A GUIDE TO

Understanding Environmental Modeling for Dairy Farms

KEY TAKEAWAYS

Modeling can be used to estimate an individual farm's environmental impact as well as understand the environmental impact for the U.S. dairy industry.

Understanding GHG emissions and energy use can highlight opportunities for reduction. There are a variety of management approaches, practices, and technologies for dairy farms that reduce GHG emissions while also aligning with positive business outcomes.

Water quality modeling can be used to better understand a farm's impact on their water system as well as assess different management practices and actions.

WHAT IS AN ENVIRONMENTAL MODEL?

An environmental model is a mathematical or computational tool used to simulate and analyze environmental systems and processes. These models are designed to represent the interactions between different components of the environment, such as the atmosphere, plants, soils, livestock, and manure storage.

Environmental models can range from simple decision-support tools to complex simulation models that require significant data inputs. They are commonly used to:

- **Obtain a baseline estimate of a farm's environmental impact**
- **Estimate the impact of management changes, including the implementation of conservation practices**

In agricultural conservation, various models are used to assess and improve sustainability, optimize resource use, and mitigate environmental impacts. There are two key model categories: Greenhouse Gas (GHG) Models and Water Quality and Soil Erosion Models.

Greenhouse Gas (GHG) Models

Purpose: These models estimate the emissions and sequestration of greenhouse gases from agricultural activities. They are crucial for understanding the carbon footprint of farming practices and evaluating strategies for reducing emissions.

Applications: Climate change mitigation, carbon offset projects, and sustainability reporting.

Water Quality and Soil Erosion Models

Purpose: These models simulate the transport and fate of pollutants, such as nutrients and sediments, within agricultural landscapes. They assess both the amount of soil loss due to erosion and the subsequent impact of sediment and nutrient runoff on water bodies. By integrating these aspects, the models help evaluate the effectiveness of conservation practices in protecting both soil and water resources.

Applications: Watershed management, erosion control planning, evaluation of best management practices, and regulatory compliance.

VALUE OF MODELING OVER DIRECT MEASUREMENT

Modeling the environmental impact of farms, rather than relying solely on direct measurement, is essential for several reasons:

Feasibility: Models offer a practical solution for assessing environmental impacts, particularly when current technology is insufficient to accurately measure complex processes like greenhouse gas fluxes, runoff, or leaching across large, dynamic systems like farms. Models can estimate these impacts by integrating various data sources and scientific understanding, even when direct measurement is not feasible.

Scalability: Models can simulate impacts across different scales, from field-level to landscape-level. Modeling allows for the assessment of large areas, such as entire watersheds or regions, where direct measurement would be logistically challenging or impossible.

Cost and Resource Efficiency: Modeling requires fewer resources compared to widespread field measurements. Once established, models can be run repeatedly at a relatively low cost to evaluate different scenarios. Conducting extensive environmental measurements across various parameters (e.g., water quality, soil health, GHG emissions) is resource-intensive and can be prohibitively expensive.

Predictive Capability: Modeling provides the ability to predict future environmental impacts under different management scenarios or changing climatic conditions. This helps in planning and decision-making to mitigate potential negative impacts before they occur.

Model Selection: When modeling, it is important to select the correct model for the specific situation. Different models can provide different results based on the purpose of the model, the inputs, and the model assumptions.

Note: Ideally, only models that have been verified with direct measurements should be used.

MODELING TOOL EXAMPLES

Software tools are available for calculating or estimating the GHG emissions and water impacts for dairy farms; however, creating tools that are easy to use while providing accurate results remains a challenge.

GHG Emission Modeling Tools

Tools	Organization/ Author	Availability	Notes
FARM Environmental Stewardship (ES)	National Milk Producers Federation	Available to members	Specifically designed to model the GHG and energy use impact of dairy farms. Evaluation performed by second-party evaluators (usually co-op field reps).
COMET-Planner	United States Department of Agriculture	Publicly available	Evaluate potential carbon sequestration and greenhouse gas reductions from adopting NRCS conservation practices.
COMET-FARM	United States Department of Agriculture	Publicly available	COMET-Farm is a whole farm and ranch carbon and greenhouse gas accounting system.

GHG Emission Modeling Tools			
Tools	**Organization/ Author**	**Availability**	**Notes**
Cool Farm Tool	Cool Farm Alliance (not-for-profit) with input from members and partners	Partially available	Cool Farm Tool is a free (for farmers) online tool that tracks GHGs, biodiversity impacts, water, and supply chain management. Use of this tool is accepted in EU markets.
Fieldprint Calculator	Field to Market	Publicly available	Assessment framework to measure the environmental impacts of commodity crop production and identify opportunities for continuous improvement.

Note: These models are GHG focused, but may also provide other impact assessments.

Water Quality Modeling Tools			
Tools	**Organization/ Author**	**Availability**	**Notes**
Model My Watershed	Stroud Water Research Center	Publicly available	An online system used to map and model your watershed using tools to analyze land use, soil data, stormwater runoff, water quality impacts, and the impact of conservation or development scenarios.
Soil and Water Assessment Tool - SWAT	Texas A&M University/ United States Department of Agriculture	Publicly available	SWAT is a commonly used model developed to quantify the impact of land management practices in complex watersheds.
Pollutant Load Estimation Tool - PLET	United States Environmental Protection Agency	Publicly available	PLET uses simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from implementing best management practices.
Surface Water Modeling	United States Environmental Protection Agency	Publicly available	A collection of tools that can help to understand water quality problems, create water use plans, evaluate the effects of potential actions on water quality, and conduct other water quality analyses.

Note: These tools are continually updated. Please consult with a farm advisor to learn more about what tools are appropriate for use in each individual case.

THE BOTTOM LINE

Environmental stewardship is a shared responsibility. Knowing a farm's environmental impact for both GHG emissions and water quality is a critical first step to making impactful changes to improve dairy farm sustainability.