GLOBAL PATTERNS OF LIVESTOCK AND ANIMAL GREENHOUSE GAS EMISSION: LOCAL CHARACTERIZATION THROUGH FRACTAL ANALYSIS

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ABSTRACT

This study attempts to uncover the local social and demographic characteristics of countries that generate smaller and larger GHG from livestock production. The study employed the descriptive design utilizing data from the internet. Using statistical software (Minitab), the histogram of the observation was determined. If the histogram obeys fractal distribution, the countries with lower methane gas were analyzed. The countries with the least amount of methane gas emission were noted to have two main characteristics, namely: (1) livestock production in these countries are minimal or non-existent, (2) the economies of these States are not based on agriculture or animal production. Countries with the highest contribution of methane gas in the atmosphere, generally have the large animal production as industries. They also possess some or all of the following characteristics: (1) they are located in temperate zones with the exception of Myanmar and Vietnam; (2) poor manure management and utilization, (3) high livestock population, (4) most are well-developed countries with mechanized livestock farming. High methane gas emission from animal manure can be attributed to high livestock and animal production activities in the various countries and population pressure. Conversely, small methane gas emission of different countries results from low livestock and animal production activities.

Keywords: greenhouse gases, fractal analysis, livestock

Introduction

Meat, milk, and eggs are the basic source of protein for human consumption and it is primarily produced by livestock. Livestock is one of the main sources of greenhouse gases which lead to global warming. Worldwide demand for livestock goods is expected to double throughout the first half of this period, as a result of the increasing human population, and its growing wealth. With increased affluence, people are eating more animal meat and dairy goods annually, according to a United Nations report (Steinfeld, 2006). The increasing demand for livestock products (mainly meat and dairy products), the animal industry globally continues growing. Since food security is still one of the highest priority issues in industrialized countries, animal production has a significant role in most of these countries. According to FAO, Global meat production is anticipated to more than double from 229 million tonnes in 1999/2001 to 465 million tonnes in 2050, while milk production is set to reach from 580 to 1043 million tonnes. The UN-FAO (2006) warns that livestock is one of the most significant contributors to today's most serious environmental problems. There must be urgent action required to remedy the situation. When greenhouse gas emissions from land use and land-use change are incorporated, the livestock sector contributes to 9% of carbon dioxide produced from human-related activities but generates a much larger portion of even more detrimental greenhouse gases. It produces 65% of human-related nitrous oxide, which has 296 times the Global Warming Potential (GWP) of CO_2. Most of this comes from manure. It explains for respectively 37 percent of all human-induced methane (23 times as warming as CO_2), which is largely formed by the digestive system of ruminants, and 64 percent of ammonia, which contributes significantly to acid rain. The unwanted side effects of high animal production, however, has remained understudied.This study attempts to uncover the local social and demographic characteristics of countries that generate smaller GHG from animal production as compared with countries producing larger amounts of GHG from their livestock production activities.

The global animal industry is growing faster than any other form of agricultural production. It provides employments to about 1.3 billion people and adds about 40% to global agricultural production. Livestock farming is also a source of renewable energy for draft and is an essential source of organic fertilizer for crops for many poor farmers in developing countries. Thirty percent of the earth's total land surface is now used for livestock farming, mainly stable grassland, but also it compromised about 33% of the global idle land used to produce feeds for livestock. As forests are cleared to make new pastures, it is a main cause of deforestation. The agricultural production produces different amounts of GHG around the world. This is because each livestock production system varies in different ways in using resources. Extensive livestock farming is a method of agricultural production that is mainly a pasture-based and land-based system. Another method in dairy or beef cattle production is an intensive system, this method has more focused operations and are often more mechanized. Each of these systems is commonly used in livestock farming all around the globe and each has an environmental impact. Carbon dioxide from livestock production is a result of fuel use from equipment and changes in the carbon content of soil, such as crops, deforestation and direct land use of animals. Livestock production is the largest methane source emitter in the world most of this methane is a result of manure storage and enteric fermentation, which is methane produced in the digestive tract of an animal (Hermansen et al., 2011).

Climate change is seen as the main threat to the survival of many species, ecosystems and the sustainability of livestock production systems in many parts of the world (Moss *et al*., 2000). It's mainly caused by human intervention in livestock production practices. In assessing global livestock and animal production practices can be one of the remedies in reducing the GHG emission in the atmosphere.

Conceptual Framework

Greenhouse gases are gases in the earth's atmosphere and can be produced in nature and through human industry. An increased amount of GHG causes high temperatures on earth. These gases are mainly produced by agricultural activity, especially livestock farming. The inventory of greenhouse gases of each country is sorted from highest to lowest and determined the histogram of the data using statistical software (Minitab). The analyses focus on the activities of countries with low methane gas production and the activities of those countries with high methane gas emission from their animal manures. It may be stated that the natural reason for the amounts of methane gas emissions observed is the presence or absence of large-scale animal farm production in the country. The schematic diagram is shown in Fig. 1.

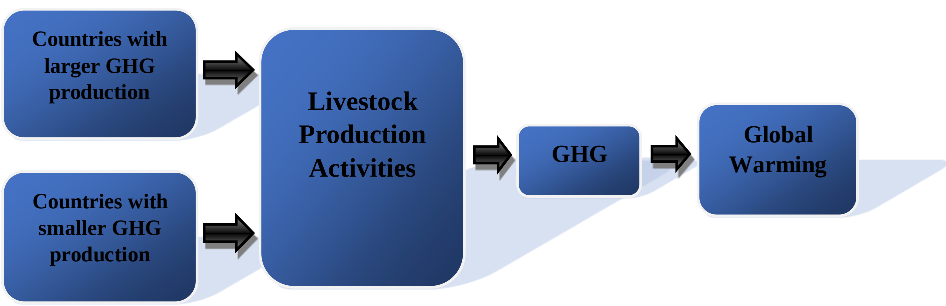

Figure 1. Schematic Diagram of the Study

Research Design and Methodology

1. Method of Fractal Data Analysis

The study employed the descriptive design to assess the activities of countries that contribute large amounts of Greenhouse gases than other countries. Data were acquired from the internet. The data were first transferred to the EXCEL and sorted from lowest to the highest. Using statistical software (Minitab), the histogram of the observation was determined. If the histogram obeys fractal distribution, the countries with lower methane gas were analyzed. The histogram below shows a typical histogram of fractal observations:

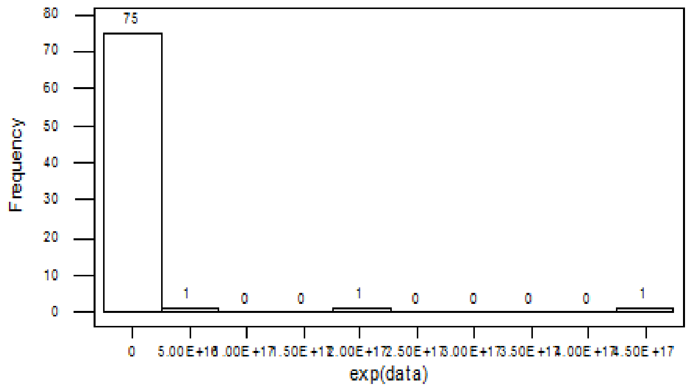

Figure 2: Histogram of Typical Fractal Observations

However, if the histogram were not fractal, then some observations were segregated from the analysis. In many cases, the histogram would suggest an exponential distribution so that:

$$Y=\exp\left(\frac{x}{\theta}\right)$$

would be fractal. The histogram below shows a typical exponential distribution for the transformation log(x/min):

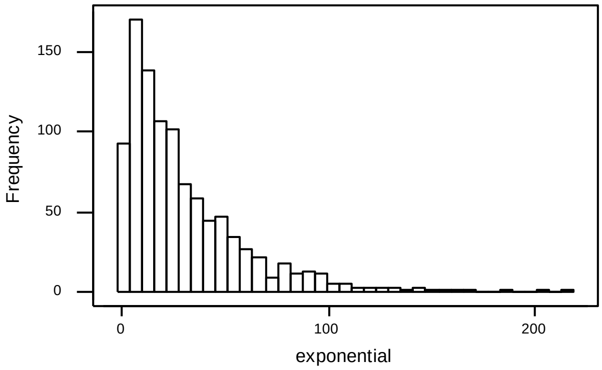

Figure 3: Histogram of a typical exponential distribution

If the histogram reflects a behavior similar to Fig. 3, then using the fundamental theorem of fractal statistics, the transformation Y = EXP (x/min) will transform the data to a fractal data set. If the histogram reflects a fractal distribution like Fig. 2, then the transformation Y = log (x/min) will convert the histogram of the data into an exponential distribution as Fig. 3.

Data Used in the Study

Table 1. The Greenhouse gas emissions from Agriculture (Data source: European Environment Agency).

Country	Methane gas production (kilotonne)
Tokelau	0.02
Saint Pierre and Miquelon	0.04
Nauru	0.06
Cayman Island	0.24
Niue	0.24
Guam	0.27
Kiribati	0.28
Tuvalu	0.29
Saint Helena, Ascension and Tristan da Cunha	0.3

Table 1 continuation…

American Samoa	0.38
Seychelles	0.82
Cook Island	0.9
Micronesia (The Federated States of)	1.29
Wallis and Futuna Islands	1.42
Bermuda	1.81
Saint Kitts and Nevis	1.84
Sao Tome and Principe	2.69
Greenland	3.33
Bahamas	3.5
Netherlands Antilles	3.99
The British Virgin Islands	4.67
Brunie Darussalam	4.83
Equatorial Guinea	5.26
Singapore	5.78
China, Hong Kong SAR	6.24
Grenada	7.93
Saint Vincent and the Grenadines	8.53
United States Virgin Islands	10.76
Mauritius	11.43
Faroe island	11.76
Liechtenstein	12.03
French Polynesia	12.91
Montserrat	13.96
Bahrain	15.26
Barbados	17.81
French Guiana	17.94
Dominica	21.11
Solomon island	21.29
Tonga	22.08
Martinique	23.51
Malta	32.34
Réunion	33.38
Samoa	45.15

Table 1 continuation…

Comoros	52.26
Trinidad and Tobago	55.65
Gabon	63.9
Suriname	70.44
Cabo Verde	72.85
Falkland Islands (Malvinas)	79.58
Guadaloupe	90.98
Liberia	98.44
Kuwait	105.88
Belize	113.77
New Caledonia	122.62
Qatar	128.18
Western Sahara	128.68
Occupied Palestinian Territory	132.66
Cyprus	141.69
Papua New Guinea	164.46
Guyana	169.37
Lebanon	174.94
Timor-Leste	175.05
Montenegro	190.79
Iceland	225.48
Vanuatu	233.02
Congo	268.43
Jamaica	274.26
Luxembourg	282.37
Bhutan	310.79
China, Taiwan Province of	314.62
Gambia	323.55
Djibouti	376.02
Jordan	390.27
Israel	400.37
Estonia	410
Fiji	457.78
Puerto Rico	486
Swaziland	492.83

Table 1 continuation…

The Republic of Moldova	535.55
The former Yugoslav Republic of Macedonia	553.07
Guinea-Bissau	594.23
Oman	631.82
Latvia	636.52
Slovenia	699.58
Lesotho	736.76
Sierra Leone	747.71
United Arab Emirates	779.91
Burundi	784.9
Armenia	786.29
Slovakia	789.45
Togo	809.26
Croatia	871.06
Bosnia and Herzegovina	956.8
The Democratic Republic of the Congo	1030.8
Democratic People's Republic of Korea	1062.22
Malaysia	1088.67
Rwanda	1214.63
Lithuania	1251.82
Libya	1269.26
Bulgaria	1284.86
Albania	1334.68
Malawi	1387.96
Sri Lanka	1404.29
Côte d'Ivoire	1428.65
Georgia	1439.07
Hungary	1452.69
El Salvador	1476.23
Finland	1541.44
Benin	1727.16
Norway	1746.7
Mozambique	1755.35
Tunisia	1788.08
Costa Rica	1826.02

Table 1 continuation…

Serbia	1951.1
Botswana	2028.84
Czech Republic	2068.16
Ghana	2113.06
Panama	2133.2
Saudi Arabia	2170.9
Namibia	2192.15
Haiti	2285.91
Eritrea	2345.39
Zambia	2365.03
Kyrgyzstan	2388.62
Sweden	2397.35
Portugal	2600.83
Switzerland	2774.6
Tajikistan	3014.3
Denmark	3103.35
The Syrian Arab Republic	3143.1
Lao People's Democratic Republic	3175.39
Greece	3206.06
Austria	3225.54
Iraq	3429.3
The Central Africa Republic	3530.1
Honduras	3531.04
Angola	3742.91
Yemen	3751.59
The Republic of Korea	3764.95
Cambodia	3778.82
Guinea	3799.84
Belgium	3831.59
Senegal	3890.27
Dominican Republic	3913.59
Zimbabwe	3981.63
Mauritania	4205.46
Azerbaijan	4246.62
Cameroon	4311.72

Table 1 continuation…

Guatemala	4336.57
Turkmenistan	4504.1
Japan	4865.78
Nicaragua	4888.3
Algeria	5014.84
Romania	5394
Chile	5406.37
Morocco	5447.42
Cuba	5516.86
Philippines	6620.16
Belarus	6626.71
Ecuador	6878.84
Netherland	7239.11
Madagascar	7387.54
Thailand	7451.93
Mongolia	7788.21
Chad	8017.25
Afghanistan	8074.94
Ukraine	8215.32
Burkina Faso	8665.76
Viet Nam	8941.17
Kazakhstan	9422.93
Poland	9641.08
Egypt	10420.29
Ireland	10484.71
Uganda	11178.23
Niger	11671.64
Nepal	11794.49
Maldives	11886.44
Spain	11987.12
Italy	12024.11
South Africa	12746.63
Somalia	12926.63
Uzbekistan	13142.41
Peru	14375.28
Bolivia (Plurinational State of)	14646.41

Table 1 continuation…

Uruguay	14722.17
Canada	15910.84
Paraguay	15913.85
Iran (The Islamic Republic of)	18108.85
The United Republic of Tanzania	18159.4
Turkey	18196.61
Venezuela (Bolivarian Republic of)	18240.23
United Kingdom	19838.1
Myanmar	19918.08
New Zealand	21276.07
Indonesia	21328.67
Germany	21591.89
Kenya	22220.59
Bangladesh	23437.99
Nigeria	23858.94
France	29331.12
Colombia	30138.39
Russian Federation	36254.28
Mexico	44264.92
Ethiopia	46820.99
Sudan (former)	47106.05
Australia	49972.36
Argentina	62510.7
Pakistan	77366.1
The United States of America	122746.57
China, Mainland	197941.74
China	198262.6
Brazil	**263542.61**
India	307753.28

Results and Discussion

Figure 4 shows the histogram of the original observations on the methane gas production from manure management of livestock and ruminants from different countries:

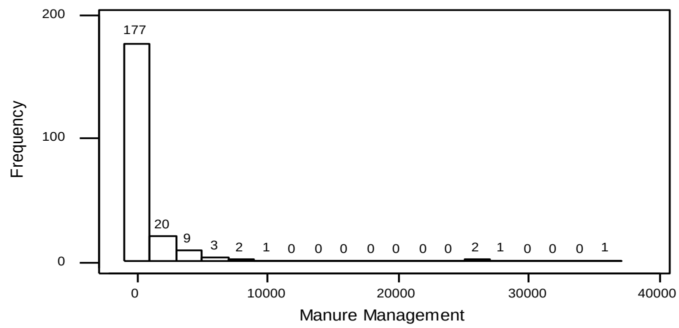

Figure 4: Histogram of the Methane Gas Production from Manure Management of Countries

The histogram above displays either a fractal or an exponential behavior. In order to make the histogram behave in a manner consistent with fractal observations, we remove the larger values to the right of the histogram after the first 177 observations. The resulting histogram is shown in Fig. 5.

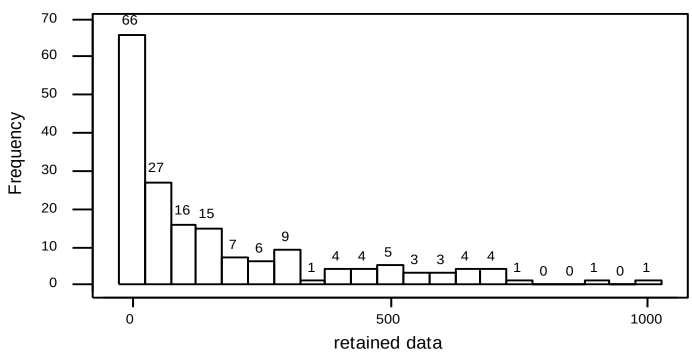

Figure 5: Histogram of the first 177 Observations

Figure 5 reveals that, in fact, the first 177 observations out of 216 countries already behave like an exponentially distributed random variable with mean 162.9 or a rate parameter of 0.0061387 producing a fractal dimension of 1.0061387. The smallest fractal dimension calculated indicates that the data is probably closer to an exponential distribution than to a real fractal or a power law distribution. In order to verify if Fig. 5 is indeed exponential, we computed for the transformation Y = min*exp (data) and plotted the histogram in Fig. 6.

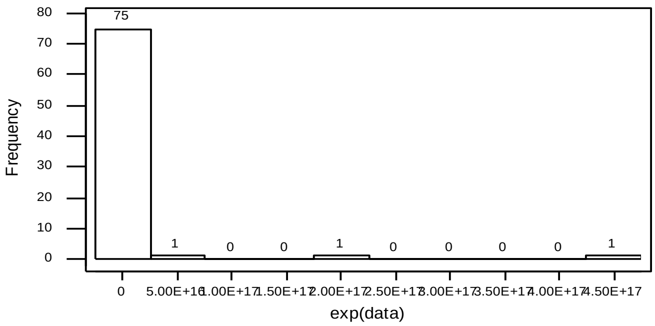

Figure 6: Histogram of Y = exp (data)

Figure 6 shows that , in fact, the transformed variable Y is distributed as a fractal random variable and consequently, that the first 177 original data were exponentially distributed. Likewise, it is noted from the histogram above that the first 75 of the 177 observations constitute the fractal component of the data set. These are the countries with relatively low methane gas emissions from animal manures in their respective livestock / animal industries.

The data analyses focus on the practices of countries with low methane gas production and the practices of those countries with high methane gas emission from their animal manures. It may be mentioned that the natural reason for the amounts of methane gas emissions observed is the presence or absence of large-scale animal farm industries in these countries. These emissions, however, are either mitigated or aggravated by the farming practices adopted by the various States. A secondary natural reason for the observed methane gas emission is the predisposition of the governments of these States to engage in animal production due to the high demand for animal meats with its population of consumers.

Discussion

The countries with the least amount of methane gas emission are shown in the table below:

Table 2: Countries with manure methane gas production of less than 20 kilotonne

NAME OF COUNTRY	METHANE PRODUCTION (Kilotonne)
Cayman Island	0.24
Saint Helena, Ascension and Tristan da Cunha	0.3
Greenland	3.33
The British Virgin Islands	4.67
Saint Pierre and Miquelon	0.04
Netherlands Antilles	3.99
Tokelau	0.02
Seychelles	0.82
Saint Kitts and Nevis	1.84
Saint Vincent and the Grenadines	8.53
Equatorial Guinea	5.26
Grenada	7.93
Niue	0.24
Sao Tome and Principe	2.69
Nauru	0.06
Bahrain	15.26

It is noted that there are two main characteristics of these countries which make them the least contributor to methane gas in the atmosphere, namely, (1) livestock production in these countries is minimal or non-existent, and (2) economies of these States are not based on agriculture or animal production. It may, thus, be concluded that smaller amounts of methane gas production observed in these countries is attributable mainly to the minimal livestock production activities engaged in by the people. Bahrain, for instance, is an oil-producing country, located in a mostly desert area, and which does not engage in livestock or ruminant production. It is an oil-based economy. Meanwhile, Macao is primarily an urban State and a cosmopolitan area where agriculture and farming are virtually non-existent. Its economy is mainly based on recreational tourism.

Countries with the highest contribution of methane gas in the atmosphere through animal manure are shown in the table below:

Table 3: Countries with highest manure methane gas emission

NAME OF COUNTRY	METHANE PRODUCTION (Kilotonne)
Myanmar	2845.53
Poland	3114.36
Viet Nam	3193.62
Australia	3691.19
Netherland	3705.24
United Kingdom	3778.87
Ukraine	3836.08
Japan	4163.94
Canada	4871.82
Italy	4953.01
Brazil	6123.19
Pakistan	6275.58
Spain	6620.68
France	7372.31
Germany	7738.50
Russian Federation	9013.14
India	26042.02
China, Mainland	26987.81
China	27291.06
The United States of America	36297.13

Countries which belong to this category have, generally, the large animal production as industries. Moreover, they also possess some or all of the following characteristics: (1) they are located in temperate zones with the exception of Myanmar and Vietnam; (2) some of these countries have poor manure management and utilization, (3) high livestock population, (4) most of these countries are belong to well-developed countries which their practices in livestock farming are more on mechanization.

The utilization of farm manure can minimize the pollution in the environment, especially in the atmosphere. The energy can be replaced with methane gas emitted from animal manure by converting it into biogas. The use of biogas or methane digesters on farms not only serves as a source of energy for the farm, thereby reducing the number of fossil fuels, but also allows in decreasing methane, CH_4, nitrous oxide deposited in the atmosphere. When manure is deposited in a digester, it is protected to prevent considerable odour escaped through the atmosphere.

Most industrialized and highly developed countries like the United States also produce high amounts of methane gas coming from animal manure despite their advanced technological status. In such instances, the only reasonable attribution for the observed methane gas emission is the relatively high level of animal production in these countries to support a huge meat-eating population.

Conclusion

High methane gas emission from animal manure can be attributed to high livestock and animal production activities in the various countries and population pressure. Conversely, small methane gas emission of different countries results from low livestock and animal production activities. Since the temperatures of the various geographic locations have a direct influence on the amounts of methane gas absorbed by the atmosphere, countries in temperate climates engaged in large-scale animal production farming are expected to have a greater contribution to the accumulation of GHG in the atmosphere. The use of methane gas extracted from animal manures as a possible alternative energy source for countries with high amounts of methane gas emission is a strategy that can be adopted by the States for a sustainable animal livestock industry in the future.

References:

Bastasch, M. (2015). *UK Gov't: Farts May Bring On The Apocalypse If YouDon't All Eat Healthier.* Retrieved from: http://dailycaller.com/2015/01/28/meat-methane-globalwarming/#ixzz3pkrIiVLh and http://dailycaller.com/2015/01/28/meatmethane-global-warming

Canberra, A. (2007). *National Greenhouse Gas Inventory.* Australian Greenhouse Office. Executive summary- Inventory of U.S Greenhouse Gas Emissions and Sinks: 1990-2009.

Hermansen, J. E. & T. Kristensen (2011). *Management options to reduce the carbon footprint of livestock products*. *Animal Frontiers*, *1*(1), 33-39.

Isolation of Succinivibrionaceae Implicated in Low Methane Emissions from Tammar Wallabies P. B. Pope, Science 333, 646 (2011). Executive Summary - Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009

Mathews, C. (2006). *Livestock a major threat to the environment*. Retrieved from:http://www.fao.org/newsroom/en/news/2006/1000448/index.html

McAllister, T.A., and T. Topp (2012). *"Role of livestock in microbiologicalcontamination of water: Commonly the blame, but not always the source". ,Animal Frontiers, 2*(2), pp. 17-27. doi : 10.2527/af.20120039. Retrieve from: http://www.agr.gc.ca/eng/abstract/?id=29225000000397

Peña, R. (2015*). Peña: Organic Farming is good for the environment*. Retrieved from: http://www.sunstar.com.ph/pampanga/opinion/2015/05/07/penaorganic-farming-good-environment-406216

Steinfeld, H. (2006). *UN- FAO, Livestock's Long Shadow–Environmental Issues and Option*. Shepherd, J. M. (2011). Carbon, Climate Change, and Controversy. *Animal Frontiers, 1*(1), 5-13.

Shourie, D. (2006). *Cattle biggest Contributor to Global Warming: UN*. Retrieved from: http://www.dnaindia.com/scitech/report-cattlebiggest-contributor-to-global-warming-un-1067005