TED ANKARA COLLEGE FOUNDATION HIGH SCHOOL

International Baccalaureate

ENVIRONMENTAL SYSTEMS

AND

SOCIETIES

Investigating how does the species in livestock (cows, goats and pigs) activities affects the methane gas emissions in different developed countries between the years 1990 to 2020?

Introduction:

As a citizen of a country that profits mostly from livestock and agriculture, this topic interests me the most. The assumptions of differet species in livestock to rising methane gas emissions in developed nations are examined in this essay. The exploration will focus on same species' methane gas emissions on each country I chose. There are a lot of unanswered questions related to the subject and the investigation's primary goal is to effectively address the questions. Like cows are said to be the main reason for methane gas emission but how about the other species like goats and sheeps effects the rising methane emissions for the nations in the modern world? If so, which specific country or countries is/are most impacted? Does the government effectively regulate livestock activities? Which country type relies most on livestock for methane emissions? What can be done to reduce the methane emissions brought on by the breeding of species for livestock? are the primary researches taken into account during the investigation? Beyond the questions, graphs taken from research papers or internet statistic sources are used to highlight the rise in methane gas emissions, the increase in the number of breeds in livestock, and relationship between the increased number livestock activities and methane gas emissions. Three options are finally explored, along with when each should be done to prevent or control methane gas release from livestock. It is also reported on how the investigation may be improved and what its limitations are.

Background Researches:

Because greenhouse gases are the primary factor in global warming, they have serious impacts on nature and the environment in today's globe. whose effects on our lifestyles and environments are not minor. The amount of methane gas in the atmosphere is rising, which is one of the main causes of the greenhouse effect. A greenhouse gas titled methane is created

from one carbon atom and four hydrogen atoms. There are two methods that it can be transferred to the environment. It can either be burned as fuel and discharged as CO_2 into the environment, or it can be directly released into the environment.[1] Every year, the breading of goats and sheeps causes great amounts of methane gas to be discharged into the atmosphere Hovewer the cows are the species that caused the most methane gas discharge. Figure 1.1 shows how the atmospheric methane gas content is increasing. Methane gas absorbs more heat than Carbon Dioxide, Ozone, and Water Vapour, making it far more dangerous and damaging than the other greenhouse gases that are emitted.[2] To put it another way, during a 100-year period, methane gas is 25 times more powerful than carbon dioxide.[3]

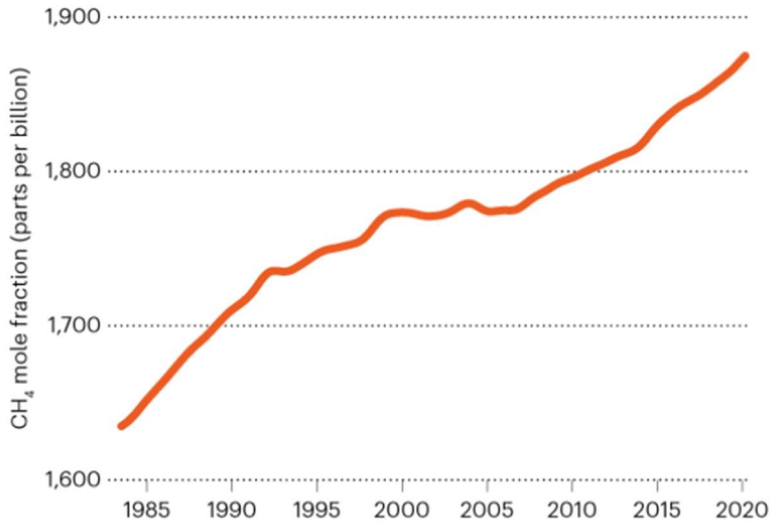


Figure 1.1: The graph shows the increase of methane gas levels in te atmosphere throughout the years 1990-2020.[4]

According to the United States Environmental Protection Agency (EPA), ruminant livestock (which includes pigs, cows, and goats) are estimated to be responsible for about 20% of the global methane emissions.[5] A single cow can generate between 70 to 120 kilogram of methane yearly. For other species like goats this number decreases to between 9.85 to 51 kilograms and for pigs the number is between 91 to 182.5 kilograms per pig. Given that there are 1.5 billion cows around 1.1 billion goats and 677.6 millions of pigs in the World[6], the

consequences of livestock and breeding activities on methane gas emissions are significant. I am mostly interested in the methane gas produced by livestock since I eat a lot of red meat and because it is an important part of the diet in my fitness progress. In my environmental systems and societies course, I was unhappy to find that eating red meat is bad for the ecosystem. I did believe, though, that there ought to be a way to somehow stop the methane released by livestock activities from harming the environment. While considering the subject, I realized that I could combine my interest in learning more with my extended essay and started researching whether the country's livestock activities had a higher impact on methane gas emissions. If raising species and livestocking indeed has a negative impact on the environment, which country types' methane emissions are most affected, and what may the answer be? I also believed that in order to realize whether there are differences between countries and why they exist, I should also take into account the activities of the government or other competent. Thus, I came up with the research question "How does the increasing methane gas emissions in developed countries from 1990 to 2020 is effected by the livestocking activities and breeding of cows, goats and sheeps for the purpose of agriculture?".

Figure 1.2 shows why I chose cows, pigs and goats as they have a huge impact on methane emission. However, Cows produce significantly more methane when compared to goats and pigs[7] because of the population difference between them.

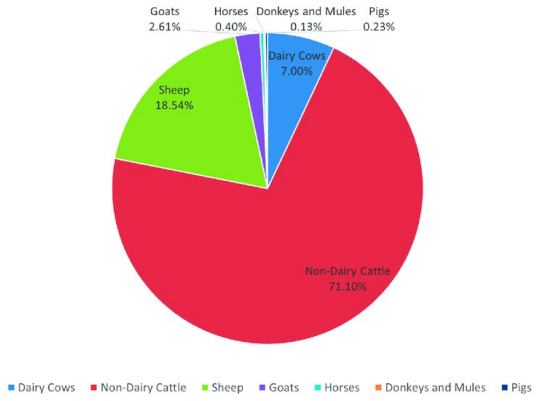


Figure 1.2: Methane gas distribution for agriculture.[8]

Methodology Preperation:

I had to work out several issues relating to the exploration before applying the process. I had to calculate the percentage of methane gas released by livestock for each species for each country in a certain timeline that I will be comparing in the exploration because there were no direct data for some of the information, such as what proportion of the methane released from the cows, goats and pigs made up the overall released methane gas for the selected country. As the annual production of methane gas from cows ranges from 70 to 120 kilograms on average, I made the assumption that all cows worldwide produce 95 kilos of methane gas. For pigs this average is 136 and for goats 30. Methane gas was converted to carbon dioxide because the country's emissions figures are based on carbon dioxide datasets such as kilotons of carbon dioxide. As 1 kilogram of methane is equal to 25 kilograms of carbon dioxide over a 100-year period.[9] I multiplied 95 (which is the cows annual production of methane gas), 136 (which is the pigs annual production of methane gas) and 30 (which is the goats annual production of methane gas) by 25. I, therefore, assumed that a single cow produces 2375 kg a single pig produces 3400 kg and a single goat produces 750 kg of carbon dioxide annually. I multiplied the numbers by the number of species in each country to determine what proportion of that country's overall carbon dioxide emissions the final value represents. As I previously stated, it was necessary to translate all measurements to carbon dioxide scale because all analytic data for all nations worldwide is measured in carbon dioxide (in kilotons). To avoid bias throughout the procedure, such as statistical selection bias, the nations are chosen at random. I used a random number generator to select 5 nations from among the many countries which are developed.

Methodology:

1. Choose countries (Developed)
2. Define a timeline. (1990-2020)
3. Determine all of the countries' carbon dioxide emission levels for the given time period.
4. Compute all of the species numbers for each country for the given time period.
5. Multiply 2375 by the number of cow 3400 by the number of pig and 750 by the number of goat in each country for the provided amount of time.
6. Increase the values by 100 as well, which you calculated by multiplying the number of species in the country by 2375, 3400, 750.
7. Divide the outcome by the country's total carbon dioxide concentration for the given year. (Remember to divide them into the same units.)
8. Create three graphs that contain CO_2 emissions, cow, pig and goat population, and the impact of their breeding on CO_2 emissions for one country from each country type for years 1990 and 2020.
9. Subtract the effect of species value in 1990 from the effect of species value in 2020 to determine how the impact of species breeding changed for the overall emission. If the result is positive, the effect of livestock on global CO_2 emissions has decreased. If the score is negative, then there have been more emissions from animals. Even though, just because the influence on overall CO_2 emissions decreased, which will be covered in the section on evaluation, does not necessarily suggest that the CO_2 emission from livestock decreased.
10. Now, subtract the CO_2 emission from 1990 from the value from 2020 to determine how much the total methane emission has increased or reduced. Moreover, it indicates subtracting CO_2 emission of the country in 2020 from the CO_2 emission of the country

in 1990. Positive values indicate a reduction in CO_2 emissions that is equal to the value. If the value is negative, the CO_2 emission rose by the same amount as the value.

11. In the final step, subtract the lower species number from the higher species number to determine the change in CO_2 emissions from the breeding of them. Subtract species population (cow, goat, pig) in 1990 from species population (cow, goat, pig) in 2020 if it is greater. Subtract species population (cow, goat, pig) in 2020 from species population (cow, goat, pig) in 1990 if it is lower. however, do not perform any calculations in this phase without first multiplying each value by 2375, 3400, 750; otherwise, you will only observe the change in the inventory of species. Following the calculation, for example if the value for the cow population in 2020 is higher, this indicates that the cow CO_2 emission has grown. If the value from 1990 is higher, then cow CO_2 emissions have dropped.

For instance, Netherlands emits 162,728 kilotons of carbon dioxide each year and has 3,800,000 cow. The total annual carbon dioxide emissions from cows are calculated as follows: 3,800,000 x 2375 = 9025000000 kilos. In order to convert 162,728 to kilograms, we must multiply it by 1000000, which results in 162728000000. Therefore, we need to multiply 9025000000 by 100 and divide the result by 162728000000 to determine what proportion of Netherlands' carbon dioxide emissions are influenced by the breeding of cow and that is 5.55. According to our calculations, breading of cow releases 5.55% of the carbon dioxide in Netherlands. This example was limited by the methodology's ninth phase. In below, examples of the 10th and 11th steps are shown.

10th Step: Netherlands' CO_2 emissions in 1990 were 198.600.000 tons. Netherlands' CO_2 emissions in 2020 were 159.500.000 tons. This means that Netherlands' CO_2 emissions have decreased by 39100000 tons of CO_2 since 1990.

11th Step: Given that one cow typically emits this amount of CO2 annually, we multiply Netherlands' cow population of 3,800,000 by 2375. 3.8 million times 2375 equals 9025000000 kg of carbon dioxide. Netherlands' had 4.200.000 cow in 1990, and when you multiply that number by 2375, you get 9975000000 animals. 9975000000-9025000000 equals 950000000. As a result, we can say that Mexico's CO2 emissions from cow decreased slightly probably because of the covid crisis in 2020. If you don't want to use this method, you may also determine the value in million tons by subtracting the original cattle number from the first cow number. Multiplying it by 2375, and then dividing it by 1000. If the value is positive, the emission has dropped; if it is negative, it has increased.

Raw datas:

The obtained and calculated datas below illustrate the change in the number of species, the change in CO_2 emissions, and the percentage of species breeding that has an impact on overall CO_2 emissions. Tables of raw data are divided into species kinds.

Countries	Cow population	Total CO_2 Emission (In million tones)	Effect of cow breeding
Netherlands 1990	4.2 million	173.500.000	5.75%
Netherlands 2020	3.8 million	163.900.000	5.506%
Canada 1990	13.2 million	460.000.000	6.82%
Canada 2020	11.2 million	577.000.000	4.61%
France 1990	20.5 million	357.000.000	13.64%

France 2020	18.3 million	307.000.000	14.16%
Switzerland 1990	1.6 million	40.200.000	9.45%
Switzerland 2020	1.5 million	38.400.000	9.28%
Australia 1990	25.7 million	267.000.000	22.86%
Australia 2020	24.1 million	532.200.000	10.75%

Table 2.1: cow population, overall CO_2 emissions, and the impact of cow breeding for selected countries are shown above.

Countries	Goat population	Total CO_2 Emission (In million tones)	Effect of goat breeding
Netherlands 1990	70.000	173.500.000	0.03%
Netherlands 2020	540.000	163.900.000	0.24%
Canada 1990	218.000	460.000.000	0.036%
Canada 2020	266.000	577.000.000	0.034%
France 1990	1.9 million	357.000.000	0.4%
France 2020	1.1 million	307.000.000	0.27%
Switzerland 1990	19.000	40.200.000	0.035%
Switzerland 2020	75.000	38.400.000	0.15%
Australia 1990	3 million	267.000.000	0.84%
Australia 2020	2.4 million	532.200.000	0.34%

Table 2.2: goat population, overall CO_2 emissions, and the impact of goat breeding for selected countries are shown above

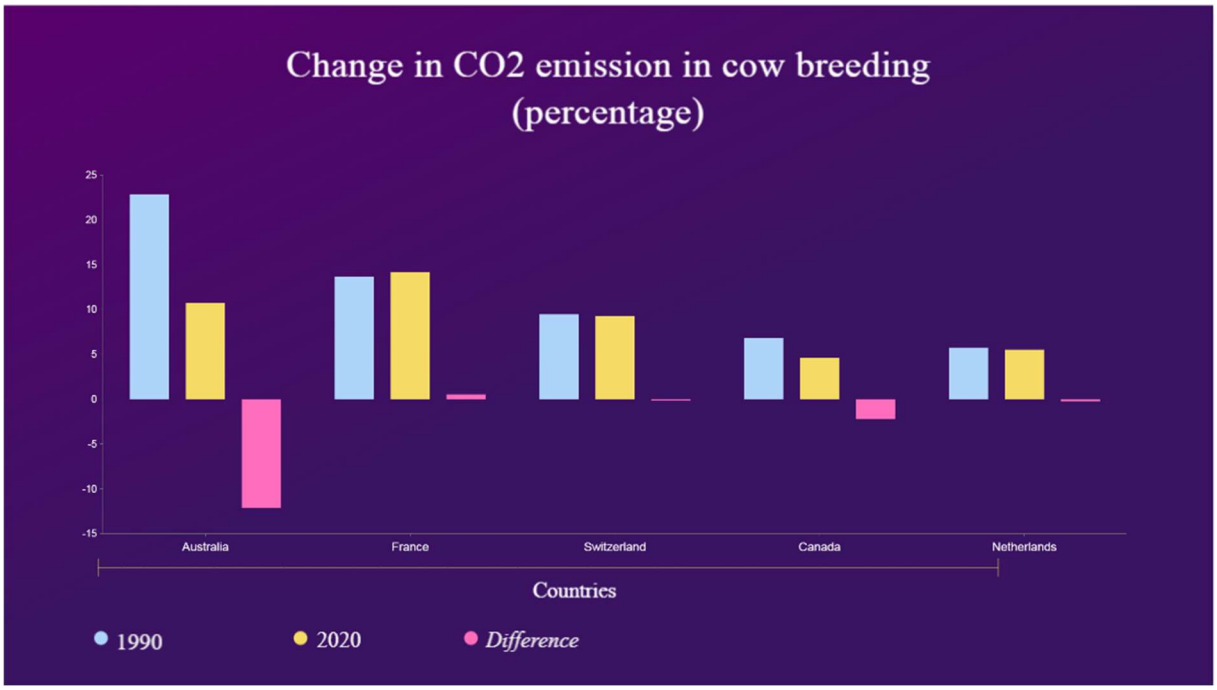
Countries	Pig population	Total CO_2 Emission (In million tones)	Effect of pig breeding
Netherlands 1990	11.6 million	173.500.000	22.7%
Netherlands 2020	12.5 million	163.900.000	25.9%
Canada 1990	12.3 million	460.000.000	9.1%
Canada 2020	14.2 million	577.000.000	8.37%
France 1990	16.8 million	357.000.000	16%
France 2020	12.5 million	307.000.000	13.8%
Switzerland 1990	1.6 million	40.200.000	13.5%
Switzerland 2020	1.5 million	38.400.000	13.3%
Australia 1990	5.5 million	267.000.000	7%
Australia 2020	2.9 million	532.200.000	1.9%

Table 2.3: pig population, overall CO_2 emissions, and the impact of pig breeding for selected countries are shown above

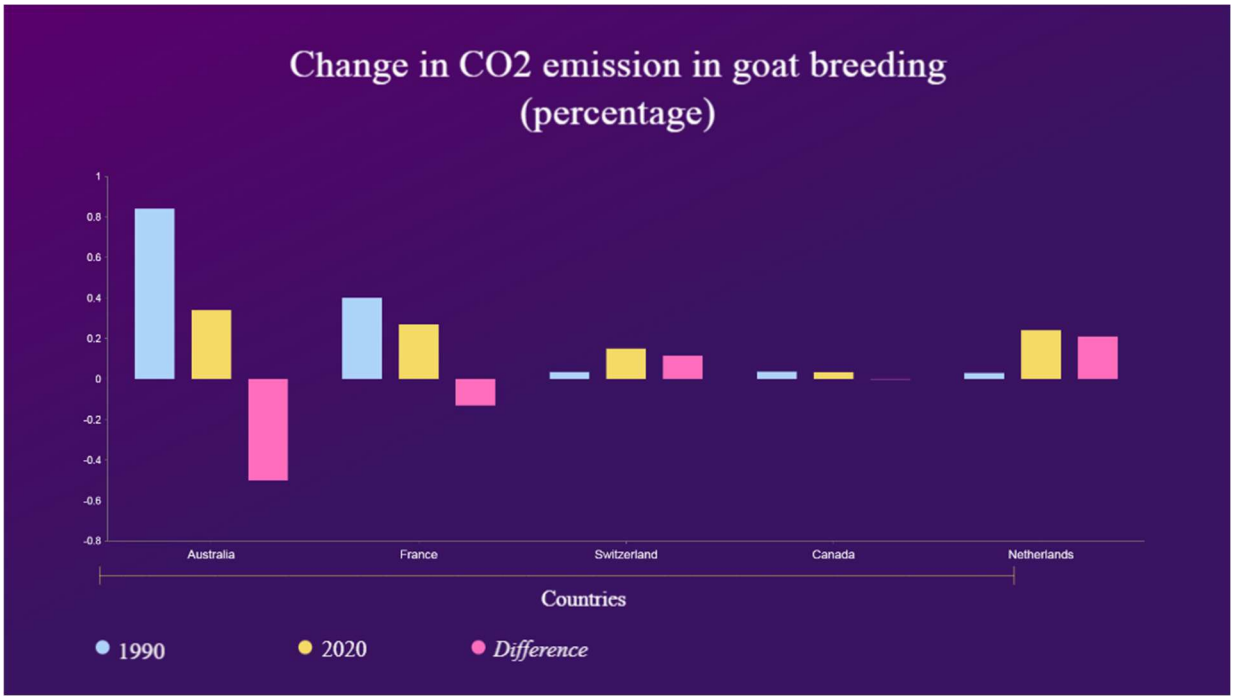
All datas in total CO_2 emission bar are from the global carbon atlas.

Data Analysis:

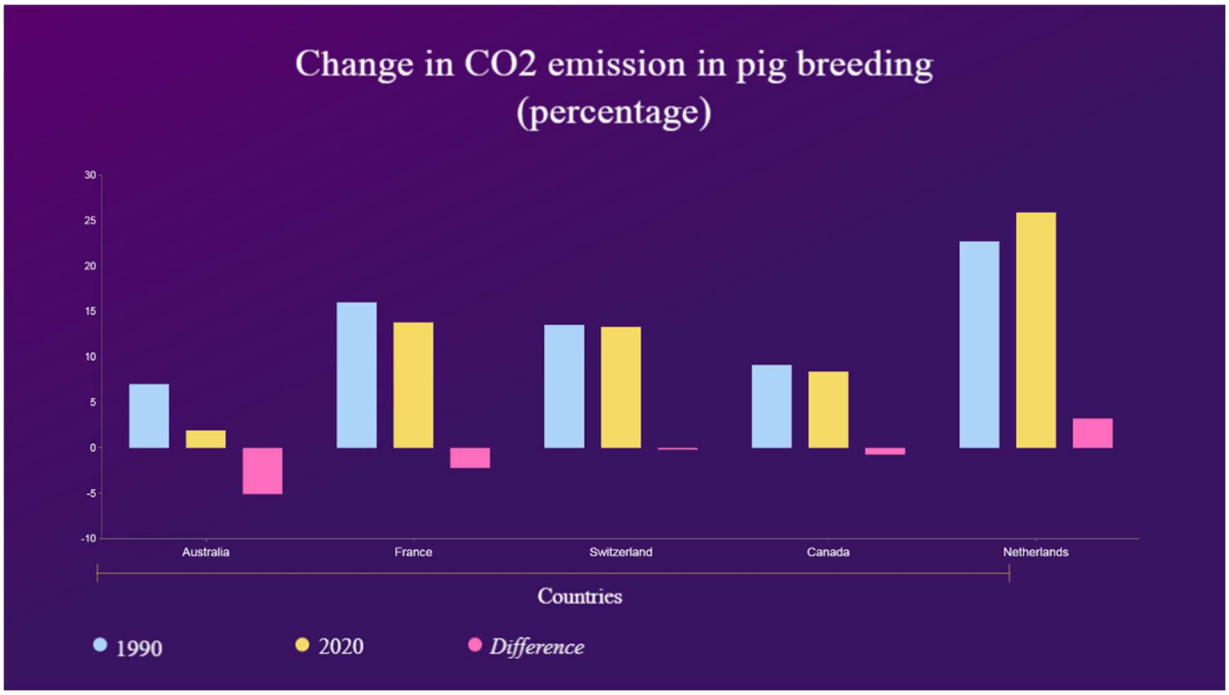
The six primary graphs in the analysis will show changes in the countries' CO_2 emission levels caused by different animals, the percentage of species breeding that contributes to total country CO_2 emissions, and the level of CO_2 emissions from breedings. It was possible to gather all the data for one graph, but it was more confusing, therefore they are displayed separately.



Graph 3.1: Trends in the countries' cow breeding related methane gas emissions 1990 until 2020



Graph 3.2: Trends in countries’ goat breeding related methane gas emissions 1990 until 2020



Graph 3.3: Trends in countries' pig breeding related methane gas emission 1990 until 2020.[10]

As we can see from the graphs, even though the change is generally minimal for all graphs (and even negative in mostly Australia in all graphs), it is still dangerous for the environment, when we look at the total CO_2 emission in the World. On the other hand, we can observe a significant decline in Australia's CO_2 emission; however, in this instance. Australia stands out because the CO_2 emission drop did not occur fully as a result of environmentally friendly or eco-friendly action; rather, wildfires occured in 2019 in the nation caused the development and the CO_2 levels to be decreased. Thus, we can claim that Canada and Switzerland have more consistent CO_2 levels. Netherlands and France are significantly weaker on the subject and unable to control their rising CO_2 emission levels caused by goats and pigs like Canada and Switzerland despite still being successful controlling cows CO_2 emission.

Conclusion For Data Analysis:

The proportion of methane gas emitted by livestock breeding did not decrease even though the percentage of carbon emissions due to it did. Still, there are more than enough emissions to damage the ecosystem. I looked at France, Australia, Switzerland, Canada and Netherlands which are all developed nations.[11] The outcome demonstrates that developed countries are successful controling cows methane emissions. However because of the other livestock animals which are held in the second place like goats and pigs, those countries are affected by livestock breeding since methane emissions have not decreased and are continuing to slowly rise. By the help of this information we can see that because of the minority of the pig population and the scarsity of the goats methane emission countries decide to focus more on cows. Although this action seems like it has no affect on short-term, if these countries continue to ignore these species they could have some difficulties in the near future.

Solutions to prevent the issue:

There are three methods for reducing livestock methane emissions. The first is to reduce the consumption of red meat. The majority of developed nations consume more red meat per person than is necessary. For instance, since the average European consumes 69.8 kg[12] of beef per year, it is possible to use plant- or fish-based sources of protein instead. Even though this is the most cost-effective option, it can be challenging to succeed in a crowded area. Breeding species that create less methane while digesting food is the second and most effective option. John Wallace, a researcher from the University of Aberdeen, found that there is a genetic connection between the bacteria that produce methane and the methane released by cattle. When compared to other cattle, genetically engineered cattle can emit up to 50% less methane.[13] which although expensive, is indeed incredibly effective and successful. So If this method can be done to other species like goats and pigs methane emission caused by livestock activities will decrease in a

large scale. The final option is to modify the livestock animals' present diet. It has been noted that cattle's methane emissions decrease when fed higher seaweed in their diets. Cattle's methane output was shown to be reduced by 67% when given just 1% more seaweed in their diet.[14] This technique is effective as well, but the issue is how the seaweed will be made available for some nations because of their climate. This issue might cause some challenging time for nations in Africa and other dry locations where it is difficult to grow and obtain seaweed.

Evaluation:

Limitiations:

Methane Emissions to CO_2 Conversion: Direct methane emissions for all the nations examined in the study were not available, but total CO_2 emissions by year for nations were. As a result, I converted the methane emissions from the breeding of species to CO_2, and then I performed the analysis. The experiment might be more accurate if data on methane emissions for all nations were available.

Information that is not open source: As various essays, studies, and analytical data on the internet required official authorization, I was unable to access some of the data that would have been useful for my analysis.

Description of the Methodology: The method was really simple to carry out but difficult to explain in words, so I used examples and tables instead. However, it is still not very clear and requires some work and time to understand.

Choosing only developed countries: By choosing only developed countries I narrowed down the range of countries a lot and choosing only one type of country gives me similar results for all developed countries as their policies about this topic are nearly the sam efor all.

Strengths of the exploration:

Applied methodology: The method used fulfilled the requirements of the exploration and reflected the facts required for us to remark on correctly, even if the total methane emissions of the countries by year were not readily accessible.

Randomly choosing a country: As noted in the "Methodology Preparation" section, if the countries were not chosen at random, the exploration might be biased toward the countries that I chose (even if I don't want it to be). The investigation was more accurate because of the random country selection.

Conclusion:

However, this does not indicate that livestock caused methane emissions are decreasing and do not harm the environment. The analysis shows that mostly cow's and goat's methane emissions are down in percentage terms in the overall methane emissions. Methane emissions caused by livestock ectivities continue to be hazardous to the environment and accelerate global warming. The way society responds to this crisis needs to be urgent. More study and research should be done on alternative solutions, and such ideas should be put into practice. If the carrying capacity, which the city has already exceeded, is not reduced, future generations' access to meat will be limited. As stated in the investigation, we must work to reduce the amount of methane gas released by livestock production and consumption in developed nations.

Bibliography:

1- https://www.epa.gov/ghgemissions/overview-greenhouse-gases#methane

2- https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter2-1.pdf

3- https://www.ipcc.ch/report/ar5/wg1/

4- https://www.nature.com/articles/d41586-020-02116-8

5- https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions#agriculture

6- https://petkeen.com/how-many-pigs-are-there-statistics/#:~:text=As%20of%202021%2C%20there%20are%20currently%20about%20677.6%20million%20pigs%20worldwide.,-(Statista) ,https://worldanimalfoundation.org/advocate/how-many-cows-are-in-the-world/#:~:text=There%20are%20approximately%201.5%20billion,every%20five%20people%20on%20earth. , https://petkeen.com/how-many-goats-are-there-statistics/#:~:text=There%20are%20around%20one%20billion,is%20found%20in%20developing%20countries.

7- https://www.ucdavis.edu/food/news/making-cattle-more-sustainable#:~:text=Cattle%20are%20the%20No.,about%20220%20pounds%20of%20methane.

8- https://www.researchgate.net/figure/Proportional-representations-of-different-animal-categories-on-enteric-methane-emissions_fig2_317065450

9- https://ecometrica.com/assets/GHGs-CO2-CO2e-and-Carbon-What-Do-These-Mean-v2.1.pdf

10- https://dashboard.visme.co/v2/projects/own

11- https://hdr.undp.org/data-center/human-development-index#/indicies/HDI

12-https://agriculture.ec.europa.eu/news/eu-agricultural-outlook-2021-31-consumer-behaviour-influence-meat-and-dairy-markets-2021-12-

09_en#:~:text=Overall%2C%20EU%20meat%20per%20capita,2018%20to%2067kg%20by%202031.

13- https://www.isi-web.org/index.php/resources/developing-countries

14- https://www.cnbc.com/2021/10/12/seaweed-could-help-cow-farts-contribute-less-to-climate-change.html#:~:text=Investing%20Club-,Methane%20from%20cows%20is%20a%20big%20contributor%20to%20climate,feeding%20them%20seaweed%20may%20help&text=About%2025%25%20of%20all%20methane,the%20University%20of%20New%20Hampshire.

16- https://www.independent.co.uk/climate-change/news/cows-cattle-gene-editing-climate-change-crisis-methane-emissions-b863386.html