The Impacts of Confined Animal Feeding Operations on Water Quality and Environmental Justice

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Executive Summary: Waste created from Confined Animal Feeding Operations (CAFOs) contaminates groundwater and surface water with nitrate pollution. Ingesting nitrate through drinking water, as well as all the potential contaminants, has been linked to several adverse health effects, such as several cancers, respiratory issues, and reproductive issues. Unfortunately, these CAFOs are strategically placed in low-income communities with a large minority population, which puts this demographic disproportionately at risk for negative health effects. To protect these communities, policies need to be implemented at the federal and state levels to ensure safety for these residents. Policy options could include the addition of buffer zones and distance requirements between CAFOs and the affected communities. Involvement from the Farm Bill, buffer zones, and anaerobic digesters are possible solutions to the growing negative impacts of CAFOs

I. Introduction

The U.S. Department of Agriculture (USDA) defines a Confined Animal Feeding Operation (CAFO) as “an animal feeding operation in which animals are raised in confinement and have greater than 1,000 animal units confined for over 45 days of a year” (Stanley, 2018). The 1,000 animal units differ depending on the livestock. For example, 1,000 animal units can be “1,000 head of beef cattle, 700 dairy cows, 2,500 swine weighing more than 55 pounds, 125,000 broiler chickens, or 82,000 laying hens” (USEPA, 2024). According to a study completed by Johns Hopkins School of Health, “more than 90 percent of all livestock raised in the U.S. are confined to CAFOs” (JHSOPH, 2019). All animal feeding operations, regardless of size, are termed an Animal Feeding Operation (AFO) on the broader scale, but once these numbers of 1,000 animal units for over 45 days are met, animal feeding operations become a CAFO (Stanley, 2018).

CAFOs have a long history, as they were not always the main way to raise livestock for meat production in the United States. As the U.S. population grew and land use changed, less space became available to spread out livestock, and the farming industry needed to find new solutions (Prisco, 2022). The first CAFO dates back to the 1950s. Originally, these early CAFOs were mainly used to raise chickens. After showing productivity, the industry expanded to include other livestock, as well. Eventually, the practice spread to the pork and beef industries in the 1970s (Prisco, 2022). By the 20th century, CAFOs became the standard way of raising animals, increasing companies’ profits. Today, CAFOs are huge competitors to livestock producers who raise range animals under more traditional structures.

Since CAFOs are a potential source for water pollution, they are subject to permits. The federal permitting process for water pollution is regulated by the National Pollution Discharge Elimination System (NPDES) under authority from the Clean Water Act and administered by the states. Without an NPDES permit, it is prohibited under the Clean Water Act of 1972 to discharge pollutants through a point source into any water of the United States (USEPA, 2024). The permit contains limits on what operators can discharge, monitoring and reporting requirements, and other provisions to prevent harm to water quality or human health (USEPA, 2024). The NPDES permits are necessary to ensure that a state's mandatory standards for clean water and the federal minimums are being met. The Environmental Protection Agency (EPA) and the United States Department of Agriculture (USDA) also require AFO farmers to implement a Comprehensive Nutrient Management Plan (CNMP). A CNMP covers feed management, manure handling and storage, land application of manure, land management, and record-keeping (EPA/USDA, 1999). The purpose of a CNMP is to minimize negative impacts on public health and water quality.

In this paper, we aim to compare different state approaches to regulations of CAFOs, specifically focusing on Michigan, Iowa, Wisconsin, North Carolina, Delaware, and Minnesota. These seven states have varying degrees of protection for CAFOs and have different impacts on the neighboring communities. Iowa has the highest number of CAFOs in the country with little constraints. Michigan has implemented restrictions that help pollution within their state. The four other states are mentioned to show how states in different geographies handle the CAFO issues. The enforcement of NPDES permits also varies by state (Table 1). Table 1 shows that not all CAFOs are regulated under individual state NPDES permits. In Iowa, for instance, the percentage of CAFOs that hold NPDES permits is about 25% lower than the national average (IDNR). The EPA found that the Iowa Department of Natural Resources does not have an adequate program to assess whether unpermitted CAFOs need NPDES permits (USEPA, 2024).

Regulating CAFOs for water pollution is important because runoff from livestock waste during large precipitation events and over-fertilization has become more apparent with an increase in CAFOs. This affects residents who live near CAFOs and communities downstream. Big environmental issues that CAFOs contribute to are ground and surface water pollution, greenhouse gas emissions, deforestation, and soil erosion, among other issues (Wang, 2014, Sierra Club, 2025). CAFOs are also more likely to be placed in economically impaired regions, which raises environmental justice concerns.

State	**Total Number of CAFOs**	**CAFOs with NPDES Permits**	**Percentage of Permitted CAFOs**
Pennsylvania	468	468	100%
Wisconsin	362	348	96.1%
Michigan	300	286	95.3%
Minnesota	1,566	1,009	64.8%
Delaware	685	193	28.2%
Iowa	4,025	157	3.9%
North Carolina	1,222	14	1.1%
Total in the US	21,179	6,174	29.2%

Table 1: NPDES Permitting on CAFOs in US States (USEPA, 2024)

i. Impacts on groundwater

Where CAFOs are the most abundant, issues with groundwater quality arise. Groundwater is an important resource since many people in the United States rely on wells for drinking water. The rising number of CAFOs without NPDES permits or regulations causes a serious public health concern. Nine locations in Iowa and one in Wisconsin have found evidence of microbial and chemical contaminants in groundwater and surface water near confined poultry feeding operations (Hubbard, 2020).

77 percent of the groundwater samples taken from bodies of water near CAFOs detected antimicrobial resistant genes (ARG), and 85 percent of the groundwater samples had viable bacteria growth or pathogen gene markers (Hubbard, 2020).

ii. Impacts on surface water

CAFO operations also pose serious threats to surface water. Surface water downstream from CAFOs is also known to increase exposure to pathogens, risking human health, as well as allowing the transfer of antibiotic resistance genes to other bacteria, increasing overall resistance, with 41.6% of bacteria near CAFOs being resistant to multiple antibiotics (West et al., 2010). Manure spills often occur when waste lagoons fail due to age or a big storm overflows them. Waste lagoons located close to a river or stream are where we see the most spills occur. Spills have been observed in Minnesota to cause massive fish kills and contamination to drinking water (Brands, 2014). A challenge is that manure spills or leakages are not systematically tracked in the US (Brands, 2014). Minnesota has enacted Rule 7020, requiring that no CAFO be sited in a shoreland of surface water (Brands, 2014). However, already existing CAFOs sited on shoreland are not required to move. Minnesota also has its own tracking system for manure spills.

iii. Impacts on human health
The hazards posed by CAFOs extend beyond water quality risk as people residing near them are at an increased risk of developing respiratory-related illnesses compared to those who do not. According to a 2022 study, those living within 15 km of a CAFO were 1.036% more likely to die from cardiovascular disease (Son, 2022). Nitrate also plays a big role in affecting the health of nearby communities. Nitrate from the large amounts of manure leaches into the groundwater. Nitrate in groundwater can cause health issues like blue baby syndrome, which turns the skin of babies blue from a lack of oxygen (Wang, 2014). The increased concentration of CAFO waste in Iowa has resulted in an increased potential for nitrate contamination of private wells (Zirkle, 2016). Ingested nitrate from contaminated drinking water is known to increase the risk of several cancers and birth defects (Minnesota Health, 2025).

Without the regulation of CAFOs to reduce human exposure to pollutants, the residents in communities located 15 km away from a CAFO are more likely to experience negative health effects. For example, those residents are 1.018 percent more likely to die from kidney disease and an overall positive association between cardiovascular mortality and all levels of CAFO exposure (Son, 2022).

II. Current regulations

i. State laws
Michigan, Wisconsin, and Iowa are three examples of different regulations among states. These three states are also located in the Midwest. Michigan is predominantly stricter towards CAFOs, where Wisconsin is in the middle, and Iowa is the least strict among the states.

Michigan
Michigan regulates CAFOs by requiring strict nutrient management plans and permits through the Natural Resources and Environmental Protection Act of 1994. Michigan has its own Water Resources Division (WRD), which has a set of their own permits that CAFO owners have to apply for before farming. For example, all waste storage systems in the state must be constructed to be able to hold all waste and runoff in the event of a 25-year, 24-hour precipitation event. Along with the federal NPDES plans, Michigan also requires farmers to make another CNMP to meet the state's standards (MCL PA 451 1994 Part 41, MAC R 323.2196).

One big manure management practice in Michigan has been the push for CAFOs to implement anaerobic digesters into their manure management. These digesters keep nutrients out of surface water while also recycling the manure. Anaerobic digesters are structures that are built on the farm to break down organic matter like livestock manure. This chamber is devoid of oxygen, which helps the bacteria break down the manure or other organic wastes. This process can help make biogas, specifically methane, that can be used for electricity or fuel. Anaerobic digestion also creates better organic fertilizer that can be used on farms.

Michigan's permitting process for CAFOs has stronger regulations compared to the other states in this paper. There is a 44-page permit that has requirements for nutrient management and how waste storage structures are required to be constructed. For example, if existing storage structures do not meet the standards, they will be immediately closed (Michigan, 2025). All CAFO waste across the state must be sampled once per year to determine the nutrient content (Michigan, 2025). The state has tables of requirements for nutrients and how much manure fertilizer can be applied. The location of CAFOs, weather, and manure sources are all taken into account when the state makes manure spreading requirements (MCL PA 451 1994 Part 41, MAC R 323.2196).

Wisconsin

Wisconsin's CAFO regulations expand beyond the minimum requirements of the EPA. The regulation focuses mainly on water protection. Wisconsin defines CAFOs as AFOs with 1,000+ animal units; however, small operations can also be considered CAFOs if they contaminate navigable waters or wells. To implement NPDES requirements by the EPA, Wisconsin has its own permit system, the Wisconsin Pollutant Discharge Elimination System (WPDES). All CAFOs and any operation intending to become a CAFO within the next 12 months are required to obtain a WPDES permit in addition to the NPDES permit. The standard for runoff to navigable waters from CAFOs is zero (WAC NR Ch. 151).

To be approved for the WPDES permit, CAFOs must have all construction plans permitted and approved with a 60-day post-construction review, a nutrient management plan, and plans for responses to spills. The nutrient management plan must be renewed annually, and if there are any substantial changes, it is subject to a 14-day public comment period. There are also inspection and reporting requirements (WAC NR Ch. 151).

These requirements are easily mapped out for farmers through a free "CAFO Compliance Calendar" released yearly. This calendar goes through every month with reminders for seasonal differences, such as land application limits in the wintertime. There are also trackers to ensure all required inspections are being completed, which are enforced by the Wisconsin Department of Natural Resources (WDNR). The WDNR website also provides a large amount of accessible information about CAFO regulations to make the rules clear to farmers. The department also provides workshops on the process of acquiring permits (Wisconsin Department of Natural Resources). Compared to other states discussed in this paper, Wisconsin is clear about the regulations that must be followed, making it easier for CAFOs to comply.

Iowa

The state of Iowa has the largest number of CAFOs in the United States, with the total in 2022 being 4,025 (USEPA, 2024). Of those, only 157 have NPDES permits, equating to just under 4% of all the CAFOs in Iowa (USEPA, 2024). Iowa's lenient regulations likely contribute to the large number of CAFOs compared to other states because there is less government oversight directing what CAFOs can and cannot do (Weida 2002). Iowa only requires NPDES permits if there is known active discharge into waterways, which is in line with federal requirements, but allows for minimal enforcement (IAC, 2025). This contrasts with some other states, such as Wisconsin and Pennsylvania, which require NPDES permits for all CAFOs regardless of active discharge (WAC NR Ch. 151).

The minimal enforcement of CAFOs in Iowa is detrimental to the water quality in the area. In 2024, 51.9% of assessed rivers and streams were impaired, 63.1% of assessed lakes and reservoirs were impaired, and 11.2% of assessed wetlands were impaired (Iowa DNR, 2024). Impaired waterways are when the water quality standards are not being met for various pollutants like phosphate, nitrate, and ammonia. These pollutants are known to be from CAFO runoff. In 2024, there were 47 fish kill events in Iowa, 14 of which were caused by animal waste, the second leading cause (Iowa DNR, 2024).

III. CAFOs and environmental injustice

Environmental injustice is the unequal distribution of environmental effects and benefits on marginalized and low-income communities (NRDC, 2023). CAFOs have a large impact on the surrounding community when it comes to water and air quality (Galarraga, 2021). Delaware and North Carolina are East Coast states that are dealing with environmental injustice issues related to the higher numbers of CAFOs compared to their neighbors. While North Carolina has strict regulations for CAFOs (General Statute 143-215.10B), it does not have any requirements for the locations of CAFOs (15A NCAC 02T .1307-.1308 and 15A NCAC 02D .1808) (NC DEC, 2023). Delaware also has strict regulations for CAFOs for pollutant discharges into streams, including their own classifications for CAFOs and AFOs that closely follow EPA guidelines (Delaware Department of Agriculture, 2024).

In Delaware, the highest number of poultry CAFOs are found in low-income areas with the highest percentage of individuals without a high school diploma who happen to depend on groundwater for residential use (Galarraga, 2021). Similarly, eastern North Carolina has a high number of hog CAFOs in an area disproportionately represented by descendants of enslaved African Americans (Nicole 2013). The odors from these hog CAFOs can cause mucosal irritation and respiratory ailments, mental stress, and elevated blood pressure (Nicole, 2013).

IV. Policy Options

i. Policy option 1. Require NPDES permits in all states

All agricultural and livestock operations that meet the levels of a CAFO should be required to have an NPDES permit in every state. The fact that North Carolina has 1.1% of CAFOs under NPDES permits is something that needs to be changed. If all CAFOs can be seen as polluters by state governments, then all CAFOs would be required for NPDES permits. Pennsylvania, for example, requires all CAFOs in the state to have NPDES permits (Commonwealth of Pennsylvania, 2025).

The NPDES program aims to eliminate point source pollution, and not all CAFOs may be seen as point source emitters (EPA, 2024). The benefits of implementing permits on all CAFOs will immediately improve surface water quality across the country. This would result in cleaner water, especially for the areas most vulnerable to the effects of CAFOs. Groundwater would see less nitrate leaching, and overall human health impacts will improve.

ii. Policy option 2. Provide financial assistance for anaerobic digesters

The U.S. Farm Bill is up for renewal on September 30, 2025. We recommend making financed loans through the Farm Bill to encourage CAFO farmers to implement anaerobic digesters on their land. Title 2 of the Farm Bill provides agricultural assistance to producers to adopt conservation activities on agricultural and forest lands to protect and improve water quality and quantity, soil health, wildlife habitat, and air quality (USDA, 2025).

Advantages

By containing the livestock waste in anaerobic chambers, waste will be kept out of the surface waters. In the past, the Farm Bill has helped decrease grain prices, which has helped lower feed costs for CAFO farmers.

Anaerobic digestion takes bad odors out of the air that can cause asthma. It also eliminates lots of waste from runoff into waterways, which may be used for drinking water.

Disadvantages

A disadvantage of anaerobic digestion is primarily the cost. An anaerobic digester can be quite expensive, with prices ranging from $400,000 to $5,000,000 to build (Anaerobic Digestion Community, 2022). Creating a program to build digesters on farms would create jobs for construction crews and would, in turn, help the local economies. Another disadvantage is the land the digester would take up. This is a smaller disadvantage compared to price, but one that farmers will care about.

iii. Policy option 3. Require buffer zones to protect waters

Buffer zones are areas filled with native plant species like shrubs and trees next to a waterway (Wild Trout Trust, 2025). Buffer zones are important for sequestering pollutants like excess phosphate and nitrate (Wang, 2014). These zones are meant to catch and slow the process of runoff from the fields carrying these pollutants (Wild Trout Trust, 2025). This process naturally improves water quality. Six states have explicitly stated requirements in place for buffer zones, allowing local governments to enact stricter regulations (Gile, 2019).

Buffer zones should be at least 100 feet in length from the end of the field to the waterway. This waterway can be something as small as an irrigation stream or a river (Gile, 2019). Buffer zones reduce the potential for nutrients to flow directly into water. Minnesota already has incentives for implementing buffer zones (Gile, 2019). States should take control of what is being emitted into waterways, and buffer zones are a way to do this. Any state can implement incentives for buffer zones because there will be less negative water quality impact. Incentives will be implemented through a state's department of environmental protection. Buffer zones will be implemented at the state level and overseen at the local level.

Advantages

The biggest advantage of buffer zones among those listed above is reducing the amount of nutrients emitted into waterways. CAFOs need this help the most. Implementing buffer zones will lower the pollutants emitted, which will in turn help farms meet their NPDES permit goals. Another advantage is that buffer zones would not cost much to plant - in the range of $200-$500 to plant the scrubs and native grasses.

Disadvantages
A disadvantage would be the loss of land that the buffer zones occupy. This disadvantage can be offset by incentivizing buffer zones. Allowing nonprofit environmental organizations to plant the buffer zones would take the cost away from the farmers which could offset the minimal loss of land. Incentives could be certain tax breaks or financial assistance on the prices of feed.

Michigan sets a good example of strict guidelines for CAFOs to follow. Many of these requirements can be implemented in other state departments of environmental protection. Each state should make sure its CAFOs have proper waste storage systems. This will, in turn, save the state's money since it would not have to spend as much to remediate surface and groundwaters from pollution.

V. Policy recommendation

Policy option 1 to require all CAFOs to implement NPDES permits is a good starting point for states. Policy option 1 is a stepping stone on the way to option 2 and 3. After all CAFOs are under NPDES permitting is where states and the federal government can help fund anaerobic digesters and buffer zones based on the amount of manure. We recommend the CAFOs with the largest numbers of livestock to invest in anaerobic digestion with help from funding. CAFOs with lower livestock totals would be pushed to add buffer zones next to waterways.

VI. Conclusion

In this work, we sampled states' enforcement of NPDES permits in certain states. CAFOs have been put in low-income areas in multiple states. In North Carolina and Delaware, there are issues of groundwater and air quality relating to CAFOs. Meanwhile, 100% of CAFOs in Pennsylvania have NPDES permits. When large precipitation events occur, there is a large amount of waste runoff from CAFOs. The contaminated water flows into streams and rivers nearby, causing large impacts to aquatic life and drinking water. Federal and state-level policy adjustments will be necessary to lessen the environmental injustice and environmental impact in the future. That is why we recommend implementing NPDES permits on every CAFO in the United States. Implementing anaerobic digesters and buffer zones on those CAFOs will help with farmers meeting the NPDES permit goals. The policy suggestions above will likely lessen the impact of CAFOs on environmental injustice in communities.

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