The Impacts of Agricultural Carbon Footprint in Salikneta, San Jose Del Monte, Bulacan

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Abstract: The subsistence of a human-induced or anthropogenic greenhouse gases (GHGs) specifically carbon dioxide (CO2) in the atmosphere can be ascribed to the processes associated predominantly with an ultimate and imperative factor: the livestock. In 2010, De La Salle Araneta University released a total 65,000 kg equivalent of CO2 into the atmosphere, a concentration that is nominal relative to the CO2 emissions in the countrywide setting. This equivalent emission serves as the baseline scenario for the University. CO2 accounting and modeling were performed using the Intergovernmental Panel on Climate Change (IPCC) and Food and Agriculture Organization (FAO) frameworks. The results were further validated using internationally-accepted schemes. Mitigating measures and adaptation capacities on how to address the environmental enigma were determined and recommended in order to offset the so-called ecological footprint. An estimated fifty percent (50%) of CO2 equivalent reduction would be reached in 2015 if these assuaging systems emerge

Key Words: Livestock; CO2 Accounting; CO2 Modelling; Climate Change Mitigation; Adaptation

1. Introduction

The critical roles of livestock in the Agricultural sector in the society are well-defined. Livestock is one of the major providers of food and essential raw-materials; it is also a big market that sustains the survival of the economy; lastly, it supports the livelihood of people involved from animals raising, production, marketing, processing and so on.

In concert with the rapid growth of the livestock industry due to changes in the demand for food, environmental contaminants arise. The greenhouse effect which is a natural phenomenon needed for the probity of the biosphere is merely an effect of the greenhouse gases (GHG) specifically carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) which are all emitted by the livestock sector.

The livestock sector is considered as one of the greater emitters of GHG through physiologic and anthropogenic processes such as the enteric fermentation of ruminants, manure management, production and utilization of fertilizers and manufacture of farm products.

In spite of the significant role of the livestock industry on the production of GHG, studies on this issue in the Philippines are not yet well-established and prioritized.

Salikneta, formerly known as Saliksik-Araneta is a 64 hectare farm owned by the De La Salle Araneta University (DLSAU) located in the city of San Jose Del Monte, Bulacan. Currently, two percent (2%) of the total population of livestock animals are buffaloes, 0.55% are ducks, 0.55% are goats, 1.24% are horses, 15.56% are pigs, 0.83% are dairy cows and 79.20% are chickens are shown in Figure 1.1. These animals are used for forestry and agricultural operations to train students of De La Salle Araneta University who are taking Doctor of Veterinary Medicine, Bachelor of Science in Agriculture and Bachelor of Science in Animal Husbandry.

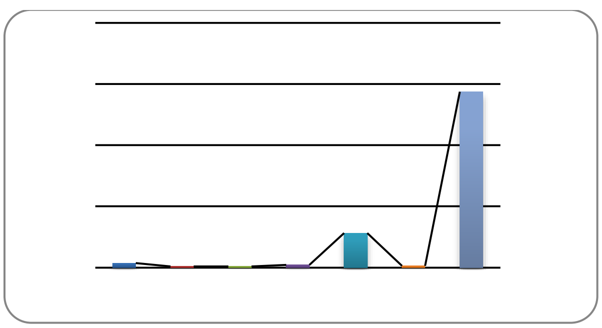

Figure 1.1 The total number of animal heads in Salikneta Farm

With the given number of the livestock animals identified, the Salikneta farm seemingly emits carbon dioxide equivalent into the air. The source of this carbon dioxide equivalent is methane (CH_4) that comes from enteric fermentation and manure management.

Enteric fermentation is a digestive process by which carbohydrates are broken down by microorganisms into simple molecules for absorption into the bloodstream of an animal. It is one of the factors in increased methane emissions. Ruminant animals are those that have a rumen. A rumen is a special stomach found in cows, sheep, and water buffalo that enables them to eat tough plants and grains that monogastric animals, such as humans, dogs, and cats, cannot digest.

Enteric fermentation occurs when methane (CH_4) is produced in the rumen as microbial fermentation takes place. Over 200 species of microorganisms are present in the rumen, although only about 10% of these play an important role in digestion. Most of the CH_4 byproduct is belched by the animal, however, a small percentage of CH_4 is also produced in the large intestine and passed out as flatulence.

Enteric fermentation is one of the largest anthropogenic sources of methane emissions in the Philippines, in 2000, methane emissions from enteric fermentation were only 314.5 Gg. This constitutes 6,604.50 Gg of CO_2 equivalents emissions (Philippine Greenhouse gas Inventory, 2000).

Manure management, which is another source of methane emission, refers to capture, storage, treatment, and utilization of animal manures in an environmentally sustainable manner. It can be retained in various holding facilities. Animal manure, which is also referred to as animal waste, can occur in a liquid, slurry, or solid form. It is utilized by distribution on fields in amounts that enrich soils without causing water pollution or unacceptably high levels of nutrient enrichment. Manure management is a component of nutrient management (http://en.wikipedia.org).

In the Philippines, a total of 87.43 Gg of CH_4, which corresponds to a value of 4,312.93 Gg CO_2 equivalent was emitted into the air. This comprises 12% of the total emissions in the agricultural sector in the Philippines in 2000 (Philippine Greenhouse Gas Inventory, 2000).

The primay objective of this study was to estimate carbon footprint, a measure of exclusive total amount of carbon dioxide emissions that are directly and indirectly caused by an activity or is accumulated over the life stages of a product.

2. METHODOLOGY

Researches related to the role of livestock in the production of carbon foot prints were collected and expansively studied. The literatures in this paper covered the previous works of International and local institutions such as Food and Agriculture Organization (FAO), Department of Agriculture (DA), and Intergovernmental Panel on Climate Change (IPCC). Data for the population of livestock animals in the Salikneta farm was provided by management since they will be used as the model subjects for this study.

Figure 2.1 provides the step-by-step procedure how carbon dioxide was estimated and modeled.

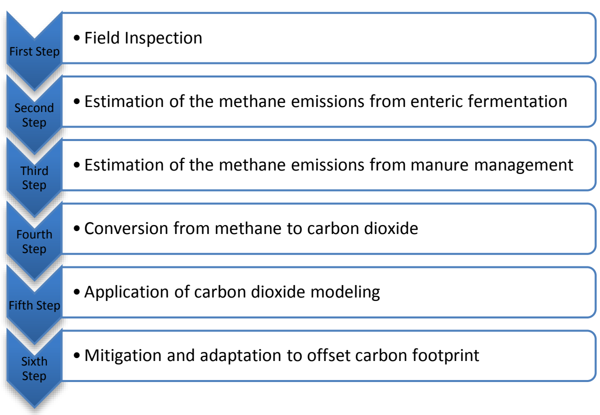

Figure 2.1 Carbon Dioxide Accounting and Modeling

2.1 Field Inspection

The Salikneta Farm was visited to characterize to determine the number of livestock animals that are present. Waste management systems and feed management systems were also evaluated for this study.

2.2 Methane Emission Estimations

In the estimation of the methane emissions from enteric fermentation and manure management, IPCC Guidelines were used. Tier 1 approach of the 2000 GHG Inventory was used. Equation 2.1 represents the methane emission from the enteric fermentation.

CH_4 Enteric Fermentation = P x EFEF x 10-3 (2.1)

Where
CH_4 Enteric Fermentation = methane emission from enteric fermentation for animal type (Gg/year)
P = Population of animal type (x 1000 heads)
EFEF = Enteric Fermentation Emission factor for enteric fermentation for animal type (kg CH_4/head/year)
10-3 = Conversion Factor

Equation 2.2 as shown represents the methane emission from manure management.

CH_4 Manure Management = P x MMEF x 10-3 (2.2)

Where
CH_4 Manure Management = methane emission from manure management for animal type (Gg/year)
P = Population of animal type (x 1000 heads)
MMEF = Manure Management Emission factor for enteric fermentation for animal type (kg CH_4/head/year)
10-3 = Conversion Factor

2.3 Emission Factors

The emission factors (EFEF and MMEF) were default values from the Intergovernmental Panel on Climate Change Guidelines. Default values were obtained from the 1996 IPCC Guidelines for National Greenhouse Gas Inventories (1996, IPCC Guidelines).

3. RESULTS AND DISCUSSION

Table 3.1 as shown provides the calculator how carbon dioxide was estimated. This was based from the International Panel on Climate Change Guidelines.

Table 3.1 Livestock Manure Management (CO_2)

LIVESTOCK GREENHOUSE GAS EMISSIONS (CH_4) References: UNFCC-IPCC		
Livestock	Number of Heads (annual)	CH_4 (kg/head/year)
Buffalo	15	825.00
Duck	4	20.00

Goats	4	20.00
Horses	9	162.00
Swine	113	113.00
Dairy Cow	6	408.00
Poultry*	575	11.50
TOTAL		1559.50
* manure management		
CO2 equivalent (GWP) in tonnes CO2	38.9875	

Based from the Table 3.1, buffalo is the most significant accounting for about 52.90% of the total value. This is trailed closely by the dairy cow of about 26.16%. Horses and swine follow with respective contributions of 10.39% and 7.25%. Ducks and goats emit the same value of carbon dioxide, which is equivalent to 1.28%. Poultry sector, which has the highest number of heads in the livestock sector only emits 0.74%.

For manure management, CH_4 emissions are generated as a result of the decomposition of manure under anaerobic conditions. These conditions occur readily when large numbers of animals are managed in a confined area resulting in the generation of a large amount of manure. The majority of poultry production systems in Salikneta handle manure as a solid, and the manure tends to decompose under aerobic conditions generating less CH_4 than would be generated under anaerobic conditions.
Table 3.2 as shown provides the greenhouse gas emissions from enteric fermentation.

Table 3.2 Enteric Fermentation (CO2)

LIVESTOCK GREENHOUSE GAS EMISSIONS (CH4) References: UNFCC-IPCC		
Livestock	Number of Heads (annual)	CH4 (kg/head/year)
Buffalo	15	30.00
Duck	4	0.08
Goats	4	0.88
Horses	9	19.71
Swine	113	791.00
Dairy Cow	6	186.00
Poultry*	575	11.50
TOTAL		1039.17
* enteric fermentation		
CO2 equivalent (GWP) in tonnes CO2	25.97925	

A significant portion (50.72%) emissions is from the swine subsector. It is followed by the dairy cow, which comprises 11.93% of the total emissions. Buffalo and horses subsector are the third and fourth emitters, which constitutes 1.92% and 1.26%, respectively. Poultry, which is the fifth emitter, encompasses 0.74%. Goats and ducks are the least carbon dioxide equivalent emitters that make-up around 0.06% and 0.005% of the total footprints.

The scientific explanation behind this emission lies on the ruminant animals. Ruminant animals are different from other animals in that they have a "rumen" – a large fore-stomach with a complex microbial environment. The rumen allows these animals to digest complex carbohydrates that nonruminant animals cannot digest; a natural component of this process also creates methane that is emitted by the animal. Ruminants (e.g. swine, cows etc.) produce much more methane per head than non-ruminant animals, with the rumen being responsible for 90 percent of the methane from enteric fermentation in a ruminant.

In aggregate, the large number of domestic ruminants, particularly beef cattle and dairy cattle, swine—combined with the high level of methane emissions per head and the high GWP of methane—make enteric fermentation a significant contributor to domestic greenhouse gases from livestock (IPCC).

3.1 Carbon Dioxide Modeling

Theoretically, if the following mitigating measures and adaptation capacities are applied, more than 50% of the total carbon footprint for the next five (5) years will be reduced. The total carbon footprint or total carbon dioxide equivalent was modeled using MATLAB. Figure 3.1 and 3.2 as shown provide the summary of the theoretical findings.

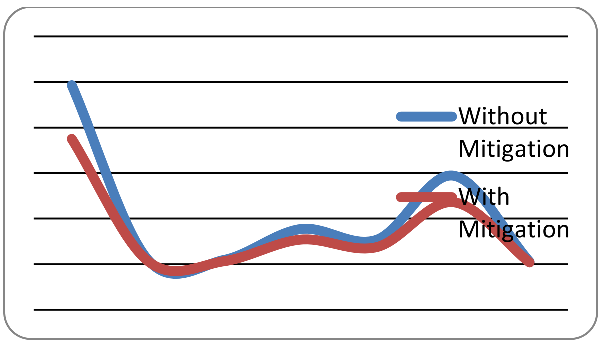

Figure 3.1 Comparison between Mitigated and Non-mitigated CO2 (Manure Management)

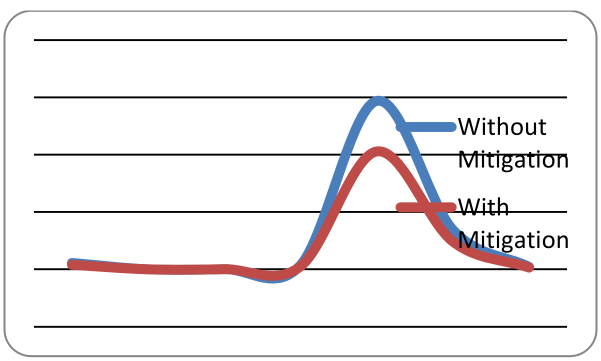

Figure 3.2 Comparison between Mitigated and Non-mitigated CO2 (Enteric Fermentation)

In these two models, the blue line in Figures 3.3 and 3.54 represents the concentration of carbon dioxide emissions for the next five years (2015). It was also found out that a reduction of more than 50% in the carbon dioxide equivalent emission would occur in 2015 if mitigating measures and adaptation practices would be implemented. These mitigating schemes were represented by a red line. These results were validated by the studies that were conducted by Smith et al (2007) where the potential for reducing CH4 emissions could only happen through improved feed practices, specific agents and dietary additives, longer term structural and management changes and animal breeding. Also, composting manure and altering feeding practices may help reduce emissions to a certain extent.

3.2 Mitigations

As the livestock industry moves towards becoming a more energy efficient and sustainable industry, it is important to have an understanding of the carbon footprint of each segment of the industry. Reductions in the carbon footprint of the livestock production will require the identification and adoption of on-farm management practices and technological changes in production and waste management that can result in positive net changes for producers and the environment.

Mitigation of GHG emissions in the livestock sector can be achieved through various activities including: (a) different animal feeding management; (b) manure management (collection, storage, spreading, etc); and (c) management of feed crop production.

Livestock contribution in emissions reduction varies; mitigation options include (FAO, 2008):

Selection of faster growing breeds - improved livestock efficiency to convert energy from feed into production, and reducing losses through waste products. Increasing feed efficiency and improving digestibility of feed intake are potential ways to reduce GHG emissions and maximize production, gross efficiency, and by reducing the number of heads (Wall, et al., 2008). This includes all the livestock practices - such as genetics, nutrition, reproduction, health and dietary supplements and proper feeding (including grazing) management – that result in the improved feed efficiency.

 Improved feeding management – the composition of feed has some effect on the enteric fermentation and emission of CH4 from the rumen or the hindgut (Dourmad, et al., 2008). Also the amount of feed intake is related to the amount of waste product. The higher proportion of concentrate in the diet results in a reduction of CH_4 emission (Yan, et al., 2000).

- Improved waste management – improving management of animal waste products through different mechanisms such as covered storage facilities is also important. The amount of GHG emission from manure (CH_4, N_2O, and CH_4 from liquid manure) will depend on the temperature and duration of the storage. Therefore long term storage in high temperature will result higher GHG emissions. In the case of ruminants, pasture grazing is an efficient way to reduce CH_4 emission from manure, because no storage is necessary. Indeed, there is not only the possibility of mitigating the GHG emissions, but also of create an opportunity for renewable energy.

Grazing management – one of the major GHG emission contributions from livestock production is from forage or feed crop production and land use of feed production. Thus pasture grazing and proper pasture management through rotational grazing is the most cost effective way to mitigate GHG emissions from feed crop production. Animal grazing on the pasture also helps reduce emission due to animal manure storage. Introduction of grass species and legumes into grazing lands can enhance carbon storage in soils.

- Lowering livestock production consumption - lowering consumption of meat and milk in areas having high standards of living will support short term response to the GHG mitigation.

3.3 Adaptation

Livestock producers have traditionally adapted to various environmental and climatic changes by building on their in-depth knowledge of the environment in which they live. However increased human population, urbanization, environmental degradation and increased consumption of animal source foods have made some of those coping mechanisms ineffective (Sidahmed, 2008). In addition, changes brought by global warming will happen at such a speed as to exceed the capacity of spontaneous adaptation by both communities and animal species in Salikneta Farm/

The following have been identified by several experts (FAO, 2008; Thornton, et al., 2008; Sidahmed et al, 2008) as ways to increase adaptation in the livestock sector:

Production adjustments: diversification, intensification, integration, of pasture management, livestock and crop production, changing land use and irrigation, altering the timing of operations, conservation of nature and ecosystems.

- a. Modifying stock routings and distances;
- b. Introducing mixed livestock farming systems – i.e. stall-fed and pasture grazing.
- Breeding strategies: many local breeds are already adapted to their harsh conditions. However, Salikneta is characterized by a lack of technology in livestock breeding and other agriculture programmes which might help to speed adaptation. Adaptation strategies include not only their tolerance to heat, but also their ability to survive, grow and reproduce in conditions of poor nutrition, parasites and diseases (Hoffmann, 2008). Those adaptation mechanisms include:
- a. Identifying and strengthening local breeds, which are adapted to local climatic stress and feed sources;
- b. Improving local genetics through cross breeding with heat and disease tolerant breeds. If climate change is faster than natural selection the risk of survival and adaptation of the new breed becomes greater (Hoffmann, 2008).
- Market responses: improvement of agriculture market, promotion of inter-regional trade, credit schemes.
- Institutional and policy changes: removal or putting in place of subsidies, insurance systems, income diversification practices as well as the introduction of Livestock Early Warning Systems, and other forecasting and crisis preparedness systems.
- Science and technology development: better understanding of the causes and impacts of climate change on livestock, development of new breeds and

genetic types, improved animal health, and improved water and soil management.

 Capacity building livestock keepers – increased awareness of global changes, and improved capacity of herders/livestock producers to understand and deal with climatic changes. Training in agroecological technologies and practices for the production and conservation of fodder is improving the supply of animal feed, reducing malnutrition and mortality in herds.

Livestock management systems – efficient and affordable adaptation practices have to be developed for Salikneta not able to buy expensive adaptation technologies.

 a. Provision of shade and water to reduce heat stress from increased temperature. Current high cost of energy, providing natural (low cost) shade instead of high cost air conditioning is more applicable to rural producers;

b. Reduction of livestock numbers – lower number of more productive animals will cause more efficient production and lesser emission of GHG from livestock production (Batima, B., 2006);

c. Change in livestock/herd composition (large animal versus small animal, etc.);

Improved management of water resources through the introduction of simple techniques for localized irrigation (e.g. drip and sprinkler irrigation), accompanied with infrastructure to harvest and store rainwater, such as small superficial and underground dams, tanks connected to the roofs of houses, etc.

4. CONCLUSIONS

Salikneta Farm of De La Salle Araneta is a key emitter of green house gases (GHGs). A total of 65,000 kg or 65 MT of CO2 was released in the atmosphere through livestock production. Much of the expected increase in the emissions will be the result of the food production growth required to feed a larger population. Despite these emissions growth, up to 50% of the theoretical mitigation potential could be realized by 2015, and this potential will only be possible if mitigating schemes and adaptation capabilities will be properly executed.

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