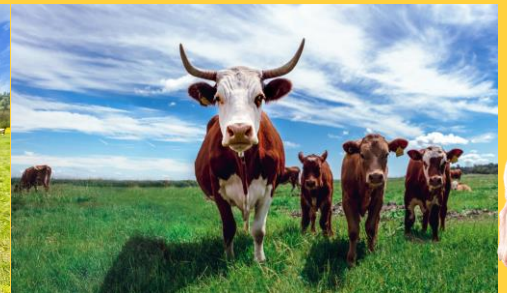
# เกษตรคาร์บอนต่ำสู่ความยั่งยืน:

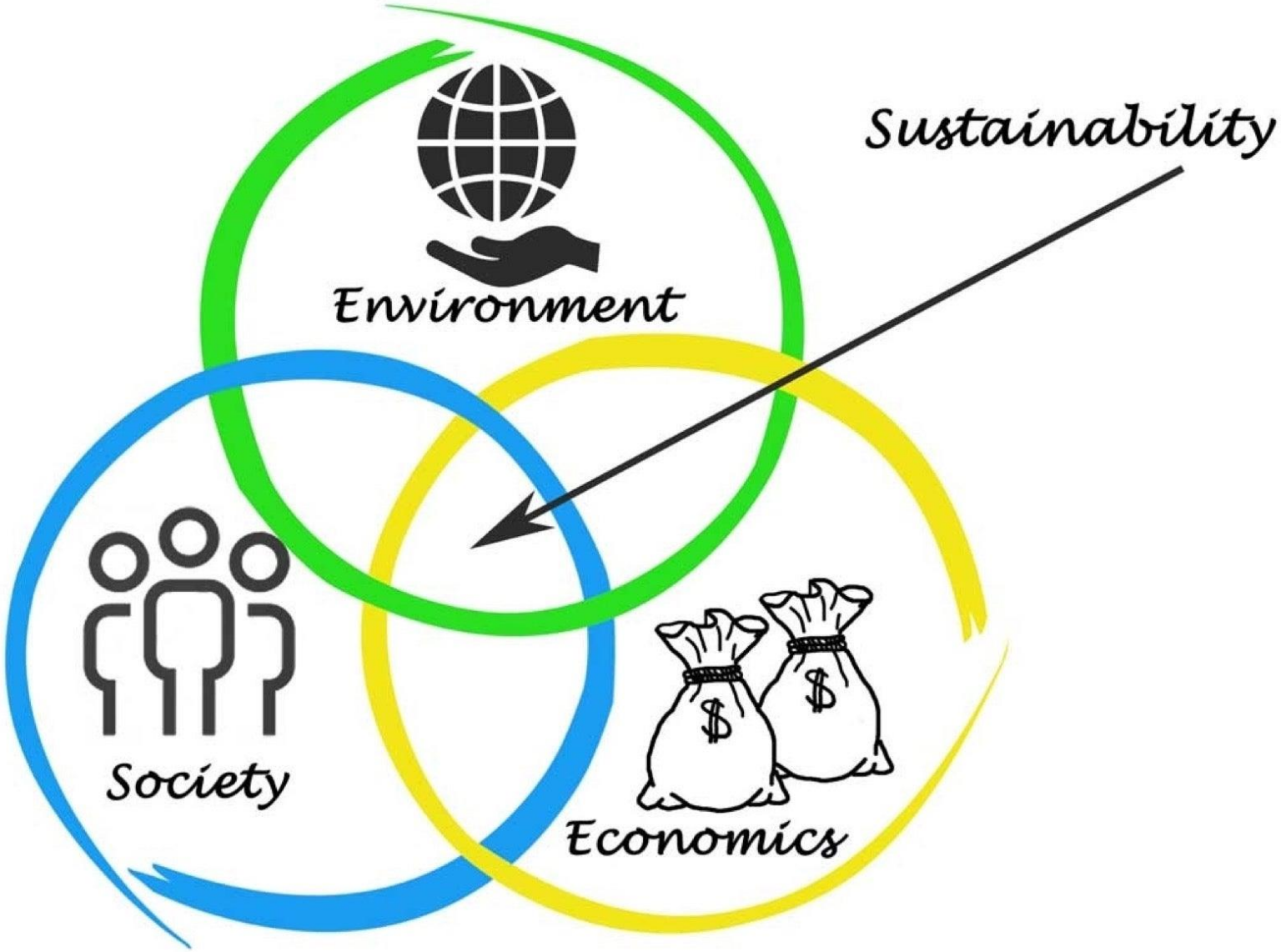
## มาตรการ/แนวทางการลดคาร์บอนในภาคปศุสัตว์ไทย

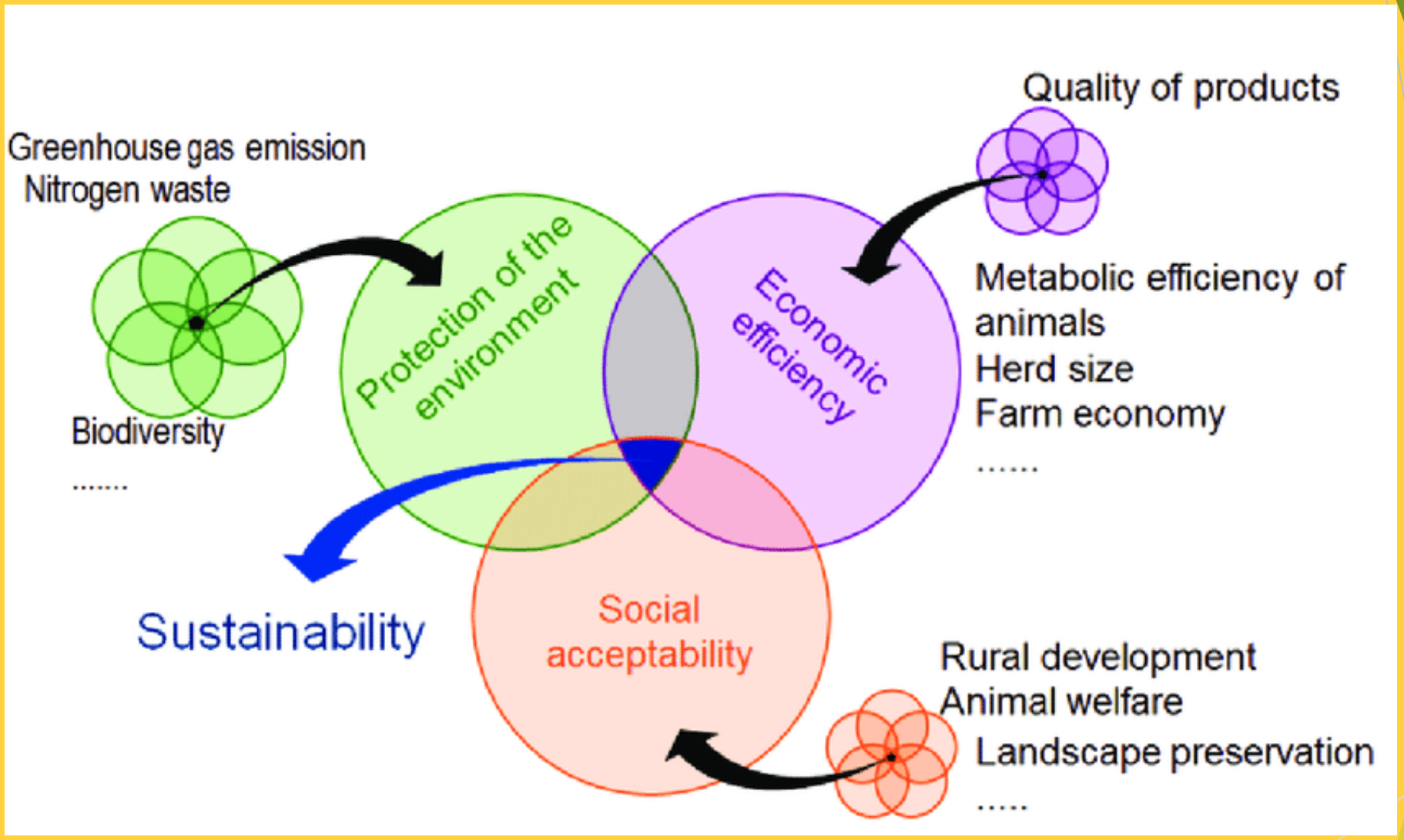
นายจีระศักดิ์ ชอบแต่ง

กรมปศุสัตว์



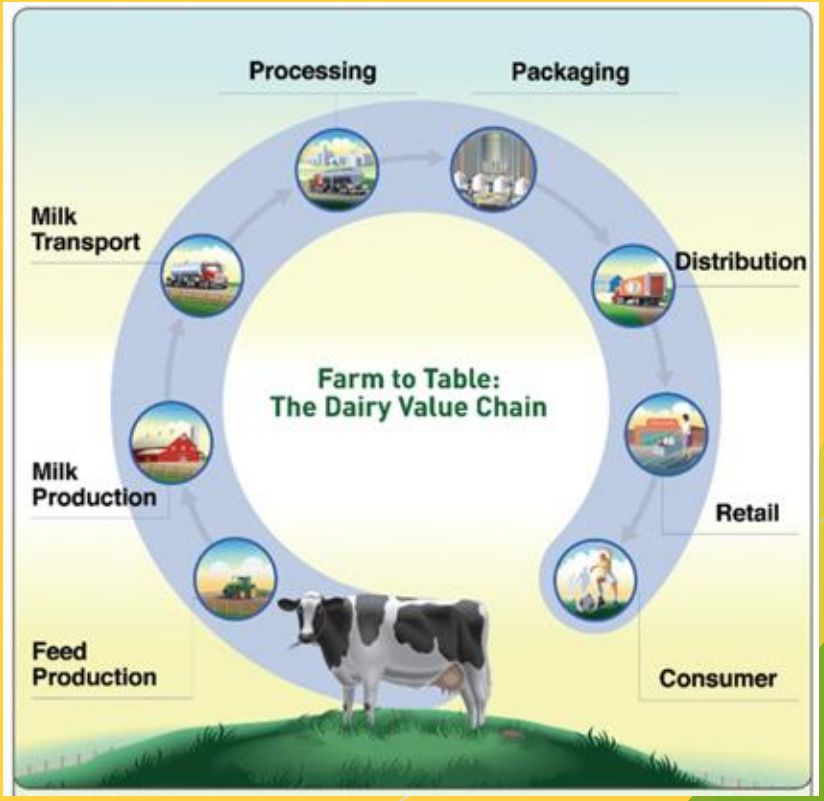




Sustainability
Environment
Society
Economics


Quality of products
Greenhouse gas emission
Nitrogen waste
Protection of the environment
Economic efficiency
Metabolic efficiency of animals
Herd size
Farm economy
.....
Biodiversity
.....
Sustainability
Social acceptability
Rural development
Animal welfare
Landscape preservation
.....

# Tools

- Life Cycle Thinking
- Life Cycle assessment (LCA)
- From Cradle-to-Grave
  - From Cradle-to-Farm gate
  - From Farm gate-to-retailer

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LCA FOR AGRICULTURE

# Appraisal of environmental profiles of pasture-based milk production: a case study of dairy farms in the Waikato region, New Zealand

Jeerasak Chobtang [1,2,3] · Stewart F. Ledgard [1,3] · Sarah J. McLaren [2,3] · Marlies Zonderland-Thomassen [1,3] · Daniel J. Donaghy [4]

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**Abstract**
*Purpose* Dairying is a relatively intensive livestock production system and contributes to a range of environmental impacts. In the southern hemisphere, dairy farming systems are based mainly on outdoor grazing of permanent pastures. The objectives of this study were to (i) assess environmental profiles and (ii) to identify environmental hotspots in a pasture-based dairy farming system. *Methods* A cradle-to-farm gate life cycle assessment of 53 dairy farms in the Waikato region, New Zealand, was carried out, using 1 kg of fat- and protein-corrected milk as the functional unit. Twelve environmental impact categories were assessed: climate change (CC), ozone depletion potential (ODP), cancer effects (Cancer), non-cancer effects (non-cancer), particulate matter (PM), ionizing radiation (IR), photochemical ozone formation potential (POFP), acidification potential (AP), terrestrial eutrophication potential (TEP), freshwater eutrophication potential (FEP), marine eutrophication potential (M
(Ecotox). C
formed to d
changes in r
*Results and*
of the total n
PM, POFP,
ment animal
indicators. Th
for use on th
results for Ne
Ecotox (19 %
the dairy far
ODP (26 %),
and Ecotox (4
on the dairy
(15 %), IR (2
onstrated the
inventories a
*Conclusions*
to 5 out of 1
impact indica
environmenta
farm and off-
(such as CC)
revealed in a

Responsible editor: Greg Thoma

**Electronic supplementary material** The online version of this article (doi:10.1007/s11367-016-1033-9) contains supplementary material, which is available to authorized users.

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Keywords I
Milk · New Z

1 Introduc

Milk from da
is increasingl



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# Life cycle environmental impacts of high and low intensification pasture-based milk production systems: A case study of the Waikato region, New Zealand

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Pasture-based system

ABSTRACT

Intensification of pasture-based dairy farming systems is usually associated with increased use of off-farm inputs to increase milk production per hectare, and additional environmental impacts may be associated with upstream production and delivery of these off-farm inputs. The objective of this study was to compare two levels of dairy farming intensification (i.e. high versus low) in pasture-based milk production systems with respect to (i) farm production and (ii) life cycle environmental indicators. The study considered 53 dairy farms in the Waikato region, New Zealand. Three farm attributes (stocking rate, amount of brought-in feeds and amount of nitrogen fertilizer used) were used to define a level of farming intensification (Intensification Index) for each dairy farm. The upper and lower quartiles of the dairy farms ranked on their Intensification Indices were chosen to represent high and low intensification groups, respectively. Twelve midpoint environmental indicators of the dairy systems were assessed using attributional Life Cycle Assessment with one kg of fat- and protein-corrected milk as a functional unit and a cradle-to-farm gate perspective as a system boundary. Compared with the low intensification group, the high intensification group had (on a per hectare basis) higher ($P < 0.001$) stocking rate, total brought-in feeds and nitrogen fertilizer use, which led to greater milk yield per cow ($P < 0.01$) and per hectare ($P < 0.001$). The different levels of farming intensification did not affect total feed conversion efficiency ($P > 0.05$). However, for the high intensification group, the results for 10 out of 12 environmental indicators per kg of fat- and protein-corrected milk were higher ($P < 0.05$) than those in the low intensification group. The main drivers for the increases in most environmental indicator results were the production of brought-in feeds, manufacturing of agrichemicals and transportation of off-farm inputs for use on dairy farms. In contrast, increased pasture intake was negatively correlated ($P < 0.05$) with all environmental impacts, indicating that efficient pasture management is also critical to mitigate environmental impacts. In conclusion, while an increase in intensification of pasture-based dairy farming systems led to increased milk production per cow and per hectare, it also resulted in increased environmental impacts for most indicators. Apart from increased resource use efficiency, increased pasture utilization efficiency is a promising measure to improve environmental sustainability of pasture-based dairy farming systems.



## 1. Introduction

The increasing global population and rising levels of affluence are driving an increased demand for food. At the same time, increasing environmental problems at both global (e.g. climate change; FAO (2006)) and local (e.g. degradation of waterways; Foote et al. (2015)) scales have focused attention on the realization of more environmentally-friendly food systems (Echeverría et al., 2014). As a consequence, consideration is being given to sustainable intensification of food production systems in order to increase

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RESEARCH AND ANALYSIS

# Consequential Life Cycle Assessment of Pasture-based Milk Production

## A Case Study in the Waikato Region, New Zealand

*Jeerasak Chobtang, Sarah J. McLaren, Stewart F. Ledgard, and Daniel J. Donaghy*

**Keywords:**
dairy
farm intensification
industrial ecology
life cycle assessment (LCA)
land use
system expansion

Supporting information is linked to this article on the *JIE* website

**Summary**
Farm intensification c
increased stocking ra
the additional feed c
per hectare, intensific
objective of the prese
potential intensificatic
region, New Zealanc
utilization efficiency (
on-farm pasture proc
feed as maize silage
PUE scenario was the
choice between the
different environment
choice associated wit
(ILUC) and (2) the cc
the co-product dairy
magnitude of the CC
and the choice assoc
results for the three i

## Introduction

A substantial increase in global demand for food prod
including dairy products, over the next decade is anticipatec
sulting mainly from increasing world population and greate
dividual household incomes (Tilman et al. 2011). Addition
globalization of feed and food systems with the concomitan
ographical separation of locations of feed/food production
consumption is likely to lead to increasingly unbalanced
trient flows, and potentially increased environmental imp
(Bouwman et al. 2013; Lassaletta et al. 2014; Adrian e
2015).

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# Environmental trade-offs associated with intensification methods in a pasture-based dairy system using prospective attributional Life Cycle Assessment

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Nitrogen fertilizer
Scenario analysis

ABSTRACT

The predicted increase in global demand for dairy products over the next decade is driving the global dairy sector to increase its production capacity. For the New Zealand dairy sector, farm intensification is a common strategy to increase milk production per hectare, and is generally achieved through increased stocking rate, predominately supported by different feed provision methods. In the present study, seven prospective intensification scenarios were established, and multiple environmental impacts of these scenarios were assessed using prospective attributional Life Cycle Assessment. Increased productivity per animal and increased pasture utilization efficiency reduced all environmental indicator results compared with a business-as-usual scenario (per kg of standardized milk). Increased use of locally produced maize silage reduced all environmental indicator results except for Ozone Depletion Potential, Photochemical Ozone Creation Potential, and Ecotoxicity for Aquatic Freshwater. On the other hand, the use of imported wheat grain increased all environmental indicator results except for Climate Change and Terrestrial Eutrophication Potential, and this was mainly due to the production and long-distance transport of wheat grain. Use of extra nitrogen fertilizer to increase on-farm pasture production increased five, and reduced six, environmental indicator results. In conclusion, increased animal productivity and increased pasture utilization efficiency are the most promising intensification scenarios for future New Zealand dairy systems from an environmental sustainability perspective. Scenario-based prospective attributional Life Cycle Assessment assists in highlighting the environmental trade-offs and hotspots among prospective farm intensification scenarios in pasture-based dairy systems.



## 1. Introduction

The predicted global demand for dairy products in 2024 will be approximately 30% more than that in 2014 (OECD/FAO, 2015). In order to support such a demand, the global dairy sector will have to increase its production capacity. For New Zealand, which is the single largest dairy exporter in the world (New Zealand Government, 2012), an increase in milk production will be associated mainly with farm intensification, generally leading to increased milk production per hectare (MacLeod and Moller, 2006).

The dairy sector in New Zealand is the single largest contributor to income from exports in the nation, accounting for ~25% of the total national export revenue in 2012 (New Zealand Government, 2013). The New Zealand Government has a clear vision to double income from agricultural exports by 2025, including dairy products (New Zealand Government, 2012). As a result, the New Zealand dairy sector is actively investigating how to increase its production capacity to support this national goal. In principle, two approaches can be used to increase total milk production: (i) farm expansion, and (ii) farm intensification. The former requires additional lands to be converted either from other existing land-based agricultural systems (e.g. sheep and beef farming systems, and forestry) or

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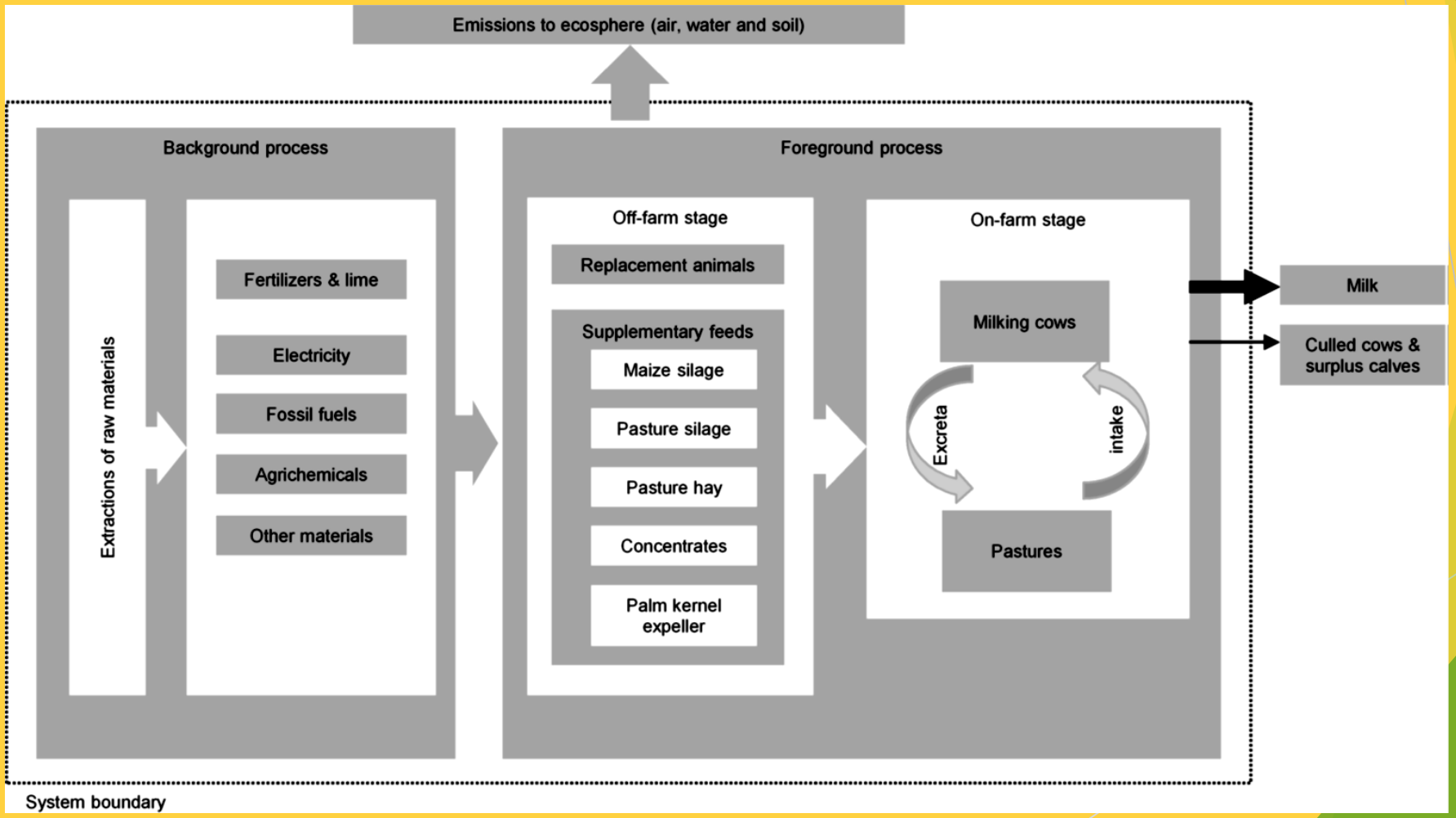
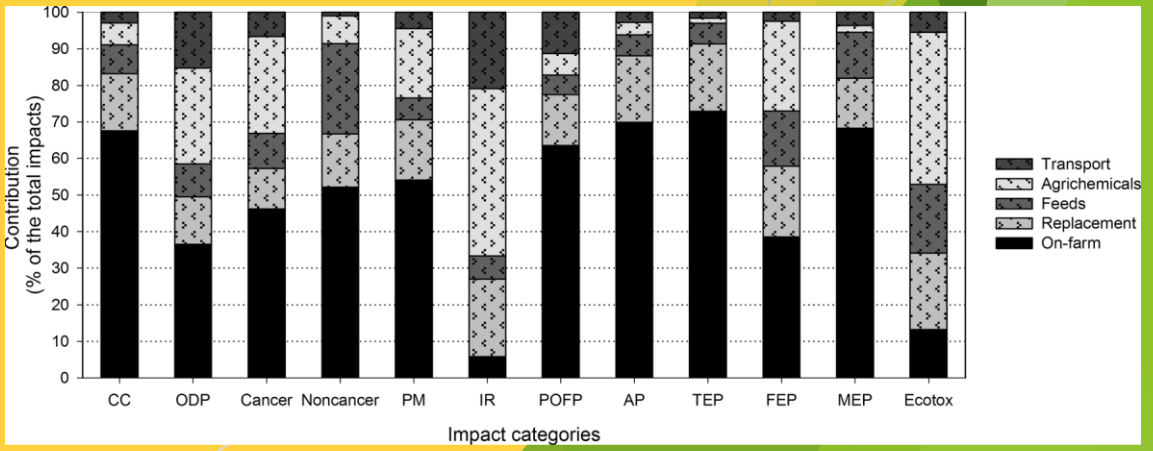
0959-6526/

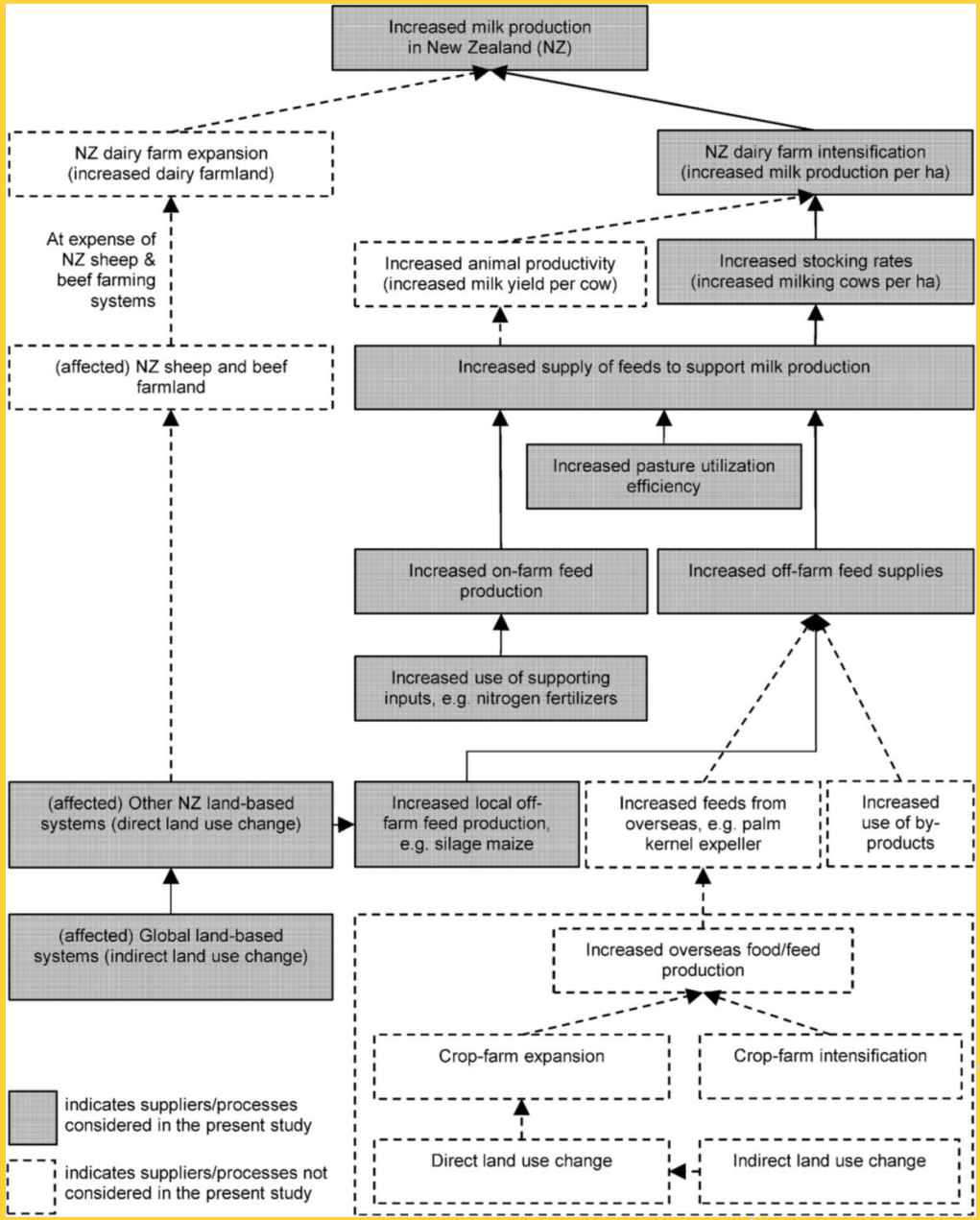
# Environmental impacts of pasture-based dairy production system

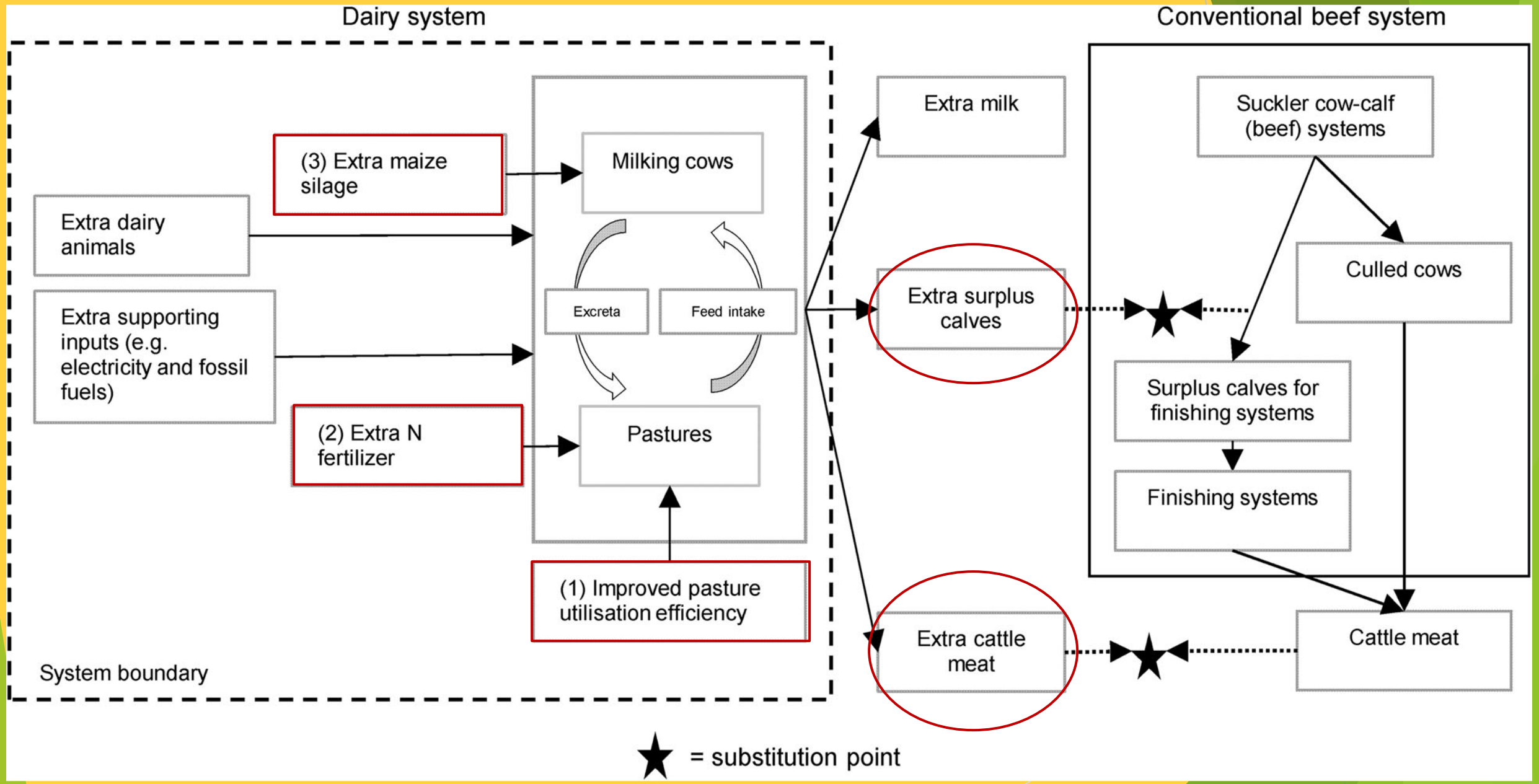


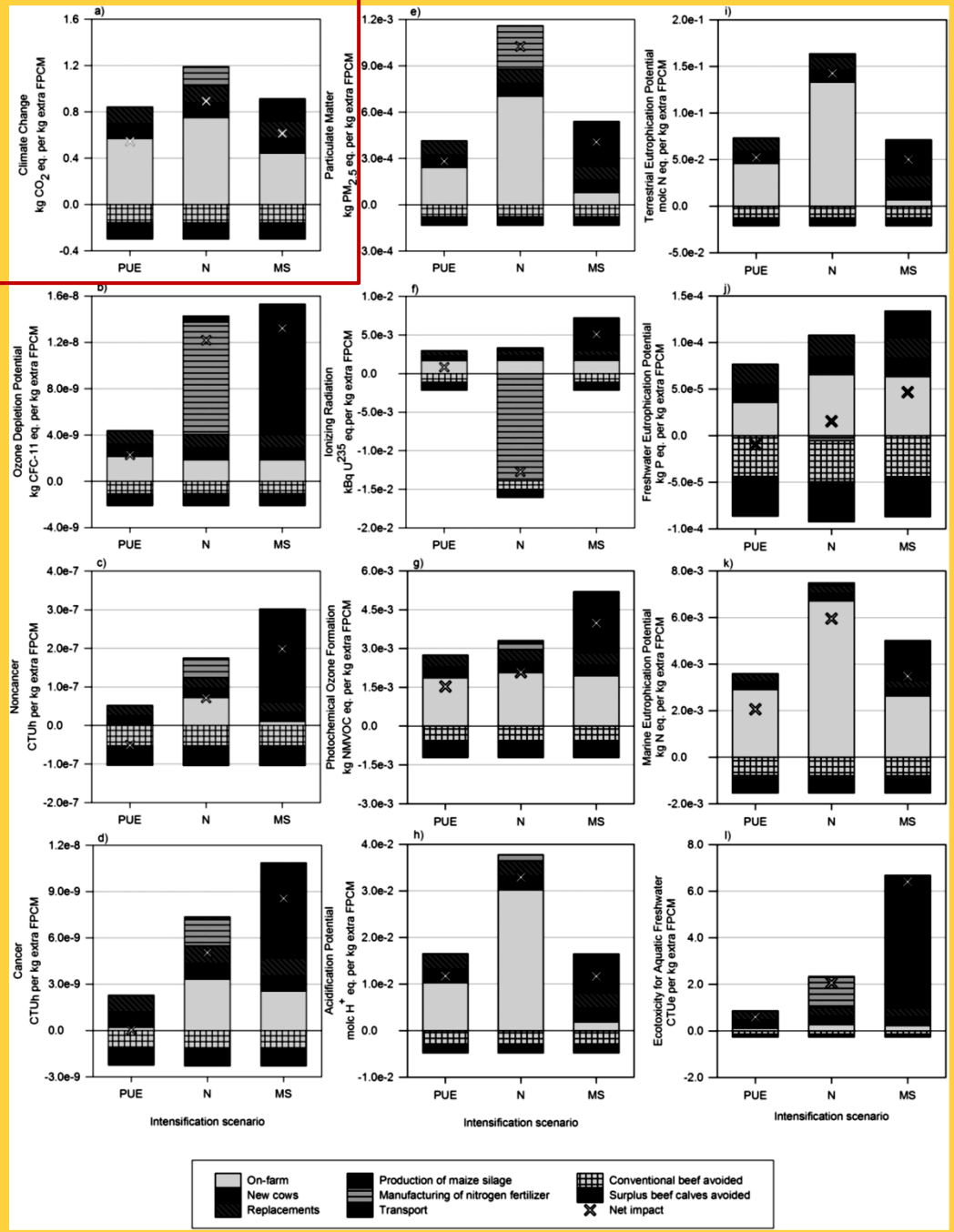
| Impact category[a] | Units | Mean | SD | 95 % CI | |
|---|---|---|---|---|---|
| | | | | Lower limit | Upper limit |
| CC | kg $CO_2$ eq. | 0.80E+00 | 0.08E+00 | 0.78E+00 | 0.82E+00 |
| ODP | kg CFC-11 eq. | 1.02E-08 | 0.17E-08 | 0.97E-08 | 1.06E-08 |
| Cancer | $CTU_h$ | 1.00E-08 | 0.40E-08 | 0.89E-08 | 1.11E-08 |
| Non-cancer | $CTU_h$ | 2.60E-07 | 0.95E-07 | 2.33E-07 | 2.86E-07 |
| PM | kg $PM_{2.5}$ eq. | 4.60E-04 | 0.74E-04 | 4.40E-04 | 4.80E-04 |
| IR | kg $U^{235}$ eq. | 1.06E-02 | 0.29E-02 | 0.98E-02 | 1.14E-02 |
| POFP | kg NMVOC eq. | 2.58E-03 | 0.28E-03 | 2.50E-03 | 2.66E-03 |
| AP | molc $H^+$ eq. | 1.53E-02 | 0.19E-02 | 1.48E-02 | 1.59E-02 |
| TEP | molc N eq. | 6.55E-02 | 0.80E-02 | 6.33E-02 | 6.77E-02 |
| FEP | kg P eq. | 0.96E-04 | 0.19E-04 | 0.91E-04 | 1.02E-04 |
| MEP | kg N eq. | 2.67E-03 | 0.43E-03 | 2.55E-03 | 2.79E-03 |
| Ecotox | $CTU_e$ | 1.23E+00 | 0.34E+00 | 1.14E+00 | 1.32E+00 |



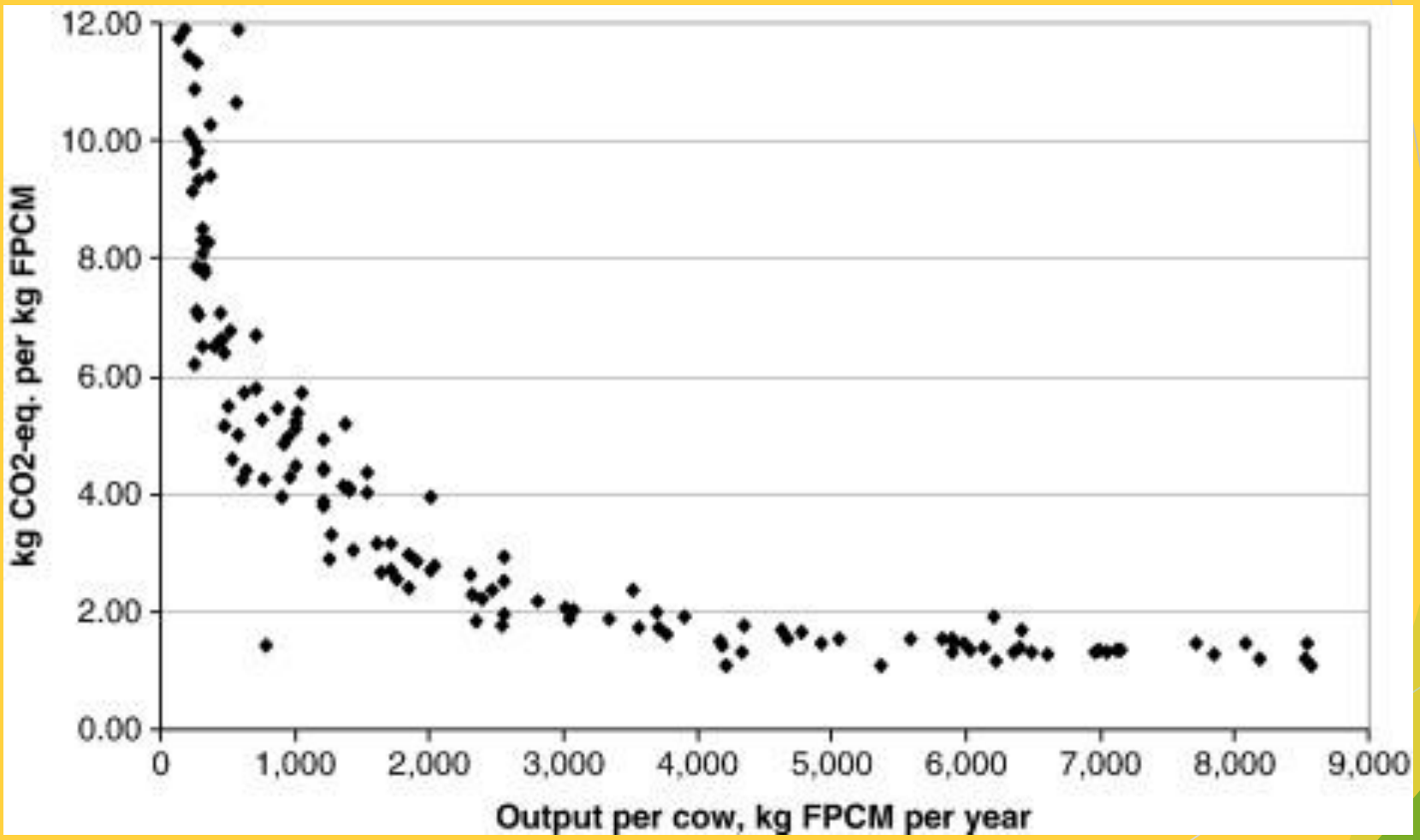
# ผลกระทบทางด้านสิ่งแวดล้อมถ้าต้องการผลิตน้ำนมโคเพิ่มขึ้น




Dairy system
Conventional beef system
(3) Extra maize silage
Extra dairy animals
Extra supporting inputs (e.g. electricity and fossil fuels)
(2) Extra N fertilizer
Milking cows
Excreta
Feed intake
Pastures
(1) Improved pasture utilisation efficiency
System boundary
Extra milk
Extra surplus calves
Extra cattle meat
Suckler cow-calf (beef) systems
Culled cows
Surplus calves for finishing systems
Finishing systems
Cattle meat
= substitution point


a)
Climate Change
kg $CO_2$ eq. per kg extra FPCM
1.6
1.2
0.8
0.4
0.0
-0.4
PUE
N
MS
e)
Particulate Matter
kg $PM_{2.5}$ eq. per kg extra FPCM
1.2e-3
9.0e-4
6.0e-4
3.0e-4
0.0
3.0e-4
i)
Terrestrial Eutrophication Potential
molc N eq. per kg extra FPCM
2.0e-1
1.5e-1
1.0e-1
5.0e-2
0.0
-5.0e-2
b)
Ozone Depletion Potential
kg CFC-11 eq. per kg extra FPCM
1.6e-8
1.2e-8
8.0e-9
4.0e-9
0.0
-4.0e-9
f)
Ionizing Radiation
kBq $U^{235}$ eq.per kg extra FPCM
1.0e-2
5.0e-3
0.0
-5.0e-3
-1.0e-2
-1.5e-2
-2.0e-2
j)
Freshwater Eutrophication Potential
kg P eq. per kg extra FPCM
1.5e-4
1.0e-4
5.0e-5
0.0
-5.0e-5
-1.0e-4
c)
Noncancer
CTUh per kg extra FPCM
4.0e-7
3.0e-7
2.0e-7
1.0e-7
0.0
-1.0e-7
-2.0e-7
g)
Photochemical Ozone Formation
kg NMVOC eq. per kg extra FPCM
6.0e-3
4.5e-3
3.0e-3
1.5e-3
0.0
-1.5e-3
-3.0e-3
k)
Marine Eutrophication Potential
kg N eq. per kg extra FPCM
8.0e-3
6.0e-3
4.0e-3
2.0e-3
0.0
-2.0e-3
d)
Cancer
CTUh per kg extra FPCM
1.2e-8
9.0e-9
6.0e-9
3.0e-9
0.0
-3.0e-9
h)
Acidification Potential
molc $H^+$ eq. per kg extra FPCM
4.0e-2
3.0e-2
2.0e-2
1.0e-2
0.0
-1.0e-2
l)
Ecotoxicity for Aquatic Freshwater
CTUe per kg extra FPCM
8.0
6.0
4.0
2.0
0.0
-2.0
Intensification scenario
On-farm
New cows
Replacements
Production of maize silage
Manufacturing of nitrogen fertilizer
Transport
Conventional beef avoided
Surplus beef calves avoided
Net impact

# Improved milk productivity




(Gerber et al., 2011)

# Consumption side

- Minimize food loss and waste
- Effective retailing systems

# แนวทางการลดคาร์บอนในภาคปศุสัตว์

ฝั่งการผลิต

- เลือกใช้ปัจจัยการผลิตที่เป็นมิตรกับสิ่งแวดล้อม
- เพิ่มประสิทธิภาพการใช้ปัจจัยการผลิตและฟาร์ม
- การจัดการของเสียที่มีประสิทธิภาพ

ฝั่งการบริโภค

- การลดการสูญเสียอาหาร
- ระบบการกระจายสินค้าที่มีประสิทธิภาพ

# Thank you

# Additional slides

# โครงการวิจัย

- ประเมินและเปรียบเทียบประสิทธิภาพการผลิตและผลกระทบทางด้านสิ่งแวดล้อมระหว่างการระบบการผลิตไข่ไก่อินทรีย์และไม่อินทรีย์โดยใช้วิธีการประเมินวัฏจักรชีวิต (Life cycle assessment)
- การประเมินลักษณะทางเศรษฐศาสตร์และผลกระทบด้านสิ่งแวดล้อมในระบบการผลิตไก่ประดู่หางดำเชียงใหม่
- การประเมินลักษณะทางด้านเศรษฐศาสตร์ สิ่งแวดล้อมและระดับการยอมรับเทคโนโลยีของระบบการเลี้ยงโคนมที่มีการจัดการอาหารสัตว์โดยใช้ศูนย์ผลิตและกระจายอาหารสัตว์ส่วนของสหกรณ์
- ผลของขนาดฟาร์มที่มีต่อประสิทธิภาพการใช้ทรัพยากร และความยั่งยืนทางด้านเศรษฐศาสตร์และสิ่งแวดล้อมของระบบการเลี้ยงโคนมในประเทศไทย

# Greenhouse gas from livestock systems

Direct

- Carbon dioxide
- Carbon monoxide
- Methane
- Dinitrogen oxide

Indirect

- Ammonia
- Nitrate