Sustainable rice-straw management for improving farmer livelihoods and low environmental footprint in rice-based production systems

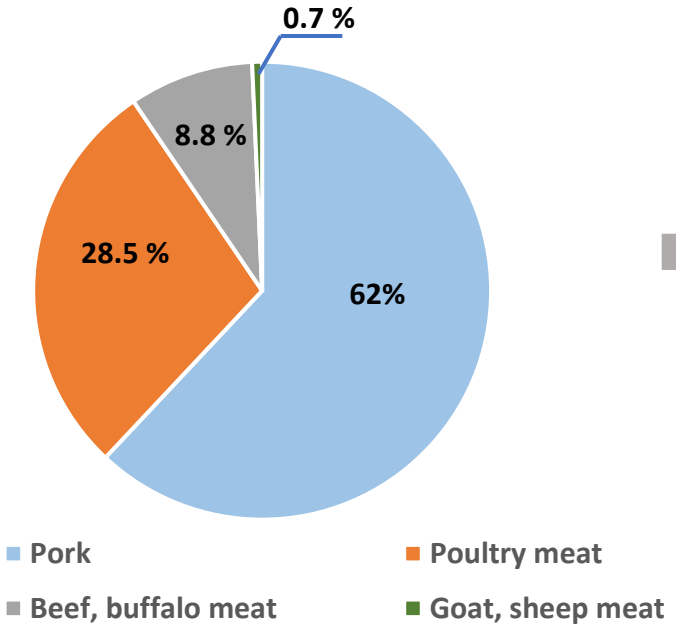
Prof. Dr. Duong Nguyen Khang
Nong lam University of Ho Chi Minh City, Viet nam

Beef cattle production in Vietnam

"Vietnam has limited potential in cattle raising for slaughter due to the small size of its grasslands. Cattle in Vietnam are usually fed with straw, sugarcane, and cassava, which are not an optimal solution; they are best raised by grass". President of Animal Husbandry Association of Vietnam – Dr. Nguyen Dang Vang.

Image source: Wikipedia

Livestock production 2021



- Ruminant production is not the main component contributed to Vietnam meat industry.
- Whilst domestic pork production is relatively sufficient for the domestic consumption demand, there is a significant shortage in the supply of beef.

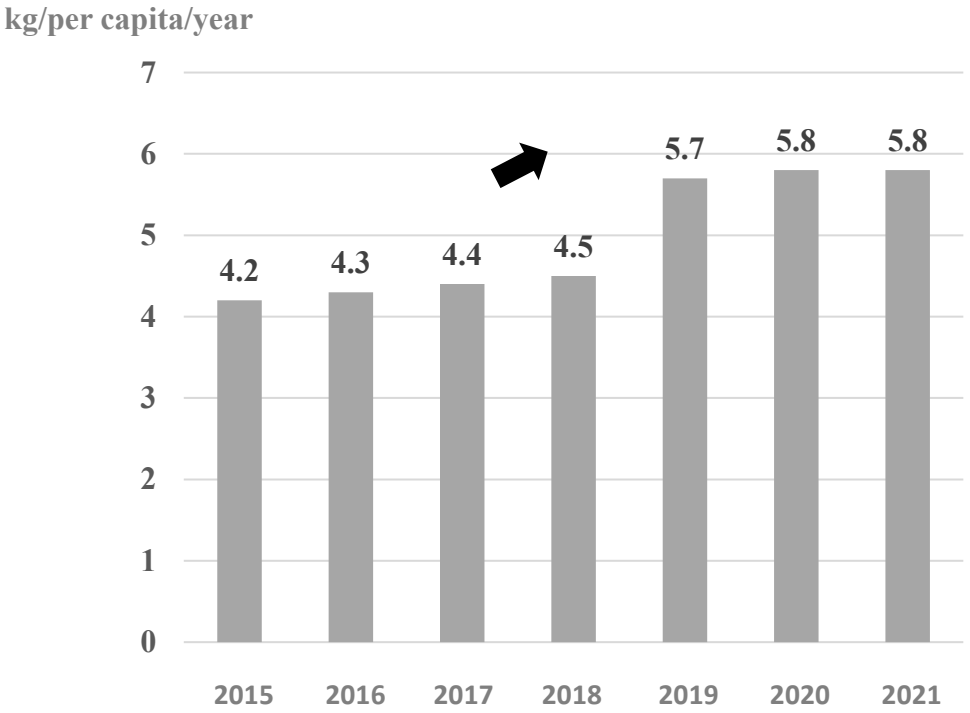
Source data: General Statistic Office (August, 2022)

Higher consumption growth rate of beef presents a positive outlook for beef production market

Vietnam's livestock consumption has risen over the last decade. Due to higher demand for red meat, Vietnam has imported a number of beef cattle. 60% of beef consumed in Vietnam are imported.

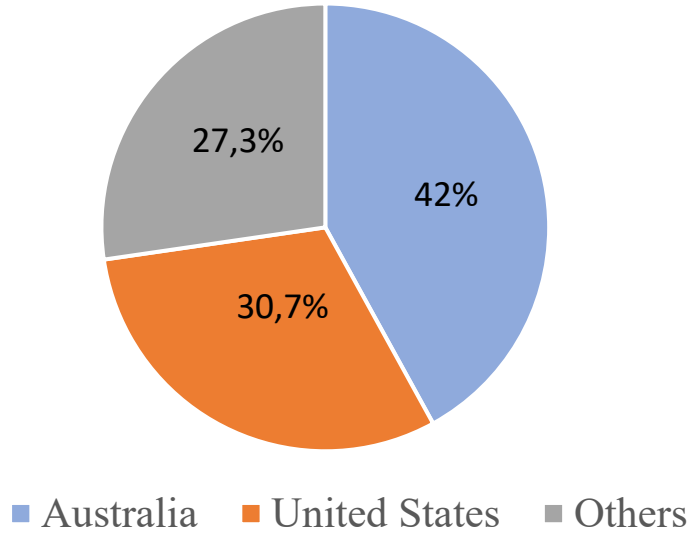
- In 2018, Vietnam import 262,321 live cattle and nearly 42,000 tons of meat, a total of $410 million (MARD, 2018).
- In 2020, Vietnam's slaughtered beef imports 106.5 thousand tons, up 30.4% compared to 2019.

Average beef, buffalo meat per capita/year



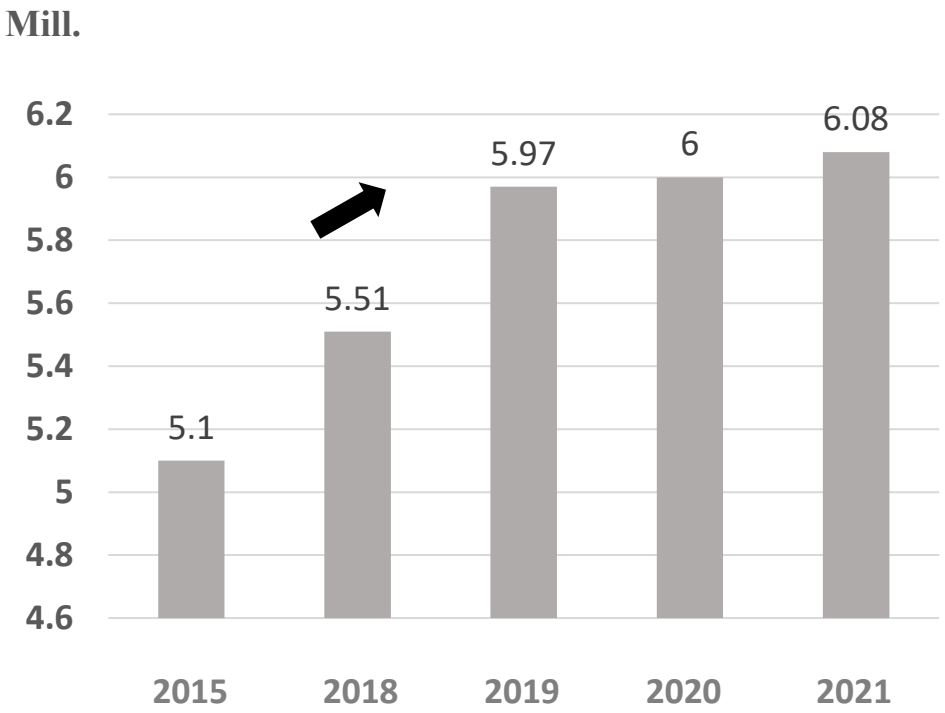
Department of livestock production (August, 2022)

Import market of slaughtered beef in Vietnam



Department of livestock production (2020)

Number of beef cattle in Viet Nam



Growth rate 3%

General Statistic Office (August, 2022)

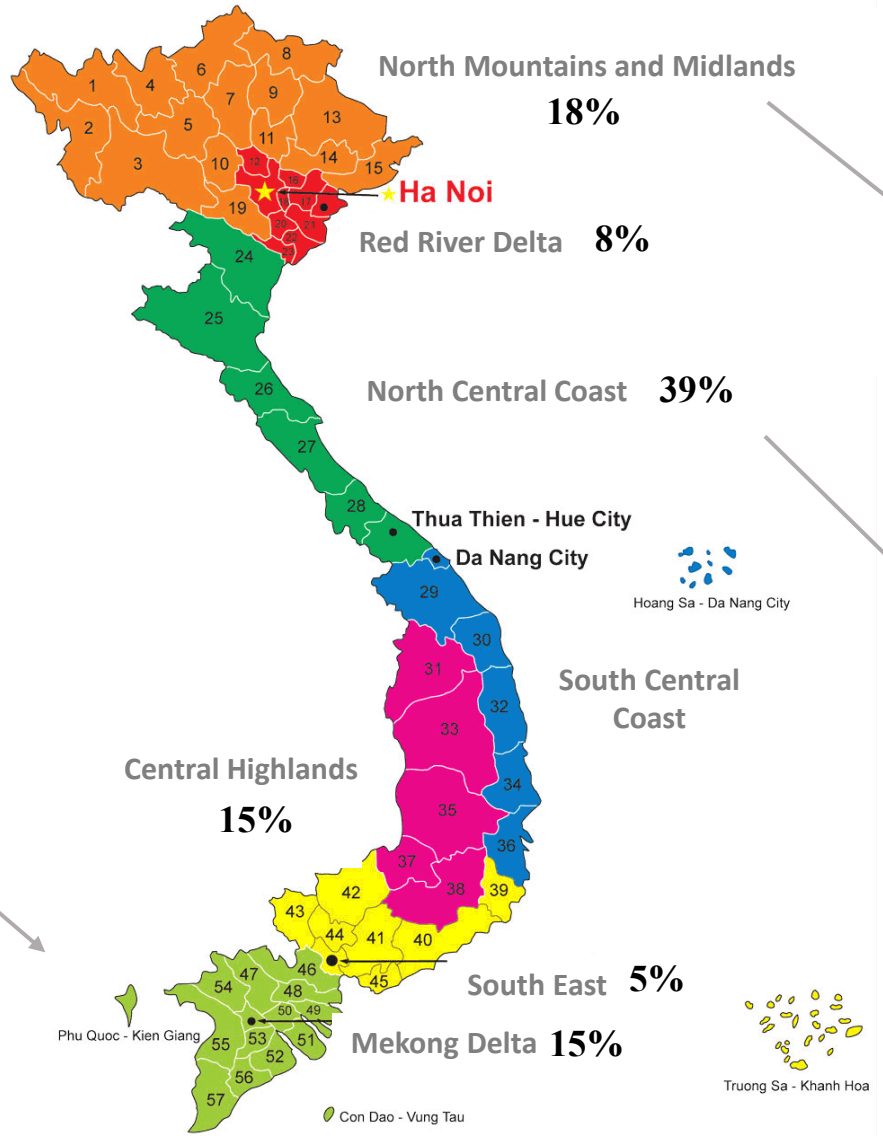
Profits from beef cattle in Vietnam are quite attractive with both smallholder and enterprise. Beside domestic market, Vietnam also exports live cattle to Chinese. The livestock industry sets a target of 550 thousand tons of beef by 2025, and from 600 to 650 thousand tons by 2030.

Early 2020, the world's largest cow ship carried 13,000 Australian cows to Hoa Phat's breeding farms

https://www.hoaphat.com.vn/news

Distribution of beef cattle heads in Vietnam 2021 in regions

In two major deltas of Vietnam (Red River Delta and Mekong Delta), cattle fattening is developing as a profitable farming activity in the medium-size family farms that are near major consumption centers and benefit from a considerable amount of rice straw of developed rice production areas.



General Statistic Office (June, 2022)

The medium-scale farms with relatively large cattle herd sizes making collective use of natural pastures have been identified as the most promising farm type for future development of profitable beef production in Northern mountainous provinces (Huyen et al., 2010)

North Central Coast Vietnam has the highest cattle production of Vietnam. However, beef cattle in this region are still raised at smallholder product system and the cattle production is mainly extensive or semi-intensive with three main rearing systems including i) free grazing, ii) grazing and feeding supplementation and iii) stall feeding (Dung et al., 2019).

Beef cattle farming system in Vietnam

Before 2000

State-run farms
Small holders

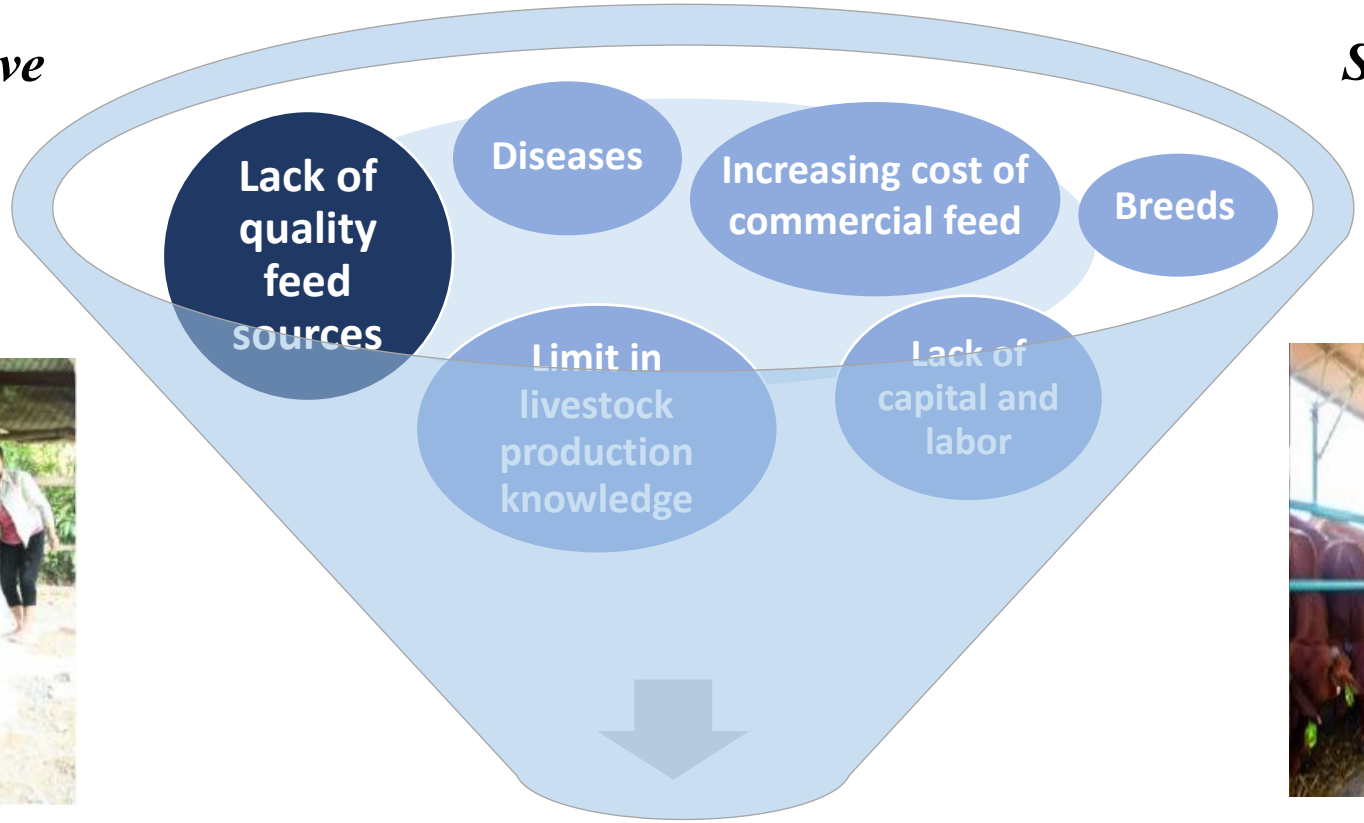
2000

The government decided to define commercial farms

After 2000

Commercial farms
Small holders

Extensive or semi-intensive



Semi-intensive or intensive

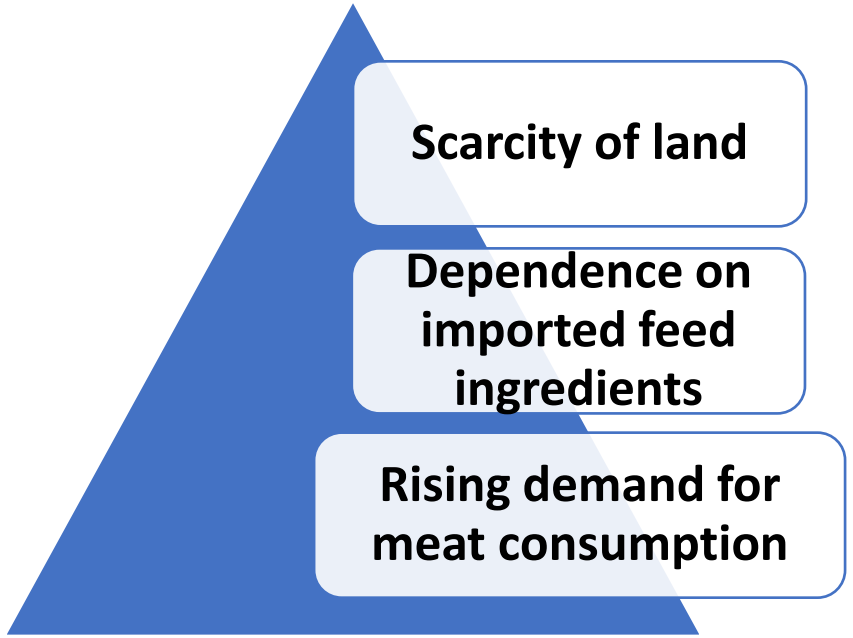
Constraints to Vietnam beef production

Crop by-products as catlle feed in Vietnam

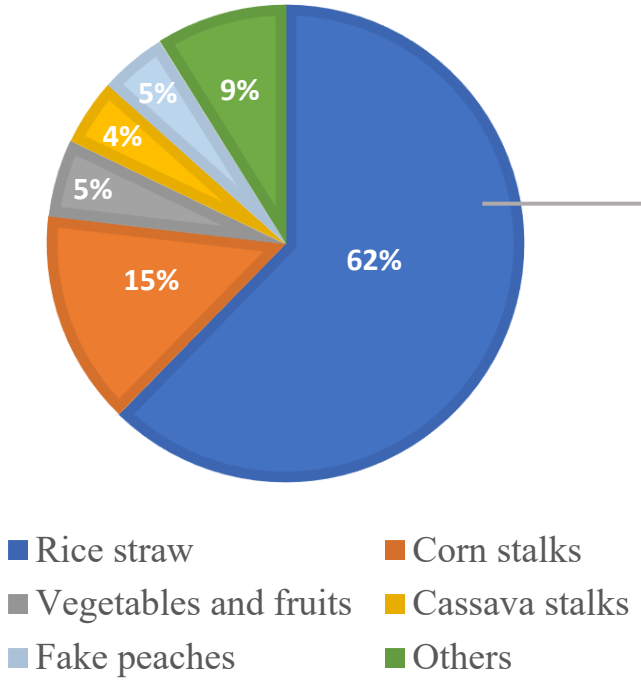
- ✓ Since Vietnam lacks of grazing land, beef cattle depend on cut grasses and by-products such as rice straw, maize foliage, cassava foliage and banana stem… (Huong et al., 2018).
- ✓ About 62-93 million tones of forage are needed for raising cattle, however; cut grasses and pastures only meet about 35-57% total forage demand leading to significant reduction of beef cattle herd number in dry or winter seasons (Nguyen et al., 2020).
- ✓ The total volume of by-products in 2020 in Vietnam is over 156.8 million tons, 88.9 million tons of crop by-products accounting for 56.7% (MOET, 2020) that have not been used efficiently.

Sustainable development of cattle production

An urgent need to better utilization of by-products to ensure the sufficient supply of forage



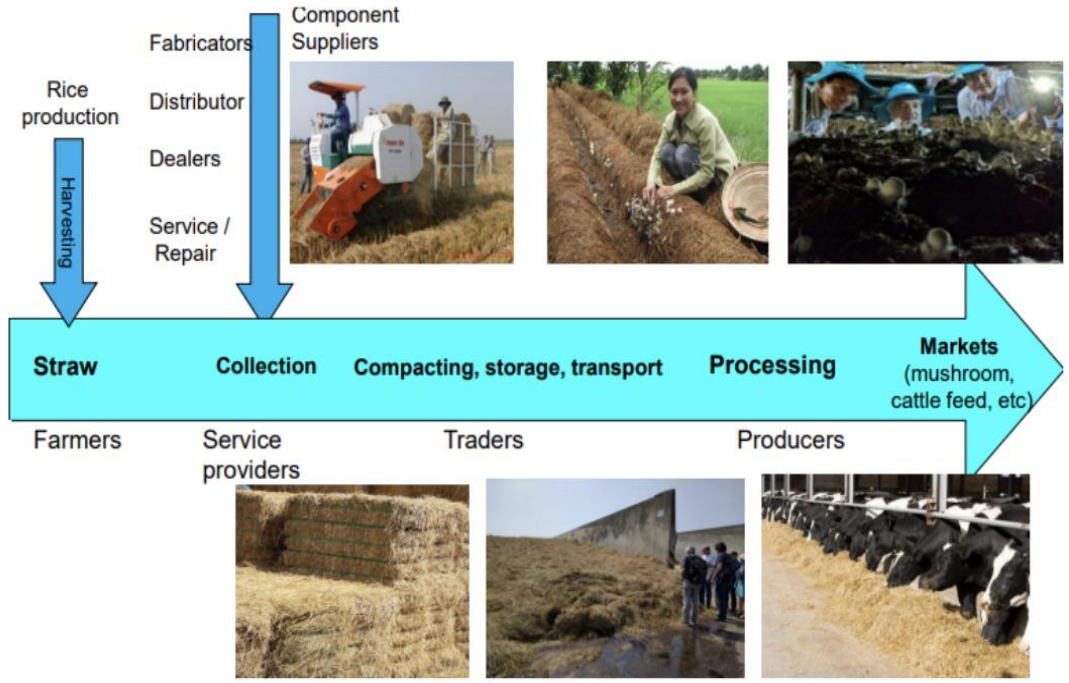
Crop by-products after harvest



MONRE, 2020

Vietnam has 44 million tonnes of rice straw. About 90% of rice production area is harvested by combine harvesters which only cut 1/3 upper top of rice (Hung et al., 2016). Rice production annually generates approximately 13 million tonnes of dry collectable rice straw as a sustainable feed for ruminant.

Rice straw supply chain and value chain in Vietnam



Nguyen, 2019 (J.Viet.Env. 11(2): 95–103

Crop by-products used for beef cattle in Viet Nam

Cassava leaf

Rice straw

Sugar cane by-product

Cassava pulp fermented

Pineapple by-products

Brewer grain

Mulberry leaf

Maize stalk

Chemical and major mineral compositions of rice straw

Compositions	Fresh rice straw	Dry rice straw
pH	6.1-6.4	5.9-6.4
Dry matter (DM) %	26.3-34.4	81.5-92.1
Organic matter, %DM	82.6-89.5	83.7-90.0
Crude protein, %DM	3.2-7.3	2.0-6.6
Crude fat, %DM	0.7-1.6	0.6-1.7
Crude fiber, %DM	27.4-43.2	30.1-42.5
NDF, %DM	63.4-72.5	66.3-73.2
ADF, %DM	34.8-43.5	36.3-42.6
Hemicellulose %DM	23.0-32.2	26.6-33.5
Cellulose, %DM	30.4-35.8	32.8-47.0
Lignin, %DM	4.3-12.5	4.0-13.2
Silica, %DM	4.4-13.0	5.9-12.8
Total Ash, %DM	10.5-17.5	10.0-16.3
Calcium, g/kg^{-1} DM	4.9-5.6	3.7-5.4
Phosphorus, g/kg^{-1} DM	1.2-1.9	1.7-2.3

Nguyen et al., 2020. Pak.J.Nutr., 19(3):91-104

- ✓ Anti-nutritional factors (silica, lignin)
- ✓ Low and unbalanced nutritive contents
- ✓ Low voluntary intake
- ✓ Slow rate of digestion
- ✓ High dry matter content, rich source of fibers

Limit the use of rice straw as catttle feed

The important key to enhance the nutritive value of rice straw is to overcome their inherent barriers to improve rumen microbial fermentation!

Possible treatments to improve rice straw

1. Physical treatment (soaking in water, grinding, pelleting)
2. Chemical treatment (urea, lime, ammonia). Urea is the most popular used treatment of rice straws
3. Biological treament including bacteria, fungi and enzymes
4. Supplementation with local feed resources

Supplements	Breed	Effects	References
Cassava root meal and groundnut cake	Lai Sindhi	Increased dry matter intake and live weight gain	Trung et al., 2014
Elephant grass and cassava powder	Lai Sindhi	Increased digestibility of nutrients and live weight gain	Ba et al., 2008
Cassava leaf meal and the mixture of molasses and urea	Lai Sindhi	Improved growth performance and feed conversion	Tham et al., 2008
Urea-sprayed and wet brewers'grains	Lai Sindhi	Improved feed intake and growth rate	Trach and Thom, 2004
The mixture of cassava chips, rice bran, crushed rice grain, fish meal, urea	Crossbred Brahman	Increased digestibility of nutrients, live weight gain	Quang et al., 2015
Mulberry leaf meal	Crossbred Brahman	Improve dry matter intake, ruminal NH_3-N and rumen ecology	Tan et al., 2012

- ✓ Rice straw has not been maximally utilised for beef cattle. It is usually fed as part of the forage component in cattle diets when fresh forage is insufficent.

- ✓ Rice straw (54-87%) has been burned on fields after harvest, causing environmental pollution.

- ✓ How to livestock production in parallel with reduction of environment pollution, in particular, methane mitigation of cattle production!

→ Technological nutrition solutions to increase protein level in diet through the improvement of the nutritional quality of rice straw, in particular to reduce the rumen methane production.

Utilization of rice straw with micro-organism as high quality feed for beef cattle is potential solutions for improvement of cattle production in a sustainable agriculture

Development of beef cattle production of smallholders

Nutrition

Breed

AgriFose 2023 project: “Sustainable rice-straw management for improving farmer livelihoods and low environmental footprint in rice-based production systems” – Sweeden

Treated rice straw as catlle feed in Vietnam

Effects of copra meal or concentrate feed supplementation on growth and methane production of cattle fed rice straw and cassava pulp (Lan et al, 2019)

Feed intake

Parameters	Treatments				SEM	P
	RS-CP	RS-CP-EG	RS-CP-CF	RS-CP-CM		
Rice straw, kg/100kg LW	1.27^{ab}	0.56^{c}	1.25^{b}	1.30^{a}	0.057	0.001
Cassava pulp, kg/100kg LW	2.40^{a}	0.98^{c}	1.25^{b}	1.35^{a}	0.039	0.001
Elephant grass, kg/100kg LW	-	2.44	-	-	-	
Copra meal, kg/100kg LW	-	-	-	1.18	-	
Concenetrate, kg/100kg LW	-	-	1.76	-	-	
Total DMI, kg	3.67	3.98	4.25	3.84	0.137	0.051
DMI/100kg LW	2.30	2.40	2.45	2.25	0.010	0.001

Methane production

Parameters	Treatments				SEM	P
	RS-CP	RS-CP-EG	RS-CP-CF	RS-CP-CM		
CH_4, litter/head/day	137.4^{a}	132.3^{a}	125.6^{a}	131.1^{a}	3.447	0.163
CH_4, litter/kg DM intake	42.00^{a}	39.20^{b}	31.27^{c}	32.69^{c}	0.540	0.001
CH_4, litter/kg LWG	621.7^{a}	441.6^{b}	317.6^{c}	374.80^{c}	15.81	0.001

Economic efficiency from cattle fed rice straw and cassava pulp supplemented with copra meal or concentrate feed (Lan et al, 2019)

Parameters, milion VND	Treatments				SEM	P
	RS-CP	RS-CP-EG	RS-CP-CF	RS-CP-CM		
Investment total	0.53 ^{d}	1.06^{c}	1.49^{a}	1.04^{b}	0.036	0.001
Income from LWG	1.89^{c}	2.39^{b}	2.84^{a}	2.65^{a}	0.065	0.001
Economic efficient	1.36	1.33	1.35	1.60	0.062	0.022
Compared with control, %	100	98.2	99.5	118	-	-

Ways to reduce methane production in ruminant (Mandi Jones, University of Nebraska–Lincoln, 2014)

Enteric methane mitigation strategies animal & feed management

- Feed processing
- Genetic selection
- Improving animal health
- Improving pasture management
- Increasing feeding level
- Increasing forage quality
- Optimizing temperature
- TMR feeding

Diet formulation

- By-products
- Decreasing forage-to-concentrate ratios
- Minerals and salts
- Oils and fats
- Oilseeds
- Increasing protein
- Tanniferous forages
- Urea
- **Seaweed!**

Rumen manipulation

- Additives
- Defaunation
- Electron sinks

Reduce methane mitigation by HCN in cassava

Principles of reduction in enteric CH_4 production

- Reducing H_2 & CO_2 production (Ionophores).
- Reducing protozoa or Defaunation- prevention of interspecies H_2 transfer (Fats, Saponins, UMMB).
- Enhancing propionate production (Acrylate, Organic acids)
- Rechanneling H_2 & CO_2 to acetate (Enhancing acetogenesis).
- Reducing or killing methanogens (AQ, BES, Vaccines).
- Use of alternate electron sink (OA, Nitrate, Sulfate).
- Enhancing hydrogen utilizers (Microbes) .

(Hossain, 2007)

- **Cuzin and Labat 1992!**
  - **HCN is toxic to bacteria that produce methane.**
  - **Cassava is excellent source of HCN.**

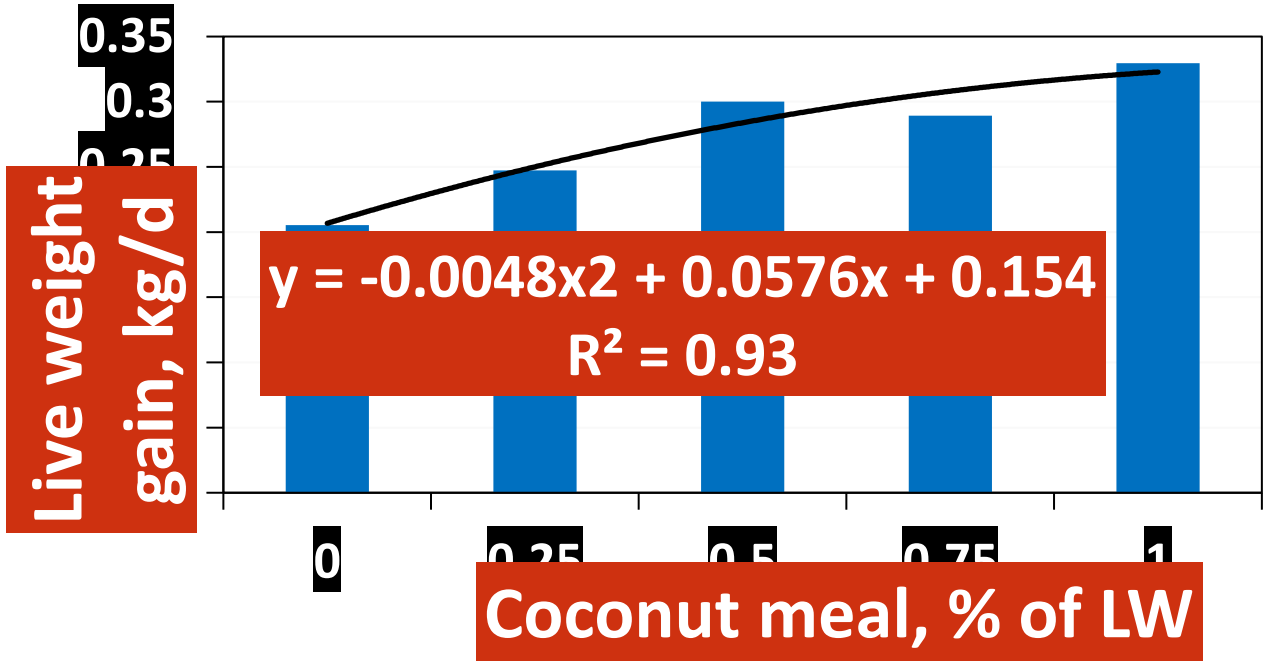
Utilization of available feed resources for increasing performance & reducing enteric methane production of cattle (Sangkhom et al, 2019)

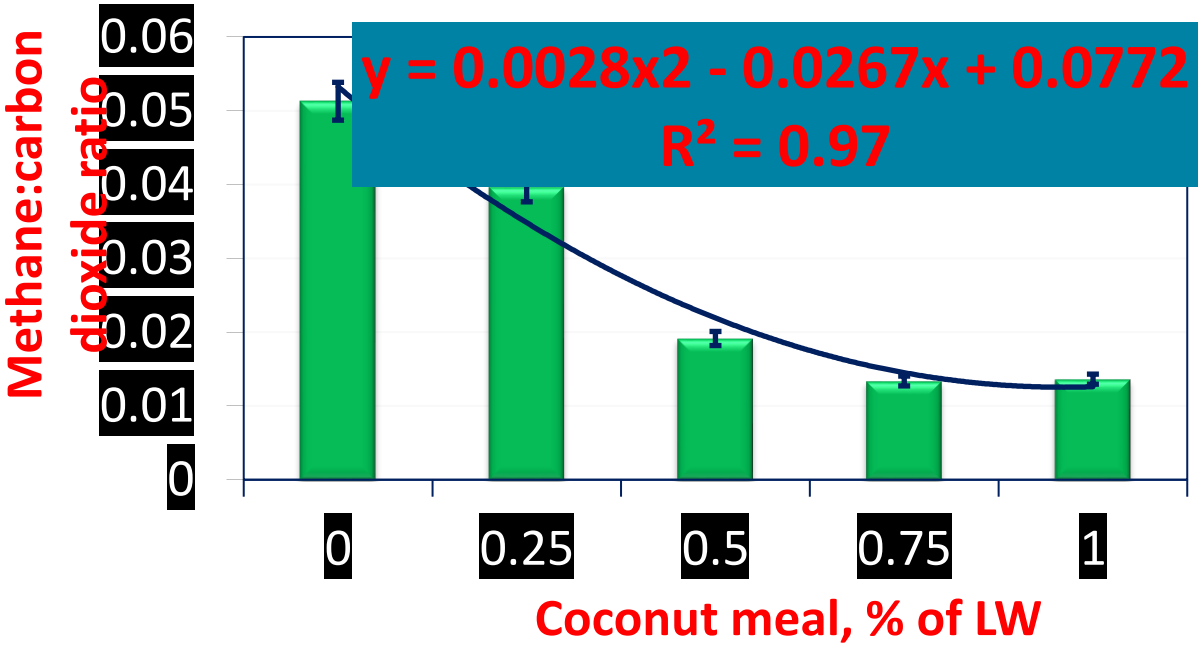
Rice distillers' by-product improved growth performance and enteric methane from "Yellow" cattle fed a fattening diet based on fermented cassava root and foliage (Sangkhom et al, 2019).

To determine the effect of Rice distillers' by-product on growth rate & enteric methane emissions from cattle fed cassava root fermented; CSF & RS as basal diets.

- **Growth rate and FCR in cattle were improved by 40 and 20%.**
- **Rice distillers' increased rumen propionic acid and reduced by 26% the ratio of CH_4 to CO_2.**

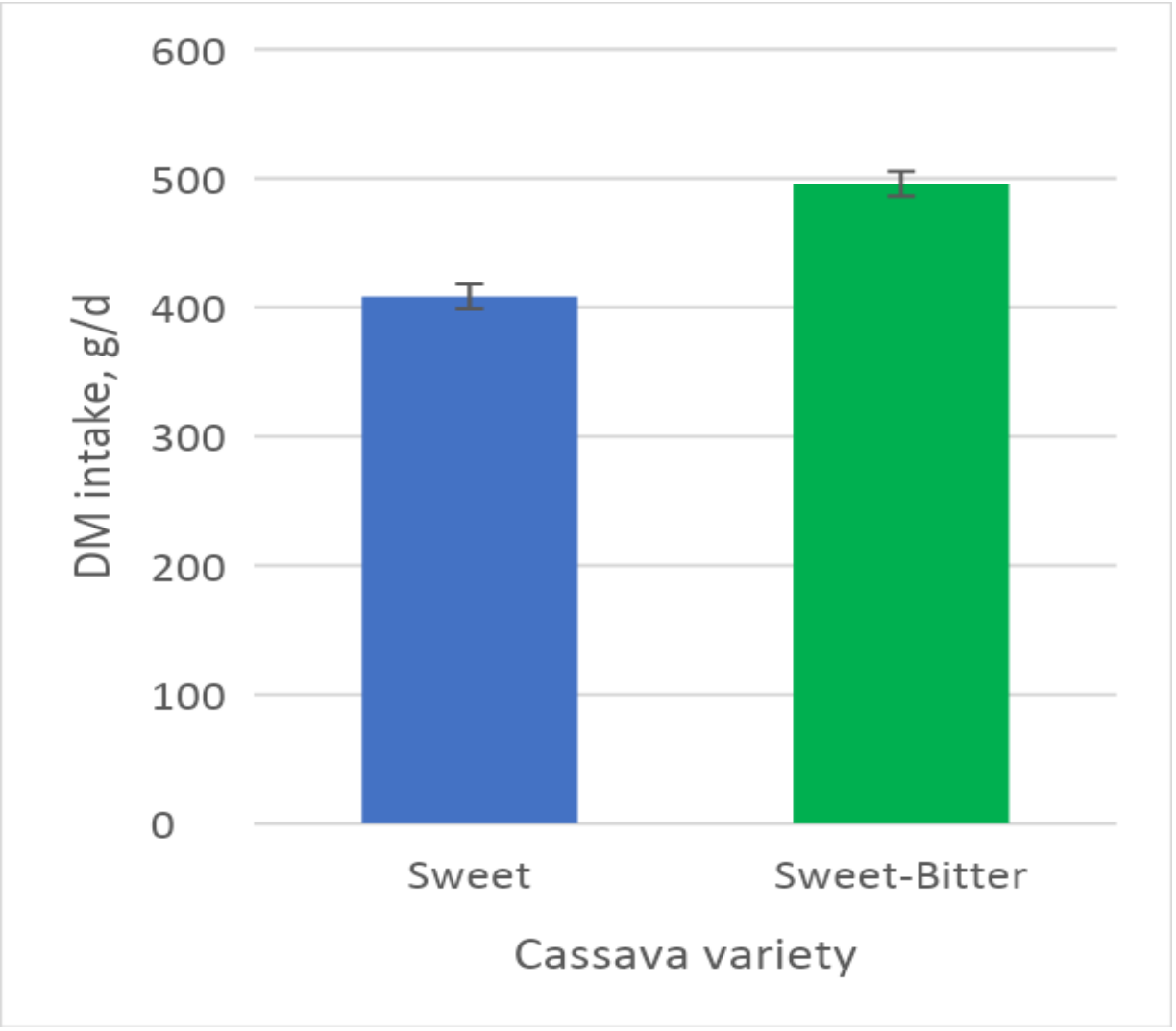
Live weight gain and ratio of CH_4:CO_2 of cattle fed elephant grass and cassava pulp (Duy et al, 2017)

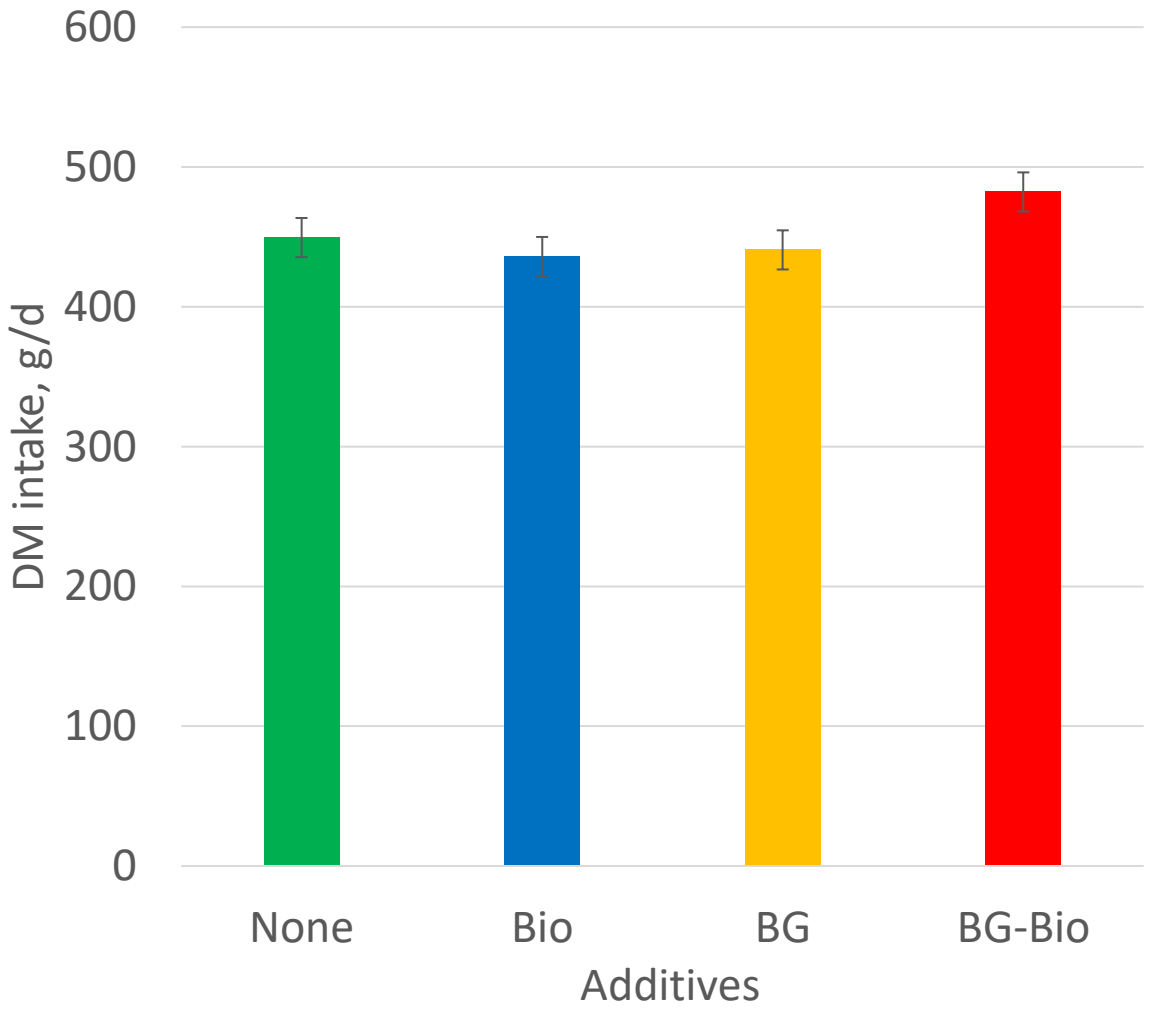




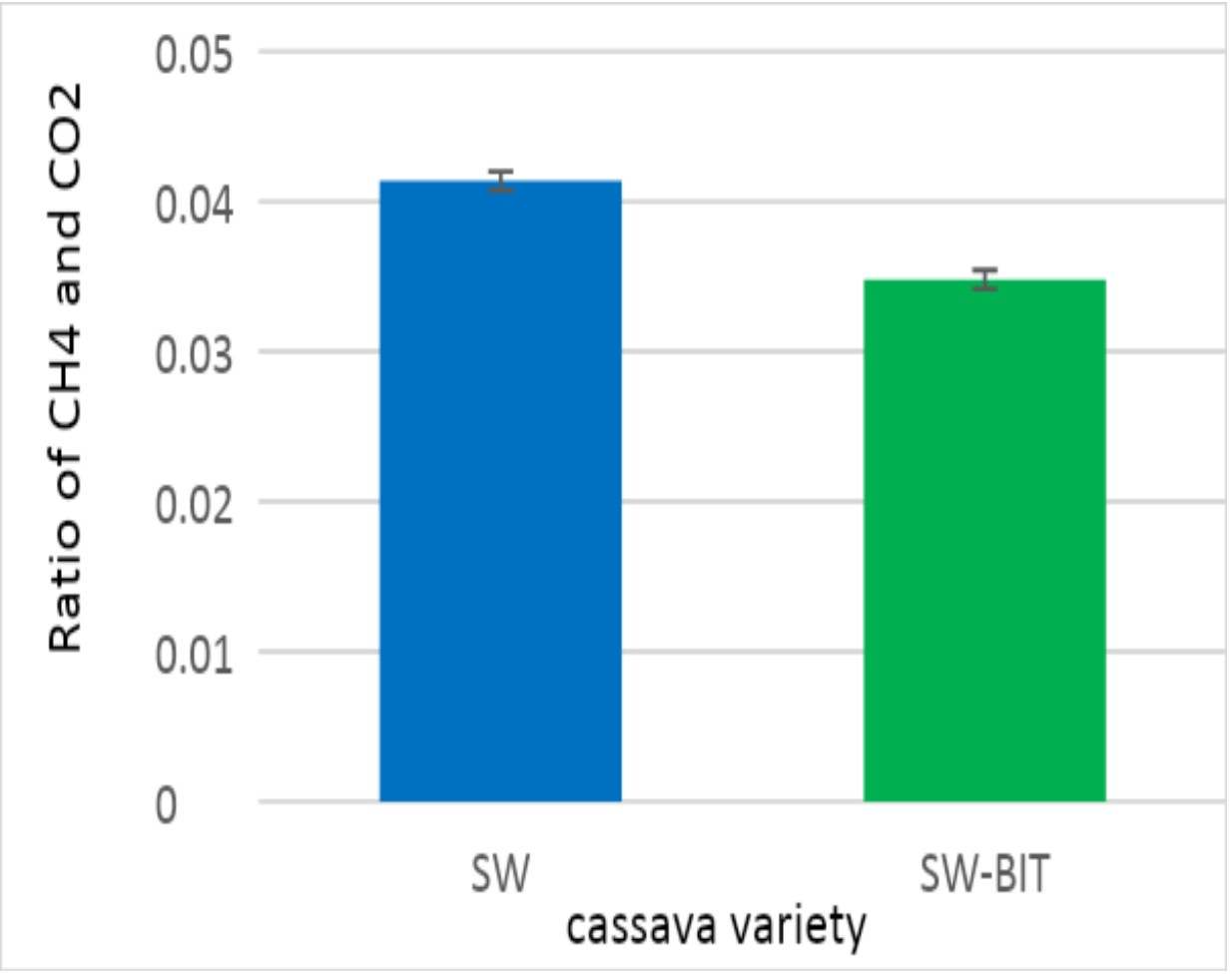
Effect of difference varieties of cassava foliage on methane emissions and ruminant performance (Phuong et al, 2019)

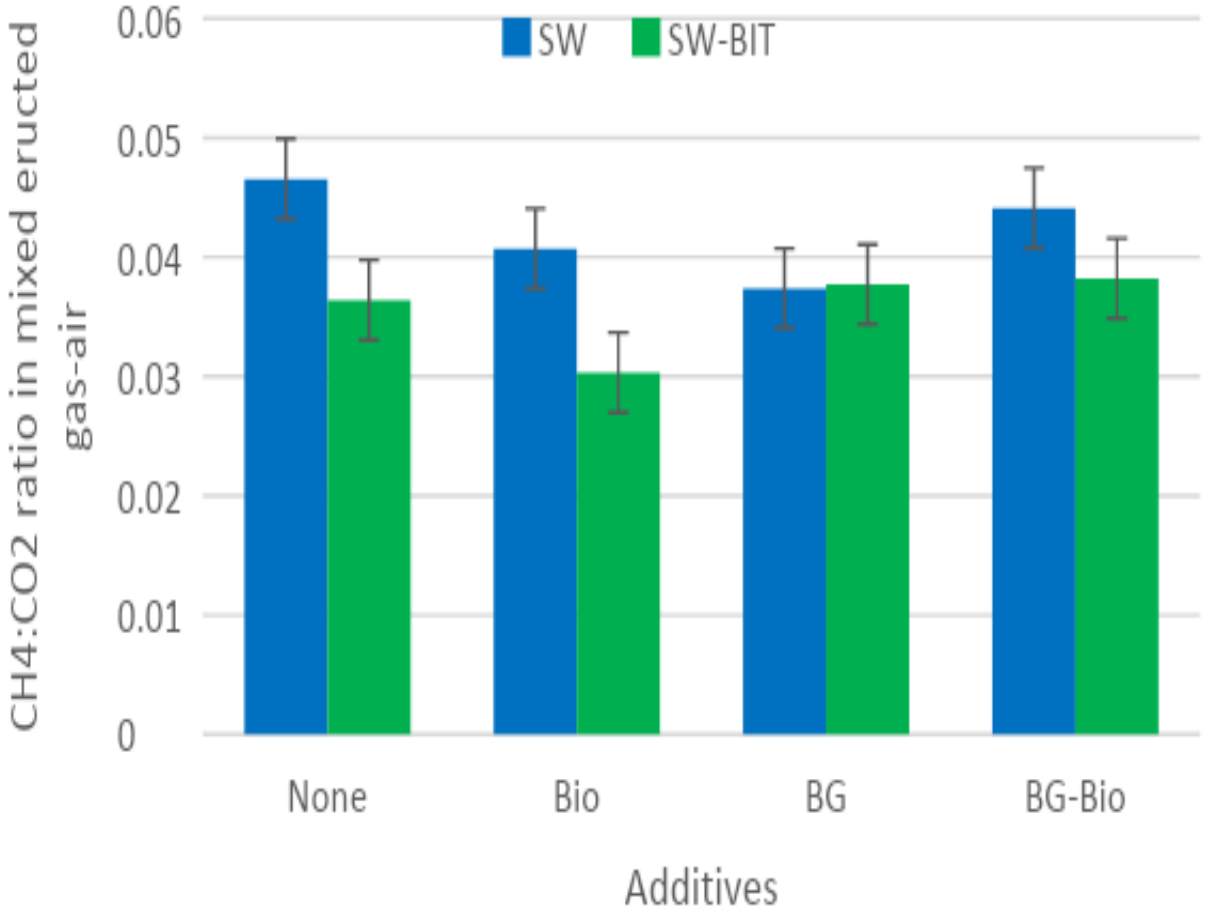
DM intake





Ratio of CH_4:CO_2 (Phuong et al, 2019)





Research and apply the methane mitigation in agricultural systems!

Transfer the agriculture toward circular and low-carbon systems!

Crops

Watering system

Food source

Farm households

Ruminant

Fish pond

Human feces

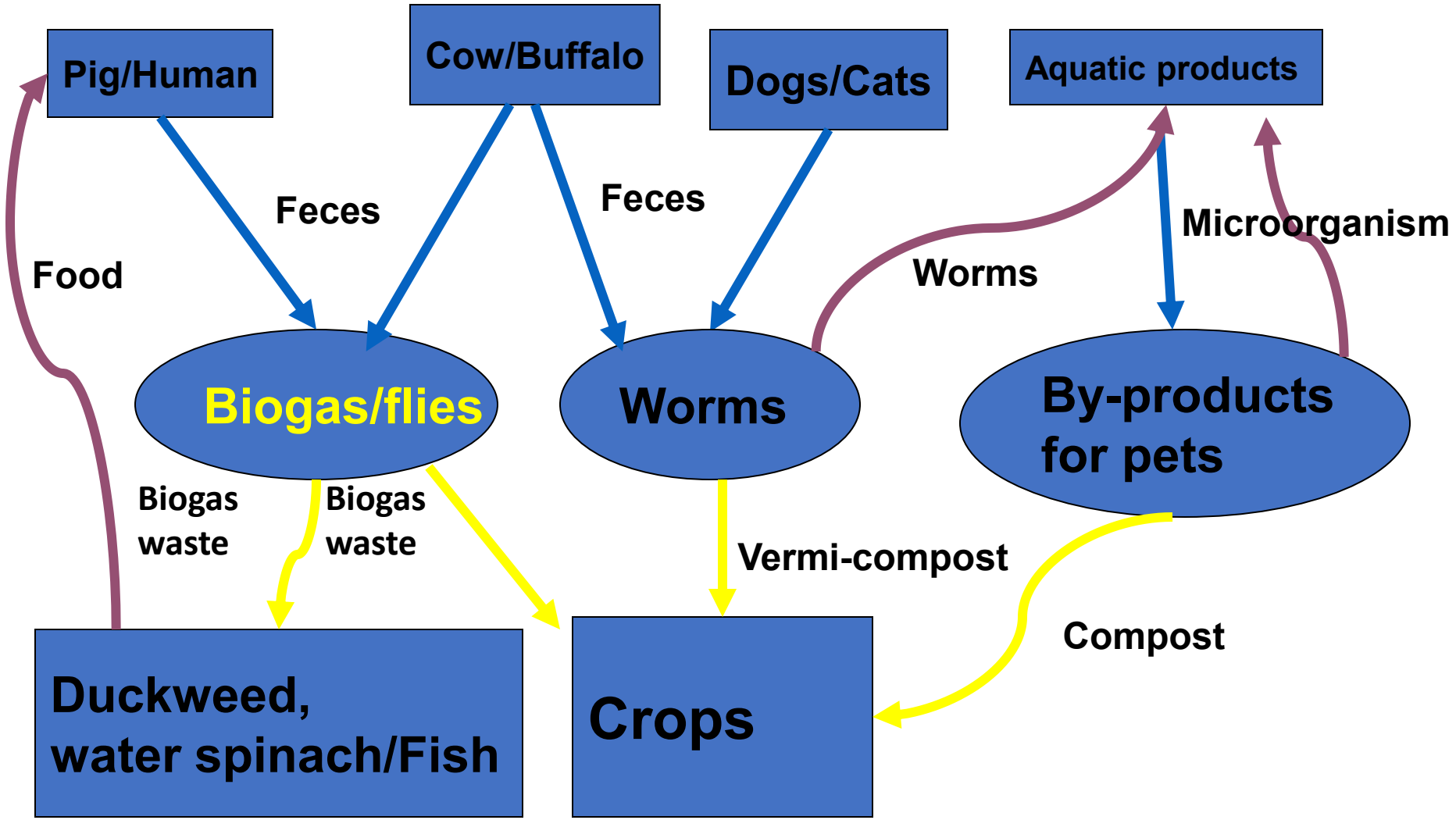
Biogas waste

Cattle manure

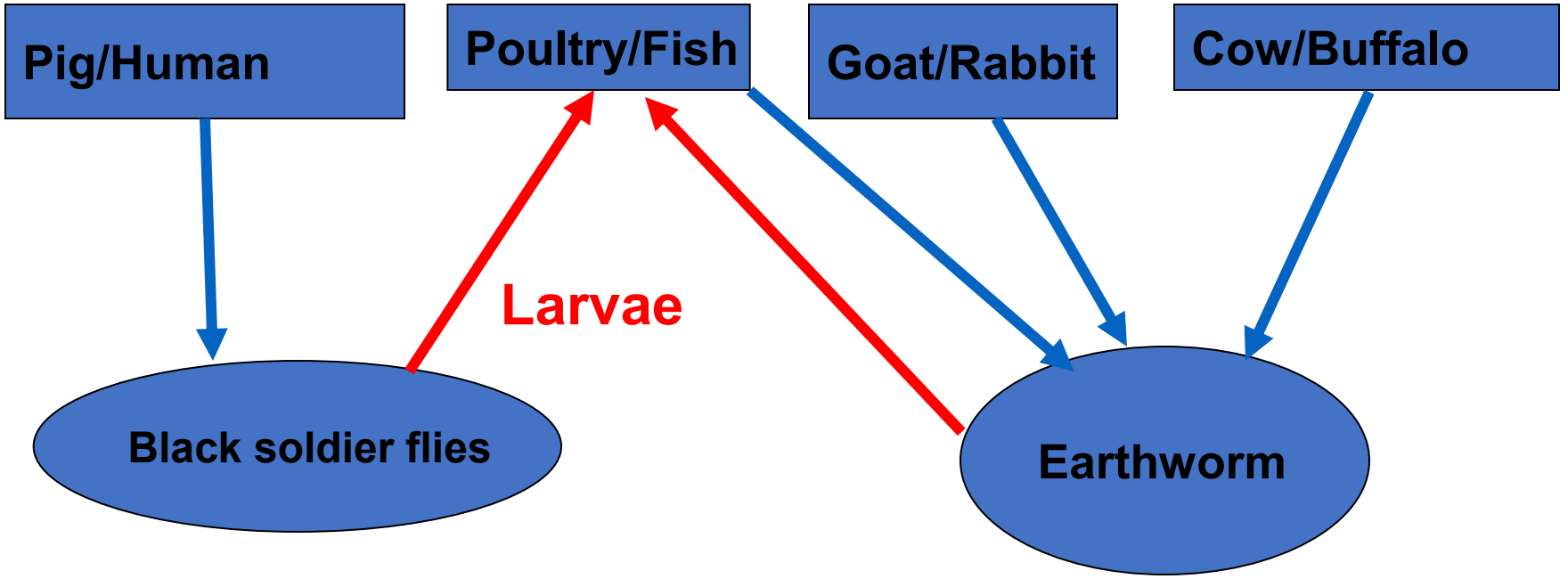
Circular agriculture system (Preston, 1990)

Biogas

Recycle livestock manure

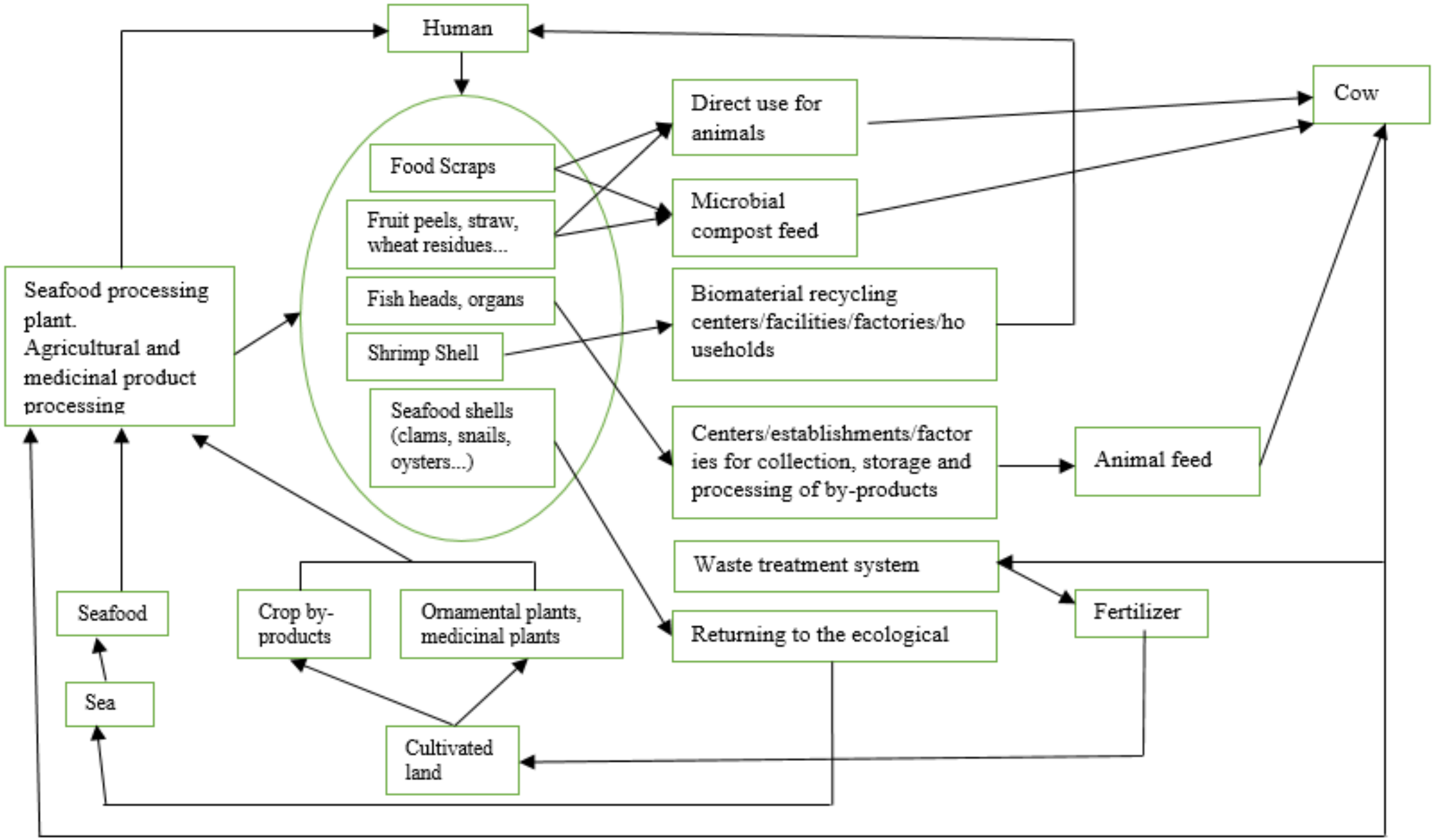


Recycle feed/food wastes



Livestock and agricultural products

Circular agricultural production



Cross or best local breeds!

Beef cattle:
- High yield: BBB, Charolaise, …
- High quality: Waygu, Angus, …

Dairy cows:
- High yield: HF, Jersey,…
- Milk quality: 2A, omega,…

Red Angus male

Red Angus female

BBB male

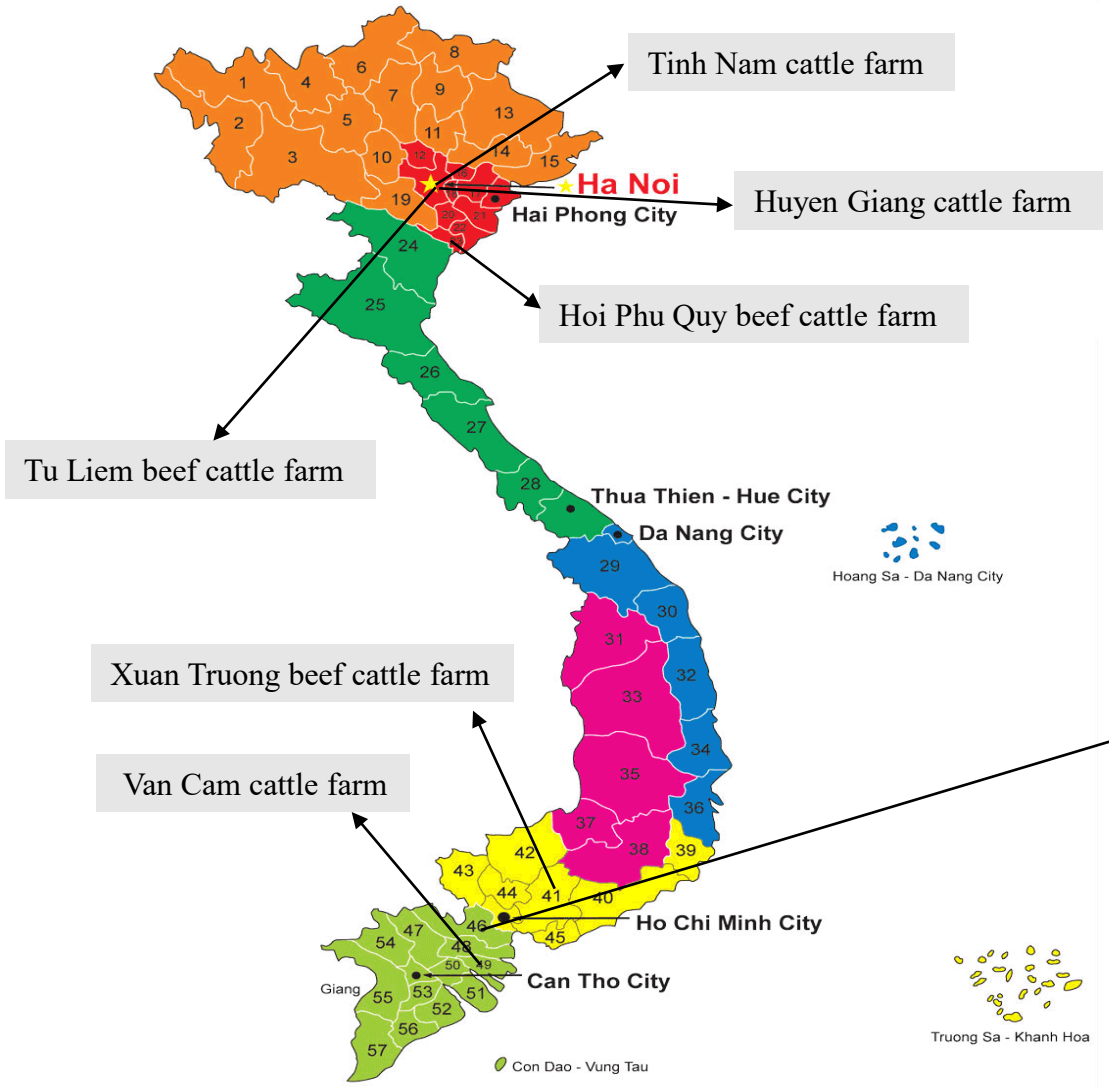
BBB female

BBB cattle in Belgium

Processing and using agricultural by-products: rice straw!

500 M tons in Asia region, 50 M tons in Vietnam!

Cassava pulp: fresh or ensilage as the basis of intensive fattening of cattle!



Potential demonstration farm for innovative feeding

For the implement of applied research on innovative feeding of Micro-organism treated rice straw:

- ✓ Number of experimental beef cattle: 20
- ✓ Weight average = 250 kg
- ✓ Randomly distributed into 2 groups: control and treatment based on live weight, age…(n=10)
- ✓ The control group is fed with basic ration. The treatment group is fed with basic ration adding Micro-organism product

Duc Ngai 1 beef cattle farm

- ✓ *Location: Chanh quartier, Duc Lap Thuong, Duc Hoa, Long An*
- ✓ *Farm scale: 200 heads*
- ✓ *Owner: Ms. Cao Thi Thuy Ngan*

Potential researchers/extension officers will be engaged

Number of researchers/extension officers will be potentially engaged: 5-6 persons

Estimation of expenses

Research plan:

- ✓ Land and barn
- ✓ Start 20 fattening cattle (BBB crossbred), weight of 250 kg.
- ✓ Expected weight gain: 1kg/head/day
- ✓ Breeding: 6 months (180 days)
- ✓ Weight of cattle after 6 months (kg/head) = 250 + 1*180 = 430 kg
- ✓ Average weight (kg/head) = (430 - 250)/2 + 250 = 340 kg
- ✓ Weight of feed/head/day (3% CF): 10.2 kg
- ✓ Cattle are fed with diets: forage (16 % DM) and commercial feed pellets (88 % DM)
- ✓ Price of raw materials: commercial feed pellets (13,000 VND/kg), forage (1,200 VND/kg).

Category	Expense, USD
Breeding	
- Option 1: Renting (negotiated price)	Negotiated
- Option 2: Purchase	21,000
Feeding for 6 months	
- Forage	4,000
- Commercial feed pellets	15,000
Others	
- Labor	3,000
- Water and electricity	570
- Direct material cost	380
- Medical and vaccine	570

Measurements:

- ✓ Feed intake
- ✓ Body weight gain
- ✓ FCR
- ✓ Enteric rumen fermentation (CH_4 production , VFA, rumen microorganism, pH)

Brief results of the survey on rice straw in Long An province:

1) In-field option: burning

2) Off-field option: foddering (cattle production)

Chopping rice straw for burning and incorporation

Packaging rice straw for foddering

Dong Xuan season (rain season Jun – Nov)

- Profit of rice straw (VND/ha)

  110 packs x 5.500 VND/pack = 600.000 VND/ha ($25)

- Rice straw yield: 16 kg/pack x 110 packs = 1.760 kg/ha

- The ratio of rice straw (tons)/rice seeds (tons): 1,8/6 = 30%

He Thu season (dry season Feb - Jul)

- Profit of rice straw (VND/ha)

  80 packs x 3.750 VND/pack = 300.000 VND/ha ($12,5)

- Rice straw yield: 16 kg/pack x 80 packs = 1,280 kg/ha

- The ratio of rice straw (tons)/rice seeds (tons): 1.28/5 = 25,6%

How to use the rice straw for cattle feed and bio-bedding

Rice straw for cattle feed

Incubation rice straw by lime

Fermentation rice straw by probiotic/prebiotic

Materials

Materials

Nylon bag

Pit

Alkalization (lime)

Microbial fermentation

Quality control

Process


CABIN
IRRI
AgriFoSe 2030
Treated rice straw for cattle feed
Rice straw from good agricultural practice field
Dried rice straw
Humidity<18%: can be stored for 6 months for use
Fresh rice straw
Humidity>18%: use immediately
Rice straw treated to soften, to increase digestion, to increase microbial activity by one of the methods:
2 kg lime + 2 kg urea + (50-80) liters of water/100 kg of rice straw
0.05 kg of probiotics + 0.1 kg of table salt + (50-80) liters of water/100 kg of rice straw
Rice straw incubated in nylon bag or pit
Or
1 nylon bag (16 - 20 kg rice straw)
Sealed bag
Incubate in a closed pit
Incubate after 7 days for feeding the cattle. Check, if it is moldy, it is not of good quality to feed the cattle
Moldy
After 7 days ✓Good
2 - 7 kg of treated rice straw/day/cattle

Rice straw bio-bedding
for treating manure and organic fertilizer

Materials

Prepare the floor of barn, microorganisms…

Practice the padding

Video

Conclusions & Recommendations

- Rice straw could be better use as the local available feed resources to ruminant, avoided pollution rice field in Asia countries.
- Feeding systems based on both conventional and non-conventional feeds are both complimentarily important, esp. high fibrous feeds (rice straw), crop residues, agro-industrial biomass, abundantly available in the seasons.
- Treatments of rice straw by micro-organism are important to enrich nutritive values, intake, digestibility and their subsequent utilization for ruminant productivity, especially for high-quality beef cattle production.
- Knowledge sharing this method to stakeholders with feed innovations is highly encouraged.
- Net-working establishment and connections should be fostered, strengthened in order to share and learn of this method findings and innovations to enhance stakeholders engaged in ruminant food chain…

Thank you for your attention!