UNCOVERING CARBON EMISSION CHARACTERISTICS OF AGRICULTURAL CROPS AND LIVESTOCK BY ARTIFICIAL INTELLIGENCE

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ABSTRACT

This study attempts to verify the results reported earlier by Atkin (2017) that plants are, in fact, the ultimate source of carbon dioxide. The study utilized the descriptive design of research. Data on carbon dioxide emissions were gathered from Carbon Dioxide Information Analysis and data of livestock and crop production were gathered from the Food and Agricultural Organization from 1960 to 2013. The data analysis is based on a simplified assumption that the accumulated CO_2 in the atmosphere includes agricultural crop production and livestock production as sources. In order to treat the data, symbolic regression was used. Symbolic regression is a type of regression analysis that does not specify the functional form of relationships between two variables. It utilizes genetic algorithms to execute the analysis. The study provides further evidence of the claim that plants actually produce more carbon dioxide than was previously held. The study also strengthens the hypothesis that with global warming and with countries in tropical climates like the Philippines, CO_2 emissions from plants can be more than 11 times higher than traditional knowledge held.

Keywords: *CO_2, photosynthesis, livestock, crop production*

1.0 Introduction

Recent research findings suggest that plants could be releasing more carbon dioxide than was previously thought (Atkin, 2017). Burning of fossil fuels released each year as reported, accumulates at around five to eight tons of carbon dioxide and is approaching to 11 times higher as estimated (Atkin, 2017). This enormous influx is considered as the fate of the future where those rates of carbon dioxide released by plants will increase as the world gets warmer. In order to provide a more sophisticated evidence, this study attempts to verify the results reported earlier that plants are, in fact, the ultimate sources of carbon dioxide.

Carbon dioxide emissions continue to rise over the past century due to identified causes such as an increase in population, animal and livestock production, burning of fossil fuels, and rampant industrial development. Carbon in nature (Lamb, 2018) is a warm gas, which concentrates in the atmosphere, causing a perceptible depletion of the ozone layer permitting the ultraviolet rays coming from the sun to enter the earth's surface. Over the past 200 years, Cerri et al., (2007) averred that there has been a marked increase of temperature and pointing to agricultural activities which involve clearing of the land, and fossil fuel decomposition as the main sources.

On the other hand, plants are known to be an important factor for sequestrating carbon dioxide by using it as fuel in order to facilitate photosynthetic activity. As part of its natural mechanism, plants need to utilize carbon dioxide and fix it, producing oxygen as a by-product. This characteristic of plants influences the amount of carbon by reducing its inputs in the atmosphere (Lamb, 2018). However, plants also produce CO_2 as a metabolic product of cellular respiration. When light is not available, i.e. when it is dark, they do not have an energy source for photosynthesis, and so cannot use CO_2 as substrate and must continue to respire to stay alive so in turn, they become net producers of carbon dioxide.

While production of agricultural crops and livestock continue to rise to meet population demand, carbon dioxide accumulation will continue to increase. Livestock (animals) is a well- known source of CO_2 as a result of metabolic process. This is supposedly balanced by the ability of the agricultural crops to absorb carbon during photosynthesis. This traditional knowledge is challenged by recent findings (Atkin, 2017) which claimed that plants may actually be net CO_2 producers. The present study seeks to investigate and test the following hypothesis: *In terms of carbon dioxide emissions attributed to agricultural activities, animal and crop production result in a net zero carbon production.*

2.0 Conceptual Framework

The increased production of carbon dioxide is a result of the changing climate patterns due to natural and anthropogenic causes. While there are many sources of carbon dioxide, agricultural activities remain as a major consideration in carbon emission. The Schematic diagram of the study is shown below:

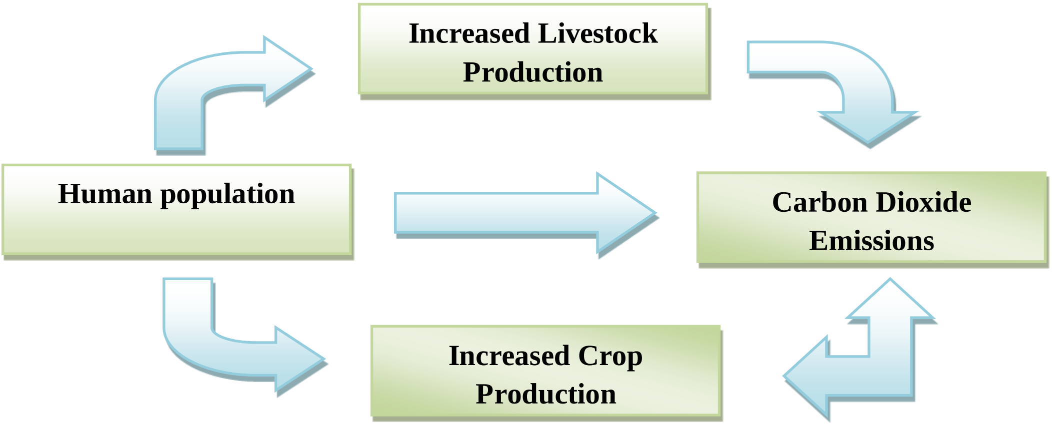

Figure. 1 Research Paradigm

Crop Production is a type of agricultural activity which aims to produce yields of products necessary for food consumption. Production of crops, especially in the tropical countries plays a vital role in their survival. Likewise, it is widely held that producing crops reduce the amount of carbon dioxide concentration in the environment and uses it as a substrate in manufacturing their own food in the process known as photosynthesis. On the other hand, **Livestock Production** is considered as a significant factor in the production of carbon dioxide as a result of cellular respiration. As the livestock production increases, the inputs of CO_2 are also vertically increasing. Controlling the production of agricultural animals may, therefore, have a significant impact in reducing the rate of carbon emissions. Traditional knowledge, such as this, has guided global agriculture for centuries (Lamb, 2018).

Green plants produce carbon dioxide and water as respiratory products. Through the bulk of the life of plant, it produces more oxygen than it removes more carbon dioxide. Exact amounts will vary based on available light, plant species, water, atmospheric condition and overall health of the plant. In general, the greener the plant is, the more the plant is involved in photosynthesis and thus, the more oxygen it produces. However, this does not account for how much oxygen it uses (and thus how much carbon dioxide it produces). In general, plants (and other chlorophyll laden life forms) consume more carbon dioxide than they create (Ford, 1986).

A research from the Australian National University (Atkin, 2017) suggests that if the "dark reaction" are accounted for, then plants do, in fact, produce more carbon dioxide than was previously thought. The traditional knowledge about the ability of the plants to also produce CO_2 is based on "light reaction" during which plants absorb CO_2 and produce O_2 as a by product. But during night time, when photosynthetic activities cease, plants respire and give off excess CO_2 into the atmosphere.

3.0 Research Methods and Design

The study made use of the descriptive design of research. Data for carbon dioxide emissions were gathered from Carbon Dioxide Information Analysis and data of livestock and crop production were gathered from the Food and Agricultural Organization since 1960-2013. The data analysis is based on a simplified assumption that the accumulated CO_2 in the atmosphere is mainly due to agricultural crop production and livestock production. Although this assumption may not conform with reality because of the numerous sources of carbon emissions, this assumption simplifies the modelling process and may be considered as a first order approximation of the relationships.

In order to treat the data, symbolic regression was used. Symbolic regression is a type of regression analysis that does not specify the functional form of relationships between two variables. It utilizes genetic algorithms to execute the analysis. This is included as an option in many statistical software. For this purpose, a one-month trial latest version of the software EUREQA was used in order to analyze the given data set. Analysis of the relationships among the given variables was done by decade in order to measure the specific trend of the production of CO_2 in relation to the production of agricultural livestock and crop.

4.0 Results and Discussion

Figure 2 shows the comparative graph of the production of agricultural livestock and crops. Trends in crop production and livestock production appear to be increasing over time because of continuous demand for consumption due to population pressure. Moreover, the gap between livestock and crop production widens over time, signifying a preference for plant-based products over animal-based products. The trend in crop production as well as in livestock production, visually fit a linear pattern with very slight upward curvature.

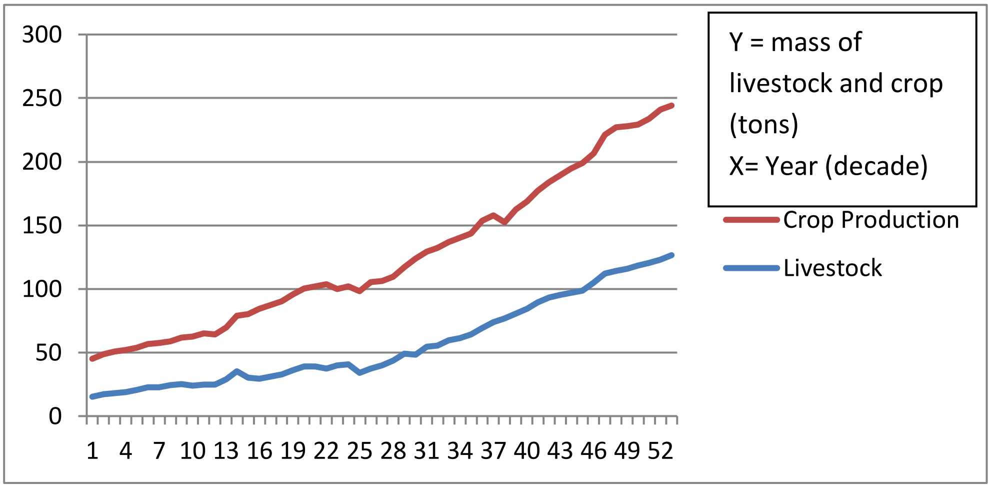

Figure 2. Production of livestock and crops

Figure 3 shows the carbon dioxide emissions for the period 1960-2013. The same upward movement of the series is prominent for the CO_2 emissions, although the upward trends are punctuated by a series of slight up and down movements. These fluctuations are indications of volatility or variations either in measurement or actual physical accumulation of CO_2. The fact that both series of CO_2 emission and agricultural production have upward trends, show that there is a relationship between these two quantities.

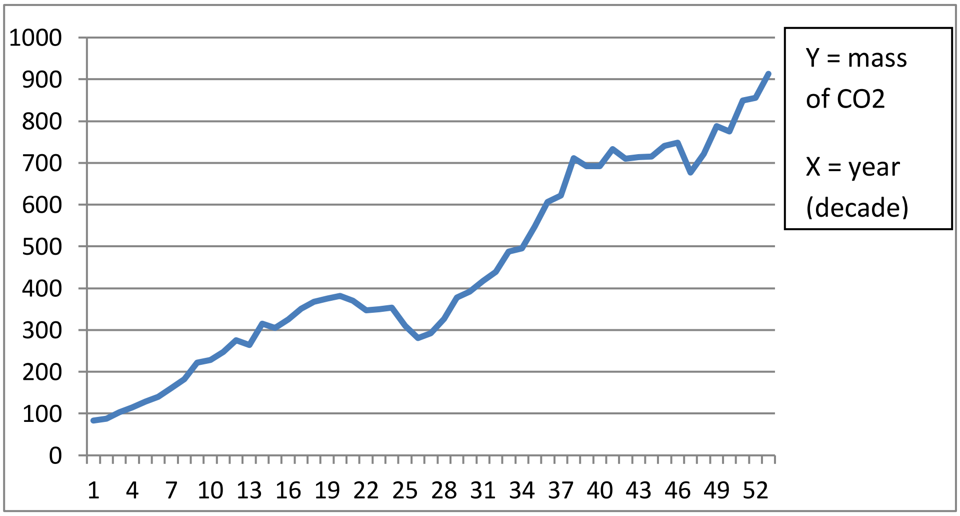

Figure 3. CO2 emission from 1960 to 2013

The Trend Curve Patterns

Detailed analysis of the observed trends in the time series graph was performed by breaking up the time periods through decades. Table 1 shows the trend of the agricultural crop production for five (5) decade periods. The computed trend lines for the first four (4) decades from 1960 reveal an upward quadratic trend which suggests a rather faster growth rate of crop production from 1960 to 2000. The growth pattern became linear in the last decade up to 2013 which reveal a deceleration in crop production in the last decade.

Table 1. The trend lines in crop production

Decade	Trend Lines (x) Crops	Mean Absolute Prediction Error
1	Yt= 13.2275+1.8825*t-7.10e-02t**2	2.36048
2	Yt= 24.5925+1.03102**t+2.33e02*t**2	5.74382
3	Yt= 41.9548-2.47220*t+0.326553*t**2	4.58115
4	Yt= 51.446+2.21197*t+0.113485*t**2	1.12647
5	Yt= 85. 9219+3.19687*t	1.23943

Meanwhile, Table 2 displays a similar trend analysis for livestock production. Livestock production, like crop production, shows a quadratic trend, but only in the first three (3) decades. This suggests rapid growth rate in livestock production from 1960 to 1990. However, the growth trends decelerated in the succeeding two (2) decades from 1990 to 2013 with a linear trend in these two time periods.

Table 2. The Trend lines in livestock production

Decade	Trend Lines (y) Livestock	Mean Absolute Prediction Error
1	Yt= 30. 3327+0.45697**t+2.77e-02**2	1.72111
2	Yt= 34.1903+3.22692*t-4.05e-02**t*2	3.54678
3	Yt= 65.218-1.53621*t+0.236212*t**2	2.91844
4	Yt= 75.2407+0.80933*t	2.16089
5	Yt= 87.1542+2.56401*t	1.74905

Finally, Table 3 summarizes the trend analysis of carbon dioxide emissions for five (5) decades. Trends in the CO_2 emission are characterized by intermittent appearances of linear and quadratic trends in contrast to the crop and livestock production trends. Such intermittent is an indicative of the presence of other human activities that contribute to the accumulation of CO2 in the atmosphere viz. industrial production, volume of motor vehicles, fossil fuel burning and others. Despite this volatile behaviour, however, it is clear that the last decade shows an alarming quadratic trend in the volume of CO2 emission in the country.

Table 3. The trend lines in CO_2 emissions

Decade	Trend Lines (z) Carbon dioxide	Mean Absolute Prediction Error
1	Yt= 51.8807+16.9635*t	2.5254
2	Yt= 229.822+18.6325*t-0.295860**t**2	2.6260
3	Yt= 423.948-42.8378*t+3.93619*t**2	4.949
4	Yt= 377.923+35.1341*t	2.625
5	Yt= 756.338-22.387*t+2.61641*t**2	2.435

Overall Trend Curves

The overall trends for the three- time series observations were obtained through symbolic regression using an artificial intelligence software called EUREQA (in its 30-day trial version). Table 4 provides the output for the trend analysis.

Table 4. Forecasted trend curve of CO_2, livestock, and crop production

Variables	Trend Lines	Mean Absolute Error	R squared
Crop production	$X= 27.7+0.204t^2+0.000138t^4+3.28 \sin(\sin(0.438t))-9.99e\text{-}9t^6-0.000904t^3$	1.5271627	0.99317865
Livestock production	$Y= 14+1.34t+0.00014t^4-t^4 \sin(1.5e\text{-}6t)-0.00295t^2$	1.6739797	0.99475506
Carbon dioxide emissions	$Z= 65.73+13.51t^2+0.007996t^3 \sin(1.767-0.2316t)+1.153t \sin(0.007752t^3 \sin(1.767-0.2316t)^2$	1.30464	0.9953317

Symbolic regression captured the presence of high frequencies or short cycles in all of the variables considered. These high frequencies accounted for the fluctuations around the trend curves for each of these variables. Crop production is dominated by a quadratic trend with high frequency fluctuations and so does the livestock production. On the other hand, the carbon dioxide emission is dominated mainly by a cubic trend. It follows that accumulation of CO2 in the atmosphere grows much faster than either crop and livestock production figures. These results are graphically presented in Figures 4 to 6.

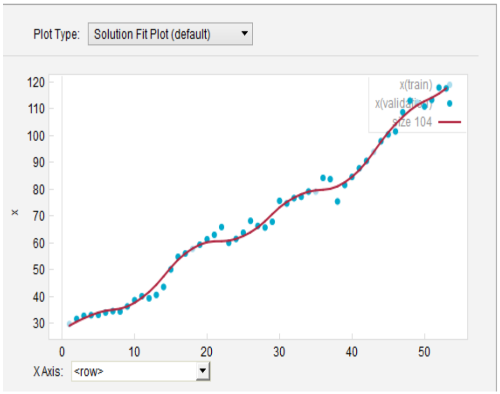

Figure 4. Trend of crop production

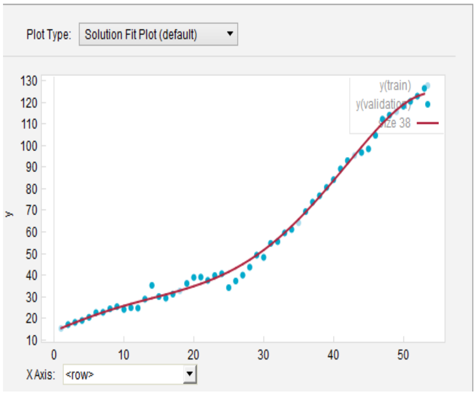

Figure 5. Trend livestock production

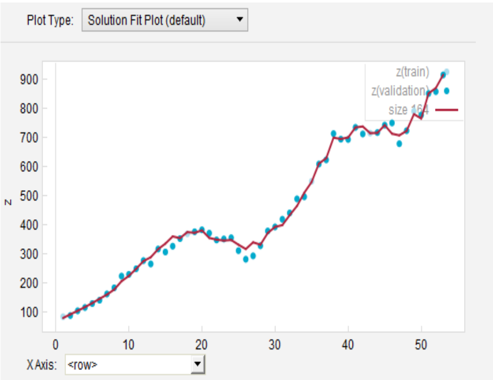

Figure 6. Trend of CO_2 emissions

Relationship Between CO_2 Emission and Crop and Livestock Production

Table 5 summarizes the relationship between CO_2 emission and Crop and Livestock Production. The first equation shows the relationship between CO_2 emission and crop production. Here, CO_2 emission varies as the cube of crop production. On the other hand, CO_2 emission varies as the square of livestock production. These relationships suggest that crop production is more related to increase in CO_2 emission than livestock production.

Table 5. Relationship of CO_2 emission with crop and livestock production

Dependent Variable: CO_2 emission

Variable	Equation	Mean Absolute Prediction	R squared
Crop Production	$Z= 39.4\log(x)+0.00166x^3+6.54x\log+1.34x\cos(5.86\log(x-5.86))+17.4\sin(39.4\log(x)+6.54x\log(x)-219-0.392$	16.038279	0.99044574
Livestock Production	$Z= 135+0.079y^2+111\sin(0.159y)-000188y^3-0.508y \sin(149y+0.0629y^3+0f$	27.615366	0.95728261

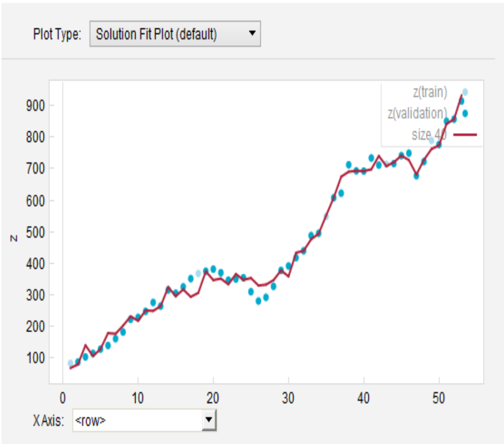

Figure 7. CO2 vs. Crop Production

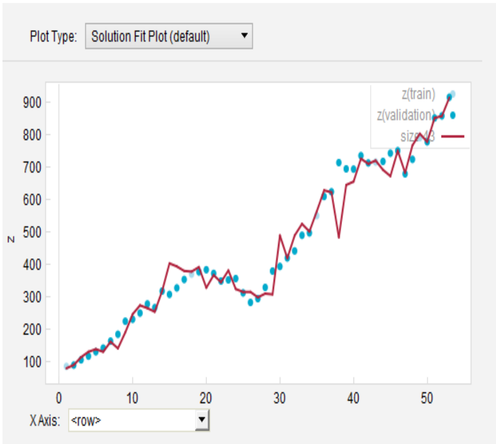

Figure 8. CO2 vs. Livestock Production

Table 6 provides an accounting of the variances explained by livestock and crop production for CO_2 emission. Tabular values show that crop production accounts for 91% of the variance in CO_2 emission while livestock production may be responsible for only 3.5% of the variance in the same quantity. The remaining 5.5% of the variance in CO_2 emission is attributed to the other unspecified factors.

Table 6. Portion of CO_2 Variance Accounted for Crop and Livestock Production

Source of Variance	Sum of Squares	Percent Contribution
Crop Production	2,612,964	91%
Livestock Production	102,046	3.5%
Other Factors	158884	5.5%
Total	2,873,894	

5.0 Conclusion

The study provides further evidence of the claim by Atkin, 2017, that plants actually produce more carbon dioxide than was previously held. In fact, in the case of agricultural production, crop production accounted for 91% of the CO_2 emissions while livestock production explained only 3.5%f of the CO_2 emissions. The study also strengthens the hypothesis that with too much carbon dioxide that is a result of global warming and with countries in temperate climates like the Philippines, CO_2 emissions from plants can be more than 11 times higher than traditional knowledge held.

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