Title: Utilizing Machine Learning for Predicting Dairy Production in New Zealand Based on Climate Factors

Abstract

The agricultural sector's sustainability, particularly dairy farming in New Zealand, is significantly influenced by climate conditions. This research employs machine learning (ML) techniques to predict milk production, utilizing variables such as rainfall, temperature, humidity, and sunshine duration. The study aims to develop a predictive model that enhances decision-making and resilience in dairy farming against the backdrop of climate change. By integrating historical climate and production data, this research not only seeks to improve operational efficiencies but also to contribute to the academic discourse on applying ML in agriculture.

1. Introduction

New Zealand is a premier dairy producing country, contributing significantly to the global dairy market. New Zealand produces approximately 21 billion litres of milk every year. That is approximately 3% of the world milk production or a milk volume equivalent for two and a half serves of dairy per day for 90 million people. Being the world’s 8th largest milk producer with a population of just five million, it exports over 95% of the milk produced in New Zealand, to more than 130 different countries worldwide [1].

The dairy sector contributed just over $11.3 billion to New Zealand’s GDP in the year to March 2023. This represented 3.2% of total GDP. Of this, dairy farming contributes $8.0 billion (2.2% of GDP) and dairy processing contributes $3.4 billion (0.9%), which is the largest of all goods producing sectors, in both the primary sector and manufacturing. Sheep and beef farming, at $3.8 billion in GDP (1.1% of the total) was a relatively distant second. Dairy processing alone is the third largest goods producing sector in the country, at $3.4 billion[2].

In the decade cow numbers have continued to decline by 2.28% to 4.67 million in 2022/23, but the number of herds was down by 1326 to 10,601 and the national average herd size was 441 in 2022/23, which was 39 cows higher than the 2012/2013 season [table1.1].

A table with numbers and a number of cows

Description automatically generated

but herd size by 63% as a result of farm amalgamation. Cow numbers increased by 650 000 and 390 000 in the South Island and North Island respectively over the same period. Milksolids per cow and per hectare increased by 14 and 28% respectively and these increases together with increased farm size increased milksolids output per farm by 90% (Table 1).

The interdependence between dairy farming and climatic conditions is well-documented, highlighting the sector's vulnerability to climate variability. The nation's economy and the global food chain heavily rely on the stability and productivity of its dairy industry (Statistics New Zealand, 2020).

1.2 The Impact of Climate on Dairy Production

Climate factors such as rainfall, temperature, and sunshine play a crucial role in pasture-based dairy farming, directly influencing milk yield and quality. Variations in these factors can lead to significant fluctuations in production, challenging the sector's sustainability (FAO, 2018).

2. State of Research

2.1 Traditional Methods in Agricultural Forecasting

Traditional forecasting methods in agriculture have predominantly relied on statistical models and historical trends. However, these approaches often fall short in capturing the complex dynamics between climatic variables and milk production (Jones et al., 2017).

2.2 Advancements in Machine Learning for Agriculture

Recent advancements in ML and data analytics have opened new pathways for predicting agricultural outcomes. ML models are adept at handling complex, nonlinear relationships between multiple variables, offering a more nuanced understanding of the factors affecting dairy production (Smith & Marshall, 2019).

3. Models and Methods

3.1 Data Collection and Preprocessing

This study will utilize historical data from various sources, including the National Institute of Water and Atmospheric Research (NIWA) and DairyNZ. The data will undergo rigorous preprocessing to ensure accuracy and consistency (NIWA, 2020; DairyNZ, 2021).

3.2 Model Selection

A comparative analysis of several ML models, including linear regression, decision trees, and neural networks, will be conducted. The selection criteria will be based on predictive accuracy, with a focus on minimizing error metrics such as MAE and RMSE (Hyndman & Athanasopoulos, 2018).

3.3 Validation and Testing

The model's performance will be validated using a split of training and test data, supplemented by cross-validation techniques to assess its generalizability across different climatic and production conditions (Kohavi, 1995).

4. Research Value

4.1 Implications for Dairy Farming

The development of a reliable ML-based predictive model for milk production has the potential to transform dairy farming practices, enabling farmers to make informed decisions and optimize production processes in the face of climate variability (FAO, 2021).

4.2 Contributions to Agricultural Research

This research aims to contribute to the broader application of ML in agriculture, providing a methodological framework that can be adapted to other contexts and promoting data-driven decision-making in the sector (Liakos et al., 2018).

References

FAO. (2018). The impact of disasters and crises on agriculture and food security. Food and Agriculture Organization of the United Nations.

FAO. (2021). Digital agriculture. Food and Agriculture Organization of the United Nations.

Hyndman, R. J., & Athanasopoulos, G. (2018). Forecasting: principles and practice. OTexts.

Jones, P., Marshall, S., & Smith, T. (2017). Climate variability and milk production: An empirical study in the dairy sector. Agriculture and Climate Journal, 5(2), 120-131.

Kohavi, R. (1995). A study of cross-validation and bootstrap for accuracy estimation and model selection. Ijcai'95.

Liakos, K. G., Busato, P., Moshou, D., Pearson, S., & Bochtis, D. (2018). Machine learning in agriculture: A review. Sensors, 18(8), 2674

[1] DCANZ – Dairy Companies Association of New Zealand.2023

[2] **Sense Partners**, Solid foundations, Dairy’s economic contribution to New Zealand,2023