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SESSION 11: METHANE EMISSION-FREE COMMUNICATIONS:
GENETICS, ENVIRONMENTAL, AND LIFE CYCLE ASSESSMENT STUDIES

# MACHINE LEARNING FOR PREDICTING ENVIRONMENTAL IMPACTS IN INTENSIVE LIVESTOCK FARMING, OVERCOMING DATA CHALLENGES

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# PROBLEM FORMALIZATION

**Context:**

- The need for more accurate Life Cycle Assessment (LCA) predictions is driving its integration with Machine Learning (ML) techniques
- Current research focuses on using ML algorithms to improve LCA models, enhancing the accuracy and efficiency of environmental impact assessments.

**Problem:**

- **Data Quality**: Accurate LCA predictions depend on high-quality data.
- **Missing Data Challenges**: A major challenge in LCA, caused by incompleteness, measurement errors, or data collection limitations.
- **Traditional Methods:** Mean- or median-based approaches for handling missing data are often limited and can result in biased or unreliable outcomes.

**ML Potential**: Machine learning techniques offer sophisticated solutions for data completion and imputation, enhancing the efficiency and reliability of LCA analyses.

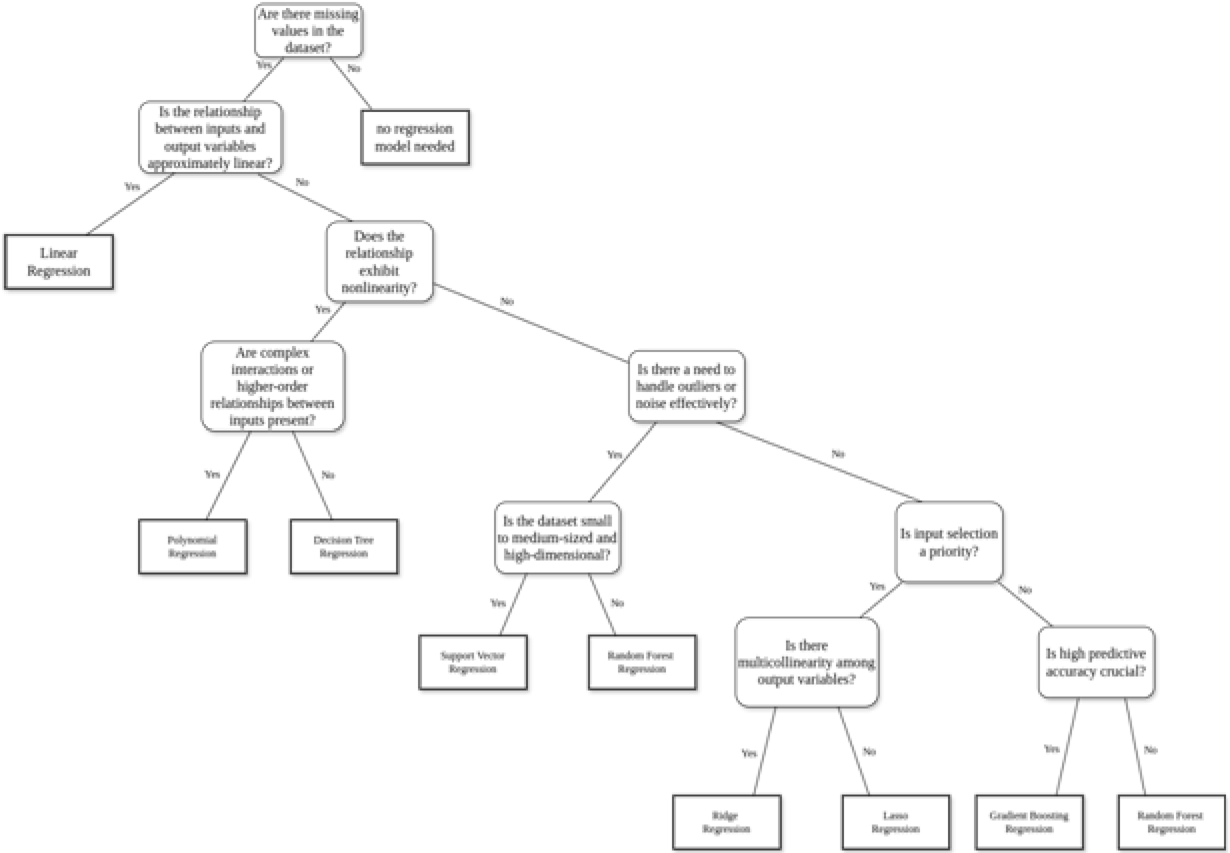
**Focus of the study:**

Selection between ML regression techniques to improve the accuracy and reliability of data predictions

# METHODOLOGY

## Approach Overview

- The methodology helps select the optimal machine learning algorithm for predictions and handling missing values.
- 8 regression algorithms were considered
- Presented as a decision tree for simplicity and usability.



# METHODOLOGY

## Methodology application

- Considered dataset: data from ~100 dairy farms in Italy/Europe, focused on Carbon Footprint analysis
- Key inputs for CF analysis: *Fat and Protein Corrected Milk (FPCM) produced, herd composition, cultivated land area, and diet details (amount and origin of forage and concentrates), energy and fuel.*
- Dataset was decomposed in 3 subdataset: Soy meal, herd size, total feed.

## Regression model evaluation

Root Mean Square Error (RMSE) was used.

- Standard deviation of prediction errors, indicating the spread of residual values.
- RMSE normalized between 0 and 1 for comparison.

# RESULTS AND DISCUSSION

*Table 1. Normalized RMSE of three different datasets.*

| Dataset/ ML model | Linear | Ridge | Lasso | Polynomial | Decision tree | Random forest | Support vector | Gradient boosting |
|---|---|---|---|---|---|---|---|---|
| Soy Meal | 0.118 | 0.116 | 0.116 | 0.114 | 0.114 | **0.105** | 0.121 | 0.115 |
| Heard Size | 0.023 | 0.019 | **0.020** | 0.033 | 0.088 | 0.091 | 0.023 | 0.081 |
| Total Feed | 0.066 | **0.058** | 0.061 | 0.086 | 0.09 | 0.08 | 0.059 | 0.076 |

## Soy meal

**Dataset characteristics:**

- Many heterogeneous inputs, presence of noise due to data collection limitations.

**Model Selection:**

- Random Forest Regression.

## Herd size

**Dataset characteristics:**

- Simpler data collection, no significant noise, no complex input selection required.

**Model Selection:**

- Lasso Regression.

## Total feed

**Dataset characteristics:**

- Correlated inputs, some multicollinearity, complex input selection required.

**Model Selection:**

- Ridge Regression.

# CONCLUSIONS

| | |
|---|---|
| **Key Findings:** | **Novel Approach Introduced:** Developed a systematic method to predict missing values in datasets |
| | **Algorithm Selection:** The approach selects the optimal ML algorithm based on dataset characteristics, enhancing prediction accuracy and reliability. |
| **Effectiveness Demonstrated:** | **Testing and Validation:** Conducted rigorous testing on three distinct datasets, each influencing the environmental impacts of cattle milk farming. |
| | **Performance:** Showcased the versatility and effectiveness of our approach in predicting missing values and improving dataset completeness. |
| **Practical Applicability:** | **Enhanced Utility:** Significantly increased the size of the dataset, improving its utility for robust environmental impact assessments. |
| **Implications:** | **ML and LCA Integration:** Demonstrated the potential of integrating ML techniques with LCA methodologies to address data-related challenges. |
| | **Improved Assessments:** Enabled more robust and comprehensive environmental impact assessments, facilitating informed decision-making and sustainable practices. |

# THANK YOU
# FOR YOUR ATTENTION

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