Journal of
Earth Science & Climatic Change

Ozbay et al., J Earth Sci Clim Change 2013, 5:2
DOI: 10.4172/2157-7617.1000175

Review Article Open Access

Overview on Sustainable Animal Farming in Relationship to Climate Change in Delmarva

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Abstract

The Intergovernmental Panel on Climate Change (IPCC), established by the United Nations and World Meteorological Organization, has determined with a 90% confidence interval that humans have very likely contributed to a net warming of the Earth due to an increase in the emissions of greenhouse gases, aerosols, and land use changes. This warming has caused glacial melting to accelerate and subsequently sea level is now a very tangible issue. In addition, extreme precipitation events are happening more often in certain geographic regions. The last few decades have seen tremendous efforts focused on the collection and distribution of scientific data to better understand trends and future projections/scenarios of climate change and how society must adapt to those changes. As science concerning global climate change advances, societal awareness and understanding of the issue appears to be lagging behind. Does the public have a solid understanding of the mechanisms and consequences of climate change? Depending on the type of government, public views can significantly influence the government to develop better climate policies. Therefore, public voice is vital in influencing political decisions concerning climate change. Clear communication of scientific knowledge can empower people to safely steer future generations out of harm's way - sharing and understanding fosters more of the same possibility. This case study discusses one of the interactive classroom activities which facilitated the active engagement of students in a discussion of local issues and potential avenues to adapt to climate change. Because climate change affects everything on our planet, animal farms on Delmarva represent one of the many economically and socially critical variables that must be protected through preemptive adaptations. Conversely, farm operations affect the rate of climate change, as well as the surrounding environment. With modern management practices and technology, farming effects on the environment and climate can be drastically reduced. On the other hand, if operations are not managed properly they can also have a negative impact on the environment and climate. Through suggestions and the adoption of modern practices, animal farming can become sustainable and environmentally friendly. The earth's climate is inherently dynamic, but with the adoption of sustainable farming practices on a global scale the rate of climate change may be decelerated.

Keywords: Delmarva; Climate change; Mitigation; Sustainable practice; Nitrogenous waste; Animal farming; Composting

Introduction

Imagine, living in a world with no food and barely any resources. No one would be able to survive in this kind of environment. Our earth has experienced climate change since its origin and is still experiencing it today. The intensity of climate change progression is increasing at an alarming rate due in part to many anthropogenic practices such as agriculture and industrial development. Climate factors such as precipitation, temperature, severe conditions like drought, floods, and storms directly affect the livestock and crop yield. Climate change affects the frequencies and intensities of various crops, pests, and irrigation water supplies which can result in drastic negative effects on food production and supply [1]. Improving the sustainability of farm practices is highly desirable and can enable farms in Delmarva to become much more environmentally friendly (Figure 1). The animal agriculture sector across the United States has been consolidated which has resulted in a drastic decline in the number of individual farms. This shift has also centralized many negative impacts of these activities and the Chesapeake Bay has seen very real threats." In 1950, there were 1.6 million farms producing 580 million chickens averaging 360 per farm. But in 2007, there were only 27,000 farms yet these fewer farms were producing 8.9 billion chickens, a dramatic increase averaging around 330,000 chickens per farm [2]. This thousand fold increase of poultry production per farm represents the industrial machine in this sector. Similar to poultry farming, this happened in beef and cattle farming but to a lesser extent. The dramatic increase in the number of animals per farm corresponds to a dramatic increase in manure and waste water generations [3].

The CO_2 emissions from animal agriculture equate to several millions of metric tons per year and the amount of fossil fuel burned depends on the species and type of animal product in question [4]. For example processing 1 kg of beef requires 4.37 Mega-Joules (MJ), and processing 1 dozen eggs requires more than 6 MJ [4]. That same 1 kg of beef may result in 36.4 kg of CO_2 with most of the energy consumed attributed to the production and transport of feed [5].

Maryland contributes roughly around 20% of the total nitrogen and phosphorous pollution in the Chesapeake Bay. Maryland State's agriculture contributes to 39% of total nitrogen and 19% of total phosphorous in the Bay. Pennsylvania contributes 44% of total nitrogen, 24% of total phosphorus and 32% of total sediment as pollution into the Bay. Of these loads, the agriculture sector contributes to 55% of total nitrogen, 24 % of total phosphorus and 35 % of total sediment contribution [3]. Based on 2009 monitoring data, Chesapeake Bay TMDL [6] reported that Delaware contributes 2% of total nitrogen and

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Received August 13, 2013; **Accepted** December 18, 2013; **Published** December 26, 2013

Citation: Ozbay G, Foster K, Taylor S, Chintapenta LK, Fleming B (2013) Overview on Sustainable Animal Farming in Relationship to Climate Change in Delmarva. J Earth Sci Clim Change 5: 175. doi:10.4172/2157-7617.1000175

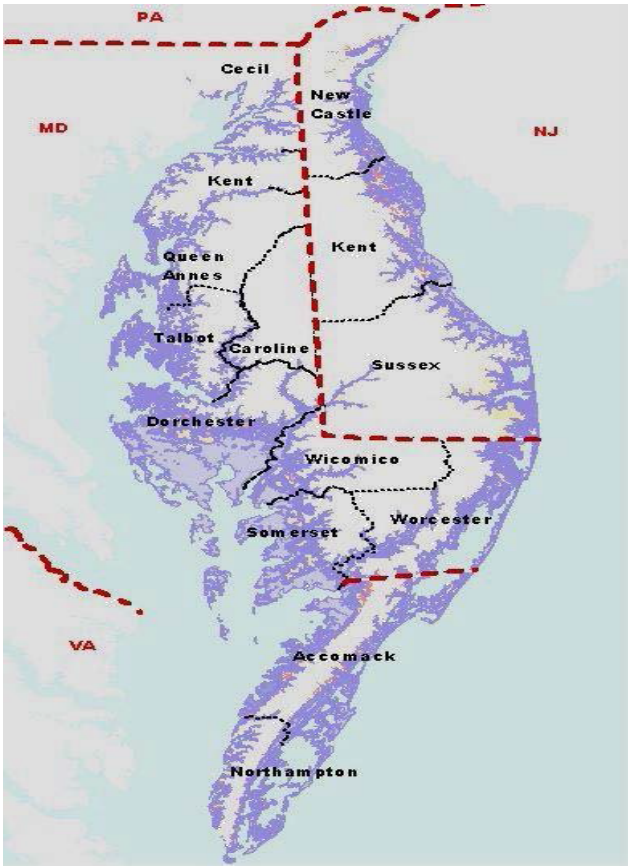

Figure 1: Delmarva region including counties [38].

1% total phosphorus loads to the bay (Figure 2). The major nitrogen and phosphorus loads are made by Virginia and Pennsylvania [6]. Due to inconsistent nutrient management practices, these areas have significant nutrient imbalances and nutrient-related local water quality impairments contributing to the highest agricultural nutrient loads to the Bay. The United States Environmental Protection Agency (USEPA) has developed an enforcement and compliance strategy to address Delmarva Peninsula areas with high loads of manure-based nutrients.

On the Delmarva Peninsula, the densely packed poultry operations are the primary source of nutrients. In south-central Pennsylvania, the primary source of nutrients is dairy operations but there are also some swine and poultry operations [3]. Previous information suggests that large livestock and poultry farming have negative impacts on the environment in their current conditions [6]. However, many fail to recognize these issues due to their importance to Delmarva's economy, making it a sensitive social issue. Therefore, the aim of this paper is to discuss various impacts of animal farming industries on climate change. Also, based on information gathered during our literature survey and through scientific discussions, we have assembled some efficient farm management practices that help to mitigate or reduce climate change.

Climate Change and Farming Industries

Impacts of climate change on farming industries

It is imperative that we recognize the negative factors associated with livestock farming and agriculture to insure that proper and more efficient farming practices become prevalent. Unfortunately, there are many negative effects of standard farming practices that contribute to climate change. On one hand, climate change causes crop yields to decrease drastically from heat stress or declined temperatures which could have catastrophic consequences on livestock that rely on the feed to survive [7,8]. We can be certain that prices will increase if a drastic drop or rise in climatic temperatures were to occur [7-10]. This will cause farmers to buy less feed which could in turn jeopardize the quality and health of the raised livestock. If temperatures continue to rise in the Delmarva regions, the livestock will have to battle heat stress during the long days of summers [7,11]. Large livestock such as cows that are subjected to unbearable temperatures and humidity will experience heat stress and this will decrease the quantity of milk produced and increase the production time of milk and gestation periods [7,12].

The optimal temperature for milk production is between 4.5 and 23.8°C [7]. Dairy production was economically affected for a long time in New York, Pennsylvania, and Vermont around 2003, losing $24.9 million in New York, $50.8 million in Pennsylvania and $5.4 in Vermont because of the diseases associated with cows' mammary glands in conjunction with lowered milk production resulting from heat stress [7]. An increase in global temperatures may increase the disease rate in cows leading to decreased milk production, subsequently causing prices to go up. This will result in an economic hit to the communities and farmers who will experience lower profits. However, if climate change causes an increase in crop production which allows livestock yields to increase, the amount of methane gas excreted from waste can in turn increase. One of the main issues concerning livestock operations is the proper management and disposal of animal excrement. In general animal farming can result in increased levels of NH_3 (ammonia) and CH_4 (methane) in the surrounding environment [13-15].

Delmarva is well known for their lucrative poultry production. Customers have come to rely on the best quality meat as well as the most organic meats that do not have preservatives. Another pressing concern is how runoff from poultry farming is affecting waterways and bays such as the Chesapeake Bay. Poultry waste as an organic fertilizer along with chemical fertilizers has historically and is currently causing degradation of the Chesapeake Bay [16]. Fractionation and denitrification occurs from wastes that are deposited into the bay and can be detrimental to the ecosystems through the over saturation of nitrogen, effect the natural balance and minimize uptakes of the essential nutrients by the aquatic species [16]. Also, fish engulf too much nutrients when poultry manure is applied to fish ponds or when fish feed is used [17]. Monie Creek, Little Creek, and Little Monie Creek are all parts of Monie Bay that are connected to the Chesapeake

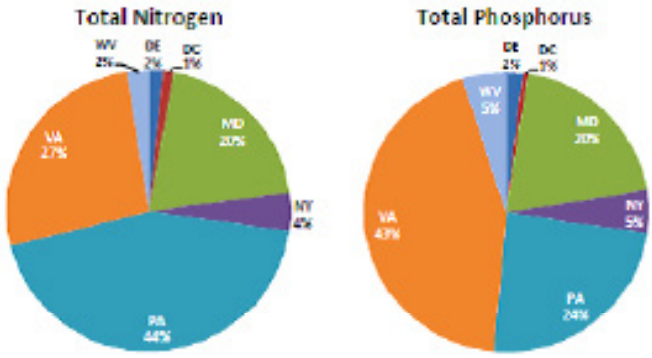

Figure 2: Distribution of total nitrogen and phosphorus loads by the states for the Chesapeake Bay Watershed based on the Model 2009 Scenario [4].

Bay. They transfer nutrients from freshwater and land deposits to downstream sites [16] (Figure 3).

Problems arise if there is too much nitrogen within an aquatic ecosystem from the combination of natural nitrogen inputs and lethal nitrogenous wastes from poultry fertilizers. Fish and other aquatic inhabitants that are not accustomed to such high levels could be lethally harmed. This should be carefully monitored due to the vast spatial scale of the Chesapeake Bay and the many tributaries extending from it, eventually emptying into the Atlantic Ocean. Figure 3 shows the locations of poultry farms and where known oyster beds are located. Oysters can be thought of as a natural filtration system for the water, but too much nitrogen would cause the oysters to expend more energy in order to compensate for the increase in the amount of filtration needed to purify the water, leaving them with little energy to perform daily activities such as searching for food, feeding, digesting, and breeding [16]. Figure 3 clearly shows that the chicken operations are centered on Monie Creek and Delmar WTP (Waste Treatment Project). Therefore, the probability of adding too much nitrogen and pollution into our Bay due to increased waste disposal is quite high [16].

Figure 4 shows that most poultry farms are inland, and most of the operations have three or more chicken houses per farm. With more chicken houses and more chickens being raised in those areas, there is more nitrogenous waste being produced. Fertilizers and wastes from the runoff may either enter the land or seep into ground water and cause pollution to be distributed throughout the aquifers and into the Chesapeake Bay. Investing for better fertilization and more effective application methods to reduce the amount of pollution and disturbance caused to surrounding wetland and coastal ecosystems will lead to better farming practices along with reduced costs for fertilizers [16].

Climate change can also have a significant impact on horse farms. Horses are imperative for the horse racing industry here on Delmarva to fulfill the needs for breeding programs, and recreational enjoyment. Negative impacts of climate change on horses will cause a huge loss in profits to the horse industry such as disease outbreaks, land degradation, depletion of water sources, and so on. As temperatures increase, large outbreaks of Brucellosis will impact humans and hoofed animals [18]. Horses can contract Brucellosis and we can infer that if there is an outbreak in Delmarva, many horse farms will be economically hurt as horses that remain lame from this disease will be worthless to potential buyers. Weese [19] stated that Brucellosis is usually dormant in equine livestock but it can be passed from horses to humans and cattle are also highly susceptible to this pathogen. It can act as a secondary pathogen causing infection in other horses [20]. Since Brucellosis is globally distributed, buffalo farms in the Delmarva region can be impacted as well. Buffalo farms are considered exotic in Delaware and are great for tourists and fieldtrips. With an outbreak of Brucellosis, buffalo farms may be potentially out of business since there are only a few farms in Delmarva. There already has been a huge decrease in the amount

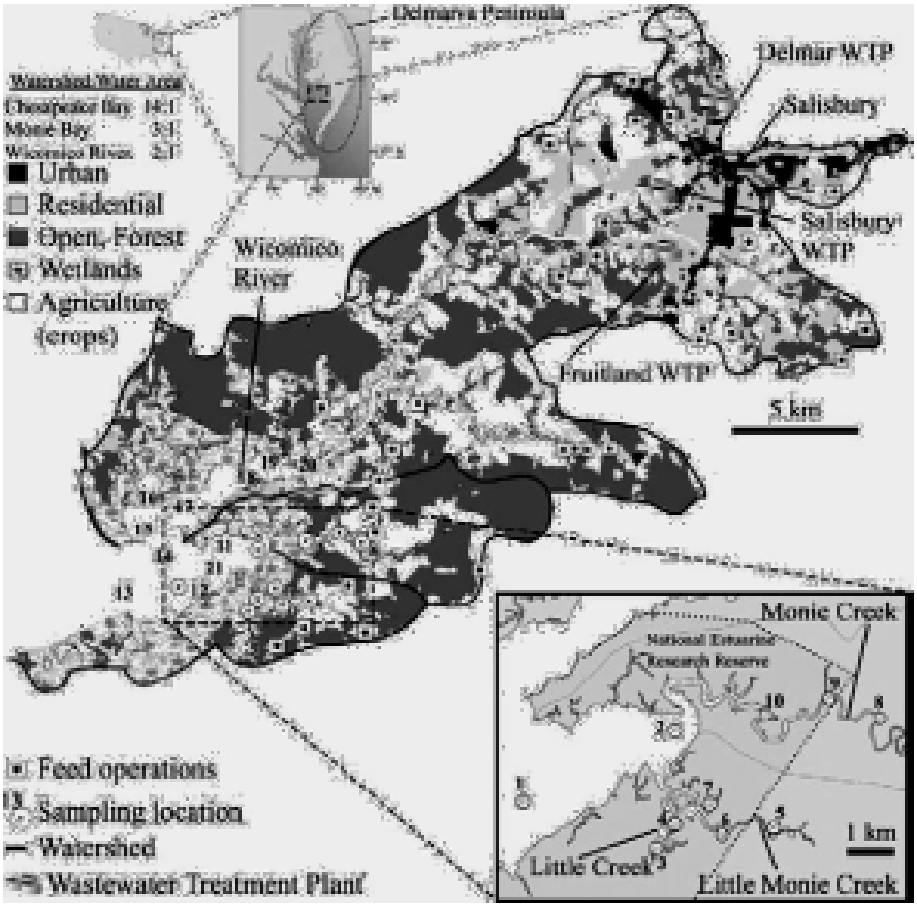

Figure 3: Map locating Monie Bay within Delmarva Peninsula. Land use for the watersheds of Little Creek/Little Monie Creek, Monie Creek, and Wicomico River are shown by color. Locations of wastewater treatment plants and poultry feed operations are noted. Locations of oyster deployment are noted and numbered [16].

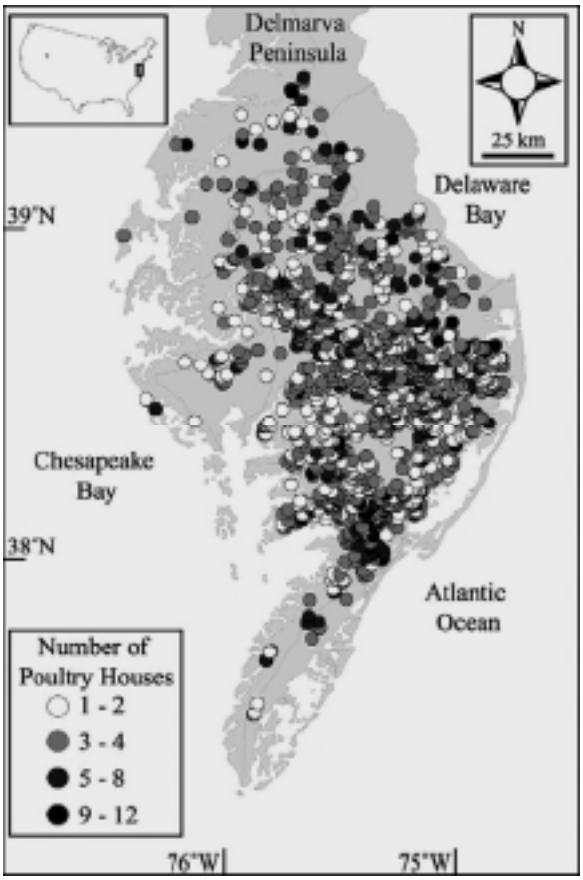

Figure 4: Poultry farm houses on Delmarva Peninsula [16].

of buffalo due to this outbreak in a previous instance [19]. Better quarantine methods including waste management are needed in order to prevent the potential outbreak of this lethal disease.

Impacts of farming industries on climate change

On the other hand, climate change is negatively affected by production of large amounts of animal waste (Figure 5). About eighty-six percent of dry matter produced in 2001 was produced primarily by animals living in confined quarters [21]. Animal excrements can contribute to air and water degradation, as well as impacting inhabitants of the surrounding environment [21]. Animal feeding methods such as Concentrated Animal Feeding Operations (CAFO's) are increasing the amount of ammonia within the atmosphere, causing problems with our water systems and atmospheric gases [14]. Livestock and pasture production have a negative impact on water quality due to soil erosion, surface run off, nutrients discharged into the soil from animal wastes, pathogens from the wastes and through fertility practices [22]. It is imperative that we find better livestock management practices for safe and large livestock productions. Sustainable practices can help livestock farms become more environment-friendly operations. In addition, animal grazing has also become very harmful to our vegetative environment, harming about 33% of plant species that are endangered in the United States as opposed to only fourteen percent of animals which are endangered [23].

Farming and people

After reviewing the negative impacts that climate change can have on animal farming in Delmarva, one can ask if there are any positive impacts of animal farming. All too often we only hear about the negative effects; this tends to put a sour taste in people's mouths about climate change. Climate change is inevitable and it occurs naturally but the activities of humans are increasing the rate at which it is occurring (Figure 5). Delmarva is comprised of Delaware, the Eastern Shores of Maryland, and Virginia. Animal farming is extremely important to the region for a number of reasons, this requires careful synthesis on how farming industries can be sustainable and climate change should be considered in the farm practices. The positive outcomes of farming can be manifested economically, socially, and environmentally. The positive aspects of livestock farming include the production of affordable protein and dairy products which enhance the standards of living for

Figure 5: Comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO_2 has increased since the Industrial Revolution [39].

people and livelihood. Therefore, we should not overlook these positive aspects because within them lies the key to developing sustainable farm operations and ability to sustain living conditions (Figure 6).

Farming on Delmarva has provided a vast amount of economic benefits. According to the Delaware Poultry Industry [24], "The chicken industry remains a huge sector of the economy on the Delmarva Peninsula according to new data supplied by The U.S. Poultry and Egg Association, National Chicken Council, National Turkey Federation, and United Egg Producers." The study shows that the chicken industry in Delaware paid nearly $619 million in state and federal businesses taxes, $237 million throughout all of Maryland, and throughout Virginia more than $590 million [24]. Another lucrative industry within the area is the sport of harness racing. Delaware and Maryland each have two race tracks and Virginia has one. As the number of horses has grown, the local farms and stables have prospered. The owners of the horses are purchasing various amounts of feed at a time. A majority of stables have between 25 and 40 horses, while some have acquired upwards of 60. There is on average about one person employed for every five horses that need care. Horses are increasing the employment rate and also encouraging people to move Delmarva from all over the country to take place in this harness horse racing industry [25]. Through the buying of supplies for the horses and homes for the caretakers, this industry positively impacts the local region of Delmarva from an economic standpoint.

Poultry and cattle farms also help Delmarva to generate money, jobs, and a larger demand of soybean products. According to the editorial [26], *Biting the Hand that Feeds Them*, "U.S. poultry and livestock farmers provide more than just meat, milk, eggs and other food, they also produce jobs, generate property tax revenues and contribute to household incomes. They also consume about 98% of the domestically used soybean meal, making them the number one customer for U.S. soybean farmers." Poultry farming is the most popular type of agricultural farming on Delmarva, but cattle production is also important. According to U.S. Environmental Protection Agency [27] beef cattle can graze in the open range and pasturelands and serve a unique role in providing high quality protein for human consumption from byproducts and forage sources that humans and non-ruminant animals do not consume. Among many other things, protein is necessary to promote growth and repair the human body. Cattle and chicken are great sources of protein as well. Beef and poultry also contain iron which is a necessary mineral to the human body. Without the production of these meats, we would have to get our iron through an oral supplement or other less iron rich sources, which in turn can result in vitamin deficiencies. The iron content and other nutrient details of beef and chicken has been displayed in Table 1 as mentioned [28].

Livestock farming is vital for meat production and it also yields dairy products and materials that are necessary for making clothes, shoes, and furniture. Cow hide is used to make leather which you can find on shoes, house furniture, and even on car seats. The wool from sheep is used in making some clothes, especially winter socks. Cows produce milk, which is used to make butter, cream, cheese and ice cream, while chickens produce the eggs. Livestock farming has some major benefits to human health by becoming essential sources of nutrients and vitamins, to improve economy by providing jobs and resources for people and to benefit to the environment by providing fertilizers organic and optimum in nutrient. Livestock farming has also impact socially as livestock in general can bring people together. Horses especially bring so much joy and entertainment to people's lives

Figure 6: Pictures of farmed animals common to Delmarva region (Photo courtesy of T. Darden).

Species	Fat (grams)	Calories (kCal)	Cholesterol (mg)	Iron (mg)	Vitamin B-12 (mg)
Buffalo	2.42	143	82	3.42	2.86
Beef (Choice)	10.15	219	86	2.99	2.65
Beef (Select)	8.09	201	86	2.99	2.64
Pork	9.66	212	86	1.1	0.75
Skinless Chicken	7.41	190	89	1.21	0.33
Sockeye Salmon	10.97	216	87	0.55	5.8

Table 1: Iron content excerpted from the USDA Handbook [28].

that can be shared, cattle are used for meat and dairy production, but in the local fairs they are also used as show animals. Improvements in livestock farming can provide a community with sustainable endeavor such as healthy and functional environment while enjoyment for farming itself. Finally, how does the environment benefit from livestock farming? People say that this is impossible because livestock farming harms the environment. However, livestock farming provides manure, which if used properly, makes wonderful fertilizer. Artificial fertilizers release their nutrients rapidly into the soil, while organic fertilizers, such as livestock manure, have a slow release of nutrients. Nature's Way Resources [29] states that studies at the Alabama Polytechnic University have shown that as much as 50% of the synthetic derived nitrogen applied to the soil will be leached out and lost and the half that does reach the plants may in fact be harmful. Other studies have shown that only 5-10% makes it available to the plant and the rest is wasted and pollutes the environment [29].

Organic fertilizers allow life to continue underground, for example spreading organic manure as fertilizer allows more worms to stay alive underground. These worms are beneficial to the soil, and therefore they are beneficial to the plants. With better plant production, there is more grain and plants for livestock to eat, and in turn, better production for humans through the animals. Not only is organic fertilizer better for the soil and plants, but it is also better for the environment [30]. Since organic fertilizer releases slowly and most of its chemicals are being absorbed by the soil, it does not get released back into the air. The characteristics of organic and inorganic fertilizers when applied to turf grasses are discussed and shown in Table 2. When inorganic fertilizers such as ammonium nitrate or ammonium sulfate are applied, nitrogen from these sources becomes available to turfgrass after immediate application of water. But the effect of fertilizer remains only for a short period and also the leaching of nutrients are very high during this process.

Characteristics of Common Turfgrass N Sources Classification, burn potential, leaching potential, low temperature response and residual effect on common turfgrass N sources					
Fertilizer Source	**N content %**	**Leaching Potential**	**Burn Potential**	**Low Temp-Response**	**Residual Effect**
Inorganic					
Ammonium nitrate	33-34	High	High	Rapid	Short
Calcium nitrate	16	High	High	Rapid	Short
Ammonium sulfate	21	High	High	Rapid	Short
Organic-Natural					
Activated sewage sludge	6	Very low	Very low	Very low	Long
Manures	03-10	Very low	Very low	Very low	Long
Other Natural Products	03-10	Very low	Very low	Very low	Long
Synthetic					
Urea	45-46	Moderate	High	Rapid	Short
Urea solutions	12-14	Moderate	High	Rapid	Short
Sulfur coated urea	14-38	Low	Low	Moderate	Moderate
Resin coated urea	24-35	Low	Low	Moderate	Long
Isobutylidene diurea (IBDU)	30-31	Mod.Low	Low	Moderate	Moderate
Methylene ureas and Ureaformaldehyde*	38	Low	Low	Low	Mod.Long to Long
*some products may contain urea in addition to the ureaformaldehyde component					

Table 2: Characteristics of common turfgrass nitrogen sources [30].

Organic fertilizers have a long term positive effect on the plants even if the nitrogen is introduced at a slow rate. Nitrogen from these organic sources becomes available to the plants only after they are metabolized by the soil microbes [30].

Animal farming generates lots of manure which produces Green House Gas (GHGs). Scientists have demonstrated that emissions from animal manure can be used for generating energy [31]. Animal wastes are also used for biogas production because they have a suitable C:N ratio. Biogas can be utilized for applications such as lighting, cooking, electricity generation and replacement for diesel. Some countries like Tanzania have initiated large-scale biogas programs [32].

Sustainable Practices and Mitigation

Animal farming has become a large aspect of climate change discussions, especially concerning outdated practices which are still used on farms today. New sustainable practices are currently the best methods to raise healthy livestock as well as facilitating a clean environment. Large amounts of excrements can runoff into nearby waterways creating high amounts of pollutants as well as large amounts of algal blooms. A way to reduce the amount of waste runoff is to reduce the number of livestock per hectare of property [33]. Farm areas that have large numbers of live stocks can try different sustainable practices. As an example, large livestock units in small areas will have large amounts of manure produced. Instead of using synthetic fertilizers, taking the manure and composting it will not only provide a large amount of nutrients, including nitrogen (a major element needed for plants) but it will also get rid of harmful pathogens in the manure [34]. The high temperature of the compost pile kills many different pathogens, such as bacteria and fungus, which would otherwise be harmful to the environment and its occupants. Farmers should learn more about better waste management so that any updates to farm infrastructures can be managed properly.

Manure from livestock is so rich in nutrients because the digested cellulose plant material is being broken down with the help of ruminant bacteria. Pasture animals consume plants that grow in the field and this process is an ongoing cycle as the plants are digested and passed through their systems in the form of animal waste. These wastes are deposited on the fields where, they provide essential nutrients for the crops [34]. However, too much nutrients are not good, because the plant can only take up a small amount. Another sustainable practice on animal farms is to rotate the livestock between farm fields. This allows the nutrients to be up taken by the plants without too much excessive nutrients leaching out of the soil as runoff into near waterways. When the livestock is appropriately managed and stocked, the ecosystems function in a more natural manner and allows for the continued production of high-quality protein (in the form of livestock) with minimal environmental impacts [34]. Organic farming is a new way for sustainable farming due to its high level of renewable inputs, high level of local inputs, and low density of energy and matter flows [35]. Today, sustainable animal farming is still in practice. Although there are some efficient management strategies that are being implemented today, there are always new policies or management practices that can be developed and adopted in the future.

Scientists estimate that global ruminant livestock industries produce about 20% methane emissions associated with human activities. Methane emissions from livestock can be reduced by supplementing the animal's diet, for example to supplement the cow's diet with substances such as urea increases the animal's ability to digest food. When digestion improves, less fermentation takes place and methane emissions per unit of forage have been reduced from 25-75 %. Also with increase in digestion, milk productivity increases and beef cattle fatten faster [36]. A better strategy for the environment, climate change mitigation, human health, and animal welfare is to reduce our overall consumption of animal products and making more climate-friendly food choices as a recommendation made not only by environmental organizations but also by the climate scientists [37].

Discussion

There is no certainty for finding definitive answers in regards to the direction climate change will take. We can only estimate what the approximate damage may be based on the data we have already collected. From there we must figure out the best ways to reduce the amount of greenhouse gases that are currently being emitted [36]. One mitigation practice to accomplish this goal is through the continued improvement of our farming practices. This would help reduce the amount of nitrogenous wastes that accumulate in the atmosphere,

reduce the amount of erosion and diseases along with many other benefits which are proposed in this paper.

Animal manure from the animal farms is often applied to the crop fields, providing crops with more nutrients from the manure than they need. This imbalance of nutrients is a major source of nonpoint nutrient water pollution. Thus proper nutrient management planning can successfully reduce commercial fertilizer inputs and nonpoint nutrient pollution, while increasing farm profits. The nutrient management planning systems must also be able to operate between farms integrating the separate crop and animal operations in order to reduce the on farm nutrient imbalances [38]. As discussed by many scientists and some practitioners, we will have a greater impact if the GHG'S from animal manure are used for generation of energy and the manure is used to produce biogas.

Climate change has become a significant debate in the political realm, especially in regards to farming operations. Climate change and livestock farming have a dynamic relationship where changes in one may result in changes on the other [1]. The relationship between these two variables must be studied in order to ensure that our future generations have security from an economic, social, physical, and emotional standpoint. Climate has been changing the way human populations grow foods since there is less land to grow crops and raise livestock due to the poor management of our lands [39].

There are many methods to raise more livestock in a cost effective manner to help make the management of farming become more efficient. Making our operations larger in order to produce more efficiency rates has caused issues within our environment [38]. Our goal is to inform citizens and businesses of climate change and to provide those entities with the knowledge to implement more efficient practices with the aim of providing benefits to not just those businesses and future generations, but to stabilize future climatic trends.

Conclusion

Climate change can affect the lives of everyone through many dynamic pathways. How each farmer decides to move forward and adapt with the ongoing threat of climate change is what will determine if the farm will continue to be sustainable and make a profit in the long run. The climate is always changing, so adaptation and mitigation are inevitable and important aspects for successful farmers to embrace. There are many negative impacts of livestock farming as we discussed in this paper including excess manure contributing to pollution in the atmosphere and surrounding environment. Large units of livestock can cause erosion in an area, mostly due to over use of the land. Disease outbreaks can occur more frequently due to overcrowding and environmental factors such as heat. With all these negative impacts, human health and the economy can be affected at alarming rates.

As with all cons, there are pros to combat them. Environmentally friendly practices and positive impacts can result in higher market values and a more productive economy. Animals make people happier in a social setting, as we stated earlier; this is another reason why we should maintain farming practices as the climate changes to ensure that future generations will be able to enjoy the same species we have today. To capitalize on the positive impacts and lessen the strain imposed by the negative ones, many different sustainable practices must be implemented. Sustainable practices like rotation of livestock from one pasture to another to slow down over-grazing and soil erosion, and having less livestock units per hectare of land, will reduce the stress put on the land. Finally, the biggest contributions to solving these problems are recycled and reused. This is the most widely used practice, from reusing manure, to the gases produced by the animals. We can perhaps reuse gases produced by animals to power future engines as automobile fuel resources are being depleted, but of course this could be debatable. Even though it will take years for significant climate change to become a reality, it is currently changing faster than historical trends [40]. In order to slow this transition down, implementing practices that lessen the greenhouse gas emissions into the environment and atmosphere will play a major role.

This paper is produced as a result of interactive classroom activities for the Climatology class during which students co-authored this paper, and had an opportunity to investigate and discuss various topics in climate change and agricultural practices in the United States. Debates, videos, presentations by climate experts, video conferencing with students at other institutions, field trips, and term papers had further advanced the students' understanding of global climate issues and impacts of the anthropogenic activities. The team of the three students focused on the animal farming operations and how farming industries can move towards sustainable practices discussed in this paper. This will serve as a good example to future students learning about climate change and how we can adapt to those changes at the same time how we can minimize our foot prints [41].

Acknowledgements

We would like to thank Kris Roeske and Brian Reckenbeil for his review and editorial assistance. This paper is funded by USDA Evans-Allen Grant, USDA-NIFA CBG Grants and NSF MADE-CLEAR Grant Programs.

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