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ANIMAL AGRICULTURE AND CLIMATE CHANGE IN MICHIGAN

Shelby Burlew[1], Marilyn Thelen[1], Wendy Powers[2], David Schmidt[3] and Misty Klotz[4]

[1]Michigan State University Extension, [2]Michigan State University, [3]University of Minnesota, [4]Michigan State University W.K. Kellogg Biological Station

Agricultural production has always been affected by weather variability, and Michigan farmers have adopted production practices appropriate to their climate. However, the weather that shapes agricultural production is changing along with climatic conditions. Examples of this in the Midwest include increases in average day- and nighttime temperatures, changes in the timing and intensity of rainfall, an increase in the number of flooding events, and warmer and more humid conditions(1). These trends are expected to continue and even accelerate(2) (see MSU Extension bulletins E3150 and E3151 for more on climate change). Increased incidents of weather extremes will have wide-ranging impacts on animal agriculture in the Midwest, and farmers will need to adapt to these impacts to remain profitable. In addition, animal agriculture has an important role to play in lessening the severity of, or mitigating, future climate changes.

Understanding the impacts of climate change allows farmers to adjust management and implement technologies to maintain profitability on the farm.

How will climate change affect animal agriculture?

Changes in climate will have both direct and indirect impacts on animal agriculture in three major ways: feed and water quality and availability, physiological responses of animals, and disease pressures on animals and plants(1, 3).

Feed and water access and quality

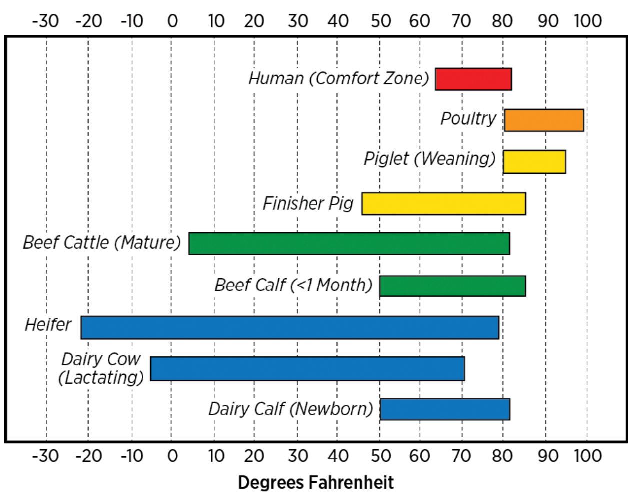
Climate change will have a critical impact on the animal feed supply and water availability(4). Animal feed supplies include grains (produced or purchased) and forage crops and pasture. Climate change may affect the time of planting, time of harvest, crop yield and the nutritional quality of feed inputs(4), all leading to impacts on availability, price and animal performance. Increasing temperatures have led to a longer growing season that may benefit forage crops(5, 6) but may increase the amount of irrigation water needed to meet crop demands. In some areas of the United States, higher temperatures may contribute to increased evaporation from farm ponds, lakes and reservoirs, and thus affect water availability for animals and irrigation(4, 6). On the other hand, other regions of the country will experience increased flooding as a result of extreme weather events. This could have an impact on feed supplies by limiting the transport of farm inputs and outputs(7) and reducing productivity in flooded fields and pastures. Furthermore, increased rainfall intensity increases erosion, and wet fields pose manure management challenges(4, 5).

Physiological and management responses

Long-term projected changes in environmental conditions (temperature, precipitation) and the inability of animals to adequately adapt to sudden or dramatic environmental changes can have significant impacts on animal health and productivity. Animals managed in unsheltered or unbuffered environments such as outdoor facilities with no access to shade or wind shelters are particularly vulnerable to extreme weather(12, 13).

Extreme heat events and the timing of these events pose an even bigger threat than increases in average temperature for animals[4, 7]. Elevated humidity intensifies the impact of high temperatures on animal health and performance. Ambient temperatures above this thermo-neutral zone (Figure 1) result in heat stress and reduced productivity. Animals can recover during the evenings when temperatures are cooler, but with the trend toward higher nighttime temperatures, this recovery period is less effective.

Figure 1. Estimated range in thermo-neutral temperatures for various livestock species[8, 9, 10, 11].



Several factors are involved in how animals are affected by extreme high temperatures[14, 15]:

- Duration of time that animals are in a heat-stressed environment.
  - Animals are better able to withstand short periods of heat stress.
  - Some acclimation to heat occurs with increasing frequency of heat stress.
- Nighttime cooling period.
  - Animals can recover from high temperatures with nighttime cooling.
- Timing of the heat event.
  - Exposure to high temperatures early in the spring will be more stressful than exposure later in the season after animals have acclimated to warmer temperatures.
- Production level of the animals.
  - Higher producing, faster growing animals produce more heat and are more sensitive to heat stress.
  - Heavier animals and very young or very old animals are more susceptible to heat stress.
- Animal genetics and coat color.
  - Some breeds are better adapted than others to dissipate heat.
  - Dark-colored cattle show more heat stress than light-colored ones.

Changes in the timing and intensity of rainfall events can result in flooding that results in damage to facilities and injury or death of animals[4]. More commonly, these events cause operational challenges such as power outages that affect ventilation, feeding or watering systems. Heavy rainfall events compromise the integrity and capacity of manure storage structures and limit the ability to get into the field to apply manure.

Disease and pest distributions

The changing climate alters disease and pest distribution in crops, forages and animals. Warmer temperatures may increase the prevalence of weeds, insect pests and diseases in field crops and forages[7]. This affects the feed supply for animal operations by limiting feed quantity, reducing its quality and increasing production costs. Warmer, more humid conditions indirectly affect animal health and productivity by promoting proliferation of insect growth and spread of disease[12]. Regional warming and changes in precipitation have the potential to change the distributions of animal diseases that are sensitive to temperature and moisture. Some diseases currently more prevalent in the southern United States may become more widespread — for example, anthrax,

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Grazing systems benefit from a stable climate.

blackleg and hemorrhagic septicemia[1]. Earlier springs and warmer winters may increase the over-winter survival of parasites and pathogens[12].

How can animal agriculture adapt to changes in the climate?

Understanding the impacts of climate change allows farmers to adjust management and implement technologies to maintain profitability on the farm. Primarily, this involves planning ahead for both short-term responses to weather events and long-term investments to help buffer these environmental impacts.

Short-term planning and adaptation start with the development of a heat stress management plan, which might include[15, 16]:

- Keeping existing ventilation and cooling systems in good repair[17].
- Being prepared to formulate, mix and feed hot-weather diets[18].
- Monitoring short- and long-term weather forecasts[19, 20].
- Monitoring manure storage capacity carefully[21].
- Developing hot-weather animal handling and transportation plans[22, 23].

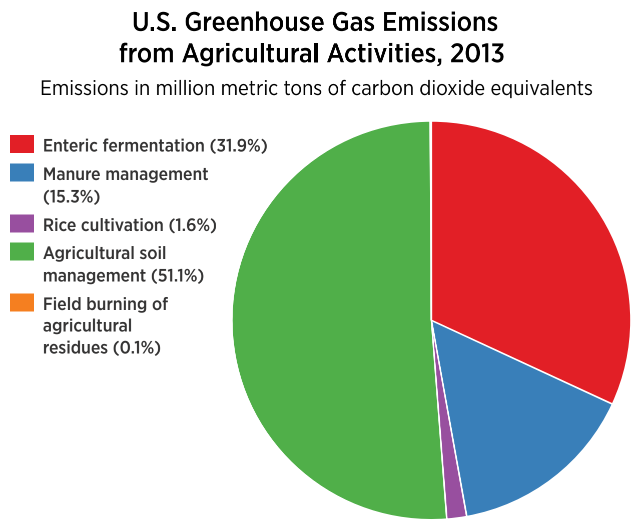
Long-term planning and adaptation might include[15, 16]:

- Installation of additional ventilation or cooling systems.
- Installation of shade structures.
- Expanded manure storage capacity to improve flexibility in timing of manure spreading.
- Installation of irrigation systems for pastures or crop production.
- Changing herd genetics to more heat-tolerant breeds.
- On-farm diversification of crops and livestock systems.

How does animal agriculture contribute to climate change?

Agriculture is a source of greenhouse gas emissions (Figure 2), notably methane (CH_4) and nitrous oxide (N_2O). Agricultural emissions of both CH_4 and N_2O are increasing. Between 1990 and 2012 in the United States, CH_4 emissions increased by 14 percent, and N_2O emissions increased by 10 percent[24]. Both CH_4 and N_2O stay in the atmosphere longer than carbon dioxide. This atmospheric lifetime, combined with the molecules' ability to absorb heat, influences a gas's global warming potential (GWP). Methane has a GWP of 28, and N_2O has a GWP of 298, making their global warming impact 21 times and 310 times greater than that of carbon dioxide, respectively[25]. (See MSU Extension bulletins E3148 and E3149 for more about greenhouses gases and agriculture.)

Figure 2. Sources of methane, nitrous oxide and carbon dioxide emissions from U.S. agriculture, expressed in carbon dioxide equivalents[26].



Ruminant animals such as cows, goats and sheep have digestive systems that are specifically designed to convert forages into usable nutrients through fermentation. Methane that is a byproduct of the rumen fermentation process is referred to as enteric CH_4. Non-ruminants such as pigs and poultry produce a much smaller amount of CH_4 in the large intestine.

Manure management is another source of CH_4 and N_2O. Manure that is stored in anaerobic conditions — for example, liquid manure in lagoons — emits CH_4 and small amounts of N_2O. Manure managed under dry conditions produces relatively less CH_4 but may increase quantities of N_2O.

Feed production is the third source of greenhouse gases related to livestock production. Agricultural soil management is the single largest source of greenhouse gas emissions from agricultural activities on a GWP basis (Figure 2). N_2O is the primary gas released, and wet conditions promote N_2O emissions. Abatement strategies include proper timing and application rate of nitrogen from both manure and commercial fertilizer sources.

Animal agriculture's contribution to total greenhouse gas emissions in the United States may be small in relation to that of other economic sectors such as transportation and energy (Figure 3), but animal agriculture often needs to uphold its environmental impact and continually demonstrate its commitment to stewardship. One way to do that is by implementing management practices that mitigate (or reduce) greenhouse gas emissions while at the same time increase production efficiency (Table 1).

Because each farm and ranch is different, mitigation practices should be tailored to the species, the type of operation and the local environment. Though some mitigation practices are currently cost-prohibitive, some have additional environmental benefits that should be considered. Benefits include odor reduction, improved air and water quality, pathogen reduction, and the potential to produce alternative revenue sources from the sale of biogas or electricity to off-farm users and manure byproducts such as compost and organic fertilizers.

Figure 3. Sources of methane, nitrous oxide and carbon dioxide emissions from U.S. economic sectors, expressed in carbon dioxide equivalents[26].

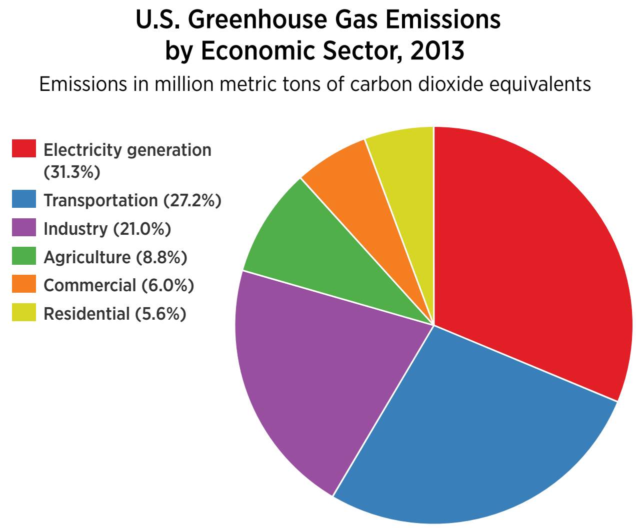


Table 1. Mitigation practices and benefits to production [23, 27].

Areas of management	**Practice**	**Benefit to farmers**	**Additional benefit to the environment**
Production efficiency	Improve feed and production efficiency. Animal health management. Typically results in less methane, nitrous oxide and carbon dioxide emissions per unit of product.	Greater production with fewer inputs may be more profitable.	Less nutrients or natural resources used per unit of output.
Manure storage	Anaerobic digestion and covered manure storages reduce methane emissions.	Both anaerobic digestion and covered storage can produce renewable energy and offset the use of fossil fuels.	Improved nitrogen availability to crops; pathogen reduction in high-temperature digester systems; reduced odor.
Land application of manure	Proper application rates and proper application timing will reduce nitrous oxide and methane emissions.	Proper manure management maximizes crop utilization of the manure nitrogen.	Reduced fossil fuel use leads to reduced water use for energy production.
Farm energy use	Improved energy efficiency through LED lighting, higher efficiency fans and motors, along with other practices can reduce energy inputs. Energy reductions reduce carbon dioxide emissions.	Capital investments are typically recovered quickly through reduced energy costs.	Reduced fossil fuel use leads to reduced water use for energy production.

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Authors

Shelby Burlew, Livestock Environmental Educator, Michigan State University Extension

Marilyn Thelen, Crop and Livestock Systems Sr. Educator, Michigan State University Extension

Dr. Wendy Powers, Professor, Director of Environmental Stewardship for Animal Agriculture Livestock Environmental Management, Michigan State University

David Schmidt, MS. PE, Regional Coordinator for the Animal Agriculture in a Changing Climate, University of Minnesota

Misty Klotz, Climate Change and Agriculture Outreach Coordinator, Michigan State University, W.K. Kellogg Biological Station

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