Introduction and Background

In 2016, greenhouse gas (GHG) emissions from agricultural activities worldwide accounted for approximately 5.3 $GtCO_2e$ (gigatons of equivalent carbon dioxide) or 11.5% of all emissions (Climate Watch, 2019), with enteric fermentation from livestock contributing 2.1 gigatons of CO_2 equivalent. The second largest contributor, manure left on pastures, contributed 850 megatons CO_2 equivalent (ibid). China, Brazil, and United States are the largest emitters of greenhouse gasses from the agricultural industry (ibid).

While agriculture is a relatively small contributor to the overall greenhouse gas emissions each year, approximately 9 percent of all emissions (Newton, 2019), there is still room for improvement. "Global demand for livestock products is expected to double by 2050" (Rojas-Downing et al., 2017) putting pressure on farmers and land stewards to find ways to increase production of crops and livestock, without increasing GHG emissions. "Agriculture can contribute to efforts to reduce GHG emissions through increased carbon sequestration, reduced methane and nitrous oxide emissions, and increased renewable energy production" (Horowitz and Gottlieb, 2015).

Practicable and Efficient Emerging Methods to Curb GHG

Practices in environmentally friendly agriculture include mitigation of GHG emissions through better livestock and manure management, increased carbon sequestration through soil conservation, and reduction of waste through the entire food system.

Managing Livestock & Manure

Livestock agriculture, specifically beef, produces methane and nitrous oxide. Methane and nitrous oxide are also released from manure and wastes on pastures left from ruminant animals (those with a four-compartment stomach like cattle), and from fertilizers used on cattle feed crops. However, emerging practices and theories recommend ways to reduce emissions without significantly changing consumption patterns. A study from the University of California, Davis proposes that including seaweed in cattle diets "can dramatically decrease their emissions of the potent gas methane" (Kennedy, 2018).

A similar study of Kenyan dairy farms found similar results (Bryan et. al, 2013). By adding "napier grass and high-protein Calliandra shrubs" to cattle's traditional diets, the cattle have faster growth rates and greater milk production. By using fewer cattle more efficiently, methane emissions per liter of milk could be reduced by up to 60%. Examples of such improved practices abound. By integrating cattle grazing with trees and grasses onto pasturelands, farmers with the International Center for Tropical Agriculture in Colombia have been able to feed four to six times as many cattle on the same plot of land.

Soil Conservation & Carbon Sequestration

While livestock breeding can create greenhouse gas emissions, soil on agriculture land is a carbon sequester. Through crop rotations, limited application of fertilizers, and reduced or eliminated tillage, more carbon can be stored in the soil. Soil carbon sequestration occurs by increasing soil organic carbon through better land management practices. Limited tillage not only can increase carbon sequestration, but may result in using less nitrogen fertilizer, which will lower nitrous oxide emissions (Johnson et al., 2007).

Increasing plant variety through rotation provides soil cover that helps to reduce nutrient loss and emissions. (Behnke, 2018) Crop rotation has been shown to increase yields, when compared to continuous farming, and diversifying crops through crop rotations has been found to increase yields by reducing weeds and diseases (Kutcher et al. 2013). Decreasing bare fallowing, or leaving land bare when not actively growing, is also critical to soil health and its ability to sequester carbon while increasing yields without additional fertilizer. One study found that planting legumes ``enhanced soil water conservation, improved soil nitrogen availability, and increased system productivity" (Gan et al, 2015). Decreased fallowing not only decreased the carbon footprint in wheat fields, it also increased crop yields (Gan et al., 2014). All these result in better yields, without having to use excess fertilizer that can lead to poor carbon sequestration in the soil, as well as problems downstream from excess fertilizer run-off.

Soil tillage practices influence not only the physical properties of soil but also the amount of carbon sequestration within the soil. Zero tilled soils contained significantly more soil organic matter (SOM), microbial biomass carbon, and microbial biomass nitrogen than tilled soils (Mangalassery, 2014). This indicates less tilling can increase the ability of the soil to sequester greenhouse gases, rather than release them. Since vegetation that is preserved over longer periods of time is effective in storing carbon, when fields are tilled the ability for vegetation to act as a sequester is stopped. Additionally, when soil is productive, the application of fertilizers can be reduced or eliminated (Lui et al., 2016). A study from Berkeley in 2012 found that "nitrogen-based fertilizer is largely responsible for the 20 percent increase in atmospheric nitrous oxide since the Industrial Revolution." (Park et. al., 2012). By combining less tillage and greater crop rotation, less fertilizer will need to be used to create productive soil, resulting in less nitrous oxide (from over-fertilizing) being absorbed into the atmosphere.

Reduction of waste in agriculture and switching to climate friend food consumption.

While increasing efficiency of livestock feeding, reducing methane released, and increasing soil productivity to sequester CO_2 all will help to reduce emissions from agriculture, no method of reducing GHG from agriculture is more effective than reducing waste in the food cycle. In the US, losses from food storage, transportation, and waste can equal between 30% and 40% of food production (USDA, n.d.). Regardless of where the food is wasted or spoiled in the food cycle, that 30-40% of food was produced needlessly and resulted in unnecessary emissions.

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Corn grown for ethanol, rather than food production, could be considered waste in the food cycle. If land is used for biofuel, rather than food, over 100 studies have shown that increased biofuel production and related policies increase food prices (Bannon, 2017).

Changing dietary patterns towards less waste and more climate friendly food consumption, can help reduce GHG without drastic changes in everyday life. Beef consumption is decreasing in the US and if this pattern can continue, agricultural expansion may not be necessary to feed 9.7 billion people. According to the World Resource Institute (Waite, 2019), if beef consumption decreased by "50 calories a day, or 1.5 burgers per person per week, it would nearly eliminate the need for additional agricultural expansion (and associated deforestation), even in a world with 9.7 billion people".

Goals to help growers adopt practices and adapt to ways that maintain yields and decrease GHG emissions.

Three goals to help farmers reduce GHG emissions include reducing emissions from livestock, increasing the removal of carbon through sequestration, and avoiding emissions altogether.

Reduction of emissions

As I have discussed above, the utilization of better feeding techniques can result in a win for both farmers and the environment. By using higher quality feed and/or better grazing methods, farmers can decrease the number of livestock needed to meet production goals for dairy and meat.

Enhancement of removal of CO_2 (sequestration)

Carbon sequestration increases when more crop residues remain on the field, increasing the volume of organic matter kept in the soil. New policies that incentivize strategies that increase the ability for vegetation to be preserved over longer periods of time would help to mitigate CO_2 levels. A change in subsidies to include long-term vegetation, such as perennial ground cover crops or vine and tree-based crops, would promote the growth of crops which sequester CO_2. An added benefit of this approach and goal would be increasing the diversity of food for consumption.

Avoiding Greenhouse Gas Altogether

If overall consumption and waste patterns can be improved, existing agricultural resources can provide for a larger population without increasing land use. As urban centers grow, farms near these centers are being pushed further out into rural areas. As this happens, transportation of product from farm to consumer generates an increasing amount of GHG. Reducing waste in the food production and consumption cycle can offset this growing impact by reducing the quantity of food needed to feed a given population.

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Conclusion

Reducing Greenhouse Gas emissions in the agriculture industry will help mitigate the climate crisis. However, agricultural practices do not need to stop at mitigation, they can contribute to reversing the amount of GHG in our atmosphere. There is tremendous potential for agriculture to help slow or reverse global heating through better livestock and soil management. For example, if farmers limit the amount of nitrogen fertilizer inhibitors or expand no-till practices which result in greater carbon sequestration, farming could move from a GHG emitting industry to one that could be eligible for cap-and-trade offset credits. The World Resource Institute (Waite, 2019) projected that using environmentally-friendly practices could increase the likeliness of being able to produce enough food a growing population without added environmental harm.

Since the Paris Agreement, 65 countries proposed agricultural emissions reductions through policies and targets (Climate Watch, n.d.). Integrating changes in human behavior to reduce food consumption and food waste, partnered with policies and practices to improve soil quality and limit livestock emissions, will lead to greater productivity and fewer emissions in the agriculture industry.

One topic not discussed in this paper is how agricultural practices also influence water use and provide the potential for economic growth in developing countries. These topics should be considered with policy changes. While each country has unique challenges, policies are beginning to change to help create more environmentally friendly farming policies.

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