur's equation.
- Manure N_2O and CH_4 emissions were estimated using IPCC methodology based on N intake and GEI obtained above, respectively.

Methods for intensive farming

- Intakes of purchased feed and roughage at fattening stage and purchased feed at calf-backgrounding stage were determined by site investigation

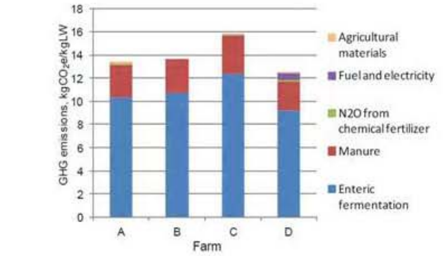
- GEI at fattening stage was based on intake and GE content of feed obtained by site investigation
- GEI at calf-backgrounding stage was calculated from ME requirements obtained using the equation for **Brahman** in WTSR based on the estimated growth curve and GE/ME ratio of the feed.

- Enteric CH_4 emission at fattening stage was estimated using IPCC equation because GEI for latter fattening stage is over the range that Chaokaur's equation covers.
- Enteric CH_4 emission at calf-backgrounding stage was estimated using Chaokaur's equation.

- CPI at fattening stage was based on intake and CP content of feed obtained by site investigation.
- CPI at calf-backgrounding stage was calculated from CP requirements obtained using the equation for **Brahman crossbred** in WTSR based on the growth curve estimated from weight and age of cattle.

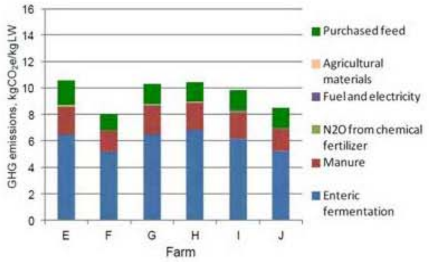
- Manure N_2O and CH_4 emissions were estimated using IPCC methodology based on N intake and GEI obtained above and in enteric CH4 calculation, respectively.

Life-cycle GHG emissions from extensive beef production in Thailand



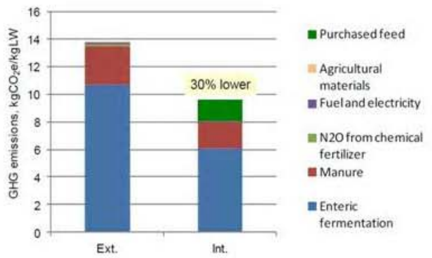
The enteric CH_4 emission and GHG emissions from manure accounted for 77% and 21% of the total, respectively.

Life-cycle GHG emissions from intensive beef production in Thailand



63% of the total GHG emissions were derived from enteric fermentation, 20% from manure management, 16% from the production and transportation of purchased feed.

Average life-cycle GHG emissions from extensive and intensive beef production in Thailand



Effect of energy intake on animal performance and methane emission in Thai native beef cattle

Materials and methods; Feeding trail, Total collection, Respiration

Statistical analysis; Randomized complete block design.

Animals; - 18 growing Thai native cattle (6 male and 12 female).

- BW 98.76±16.70 kg, 13.71 month age

Dietary treatments; 3 treatments with 6 replications.

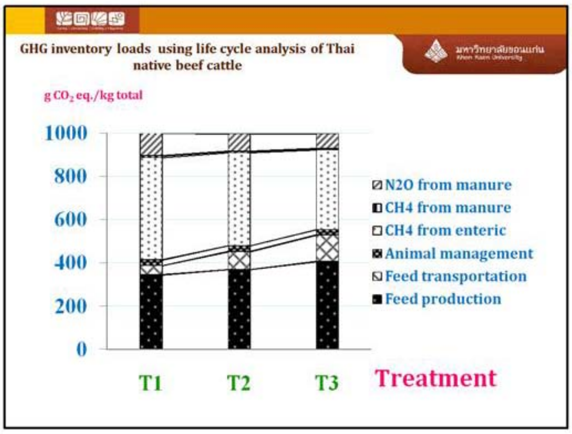
Feed ingredients and analyzed nutrient composition

Feed ingredients	T 1	T 2	T 3
Rice straw	500	300	100
Starch-cassava pulp	100	300	500
Palm kernel cake	235	235	235
Soybean meal	50	50	50
Rice bran	100	100	100
Urea	5	5	5
Mineral	5	5	5
Premix	5	5	5
Total	1000	1000	1000
Chemical composition			
DM, g/kg	365	352	358
OM, g/kg DM	895	921	946
CP, g/kg DM	99	96	98
EE, g/kg DM	59	59	59
NDF, g/kg DM	635	523	451
ADF, g/kg DM	491	387	311
ADL, g/kg DM	80	74	63
GE, MJ/kg DM	17.29	17.77	17.71
DE, MJ/kg DM	11.13	12.62	13.48
ME, MJ/kg DM	9.75	11.43	12.44

Life cycle analysis of Thai native beef cattle

Item	T1	T2	T3	SEM[1/]	Contrast[2/]	
					L	Q
Global warming potential (GWP)						
Inventory loads (g CO_2 eq./kg total)						
Feed production	347^{b}	371^{ab}	408^{a}	13.0	<0.01	0.73
Feed transportation	42^{c}	84^{b}	123^{a}	3.7	<0.01	0.78
Animal management	27	26	25	0.8	0.34	0.85
CH_4 from enteric	473^{a}	430^{ab}	370^{b}	19.5	<0.01	0.72
CH_4 from manure	8.8^{a}	7.3^{ab}	5.0^{b}	0.7	<0.01	0.71
N_2O from manure	103^{a}	81^{b}	69^{c}	3.5	<0.01	0.28
Cow-calf and back grounding at BW 0-200 kg						
kg CO2 eq./head	2188^{a}	2054^{b}	2030^{b}	41.6	<0.05	0.30
kg CO_2 eq./kg BW	10.93^{a}	10.26^{b}	10.13^{b}	0.2	<0.05	0.32
Average GWP from Ym (kg CO_2 eq./kg BW)						
Ym = 0.059 GEI (This study)	10.80^{a}	10.32^{ab}	10.17^{b}	0.2	<0.05	0.46
Ym = 0.065 GEI (IPCC, 2006)	10.99^{a}	10.48^{ab}	10.30^{b}	0.2	<0.05	0.48
Ym = 0.104 GEI (Chuntrakort et al., 2014)	12.23^{a}	11.54^{ab}	11.19^{b}	0.2	<0.05	0.56

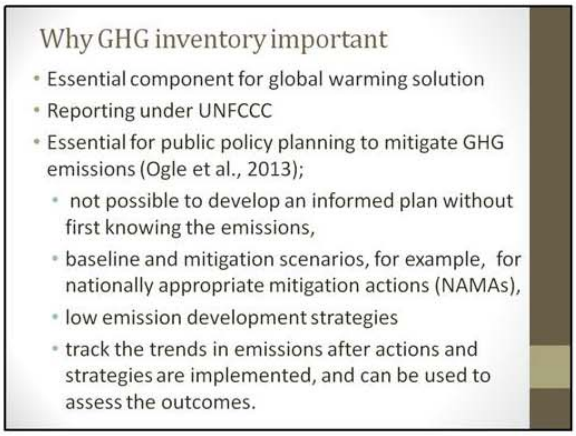
[1/]SEM = Standard Error of the Mean, [2/]Orthogonal polynomial contrast, L = Linear and Q = Quadratic, [a, b, c] Means within the same row with different superscripts are significantly different (P<0.05).

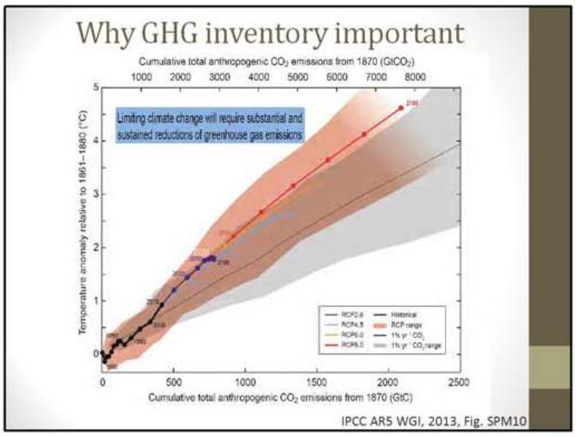

GHG inventory loads using life cycle analysis of Thai native beef cattle
g CO_2 eq./kg total
1000
800
600
400
200
0
N2O from manure
CH4 from manure
CH4 from enteric
Animal management
Feed transportation
Feed production
T1
T2
T3
Treatment

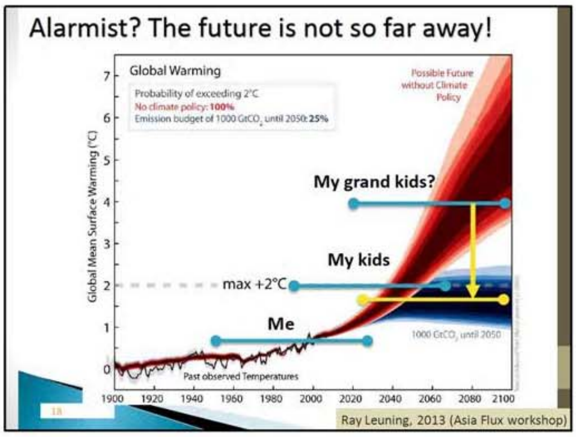

Thank you!
Contact Address:
Associate Professor Kritapon Sommart, Ph.D.
Faculty of Agriculture, Khon Kaen University
Tel: +66-(0)89-7117898 Email: kritapon@kku.ac.th

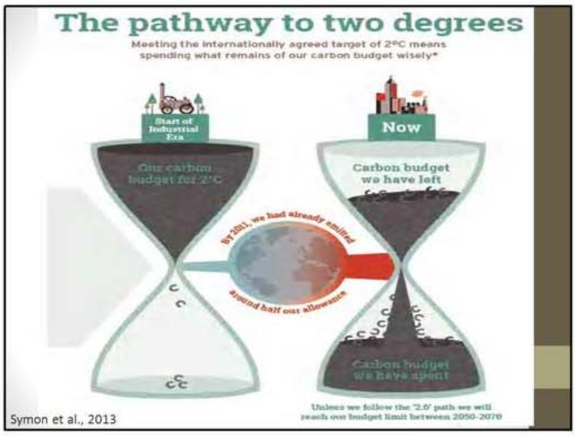
3. Emissions inventory of greenhouse gases from livestock and manure management

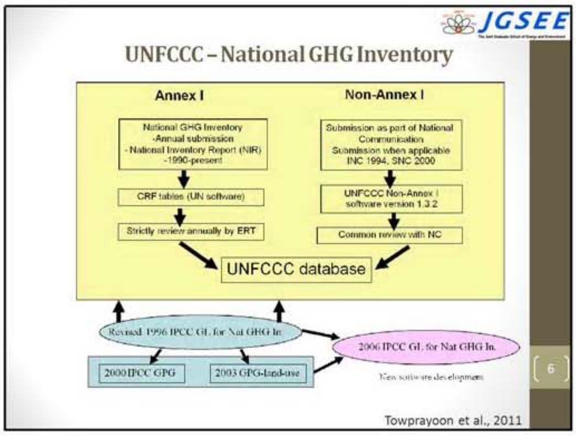
Assoc.Prof. Dr. Amnat Chidthaisong King Mongkut's University of Technology Thonburi (KMUTT). Thailand











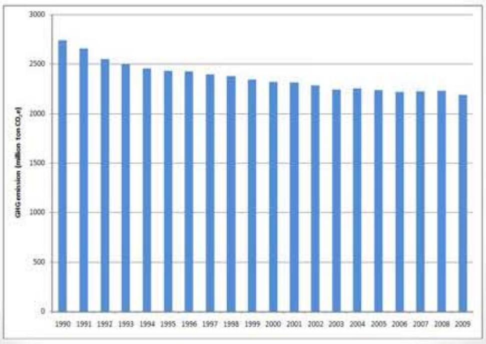
Main principles--**TA**CCC

- **Transparency**
  - Assumptions and methodologies are clearly explained and documented to facilitate replication and assessment
  - If such information not provided, there is no way to demonstrate that any of the other principles has been met.
- **Accuracy**
  - Relative measure of the exactness of emission/removal estimates
  - Estimates must be systematically neither over nor under true emissions/removals, as far as can be judged according to the available data and information
  - Uncertainties must be reduced as far as practicable
  - Appropriate methodologies must be used, in accordance with IPCC guidelines.

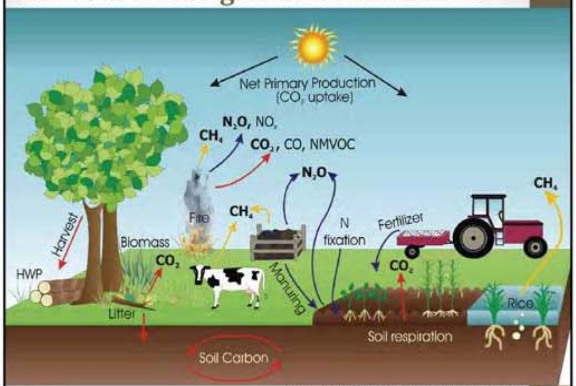
Main principles--TA**CCC**

- Completeness
  - **Inventory internally consistent in all its elements with inventories from previous years;**
  - **Same methodologies for the base year and all subsequent years**
  - **Consistent data sets to estimate emissions and removals from sources/sinks.**
- Comparability
  - **Estimates must be comparable among Parties**
  - **Methodologies and formats as agreed by COPs**
  - **Allocation of source/sink categories, according to the Revised 1996 IPCC Guidelines.**
- Consistency
  - **All sources/sinks and gases included in the IPCC Guidelines**
  - **Other existing specific source/sink categories**
  - **Full geographic coverage of sources/sinks of a Party.**

Emission from agriculture (Annex I)

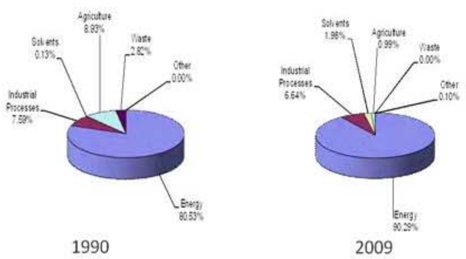


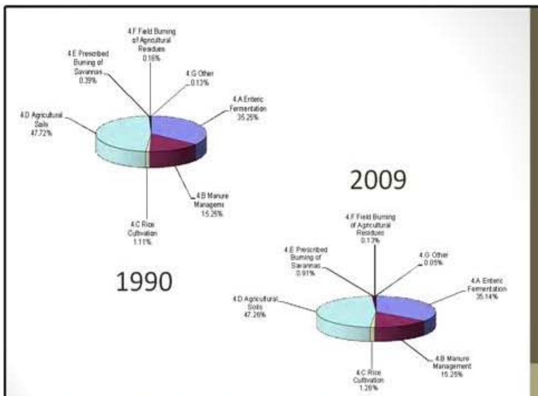
GHG Sources in Agriculture and LULUCF



From 2006 IPCC GHG Inventory Guidelines

Livestock and manure management as the important source (Annex I)



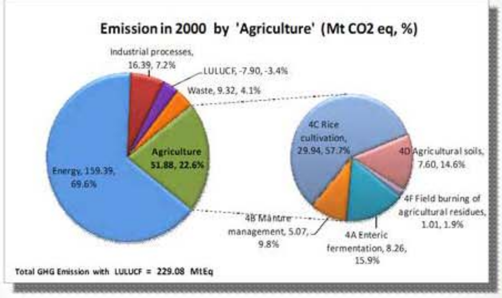


Livestock and manure management as the important source (Annex I)

Emissions from agriculture for non-Annex I

- 25.8 % of the total emission, after energy sector (63.9%)
  - Main sources include rice fields, agricultural soils, enteric fermentation & manure management

GHG emission from Thai agriculture



บัณฑิตวิทยาลัยร่วมด้านพลังงานและสิ่งแวดล้อม 2010

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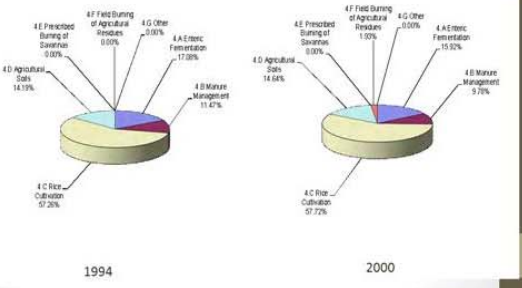
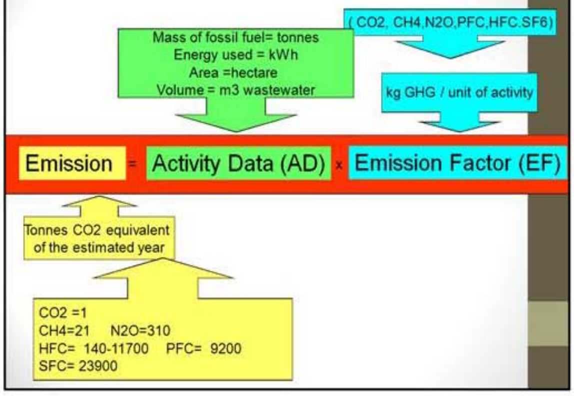
14

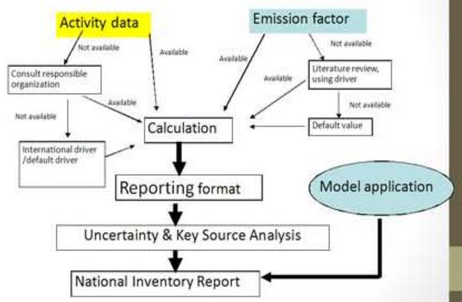
GHG emissions from Thai agriculture



ONEP, 2000 & 2010



Conceptual framework of GHG estimation



IPCC guidelines

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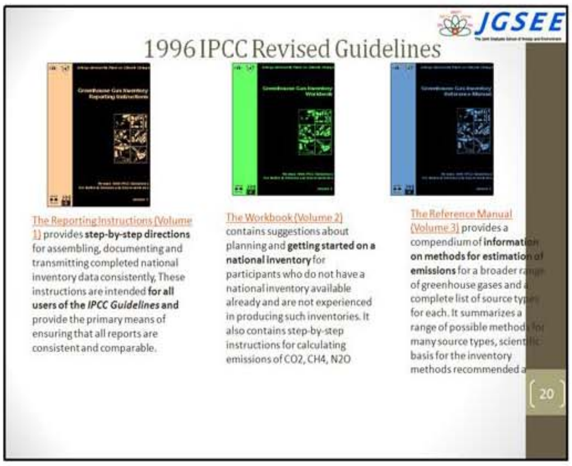
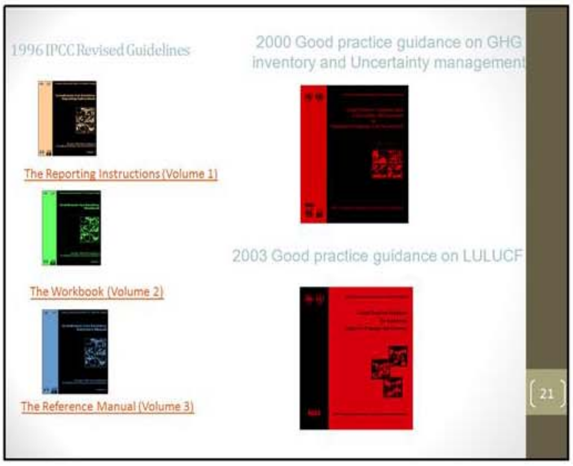
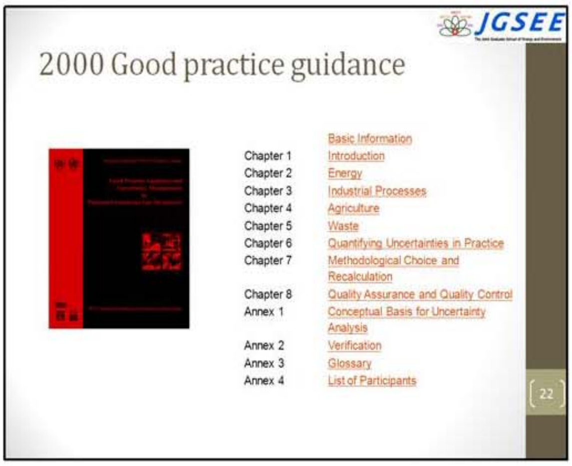
- UNFCCC requests IPCC to provide methodology to estimate National GHG (NGI) Inventory to be reported with the same standard for both Annex I and Non-Annex I
- IPCC has developed two guidelines (two good practice guidance since 1995)
  - 1996 IPCC Revised Guidelines for NGI
    - 2000 Good practice guidance on NGI
    - 2003 Good practice guidance on LULUCF
  - 2006 IPCC Guidelines for NGI (new GL)

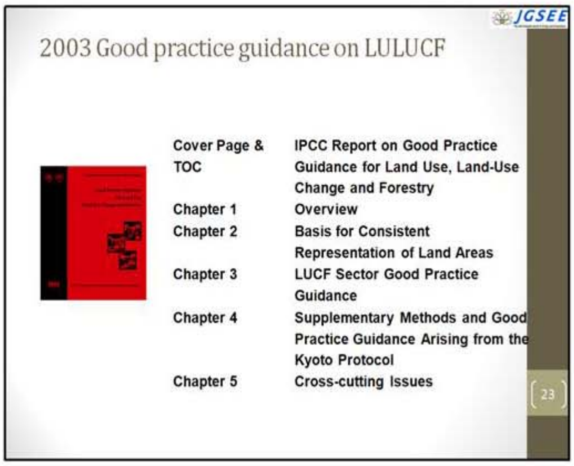
18

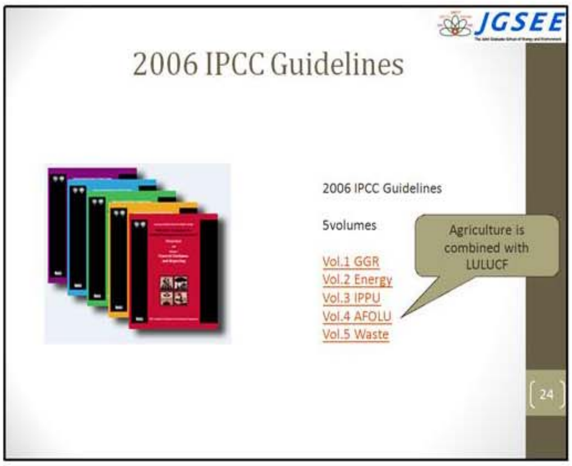

Reference documents
• Revised 1996 IPCC Guidelines for National GHG Inventories http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html
• IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories (2000) http://www.ipcc-nggip.iges.or.jp/public/gp/english/
• IPCC Emission factor database (EFDB) http://www.ipcc-nggip.iges.or.jp/EFDB/main.php
• UNFCCC software http://unfccc.int/resource/cd_roms/na1/ghg_inventories/index.htm
• Colorado State University ALU software http://www.nrel.colostate.edu/projects/ALUsoftware/

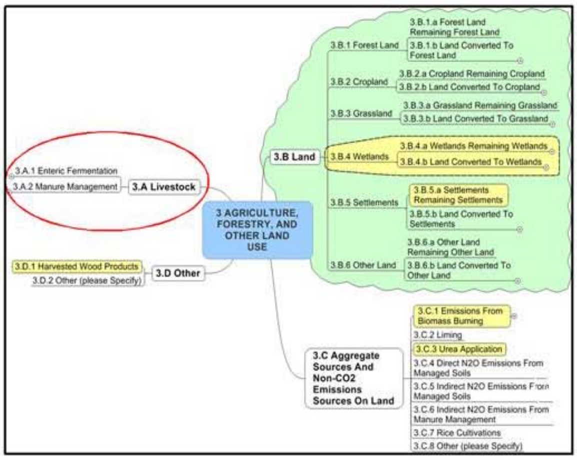

JGSEE
1996 IPCC Revised Guidelines
The Reporting Instructions (Volume 1) provides step-by-step directions for assembling, documenting and transmitting completed national inventory data consistently. These instructions are intended for all users of the IPCC Guidelines and provide the primary means of ensuring that all reports are consistent and comparable.
The Workbook (Volume 2) contains suggestions about planning and getting started on a national inventory for participants who do not have a national inventory available already and are not experienced in producing such inventories. It also contains step-by-step instructions for calculating emissions of CO2, CH4, N2O
The Reference Manual (Volume 3) provides a compendium of informati on methods for estimation of emissions for a broader r of greenhouse gases and complete list of source ty for each. It summarizes a range of possible method many source types, scient basis for the inventory methods recommended
20

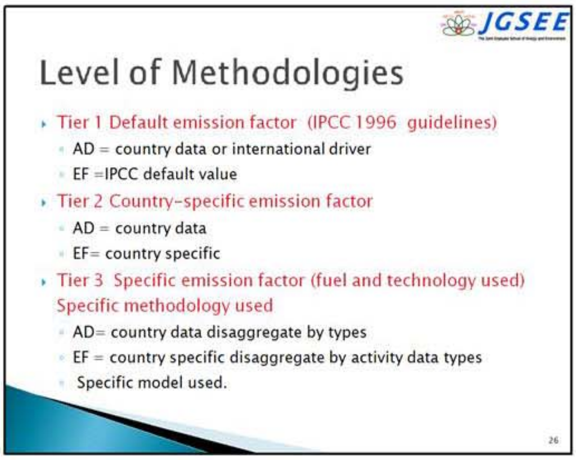

1996 IPCC Revised Guidelines
2000 Good practice guidance on GHG inventory and Uncertainty management
The Reporting Instructions (Volume 1)
The Workbook (Volume 2)
The Reference Manual (Volume 3)
2003 Good practice guidance on LULUCF
21

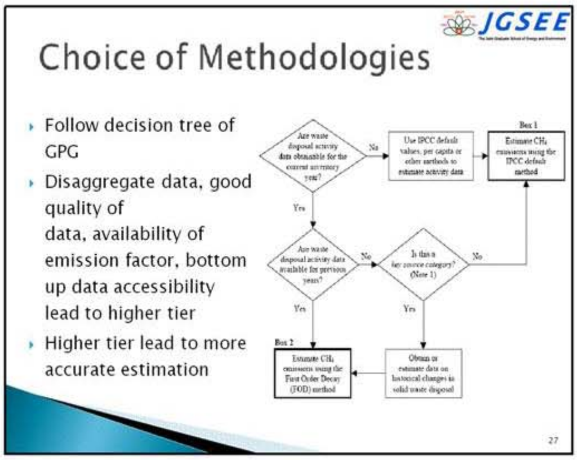

JGSEE
2000 Good practice guidance
Basic Information
Chapter 1 Introduction
Chapter 2 Energy
Chapter 3 Industrial Processes
Chapter 4 Agriculture
Chapter 5 Waste
Chapter 6 Quantifying Uncertainties in Practice
Chapter 7 Methodological Choice and Recalculation
Chapter 8 Quality Assurance and Quality Control
Annex 1 Conceptual Basis for Uncertainty Analysis
Annex 2 Verification
Annex 3 Glossary
Annex 4 List of Participants
22

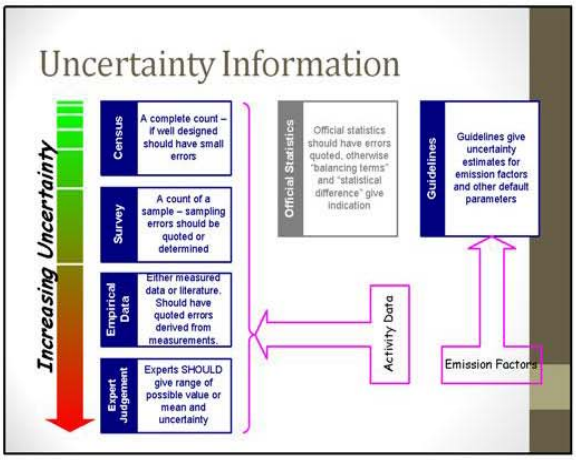

JGSEE
2003 Good practice guidance on LULUCF
Cover Page & TOC IPCC Report on Good Practice Guidance for Land Use, Land-Use Change and Forestry
Chapter 1 Overview
Chapter 2 Basis for Consistent Representation of Land Areas
Chapter 3 LUCF Sector Good Practice Guidance
Chapter 4 Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol
Chapter 5 Cross-cutting Issues
23

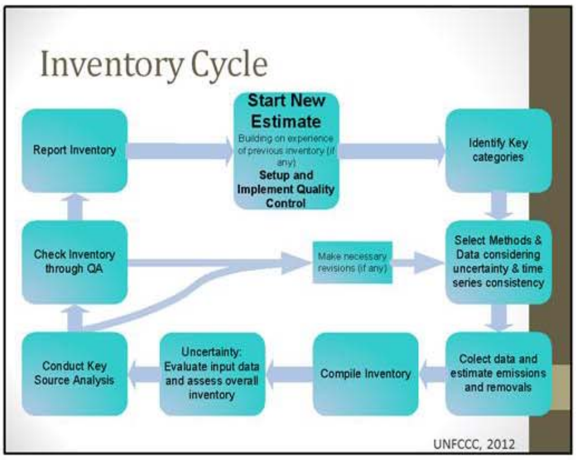

JGSEE
2006 IPCC Guidelines
2006 IPCC Guidelines
5volumes
Vol.1 GGR
Vol.2 Energy
Vol.3 IPPU
Vol.4 AFOLU
Vol.5 Waste
Agriculture is combined with LULUCF
24

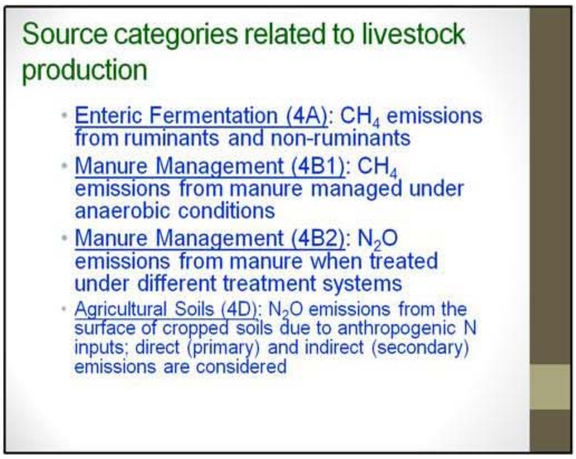

3 AGRICULTURE, FORESTRY, AND OTHER LAND USE
3.A Livestock
3.A.1 Enteric Fermentation
3.A.2 Manure Management
3.B Land
3.B.1 Forest Land
3.B.1.a Forest Land Remaining Forest Land
3.B.1.b Land Converted To Forest Land
3.B.2 Cropland
3.B.2.a Cropland Remaining Cropland
3.B.2.b Land Converted To Cropland
3.B.3 Grassland
3.B.3.a Grassland Remaining Grassland
3.B.3.b Land Converted To Grassland
3.B.4 Wetlands
3.B.4.a Wetlands Remaining Wetlands
3.B.4.b Land Converted To Wetlands
3.B.5 Settlements
3.B.5.a Settlements Remaining Settlements
3.B.5.b Land Converted To Settlements
3.B.6 Other Land
3.B.6.a Other Land Remaining Other Land
3.B.6.b Land Converted To Other Land
3.C Aggregate Sources And Non-CO2 Emissions Sources On Land
3.C.1 Emissions From Biomass Burning
3.C.2 Liming
3.C.3 Urea Application
3.C.4 Direct N2O Emissions From Managed Soils
3.C.5 Indirect N2O Emissions From Managed Soils
3.C.6 Indirect N2O Emissions From Manure Management
3.C.7 Rice Cultivations
3.C.8 Other (please Specify)
3.D Other
3.D.1 Harvested Wood Products
3.D.2 Other (please Specify)

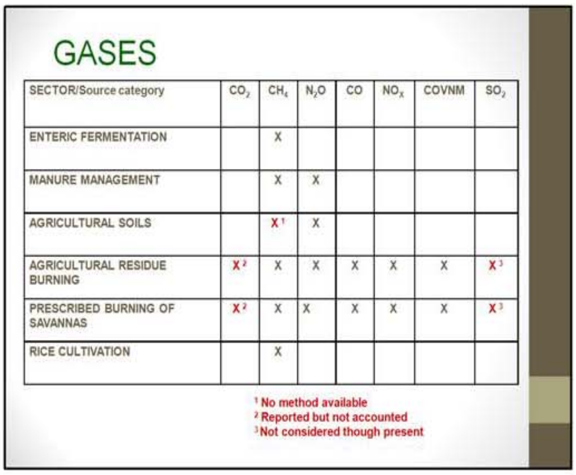

JGSEE
Level of Methodologies
Tier 1 Default emission factor (IPCC 1996 guidelines)
AD = country data or international driver
EF =IPCC default value
Tier 2 Country-specific emission factor
AD = country data
EF= country specific
Tier 3 Specific emission factor (fuel and technology used)
Specific methodology used
AD= country data disaggregate by types
EF = country specific disaggregate by activity data types
Specific model used.
26


JGSEE
Choice of Methodologies
Follow decision tree of GPG
Disaggregate data, good quality of data, availability of emission factor, bottom up data accessibility lead to higher tier
Higher tier lead to more accurate estimation
27


Uncertainty Information
Increasing Uncertainty
Census
A complete count – if well designed should have small errors
Survey
A count of a sample – sampling errors should be quoted or determined
Empirical Data
Either measured data or literature. Should have quoted errors derived from measurements.
Expert Judgement
Experts SHOULD give range of possible value or mean and uncertainty
Official Statistics
Official statistics should have errors quoted, otherwise "balancing terms" and "statistical difference" give indication
Guidelines
Guidelines give uncertainty estimates for emission factors and other default parameters
Activity Data
Emission Factors

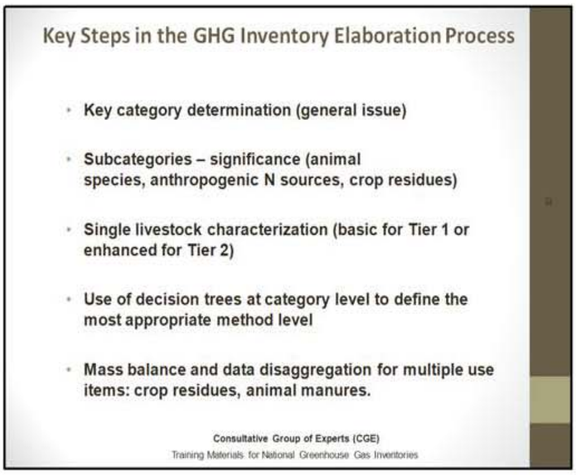

Inventory Cycle
Start New Estimate
Building on experience of previous inventory (if any)
Setup and Implement Quality Control
Identify Key categories
Select Methods & Data considering uncertainty & time series consistency
Colect data and estimate emissions and removals
Compile Inventory
Uncertainty: Evaluate input data and assess overall inventory
Conduct Key Source Analysis
Check Inventory through QA
Report Inventory
Make necessary revisions (if any)
UNFCCC, 2012

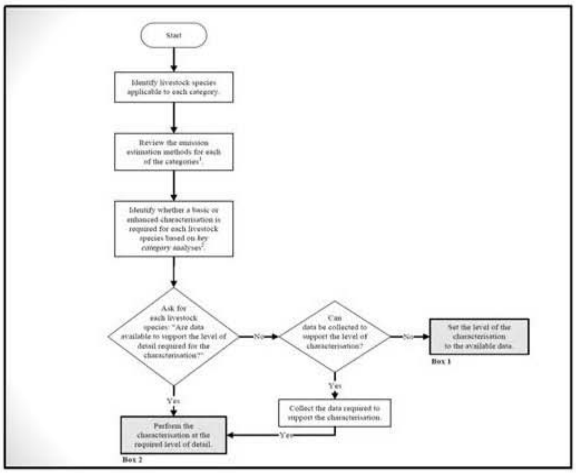

Source categories related to livestock production
Enteric Fermentation (4A): CH4 emissions from ruminants and non-ruminants
Manure Management (4B1): CH4 emissions from manure managed under anaerobic conditions
Manure Management (4B2): N2O emissions from manure when treated under different treatment systems
Agricultural Soils (4D): N2O emissions from the surface of cropped soils due to anthropogenic N inputs; direct (primary) and indirect (secondary) emissions are considered

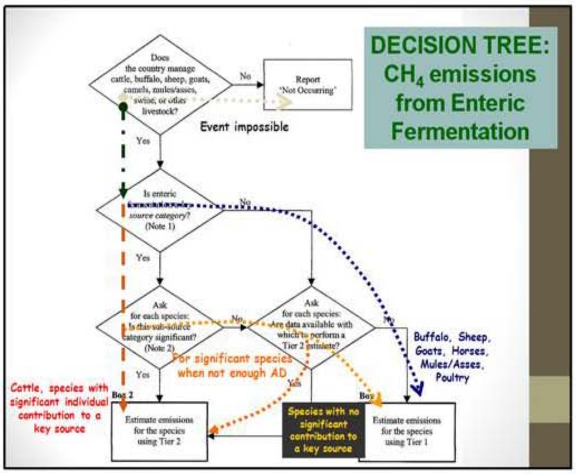


SECTOR/Source category	CO_2	CH_4	N_2O	CO	NO_X	COVNM	SO_2
ENTERIC FERMENTATION		X					
MANURE MANAGEMENT		X	X				
AGRICULTURAL SOILS		X [1]	X				
AGRICULTURAL RESIDUE BURNING	X [2]	X	X	X	X	X	X [3]
PRESCRIBED BURNING OF SAVANNAS	X [2]	X	X	X	X	X	X [3]
RICE CULTIVATION		X					

[1] No method available
[2] Reported but not accounted
[3] Not considered though present







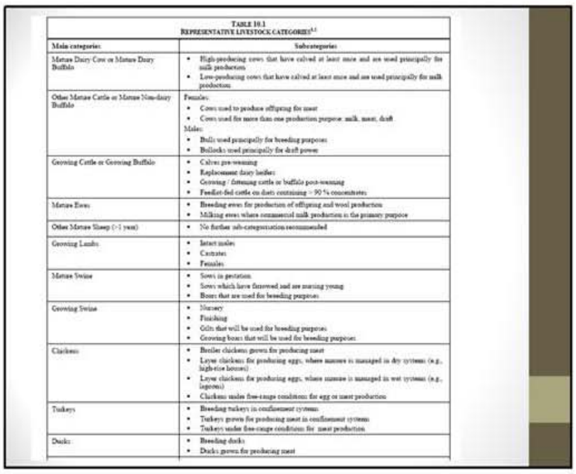
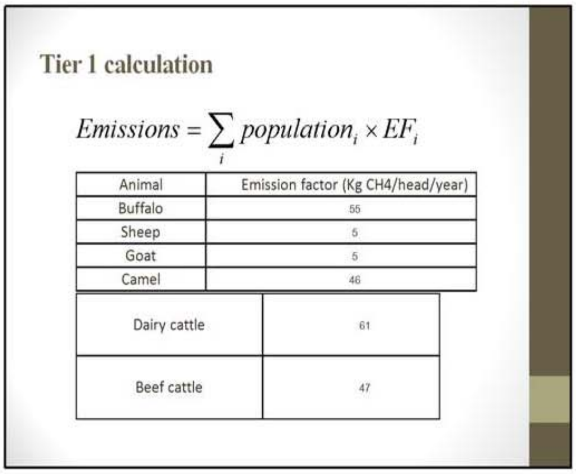


TABLE 10.1
REPRESENTATIVE LIVESTOCK CATEGORIES[1,2]

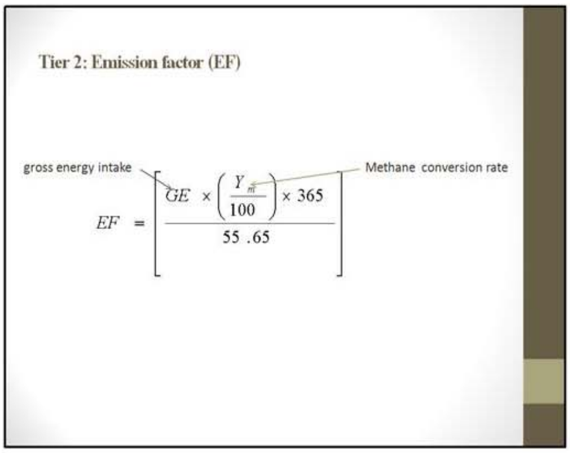
Main categories	Subcategories
Mature Dairy Cow or Mature Dairy Buffalo	• High-producing cows that have calved at least once and are used principally for milk production • Low-producing cows that have calved at least once and are used principally for milk production
Other Mature Cattle or Mature Non-dairy Buffalo	Females: • Cows used to produce offspring for meat • Cows used for more than one production purpose: milk, meat, draft Males: • Bulls used principally for breeding purposes • Bullocks used principally for draft power
Growing Cattle or Growing Buffalo	• Calves pre-weaning • Replacement dairy heifers • Growing / fattening cattle or buffalo post-weaning • Feedlot-fed cattle on diets containing > 90 % concentrates
Mature Ewes	• Breeding ewes for production of offspring and wool production • Milking ewes where commercial milk production is the primary purpose
Other Mature Sheep (>1 year)	• No further sub-categorisation recommended
Growing Lambs	• Intact males • Castrates • Females
Mature Swine	• Sows in gestation • Sows which have farrowed and are nursing young • Boars that are used for breeding purposes
Growing Swine	• Nursery • Finishing • Gilts that will be used for breeding purposes • Growing boars that will be used for breeding purposes
Chickens	• Broiler chickens grown for producing meat • Layer chickens for producing eggs, where manure is managed in dry systems (e.g., high-rise houses) • Layer chickens for producing eggs, where manure is managed in wet systems (e.g., lagoons) • Chickens under free-range conditions for egg or meat production
Turkeys	• Breeding turkeys in confinement systems • Turkeys grown for producing meat in confinement systems • Turkeys under free-range conditions for meat production
Ducks	• Breeding ducks • Ducks grown for producing meat

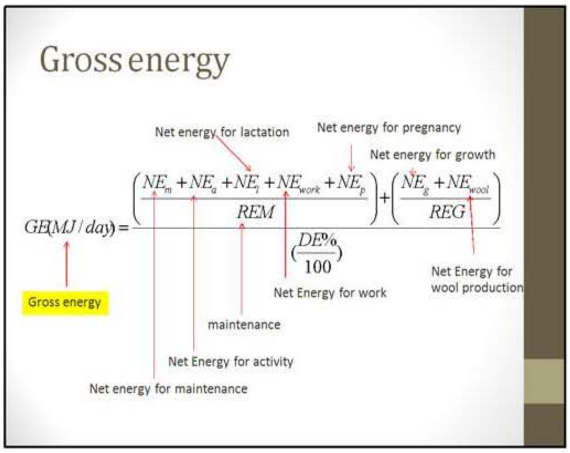


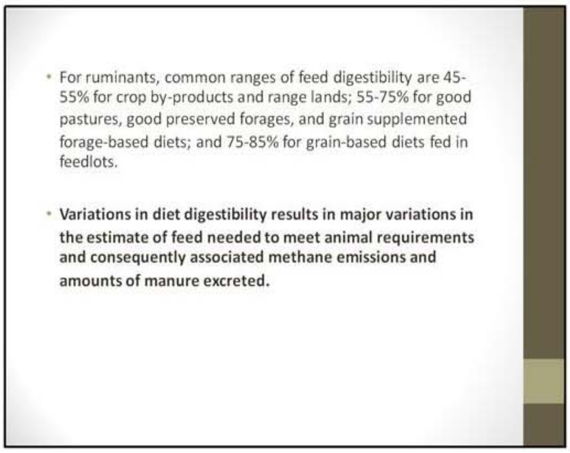
$$Emissions = \sum_i population_i \times EF_i$$

Animal	Emission factor (Kg CH4/head/year)
Buffalo	55
Sheep	5
Goat	5
Camel	46

Dairy cattle	61
Beef cattle	47







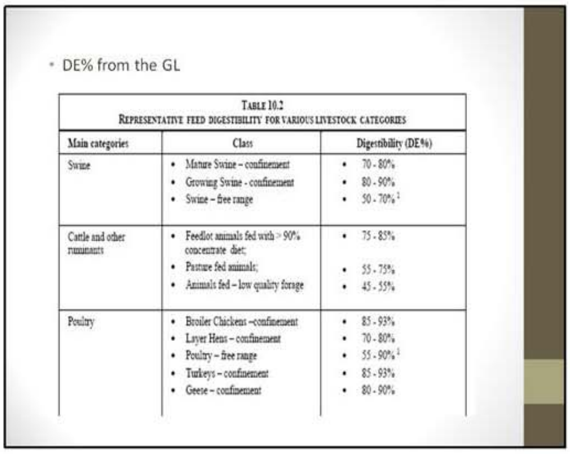
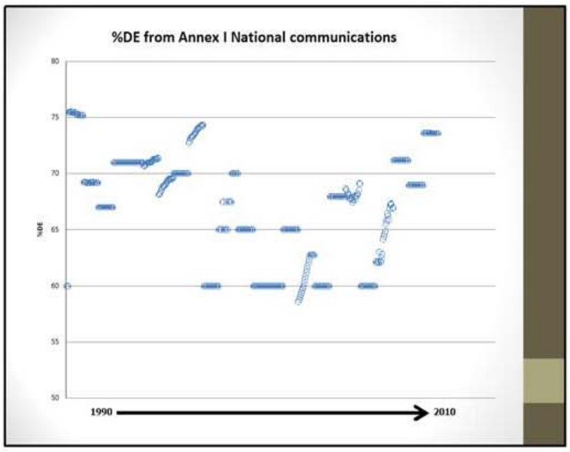


TABLE 10.2
REPRESENTATIVE FEED DIGESTIBILITY FOR VARIOUS LIVESTOCK CATEGORIES

Main categories	Class	Digestibility (DE%)
Swine	• Mature Swine – confinement • Growing Swine - confinement • Swine – free range	• 70 - 80% • 80 - 90% • 50 - 70% [1]
Cattle and other ruminants	• Feedlot animals fed with > 90% concentrate diet; • Pasture fed animals; • Animals fed – low quality forage	• 75 - 85% • 55 - 75% • 45 - 55%
Poultry	• Broiler Chickens –confinement • Layer Hens – confinement • Poultry – free range • Turkeys – confinement • Geese – confinement	• 85 - 93% • 70 - 80% • 55 - 90% [1] • 85 - 93% • 80 - 90%



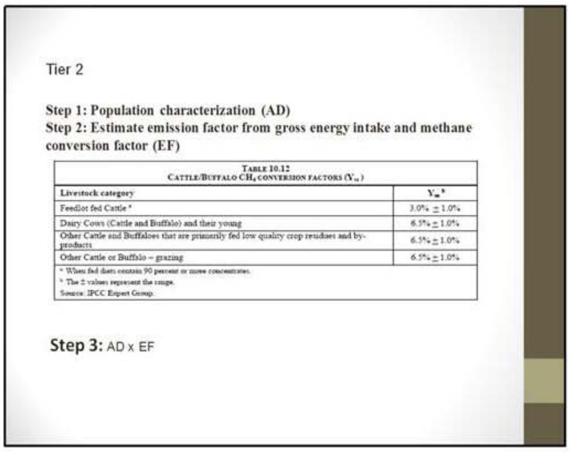
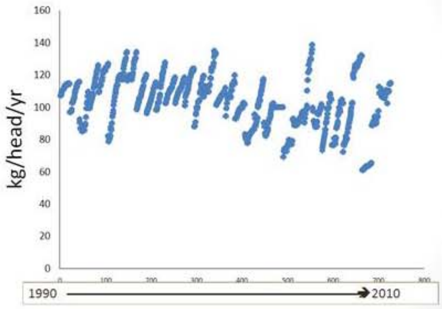


TABLE 10.12
CATTLE/BUFFALO CH_4 CONVERSION FACTORS (Y_m)

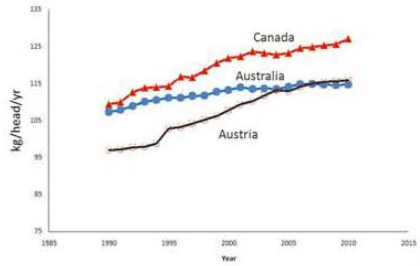
Livestock category	Y_m [b]
Feedlot fed Cattle [a]	3.0% ± 1.0%
Dairy Cows (Cattle and Buffalo) and their young	6.5% ± 1.0%
Other Cattle and Buffaloes that are primarily fed low quality crop residues and by-products	6.5% ± 1.0%
Other Cattle or Buffalo – grazing	6.5% ± 1.0%

[a] When fed diets contain 90 percent or more concentrates.
[b] The ± values represent the range.
Source: IPCC Expert Group.

Enteric methane emission factor (Annex I, dairy cattle)



Tier 2 Methane emission factor (Dairy, Annex I)



Manure management-CH_4

Tier 1 (Asia, warm >28C)

Livestock cat.	Kg CH4/head/year
Sheep	0.20
Goat	0.22
Camel	2.56
Horse	2.19
ลาและล่อ	1.20
Poultry	0.02
Dairy cattle	31
Beef cattle	1
Swine	7
Baffalo	2

Tier 2 emission factor

daily volatile solid excreted

Methane conversion factors for each manure management system

$$EF_{(T)} = \left(VS_{(T)} \times 365 days/yr\right) \times \left[B_{o(T)} \times 0.67 kg/m^3 \times \sum_{S,k}\left(\frac{MCF_{S,k}}{100} \times MS\%_{(T,S,k)}\right)\right]$$

Maximum methane producing capacity

% population t with manure waste management system s in region k

VS estimation

ash content of the manure

$$VS = \left[GE \times \left(1 - \frac{DE\%}{100}\right) + (UE \times GE)\right] \times \left[\left(\frac{1 - ASH}{18.45}\right)\right]$$

urinary energy expressed as fraction of GE (~0.04GE)

- Bo (Maximum methane producing capacity)
  - Country specific if possible (varies on species and diets)
  - If not, provided in Table 10A.4-10A.9
- MCFs is provided in Table 10.17 (temperature and MMS)

TABLE 10.17
MCF VALUES BY TEMPERATURE FOR MANURE MANAGEMENT SYSTEMS

System*		MCFs by average annual temperature (°C)																		
		Cool					Temperate											Warm		
		≤ 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	≥ 28
Pasture/Range/Paddock		1.0%					1.5%											2.0%		
Daily spread		0.1%					0.5%											1.0%		
Solid storage		2.0%					4.0%											5.0%		
Dry lot		1.0%					1.5%											2.0%		
Liquid/Slurry	With natural crust cover	10%	11%	13%	14%	15%	17%	18%	20%	22%	24%	26%	29%	31%	34%	37%	41%	44%	48%	50%
	Without natural crust cover	17%	19%	20%	22%	25%	27%	29%	32%	35%	39%	42%	46%	50%	55%	60%	65%	71%	78%	80%

Table 10.18
Definitions of manure management systems

System	Definition
Pasture/Range/Paddock	The manure from pasture and range grazing animals is allowed to lie as deposited, and is not managed.
Daily spread	Manure is routinely removed from a confinement facility and is applied to cropland or pasture within 24 hours of excretion.
Solid storage	The storage of manure, typically for a period of several months, in unconfined piles or stacks. Manure is able to be stacked due to the presence of a sufficient amount of bedding material or loss of moisture by evaporation.
Dry lot	A paved or unpaved open confinement area without any significant vegetative cover where accumulating manure may be removed periodically.
Liquid/Slurry	Manure is stored as excreted or with some minimal addition of water in either tanks or earthen ponds outside the animal housing, usually for periods less than one year.
Uncovered anaerobic lagoon	A type of liquid storage system designed and operated to combine waste stabilization and storage. Lagoon supernatant is usually used to remove manure from the associated confinement facilities to the lagoon. Anaerobic lagoons are designed with varying lengths of storage (up to a year or greater), depending on the climate region, the volatile solids loading rate, and other operational factors. The water from the lagoon may be recycled as flush water or used to irrigate and fertilise fields.
Pit storage below animal confinements	Collection and storage of manure usually with little or no added water typically below a slatted floor in an enclosed animal confinement facility, usually for periods less than one year.
Anaerobic digester	Animal excreta with or without straw are collected and anaerobically digested in a large containment vessel or covered lagoon. Digesters are designed and operated for waste stabilization by the microbial reduction of complex organic compounds to CO_2 and CH_4, which is captured and flared or used as a fuel.
Burned for fuel	The dung and urine are excreted on fields. The sun dried dung cakes are burned for fuel.
Cattle and Swine deep bedding	As manure accumulates, bedding is continually added to absorb moisture over a production cycle and possibly for as long as 6 to 12 months. This manure management system also is known as a bedded pack manure management system and may be combined with a dry lot or pasture.
Composting - in-vessel[a]	Composting, typically in an enclosed channel, with forced aeration and continuous mixing.
Composting - Static pile[a]	Composting in piles with forced aeration but no mixing.
Composting - Intensive windrow[a]	Composting in windrows with regular (at least daily) turning for mixing and aeration.
Composting - Passive windrow[a]	Composting in windrows with infrequent turning for mixing and aeration.
Poultry manure with litter	Similar to cattle and swine deep bedding except usually not combined with a dry lot or pasture. Typically used for all poultry breeder flocks and for the production of meat type chickens

Direct N_2O emission from MM

$$N_2O_{D(mm)} = \left[\sum_S\left[\sum_T\left(N_{(T)} \bullet Nex_{(T)} \bullet MS_{(T,S)}\right)\right] \bullet EF_{3(S)}\right] \bullet \frac{44}{28}$$

Nitrogen excretion rate for T livestock

Livestock T population

Fraction of N excretion/year of livestock T under manure management system s.

Nex vaules

Table 10.19
Default values for nitrogen excretion rate[a] (kg N (1000 kg animal mass)$^{-1}$ day^{-1})

Category of animal	Region							
	North America	Western Europe	Eastern Europe	Oceania	Latin America	Africa	Middle East	Asia
Dairy Cattle	0.44	0.48	0.35	0.44	0.48	0.60	0.70	0.47
Other Cattle	0.31	0.33	0.35	0.50	0.36	0.63	0.79	0.34
Swine[b]	0.50	0.68	0.74	0.71	1.64	1.64	1.64	0.50
Market	0.42	0.51	0.55	0.53	1.57	1.57	1.57	0.42
Breeding	0.24	0.42	0.46	0.46	0.55	0.55	0.55	0.24
Poultry	0.83	0.83	0.82	0.82	0.82	0.82	0.82	0.82
Hens >= 1 yr	0.83	0.96	0.82	0.82	0.82	0.82	0.82	0.82
Pullets	0.62	0.55	0.60	0.60	0.60	0.60	0.60	0.60
Other Chickens	0.83	0.83	0.82	0.82	0.82	0.82	0.82	0.82
Broilers	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Turkeys	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
Ducks	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
Sheep	0.42	0.85	0.90	1.13	1.17	1.17	1.17	1.17
Goats	0.45	1.28	1.28	1.42	1.37	1.37	1.37	1.37
Horses (and mules, asses)	0.30	0.26	0.30	0.30	0.46	0.46	0.46	0.46
Camels[c]	0.38	0.38	0.38	0.38	0.46	0.46	0.46	0.46
Buffalo[c]	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Mink and Polecat (kg N head^{-1} yr^{-1})[d]	4.59	4.59	4.59	4.59	4.59	4.59	4.59	4.59
Rabbits (kg N head^{-1} yr^{-1})	8.10	8.10	8.10	8.10	8.10	8.10	8.10	8.10
Fox and Racoon (kg N head^{-1} yr^{-1})[d]	12.09	12.09	12.09	12.09	12.09	12.09	12.09	12.09

EF3(s)

Table 10.21
Default emission factors for direct N_2O emissions from manure management

System	Definition	EF_3 [kg N_2O-N (kg Nitrogen excreted)$^{-1}$]	Uncertainty ranges of EF_3	Source[a]
Pasture/Range/Paddock	The manure from pasture and range grazing animals is allowed to lie as is, and is not managed.	Direct and indirect N_2O emissions associated with the manure deposited on agricultural soils and pasture, range, paddock systems are treated in Chapter 11, Section 11.2, N_2O emissions from managed soils.		
Daily spread	Manure is routinely removed from a confinement facility and is applied to cropland or pasture within 24 hours of excretion. N_2O emissions during storage and treatment are assumed to be zero. N_2O emissions from land application are covered under the Agricultural Soils category.	0	Not applicable	Judgement by IPCC Expert Group (see Co-chairs, Editors and Experts; N_2O emissions from Manure Management).
Solid storage[b]	The storage of manure, typically for a period of several months, in unconfined piles or stacks. Manure is able to be stacked due to the presence of a sufficient amount of bedding material or loss of moisture by evaporation.	0.005	Factor of 2	Judgement of IPCC Expert Group in combination with Amon *et al.* (2001), which shows emissions ranging from 0.0027 to 0.01 kg N_2O-N (kg N)$^{-1}$.
Dry lot	A paved or unpaved open confinement area without any significant vegetative cover where accumulating manure may be removed periodically. Dry lots are most typically found in dry climates but also are used in humid climates.	0.02	Factor of 2	Judgement of IPCC Expert Group in combination with Kulling (2003).

Indirect N_2O from manure management

Step 1-1: N volatilization

$$N_{volatilization-MMS} = \sum_S\left[\sum_T\left[\left(N_{(T)} \bullet Nex_{(T)} \bullet MS_{(T,S)}\right) \bullet \left(\frac{Frac_{GasMS}}{100}\right)_{(T,S)}\right]\right]$$

Step 1-2: Emission

$$N_2O_{G(mm)} = \left(N_{volatilization-MMS} \times EF_4\right) \times \frac{44}{28}$$

Table 10.22
Default values for nitrogen loss due to volatilisation of NH_3 and NO_x from manure management

Animal type	Manure management system (MMS)[a]	N loss from MMS due to volatilisation of N-NH_3 and N-NO_x (%)[b] $Frac_{GasMS}$ (Range of $Frac_{GasMS}$)
Swine	Anaerobic lagoon	40% (25 – 75)
	Pit storage	25% (15 – 30)
	Deep bedding	40% (10 – 60)
	Liquid/slurry	48% (15 – 60)
	Solid storage	45% (10 – 65)
Dairy Cow	Anaerobic lagoon	35% (20 – 80)
	Liquid/Slurry	40% (15 – 45)
	Pit storage	28% (10 – 40)
	Dry lot	20% (10 – 35)
	Solid storage	30% (10 – 40)
	Daily spread	7% (5 – 60)
Poultry	Poultry without litter	55% (40 – 70)
	Anaerobic lagoon	40% (25 – 75)
	Poultry with litter	40% (10 – 60)
Other Cattle	Dry lot	30% (20 – 50)
	Solid storage	45% (10 – 65)
	Deep bedding	30% (20 – 40)
Other[c]	Deep bedding	25% (10 – 30)
	Solid storage	12% (5 – 20)

Step 2-1: N loss due to leaching

$$N_{leaching-MMS} = \sum_{S} \left[\sum_{T} \left[\left(N_{(T)} \times Nex_{(T)} \times MS_{(T,S)} \right) \times \left(\frac{Frac_{leachingMS}}{100} \right)_{(T,S)} \right] \right]$$

Step 2-2:Emission

$$N_2O_{L(mm)} = \left(N_{leaching-MMS} \times EF_5 \right) \times \frac{44}{28}$$

TABLE 11.3
DEFAULT EMISSION, VOLATILISATION AND LEACHING FACTORS FOR INDIRECT SOIL N_2O EMISSIONS

Factor	Default value	Uncertainty range
EF_4 [N volatilisation and re-deposition], kg N_2O–N (kg NH_3–N + NO_X–N volatilised)$^{-1}$ [22]	0.010	0.002 - 0.05
EF_5 [leaching/runoff], kg N_2O–N (kg N leaching/runoff)$^{-1}$ [23]	0.0075	0.0005 - 0.025
$Frac_{GASF}$ [Volatilisation from synthetic fertiliser], (kg NH_3–N + NO_x–N) (kg N applied)$^{-1}$	0.10	0.03 - 0.3
$Frac_{GASM}$ [Volatilisation from all organic N fertilisers applied , and dung and urine deposited by grazing animals], (kg NH_3–N + NO_x–N) (kg N applied or deposited)$^{-1}$	0.20	0.05 - 0.5
$Frac_{LEACH-(H)}$ [N losses by leaching/runoff for regions where Σ(rain in rainy season) - Σ (PE in same period) > soil water holding capacity, OR where irrigation (except drip irrigation) is employed], kg N (kg N additions or deposition by grazing animals)$^{-1}$	0.30	0.1 - 0.8

Concluding remarks: Livestock and manure management greenhouse gases emission

- Enteric Fermentation--Methane
- Manure management--Methane & Nitrous oxide (Direct & indirect)
- Key sources in most of Annex & non-Annex countries
- Key parameters for estimating greenhouse gas emission vary on species, diet and waste treatments.
- For reasonably reliable estimate, important parameters should be country-specific (e.g. DE, VS)

Thank you

REVISED 1996 IPCC GUIDELINES

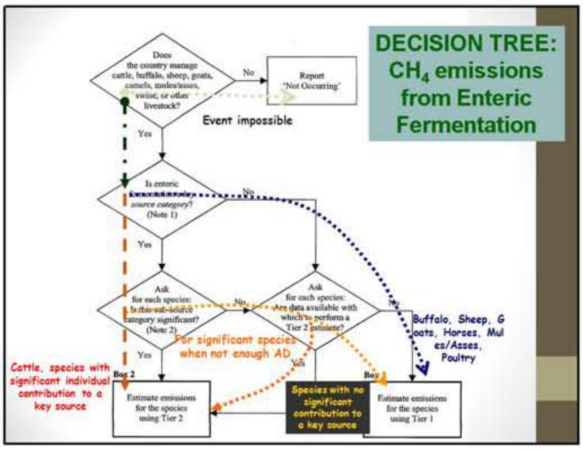
- **Agriculture Sector Sink/Source Categories (1)**
  - **Enteric Fermentation (4A):** CH_4 emissions by ruminants and non-ruminants
    - Information organized by animal species
    - Tier 1 method based on multiplication of number of animals in each category by an EF
    - Tier 2 method (cattle only) uses enhanced characterization of livestock, which results in estimation of annual feed intake (parameter used to estimate specific EFs)

REVISED 1996 IPCC GUIDELINES

- **Agriculture Sector Sink/Source Categories (2)**
  - **Manure Management (4B):** CH_4 (4Ba) and N_2O (4Bb) emissions from decomposition of manure during storage
    - Information organized by animal groups and manure management systems (MMS)
    - Tier 1 method requires livestock population data by climate region and animal waste management system and uses default EFs.
    - Tier 2 method estimates EF from manure characteristics (VS, B_o, MCF) (for CH_4 emissions from cattle, swine and sheep)

REVISED 1996 IPCC GUIDELINES

- Agriculture Sector Sink/Source Categories (4)
  - **Agricultural Soils (4D):** covers N_2O emissions only (no methods are provided for CH_4 emissions and removals, or for N_2O removals). Tier 1 method for both direct/indirect emissions
    - **Direct N_2O emissions**: requires AD (use of fertilizers and manure, amount of N fixed by crops, amount of crop residues returned to soil, N-fixing crops, area of cultivated histosols) and 2 EFs (one for N inputs into soil and one for cultivation of organic soils)
    - **Indirect N_2O emissions**: 3 sources: (a) volatilization and deposition of N in fertilizers/manure; (b) leaching and run-off of applied fertilizers/manure; (c) discharge of human sewage into rivers or estuaries



ENTERIC FERMENTATION

- Two methods for estimating emissions from enteric fermentation:
  - Tier 1, simplified approach, relies on default EFs drawn from previous studies
  - Tier 2, complex approach, requires detailed CS data on nutrient requirements, feed intake and CH_4 conversion rates for specific feed types, to develop CS EFs for country-defined livestock categories
    - CS EFs, derived from enhanced characterization. The IPCC good practice guidance provides information to develop EF for cattle and sheep (for buffalo, approach described for cattle can be applied)

MANURE MANAGEMENT

- CH_4 emissions
  - single livestock characterization provides the data to support the estimates
  - default or CS EFs (based on manure characteristics, B_o, VS, MCF, and manure management systems), depends on the species significance
  - decision tree defines the route the Party should follow to produce accurate estimates (Figure 4.3 in the IPCC good practice guidance)

MANURE MANAGEMENT

- Tier 1 method requires livestock population data by animal species, category, and climate region (i.e. cool, temperate, warm)
- Tier 2 method requires detailed information on animal characteristics and the manner the manure is managed; activity data are:
  - volatile solid (VS) excretion rates; Country-specific VS values are based on estimated daily average feed intake, digestible energy of the feed, and ash content of the manure
  - maximum CH_4 producing capacity of the manure (Bo), and
  - CH_4 conversion factor (MCF)
- Level depending on data availability and natural circumstances. Parties should make their best for tier 2

MANURE MANAGEMENT

- Main features from the decision tree:
  - if no domestic animal production, then "not occurring"
  - if the source occurs buy not key source, emission estimates for all species may come from:
    basic characterization – default emission factors
  - if the source occurs and key source:
    - for those significant species (normally cattle, sheep, swine):
      enhanced characterization – CS emission factors
    - for the non-significant species (normally goats, horses, camels, mules, asses, poultry):
      basic characterization – default emission factors

SOME TIPS: summary table

ANIMAL SPECIES	CHARACTERIZATION LEVEL	ENTERIC FERMENTATION methane	MANURE MANAGEMENT methane
DAIRY CATTLE	SINGLE (ENHANCED)	T_1 (T_2)	T_1 (T_2)
NON-dairy CATTLE	ENHANCED	T_2	T_2
SHEEPS	BASIC (ENHANCED)	T_1	T_1 (T_2)
GOATS	BASIC	T_1	T_1
HORSES	BASIC	T_1	T_1
MULES & ASSES	BASIC	T_1	T_1
SWINE	ENHANCED	T_1	T_2
POULTRY	BASIC	T_1	T_1 (T_2)
OTHERS	BASIC	T_1	T_1

MANURE MANAGEMENT

- N_2O emissions
  - To estimate emissions, the livestock data must come from the single livestock characterization, to determine:
    - annual average nitrogen excretion rate per head (Nex) for each animal species/category (T)
    - fraction of the total annual excretion for each livestock species/category that is managed with each manure management system type (MS)
    - N_2O emission factors for each manure management system type

MANURE MANAGEMENT

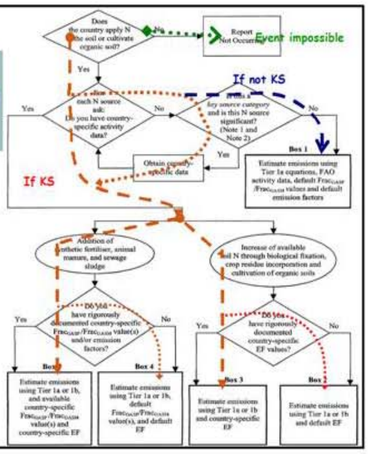
- Activity data – required in addition to those necessary for the livestock characterization – are:
  - annual average N excretion per head/category/species
  - fraction of total annual excretion for each livestock species/category that is managed in a manure management system
- If no available data on the distribution of manure management systems, the Party should conduct a survey
- If not possible, values can be derived from expert opinions
- Parties are also encouraged to disaggregate the activity data for each major climatic zone

AGRICULTURAL SOILS

- N inputs (origin of direct N_2O emissions):
  - application of synthetic fertilizers (FSN)
  - application of animal manure (FAM)
  - cultivation of nitrogen-fixing crops (FBN)
  - incorporation of crop residues into soils (FCR)
  - soil N mineralization due to cultivation of organic soils (FOS)
  - other sources, such as sewage sludge
- The inventory team must avoid double counting of emissions from synthetic fertilizer, animal manure, and other sources

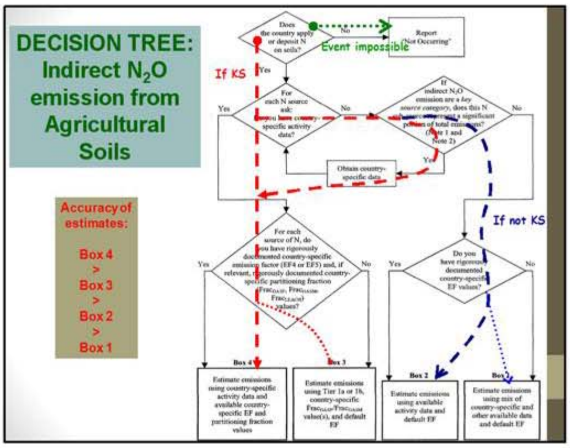
DECISION TREE: Direct N_2O emission from Agricultural Soils

Accuracy of estimates:
FAMSS NFCCR
Box 5 Box 3
> >
Box 4 Box 2
> >
Box 1



AGRICULTURAL SOILS

- Indirect N_2O emissions
  - atmospheric deposition on soils of NO_X and NH_4^+ associated with N from the different inputs (method available for synthetic fertilizers and animal manure)
  - leaching and run-off of the N applied to soils (method available for synthetic fertilizers and animal manure)
  - disposal of sewage N (method available for discharge of sewage N into rivers or estuaries)
  - formation of N_2O in the atmosphere from NH_3 emissions originating from anthropogenic activities (*no method available*)
  - disposal of effluents from food processing and other operations (*no method available*)



AGRICULTURAL SOILS

- Activity data (collectable, field measurement):
  - Nitrogen content in manures and sewage
  - synthetic fertilizers: amount of nitrogen applied as fertilizers
  - animal manure:
    - total amount of animal manure produced
    - amount of animal manure for other uses: 1) treated in animal waste management systems, accounted under manure management; 2) manure from grazing animals, accounted for under animal production; 3) manure used as fuel; and 4) manure used as animal food
  - for sewage sludge: amount applied to soils
  - partition coefficients: $FRAC_{GASF}$, $FRAC_{GASM}$, and $FRAC_{LEACH}$

AGRICULTURAL SOILS

- N_2O emissions from animal production (pasture, range, and paddock)
  - Three potential sources of N_2O emissions relating to animal production:
    - animals themselves (not accounted, assumed negligible)
    - animal wastes during storage and treatment (accounted for under manure management)
    - *dung and urine deposited by free-range grazing animals* (accounted for here)

AGRICULTURAL SOILS

- Activity data can be taken from agricultural soils and manure management:
  - the data required to estimate N_2O emissions from each relevant animal waste management system used by the Party
  - fraction of animal populations managed as direct grazing, per animal species, and
  - nitrogen excretion rates per animal species
- Methodology for N_2O emissions from animal production is addressed in the IPCC good practice guidance under Manure Management
- It is also important that activity data come from a single livestock characterization

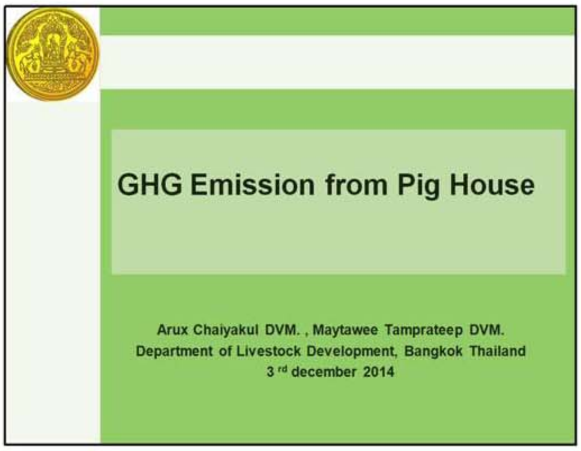
Acknowledgement

- CGE GHG inventories training material available at http://unfccc.int/national_reports/non-annex_i_natcom/training_material/methodological_documents/items/349.php

Thank you

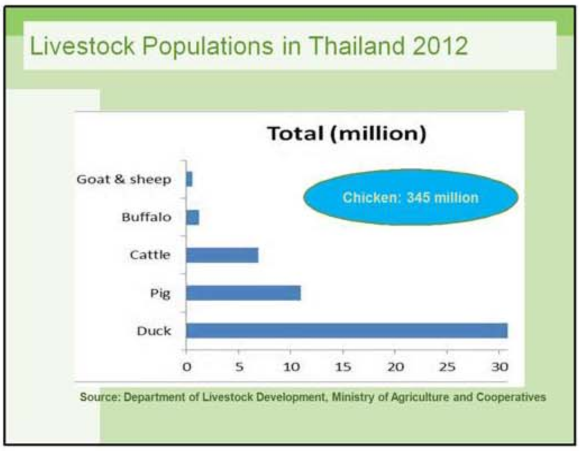
4. GHG Emissions from Pig House.

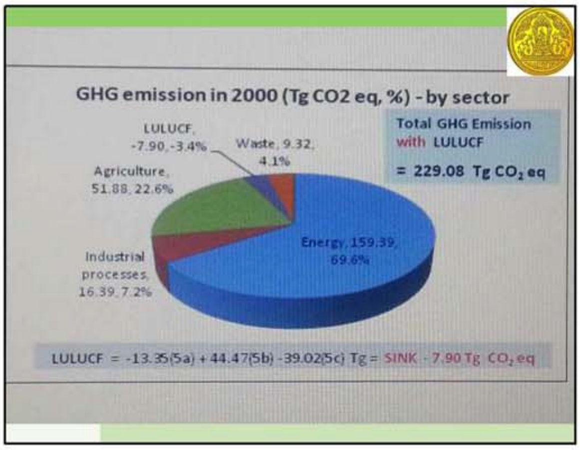
Dr Arux Chaiyakul. Senior Veterinarian. Department of Livestock. Development. Bangkok. Thailand

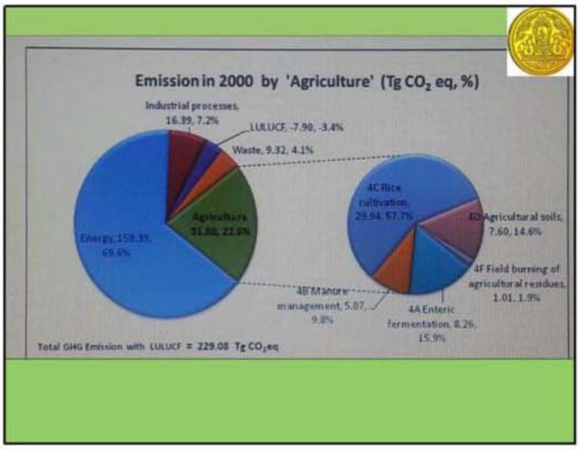



Livestock population in Thailand 2004 - 2008

Year	Number of livestock (head)						
	beef	buffalo	pig	goat	sheep	chicken	duck
2004	9,112,093	1,359,807	7,740,575	374,029	43,738	235,599,566	22,722,647
2005	8,595,428	1,388,685	8,537,703	383,796	40,269	2,8167,234	27,565,231
2006	6,426,853	1,190,886	8,347,017	380,277	43,139	266,034,477	292,329,525
2007	6,583,106	1,234,179	9,681,774	427,567	51,735	316,536,364	32,179,227
2008	6,333,816	1,241,896	10,978,834	491,779	54,221	384,182,720	36,694,795
รวม	37,051,296	6,415,453	45,285,903	2,057,448	233,102	1,230,520,361	411,491,425



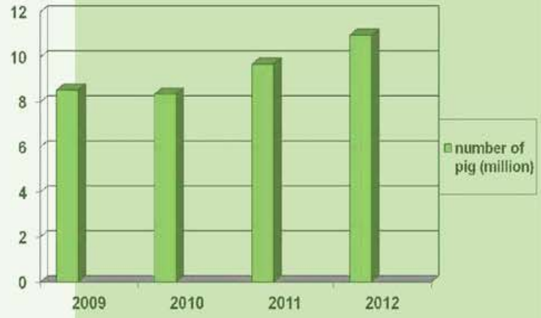




Pig production overview

- Pork is currently the most widely consumed meat product in the world. (38% of total meat consumption)
- In 2050, pig consumption is expected to increase by 40%, (FAO, 2011).
- Pig sector contribute to about 15% of livestock emissions (Olivier et al., 1998; FAO, 2006 and 2011).

Pig population in Thailand



Introduction

- Increasing livestock production in many countries leads to negative environmental and climatic consequences.
- **Greenhouse gas** : carbon dioxide (CO_2), methane (CH_4) and nitrousoxide(N_2O)
- **Amospheric pollutant** : ammonia(NH_4)

(FAO, 2006)

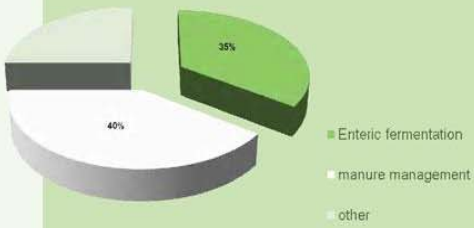
Manure management

The main GHGs emitted from manure management are CO_2, CH_4 and N_2O, coming from….

1. Daily Spread
2. Dry Lot
3. Grazing
4. Solid storage
5. Liquid or slurry
6. Anerobic Lagoon
7. Pit Storage Under Animal Confinement
8. Anaerobic Digester
9. Aerobic Treatment

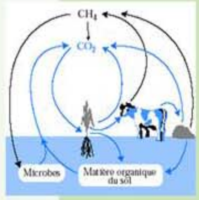
Introduction

World's anthropogenic CH_4 emission

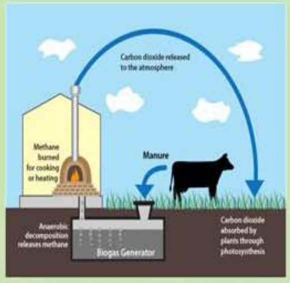


Sources of Methane from pig house

Cycle of Methane



Source: http://la.climatologie.free.fr/rechauffement/rechauffement1.htm



Source: http://geotech.com.vn/en/vi/cong-nghe/print/Biogas/Biogas-3/

Methane (CH_4)

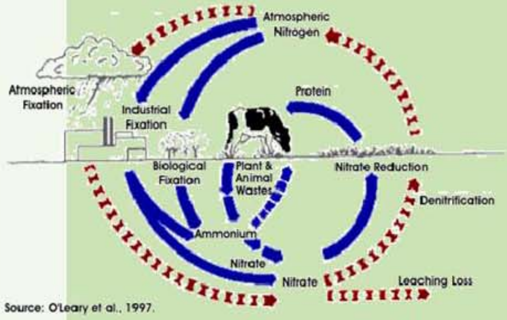
- Global warming potentials: 23 times greater than CO_2. (IPCC, 2007)
- Produced by the anaerobic breakdown, or digestion of organic material by Methanogenic bacteria.
- The bacterial activity is closely related to temperature (decreases significantly at low temperatures)
- Produced and emitted from **swine barns** and **slurry tanks**.

Methane (CH_4):Influencing factors

- **Temperature** :an exponential dependence of methane emission rate on temperature (Husted, 1994; Khan et al., 1997; Sommer et al., 2000).
- **Anarerobic condition**: anaerobic zones generate methane (not much methane is produced in well oxygen supplied condition.) However, these aerobic zones may heat up the anaerobic zones which generate methane.
- **Number/ compartment(growing stages) of animals**

Sources of N2O from pig house

The Nitrogen Cycle



Source: O'Leary et al., 1997.

Nitrous oxide (N_2O)

- Global warming potentials : 296 times greater than CO_2.(IPCC, 2007)
- Livestock activities contribute with 65% of the global anthropogenic N_2O emissions. (FAO, 2006).
- emitted from the nitrogen contained in manure during storage and application on cultivated soils.

Nitrous oxide (N_2O)

- Occurs during incomplete nitrification/denitrification processes.

Nitrification Reaction Sequence

$$NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$$

Ammonium, Nitrite, Nitrate

Denitrification Reaction Sequence

$$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$$

Nitrate, Nitrite, Nitric Oxide, Nitrous Oxide, Nitrogen Gas

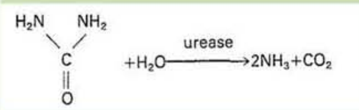
Source: http://wwwbrr.cr.usgs.gov/projects/EC_biogeochemistry/Cape.htm

Nitrous oxide (N_2O):Influencing factors

- **Temperature**: The rate of both these processes increases with increasing temperature (Granli and Bøckman,1994).
- **Seasonal dependence :** N_2O emissions from soils increasing during warmer months.
- **Slurry system:** in anaerobic conditions Nitrous oxide emissions assumed to be zero. (Monteny et al., 2001)
- **Number/ compartment (growing stages) of animals**

Ammonia (NH_3)

- Atmospheric pollutant (not a greenhouse gas)
- The urine of animals is the main source of ammonia.
- Hydrolysis of urea by the urease leading to ammonia (Cortus et al., 2008).

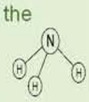


Ammonia (NH_3)

- Another source is the degradation of undigested proteins (nitrogenous components) in the manure by bacteria. (slow and of secondaryimportance) (Zeeman,1991)
- Emitted from :
  - animal husbandry
  - slurry (liquid manure) storage place
  - slurry spreading in the fields as a fertilizer

Ammonia (NH_3)

- Emissions of NH_3 to the atmosphere originate from livestock management account for about 64% of the agricultural sector (FAO, 2006).



- Excessive levels of NH_3 emissions contribute to eutrophication and acidification (Schuurkes and Mosello, 1988).
- Livestock excreta and manure stored in housing, in manure stores, in beef feedlots are themost important sources of NH_3 in the atmosphere. (Sommer et al.2006)

Ammonia (NH_3)

- *Animal housing, stored animal manure, and exercise areas account for about 69–80% of the total emission of NH_3 in Europe (ECETOC, 1994; Hutchings et al., 2001).*

Ammonia (NH_3) : Influencing factors

1. **Urease activity** : affected by
- **pH :** with optimum ranging from 6 to 9 (animal manure pH 7.0 - 8.4)
- **Temperature :** low activity below 5–10°C and above 60°C (Sommer et al., 2006).
- **Manure moisture content :** optimal between 40% and 60% because water is necessary for bacterial activity (Groot Koerkamp, 1994).

  Ammonia production stops below 5–10% moisture content (Elliot and Collins, 1983).

Ammonia (NH_3) : Influencing factors

2. **Number of animals**

   NH_3 emissions are higher in areas characterized by intensive livestock production.
3. **Dietary crude protein**

   Ammonia emission decrease as dietary CP level decrease.
4. **Building ventilation rate** (farm level)

   base on ambient temperature and wind speed (sophisticated in naturally ventilated buildings)

Summary

- N_2O and CH_4 can be produced and emitted at each stage of the "manure management continuum"
- emissions from manure management have the largest uncertainty due to the high natural variability of manure. (Merino et al.2011)
- reducing dietary CP level did not affect CH_4 and also did not affect N_2O concentrations in air above the manure pit. (P.D. Le et al.2008)

Summary

- *Ammonia emission from pig manure is mainly influenced by pH and ammonium concentration in manure.*

  Lowering manure pH and ammonium concentration decreased ammonia emission from pig manure (Canh et al., 1998).
- *Webb et al. (2005) found that among the larger sources of NH3 emissions, those from buildings housing pigs on straw were the most uncertain.*

Summary

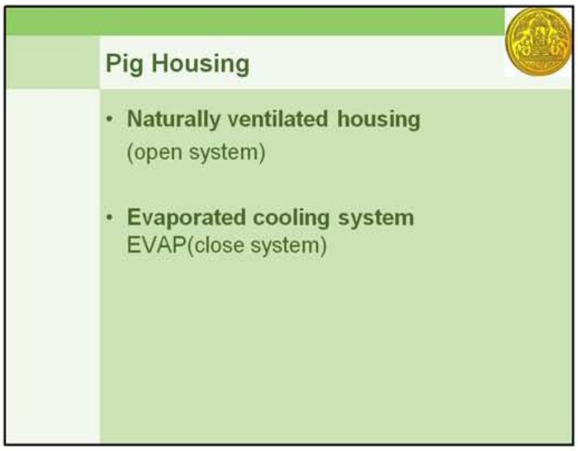
- **Environmental factors**

  such as temperature and water availability effect microbial processes

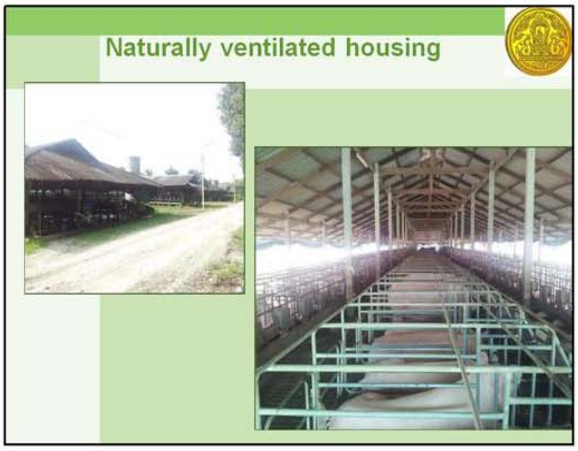
  (i.e., nitrification, denitrification, methanogenesis, CH_4 oxidation),

  affecting the magnitude of emissions from each stage of the manure management.

  (Chadwick et al., 2011).


Pig Housing
• Naturally ventilated housing
(open system)
• Evaporated cooling system
EVAP(close system)

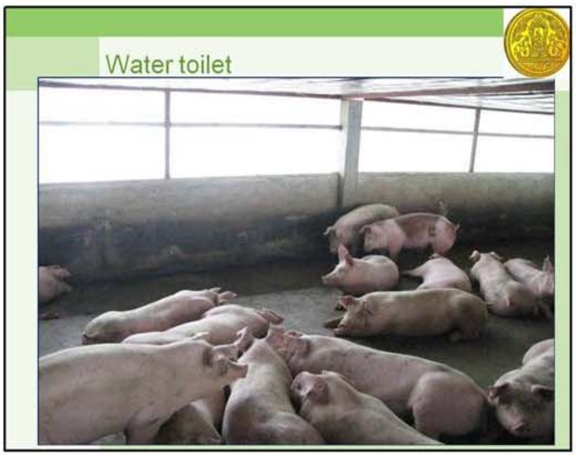

Housing


Naturally ventilated housing


Evaporated cooling system (EVAP)


Pig Housing : Floor


Water toilet


Water toilet

Manure Management in Thailand

- **Main goal:** improving rural livelihoods
- Strong focus on biogas production
  - Provides income and offsets costs
  - Supports the goal of the "Alternative Energy Development Plan (AEDP 2012-2021)" to increase the share of renewables in the energy demand mix to 25% by 2021.
- Nutrient cycling and food security an important strategy
  - Porpeang (Sufficiency) Economy by Livestock department, Ministry of Agriculture
- Local environmental impacts also important
  - Odors, water pollution, disease
- Short-lived climate pollutants are not on the agenda, but existing activities do support SLCP reduction.

Household biogas production for cook stove

Biogas project from livestock production: medium and large scale farm

Phase1: 3-year 2-month (Oct.1995- Dec. 1998)

Phase 2: 6 year 4 month (Oct. 1997-Feb. 2003)

Phase 3 : 6 year 9 month (Sep. 2002-Feb 2009)

Phase 4 : 5year (Jan.2008-Jan. 2013)

Budget: 1,464.8 million baht (€3.3 million) from reduced energy purchases, Ministry of Energy

Implemented by Energy research Development (ERDI), Chiang Mai University

Source: ERDI

On going projects: Biogas project in Chicken farm and slaughter

Pig slaughter 5 years, Jul. 2008- July 2013 80 stations

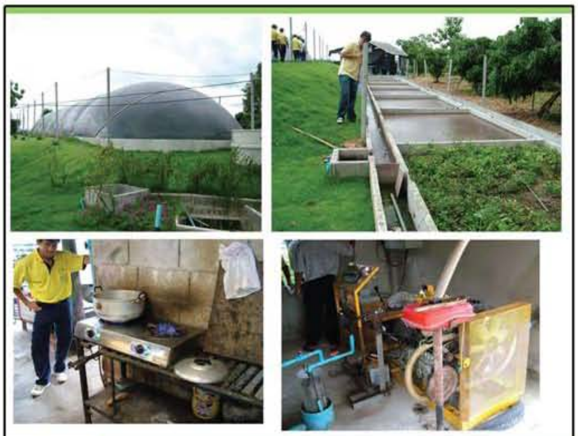
chicken slaughter 2 years 6 months Produced chicken<100000 per day 5 stations

small scale Pigs<500 5 years (July 2008- Jul 2013)

Phase1 of biogas in chicken farm 3years (Sep 2010- Sep 2013)

Phase 4 : 5year (Jan.2008-Jan. 2013)

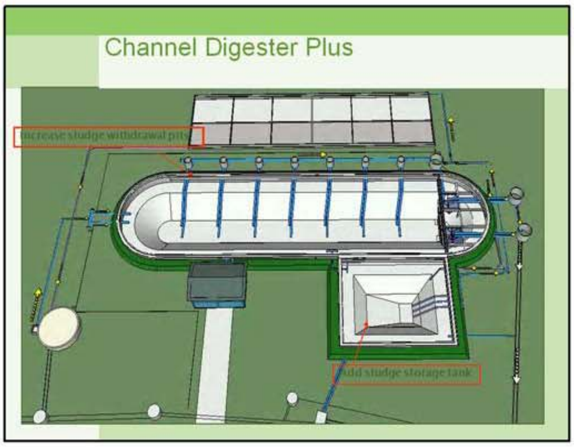
Source: ERDI

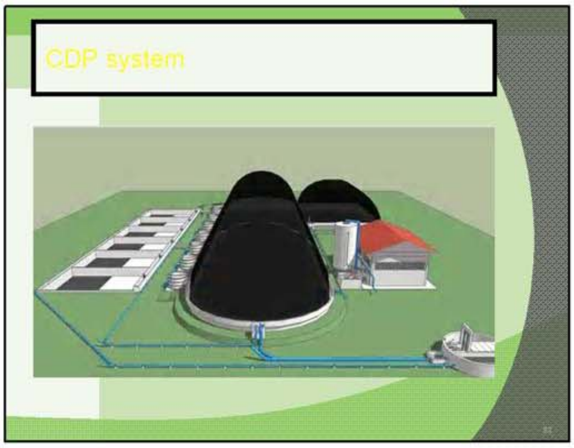


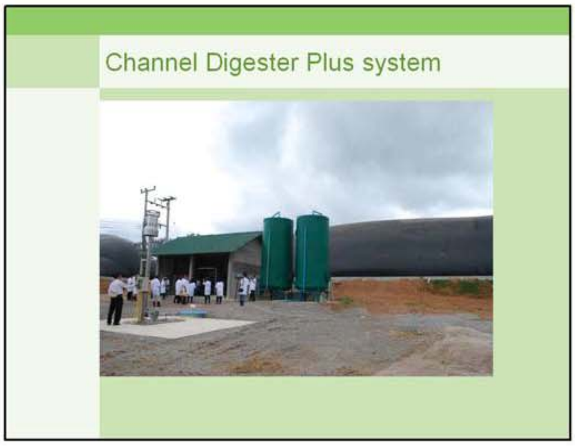
Cover lagoon


Sludge dry bed


Channel Digester Plus system


Channel Digester Plus
Increase sludge withdrawal pit
Add sludge storage tank


CDP system


Channel Digester Plus system


Gas Purifier Unit


Control room


Recorder


Recorder
28.5
3520.3
-0.0
10589.7
42.7
39.3
443.9
0h56:48


Flare


Sludge withdrawer


GHG Emission Reduction Supported by WB and GMI
Finished project supported by WB,GMI from year 2008 to 2011 to treat waste for 240,000 pigs
GHG emission reduction equal to 120,000 ton CO_2e/year

Area of waste water treatment system(A_W)

- **waste water treament area per housing area**

4 model

1. Treatment system without biogas
2. Treatment system with biogas and lagoon system
3. Waste water storage, no discharge
4. Treatment system with biogas with application on crop land

1. Treatment system without biogas

Oxidation pond	Treatment system area/housing area (square meter)
pond 1	6.5
pond2	2.1
pond3	2.4
Total area	11.1

1. treatment system without biogas

1.2 mixed oxidation pond

pond no.	Type of pond	Treatment system area/housing area(square meter)
Pond 1	Oxidation pond	6.5
Pond 2	Polishing pond	2.1
Pond 3	Polishing pond	1.0
	Total area	9.6

1. Treatment system without biogas

1.3 Anarobic lagoon with oxidation pond

pond no.	Type of pond	Treatment system area/housing area
1	Anaerobic pond	2.9
2	Oxidation pond	1.4
3	Polishing pond	0.8
4	Polishing pond	0.5
	Total area	5.6

Comparing area use of treatment system without biogas

Type of treatment system	Treatment area/housing area
1. Oxidation pond	11.1
2. Mixed oxidation pond	9.6
3. Anaerobic pond with mixed oxidation pond	5.6

2. Biogas system with post ponding system

Biogas system	Treatment system area/housing area(square meter)
(Covered lagoon)	0.7
(Channel digester,CD)	0.03
(Package biogas)	0.2
(Fixed dome)	0.1
(Anaerobic filter)	0.1

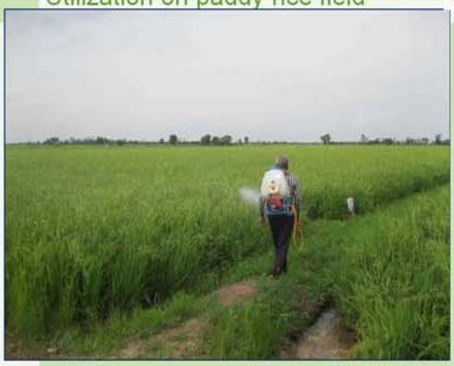
ใช้ระบบผลิตก๊าซชีวภาพร่วมกับบ่อ บำบัดขั้นหลัง

2. biogas with post treatment system

Treatment system	Treatment system area/housing area(square meter)
1. Cover lagoon	3.2
2. Other biogas	2.7

Post - treatment System

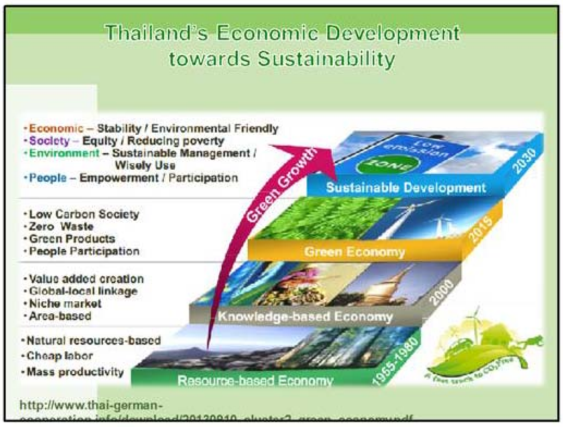
Utilization on paddy rice field



Production compare

Green Agriculture City Project

- To promote biogas system and bio-fertilizer from waste
- Area wide integrated system
- Low carbon

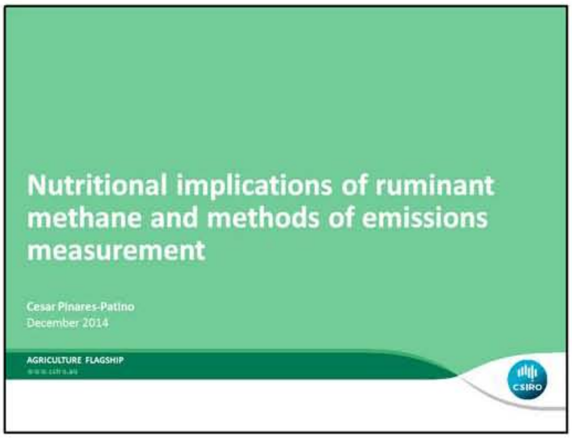

Thailand's Economic Development towards Sustainability
•Economic – Stability / Environmental Friendly
•Society – Equity / Reducing poverty
•Environment – Sustainable Management / Wisely Use
•People – Empowerment / Participation
•Low Carbon Society
•Zero Waste
•Green Products
•People Participation
•Value added creation
•Global-local linkage
•Niche market
•Area-based
•Natural resources-based
•Cheap labor
•Mass productivity
Green Growth
Sustainable Development
2030
Green Economy
2015
Knowledge-based Economy
2000
Resource-based Economy
1965-1980
http://www.thai-german-

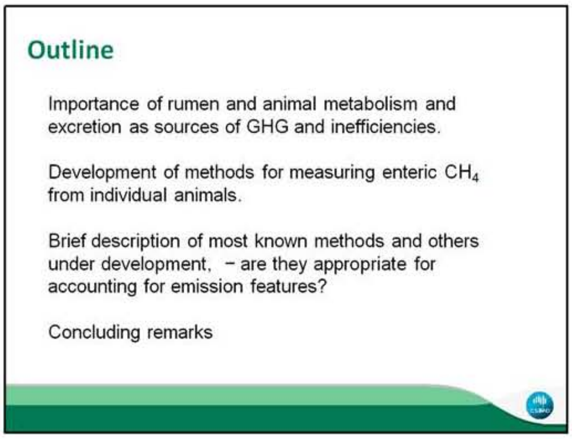

Post - treatment System

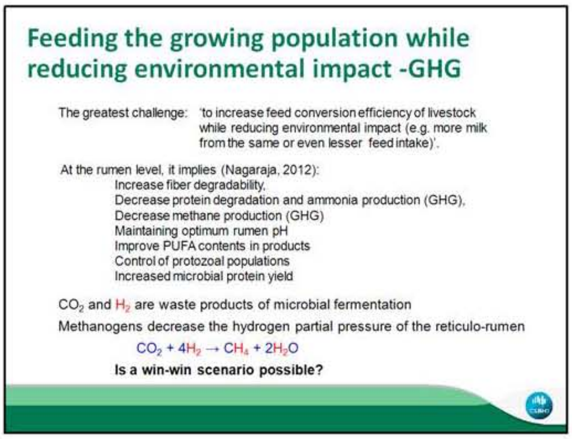

THANK YOU

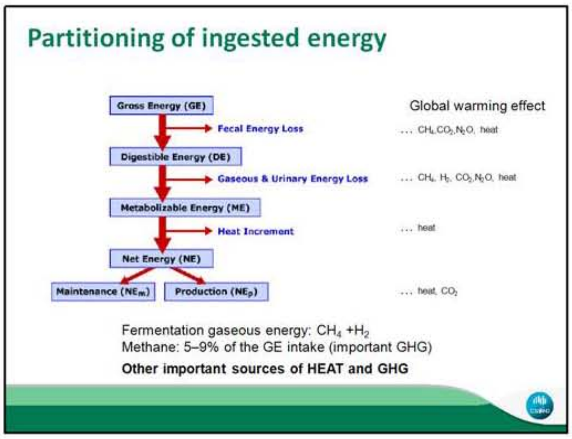
5. Nutritional Implications of Ruminant Methane Emissions and Measurement Methods

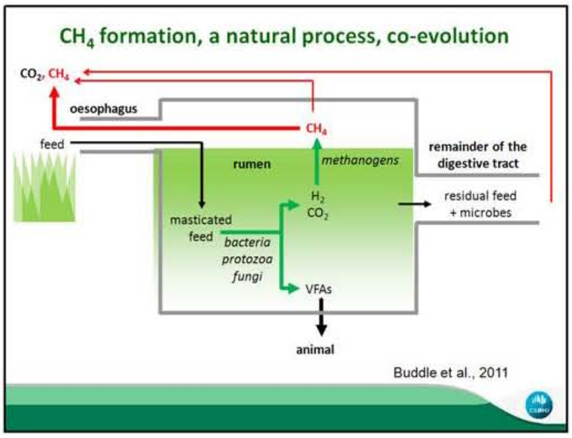
Cesar Pinares Patino. Research Scientist. CSIRO. Australia Agriculture Flagship, Integrated Agricultural Systems. GPO Box 1600. Canberra ACT 2601. Australia.

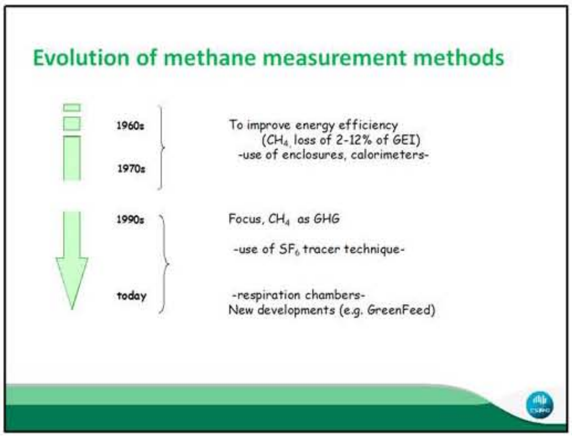


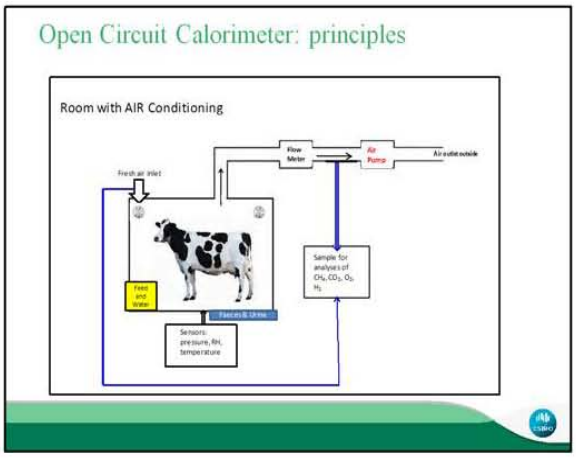




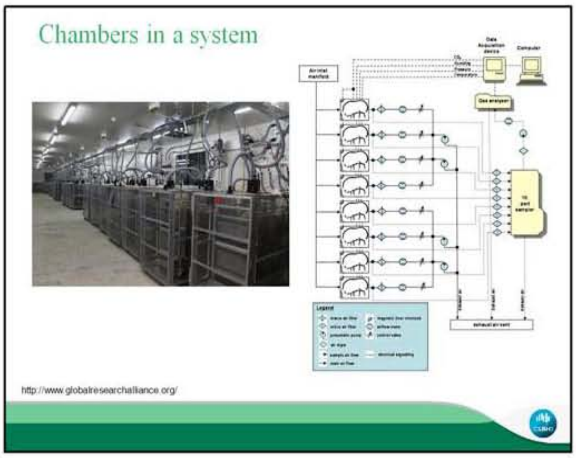


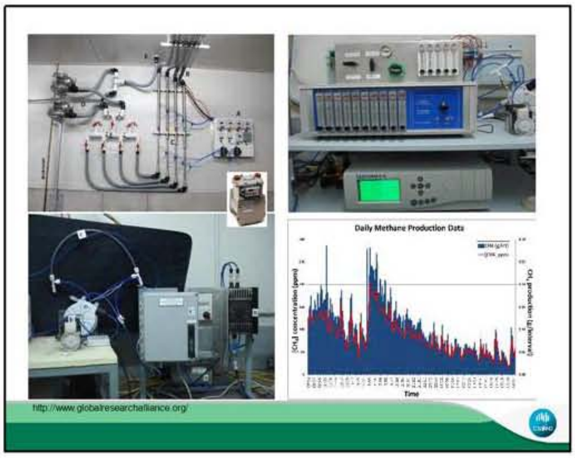


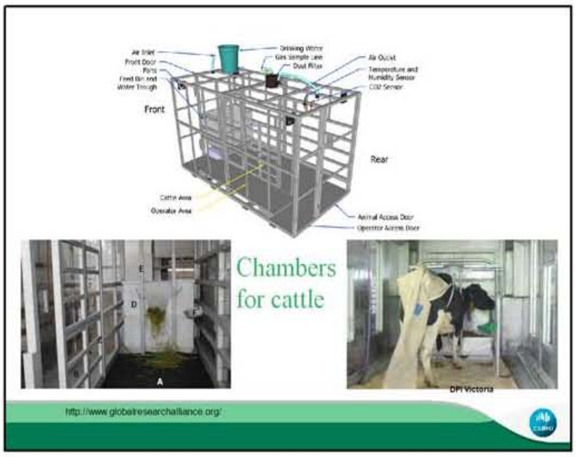


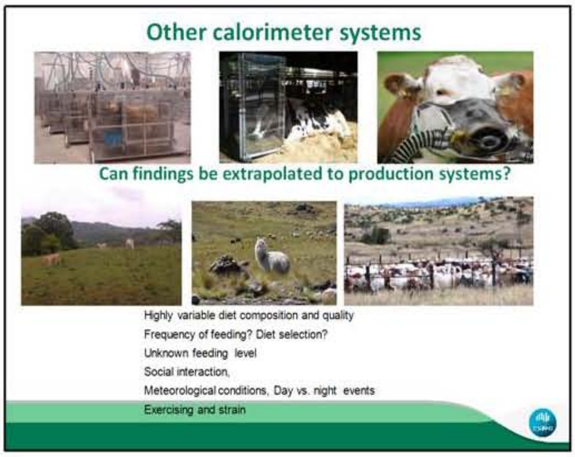

Open Circuit Calorimeter: principles
Room with AIR Conditioning
Flow Meter
Air Pump
Air outlet outside
Fresh air inlet
Feed and Water
Faeces & Urine
Sample for analyses of CH_4, CO_2, O_2, H_2
Sensors: pressure, RH, temperature

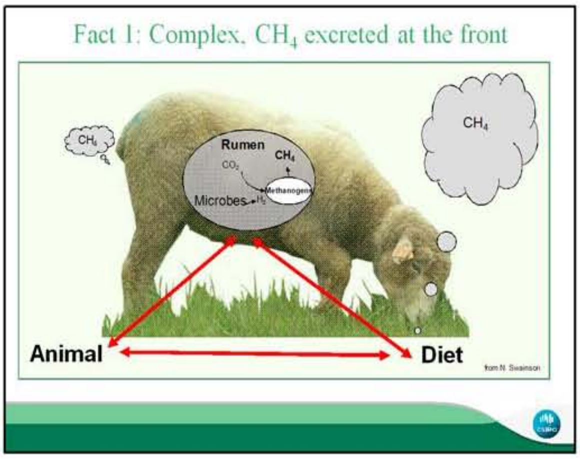

Chambers for small ruminants
http://www.globalresearchalliance.org/

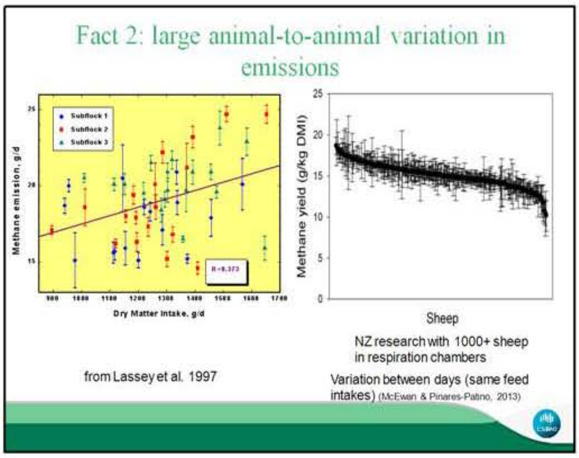

Chambers in a system
http://www.globalresearchalliance.org/

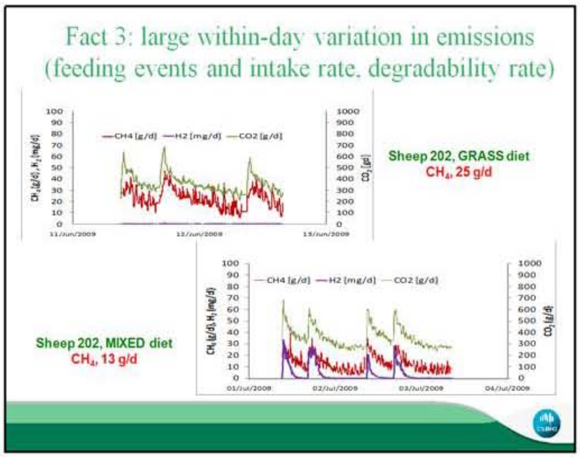

Daily Methane Production Data
Time
http://www.globalresearchalliance.org/


Front
Rear
Chambers for cattle
DPI Victoria
http://www.globalresearchalliance.org/

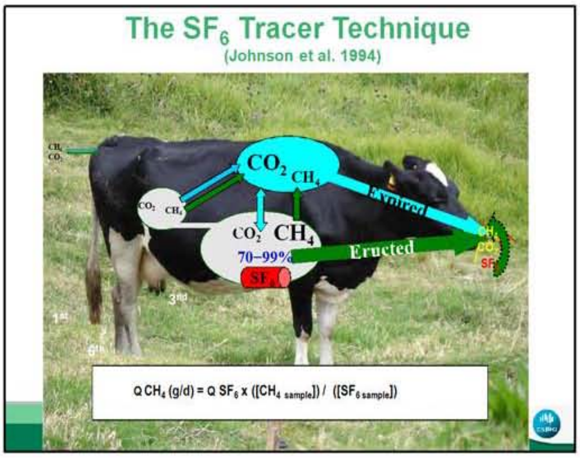

Other calorimeter systems
Can findings be extrapolated to production systems?
Highly variable diet composition and quality
Frequency of feeding? Diet selection?
Unknown feeding level
Social interaction,
Meteorological conditions, Day vs. night events
Exercising and strain

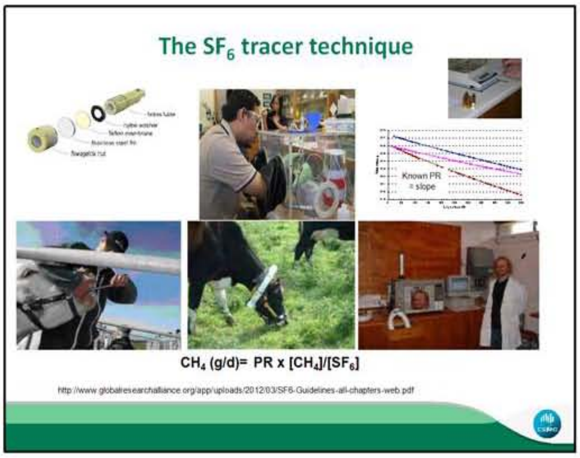

Fact 1: Complex, CH_4 excreted at the front
CH_4
Rumen
CH_4
CO_2
Methanogens
Microbes
H_2
CH_4
Animal
Diet
from N. Swainson

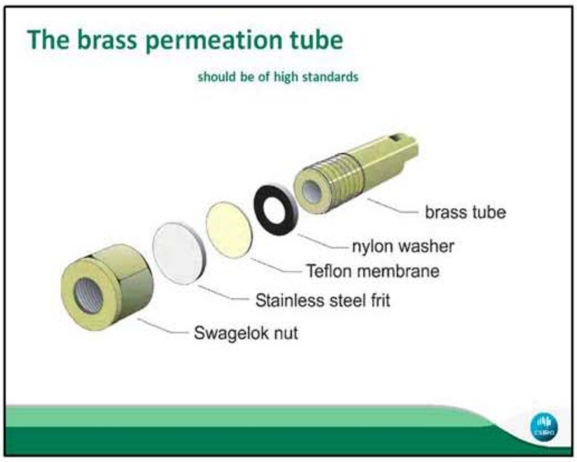

Fact 2: large animal-to-animal variation in emissions
Subflock 1
Subflock 2
Subflock 3
Methane emission, g/d
Dry Matter Intake, g/d
Methane yield (g/kg DMI)
Sheep
NZ research with 1000+ sheep in respiration chambers
from Lassey et al. 1997
Variation between days (same feed intakes) (McEwan & Pinares-Patino, 2013)

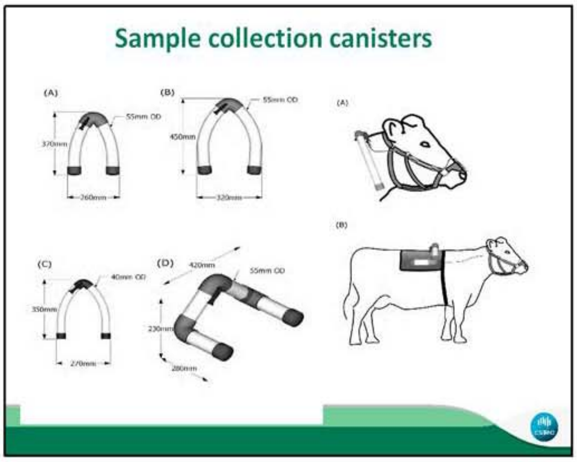

Fact 3: large within-day variation in emissions (feeding events and intake rate, degradability rate)
CH4 [g/d]
H2 [mg/d]
CO2 [g/d]
Sheep 202, GRASS diet
CH_4, 25 g/d
Sheep 202, MIXED diet
CH_4, 13 g/d


Fact 4: All CH_4 come from feed eaten
Do we know the amount eaten?
Do we know what they ate?
Feed DMI estimated
Gross CH_4 emissions (g/d)?
Expression of CH_4 emission per unit of :
DMI, LW, product?


The SF_6 Tracer Technique
(Johnson et al. 1994)
CO_2 CH_4
Expired
CO_2 CH_4
70–99%
Eructed
SF_6
3rd
1st
5th
$Q\,CH_4\,(g/d) = Q\,SF_6 \times ([CH_{4\,sample}]) / ([SF_{6\,sample}])$

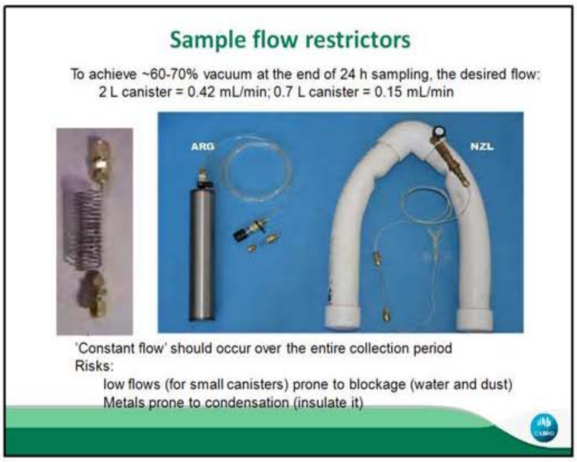

The SF_6 tracer technique
Known PR = slope
$CH_4\,(g/d) = PR \times [CH_4]/[SF_6]$
http://www.globalresearchalliance.org/app/uploads/2012/03/SF6-Guidelines-all-chapters-web.pdf

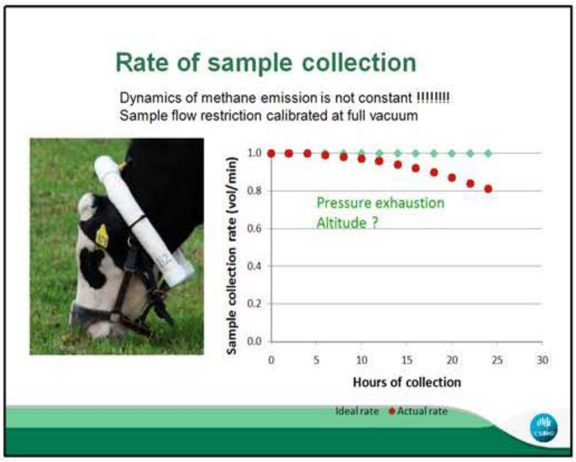

The brass permeation tube
should be of high standards
brass tube
nylon washer
Teflon membrane
Stainless steel frit
Swagelok nut


Sample collection canisters


Sample collection gear (AFBI)
Sheep collar
'U' tube on saddle
Head collar
Cylinder

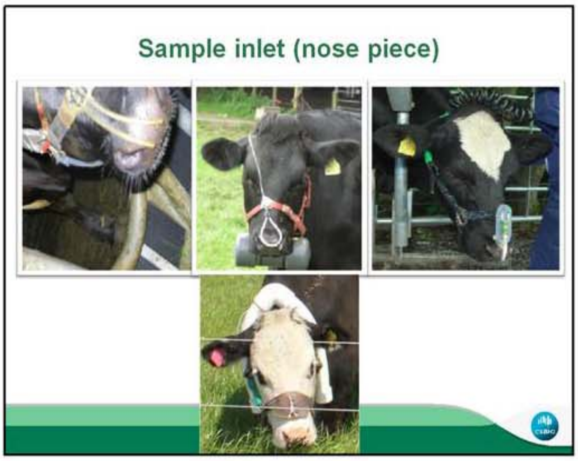

SS collection canister at DPI Victoria
1
2
2
3
4
5

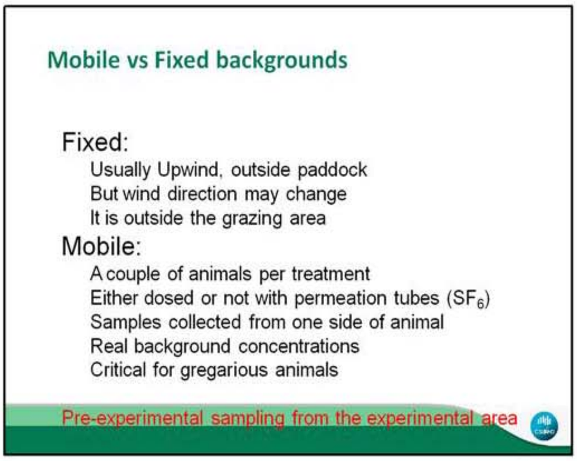

Sample flow restrictors
To achieve ~60-70% vacuum at the end of 24 h sampling, the desired flow:
2 L canister = 0.42 mL/min; 0.7 L canister = 0.15 mL/min
ARG
NZL
'Constant flow' should occur over the entire collection period
Risks:
low flows (for small canisters) prone to blockage (water and dust)
Metals prone to condensation (insulate it)

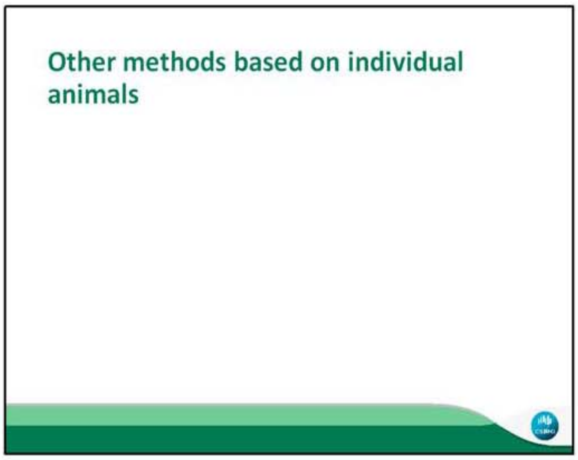

Rate of sample collection
Dynamics of methane emission is not constant !!!!!!!
Sample flow restriction calibrated at full vacuum
Pressure exhaustion
Altitude ?
Sample collection rate (vol/min)
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
20
25
30
Hours of collection
Ideal rate
Actual rate


The sample collection gear
Length and diameter of tubing, dead space
1/8" OD nylon tubing
Capillary flow restrictor
Nose piece
Quick connector
vacuum

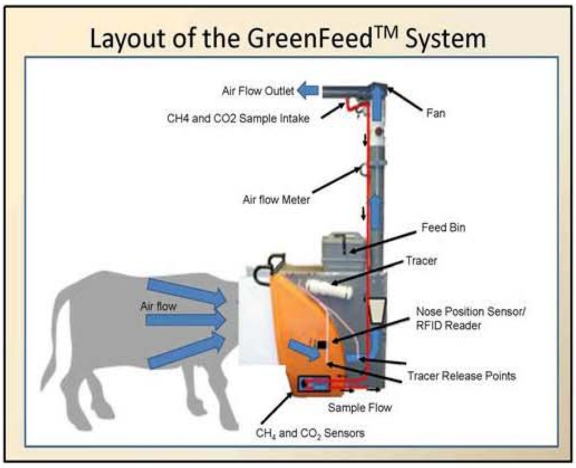

Extra protection of gear
coil

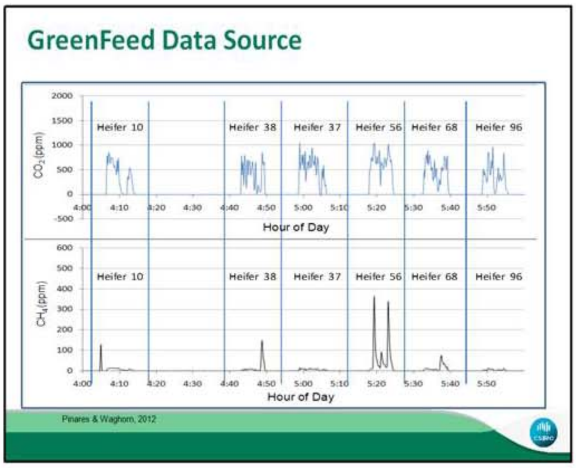

Sample inlet (nose piece)

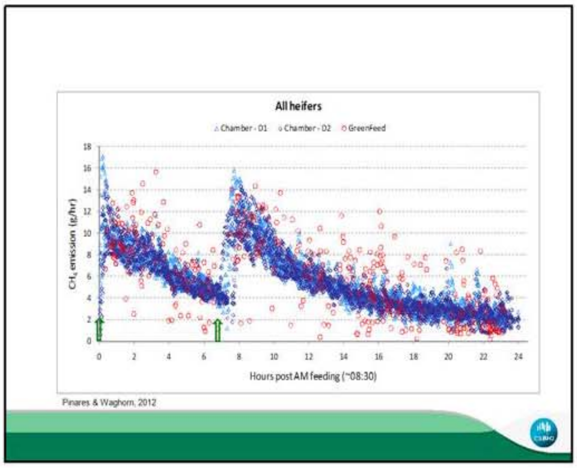

Mobile vs Fixed backgrounds
Fixed:
Usually Upwind, outside paddock
But wind direction may change
It is outside the grazing area
Mobile:
A couple of animals per treatment
Either dosed or not with permeation tubes (SF_6)
Samples collected from one side of animal
Real background concentrations
Critical for gregarious animals
Pre-experimental sampling from the experimental area

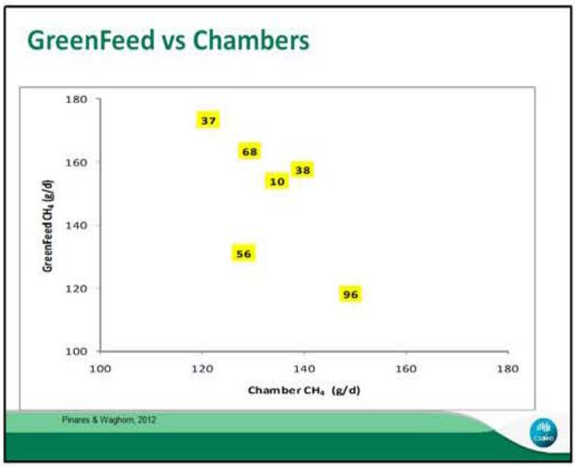

Other methods based on individual animals

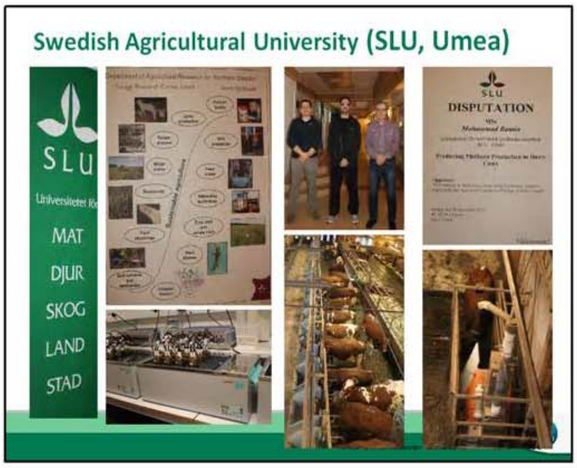

Portable Accumulation Chambers


Layout of the GreenFeedTM System
Air Flow Outlet
CH4 and CO2 Sample Intake
Fan
Air flow Meter
Feed Bin
Tracer
Air flow
Nose Position Sensor/
RFID Reader
Tracer Release Points
Sample Flow
CH4 and CO2 Sensors

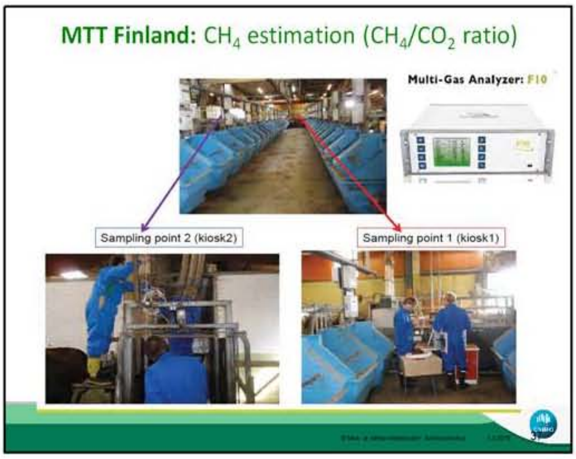

GreenFeed Data Source
Heifer 10
Heifer 38
Heifer 37
Heifer 56
Heifer 68
Heifer 96
CO2 (ppm)
CH4 (ppm)
Hour of Day
Pinares & Waghorn, 2012


All heifers
Chamber - D1
Chamber - D2
GreenFeed
CH4 emission (g/hr)
Hours post AM feeding (~08:30)
Pinares & Waghorn, 2012


GreenFeed vs Chambers
37
68
38
10
56
96
GreenFeed CH4 (g/d)
Chamber CH4 (g/d)
Pinares & Waghorn, 2012


Swedish Agricultural University (SLU, Umea)
SLU
MAT
DJUR
SKOG
LAND
STAD
DISPUTATION


The CH4/CO2 ratio, CO2 as tracer
Gasmet technology



Conclusions

Methane emissions have a large variability between animals, between days and within-day.

Methods of measurement need to account for these variation sources.

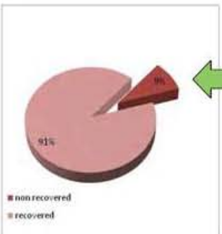
All methane come from feed eaten, feed usually have >24 transit time in the GIT. It implies that feed intake and characteristics of it need to be measured/estimate in parallel.

The SF_6 tracer technique is the method of choice for animals in production conditions. It needs to be adapted to particular situations and ways of cost reduction is needed (e.g. sampling length)

Acknowledgements:

AgResearch Limited, NZ MPI, GRA
Francis Lively AFBI Ireland
Keith Lassey Lassey Research & Education
NZ MPI

Sample collection failure (AFBI)

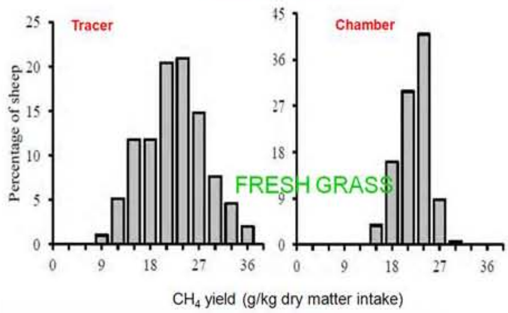


Reason for non recovery	Percentage
Line Broken	51
Canister Broken	11
Disconnected	13
Line blocked	10
Discounted	15

F. Lively

Reliability of the SF_6 tracer technique

(accuracy and precision)



Hammond (20...)

6. Mitigating Farm Livestock Greenhouse Gas Emissions

Dr. Kalaya Boonyanuwat Senior Animal Scientist. Department of Livestock Development. Bangkok Thailand.

Mitigating Farm Livestock Greenhouse Gas Emissions

Kalaya Boonyanuwat

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Animal production is a significant source of greenhouse gas (GHG) emissions worldwide. Depending on the accounting approaches and scope of emissions covered, estimates by various sources (IPCC, FAO, EPA or others) place livestock contribution to global anthropogenic GHG emissions at between 7 and 18 percent. The current analysis was conducted to evaluate the potential of nutritional, manure and animal husbandry practices for mitigating methane (CH_4) and nitrous oxide (N_2O) – i.e. non-carbon dioxide (non-CO_2) – GHG emissions from livestock production. These practices were categorized into enteric CH_4, manure management and animal husbandry mitigation practices. Emphasis was placed on enteric CH_4 mitigation practices for ruminant animals (only *in vivo* studies were considered) and manure mitigation practices for both ruminant and monogastric species. Over 900 references were reviewed; and simulation and life cycle assessment analyses were generally excluded. In evaluating mitigation practices, the use of proper units is critical. Expressing enteric CH4 energy production on gross energy intake basis, for example, does not accurately reflect the potential impact of diet quality and composition. Therefore, it is noted that GHG emissions should be expressed on a digestible energy intake basis or per unit of animal product (i.e. GHG emission intensity), because this reflects most accurately the effect of a given mitigation practice on feed intake and the efficiency of animal production.

Enteric CH_4 mitigation practices

Increasing forage digestibility and digestible forage intake will generally reduce GHG emissions from rumen fermentation (and stored manure), when scaled per unit of animal product, and are highly-recommended mitigation practices. For example, enteric CH_4 emissions may be reduced when corn silage replaces grass silage in the diet. Legume silages may also have an advantage over grass silage due to their lower fibre content and the additional benefit of replacing inorganic nitrogen fertilizer. Effective silage preservation will improve forage quality on the farm and reduce GHG emission intensity. Introduction of legumes into grass pastures in warm climate regions may offer a mitigation opportunity, although more research is needed to address the associated agronomic challenges and comparative N_2O emissions with equivalent production levels from nitrogen fertilizer.

Dietary lipids are effective in reducing enteric CH_4 emissions, but the applicability of this practice will depend on its cost and its effects on feed intake, production and milk composition. High-oil by-product feeds, such as distiller's grains, may offer an economically feasible alternative to oil supplementation as a mitigation practice, although their higher fibre content may have an opposite effect on enteric CH_4, depending on basal diet composition.

Inclusion of concentrate feeds in the diet of ruminants will likely decrease enteric CH_4 emissions per unit of animal product, particularly when above 40 percent of dry matter intake. The effect may depend on type of 'concentrate' inclusion rate, production response, impact on fibre digestibility, level of nutrition, composition of the basal diet and feed processing. Supplementation with small amounts of concentrate feed is expected to increase animal productivity and decrease GHG emission intensity when added to all-forage diets. However, concentrate supplementation should not substitute high-quality forage. Processing of grain to increase its digestibility is likely to reduce enteric CH_4 emission intensity. Nevertheless, caution should be exercised so that concentrate supplementation and processing does not compromise digestibility of dietary fibre. In many parts of the world, concentrate inclusion may not be an economically feasible mitigation option. In these situations improving the nutritive value of low-quality feeds in ruminant diets can have a considerable benefit on herd productivity, while keeping the herd CH_4 output constant or even decreasing it. Chemical treatment of low-quality feeds, strategic supplementation of the diet, ration balancing and crop selection for straw quality are effective mitigation strategies, but there has been little adoption of these technologies.

Nitrates show promise as enteric CH_4 mitigation agents, particularly in low-protein diets that can benefit from nitrogen supplementation, but more studies are needed to fully understand their impact on whole-farm GHG emissions, animal productivity and animal health.

Adaptation to these compounds is critical and toxicity may be an issue. Through their effect on feed efficiency, ionophores are likely to have a moderate CH_4 mitigating effect in ruminants fed high-grain or grain-forage diets. However, regulations restrict the availability of this mitigation option in many countries. In ruminants on pasture, the effect of ionophores is not sufficiently consistent for this option to be recommended as a mitigation strategy. Tannins may also reduce enteric CH_4 emissions, although intake and milk production may be compromised. Further, the agronomic characteristics of tanniferous forages must be considered when they are discussed as a GHG mitigation option. There is not sufficient evidence that other plant-derived bioactive compounds, such as essential oils, have a CH_4-mitigating effect. Some direct-fed microbials, such as yeast-based products, might have a moderate CH_4-mitigating effect through increasing animal productivity and feed efficiency, but the effect is expected to be inconsistent. Vaccines against rumen archaea may offer mitigation opportunities in the future, although the extent of CH_4 reduction appears small, and adaptation and persistence of the effect is unknown.

Manure management mitigation practices

Diet can have a significant impact on manure (faeces and urine) chemistry and therefore on GHG emissions during storage and following land application. Manure storage may be required when animals are housed indoors or on feedlots, but a high proportion of ruminants are grazed on pastures or rangeland, where CH_4 emissions from their excreta is very low and N_2O losses from urine can be substantial. Decreased digestibility of dietary nutrients is expected to increase fermentable organic matter concentration in manure, which may increase manure CH_4 emissions. Feeding protein close to animal requirements, including varying dietary protein concentration with stage of lactation or growth, is recommended as an effective manure ammonia and N_2O emission mitigation practice. Low-protein diets for ruminants should be balanced for rumen-degradable protein so that microbial protein synthesis and fibre degradability are not impaired. Decreasing total dietary protein and supplementing the diet with synthetic amino acids is an effective ammonia and N_2O mitigation strategy for non-ruminants. Diets for all species should be balanced for amino acids to avoid feed intake depression and decreased animal productivity. Restricting grazing when conditions are most favourable for N_2O formation, achieving a more uniform distribution of urine on soil and optimizing fertilizer application are possible N_2O mitigation options for ruminants on pasture. Forages with higher sugar content (high-sugar grasses or forage harvested in the afternoon when its sugar content is higher) may reduce urinary nitrogen excretion, ammonia volatilization and perhaps N_2O emission from manure applied to soil, but more research is needed to support this hypothesis. Cover cropping can increase plant nitrogen uptake and decrease accumulation of nitrate, and thus reduce soil N_2O emissions, although the results have not been conclusive. Urease and nitrification inhibitors are promising options to reduce N_2O emissions from intensive livestock production systems, but can be costly to apply and result in limited benefits to the producer.

Overall, housing, type of manure collection and storage system, separation of solids and liquid and their processing can all have a significant impact on ammonia and GHG emissions from animal facilities. Most mitigation options for GHG emissions from stored manure, such as reducing the time of manure storage, aeration, and stacking, are generally aimed at decreasing the time allowed for microbial fermentation processes to occur before land application. These mitigation practices are effective, but their economic feasibility is uncertain.

Semi-permeable covers are valuable for reducing ammonia, CH_4 and odour emissions at storage, but are likely to increase N_2O emissions when effluents are spread on pasture or crops. Impermeable membranes, such as oil layers and sealed plastic covers, are effective in reducing gaseous emissions but are not very practical. Combusting accumulated CH_4 to produce electricity or heat is recommended. Acidification (in areas where soil acidity is not an issue) and cooling are further effective methods for reducing ammonia and CH_4 emissions from stored manure. Composting can effectively reduce CH_4 but can have a variable effect on N_2O emissions and increases ammonia and total nitrogen losses.

Anaerobic digesters are a recommended mitigation strategy for CH_4 generate renewable energy, and provide sanitation opportunities for developing countries, but their effect on N_2O emissions is unclear. Management of digestion systems is important to prevent them from becoming net emitters of GHG. Some systems require high initial capital investments and, as a result, their adoption may occur only when economic incentives are offered. Anaerobic digestion systems are not recommended for geographic locations with average temperatures below 15 °C without supplemental heat and temperature control.

Lowering nitrogen concentration in manure, preventing anaerobic conditions and reducing the input of degradable manure carbon are effective strategies for reducing GHG emissions from manure applied to soil. Separation of manure solids and anaerobic degradation pre-treatments can mitigate CH_4 emission from subsurface-applied manure, which may otherwise be greater than that from surface-applied manure. Timing of manure application (e.g. to match crop nutrient demands, avoiding application before rain) and maintaining soil pH above 6.5 may also effectively decrease N_2O emissions.

Animal Genetics Improvement practices

Animal genetics improvement can be direct and indirect effects. For indirect effects, it can be done as genetics improvement for increasing production efficiency and feed efficiency. For direct effects, it can be done by decreasing methane emission. If they are improved for low residual feed intake together with low methane emission, it can have more quickly genetic progress of low methane emission.

Animal husbandry mitigation practices

Increasing animal productivity can be a very effective strategy for reducing GHG emissions per unit of livestock product. For example, improving the genetic potential of animals through planned cross-breeding or selection within breeds, and achieving this genetic potential through proper nutrition and improvements in reproductive efficiency, animal health and reproductive lifespan are effective and recommended approaches for improving animal productivity and reducing GHG emission intensity. Reduction of herd size would increase feed availability and productivity of individual animals and the total herd, thus lowering CH4 emission intensity. Residual feed intake may be an appealing tool for screening animals that are low CH_4 emitters, but currently there is insufficient evidence that low residual feed intake animals have a lower CH_4 yield per unit of feed intake or animal product. However, selection for feed efficiency will yield animals with lower GHG emission intensity. Breed difference in feed efficiency should also be considered as a mitigation option, although insufficient data are currently available on this subject. Reducing age at slaughter of finished cattle and the number of days that animals are on feed in the feedlot by improving nutrition and genetics can also have a significant impact on GHG emissions in beef and other meat animal production systems.

Improved animal health and reduced mortality and morbidity are expected to increase herd productivity and reduce GHG emission intensity in all livestock production systems. Pursuing a suite of intensive and extensive reproductive management technologies provides a significant opportunity to reduce GHG emissions. Recommended approaches will differ by region and species, but will target increasing conception rates in dairy, beef and buffalo, increasing fecundity in swine and small ruminants, and reducing embryo wastage in all species. The result will be fewer replacement animals, fewer males required where artificial insemination is adopted, longer productive life and greater productivity per breeding animal.

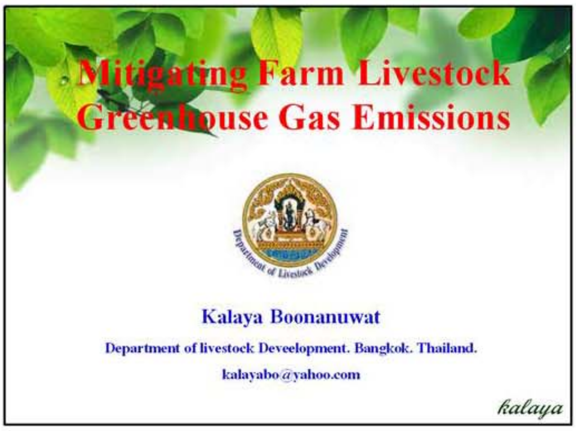
Grazing systems can enhance the removal of CO_2 from the environment

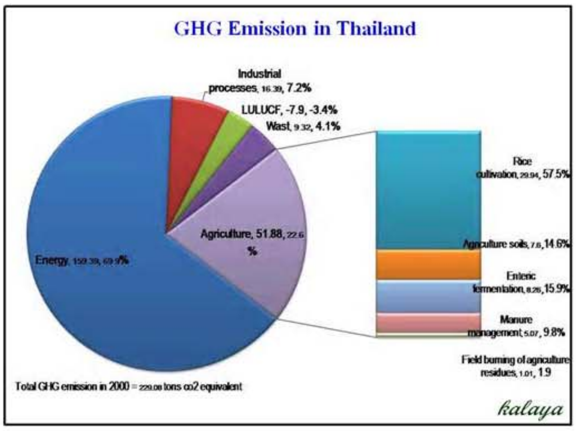
Carbon can be sequestered (or, captured) from the atmosphere via improved management. Any practice that increases the photosynthetic uptake of carbon or slows the return of stored carbon to CO2 via respiration, fire, or erosion will increase carbon reserves, thereby sequestering carbon. Significant amounts of soil carbon could be stored in rangelands or in silvopastoral systems through practices suited to local conditions. This would not only improve carbon sequestration but could also turn into an important diversification option for sustaining livelihoods of smallholders and pastoralists through collection of payments for ecosystem services.

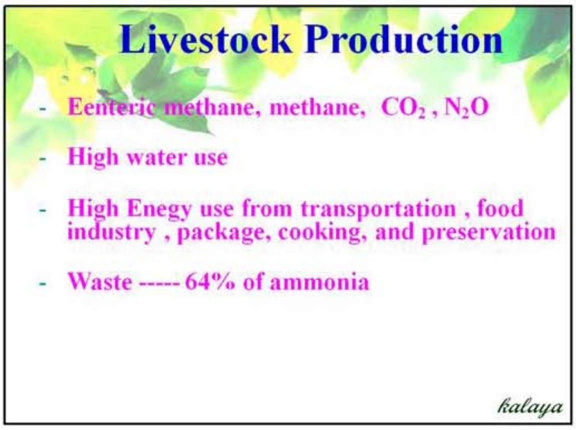
Finally, livestock is integrally linked to crop production in the developing world. Crops and residues from agricultural lands are used to feed livestock, and manure is a crucial source of nutrients for crop growth and as fuel in crop–livestock systems. Crop residues can also be used as a source of fuel, either directly or after conversion to fuels such as ethanol or diesel. While these bioenergy feedstocks still release CO2 upon combustion, the carbon is of recent atmospheric origin (via photosynthesis), rather than from fossil carbon. The net benefit of these bioenergy sources to the atmosphere is equal to the fossil-derived emissions displaced, less any emissions from producing, transporting, and processing. CO2 emissions can also be avoided through agricultural management practices that forestall the cultivation of new lands now under forest, grassland, or other nonagricultural vegetation.

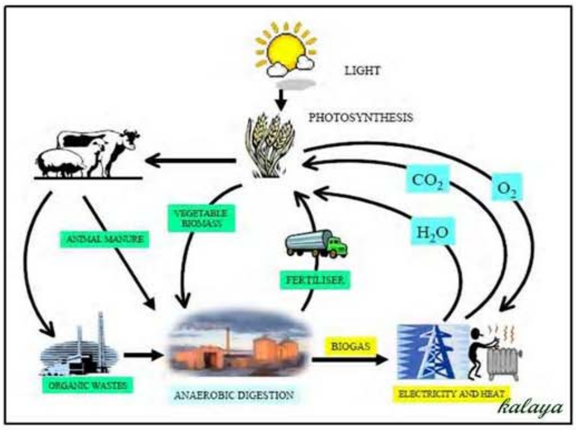
Conclusions

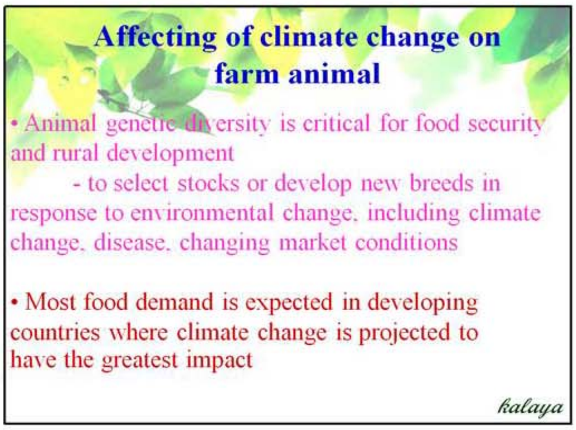
Overall, improving forage quality and the overall efficiency of dietary nutrient use is an effective way of decreasing GHG emissions per unit of animal product. Several feed supplements have a potential to reduce enteric CH_4 emission from ruminants, although their long-term effect has not been well-established and some are toxic or may not be economically viable in developing countries. Several manure management practices have a significant potential for decreasing GHG emissions from manure storage and after application or deposition on soil. Interactions among individual components of livestock production systems are very complex, but must be considered when recommending GHG mitigation practices. One practice may successfully mitigate enteric CH_4 emission, but increase fermentable substrate for increased GHG emissions from stored or land applied manure. Some mitigation practices are synergistic and are expected to decrease both enteric and manure GHG emissions (for example, improved animal health and animal productivity). Optimizing animal productivity can be a very successful strategy for mitigating GHG emissions from the livestock sector in both developed and developing countries.

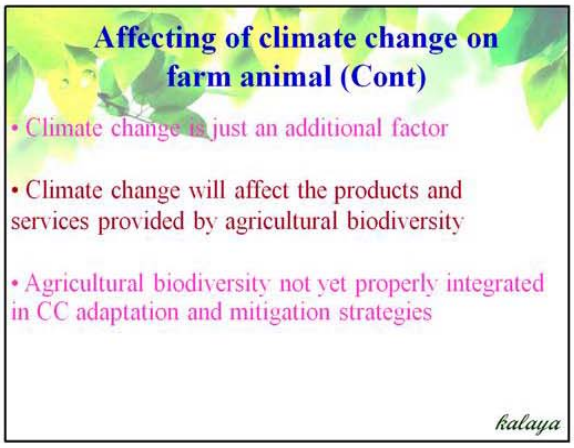


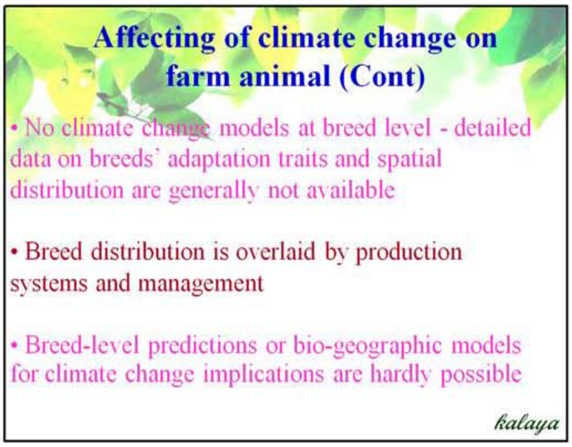









Affecting of climate change on farm animal (Cont)
• Climate change is just an additional factor
• Climate change will affect the products and services provided by agricultural biodiversity
• Agricultural biodiversity not yet properly integrated in CC adaptation and mitigation strategies
kalaya


Affecting of climate change on farm animal (Cont)
• No climate change models at breed level - detailed data on breeds' adaptation traits and spatial distribution are generally not available
• Breed distribution is overlaid by production systems and management
• Breed-level predictions or bio-geographic models for climate change implications are hardly possible
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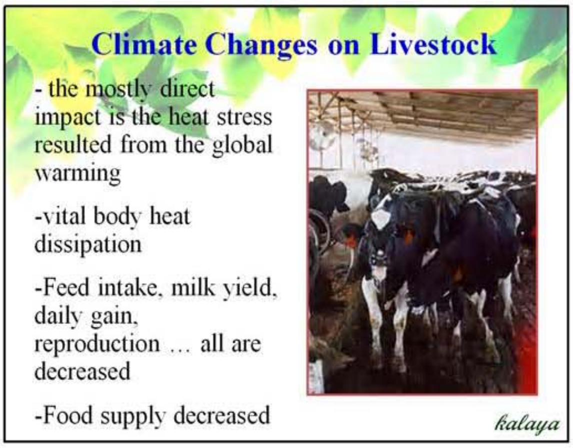
Climate Changes on Livestock
- the mostly direct impact is the heat stress resulted from the global warming
-vital body heat dissipation
-Feed intake, milk yield, daily gain, reproduction … all are decreased
-Food supply decreased
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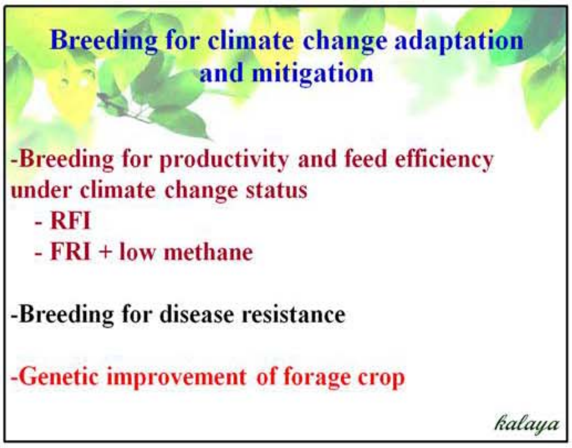
Breeding for climate change adaptation and mitigation
-Breeding for productivity and feed efficiency under climate change status
- RFI
- FRI + low methane
-Breeding for disease resistance
-Genetic improvement of forage crop
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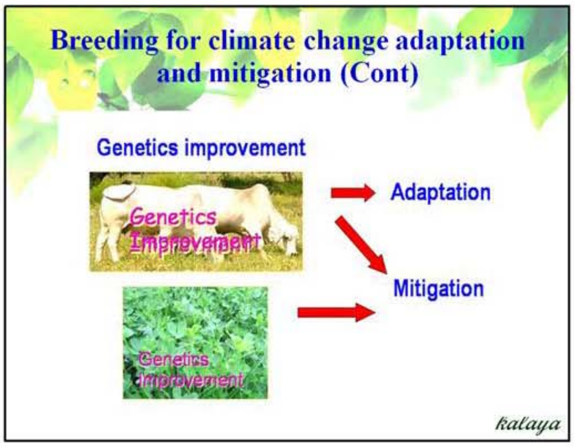
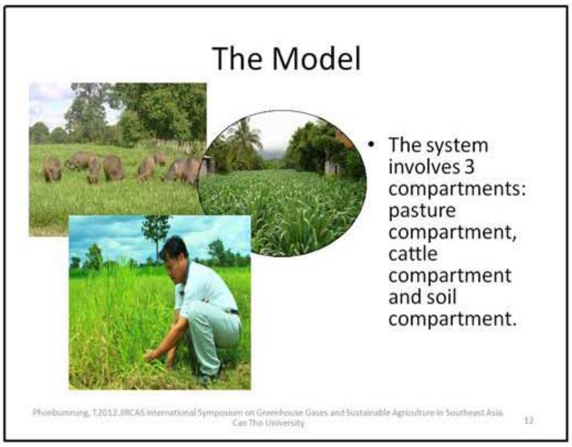
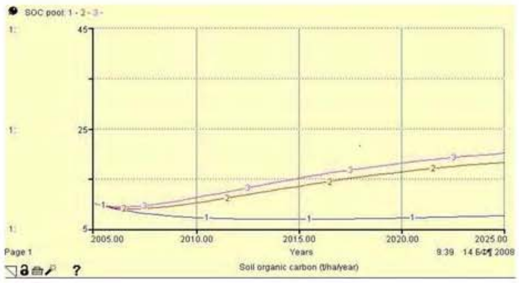

Breeding for climate change adaptation and mitigation (Cont)
Genetics improvement
Genetics Improvement
Adaptation
Mitigation
Genetics Improvement
kalaya

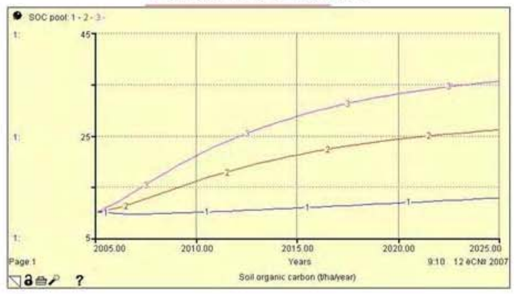

The Model
• The system involves 3 compartments: pasture compartment, cattle compartment and soil compartment.

Carbon sequestration of chemical fertilized Pasture



Phonbumrung, T.2012.JIRCAS International Symposium on Greenhouse Gases and Sustainable Agriculture in Southeast Asia. Can Tho University 13

Carbon sequestration of Manure Fertilized Pasture



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Feeding Management

-oil seed sources had a high potential for rumen methane mitigation

-improved feed quality

-mangosteen peel-garlic powder pellet supplementation on rumen ecology and methane gas production in beef cattle

-increasing of level of digestible energy intake and metabolizable energy intake level can reduce methane production

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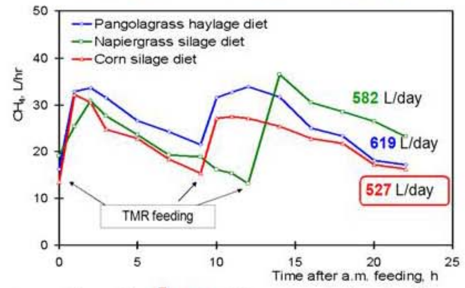
GHG Mitigation strategy: Forage type



Corn silage diet ↓ 12% of the CH_4 production from rumen fermentation of lactating Holstein cows

Farm Management

- Production efficiency

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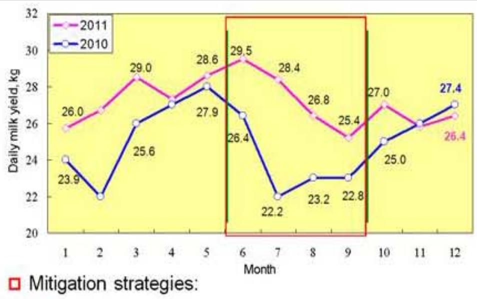

- Mitigation strategies:
  - ✓ Barn cooling: tunnel-ventilated, sprinkling
  - ✓ TMR: low forage (34%), high local by-products (38%), grain mixture (28%)
- Lactating performance: ↑ 3.5 kg/cow/day in summer

Waste Management

- Additives (single super phosphate, lime, straw) increased the potential fertilizer value of composted pig manure
- Effect of treating swine manure to survival of bacteria
- Bacteria at Integrated Pig-Fish Farms
- Management for assessment of nitrogen flow from feed to pig manure
- Biogas production

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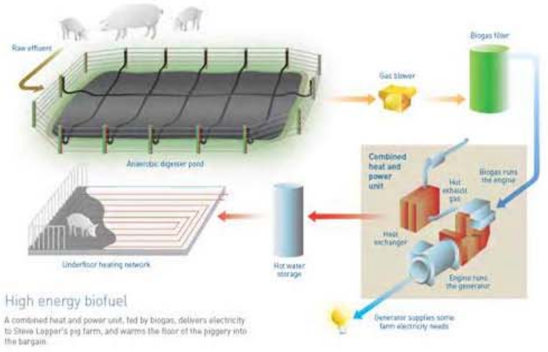


Anaerobic Digester with Solids Dry Pit in the foreground (Thailand)

MC-UASB

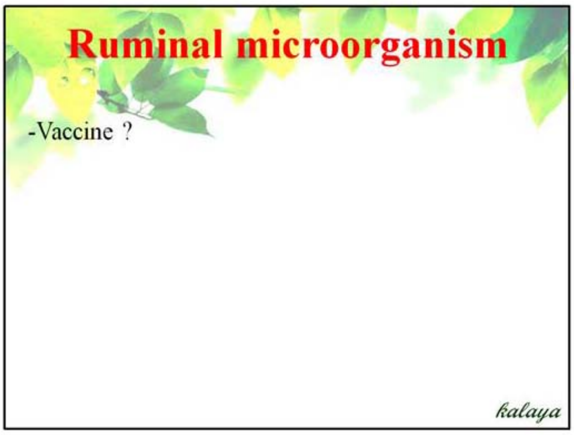
(Medium Farm Channel-Up flow Anaerobic Sludge Blanket)

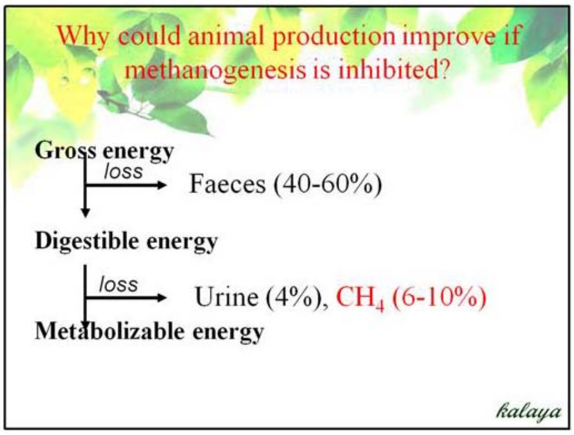
Capacity 400 m^3 for 1600 pigs

Generator

Electricity generation of 400 kW/hr/day

BIOGAS in Pig Farm





Breeding for climate change adaptation and mitigation

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  - RFI
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Ruminal microorganism

- Apply Ruminal microorganism genetics to produce methanogen inhibitor vaccines.
- Apply Ruminal microorganism to produce methanogen inhibitor additives.

Developing countries submit national report every 2 year. In NZ, they have policy of GHG mitigation. By the program of GHG inventory, research, production efficiency, they can decrease GHG emission. About GHG inventory system, to calculate GHG emission, there 3 levels of methodology, tier 1, tier 2, tier 3. Each methodology is optimized for each spicies, such as tier 2 is suitable for dairy cattle. About GHG inventory system, real measurement of GHG emission is very important. Research for mitigation technology is very important.

Speaker emphasized in presentation on how to enhance digestion and metabolism of nutrients by livestock. The mention on partitions of the energy intake and how to improve fiber degradability, stabilized population and action of protozoa, leveling ruminal pH and consequently reducing NH_3 and CH_4 emission were focus in workshop. According to speaker, there should be a win-win solution; such that while improving the production of efficiency of livestock there should be a considerable reduction of GHG emission.

Several measurements of methane emission were also discussed such as the use of calorimerty, the use of tracer technique using SF_6, use of respiration chamber and the use of greed feed technique. Pictures related to these techniques including the process how these techniques were use under intensive and under grazing systems of livestock management were presented to the participants.

About manure management from pig house, the speaker shared his experience in the implementation of program of Thailand on the adaptation and mitigation of emission of green house gasses from pig production. He presented about 9 systems of manure management including the different housing designs for raising pigs. The farmers are required to prepare their manure management plant before they will be given approval to venture on pig farming. The farmers can also select the design of manure management they want to construct base on the size and efficiency in the reduction of GHG emission.

Ventilated and open system of pig farming were compared according the its advantage on animal productivity, environmental impact such as odor and reduction of GHG emission such as CH_4 and NO_2 or NH_3. The project on crop-livestock and low-carbon society under the Thailand system was also made mentioned by the speaker.

The practical side of mitigating GHG emission through feeding management, intervention using essential oils, the use of mangosteen peels with ground garlic pellets. The speaker talked more on animal genetic diversity, breeding for disease resistance, breeding diversity for crops, legumes and carbon sequestration. The importance of residual feed intake (RFI) and RFI + low CH4 emission was also given emphasized in the lecture.

The speaker also talked on 3 systems of C-sequestration that is the interrelationships of soil, crops and the host animals.

There was a lively discussion on the 3 topics which focused on which to be given priority, is it the food security or the effect of climate change brought about by GHG emitted by the livestock. Setting the standards of how much GhG to be reduced without affecting the efficiency of livestock production shall be an open issue to be resolved.

Economy report

1. **Policies and Strategies on Greenhouse Gas Mitigation of the Livestock Industry in Chinese Taipei**

   Ai-Yen, Shih. Pollution Control Division, Animal Industry Department, Council of Agriculture, Taiwan, Chinese Taipei

Scientific Workshop on Measurement and Mitigation of Greenhouse Gases in Livestock Systems for Green Production and Environment of APEC Members

Policies and Strategies on Greenhouse Gas Mitigation of the Livestock Industry in Chinese Taipei

Pollution Control Division, Animal Industry Department, Council of Agriculture

Ai-Yen, Shih

1. Introduction

Situated at the intersection of East and Southeast Asia, Taiwan borders the Pacific Ocean on the east and the Taiwan Strait on the west, spans from 119 to 124 degrees east longitude and from 21 to 25 degrees north latitude, and has a land area of 3,618,995 hectares. Taiwan Island is about 377 km long and 142 km wide. Two-third of the entire island is mountains and hills. The cultivated land area is 799,830 hectares, occupying 22.21% of the total land area.

According to the recent surveys, there are 5,539,130 hogs, 94,059,524 poultry and 148,108 cattle at the end of year 2013. In 2013, agricultural sector accounted for only 5.0% of Taiwan's employment and just 1.7% of GDP. The total value of agricultural production was roughly NT$ 482,493,467 thousands in 2013, an increase of 0.8% compared to 2012. The total value of livestock production was roughly NT$ 149,955,351 thousands in 2013. The major products sequentially are pork, chicken and dairy products. The value of livestock production accounted for 31.08% of the total value of agricultural production. The average food self-sufficiency rate was 33.3% in 2013, an increase of 0.6% compared to 2012.

2. Greenhouse Gas Emission in Taiwan

Taiwan's greenhouse gas (GHG) emission statistics are based on national GHG inventories established according to the Guidelines for National Greenhouse gas inventories issued by intergovernmental panel on climate change (IPCC) and with reference to uncertainty management and estimated according to actual situations.

Total GHG emission increased from 136,681 kilotons of carbon dioxide equivalents (CO_{2e}) in 1990 to 270,744 kilotons of CO_{2e} in 2012. The GHG emission by energy sector accounted for 90.36%, industrial manufacturing sector accounted for 7.53%, agricultural sector accounted for 1.39%, and waste treatment sector accounted for 0.72% of total GHG emission in Taiwan. On the other hand, land use change and forestry sector had absorbed 19,129 kilotons of CO_{2e}. GHG emission trend by individual sector in Taiwan is shown in figure1 and 2.

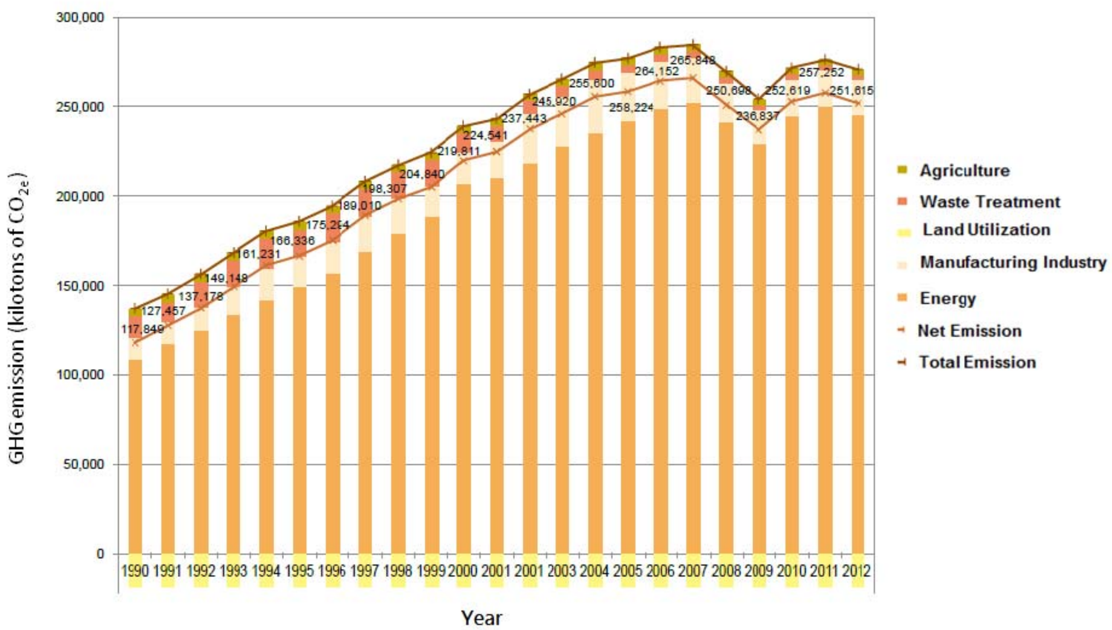

Figure1. Taiwan Greenhouse Gas Emission Trend by individual sector between 1990 and 2012 (Source: 2014 National Inventory Report)

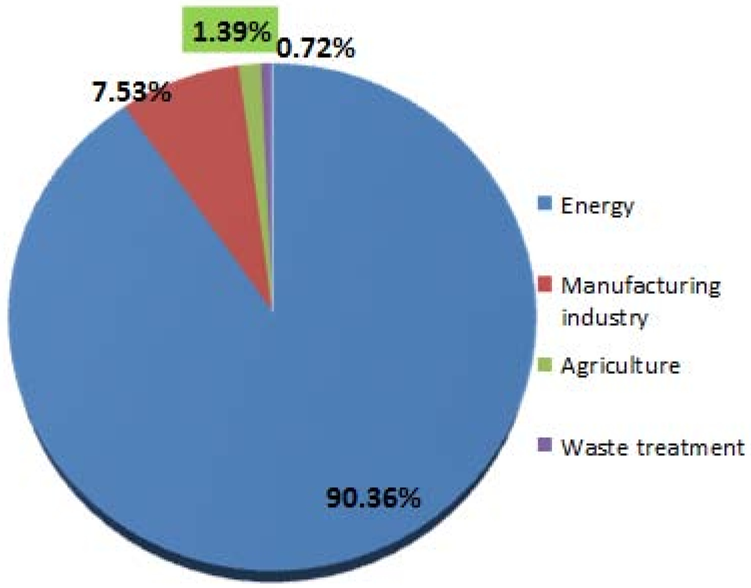

Figure2. Taiwan Greenhouse Gas Emission Trend by individual sector in 2012 (Source: 2014 National Inventory Report)

The types of GHG emitted by the agriculture sector include methane and nitrous oxide. In 2012, the amount of GHG emission was 3,764 kilotons of CO_2e, a 1.01% increase over 2011. Livestock gastrointestinal fermentation caused 13.32%, animal waste caused 5.79%, rice field caused 12.04%, soil caused 68.66%, and residue combustion caused 0.19% of agricultural GHG emissions.

The methane emission of livestock industry mostly comes from gastrointestinal fermentation and waste treatment, which were 45.39% and 13.08% of agricultural GHG emissions, respectively. The trend of GHG emission for livestock industry is shown in figure 3.

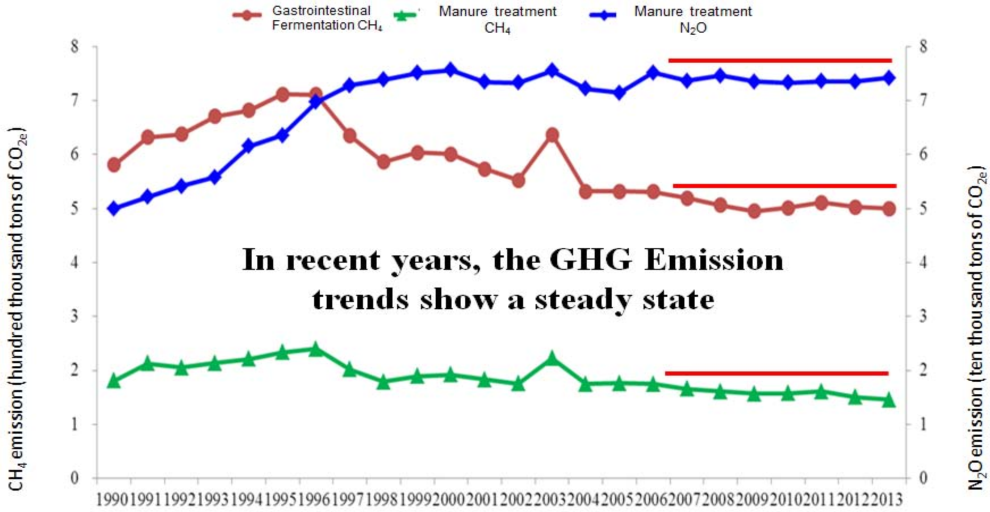

Figure3. The GHG Emission for Livestock Trend between 1990 and 2012 (Source: Source:2014 National Inventory Report and National Yunlin University Horng, Jao-Jia)

3.**Policies on Mitigation of GHG Emission of Livestock**

Climate changes impacts the livestock industry. Higher temperature may cause heat stress, affecting animals' abilities of growing, milking, and breeding. The heat also contributes to a more disease-favorable environment, increasing the risk of infection, lowering the quality and quantity of livestock feed, and decreasing the genetic diversity of livestock. Furthermore, rising temperature may lower the quality and quantity of forage crops and cause a shortage of water for animal farming, resulting in higher cost and risk for the livestock industry.

Taiwan's agriculture sector has implemented the following policies and measures to mitigate the GHG emission:(1) supporting the research on local GHG emission factors, and establishing GHG estimation, investigation and monitoring system for agriculture sector; (2) through the agricultural policy of providing low-interest loan, encouraging the use of agricultural equipment that operates on clean energy such as solar energy or wind power energy to reduce the GHG emission; (3) supporting the consultants to assist the farmers in promoting management efficiency and reducing the use of nitrogen fertilizer to mitigate nitrous oxide emission; (4) encouraging farmers to provide shield and water to lower the temperature in the animal houses and replace air conditioners to reduce energy usage and cost; (5) providing technology on improving feed efficiency to lower manure generation, and using additives to reduce methane generation in the digestion process.

Scientific Workshop on Measurement and Mitigation of Greenhouse Gases in Livestock Systems for Green Production and Environment

Policies and Strategies on Greenhouse Gas Mitigation of the Livestock Industry in Chinese Taipei

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Outline

- Foreword
  - Greenhouse Gas (GHG) Emission
  - Challenge of Climate Change on Agriculture Production
- Policies and Research on Mitigation of GHG Emission from Livestock Industry
- Measurement of GHG
- Conclusion

2

Foreword

Background information of Taiwan:

- Area: 3,618,995 ha
  - **The cultivated land area is 799,830ha, occupying 22.21% of the total land area**
- Livestock industry：

Items	No. of farms	No. of animals on farms
Hog	8,198	5,539,130
Cattle	2,282	148,108
Goat	2,252	164,633
Poultry (Chicken)	5,723	94,059,524

Source：Pig survey conducted in May and July 2014
Livestock survey conducted in April and June 2014

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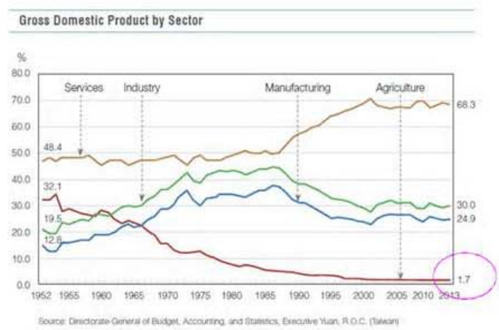

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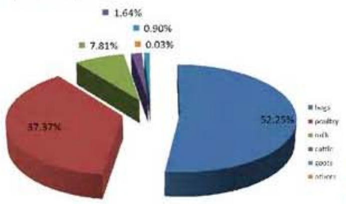
Value of Livestock Products

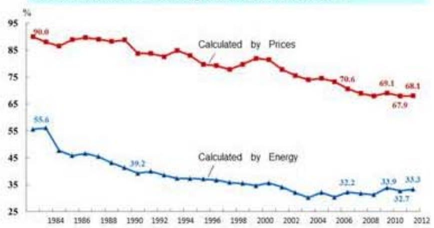
Total livestock industry production reached NT$150 billion, about 31.08% of total agricultural production, in 2013

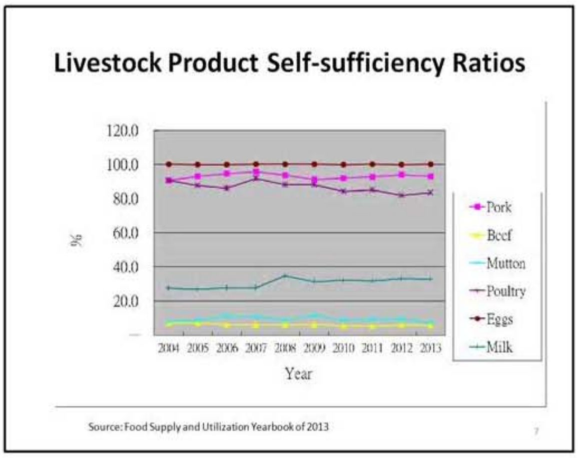


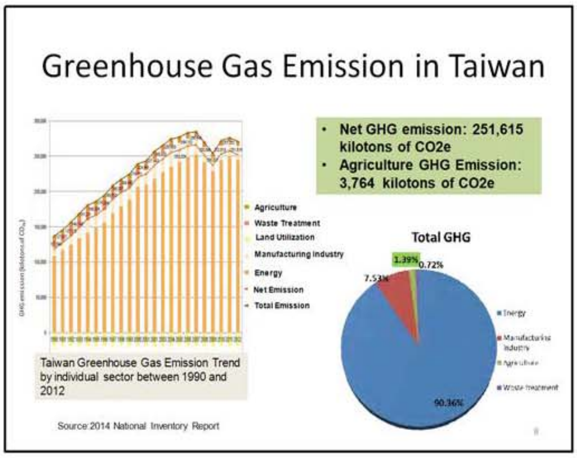
Source：AG. STATISTICS YEARBOOK 2013

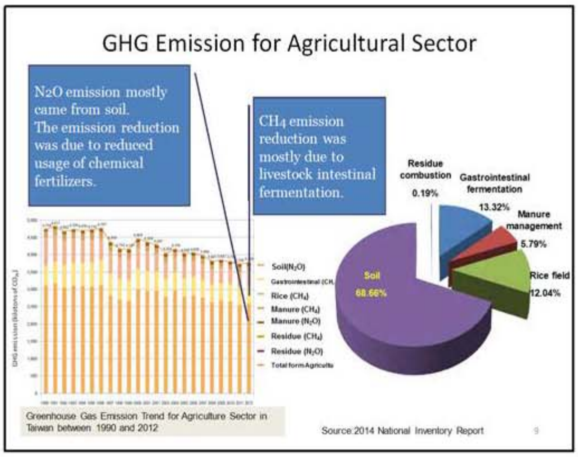
Food Self-sufficiency

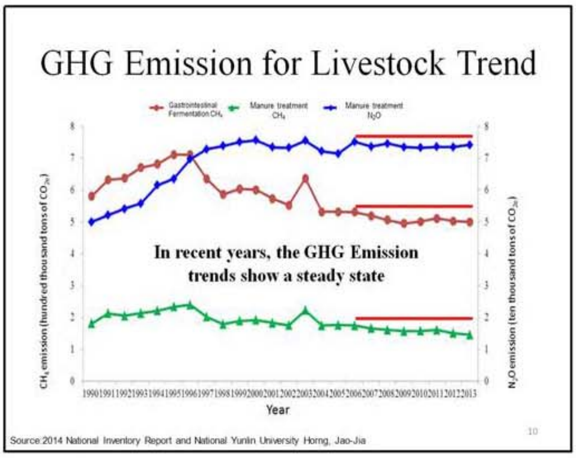
Average Food Self-sufficiency Rate 33.3% in 2013
Almost the lowest among East-Asian economies

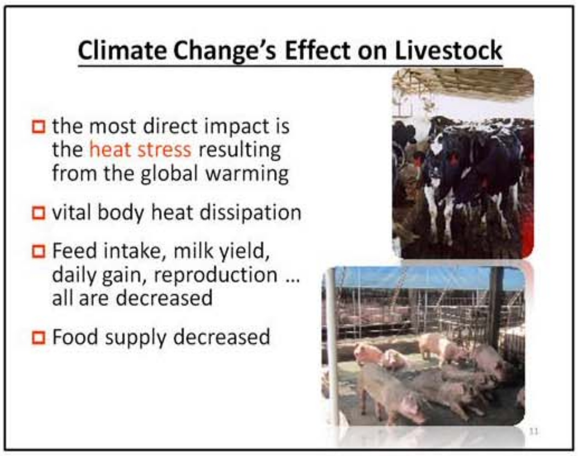


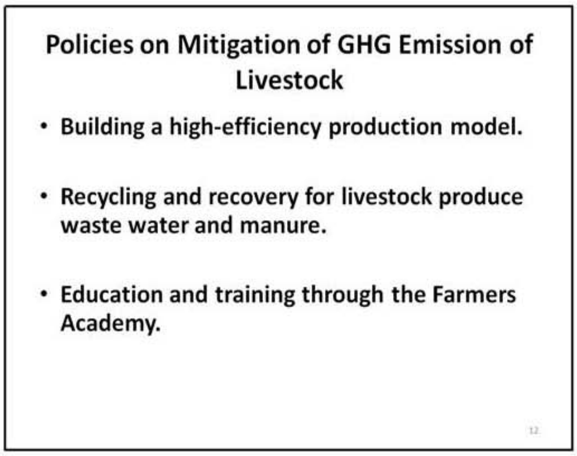

Livestock Product Self-sufficiency Ratios
120.0
100.0
80.0
60.0
40.0
20.0
%
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Year
Pork
Beef
Mutton
Poultry
Eggs
Milk
Source: Food Supply and Utilization Yearbook of 2013
7


Greenhouse Gas Emission in Taiwan
Net GHG emission: 251,615 kilotons of CO2e
Agriculture GHG Emission: 3,764 kilotons of CO2e
Agriculture
Waste Treatment
Land Utilization
Manufacturing Industry
Energy
Net Emission
Total Emission
Total GHG
1.39%
0.72%
7.53%
90.36%
Energy
Manufacturing industry
Agriculture
Waste treatment
Taiwan Greenhouse Gas Emission Trend by individual sector between 1990 and 2012
Source: 2014 National Inventory Report
8


GHG Emission for Agricultural Sector
N2O emission mostly came from soil.
The emission reduction was due to reduced usage of chemical fertilizers.
CH4 emission reduction was mostly due to livestock intestinal fermentation.
Residue combustion
0.19%
Gastrointestinal fermentation
13.32%
Manure management
5.79%
Rice field
12.04%
Soil
68.66%
Soil(N2O)
Rice (CH4)
Manure (CH4)
Manure (N2O)
Residue (CH4)
Residue (N2O)
Greenhouse Gas Emission Trend for Agriculture Sector in Taiwan between 1990 and 2012
Source: 2014 National Inventory Report
9


GHG Emission for Livestock Trend
In recent years, the GHG Emission trends show a steady state
Year
Source: 2014 National Inventory Report and National Yunlin University Horng, Jao-Jia
10


Climate Change's Effect on Livestock
the most direct impact is the heat stress resulting from the global warming
vital body heat dissipation
Feed intake, milk yield, daily gain, reproduction … all are decreased
Food supply decreased
11

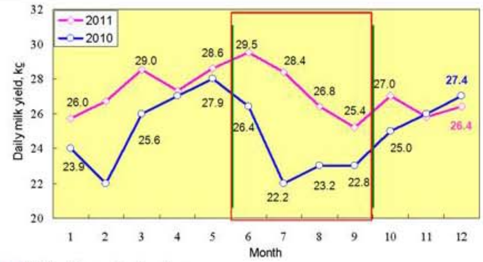

Policies on Mitigation of GHG Emission of Livestock
Building a high-efficiency production model.
Recycling and recovery for livestock produce waste water and manure.
Education and training through the Farmers Academy.
12

Research on GHG Measure and Mitigation of impact on Livestock Industry

- Evaluation of the energy-saving strategy for different livestock building
- Development of an energy-saving and low-carbon emission drying system for hay production
- The effects of LED illumination on the laying performance of waterfowl
- Studies on the livestock in vivo GHG emission and reduction strategies
- Studies on reduction of greenhouse gas from livestock excreta
- Investigation of GHG emission from wastewater treatment system and reutilization of livestock wastewater
- The effect of biochar on forage production and carbon sequestration
- The carbon footprint of domestic dairy production by life-cycle assessment

Source: Livestock Research Institute, Council of Agriculture

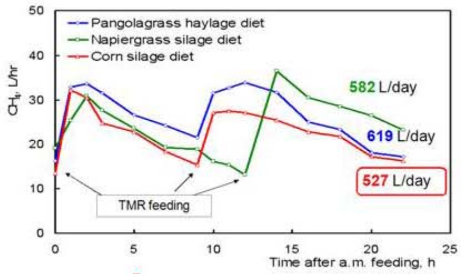
13



- Mitigation strategies:
  - ✓ Barn cooling: tunnel-ventilated, sprinkling
  - ✓ TMR: low forage (34%), high local by-products (38%), grain mixture (28%)
- Lactating performance: ↑ 3.5 kg/cow/day in summer

14

GHG Mitigation Strategy: Forage Type



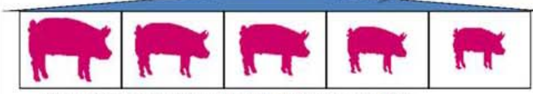
Corn silage diet ↓ 12% of the CH_4 production from rumen fermentation of lactating Holstein cows

15

Hog Livestock Production

- Continuing production system

Accounting for 85~90% in Taiwan



(Pitcher, 1997 University of Pennsylvania School of Veterinary Medicine)

- Multi-site production system (all-in/all-out)

Sow Livestock (Sow、Piglets) → Nursing Pig Livestock | Finish Pig Livestock

Each breeding unit adopt all-in/all-out, meanwhile, the necessary condition that people, vehicles and facilities can't share.

16

Multi-site Production System Promotes Achievement

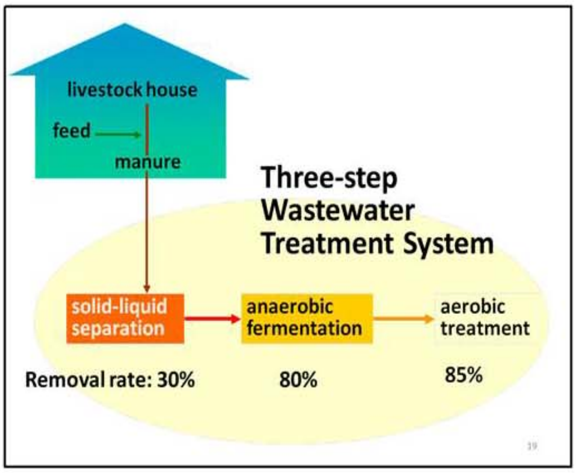
17

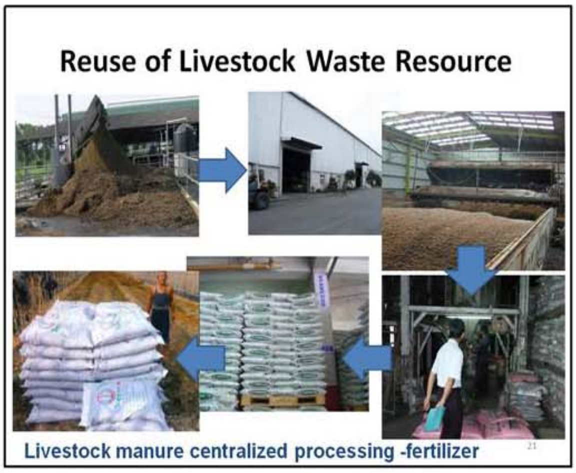
Multi-site Production System Improves Outcomes

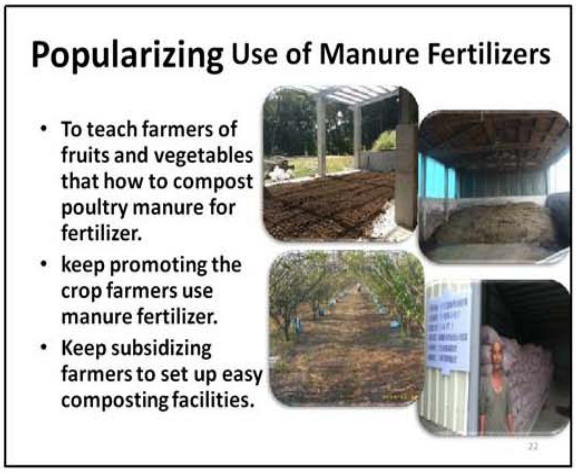
Item	Improvement
Reproduction efficiency	+3~15%
Nursing Pigs livability	+8~11%
Hog livability	+5~10%
Piglets Scours	-10~20%
Feed Conversion Rate (FCR)	3.3→3.15

Source: Taiwan Animal Technology laboratories Chang-Yeu Liu

18







Methane and nitrous oxide emission factor for composting of swine and cattle manure with intermittent aeration

	Aeration min/hr	Power consumed Kwh	CH_4 emission kg	EF %	N_2O emission kg	EF %	CO_2e kg/kg DM
swine	3.0	92.7	0.511	0.22	0.038	0.30	0.15
	0.5	15.5	2.80	1.18	0.102	0.81	0.20
	0	0	12.6	5.31	0.083	0.66	0.63
cattle	6	75.0	4.34	1.05	0.166	1.04	0.22
	3	37.5	13.0	3.38	0.335	2.40	0.53
	0	0	12.1	3.26	0.981	6.72	0.71

CO_2e=(power consumed*0.612kg+ CH_4* 25 + N_2O*298)/initial weight
EF% = emission weight/initial C (N)weight *100%

Aeration reduces CH_4 and N_2O emission during composting processes

Hog CH_4 Electric Generation Efficiency

Hog Head	Cost				Income					Economic(10thousand/year)	Payback Years
	Remove H_2S Facility(set/ten thousand NT$)	Electric Generation Facility (Power/ten thousand NT$)	Maintain(ten thousand NT$/year)	Total (ten thousand NT$/year)	CH_4 Product Capacity (m^3/year)	Generating Capacity(ten thousand NT$/year)	GHG Mitigation(ton CO_2e/year)	GHG Mitigation (ten thousand NT$/year)	Total		
1,000	38	12kW/34	6.6	78.6	36,500	52,143/13	1,000	21	34	-45	2.3
2,000	38	20kW/47	7	92	73,000	104,286/25	2,000	42	67	-25	1.4
3,000	46	30kW/56	9	111	109,500	156,429/38	3,000	63	101	-10	1.1
5,000	58	50kW/67	12	137	182,500	260,714/63	5,000	105	168	31	0.82
10,000	98	100kW/108	17	223	365,000	521,429/125	10,000	210	335	112	0.66

Source: Calculateion of NTU JUNG-JENG SU

Education and Training through the Farmers Academy

25

Livestock GHG Measurement Method

GHG Calculate adopt IPCC Tier 1:

Emission Factor (EF) × Livestock Total Number × (Gg / 10^6 kg)

Gastrointestinal fermentation CH_4 (Local factor)

Item		Emission Factor (EF)		
		Factor	Unit	Remark
Cattle	Dairy	134.7	kg/head/yr	IPCC 56
	Non-Dairy	64.3		IPCC 44
Buffalo		64	kg/head/yr	IPCC 55
Poultry	Broiler	1.587×10^{-5}	kg/bird/life cycle	IPCC has none of this item
	Colored Broilers	8.482×10^{-5}	kg/bird/life cycle	
	Layers	1.061×10^{-2}	kg/head/yr	
	Geese	1.50×10^{-3}	kg/bird/life cycle	
	Ducks	2.071×10^{-3}	kg/bird/life cycle	

※Other animals type adopt IPCC factor

Source:2014 National Inventory Report

26

Manure Treatment CH_4 (Local factor)

Item		Emission Factor (EF)		
		Factor	Unit	Remark
Cattle Dairy		4.898	kg/head/yr	IPCC 16
Hogs		0.768	kg/head/yr	IPCC 5
Poultry	Broilers	0.00476	kg/bird/life cycle	IPCC 0.117
	Colored Broilers	0.00476	kg/bird/life cycle	
	Layers	0.00999	kg/head/yr	

Manure treatment N_2O

Item		Emission Factor (EF)		
		Factor	Unit	Remark
Cattle Dairy		0.011	kg/head/yr	
Hogs		0.002		
Poultry	Broilers	6.43×10^{-6}	kg/bird/life cycle	
	Colored Broilers	6.43×10^{-6}	kg/bird/life cycle	
	Layers	0.0055	kg/bird/yr	

Source:2014 National Inventory Report

※Other animals type adopt IPCC factor

On going Strategy:

Developing:

- Cost effective, natural and social-economic science integrated
- Ecosystem service sustainability-based production system
- Social/community recognizability and support
- Education and extension

28

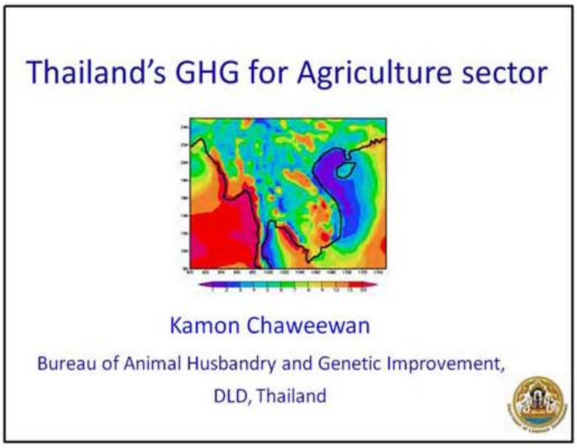
Thanks for your attention!
謝謝!

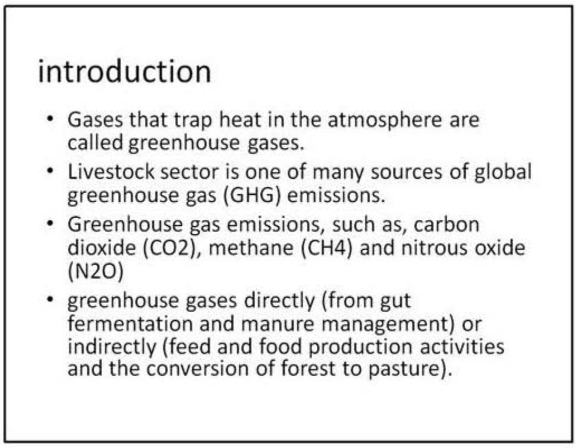
Name: Ai-Yen, Shih
Email: aiyen@mail.coa.gov.tw

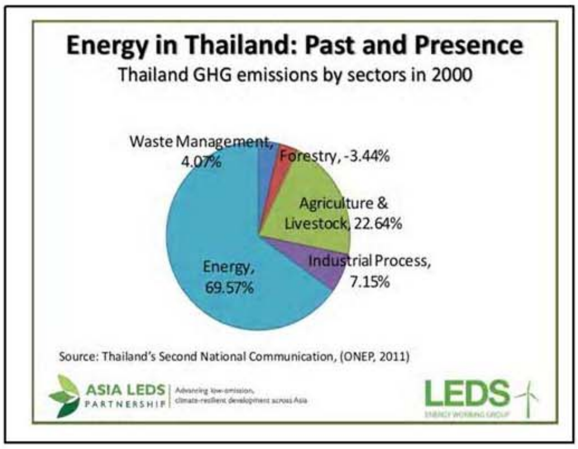
29

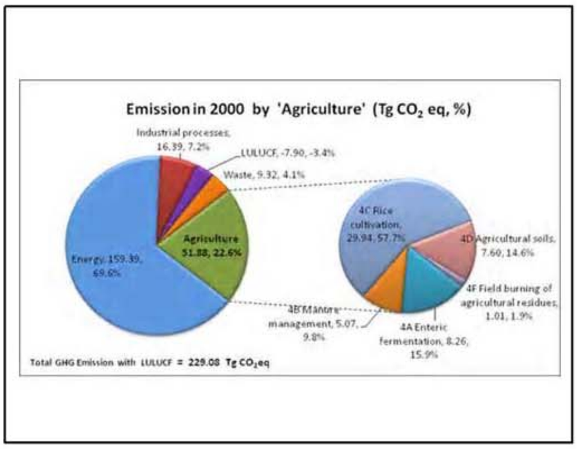
2. Thailand's GHG for Agriculture sector

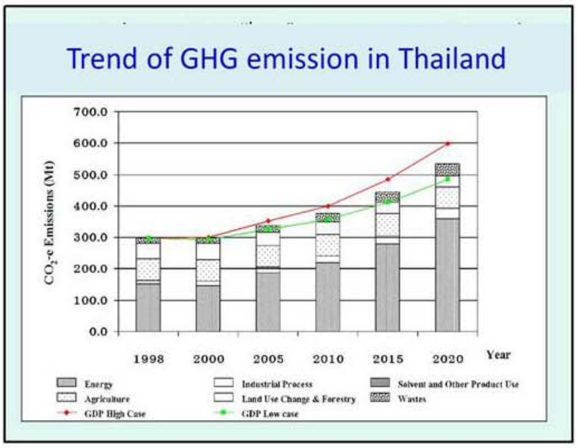
Varocha Jumparat and Kamon Chaweewan. Rakornrachasrima Livestock Research and Breeding Center. Bureau of Animal Husbandry and Genetic Improvement. Department of Livestock Development. Thailand.











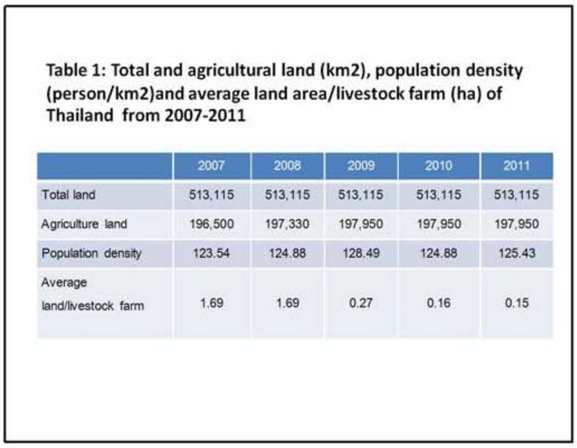


Table 1: Total and agricultural land (km2), population density (person/km2)and average land area/livestock farm (ha) of Thailand from 2007-2011

	2007	2008	2009	2010	2011
Total land	513,115	513,115	513,115	513,115	513,115
Agriculture land	196,500	197,330	197,950	197,950	197,950
Population density	123.54	124.88	128.49	124.88	125.43
Average land/livestock farm	1.69	1.69	0.27	0.16	0.15

Table 2: Temperature(ºC), precipitation(mm), and humidity(%) of Thailand from 2007-2011*

	2007	2008	2009	2010	2011
Temperature (ºC)	26.93	26.86	26.94	27.59	27.15
Humidity (%)	79.74	79.74	80.69	80.43	81.53
Precipitation (mm)	2006	3295	2935	2590	2466

*Thailand Meteorological Department

The problem*

- Heat Stress - many high output breeds of all species are not good at coping with heat
- Pests and Diseases - will move geographic areas and be exposed to 'new' breeds - will survive better as less exposure to cold - short-term weather event can trigger disease
- Water availability – renewable water reduces by 20% for additional 7% world population - consumption by animals will increase to cope with heat
- -sudden weather events will increase (flooding)

David E. Steane, 2014

The problem -indirect

- Crop yields - likely to reduce (wheat, maize, soybean probably by 5-10%) while predicted demand increase of 14% per decade!
- Crop quality – high temperatures will increase lignifications (movement from C3 to C4 plants) – growing season will lengthen so more yield - so large amounts of low quality dry matter
- Crop Risk – will increase due to more sudden weather events
- Plant breeding will hold a major key to the effects on livestock production systems and animal genetic resources

Thailand Climate Change Master Plan (2012–2050):

The plan includes three key strategies:

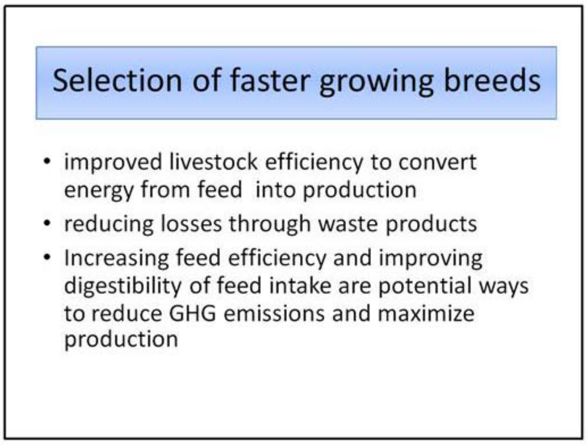
1. Mitigation of greenhouse gas (GHG) emissions and increase of GHG sinks to promote sustainable development
2. Strengthening the capacity of human resources and institutions and to manage the risks from the effects of climate change and cross cutting issues
3. Adaptation for coping with the negative effects of climate change

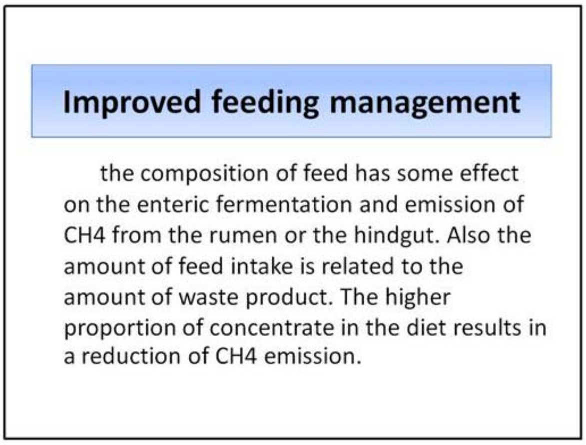
Sector	
energy	• Targeting a 25 percent GHG energy intensity reduction by 2030, with alternative energy comprising 20 percent of total energy use • Developing the 20-Year Energy Efficiency Development and the Alternative Energy Development Plan
Agriculture and Forestry	• Encouraging local authorities to enhance carbon sinks throug forestation and sustainable forest resource management • Allocating national budget to establish an information center and satellite systems to track forest cover, land use, and land-use change
Waste	Developing an incentive scheme to promote electricity generation from waste, including plans to build a plant in Bangkok
Sub-national	Promoting the "Clean City Clean Mind" and "Low Carbon City" initiatives, providing technical assistance to local governments

Mitigation of GHG emissions in the livestock sector can be achieved through various activities including (FAO, 2013)

In the livestock production system, there are three main sources of the GHG emissions:

- the enteric fermentation of the animals
- manure (waste products)
- production of feed and forage (field use)





3. **Philippine Government Initiatives Policies & Program Related to Green House Gas Abatement & Mitigation of Climate Change : Focus on Livestock Production**

Daniel L. Aquino, PhD. Philippine Carabao Center. Department of Agriculture. Email: dalla_1358@yahoo.com
Hernando F. Avilla, MSA, MPSBureau of Animal Industry. Department of AgricultureE-mail: hernand.bai@gmail.com

PHILIPPINE COUNTRY REPORT

[ATC 01 2013A] Scientific Workshop on Measurement and Mitigation of Greenhouse Gases in Livestock Systems for Green Production andEnvironment of APEC Members
Bangkok, Thailand
December 2-4, 2014

Participants:

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INTRODUCTION

The current status of the Agriculture Sector showed a 0.33% growth in the first nine (9) months of 2014. Despite the considerable damages caused by Typhoons "Glenda", "Luis" and "Mario" during the months of July and September, the crops and livestock subsectors came up with output increments. However, the poultry and fisheries subsectors contracted during the period. Overall, the sector grossed P1.1 trillion at current prices. This was 9.55% more than last year's gross receipts, (BAS, 2014)

The crops subsector grew by 1.20%. It contributed 51.03% to total agricultural output. Slower production gains were noted for palay and corn at 0.41 percent and 0.07%, respectively. Improved growth records were registered by sugarcane, mango, tobacco and onion. At current prices, the subsector's gross value of output amounted to P633.7 billion or 14.95%higher than last year's record, (BAS, 2014)

The livestock subsector which shared 16.11% in total agricultural production expanded by 1.05%. Hog was the subsector's source of growth. Gross earnings amounted to P176.9 billion at current prices. This registered a 6.06 percent increase from last year's gross receipts,(BAS, 2014)

Production of the poultry subsector was declined by 0.74%. It accounted for 14.85% of the total agricultural output. Production increments were noted for chicken and duck while there was contraction in egg production. The subsector grossed P138.0 billion at current prices or 7.60 percent more this year, (BAS, 2014)

The fisheries subsector which contributed 18.01% to total agricultural output went down by 1.80%. Except for skipjack, all species recorded reduced production. At current prices, the subsector's gross value of output amounted to P176.9 billion. This indicated a 2.30% drop from last year's gross receipts,(BAS, 2014)

On the average, prices of agricultural commodities increased by 9.19 percent in the first nine (9) months of the year. Average price increases were higher in the crops and poultry subsectors at 13.59% and 8.40%, respectively. The livestock subsector posted an average price increment of 4.96%. On the other hand, the fisheries subsector recorded an average price decline of 0.50%, (BAS, 2014)

VULNERABILITY AND IMPACT ASSESSMENT ON CLIMATE CHANGE

The Philippines ranked 47thout of the 210 countries as contributor to global warming. The report of New Scientist: http:/Asia tops climate change's 'most vulnerable' list, October 2010. www.newscientist.com showed that in terms of vulnerability, the Philippines rank sixth among the vulnerable countries in Asia). The top five vulnerable countries are Bangladesh (1st) followed by India, Madagascar, Nepal and Mozambique. As regards to the world's risk index, the UNU IEHS (Sept 26, 2011) reported that the Philippines is on the 3rd place, Table 1.

Vulnerability Rank	Country	World Risk Index	Country	Risk (%)
1	Bangladesh	1	Vanuatu	32.00
2	India	2	Tonga	29.08
3	Madagascar	3	Philippines	24.32
4	Nepal	4	Solomon Islands	23.51
5	Mozambique	5	Guatemala	20.88
6	Philippines	6	Bangladesh	17.45
7	Haiti	7	Timor-Leste	17.45
8	Afghanistan	8	Costa Rica	16.74
9	Zimbabwe	9	Cambodia	16.58
10	Mayanmar	10	El Salvador	16.49
11	Ethiopia	11	Nicaragua	15.74
12	Cambodia	12	Papua New Guinea	15.45
13	Viet Nam	13	Madagascar	14.46
14	Thailand	14	Brunei Darussalam	14.08
15	Pakistan	15	Afghanistan	14.06

Source: UNU IEHS (Sept 26,2011), http://ihrrblog.org/2011/09/26/2011-un-world-risk-index

According to the report of C. Godilano; 2013, the Philippines is No.1 in terms of exposure, susceptibility, coping capacities and adaptive capacities to natural disasters. The Philippines also ranks No.5 in terms of sea level rise affecting about 14 million people.

Looking at the effects of climate change on animal production, the poultry and livestock are threatened both direct and indirect effect of climate change impacts. The direct effects include the high environmental temperatures, excessive rainfall, flooding, and droughts while the indirect effects include low quantity and quality of forage/feed supply, high cost of feed grains, high cost of fossil fuel, and emergence of new diseases, among others, (Sevilla, 2013).

1. **Direct effects of high environmental temperature and humidity on animal production**

Under a hot and humid environment, the behavioral and physiological cooling mechanisms of high-producing farm animals such as affect their voluntary feed intake, seeking shade, sweating, hyperventilation, defecation, urination, and salivation may not be sufficient to dissipate body heat. Consequently, they succumb to excess heat load resulting in thermal stress. Heat-stressed animals will exhibit poor production and reproduction performance or may even die of heat stroke.

The forages available to ruminant feeding are highly lignified and fibrous. When taken in by ruminants it requires longer period of fermentation in the rumen, a process that generates high amount of heat inside the body, among other fermentation end-products. As well, fast-growing modern swine and poultry breeds generate more body heat when fed high-energy diets in a hot environment. Animals subjected to a regime of continuous high ambient temperature initially will reduce their voluntary feed intake and subsequently suffer from lower meat, milk and egg production, lower reproductive rate, and poor health condition.

In swine, an analysis of three-year (2005 to 2008) monthly production data of 24 commercial farms (15 large, 4 medium and 5 small) with a total of 1,761 sow level was conducted by Vega *et al.* (2002). Statistical analysis revealed a "third quarter swine reproductive syndrome," where values for farrowing interval and non-productive days were found to be worst during the months of July, August, and September. Among the possible reasons were that the animals were subjected to prolonged heat stress during the hot months of the second quarter (April – June) and continued until the hot and humid months of the third quarter (July – August) in time for parturition. Humidity per se has no direct negative impact on the animals. But combined with high temperature, it contributes to the occurrence of heat stress.

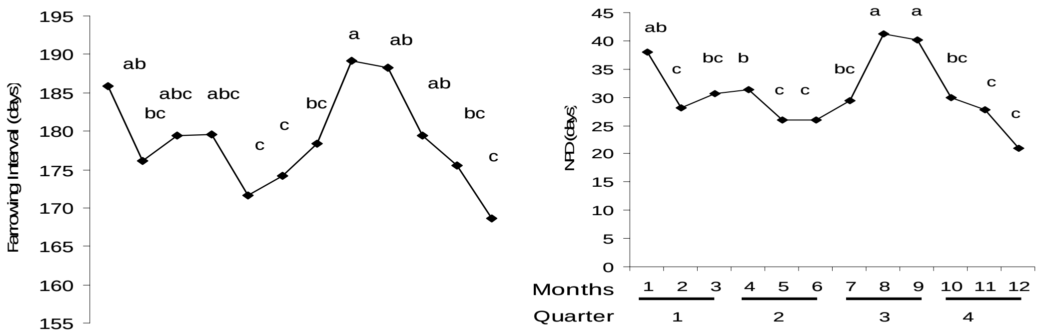

Figure1.Monthly means of farrowing interval and non-productive days of swine commercial farms extracted from 2006, 2007 and 2008 performance data(significant differences at P<0.05)

A survey conducted in the province of Laguna on the interrelationships of animal production, animal health, and the environment showed that a majority of the smallholder farmers as well as most commercial animal raisers perceived weather change as the major predisposing factor in the outbreak of diseases, followed by lack of health management and inadequate feeding and poor sanitation (Espaldon et al., 2008).

Direct effects of drought and excessive rainfall on animal production

The typhoon Yolanda that hit the country has affected 80,000 families and 44,000 rice farmers in region 8 of the country with an estimated losses in agriculture amounting to U$110M. For livestock and poultry the total estimated amount of damaged was P2.7 MP of which 1.298 M from poultry production and the remaining amount comes from swine, cattle, carabao and goat production. Another typhoons/floods hit Regions 1 and 2 (Luis) and Region 4 &5 (Glenda) and the estimated damages were P409M and P250M respectively. The damages for livestock was accounted for P140,000 for Luis and P5M for Glenda.

2. Indirect impacts of extreme climate events on the nutritional and health status of livestock and poultry

The health and nutrition of livestock and poultry are predispose to the increase in temperature that leading to lower feed intake, inadequate nutrition, and disease outbreak. As experienced, grazing large ruminant decline about 90-110 grams of body weight during the months from February to May coinciding the summer months. Climate change brings negative impact on the yield of major sources of feed ingredients as well as the feeding value of forages. Among ruminants, lignification of pasture grasses with increasing temperature prolonged rumen fermentation resulting in lower feed intake and higher carbon dioxide and methane emissions.

ADAPTATION MEASURES

Commercial and smallholder animal producers develop adaptive mechanisms to minimize the effects of heat stress on productivity of genetically superior breeds. While pig pens had concrete walls, these have now been replaced with iron bars or bamboo poles (in the case of smallholder farms) for better ventilation. More recently, there has been an increasing adoption of tunnel ventilation in commercial swine and poultry farms primarily to minimize heat stress and consequently prevent outbreak of diseases. Smallholder swine and poultry houses are built using light materials instead of galvanized iron sheets as roofing materials of animal pens and poultry houses to minimize heat.

In cattle, buffalo and goat production, the backyard farmers are shifting from tethering to complete confinement system to reduce heat stress and also incidence of internal parasites. Some dairy farms provide electric fans or showers for their animals to improve cooling and air movement inside the pens. Dairy farmers are provided with technical assistance in forage production, conservation and even enrichment of low quality farm by-products.

Development of climate resilient native animals- The Philippine Native Animal Development (PNAD) which seeks to develop policies on conservation and production of native animals in support to food security program of the government.

Disaster preparedness through the institutionalization of Animal Relief and Rehabilitation Program (ARRPh) was launched by the government to assist the livestock farmers in the Affected areas.
Similarly, inclusion on the prevention

MITIGATION MEASURES

Livestock and poultry production requires large tract of agricultural land for grazing and feed crop production. With decreasing land area and an increasing demand for animal products, animal production systems have shifted from the extensive, less efficient (grazing animals) to the more efficient and intensive (swine, poultry, dairy cattle) system. The industrialization of animal production and the consequent concentration of large number of animals in small areas have resulted in serious environmental concerns. These constitute the sector's contribution to climate change, pollution, and human health.

Manure and enteric fermentation end products from animal production are significant sources of greenhouse gases. In Laguna, the global warming potential from livestock and poultry was estimated at 50.144 tons of carbon dioxide (Espaldon et al, 2008). The combined population of carabaos, cattle, goats, sheep, and horses contributed 36.52 tons, while swine and poultry species contributed 12.18 tons and 1.44 tons of carbon dioxide equivalent; respectively.

The following are some of the on-going mitigation measures being implemented by the livestock farmers to help reduced the GhG emission and effect of global warming:

1. Implementation of the National Organic Agriculture Program (NOAP) .This program encourages livestock farmers to practice organic farming. This program aims to promote, propagate and implement practice of organic farming towards a competitive and sustainable organic agriculture industry.

2. Vermicomposting – the use of worms to ferment and utilize the nutrients from manure of poultry and livestock is very practical under backyard and commercial farms. Vermicasts, vermin-tea and saleable worms are some of the products produced. This mitigation measure practical and will serves as an additional source of income by the livestock farmers.

3. Biogas Production – Biogas produced from livestock manure are being used by some commercial piggeries and dairy farms to supply the power requirement for their operation. This, however, require some investment. In smallhold farms, biogas models adapted to the size of operation are now being promoted and provision of technical guidance is on its way to minimize pollution brought about by animal manure.

POTENTIAL MEASURE TO MITIGATE CLIMATE CHANGE

With all the mitigation programs and laws developed by the government and other countries, the most important aspect to address climate change is the strict implementation of the developed laws and policies. The most important is how serious our leaders and the whole citizenry in saving the mother earth?

FINANCIAL OPTIONS

The Philippines is really serious in its worldwide participation and implementation of the adaptation and mitigation programs to help address climate change and its effect to the environment and health of the people. The government through the Climate Change Commission has invested human and equipment resources including budget to overcome such effect especially when unforeseen disasters hit the country.

GAPS

The present concern is the development of a climate change program that will address the sustainability and economic viability of livestock production systems, while mitigating the negative impacts of livestock and poultry on the environment.

Proper nutrition for better digestion of feeds will minimize methane and nitrous oxide emissions from animal wastes. At present, enzymes and other feed additives are widely used in commercial feed formulations of swine and poultry to improve the conversion of feed nutrients into animal products. There are no similar nutritional interventions in ruminants to minimize methane and carbon dioxide emission from rumen fermentation.

Science and Technology Priorities

Priorities for knowledge and technology generation are as follows:

- Improvement of digestibility of both conventional and unconventional feeds
- Revisit crop-animal integration for efficient use of resource and conservation and use of biodiversity
- Study on nutritional intervention to minimize enteric gas emission
- Study on more efficient and economical means of animal waste management
- Application of rumen biotechnology to enhance rumen functions but reducing enteric fermentation
- Deeper understanding on the role of methanogens in livestock production
- Development of heat resistant livestock breeds
- Establishment of climate smart feeding systems
- Development of heat resistant grasses and legume varieties as feed sources

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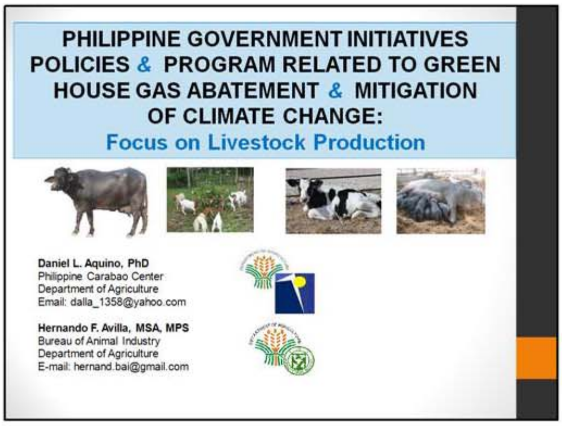
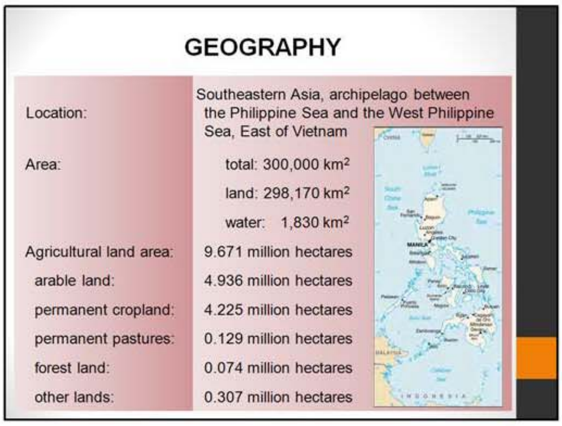
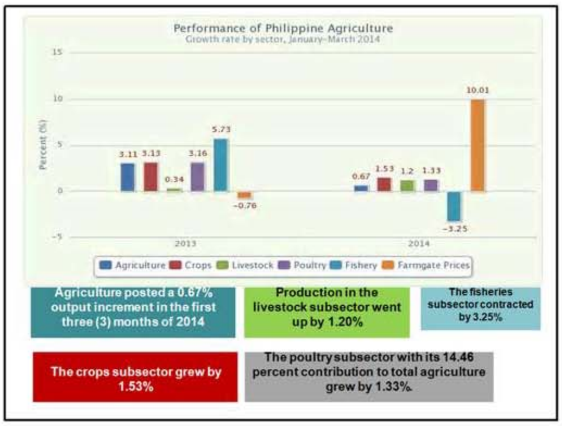


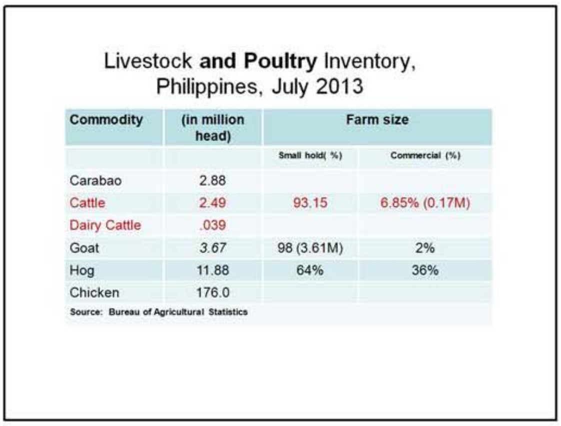



PROFILES OF THE PHILIPPINES

ITEM	PHILIPPINES
Population	98,390,000
Growth Rate, %	1.70
Infant Mortality, %	20.56/1000
Unemployment rate, %	6.7*
Life Expectancy, yrs.	68.9
Men	67
Women	71

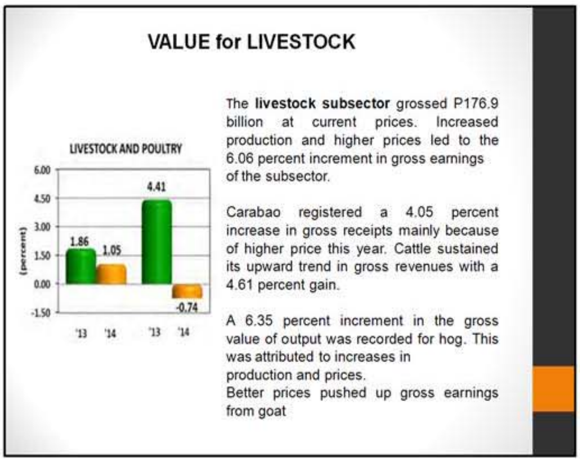
BAS, 2013 , *BAS, 2014

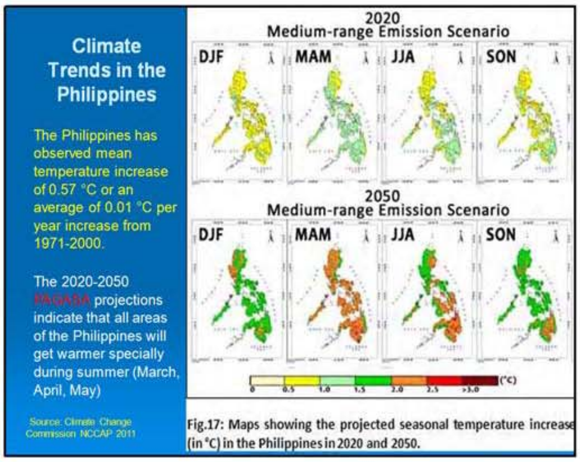


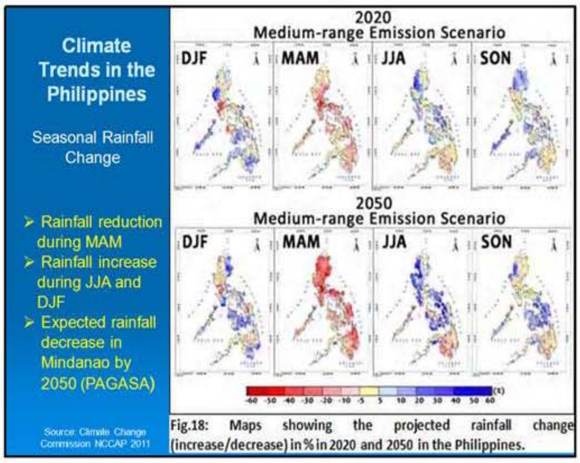

Livestock **and Poultry** Inventory, Philippines, July 2013

Commodity	(in million head)	Farm size	
		Small hold(%)	Commercial (%)
Carabao	2.88		
Cattle	2.49	93.15	6.85% (0.17M)
Dairy Cattle	.039		
Goat	*3.67*	98 (3.61M)	2%
Hog	11.88	64%	36%
Chicken	176.0		

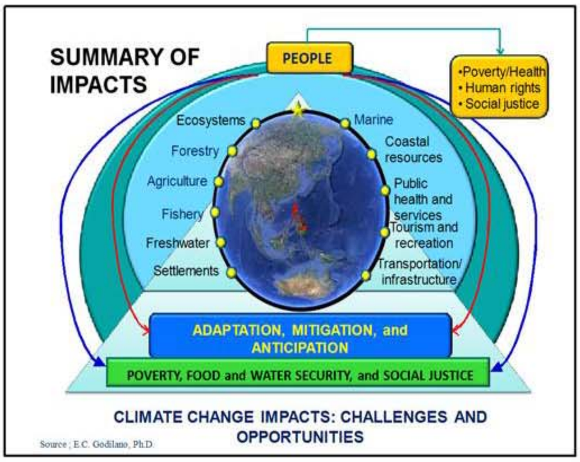
Source: Bureau of Agricultural Statistics

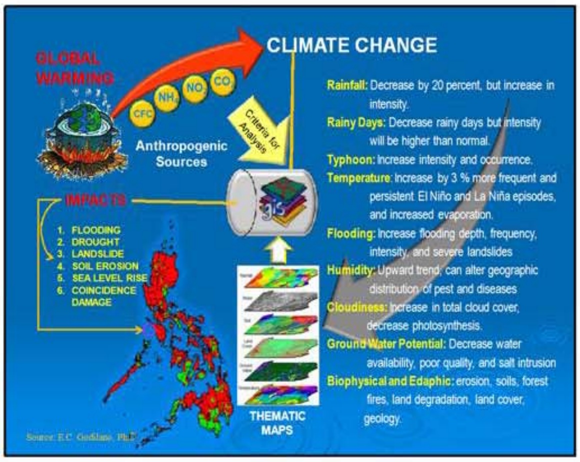

VALUE for LIVESTOCK
LIVESTOCK AND POULTRY
(percent)
6.00
4.50
3.00
1.50
0.00
-1.50
1.86
1.05
4.41
-0.74
'13 '14 '13 '14
The livestock subsector grossed P176.9 billion at current prices. Increased production and higher prices led to the 6.06 percent increment in gross earnings of the subsector.
Carabao registered a 4.05 percent increase in gross receipts mainly because of higher price this year. Cattle sustained its upward trend in gross revenues with a 4.61 percent gain.
A 6.35 percent increment in the gross value of output was recorded for hog. This was attributed to increases in production and prices.
Better prices pushed up gross earnings from goat

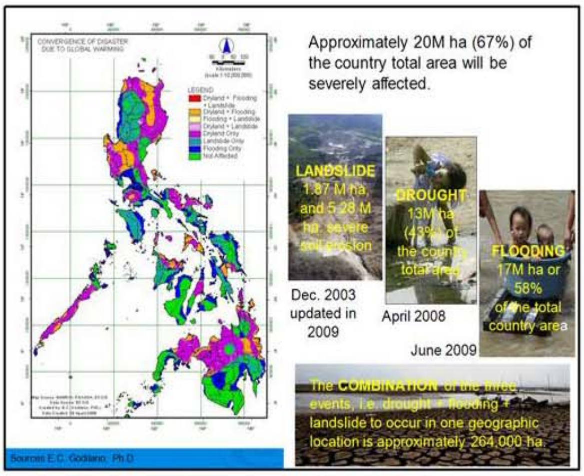

Climate Trends in the Philippines
The Philippines has observed mean temperature increase of 0.57 °C or an average of 0.01 °C per year increase from 1971-2000.
The 2020-2050 PAGASA projections indicate that all areas of the Philippines will get warmer specially during summer (March, April, May)
Source: Climate Change Commission NCCAP 2011
2020
Medium-range Emission Scenario
DJF
MAM
JJA
SON
2050
Medium-range Emission Scenario
DJF
MAM
JJA
SON
(°C)
Fig.17: Maps showing the projected seasonal temperature increase (in °C) in the Philippines in 2020 and 2050.

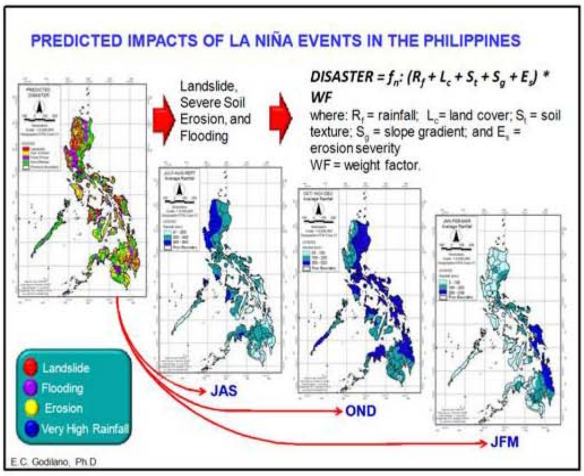

Climate Trends in the Philippines
Seasonal Rainfall Change
➤ Rainfall reduction during MAM
➤ Rainfall increase during JJA and DJF
➤ Expected rainfall decrease in Mindanao by 2050 (PAGASA)
Source: Climate Change Commission NCCAP 2011
2020
Medium-range Emission Scenario
DJF
MAM
JJA
SON
2050
Medium-range Emission Scenario
DJF
MAM
JJA
SON
Fig.18: Maps showing the projected rainfall change (increase/decrease) in % in 2020 and 2050 in the Philippines.


IMPACTS IN THE PHILIPPINES AND LINKS TO DEVELOPMENT


SUMMARY OF IMPACTS
PEOPLE
•Poverty/Health
• Human rights
• Social justice
Ecosystems
Forestry
Agriculture
Fishery
Freshwater
Settlements
Marine
Coastal resources
Public health and services
Tourism and recreation
Transportation/ infrastructure
ADAPTATION, MITIGATION, and ANTICIPATION
POVERTY, FOOD and WATER SECURITY, and SOCIAL JUSTICE
CLIMATE CHANGE IMPACTS: CHALLENGES AND OPPORTUNITIES
Source : E.C. Godilano, Ph.D.


GLOBAL WARMING
CLIMATE CHANGE
CFC
NH3
NO
CO
Anthropogenic Sources
Criteria for Analysis
IMPACTS
1. FLOODING
2. DROUGHT
3. LANDSLIDE
4. SOIL EROSION
5. SEA LEVEL RISE
6. COINCIDENCE DAMAGE
THEMATIC MAPS
Rainfall: Decrease by 20 percent, but increase in intensity.
Rainy Days: Decrease rainy days but intensity will be higher than normal.
Typhoon: Increase intensity and occurrence.
Temperature: Increase by 3 % more frequent and persistent El Niño and La Niña episodes, and increased evaporation.
Flooding: Increase flooding depth, frequency, intensity, and severe landslides
Humidity: Upward trend, can alter geographic distribution of pest and diseases
Cloudiness: Increase in total cloud cover, decrease photosynthesis.
Ground Water Potential: Decrease water availability, poor quality, and salt intrusion
Biophysical and Edaphic: erosion, soils, forest fires, land degradation, land cover, geology.
Source: E.C. Godilano, Ph.D.





LANDSLIDE PRONE PROVINCES DURING LA NIÑA EVENTS

69 Provinces

Months	No. of Prov
JAS	7
JAS-OND	23
OND	38
OND-JFM	5
JFM	18

30
66
23


Typhoon Juan, Isabela

Province	Month	Province	Month	Province	Month
Baguio City	JAS	Antique	OND	Biliran	OND + JFM
Ilocos Norte	JAS	Davao Oriental	OND	Catanduanes	OND + JFM
Iloilo	JAS	Dinagat Islands	OND	Agusan del Sur	OND + JFM
La Union	JAS	Eastern Samar	OND	Albay	OND + JFM
Pangasinan	JAS	Iloilo	OND	Agusan del Norte	OND + JFM
Tarlac	JAS	Laguna	OND	Antipolo City	JFM
Zambales	JAS	Lanao del Sur	OND	Agusan del Norte	JFM
Abra	JAS + OND	Leyte	OND	Agusan del Sur	JFM
Aklan	JAS + OND	Marinduque	OND	Albay	JFM
Antique	JAS + OND	Masbate	OND	Biliran	JFM
Apayao	JAS + OND	Misamis Oriental	OND	Catanduanes	JFM
Bataan	JAS + OND	Naga City	OND	Compostela Valley	JFM
Benguet	JAS + OND	Negros Occidental	OND	Davao del Norte	JFM
Cagayan	JAS + OND	Negros Oriental	OND	Davao Oriental	JFM
Capiz	JAS + OND	Northern Samar	OND	Dinagat Islands	JFM
Ifugao	JAS + OND	Quezon	OND	Eastern Samar	JFM
Ilocos Sur	JAS + OND	Rizal	OND	Leyte	JFM
Isabela	JAS + OND	Romblon	OND	Northern Samar	JFM
Kalinga	JAS + OND	Sorsogon	OND	Quezon	JFM
Lanao Del Norte	JAS + OND	Southern Leyte	OND	Sorsogon	JFM
Mindoro Occidental	JAS + OND	Surigao del Norte	OND	Southern Leyte	JFM
Mindoro Oriental	JAS + OND	Surigao del Sur	OND	Surigao del Norte	JFM
Misamis Occidental	JAS + OND	Western Samar	OND	Surigao del Sur	JFM
Mountain Province	JAS + OND	Zamboanga del Norte	OND	Western Samar	JFM
Nueva Ecija	JAS + OND	Zamboanga Sibugay	OND		
Nueva Vizcaya	JAS + OND	Aurora	OND		
Palawan	JAS + OND	Batanes	OND		
Pampanga	JAS + OND	Batangas	OND		
Quirino	JAS + OND	Bukidnon	OND		
Zamboanga del Sur	JAS + OND	Bulacan	OND		
Bohol	OND	Camarines Norte	OND		
Cebu	OND	Camarines Sur	OND		
Compostela Valley	OND	Camiguin	OND		
Davao del Norte	OND	Cavite	OND		

JAS: July- August-Sept
OND: Oct-Nov-December
JFM: Jan-Feb-March

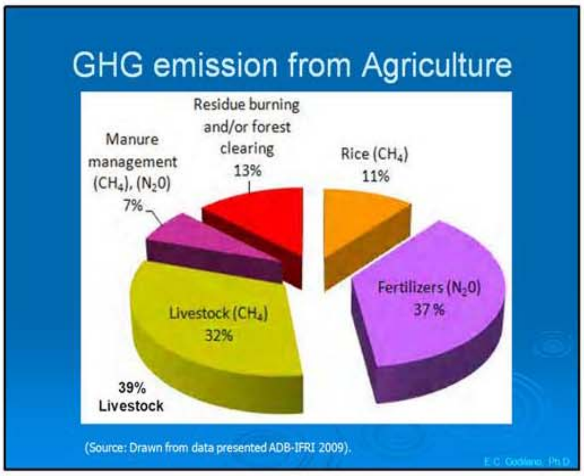
E.C. Godilano, Ph.D

Contribution of ANR

- Carbon dioxide (CO_2) releases linked to deforestation and land use,
- Methane (CH_4) releases from rice cultivation,
- Nitrous oxide (N_2O) releases from fertilizer application,
- Methane releases from enteric fermentation in ruminants

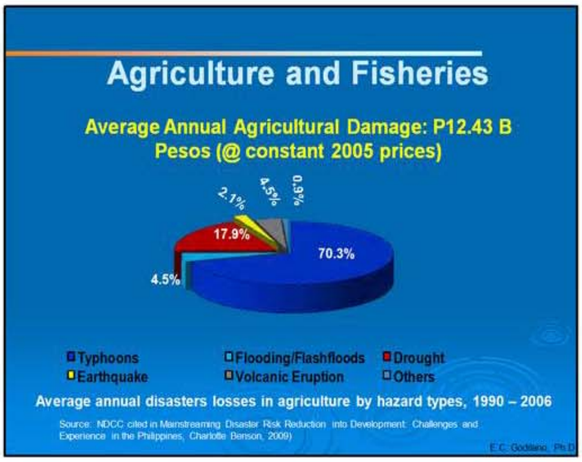
Together, these ANR processes comprise 54% of CH_4 emissions, roughly 80% of N_2O emissions, and almost all CO_2 emissions tied to land use.

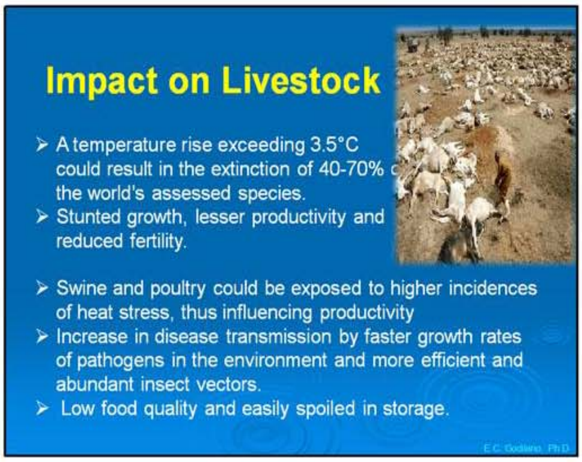
E.C. Godilano, Ph.D

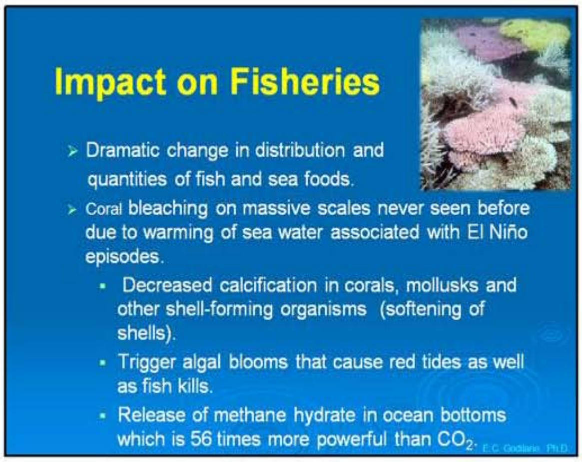


- Changes in yields due to precipitation and temperature extremes.
- Increases in pests and disease; salinization of irrigation water.
- Increase frequency of weather extremes storms/floods/ landslide/droughts).
- Loss of fertile coastal lands caused by rising sea levels and storm surge.
- More unpredictable farming conditions.

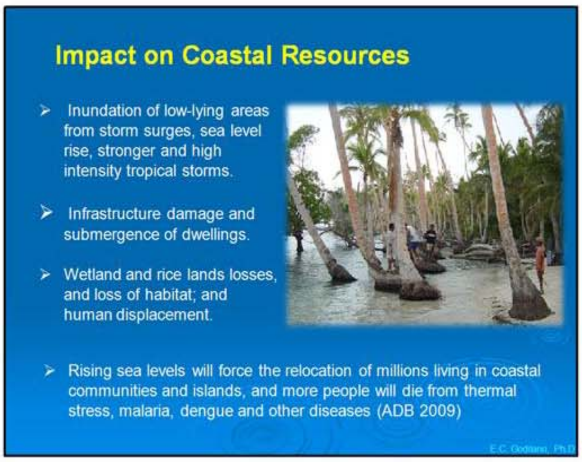
E.C. Godilano, Ph.D

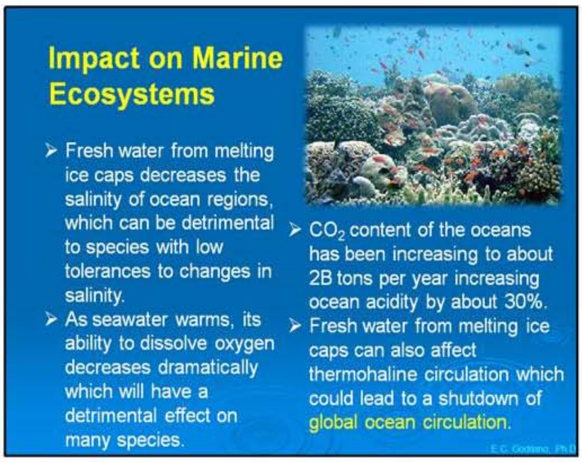

Agriculture and Fisheries
Average Annual Agricultural Damage: P12.43 B Pesos (@ constant 2005 prices)
2.1%
4.5%
0.9%
17.9%
70.3%
4.5%
Typhoons
Flooding/Flashfloods
Drought
Earthquake
Volcanic Eruption
Others
Average annual disasters losses in agriculture by hazard types, 1990 – 2006
Source: NDCC cited in Mainstreaming Disaster Risk Reduction into Development: Challenges and Experience in the Philippines, Charlotte Benson, 2009)
E.C. Godilano, Ph.D


Impact on Livestock
A temperature rise exceeding 3.5°C could result in the extinction of 40-70% of the world's assessed species.
Stunted growth, lesser productivity and reduced fertility.
Swine and poultry could be exposed to higher incidences of heat stress, thus influencing productivity
Increase in disease transmission by faster growth rates of pathogens in the environment and more efficient and abundant insect vectors.
Low food quality and easily spoiled in storage.
E.C. Godilano, Ph.D


Impact on Fisheries
Dramatic change in distribution and quantities of fish and sea foods.
Coral bleaching on massive scales never seen before due to warming of sea water associated with El Niño episodes.
Decreased calcification in corals, mollusks and other shell-forming organisms (softening of shells).
Trigger algal blooms that cause red tides as well as fish kills.
Release of methane hydrate in ocean bottoms which is 56 times more powerful than CO_2.
E.C. Godilano, Ph.D


Impact on Fresh Water
Salinazation of fresh water; water table/aquifer depletion; increased runoff and pollution of freshwater sources, thus affecting the quality of drinking water and impact public health.
Alter the quantity and quality of available fresh water and increase the frequency and duration of floods, droughts, and heavy precipitation events.
E.C. Godilano, Ph.D


Impact on Coastal Resources
Inundation of low-lying areas from storm surges, sea level rise, stronger and high intensity tropical storms.
Infrastructure damage and submergence of dwellings.
Wetland and rice lands losses, and loss of habitat; and human displacement.
Rising sea levels will force the relocation of millions living in coastal communities and islands, and more people will die from thermal stress, malaria, dengue and other diseases (ADB 2009)
E.C. Godilano, Ph.D


Impact on Marine Ecosystems
Fresh water from melting ice caps decreases the salinity of ocean regions, which can be detrimental to species with low tolerances to changes in salinity.
As seawater warms, its ability to dissolve oxygen decreases dramatically which will have a detrimental effect on many species.
CO_2 content of the oceans has been increasing to about 2B tons per year increasing ocean acidity by about 30%.
Fresh water from melting ice caps can also affect thermohaline circulation which could lead to a shutdown of global ocean circulation.
E.C. Godilano, Ph.D

ADAPTATION AND MITIGATION

Laws and Policies Related to Greenhouse gas Mitigation

Let us walk the talk

1. Clean Air Act
2. Clean Water Act
3. Ecological Solid Waste Management Act
4. Agriculture and Fisheries Modernization Act
5. Organic Agriculture Act
6. Indigenous People's Act
7. Coconut Preservation Act
8. Renewable Energy Act
9. Chain Saw Act
10. Fishery Code
11. Water Code
12. Toxic Waste
13. NIPAS Act
14. Mining Act (EO 79)
15. Environmental Impact Systems
16. Pasture Land Act
17. Water Crisis Act
18. Forestry Code
19. Biofuel Act
20. Climate Change Act
21. Disaster Risk Reduction Management Act

Source: E.C. Codilano, Ph.D

Inventory of Greenhouse Gas

- The Philippine Second National Communication on Climate Change (SNC) 2010 headed by Environmental Management Bureau – Department of Environment and Natural Resources (EMB-DENR)

(Emissions Profiles and Trends)

The Philippines' 2000 Greenhouse Gas Inventory

Sector	CO_2, Gg	CH_4, Gg	N_20, Gg	*CO_2e Emission, Gg
Energy	62,499.10	304.14	2.52	69,667.24
Industrial Processes	8,604.74	0.24	--	8,609.78
Agriculture	--	1,209.79	37.41	37,002.69
LUCF	(104,040.29)	(46.28)	(0.32)	(105,111.37)
Waste	--	500.67	3.50	11,599.07
Total	(32,936.45)	1,968.56	34.11	21,767.47

Source: Philippines' Second National Communication on Climate Change (SNC), 2010, EMB/DENR

DA Administrative Order No. 02 Series of 2014

- **Institutionalizing the Animal Relief and Rehabilitation Philippines (ARRPh) of Bureau of Animal Industry (BAI) (signed last March 21, 2014)**

Directs BAI to:

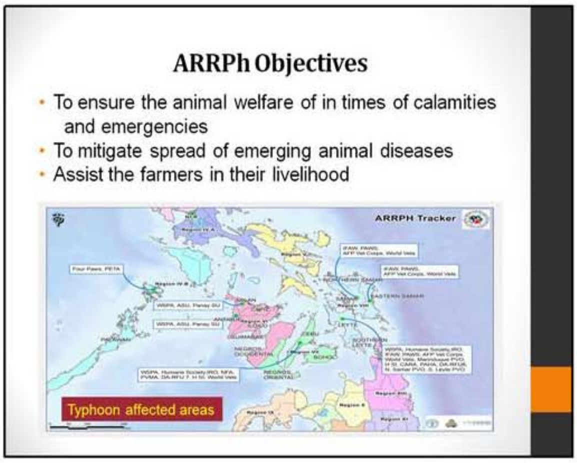
- Convene and coordinate with other livestock agencies, Department of Agriculture Regional Field Offices (DARFOs), non-government and international organizations in providing relief and rehabilitation of animals in times of disasters and emergencies;
- Mobilize resources and rapid assistance in terms of available veterinary medicines (i.e. supplements, vaccines, antibiotics) and supplies needed in the areas affected particularly by typhoon 'Haiyan' (Yolanda) and in future disasters;

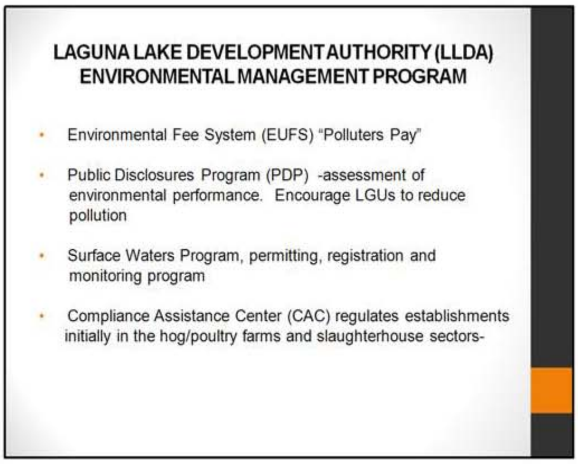
WATER SURGE/WAVES CARRIED BY TYPHOON "YOLANDA"

Government Initiatives/Programs and Policies/Mitigation

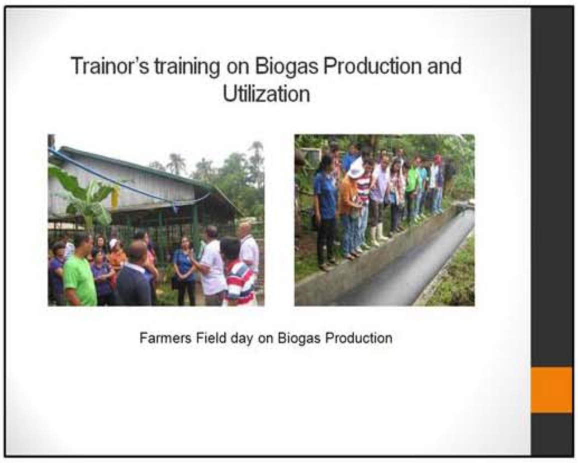
Devastation caused by Typhoon Hayan "Yolanda" to the Philippines (November 2013)


Animal Relief Rehabilitation Philippines (ARRPh)
Activities
• Animal Distribution
• Vaccines/medicines distribution
• Feeds and Veterinary supplies distribution
• Fund transfer to rehabilitate animal houses and facilities
• Transfer of animal to Government Stations
• Establishment of Forage Nurseries


ARRPh Objectives
• To ensure the animal welfare of in times of calamities and emergencies
• To mitigate spread of emerging animal diseases
• Assist the farmers in their livelihood
ARRPH Tracker
Typhoon affected areas


LAGUNA LAKE DEVELOPMENT AUTHORITY (LLDA) ENVIRONMENTAL MANAGEMENT PROGRAM
• Environmental Fee System (EUFS) "Polluters Pay"
• Public Disclosures Program (PDP) -assessment of environmental performance. Encourage LGUs to reduce pollution
• Surface Waters Program, permitting, registration and monitoring program
• Compliance Assistance Center (CAC) regulates establishments initially in the hog/poultry farms and slaughterhouse sectors-


Promotion of different models of digesters suitable to small and medium scale pig enterprise


Trainor's training on Biogas Production and Utilization
Farmers Field day on Biogas Production


VERMICOMPOSTING PROJECT USING BUFFALO MANURE TO REDUCE GhG EMISSION
VERMICOMPOSTING USING BUFFALO MANURE

Development of climate change resilient animals

Promotion and utilization of local materials for housing

Characterization, conservation and commercialization of Philippine Native pigs

Philippine native chicken

RESEARCH AGENDA TO ADDRESS CLIMATE CHANGE

- **Development of heat resistant livestock breed**
- **Deeper understanding on the role of methanogens in livestock production**
- **Revisit crop-animal integration for efficient use of resource and conservation and use of biodiversity**
- **Application of rumen biotechnology to enhance rumen functions but reducing enteric fermentation**
- **Development of suitable livestock housing design**

RESEARCH AGENDA TO ADDRESS CLIMATE CHANGE

- **Improvement of digestibility of both conventional and unconventional feeds**
- **Study on more efficient and economical means of animal waste management**
- **Establishment of climate smart feeding systems**
- **Development of heat resistant grasses and legume varieties as feed sources**

Financing

Land Bank of the Philippines Program of Activities (POA)-Financing of Commercial and Medium Scale Livestock Production and Renewable Source of Energy from Livestock

Needs

- Capacitate the manpower involved in the green house gas inventory
- Policy studies/formulation to provide basis for lawmakers in the country
- Strict implementation of laws

Budget allocation

- For research
- For the implementation of adaptation and mitigation program

THANK YOU

4. Viet Nam Report on GHG in Livestock

La Van Kinh and Nguyen Thanh Van Institute of Animal Sciences for Southern Viet Nam.

REPORT ON GHG IN LIVESTOCK

La Van Kinh[1] *and Nguyen Thanh Van*

Institute of Animal Sciences for Southern Viet Nam

1. Situation of greenhouse gas emissions in Viet Nam

The total area of Viet Nam is 330,972square km; of which 75 % for mountains and only 25% percent of the area is arable (GSO, 2013). The S-shaped country has a north-to-south distance of 1,650 kilometers and is about 50 kilometers wide at the narrowest point. Climate is monsoon tropical climate with annual mean temperature varying from 12.8^{o}C to 27.7^{o}C (Hoang Manh Hoa, 2012), with humidity averaging 84% throughout the year. Total population of the country is 89.7 million (GSO, 2013). According to the World Bank (2013),GDP in Viet Nam was worth 171.39 billion US dollars in 2013, representing 0.28 percent of the world economy.

Viet Nam is an developing country with 70 percent of population living in rural areas and around 50 percent of labor force working in agriculture. However, agriculture development is based on small-scale households, financial resources are scarce, service is underdeveloped, linkage producing with processing and trading is limited, farmers are difficult to access to financial service, there is a little of agro-product benchmark, leading to low competitiveness in agricultural products (Duong Ngoc Thi, 2013).

Greenhouse gas (GHG) emissions from human activities are the primary cause of global warming (IPCC, 2007). Total GHGs released from all sectors in Viet Nam was 103.9 Mt CO_2^{-e} in 1994 and tended to increase by 150.9 Mt CO_2^{-e} in 2000. GHG emissions from agricultural sector accounted for 52.5 Mt CO_2^{-e} in 1994 and tended to increase by 65.1 Mt CO_2^{-e} in 2000.

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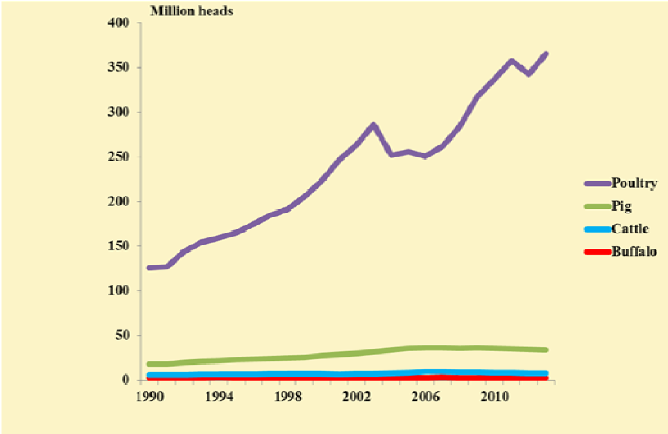
Email: bakinh4@gmail.com

Table 1: Evolution of GHG emission in Viet Nam

Sectors	1994		1998		2000	
	Emission in CO_2^{-e}(million tons)	**%**	**Emission in CO_2^{-e}(million tons)**	**%**	**Emission in CO_2^{-e} (million tons)**	**%**
Energy	25.6	24.7	43.5	35.9	52.8	35
Industrial processes	3.8	3.7	5.6	4.6	10	6.6
LULUCF	19.4	18.7	12.1	10	15.1	10
Agriculture	52.5	50.5	57.4	47.4	65.1	43.1
Waste	2.6	2.4	2.6	2.1	7.9	5.3
Total	103.9	100	121.2	100	150.9	100

Source: UNVN, 2011. Climate Change Factsheets

In 70% of the residence living in rural areas, in which almost 80% of people involved husbandry activity. Livestock production contributed about 26.8% of the output value to GDP of agriculture sector (GSO, 2012), mainly including swine, poultry and cattle. Small-scale householding accounts for about 85% of the cattle, 80% of the poultry population and 75% of pigs (Hoang Kim Giao, 2011). The increase of population and per capita income as well boosted the annual demand for meat, eggs and milk. Furthermore, the orientation of the Vietnamese government for the development of the livestock production promotes strongly the number of animal heads to reach 42% GDP of agricultural output value by 2020. In the other hand livestock sector is one of the major causes of the pressing environmental problems Solid manure was used as valuable organic fertilizer for cultivation; as a result it emitted nitrous oxide (N_2O) to the atmosphere. The slurry (liquid manure) storage emitted mainly methane (CH_4) and nitrous oxide (N_2O), especially in swine industry. These greenhouse gases from livestock production cause potentially global warming effect. Annual volume of manure was estimated approximately 85 million tons, in which there were 30 million tons for cattle, 25 million tons for swine and 23 million tons for poultry. Enteric fermentation and manure management released 8.4 and 4.3Mt CO_2^{-e}per year (table 2), respectively. Methane emission from livestock production was estimated a contribution to 17% (equal to 12.7 Tg CO_2^{e}) of GHG emissions within agriculture sector. Nitrous oxide emission accounts for 19.1 Gg N_2O (equal to 5.93 Tg CO_2^{e}) from solid manure management. In particular, swine production contributed approximately 88% of manure methane production and 45 % of nitrous oxide emission in livestock sector as compared to the other livestock.



Livestock production in Viet Nam from 1990-2013

Table 2: Manure and Methane Release from main livestock in Viet Nam in 2013

Animals	Million heads (2013)	Enteric CH4 production (ton/year)*	Total manure (million tons/year)	Manure CH4 production (ton/year)*
Cattle	5.16	227,040	18.8	10,320
Buffalo	2.56	140,800	14.0	7,680
Pig	26.26	26,260	24.0	183,820
Poultry	313.8	0	22.9	7,217
Goat, sheep	1.43	7,150	0.78	314.6
Total	**8.426 Mt CO_2^{-e}**		80.5 (> 20 Mt DM)	**4.396 Mt CO_2^{-e}**

Source: *Data Estimation based on IPCC (1996)

Governmental policies to mitigate greenhouse gas emissions

With many policies relating climate change and greenhouse gases from Vietnamese government, Ministry of Agriculture and Rural Development (MARD) approved program of Greenhouse gas emissions reduction in the agriculture sector up to 2020 through Decision No. 3119/QD-BNN-KHCN dated 16 December 2011. This commitment aims to reduce emissions by 20% (18.87 million ton CO_2^{-e}) and simultaneously ensure the growth target of agriculture and rural development, and reduce the poverty rate by 2020.In particularly, GHG emissions from livestock sector will reduce 6.30 million ton of CO_2^{e} (equivalent to 25.84%of total forecasted GHG emission in the livestock sector up to2020), the following main activities should be implemented such as changing diet (reducing 0.91 CO_2^{-e}, ~ 3.7%), molasses urea block supplementation to dairy cow (reducing 0,37 CO_2^{-e}, ~1.5%), animal waste management and renewable energy production from biogas (reducing 1,46 CO_2^{-e}, ~ 5.9%), anaerobic fermentation of animal waste (reducing 3.56 CO_2^{-e}, ~14,6%) and other methods (VietGAP application, converting roughage to concentrate, quality improvement of silage ; enhancing animal immunity, using probiotic and improving collection, storage/ treatment system of animal waste).

Advantages of policies to GHG emission mitigation

Viet Nam is a developing country which not required to cut absolute GHG emissions by Kyoto protocol. Policies of reducing GHG emissions should be suitable to capability of the country in its stage of development. It is necessary to implement comprehensively national studies.

GHG reduction policies as commitment of the country would encourage investment in the related areas (such as renewable energy development, selection of high technologies).

Develop bilateral and multilateral cooperation with various international stakeholders and actively participate in regional and international forum, alliance and network of GHG emission reduction in the sector. GHG mitigation commitment at suitable level would draw attention of international communities, bringing about their technical assistance and financial support.

Seek the international donors to develop carbon credit market, connect domestic carbon into international carbon market through CDM.

GHG mitigation policies will promote efficient livestock production through feed efficiency, productivity, reduction of environmental pollution and development of biogas energy.

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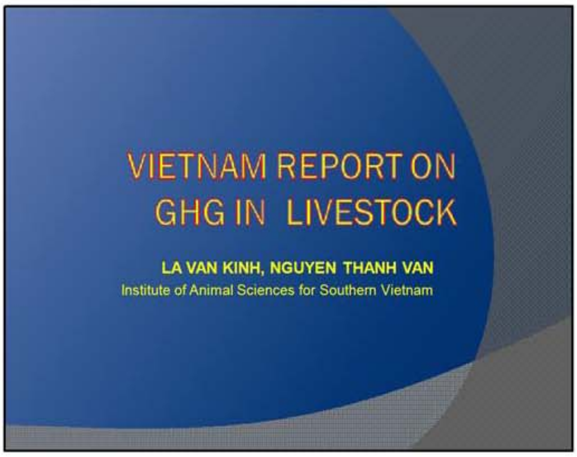
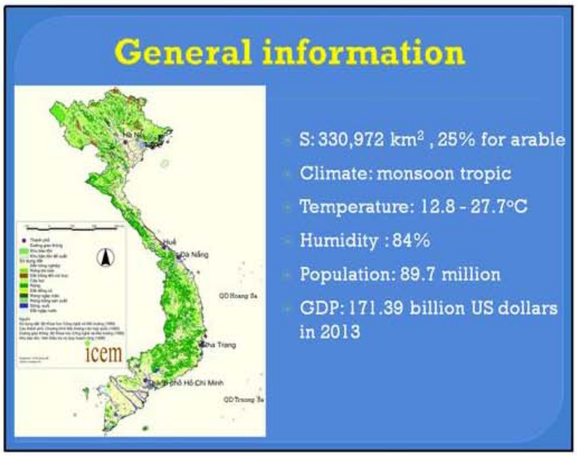
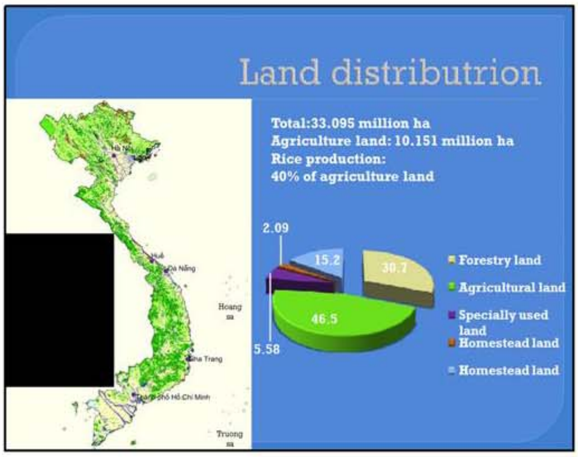
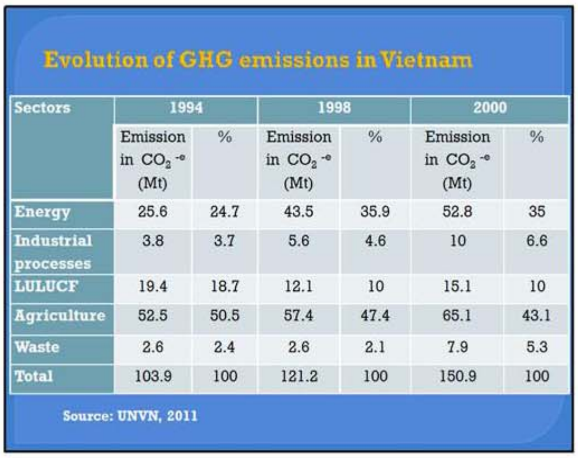




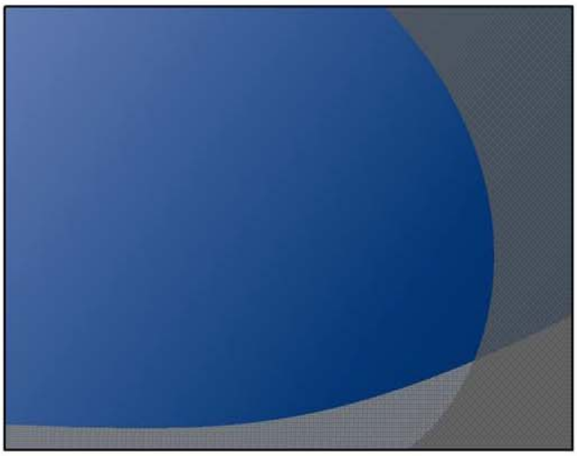


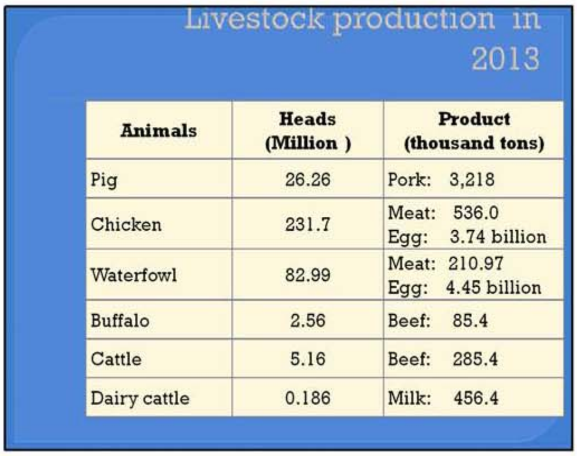


Evolution of GHG emissions in Vietnam

Sectors	1994		1998		2000	
	Emission in CO_2-e (Mt)	%	Emission in CO_2-e (Mt)	%	Emission in CO_2-e (Mt)	%
Energy	25.6	24.7	43.5	35.9	52.8	35
Industrial processes	3.8	3.7	5.6	4.6	10	6.6
LULUCF	19.4	18.7	12.1	10	15.1	10
Agriculture	52.5	50.5	57.4	47.4	65.1	43.1
Waste	2.6	2.4	2.6	2.1	7.9	5.3
Total	103.9	100	121.2	100	150.9	100

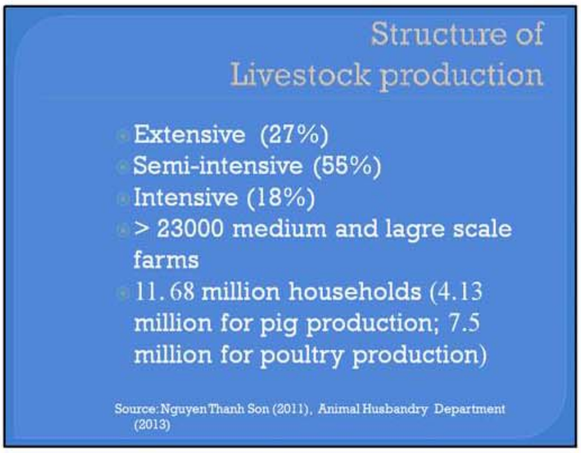
Source: UNVN, 2011





Livestock production in 2013

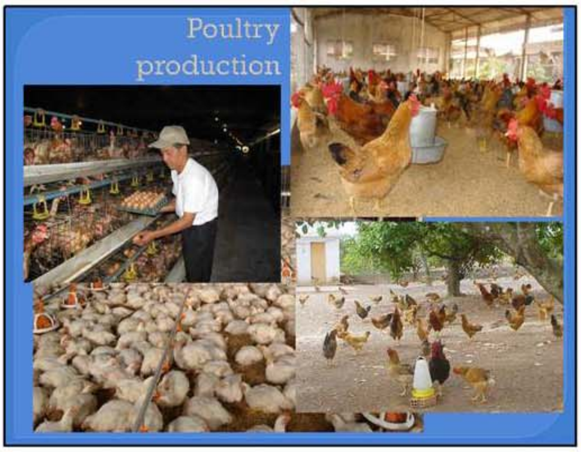
Animals	Heads (Million)	Product (thousand tons)
Pig	26.26	Pork: 3,218
Chicken	231.7	Meat: 536.0 Egg: 3.74 billion
Waterfowl	82.99	Meat: 210.97 Egg: 4.45 billion
Buffalo	2.56	Beef: 85.4
Cattle	5.16	Beef: 285.4
Dairy cattle	0.186	Milk: 456.4


Structure of
Livestock production
Extensive (27%)
Semi-intensive (55%)
Intensive (18%)
> 23000 medium and lagre scale farms
11. 68 million households (4.13 million for pig production; 7.5 million for poultry production)
Source: Nguyen Thanh Son (2011), Animal Husbandry Department (2013)

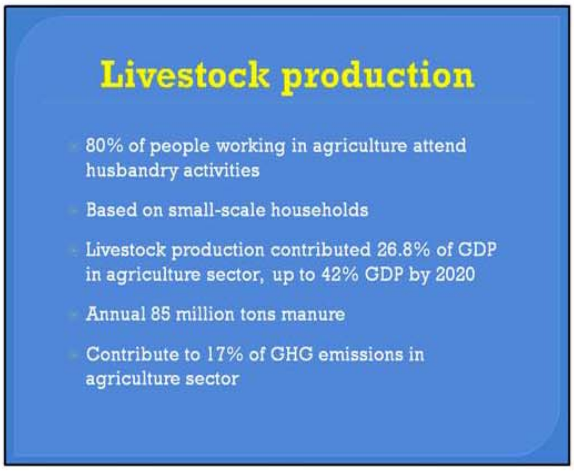

Grazing


Cattle
production

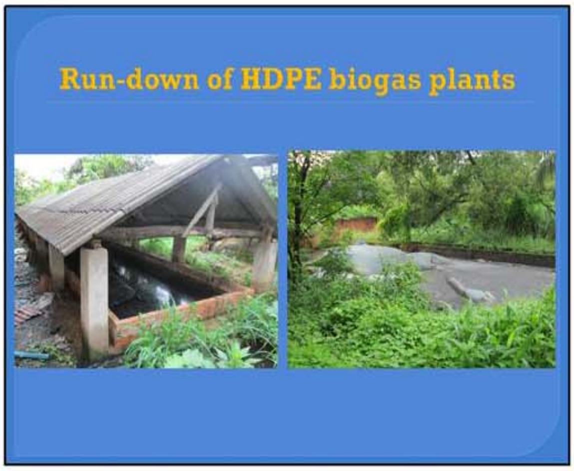

Pig production


Poultry
production


Duck
production


Livestock production
80% of people working in agriculture attend husbandry activities
Based on small-scale households
Livestock production contributed 26.8% of GDP in agriculture sector, up to 42% GDP by 2020
Annual 85 million tons manure
Contribute to 17% of GHG emissions in agriculture sector


Slurry released to the environment
Flushing


Run-down of HDPE biogas plants


Few biogas plants are running


The effluent was stored in pond


Manure for fertilizing or selling

Manure and methane released in 2013

Animals	Million heads (2013)	Enteric CH_4 production (ton/year)*	Total manure (million tons/year)	Manure CH_4 production (ton/year)*
Cattle	5.16	227,040	18.8	10,320
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Pig	26.26	26,260	24.0	183,820
Poultry	313.8	0	22.9	7,217
Goat, sheep	1.43	7,150	0.78	314.6
Total		**8.426 Mt CO_2-e**	**80.5 (> 20 Mt DM)**	**4.396 Mt CO_2-e**

Source: *Data Estimation based on IPCC (1996)

Project of GHG mitigation of Livestock section by 2020

Objective: reducing 6.30Mt CO_2e of (25.8% of estimated GHG emissions in agriculture sector by 2020)

- 1. Changing diet: ↓0.91 Mt CO_2-e (~ 3.7%)
- 2. Molasses Urea Block supplementation to dairy cow : ↓0,37 Mt CO_2-e (~1.5%)
- *3.* Animal waste management and renewable engergy production from biogas: ↓ 1.46 Mt CO_2-e (~ 5.9%)

Project of GHG mitigation of Livestock section by 2020

- *4.* Anaerobic fermentation of aminal waste: ↓ 3.56 Mt CO_2-e (~14.6%)
- *Other methods:*
  - VietGAP application
  - Converting roughage to concentrate, quality improvement of silage
  - Enhancing animal immunity
  - Using probiotic
  - Improving collection, storage/ treatment system of animal waste

Advantages of policies

- Encourage to implement comprehensively national studies
- Encourage investment in renewable energy development, selection of high technologies
- Develop international cooperation, actively participate in international networks
- Seek the international donors to develop carbon credit market
- Promote efficient production, in particularly livestock production

Thank you for your attention

5. Indonesian GHG for Agriculture Sector

RA Yeni Widiawati Indonesian Research Institute for Animal Production, IRIAP, IAARD
Ani Susilawati. Swamp Land Agricultural Research Center, IAARD

COUNTRY REPORT : INDONESIA

Yeni Widiawati and Ani Susilawati

Scientific Workshop
Measurement and Mitigation of Greenhouse Gases in Livestock Systems for Green Production and Environment
of APEC Members,
Bangkok, 2 - 4 December 2014

Indonesia consists of an archipelago located in South East Asia. The area of Indonesia is 190 million ha with five large islands and more than 13,000 small islands. Only 7% of the island in Indonesia are permanently inhabited. The current population is252 million, projected to grow to over 300 million by 2030. Gross domestic product (GDP) is approximatelyUS$175 billion, with a growth rate of 6.3% in 2007.

Indonesia has a rich forest resource which is however subject to heavy degradation and deforestation due to the the forest conversion for establishment of agriculture plantation, transmigration areas, and establishment of new districts, development of new rice fields, and large-scale mining activities. The area of agricultural land has increased dramatically, particularly due to the high growth of palm oil plantations. The rapid increase in the palm oil plantations is driven by the demand increase in the domestic and international markets, including the demand for bio-diesel. To secure rice production in the future, Indonesia also plans to have 15 million ha of land permanently allocated as cropland.

In line with the country’s economic and population growth, final energy consumption has been growing by about 3% per year since the year 2000. The share of total energy consumption by sector in 2008 is industry 48%, transportation 31%, households 13%, commercial 4%, and agriculture, construction and mining (ACM) 5 %.

Indonesia’s GHG emissions

Based on the GHG inventory, the total Indonesian emissionGHG emissions in 2000 for the three main greenhouse gases without LUCF reached 556 MtCO2-eq. With the incusion of LUCF, total net GHG emission from Indonesia increase significantly to abot 1,377,753 GgCO2e. The proporsion of contributors fromeach sector withinclusion of LUCF are from peat fire is 13%, waste 11%, energy 20%, industry 3%, agriculture 6% and land use change and forestry 47%. When estimated was made without LUCF, the contribution of each are waste 28.3%; energy 50.5%, industry 7.7% and agriculture 13.6%. The Indonesian emission profie is presented in table 1.

Within the agricultural sectors, the contribution from livestock is about 19.4% below the contribution from rice cultivation that accounted for about 46.2%. The rest are comming from N_2O from managed soil 28%, urea fertiliser 2.6%, liming 0.3%, grassland burning 1.6% and cropland biomass burning 1.8%.

Table1. Indonesian emission profile based on GHG inventory

NO	SECTOR	GgCO2e
1	Energy	280,938
2	Industry	42,814
3	Agriculture	75,420
4	Land use Change and Forestry (excl.peat fire)	649,254
5	Peat Fire	172,000
6	Waste	157,328
	REMOVAL	**556,449**
	Nett Emission	**1,377,753**

Agriculture and Climate Change

Related to the climate change, the agriculture sector is stand on two sides, as a victime as well as a contributor. Although the agricultural sectors contribute to the GHG and climate, change, this sectors also facing the increasing in the vulnerability to the climate change. The impacts of climate change on agriculture are expected to be substantial on1) natural resource base, livelihoods, economy; 2) lack of plans for resource management strategies; 3) public and private investments; 4) policy changes; and 5) future capacity to respond to changes climatevariabilityversus climatechange.

For livestock sector, the climate change can also influence animal physiology. High temperatures cause a decrease in feed intake and production efficiency of animals. Higher temperatures can affect the quality and quantity of forage from grasslands and other food supplies. Furthermore, it was found that climate change tended to restrict livestock productivity (e.g. reducing milk production) through both declining forage quality and increased ambient temperature.Some diseases also rise on the higher temperature, which affect the animal’s health.

Projection of Indonesia net emission

In year 2000 the Indonesian net emission was accounted for about 1,38 Ggton CO_2e and projected increased up to 2,95 Ggton CO_2e in year 2020. The agriculture sector was projected will increased from 0.05 Ggton CO_2e to become 0.06 Ggton CO_2e. While there will be a reduction on foresty sector for about 0.43 Ggton CO_2e in year 2000 to 0.29Ggton CO_2e in year 2005 and decreades to 0.13 Ggton CO_2e in year 2020.

Recognizing the domestic and international importance of its tropical landscape and the people in it, the Indonesian government has made encouraging decisions; it has voluntarily committed to a minimum 26% reduction in greenhouse gas emissions by 2020 and developed a strategy for land use and forestry emissions, extended a moratorium on new clearing of primary forests and peat lands from 2 to 4 years (2013-2015). Indonesia must balance these environmental and social goals with a rapidly growing economy based on natural resources and corporate interests.As President Susilo BambangYudhoyono issued in year 2009 that a decree to reduce greenhouse gas emissions by 26% by 2020, and up to 41% if developed countries provided finance or other support. The legal basis of action are based on Presidential Decree No. 61/2011 on National Action Plan for Reducing GHG Emission and Presidential Decree No. 71/2011 onNational GHG Inventory

In Liverstock sector, since the application of mitigation technologies through better feeding management on year 2011, the emission was started to decreases since year 2012 and it is projected to decrease up to 5.29 million ton CO_2e in year 2020 or for about 15% of BAU baseline.

National Emission Reduction Plan

Some actions have been planned to reduce the emission from many sectors. In forestry and peatland some activities planned are land and forest fires control, water resources and system management; forest and land rehabilitation, industrial plantation forest/HTI, communal forest/HR, illegal logging eradication, deforestation prevention, and community empowerment. The reduction targeted is about 0.672 Ggtonnes CO_2e or up to 1.039 Ggtonnes CO_2e if developed countries support for financial. In agricultural sector in year 2020 it is targeted to reduced up to 0.008 Ggtonnes CO_2e or up to 0.011 Ggtonnes CO_2e if there is a financial supporting. Some actions planned are introduction of low emission rice variety, efficiency of water irrigation, organic fertilizer utilization, animal's breeding selection, mitigation technologies trought better feeding and manure management. Application of 3R strategy of waste management and integrated waste management in urban areas are the action planned to reduced emission from waste up to 0.078 Ggtonnes CO_2e with supporting financial from developed countries.

In particular for livestock sector, there are three major action planned in facing the climate change and also in reducing the emission. The first action is adaptation through animal's breed selection and using local feedstuff as main feed sources. The second action is application of mitigations technologies founded in particular through feeding management by applied balance nutrients in daily rations, feed additives such as tannin, saponin and probiotics from local plants, and feed processing for low qualit feed. Other action planned is manure management by using the manure for bio-energy through biogas system and also organic fertilizer by using good composting process. Those actions has been started since year 2011 and need to be developed for many regions in Indonesia in order to reach the target on emission reduction in year 2020.

Greenhouse gasses measurement methods

Indonesia still use the default factor from IPCC in estimating the national emission and following the instruction on the Guidline book of IPCC 2006. However, Indonesia has also developed some measurement techniques to directly measure the emission. In paddy sector, field measurement equipments such asan automatic chamber for measuring CH_4,CO_2 and N_2O and a laboratory wiht Shimadzu GC 8A for measuringCH_4 and Shimadzu GC 2014 for analyzing CH4, CO_2 and N_2Ohave been built. Similar equipments also provided for emission measurement in palm oil plantation. In livestock sector, a laboratory has been built with automatic head box chamber connected to CH_4, CO_2 and O_2 analyzer from Seable that automatically measured for 24 hours. There is also an equipment that prepared for measurement in the field by using portable headbox chamber and portable GC from Agilent.

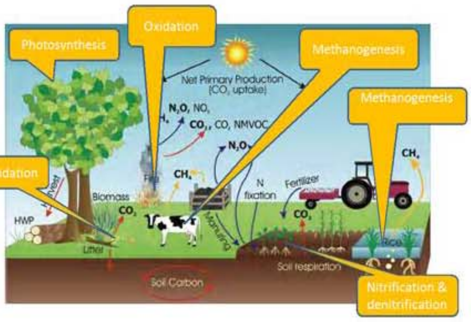
Indonesian GHG for Agriculture Sector

Scientific Workshop on Measurement and Mitigation of Greenhouse Gases in Livestock Systems for Green Production and Environment of APEC Members

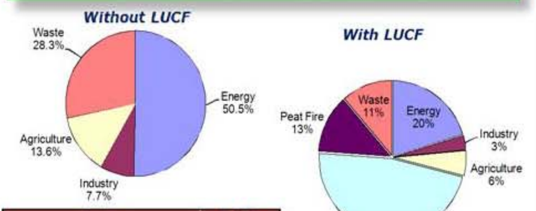
Introduction

- Changes due to land use change and management of the biosphere have a significant influence on the greenhouse gas concentrations in the atmosphere.
- Processes accounting for emissions and removals in the biosphere are: photosynthesis, respiration, decomposition, nitrification/de-nitrification, enteric fermentation, and combustion that are driven by the biological activity and physical processes.
- Agriculture and land-use emissions and removals account for a very significant proportion of GHG emissions/removals in developing countries.

Terrestrial sources/sinks of GHGs



Indonesian Emission Profile



Sector	Gg CO2e
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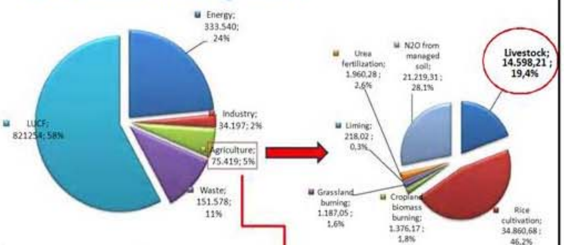
Agriculture	75,420
Land Use Change and Forestry (excl. peat fire)	649,254
Peat Fire	172,000
Waste	157,328
Removal	**556,449**
NETT EMISSION	**1,377,753**

2000 INDONESIA'S GHG INVENTORY

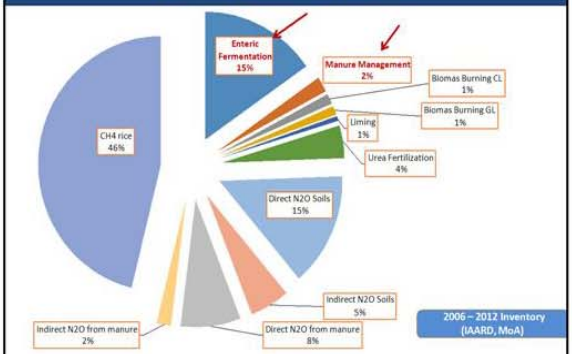
GHG Emission from Agriculture

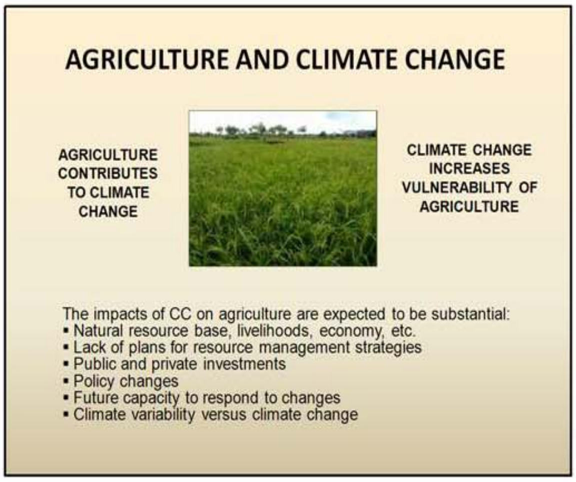


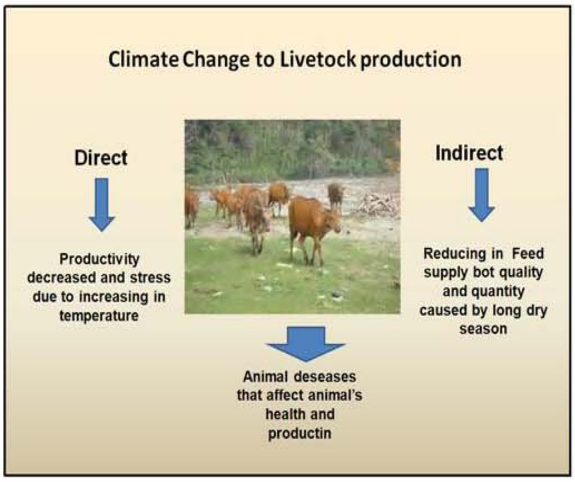
Sumber : SNC 2009

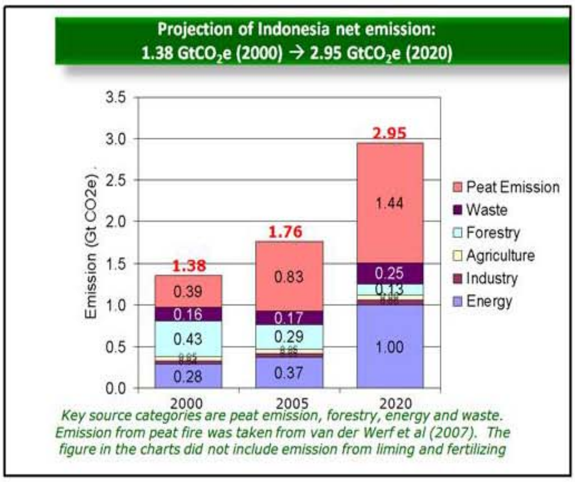
Gas	2000	2001	2002	2003	2004	2005
CO_2	2,178	3,232	3,215	3,457	3,692	3,837
CH_4	50,800	50,677	50,833	52,547	49,342	50,670
N_2O	22,441	23,592	22,982	23,825	24,828	25,672
Total	75,420	77,501	77,030	79,829	77,863	80,179

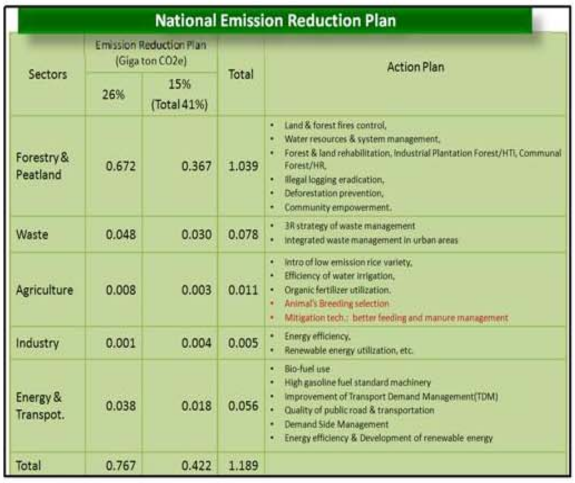
Agriculture emission 2012



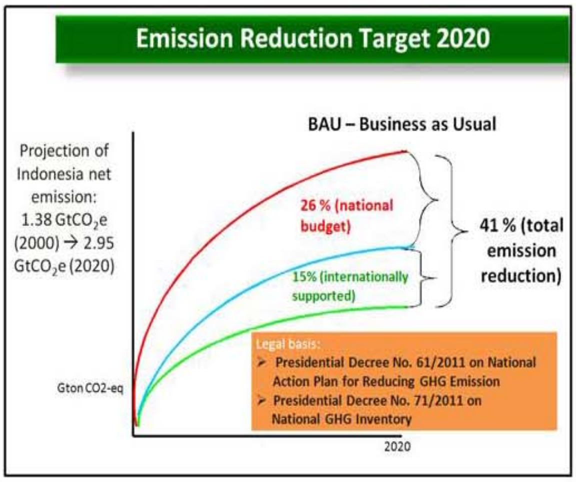


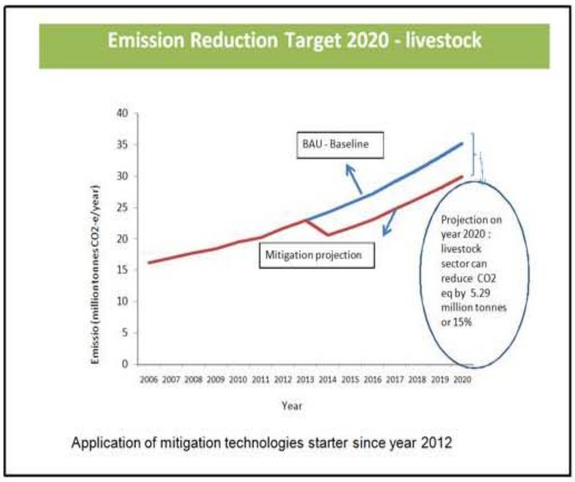


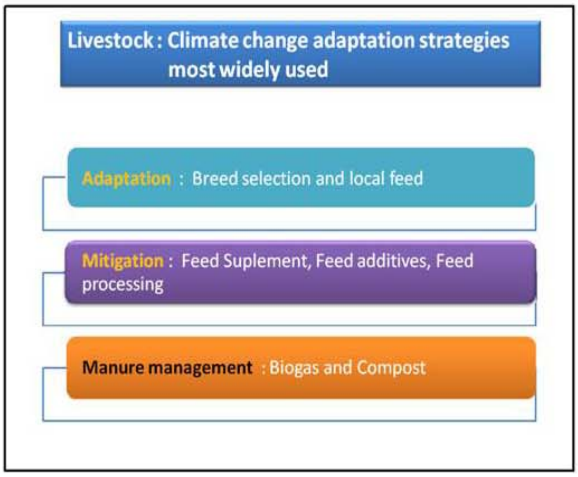


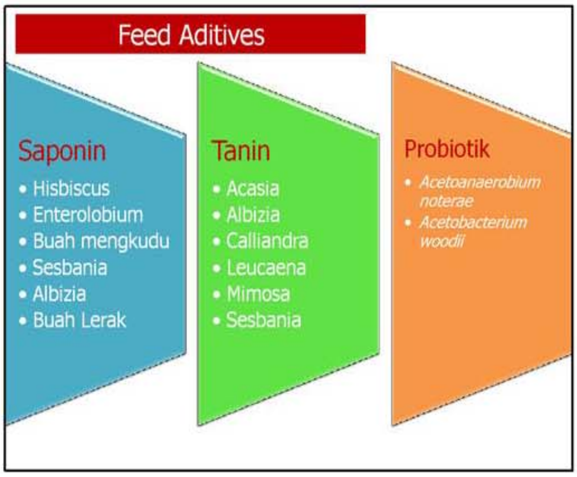

National Emission Reduction Plan

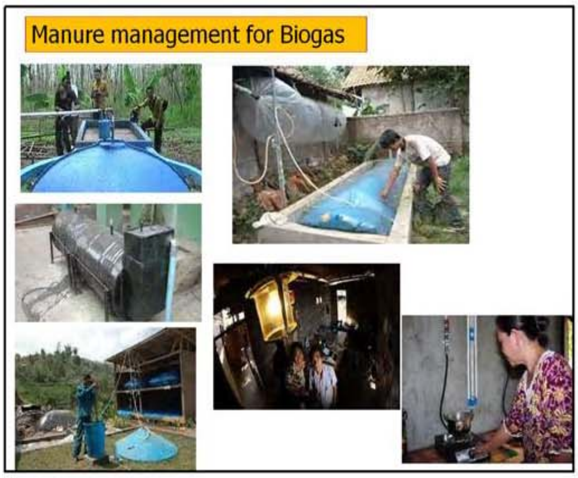
Sectors	Emission Reduction Plan (Giga ton CO2e) 26%	15% (Total 41%)	Total	Action Plan
Forestry & Peatland	0.672	0.367	1.039	• Land & forest fires control, • Water resources & system management, • Forest & land rehabilitation, Industrial Plantation Forest/HTI, Communal Forest/HR, • Illegal logging eradication, • Deforestation prevention, • Community empowerment.
Waste	0.048	0.030	0.078	• 3R strategy of waste management • Integrated waste management in urban areas
Agriculture	0.008	0.003	0.011	• Intro of low emission rice variety, • Efficiency of water irrigation, • Organic fertilizer utilization. • Animal's Breeding selection • Mitigation tech.: better feeding and manure management
Industry	0.001	0.004	0.005	• Energy efficiency, • Renewable energy utilization, etc.
Energy & Transpot.	0.038	0.018	0.056	• Bio-fuel use • High gasoline fuel standard machinery • Improvement of Transport Demand Management(TDM) • Quality of public road & transportation • Demand Side Management • Energy efficiency & Development of renewable energy
Total	0.767	0.422	1.189	

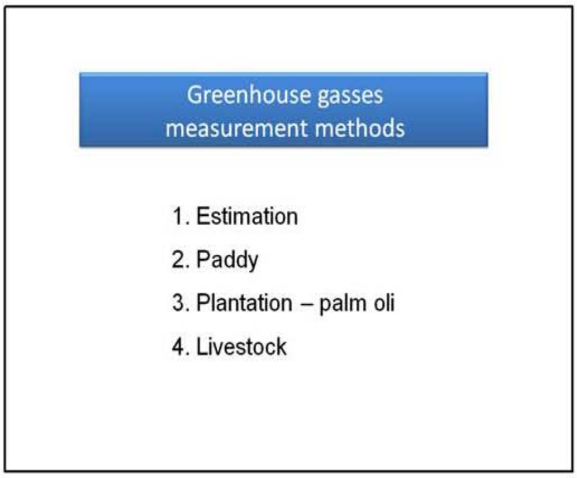


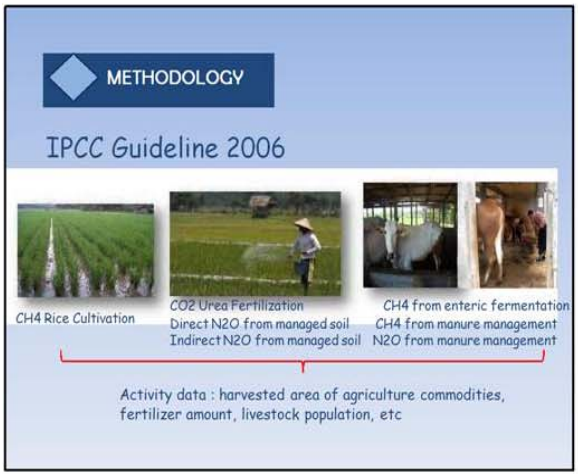


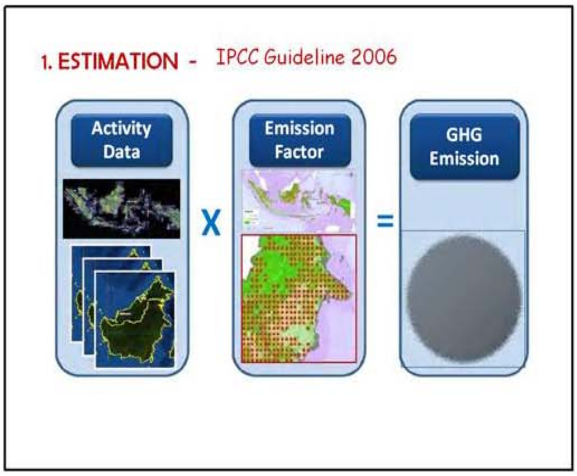

Livestock : Climate change adaptation strategies most widely used
Adaptation : Breed selection and local feed
Mitigation : Feed Suplement, Feed additives, Feed processing
Manure management : Biogas and Compost

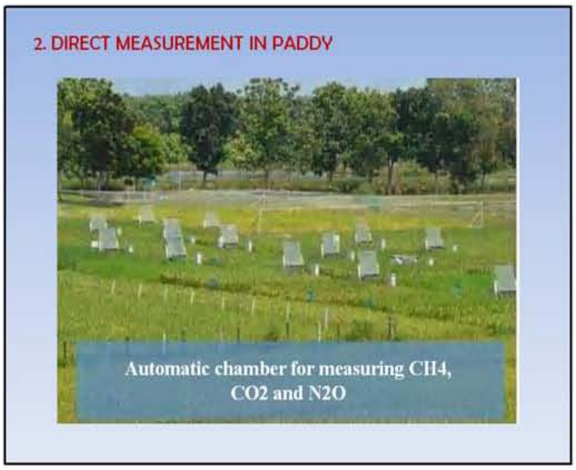

Feed Aditives
Saponin
• Hisbiscus
• Enterolobium
• Buah mengkudu
• Sesbania
• Albizia
• Buah Lerak
Tanin
• Acasia
• Albizia
• Calliandra
• Leucaena
• Mimosa
• Sesbania
Probiotik
• Acetoanaerobium noterae
• Acetobacterium woodii


Manure management for Biogas


Greenhouse gasses measurement methods
1. Estimation
2. Paddy
3. Plantation – palm oli
4. Livestock


METHODOLOGY
IPCC Guideline 2006
CH4 Rice Cultivation
CO2 Urea Fertilization
Direct N2O from managed soil
Indirect N2O from managed soil
CH4 from enteric fermentation
CH4 from manure management
N2O from manure management
Activity data : harvested area of agriculture commodities, fertilizer amount, livestock population, etc

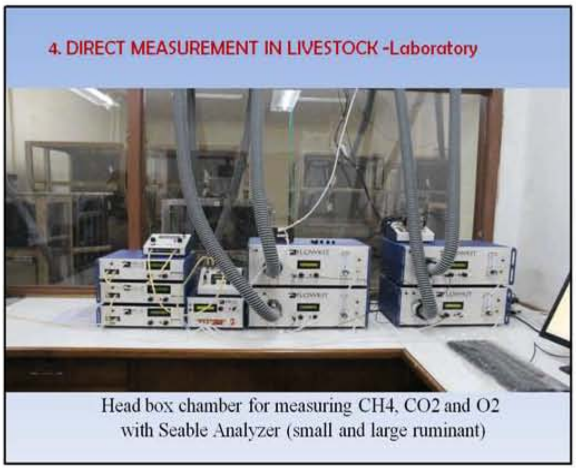

1. ESTIMATION - IPCC Guideline 2006
Activity Data
X
Emission Factor
=
GHG Emission


2. DIRECT MEASUREMENT IN PADDY
Automatic chamber for measuring CH4, CO2 and N2O


Shimadzu GC 8A for measuring CH4
Shimadzu GC 2014 for analyzing CH4, CO2 and N2O


GHG Laboratory


3. DIRECT MEASUREMENT IN PALM OIL
chamber for measuring CH4, CO2 and N2O


4. DIRECT MEASUREMENT IN LIVESTOCK -Laboratory
Head box chamber for measuring CH4, CO2 and O2 with Seable Analyzer (small and large ruminant)


4. DIRECT MEASUREMENT IN LIVESTOCK - Field
Head box chamber for measuring CH4 – large ruminant
Agilent GC for CH4

6. Country's Report

Mario A. Cobos Peralta. Colegio de Postgraduados in Agricultural Sciences, COLPOS Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food of Mexico (SAGARPA) cobos@colpos.mx

MEXICO COUNTRY REPORT

Climate change in livestock: vulnerability, adaptation strategies, and other aspects

Mario A. Cobos Peralta

Graduate College in Agricultural Sciences of Mexico (COLPOS)

Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food of Mexico (SAGARPA)

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In 2013, Mexico's cattle stocks was forecast to continue their downward trend as the industry has been hit by drought, high feed prices, and large live cattle export numbers. In comparison to the crop production, livestock accounts for 30 percent of Mexico's agricultural output. On average, livestock or livestock products produced in greatest number were milk (8.96 billion liters), poultry (1.72 billion tons), eggs (1.63 billion tons), and beef (1.39 billion tons). Mexico is not self-sufficient in the production of meat.

Within the livestock sector, methane from enteric fermentation is the most significant source of greenhouse gas (GHG) emissions and the most significant source of emissions from the ruminant sector. Of the total methane emissions from livestock in México for the period 1990-2002, 89 % came from beef cattle(31.5 million head), 10% from dairy cattle (2.1 million) and 1% from other livestock. These emissions represent 88 % of total livestock related emissions, the remaining 12 % came from manure management.

Particular climate change vulnerabilities of economy and how these affect livestock productivity and food security

Accroding with the Third National Communication the following climatic changes with relevance to the agricultural sector can be expected in Mexico:

a) Increases in temperature.- by 2020 projected temperature increases in the winter are between 0 and 2.5^{o}C 2.5^{o} and in the summer are in the range of 0.9 and 2.2 ^{o}C.

b) Reduction in precipitation. The rainfall will decrease by up to 15% in the Central part and by less than 5% in the area of the Golf of Mexico.

c) Increased frequency and intensity of extreme weather events. The number of severe storms and the intensity of periods of severe drought will also increase. The seawater temperature will increase between 1 and 2 C leading to stronger and more intense tropical hurricanes in the Golf of Mexico and the Mexican portion of the Pacific Ocean, the cold fronts may become less frequent.

According to the World Bank, México is one of the most vulnerable countries to the global climate Change: 68 % of its population, 71 % of its economy and 15 % of its territory are exposed to the negative effects related with the Climate Change. The animal husbandry productivity is under different risk in different areas. The whole industry is vulnerable and the capacity to adapt to climate change is poor.

Climate change adaptation strategies most widely used and how/why these have been selected

a) Rehabilitation of grazing and rangelands - rehabilitate 450,000 ha of grazing and rangelands through the Program for Support Cattle Production (PROGAN, Spanish acronym).

b) Reduction of methane emissions by introduction of alternative technologies for ruminant's production.

c) Adequate management of manure in 1,200 farms (building of biodigesters), (FIRCO).

d) The National Greenhouse Gas Emissions Inventory (INECC), it is very helpful to estimate the effects of different strategies on emissions by sources and sinks for the period 1990-2006. It is made according to the provisions of Articles 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC).

e) The Ministry of Agriculture (SAGARPA, Spanish acronym), through its different public institutions, is responsible for specific response actions (programs and research) related to climate change aspects in livestock, manure management and land use, as well as the assessment of vulnerabilities to climate change and work pertaining toinnovation and technology Among these institutions are: Colegio de Postgraduados en Ciencias Agrícolas (COLPOS), Instituto Nacional de Investigación Forestal, Agricola y Pecuaria (INIFAP),CoordinaciónNacional de las Fundaciones Produce (COFUPRO), and Fideicomiso de Riesgo Compartido (FIRCO).

f) Involving or participating in international research groups on climate change, for example the Livestock Research Gropu of the Global research Alliance.

g) The final aim is reducing methane emissions 30% by 2020.

Which of these strategies have been proven to have mitigation potential, and benefits obtained from these strategies

a) Manure management by its treatment in biodigester.

b) Rehabilitation of grazing and ranglands.

c) Building capabilities of students and researchers on methods to reduce methane emissions from enteric fermentation, and manure management using biodigester technologies.

Greenhouse gasses measurement method using in each economy

Mexico is the only developing country to have submitted three national communications to the United Nations Framework Convention on Climate Change (UNFCCC), indicating strong commitment by the government for addressing climate change across sectors. Agriculture contributes little, in relative terms, to total GHG emissions and the emission reduction potential in the sector is small and primarily focused on methane reduction, though more diversified carbon trading opportunities can be pursued.

Modeling climate scenarios and impacts by different institutions or research centers including: the Centro Mario Molina, the National Institute of Ecology and Climate Change (INECC), and in the Center for Atmospheric Sciences in the Universidad Nacional Autónoma de Mexico (UNAM).

Financing options

a) National Council of Science and Technology (CONACYT, Spanish acronym). This council grants Mexican researchers, but not always related with mitigation of GHG from the livestock sector or adaptation to climate change.

b) The Clean Development Mechanism (CDM). The projects supported by CDM are addressed to reduce GHG through best manure management practices. In 2009 there were 110 registered projects in México representing 28 % of all registered projects in Latin America.

c) The Graduate College in Agricultural Science (COLPOS)has a limited budget to support projects related with microbiology alternatives to decrease methane emissions from enteric fermentation in ruminants.

d) The National Institute of Forestry, Agriculture and Livestock Research (INIFAP)have a limited budget to support projects related with manure management alternatives to decrease greenhouse gases emissions.

SAGARPA
SECRETARÍA DE AGRICULTURA, GANADERÍA, DESARROLLO RURAL, PESCA Y ALIMENTACIÓN

Department of Livestock Development

APEC
Asia-Pacific Economic Cooperation

Scientific Workshop on measurement and mitigation of greenhouse gases in livestock systems for green production and environment of APEC members

Country Report
MÉXICO

Mario A. Cobos Peralta
Colegio de Postgraduados in Agricultural Sciences, COLPOS
Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food of Mexico (SAGARPA)
cobos@colpos.mx

Bangkok, Thailand, December 2-4, 2014

Ruminants production in Mexico


30 million of beef cattle


2.3 million of dairy cattle

- More than one-third of the total land area is suitable for pasture and livestock production in Mexico.
- In 2010, the livestock population was estimated at 32.3 million head of cattle, 9 million goats, and 6.4 million sheep.
- Output of livestock products in 2013 were: 8.96 billion L of cows' milk, 1.72 billion t of poultry, 1.63 billion t of eggs, 1.39 billion t of beef and veal, and 1.4 million L of goats' milk.
- Mexico is not self-sufficient in the production of meat and milk.

Mexico and Climate Change Vulnerability

With relevance to the agricultural sector it can be expected:

- Increases in temperature, by 2020 it is projected temperature increases:
  - in the winter: 0 and 2.5°C
  - in the summer: 0.9 and 2.2°C.
- Reduction in precipitation. The rainfall will decrease by up to 15% in the Central part, and by less than 5% in the area of the Golf of Mexico.
- Increases frequency and intensity of extreme weather events.
  - The number of severe storms, and
  - the intensity of periods of severe drought.
- More intense tropical hurricanes in the Golf of Mexico and the Mexican portion of the Pacific Ocean.

Mexico and Climate Change Vulnerability

- According with the World Bank (2011), Mexico is one of the most vulnerable countries to the Global Climate Change:
- 68 % of its population, 71% of its economy, and 15% of its territory are exposed to the negative effects related with the climate change.

The animal husbandry productivity is under different risk in different areas (Mexico has a temperate, tropical and semi-arid climates).

The whole industry is vulnerable and the present capacity for adaption to climate change is poor.


Severe drought in Balancán Tabasco, Golf of Mexico. Tropical climate


Severe flooding in Tepatitlán, Jalisco, Central Mexico. Temperate climate

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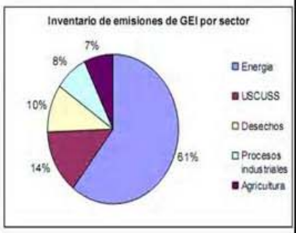
Climate change adaptation strategies most widely used and how/why these have been selected

According to the National Inventory of GHG (INEGI, SEMARNAP)
Between 1990 a 2002.

The agriculture sector was responsible of 7% of the GHG emitted.

84% as methane (CH_4)
16% nitrous oxides (N_2O)



Livestock sector: methane from enteric fermentation is the most significant source of GHG emissions.
Period 1990-2002: 89 % came from beef cattle (31.5 million head), 10% from dairy cattle (2.1 million) and 1% from other livestock.
These emissions represented 88 % of total livestock related emissions; the remaining 12 % came from manure management.

Cuadro 4.8. Emisiones de metano de la sección ganadera, expresadas en Gg, para el periodo 1990 – 2002 en México.

Emisiones de metano	1990	1992	1994	1996	1998	2000	2002
Ganado bovino - vacas leche	156.19	161.78	170.01	177.90	190.51	217.92	227.55
Ganado bovino - vacas carne	1,551.72	1,508.33	1,459.57	1,384.56	1,415.77	1,377.20	1,414.72
Búfalos	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ovino - borregos	30.04	31.44	33.19	31.78	29.83	31.07	32.98
Cabras	53.75	50.13	52.83	49.26	46.55	44.82	47.01
Camellos	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Caballos	56.81	57.62	58.48	59.39	60.35	61.36	62.41
Mulas y asnos	27.09	26.05	24.95	23.80	22.60	21.35	20.04
Cerdo - porcino	25.76	23.33	27.61	26.10	25.37	26.08	25.62
Aves	1.97	2.00	2.79	3.24	3.42	3.65	4.01
Total	1,903.33	1,860.69	1,829.42	1,756.04	1,794.40	1,783.45	1,834.35

National Inventory of GHG 1990-2002 (INE, 2005)

Climate change adaptation strategies most widely used and how/why these have been selected.

The Mexican strategy establishes the following mitigation measures:

- Rehabilitation of grazing and rangelands - rehabilitate 450,000 ha of grazing and rangelands through the Program for Support Cattle Production (PROGAN, Spanish acronym).
- Adequate management of farm manure in 1,200 small farms through biodigester technologies.
- The final aim is reducing methane emissions 30% by 2020.

- **There are not strategies to directly decrease the enteric methane emissions in ruminants.**
- **Most strategies based on manure management (but manure is not the main source of GHG)**

Biodigesters in Mexico

AgCert, an Ireland-based company that produces and sells bodigesters for big farms in Mexico, and sells greenhouse gas emission credits (currently in bankruptcy)

Biodigesters in Mexico

Big biodigester located in Tepatitlan, Jalisco.

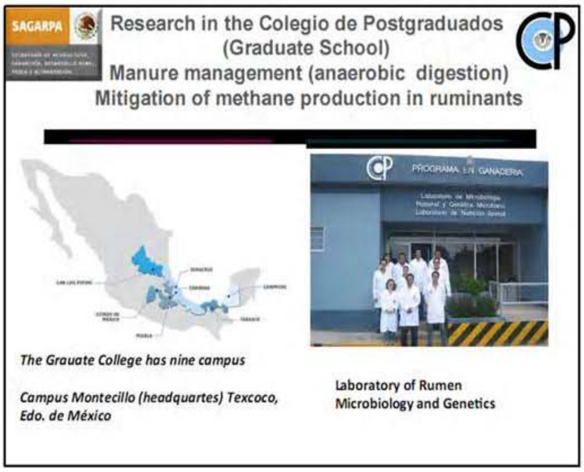
- Oportunities
- Biogas: the use of swine manure and cattle manure manure as an alternative source of energy.
- Differente national and international mechanisms:
  - CDM, Clean Development Mchanism (Kyoto protocol).
  - M2M, Methane to markets, Environmetal Protection Agency, EUA.
- Also, Fideicomiso de Riesgo Compartido (FIRCO, SAGARPA) produces biodigesters for intensive production systems, mainly pig systems.

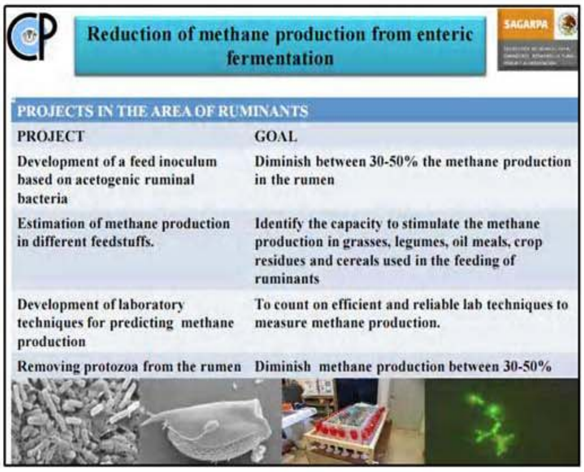
ESQUEMAS DE FINANCIAMIENTO DE BIODIGESTORES				
No.	ESTADO	TOTAL DE BIODIGESTORES	ESQUEMA MDL	ESQUEMAS GUBERNAMENTALES
1	Coahuila	6	6	0
2	Durango	6	6	0
3	Guanajuato	16	12	4
4	Jalisco	107	86	21
5	Michoacán	11	9	2
6	Nuevo León	16	9	7
7	Puebla	19	17	2
8	Querétaro	7	6	1
9	Sonora	116	115	1
10	Veracruz	3	0	3
11	Yucatan	38	2	36
TOTAL		345	268	77

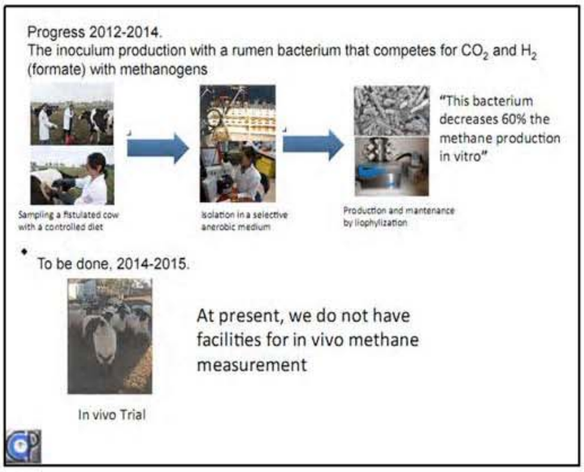
Biodigesters in Mexico

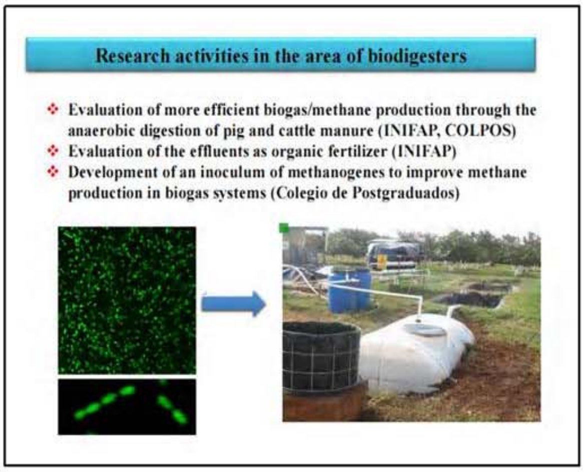


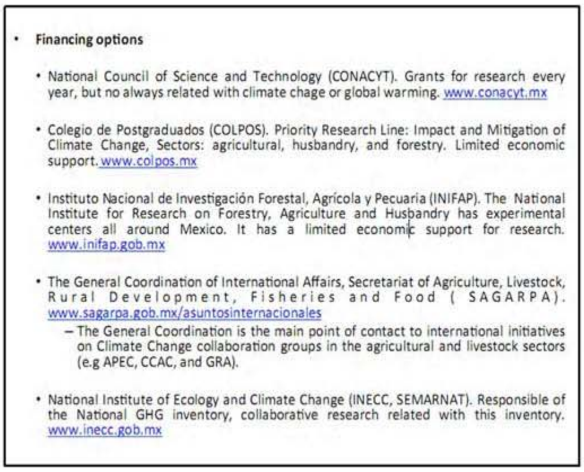

Small biodigester located in Puebla.
They use biogas for cook and the effluents as organic fertilizer
Limited numbers but growing and limited assistance


SAGARPA
Research in the Colegio de Postgraduados
(Graduate School)
Manure management (anaerobic digestion)
Mitigation of methane production in ruminants
PROGRAMA EN GANADERIA
The Grauate College has nine campus
Campus Montecillo (headquartes) Texcoco, Edo. de México
Laboratory of Rumen Microbiology and Genetics


Reduction of methane production from enteric fermentation
SAGARPA
PROJECTS IN THE AREA OF RUMINANTS
PROJECT
GOAL
Development of a feed inoculum based on acetogenic ruminal bacteria
Diminish between 30-50% the methane production in the rumen
Estimation of methane production in different feedstuffs.
Identify the capacity to stimulate the methane production in grasses, legumes, oil meals, crop residues and cereals used in the feeding of ruminants
Development of laboratory techniques for predicting methane production
To count on efficient and reliable lab techniques to measure methane production.
Removing protozoa from the rumen
Diminish methane production between 30-50%


Progress 2012-2014.
The inoculum production with a rumen bacterium that competes for CO_2 and H_2 (formate) with methanogens
Sampling a fistulated cow with a controlled diet
Isolation in a selective anerobic medium
Production and mantenance by liophylization
"This bacterium decreases 60% the methane production in vitro"
To be done, 2014-2015.
At present, we do not have facilities for in vivo methane measurement
In vivo Trial


Research activities in the area of biodigesters
Evaluation of more efficient biogas/methane production through the anaerobic digestion of pig and cattle manure (INIFAP, COLPOS)
Evaluation of the effluents as organic fertilizer (INIFAP)
Development of an inoculum of methanogenes to improve methane production in biogas systems (Colegio de Postgraduados)


Financing options
National Council of Science and Technology (CONACYT). Grants for research every year, but no always related with climate chage or global warming. www.conacyt.mx
Colegio de Postgraduados (COLPOS). Priority Research Line: Impact and Mitigation of Climate Change, Sectors: agricultural, husbandry, and forestry. Limited economic support. www.colpos.mx
Instituto Nacional de Investigación Forestal, Agrícola y Pecuaria (INIFAP). The National Institute for Research on Forestry, Agriculture and Husbandry has experimental centers all around Mexico. It has a limited economic support for research. www.inifap.gob.mx
The General Coordination of International Affairs, Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA). www.sagarpa.gob.mx/asuntosinternacionales
– The General Coordination is the main point of contact to international initiatives on Climate Change collaboration groups in the agricultural and livestock sectors (e.g APEC, CCAC, and GRA).
National Institute of Ecology and Climate Change (INECC, SEMARNAT). Responsible of the National GHG inventory, collaborative research related with this inventory. www.inecc.gob.mx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Department of Livestock Development
APEC
Asia-Pacific Economic Cooperation
¡Gracias!

Every economy has policy and strategy plan of climate change and mitigation program, especially, decreasing GHG emission by manure management. The contents in their reports are similar. They report about animal population, GHG emission from agriculture sector and livestock sector. The impacts of climate change on agriculture, livestock, soils, and water supply. Especially in Philippines, they also focus on fishery and ecosystem. They have strategies about adaptation and mitigation. About mitigation program, they forcus about manure management. They use manure management for biogas and fertilizer. For Viet Nam, Indonesia, and Philippines, they also focus on GHG inventory system and GHG measurement. In Indonesia, they have experiences about GHG measurement.

The final discussion is focus about the important of adaptation in climate change. The adaptation strategy has wider frame work. It has more important and significant to climate change on livestock sector. By the big frame work, it can be used for livestock development considered to climate change. About adaptation and mitigation strategies, they should be worked together.

About the workshop concerned with climate change and livestock should be arrange in every year for APEC members to improve for green production of livestock sector.

Every economy ask APEC secretariat to urge and encourage every economy to arrange national policy about climate change in livestock sector, especially, adaptation and mitigation program. About livestock production, they should improve production efficiency to decrease GHG emission per production unit.

Recycling and recovery for livestock waste, water, and manure is very important. It concern to ecosystem and water supply. This is the big important frame work of climate change in livestock sector. It should be put in national policy.

The important things with best practice for adaptation and mitigation in climate change are education and training of officers and farmers. Education and training should be built through the Farmers Academy. In part of capacity building, the participant should continue discuss through the workshop website to improve knowledge of climate change in livestock sector.

The other important thing about climate change in livestock sector is GHG measurement. To develop the GHG measurement instrument is very important. Before the set up of policy, we should know how much GHG emitted from livestock sector. So the first that we should do is GHG measurement instrument establishment.

Finally for adaptation and mitigation program we should do with research. Research is very important. We should research with genetic improvement, feeding management, farm management, waste management, ruminal microorganism, feed additive, biogas production. And the other thing is implementation of research output to develop adaptation and mitigation program for green production in livestock sector.

Field trip

The field trip was arranged in Santirath Agricultural Farm of Charoen Pokphand food (CPF) in Chonburi Province. Charoen Pokphand food is a private enterprise for the role of agriculture and food. It recognizes the quality of life of the retired civil servants, especially the police man. When the day comes, they retire and remove a career to earn money for their families.

Mr. Thanin Jiaravanont, the president of Charoen Pokphand company, set up this concept. The concept of allocating farm to supplement their income and build a career with a sustainable income. While both the government and after retiring from office behind.

The CP has assigned business units in subsidiaries to promote the cultivation of grape sand vegetables are organically grown, frog ponds and greenhouse gases unit to reduce GHG. They have big farms of 10,168 for breeding swine model with 8,000 biogas digester, or bio-gas for the treatment of waste from pig manure. The value of investment projects totaling 155.3 million baht.

The pilot program held in 2548 at Tambon Nong HinYai. Chonburi province. It cooperate with the office of the National Coordinator, TMB Bank, and Chonburi police Station. CPF impresario performed in a "one village 4 products."

Mr. Saroj Jiarakongmun, CPF Vice President said, "The CPF committed Santirat agricultural village. The first of a newline of action started with more than 230 hectares of land reform to the Police Commissioner Chang membership.

Promoting the engagement three career major grape growing and growing vegetables are organically grown. Frog and pig farming supports with one occupation is native chickens.

The project was divided into two parts: a residential area about50 acres (1.5 hectares of land per family, with native broiler houses), with another 180 acres for agricultural operations.

Today all members of "Santirat agricultural projects" are united to develop their career strongly. Farmers are committed to building capacity and stability to the family of retired police officers back to the concrete sustainability.

The model is hoped this helps spark to other sectors have followed or a concept for improving strengthen civil society in the future.

The other program in the same area, CPF has swine farm as green farm. This farm is in the CSR program of CPF. CPF receive award about green production farm. Product from this farm and from members have production standard control by Department of Livestock Development. Every product from Santirat agricultural farm, pork, chicken meat, vegetable and grapes were sent to other unit of CPF to produce safety food for consumers in country and for export.

Workshop findings

Participants at the workshop agreed that:

- CH4 emissions differ between sub-categories of animals as well as due to the differences in the amount and type of feed consume at each economy country. Therefore each country has different type of feed offered to the animals. So in each economy should develop own emission factors for each sub-category
- To develop own emission factors for each sub-category, each economy should develop and establish GHG measurement instrument.
- There are many methods in mitigation method such as: feeding improvement, genetic improvement, farm management, and manure management.
- About feeding management, each economy can use feed suplement, feed additives, feed processing, local feed, high quality feed.
- We can use knowledge of rumen microorganism genetics to produce methanogen inhibitor vaccine or methanogen inhibitor feed additives.
- There are many agriculture by-products such as: mangosteen peel, Leucaena leaf, which can be used as feed stuff to reduce methane emission.

- About genetic improvement, they can be used in adaptation and mitigation practice. For mitigation practice, they can use genetic improvement of low residual feed intake and low CH4 emission, and also for genetic improvement of forage crop.
- Genetic selection and targeted breeding could reduce methane emissions per unit product through selecting genetic traits that increase the general efficiency of production (eg milk yield and reproductive efficiency per animal)
- About farm management, they can improve for cooling house, good ventilation house.
- About manure management, they can produce biogas and compost fertilizer.
- It is very important that livestock production is important for food security. So in term of mitigation, we can reduce GHG emission per production unit.
- To reduce GHG emission per production unit, we can improve production efficiency.
- About GHG measurement method, especially enteric methane, we use respiration chamber and SF6 technique.
- It is very important to arrange about GHG measurement method training course supported by APEC.
- There is valuable in establishing a network in the research area of mitigation. To combine database and exchange knowledge about climate change in livestock sector among APEC economy is very important.
- It is very important to arrange the workshop continuously once per year.
- The other thing, to set the strategy about adaptation for climate change in livestock sector is very important. It is more benefit.
- Since almost all countries members has develope biogass system, therefore it is needed to make a standard on methane production efficiency on Biogass system. How much methane must be produce per unit of manure processes.
- To optimize the utillization of Biogass produced, it is also required to find a packaging technology to pack Biogass produced, so it can be tranferred to other area.
- Many technologies on mitigation has developed in the countries members. The main problem in implementing these technologies are many farmers in particular small-scale farmers are difficult to accept the news technologies. Therefore it is needed to find the best way how the small-scale farmerscan addopt new tecnologies.

Reccommendation

The workshop agreed on the following priority issues and actions, subject to APEC member economies being able to secure necessary funding to deliver on these action points.

1. The establishment of an international scientific network aimed at adaptation and mitigation through improved animal production by using feeding, farming, manure management, and genetic improvement. APEC economies scientists would take primary responsibility for the establishment and management of the Network. While this network will initially involve scientists working in the area of mitigating methane emissions intensity and adaptation, the option of including research around other greenhouse gases as the network progresses, is open
2. The establishment of a common database for the storage of GHG emission in area of adaptation and mitigation are recorded. These data would be available for use in wide association studies.

3. Continue discussions on defining which co-benefit between mitigation and adaptation should be targeted and how these will be incorporated into objectives.
4. Develop a set of common protocols to guide the search for the rapid measurement of CH4 and intake when repeated measurements on large numbers of animals are required.

Appendix

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Activities

ATC 01 2013A - Scientific Workshop on measurement and mitigation of greenhouse gases in livestock systemsfor green production and environment of APEC members


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