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THE DECISION MAKING TO REDUCE CARBON EMISSION UNDER UNCERTAINTY OF HERBIVORE MEAT PRODUCTION

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ABSTRACT

Ox and buffalo are herbivores that are raised for their meat, however, production of ox and buffalo produce emission of both CO_2 and CH_4. The carbon budget of oxen and buffaloes during meat production were studied for the decision making to reduce carbon emission under uncertainty of ox and buffalo meat production. The decision made under uncertainty of this study that could analyzed environmental problems from the CO_2 and CH_4 gases are greenhouse gases which were emitted from faeces, enteric fermentation and respiration of ox and buffalo and the energy using of herbivore meat production at farms and slaughterhouses. The study showed that the carbon emission factors per unit from ox and buffalo farms and slaughterhouses in ox and buffalo meat production were 6.62×10^{-3} and 5.09×10^{-3} kg.C/kg.living weight/day, respectively. The carbon fixation factor in meat and organs, of oxen and buffaloes were 10.22×10^{-3} and 10.35×10^{-3} kg.C/kg.living weight/day, respectively and the rate of carbon massflow from grass and plants to oxen and buffaloes were 14.76×10^{-3} and 14.27×10^{-3} kg.C/kg.living weight/day, respectively. This study also showed the ratio of the carbon fixation in ox or buffalo meat and organs to the sum of carbon contents in grass, which humans cannot use the carbon in grass but herbivores can, of ox and buffalo were 0.69 and 0.72, respectively. The ratio of total carbon emitted per unit to total carbon contents per unit in grass of ox and buffalo meat production were 0.31 and 0.28, respectively. The ratio of total carbon emitted per day to carbon fixation per day in meat and organs of an ox and a buffalo was 0.45 and 0.38, respectively. Measures to reduce the amount of carbon emission that could be did another way. The first approach was prioritizing types of animals that should encourage the fed to produce meat. The second approach should take into account the times that farmers took to fed ox and buffalo to suit the increased weight to reduce unnecessary carbon emissions from farming with a period inappropriate. The third approach was the reduction in the number of oxen down and the increasing the number of buffaloes to compensate for the amount of meat produced with the same rate. Ox production produced more environmentally harmful carbon than buffalo production. For the same quantity of meat production it could be suggested that decreasing ox meat production and increasing buffalo meat production could be decrease of the environmental problems. According to theories and rules applied such as the pay off the matrix, the laplace rule, the maximax rules and the minimax regret rule in making the decision on environmental problems, it could be concluded that the buffalo meat production was the best alternative but the ox meat production caused highest environmental problems among these two alternatives of the herbivore meat production. Therefore, consumers should reduced emissions from meat consumption such as chosen buffalo meat consumption. It was suggested that the ox production should be reduced because it created the highest carbon emission.

Keywords: carbon, herbivore meat production, uncertainty.

INTRODUCTION

Ox and buffalo are herbivores that are raised for their meat, however, production of ox and buffalo produce emission of both CO_2 and CH_4. One product of carbon fixation is the protein in meat and animal products. The net carbon production is the rate at which carbon is fixed during growth. The net carbon production can be used to explain the time averaged C stocks by carbon weight per time (van Noordwijk, *et al*., 1997 and 1998). In agriculture, this stresses the need for methods, which go beyond simple calculations of the type:

$$\text{Emission rate} = \text{animal number} \times \text{emission factor} \quad (1)$$

The reduction of emissions of air pollutions is subject of international conventions, which include reporting of emissions in accordance with guidelines or guidebooks provided. With respect to emissions from agricultural sources, in particular from animal husbandry, the calculation procedure making use of partial emission factors for the various sources of emissions (animal house, storage, manure application, etc.) is being replaced by a mass flow concept for carbon species. The way to describe emissions from animal husbandry was to apply a mass flow approach, which depicts the pathways of C species strictly under the aspect of mass conservation (Dämmgen and Webb, 2006).

Simpler methodologies calculate overall emissions in animal husbandry using fixed amounts per animal or animal place such as illustrated in Figure-1 where; E is the emission (kg × area^{-1}).

$$E_{total} = E_{metabolic} + E_{grazing} + E_{housing} + E_{storage} + E_{spreading} \quad (2)$$

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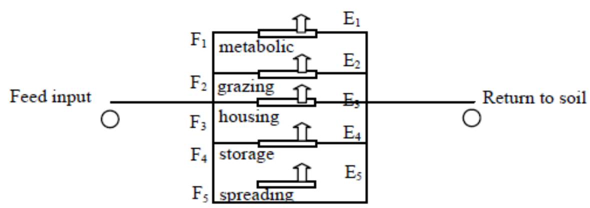

Figure-1. Losses from animal excreta due to metabolic processes, during grazing, housing, storage and spreading according to the approach using "classical" partial emission factors for parallel flows. F denotes fluxes and E denotes emissions. (Dämmgen and Webb, 2006).

For a given number of animals, total emissions are calculated using the sum of the partial emission factors where; n is the number of animals considered and EF is the emission factor (kg × $animal^{-1}$ × $area^{-1}$).

$$E_{total} = n_{animal} \times (EF_{metabolic} + EF_{grazing} + EF_{housing} + EF_{storage} + EF_{spreading}) \quad (3)$$

Crops produced can serve as animal feed. They are inputs into the animal subsystem. In the animal subsystem, direct metabolic emissions will occur, in particular of CH_4 from enteric fermentation. C excreted are then stored and eventually spread. These flows and the respective emissions are dealt with in the manure management subsystem. Slurry and manure treatments are important measures to reduce emissions (Dämmgen, *et al*., 2003).

Carbon is an important element for humans because it is the primary element of both plants and animals and cycles through living and non-living components (Ichhponani, *et al*., 1971). The focus of this study is on carbon which is transferred to the food chain and fixed in ox and buffalo. Therefore it is important to study the relationship between the carbon emissions, carbon mass flow, and energy use for herbivores meat production.

Decision making under uncertainty

The results of this study could be analyzed environmental problems from the ox and buffalo meat production. The analysis was based on pay of matrix principle by using all alternatives were the energy sectors, carbon emission situations. Then make the decision follow theories and laws. The applied analysis using laplace rule to choose the alternative of the ox and buffalo meat production which cause the highest environmental problems by setting the probability of the equal situations. According to the laplace rule, it could be advised that the best alternative of the ox and buffalo meat production cause more environmental problems. The maximax rules was applied to indicate the problems of the alternative of the ox and buffalo meat production by selection of situations which got the maximum result and then selected the maximum result from every alternative again. It could be stated by this following mathematical model:

$$\max_i \left[\max_j P_{ij} \right] \quad (4)$$

Where, i = The alternative of the herbivore meat production
j = The situations of carbon emission
P_{ij} = Result from the application of the maximax rules

The minimax regret rule was applied to avoid the regret that the decision was already made in taking the poor alternative. The maximum result of each situation was considered to minus the all alternatives in each situation. Then the results were set the matrix form and selected the maximum regret in each alternative. Each alternative was selected to find minimum value again and could be shown as:

$$\min_i \left[\max_j R_{ij} \right] \quad (5)$$

Where, i = The alternative of the herbivore meat production
j = The situations of carbon emission
R_{ij} = Regret value from take the maximum of each situation minus the all alternatives in each situation

According to theories and rules applied such as pay off matrix, laplace rule, maximax rules and minimax regret rule in making the decision on environmental problems.

LCA methodology applied in this study

The Society of Environmental Toxicity and Chemistry are generally credits for the current LCA methodological framework. Recent standard by the International Organization for Standardization have defined LCA as the study related to the environmental aspects and potential impacts throughout the life of products from raw materials acquisition through production, use and disposal (Leng, *et al*., 2008). The International Organization for Standardization of 14000 series was formed to accept as providing a consensus framework for LCA (Rebitzer, *et al*., 2004). Inventory analysis involves data collection and calculation procedures to quantify the relevant input and outputs of a product system. These inputs and outputs may include the use of resources and releases to air, water and land associated with the system (Thu Lan, 2007). Life cycle study, data collection represented a time consuming task and it was important to obtain quantitative information concerning various processes in the product system. A significant part of data associated with ox and buffalo

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production life cycle were collected from ox and buffalo farms and slaughterhouses. Data for carbon emission, mass flow and energy consumption, resources and material were obtained directly from ox and buffalo farms and slaughterhouses. A useful instrument facilitating the estimation of gas emissions was the emission factor, which was a representative value attempts to link the associate with the system output. The process of impact assessment analyzes the environmental burdens associated with the material and energy flows determined in the inventory analysis phase though successive steps listed as follow classification, characterization, normalization and weighting (Curran, 1996). The study of life cycle assessment to evaluate carbon emission for the ox and buffalo meat production was shown in Figure-2.

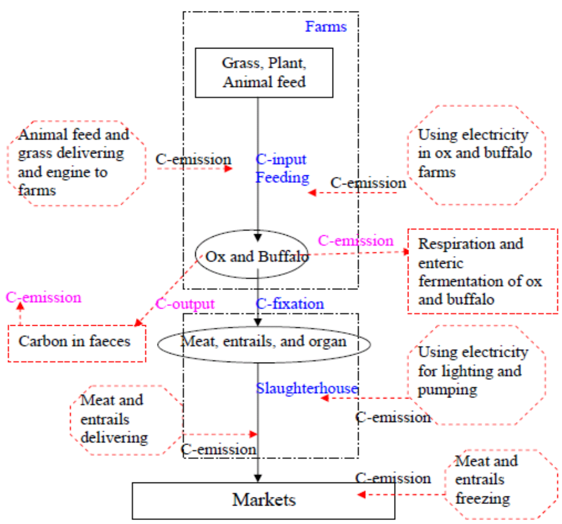

Figure-2. Life cycle assessment to evaluate carbon mass flow for the ox and buffalo meat production.

The final phases of LCA were made based on the combination of findings from the inventory analysis and the impact assessment, consistent with the objective and scope definition. The environmental impact potentials in global warming were calculated in this step. This environmental impact in global warming was caused by the emission of green house gases such as CO_2, CH_4, N_2O, and etc. Thanee, *et al.* (2009b) concluded that CO_2 emission was 0.18 kg C/kWh, CO_2 emission from LPG was 3.0102 kg CO_2 eq./1kg.LPG, CO_2 emission from diesel oil was 0.61 kg C/L and CO_2 emission from gasoline was 0.57 kg C/L, and Keeratiurai (2012) have suggested CO_2 emission was 74.5 kg.CO_2/1 Ton/500 km.

The calculations were carried out with the equation given below. The potential environment impacts were calculated as follows (Thu Lan, 2007).

$$\Sigma EP_i = \Sigma Q_i \times EF \qquad (6)$$

Where, EP_i = The emission potential contribution to the environment impact

Q_i = The magnitude of emission of substance

EF = The substance's equivalency factor for the environmental impact category

Size of samples, site sampling methods and analytical methods

We studied ox and buffalo farms and slaughterhouses, in 32 districts of Nakhon Ratchasima province. Nakhon Ratchasima province has an agricultural area of 12, 469.46 square kilometers which is the largest area of ox and buffalo farms in Thailand (Center for Agricultural Information, 2004). The numbers of farms, oxen and buffaloes in each district were calculated by determining the number of ox and buffalo farms and the number of oxen and buffaloes in the province at 95% confidence level (Cavana, *et al.*, 2000). Therefore, the sample groups were calculated by Taro Yamane's formula (Yamane, 1973) as follows;

$$n = \frac{N}{1 + Ne^2} \qquad (7)$$

Where, n = Sample size

N = Population size

e = The error of sampling

The sampling numbers were 398 ox farms, 390 buffalo farms, 17 slaughterhouses, 400 oxen, and 398 buffaloes. Grass and food for oxen and buffaloes, meat and faeces of oxen and buffaloes were collected and transferred to the laboratory at Suranaree University of Technology. The analytical methods were shown in Table-1.

Table-1. Methods for property analysis of animal feed, meat, entrails, gases, and faeces from oxen and buffaloes.

Properties	Analytical methods	References
Moisture content	By weighing sample after oven drying at 103-105 °C for 24 hours	Manlay *et al.* (2004)
Carbon content (C)	By CNS-2000 Elemental analyzer and gas analyzer	Manlay *et al.* (2004)
Volatile and fixed solids	By weighing the known weight of the sample after burning at 550 °C for 30 minutes	APHA, AWWA, WEF. (1992)
Weight of ox and buffalo	By weighing or using ox and buffalo weighing tape	Bunyavejchewin *et al.* (1985), Vudhipanee *et al.* (2002)

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RESULTS AND DISCUSSIONS

The rate of carbon massflow, carbon fixation, and the C emitted factors

This study determined that the rate of carbon massflow from grass for feeding to the biomass and faeces of oxen and buffaloes (C_{input}). The rate of transference of carbon contents from plants to ox and buffalo were 4.46 ± 1.93 and 6.51 ± 3.14 kg.C/head/day, (average ± standard deviation) respectively (Table-2). Table-2 shows the carbon fixation factors of ox and buffalo were 3.09 ± 1.97 and 4.72 ± 3.14 kg.C/head/day, respectively. Carbon contents were calculated by mass balance. The transference of carbon contents (C_{input}) minus the carbon contents emitted in faeces, enteric fermentation, and respiration ($C_{emitted}$) were the carbon mass fixed in the body ($C_{fixation}$). The carbon emitted factors for ox and buffalo were 1.376 ± 0.36 and 1.801 ± 0.51 kg.C/head/day, respectively. The results of this study also shown the percentage of the carbon contents transferred to ox and buffalo by feeding. The carbon mass fixed in the biomass of ox and buffalo were 69.18% and 72.38%, respectively, and emitted from faeces, enteric fermentation and respiration of ox and buffalo were 30.82% and 27.62%, respectively. Carbon emissions which contribute to environmental problems that buffalo encourage global climate change lower than ox because buffalo fixed the carbon contents in its body more efficiently than ox.

Table-2. The average of C_{input}, $C_{fixation}$, $C_{emitted}$, C_{output}, and $C_{emission}$ of CO_2 and CH_4 from ox and buffalo in farms.

Kind of animal	C_{input} transferred from plant by feeding (kg.C/head/day)	$C_{fixation}$ (kg.C/head/day)				$C_{emitted}$ (kg.C/head/day)			
		Total $C_{fixation}$	Meat	Entrails	Bone, skin, blood and etc.	Total $C_{emitted}$ from animal	Dried Faeces	$C_{emission}$ of CO_2 and CH_4 gases: Faeces	$C_{emission}$ of CO_2 and CH_4 gases: Enteric fermentation and respiration
Ox	4.46 ± 1.93	3.09 ± 1.97	0.031	0.0040	3.055	1.376 ± 0.36	0.894 ± 0.31	0.011 ± 0.005	0.471 ± 0.188
Buffalo	6.51 ± 3.14	4.72 ± 3.14	0.0198	0.0039	4.696	1.801 ± 0.51	1.120 ± 0.44	0.021 ± 0.012	0.660 ± 0.277

Table-2 also shows the ratio of $C_{emitted}$ per day from ox and buffalo to C_{input} per day of ox and buffalo by feeding were 0.31 and 0.28, respectively. This ratio of $C_{emitted}$ to C_{input} shows the contribution to global climate changes from buffalo is lower than for ox. This study shows that the percentage of meat to weight before killing of ox and buffalo was 46.55±11.96 and 34.65±7.14, respectively, the percentage of entrails to weight before killing of ox and buffalo was 8.52±2.61 and 8.32±1.06, respectively, and the percentage of skin, blood, and bone to weight of ox and buffalo that were killed in slaughterhouses was 44.93 and 57.03, respectively. The results also shown that the average weight of oxen and buffaloes before killing at slaughterhouses were 302.25±100.72 kg/head and 456.10±134.38 kg/head, respectively. The CO_2 and CH_4 gases are greenhouse gases which were emitted from faeces, enteric fermentation and respiration of ox and buffalo are shown in Table-3. The percentages of CH_4 and CO_2 gases emitted from faeces of ox was 23% and 77%, respectively and the percentages of CH_4 and CO_2 gases emitted from faeces of buffalo was 15% and 85%, respectively. The results also shown that the percentages of CH_4 and CO_2 gases emitted from enteric fermentation and respiration of ox was 17% and 83%, respectively and the percentages of CH_4 and CO_2 gases emitted from enteric fermentation and respiration of buffalo was 14% and 86%, respectively. Comparison of the ratio of CH_4 to CO_2 emitted from ox was 2.415×10^{-4} and buffalo was 1.359×10^{-4} that the ratio of CH_4 to CO_2 emitted from ox greater than the value for buffalo. These results were similar to the results of Ichhponani *et al*. (1971) observed that buffaloes digest cellulose was better than oxen. Therefore ox was contributing more global climate change than buffalo.

Table-3. The average of greenhouse gases from ox and buffalo in farms in Nakhon Ratchasima province.

Kind of animal	Average of gases	CH_4 (kg/head/day)	CO_2 (kg/head/day)	$CH_4 : CO_2$
Ox	Faeces	0.004 ± 0.002	0.031 ± 0.015	2.415×10^{-4}
	Enteric fermentation and respiration	0.104 ± 0.063	1.440 ± 0.618	
Buffalo	Faeces	0.005 ± 0.003	0.062 ± 0.035	1.359×10^{-4}
	Enteric fermentation and respiration	0.127 ± 0.068	2.069 ± 0.942	

Carbon contents of energy sectors for meat production

The ox and buffalo farms in Nakhon Ratchasima province used little energy for feeding. The first sector was electric light energy. The second sector was petrol used for animal transport. The third sector was petroleum for cutting grass and transferring it to farms for feeding.

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The $C_{emission}$ per unit of all 3 energy sectors at ox farms was 0.10 ± 0.14 kg.C/head/day, respectively. The $C_{emission}$ per unit of all 3 energy sectors at buffalo farms was 0.08 ± 0.16 kg.C/head/day, respectively. On the other hand, the slaughterhouses in Nakhon Ratchasima used energy for electric light and delivering meat from slaughterhouses to markets with $C_{emission}$ per unit of energy used by slaughterhouses for ox meat production was 0.52 ± 0.44 kg.C/head/day, respectively. The $C_{emission}$ per unit of energy used for buffalo meat production by slaughterhouses was 0.44 ± 0.40 kg.C/head/day, respectively. The total carbon contents of farms and slaughterhouses per unit in ox and buffalo meat production were 0.62 ± 0.58 kg.C/head/day and 0.52 ± 0.56 kg.C/head/day, respectively. The results showed that the carbon contents in energy pattern are less important for meat production.

Alternatives to reduce carbon emission of the herbivores meat production

While CO_2 and CH_4 were released from the oxen and buffaloes more than energy using for fed at the farms and the killing and butchering meat at slaughterhouses. Therefore, approaches to reduce CO_2 and CH_4 gases, especially CH_4 should considered the characteristics of the feed or adjustment reduced the ratio of roughage to concentrate food for reduced the amount of CH_4 gas that was released from the digestive process of the methanogenic bacteria that produced gas CH_4. Moe and Tyrell (1979) said that the roughage such as straw or hay required a long period of rumination. Roughage was difficult to digest and had high cellulose. Food groups that had cellulose would contribute to the production CH_4 gas more than the starch diet. Ichhponani *et al*. (1971) noted that buffalo digest cellulose, were better than ox and eructation of an ox had CH_4 gases more than a buffalo at the same of amount of food that were eaten. Measures to reduce the amount of carbon emission that could be did another way. It was prioritizing types of animals that should encourage the fed to produce meat. For example, to encourage the buffalo farming instead of the ox farming because of all carbon were emitted from buffalo and energy using for the production of buffalo meat was lower than the ox meat production. And should take into account the times that farmer took to fed ox and buffalo to suit the increased weight to reduce unnecessary carbon emissions from farming with a period inappropriate. Because of farmers did not the exact times to raising ox or buffalo. Most were sold to slaughter houses when they want the money. The result showed the relationship between the average body weight of an ox and buffalo at various ages as shown in Figure-3. The results of this study also showed the weight measurements of ox and buffalo at farms found that oxen were 61 - 608 kg/head at 0.17 - 14.84 years old and buffaloes were 63 - 861 kg/head at 0.17 - 20 years old. Figure-3 showed the relation of the weight of oxen and buffaloes with age that the equation as follow: growth $rate_{ox}$ = -82.53 ln (age_{ox}) + 211.67 (R^2 = 0.7943) and growth $rate_{buffalo}$ = -72.622 ln ($age_{buffalo}$) + 216.35 (R^2 = 0.8235). They showed that oxen fixed carbon contents more than buffaloes in first year but buffaloes fixed carbon more than oxen after one year of age.

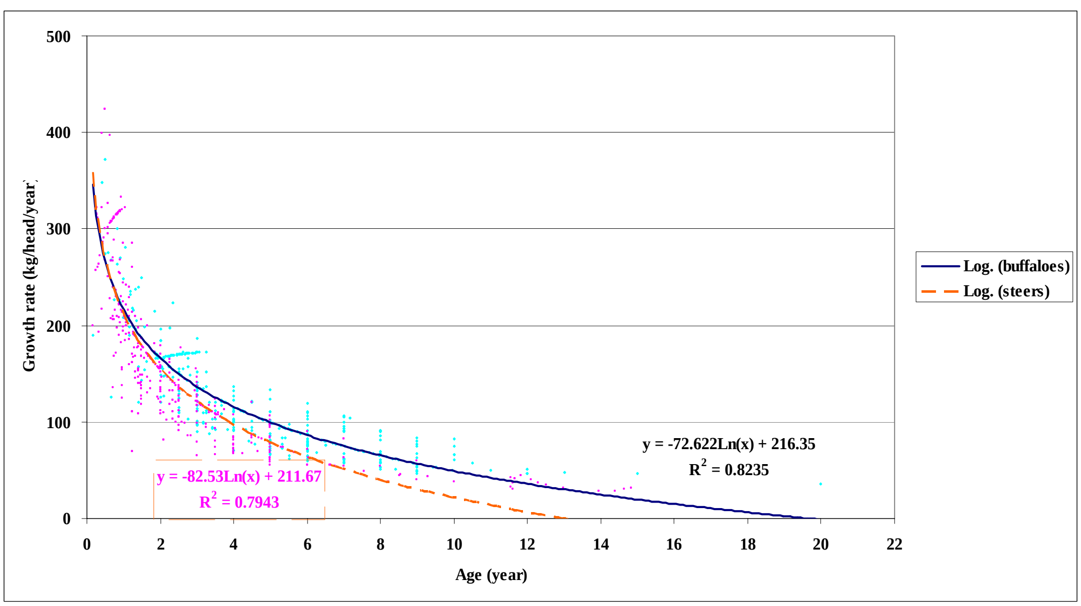

Figure-3. The relation of ox and buffalo weights with their age.

Because people would eaten renewable between ox meat and buffalo meat. Therefore it was possible to reduce carbon emissions from the production of meat. With the number of oxen were reduced and the number of buffalo

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rearing were increased to compensate for the amount of meat was produced with the same rate. The prediction of the amount of carbon emissions from the production of ox and buffalo meat was expected of raising oxen and buffaloes in 2009 - 2010. Estimates of the number of oxen and buffaloes as possible and linear regression analysis showed the sig. F and P-value <0.05. Carbon emissions from the production of ox meat and buffalo meat by the increasing or decreasing in proportion to the number of buffaloes and oxen raising was a chart as shown in Figure-4. The chart was shown the trend lines in three groups. The orange lines at the bottom of the first groups were graph showed the amount of carbon emissions from buffaloes fed 10% - 100% of the total number of oxen and buffaloes. The blue lines at the middle of the second groups were graph showed the amount of carbon emissions from oxen fed 10% - 100% of the total number of oxen and buffaloes. The gray lines in the final groups at the top were the graph that showed the amount of total carbon emissions from the number of animals of both species in the proportion of oxen to buffaloes since 100: 0, 90: 10, 80: 20, 70: 30, 60: 40, ..., 0: 100, respectively. The graph lines were found to be proportional to the reducing or the increasing of the number of oxen to buffaloes in 3 ratios were true that they were the ratios of 80: 20, 70: 30, and 60: 40 yielded in linear regression analysis. They were the certified emission reduction: CER_t (oxen: buffaloes). They reduced the carbon emission from the ox and buffalo production as shown in Figure-4. The three blue line graphs in the middle groups showed C-emitted by the number of oxen 60%, 70% and 80% of the total number of both types of animals, respectively. The three blue lines made up the C-emitted $_{(ox+buffalo)}$ decreased. Linear regression analysis of this blue line graphs showed the sig. F <0.05 at 95% confidence level. The total C-emitted $_{(ox+buffalo)}$ could be reduced by adjusting the rearing ratio of the number of oxen decreasing and the number of buffaloes increasing in proportion to the number of ox: buffalo were 80:20, 70:30 and 60:40, respectively.

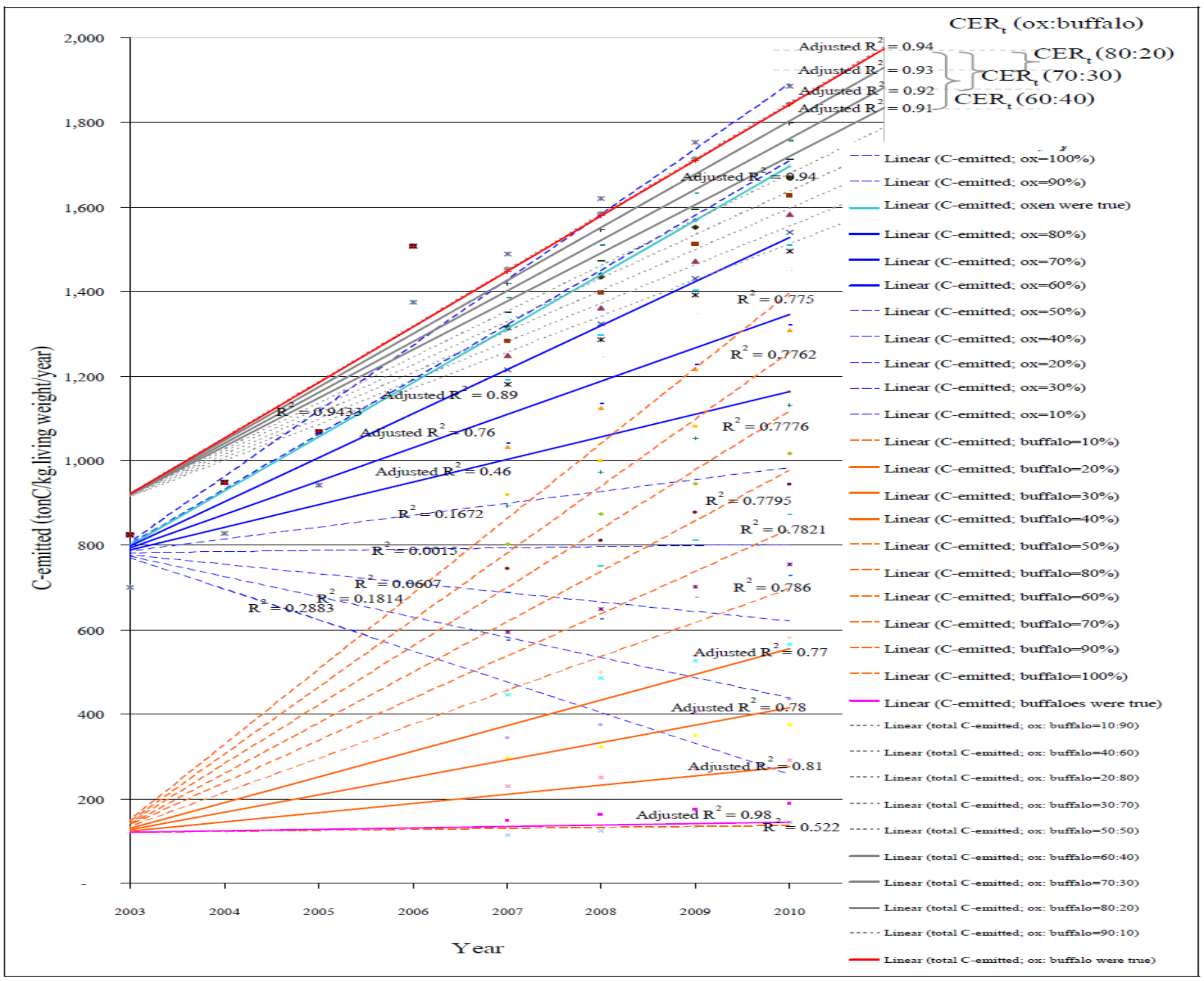

Figure-4. Trend of carbon emissions reduction from the ox and buffalo meat production (tonC./kg.living weight/year) by adjustment of the number reducing of oxen and the number increasing of buffaloes.

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Proportion of oxen: buffaloes were 80: 20 to be told that the number of ox farming was estimated to be 625, 944 heads and the number of buffaloes to be fed approximately equal to 156, 486 heads in 2010. The CER_{2010} (80: 20) was 43 ton C/kg. living weight/year that was shown the certified emission reduction compared to the total C-emitted $_{(ox+buffalo)}$ as normal, that it did not scaled of oxen: buffaloes on the red line graph, as shown in Figure-4. While the linear regression analysis of the ratio of oxen: buffaloes were 70: 30 showed the sig. F <0.05. Proportion of oxen: buffaloes were 70: 30 to be told that the number of ox farming was estimated to be 547, 701 heads and the number of buffaloes to be fed approximately equal to 234, 729 heads in 2010. The certified emission reduction was evaluated that the CER_{2010} (70: 30) was 87 ton C/kg. living weight/year. In addition, the linear regression analysis of the ratio of oxen: buffaloes was 60: 40 showed that the number of oxen and buffaloes should be approximately equal to 469, 458 heads and 312, 972 heads, respectively in 2010 at the sig. F <0.05 and 95% confidence level. This final proportion showed the CER_{2010} (60: 40) maximum was 130 ton C/kg. living weight/year as shown in Figure-4.

Decision making under uncertainty

The results of this study could be analyzed environmental problems from the CO_2, and CH_4 gases are greenhouse gases which were emitted from faeces, enteric fermentation and respiration of ox and buffalo and the energy using of herbivore meat production at farms and slaughterhouses. The analysis was based on pay of matrix principle by using all alternatives were the type of herbivores, carbon emission from ox and buffalo and the energy using of herbivore meat production were situations as shown in Table-4. Then make the decision follow theories and laws.

Table-4. The analysis under uncertainty was based on pay of matrix principle.

Choices of the herbivore meat production	**Situation of carbon emission (**kg.C**/**living weight**/**day**)**	
	C-emitted from herbivores	**C-emission from energy using**
Ox	4.57×10^{-3}	2.05×10^{-3}
Buffalo	3.95×10^{-3}	1.14×10^{-3}

The applied analysis using the laplace rule to choose the alternative of the herbivores meat production which cause the highest environmental problems by setting the probability of the equal situations (n=2), results as in Table-5. According to the laplace rule, it could be advised that the best alternative of the ox meat production cause more environmental problems.

Table-5. Result from the application of laplace rule.

Choices of the herbivore meat production	**(C-emitted + C-emission)/n**
Ox meat production*	$(4.57+2.05)/2 \times 10^{-3}$
Buffalo meat production	$(3.95+1.14)/2 \times 10^{-3}$

Note: *Selected the alternative of herbivores meat production which created maximum environmental problem

The maximax rules was applied to indicate the problems of the alternatives of the herbivores meat production by selection of situations (Table-4) which got the maximum result and then selected the maximum result from every alternative again. The results were shown in Table-6 which showed that the ox meat production was the worst alternative among these two alternatives of the herbivores meat production.

Table-6. Result from the application of the maximax rules.

Choices of the herbivore meat production	$\frac{\max Pij}{i(x)}$
Ox meat production*	4.57×10^{-3}
Buffalo meat production	3.95×10^{-3}

Note: *Selected the alternative of herbivore meat production which created maximum environmental problem

The minimax regret rule was applied to avoid the regret that the decision was already made in taking the poor alternative. Consideration of the maximum result in each situation was set in the matrix as shown in Table-7. And select the maximum regret in each alternative. Each alternative was selected to find minimum value again. The results were in Table-8 which showed that the buffalo meat production was recommended but the ox meat production caused more environmental problems.

Table-7. Regret value of each alternative of the herbivore meat production.

Choices of the herbivore meat production	Situation of carbon emission (kg.C/living weight/day)	
	C-emitted from herbivores	C-emission from energy using
Ox meat production	3.81×10^{-3}	75.81×10^{-3}
Buffalo meat production	4.43×10^{-3}	76.72×10^{-3}

Table-8. Maximum regret value of each alternative of the herbivore meat production.

Choices of the herbivore meat production	$\frac{\max Rij}{j}$
Ox meat production*	75.81×10^{-3}
Buffalo meat production	76.72×10^{-3}

Note: *Selected the alternative of herbivore meat production which created maximum environmental problem

According to theories and rules applied such as pay off the matrix, the laplace rule, the maximax rules and the minimax regret rule in making the decision on environmental problems, it could be concluded that buffalo meat production was the best alternative but ox meat production caused highest environmental problems among these two alternatives of the herbivore meat production.

CONCLUSIONS

The study showed that the carbon emission factors per unit from ox and buffalo farms and slaughterhouses in ox and buffalo meat production were 6.62×10^{-3} and 5.09×10^{-3} kg.C/kg.living weight/day, respectively. The carbon fixation factor in meat and organs, of oxen and buffaloes were 10.22×10^{-3} and 10.35×10^{-3} kg.C/kg.living weight/day, respectively and the rate of carbon massflow from grass and plants to oxen and buffaloes were 14.76×10^{-3} and 14.27×10^{-3} kg.C/kg.living weight/day, respectively. This study also showed the ratio of the carbon fixation in ox or buffalo meat and organs to the sum of carbon contents in grass, which humans cannot use the carbon in grass but herbivores can, of ox and buffalo were 0.69 and 0.72, respectively. The ratio of total carbon emitted per unit to total carbon contents per unit in grass of ox and buffalo meat production were 0.31 and 0.28, respectively. The ratio of total carbon emitted per day to carbon fixation per day in meat and organs of an ox and a buffalo was 0.45 and 0.38, respectively. The results of study concluded that the production of ox and buffalo meat used less energy at farms and slaughterhouses. Carbon emissions were mostly in the form of faeces, enteric fermentation and respiration. Measures to reduce the amount of carbon emission that could be did another way. The first approach was prioritizing types of animals that should encourage the fed to produce meat. For example, to encourage the farming of buffalo instead of the ox farm because of all carbon were emitted from a buffalo and energy using for the production of buffalo meat was lower than the ox meat production. The second approach should take into account the times that farmers took to fed ox and buffalo to suit the increased weight to reduce unnecessary carbon emissions from farming with a period inappropriate. The carbon in grass was most accumulated in the body of oxen come up between the ages of 0-2 years, while buffaloes were most accumulated in 0-4 year olds. Thus, oxen and buffaloes should be killed and butchered of this age too. After this time, the rate of carbon accumulation in the body of oxen and buffaloes would be reduced. When evaluating the reduction of carbon emissions from the production of meat, especially ox and buffalo meat could be substituted for each other. The third approach was the reduction in the number of oxen down and the increasing the number of buffaloes to compensate for the amount of meat produced with the same rate. The results of the linear regression analysis of the proportion of the number of oxen: buffaloes at the sig. F <0.05 and 95% confidence level showed that the CER_{2010} (80: 20) was 43 ton C/kg. living weight/year, the CER_{2010} (70: 30) was 87 ton C/kg. living weight/year, and the CER_{2010} (60: 40) maximum was 130 ton C/kg. living weight/year. The decision made under uncertainty of this study that could analyzed environmental problems from the herbivore meat production. According to theories and rules applied such as the pay off the matrix, the laplace rule, the maximax rules and the minimax regret rule in making the decision on environmental problems, it could be concluded that the buffalo meat production was the best alternative but the ox meat production caused highest environmental problems among these two alternatives of the herbivore meat production.

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