Predictive Analytics of Climate Stress Impact on the Italian Mediterranean Buffalo

Presented by

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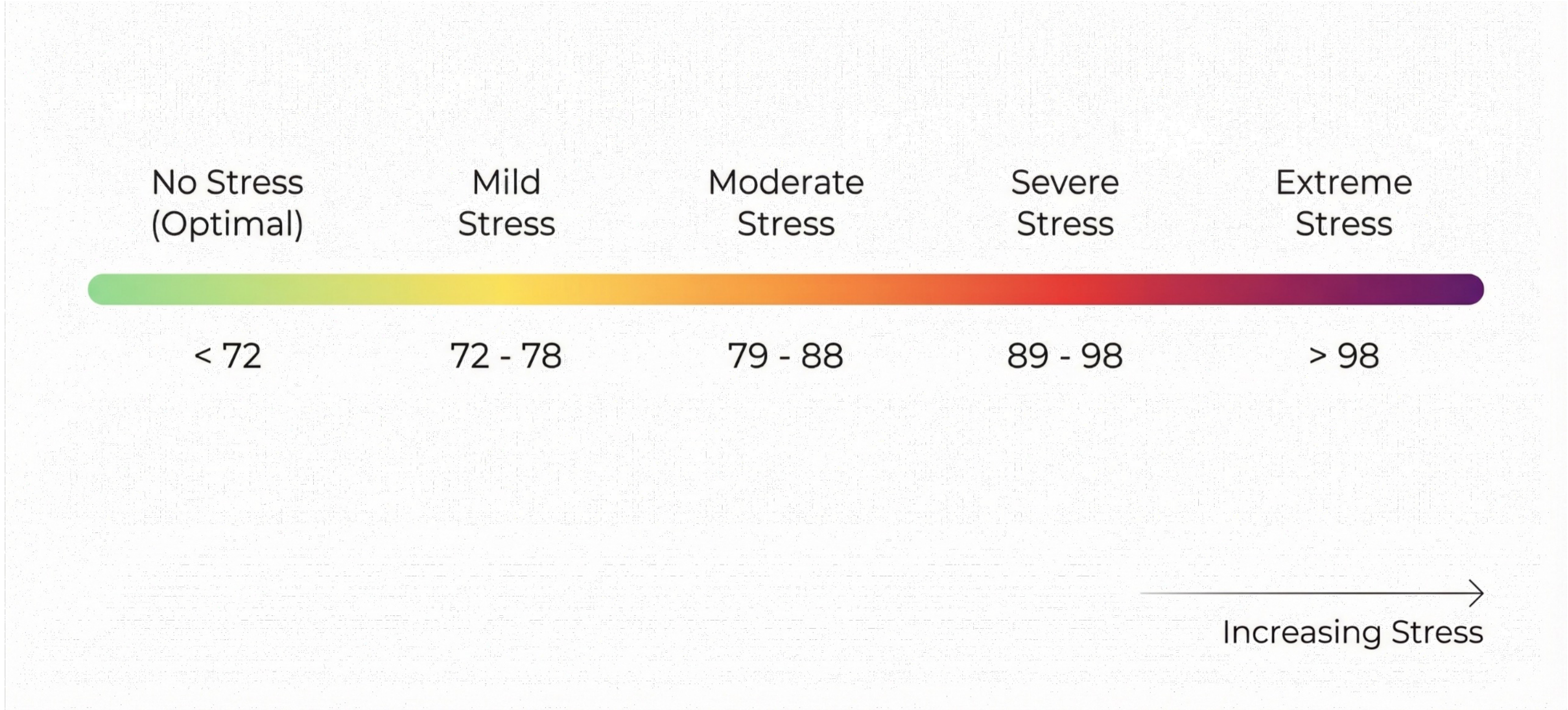
Heat Stress

↓ milk production
↓ feed intake
↓ performance.

↑ Diseases
↑ Sweating
↑ Blood flow to skin
↑ heart and respiration rate [1]

THI ranges were reported by Dash et al. [2]:

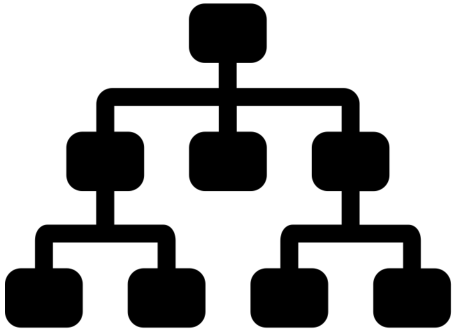


Studies on Milk Prediction

- Effect of HS on cow milk yield ,by Hassan, 2025
- individual models for predicting cow milk production in Korea, by Song,2025
- predict the next month's daily cow milk yield in Australia by Ji,2022
- predict SCC in the Italian Mediterranean Buffaloes by Bobbo, 2022

Hierarchy in time series (HTS)

- Time series data can be naturally hierarchical.
- Data can be aggregated or disaggregated based on:
  - Types
  - Features
  - geographic division. [4]



Hierarchy in time series (HTS)

The value of parent is always equals to the sum of the values of its children.

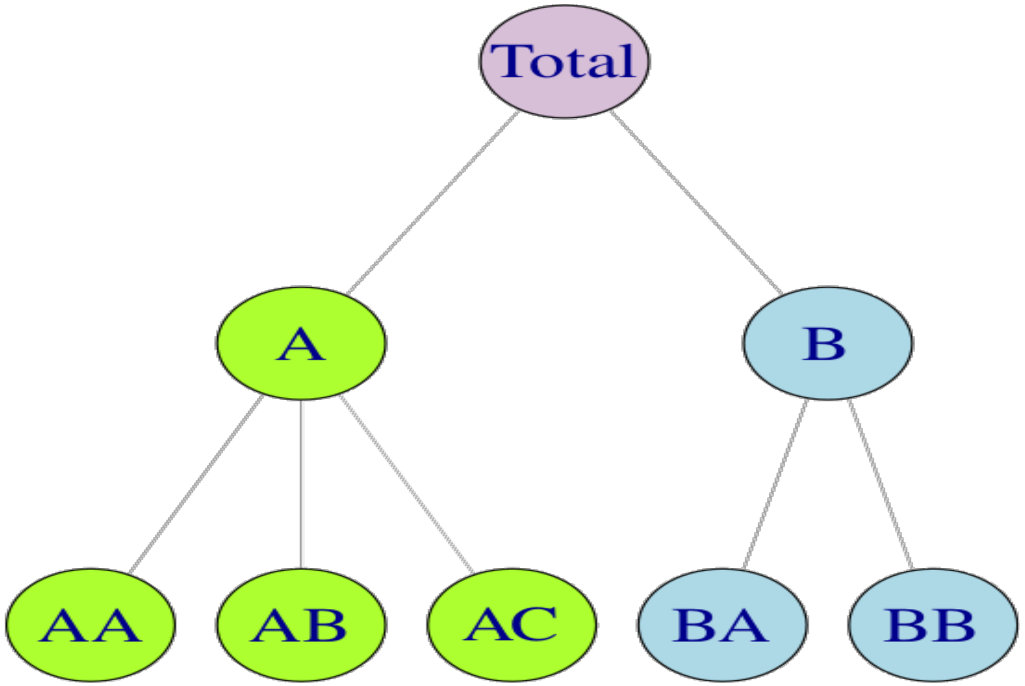
So, if $y_{j,t}$ equals The value of j at time t, then, we have :

$$y_t = y_{A,t} + y_{B,t}.$$

$$y_{A,t} = y_{AA,t} + y_{AB,t} + y_{AC,t}$$

$$y_{B,t} = y_{BA,t} + y_{BB,t}$$

Finally, we can say our data is **Coherent.** [4]



Applications on HTS

- Tourism
  - Forecasting number of tourists going to visit a country divided by region, city, season. [4]
- supply chain
  - Forecasting sales of products based on type, location. [11]
- Energy Consumption
- Forecasting energy consumption based on region, city, hour. [12]

Animal_ID	Farm_ID	Date	Age	MILK	DIM	Protein	Fat	SCC
1001	102	25-01-01	4	20 Kg	154	10%	12%	200K/mm
1004	103	25-01-01	6	35 Kg	114	10%	12%	200K/mm
1003	102	25-01-01	5	15 Kg	204	10%	12%	200K/mm
1002	103	25-01-02	7	30 Kg	94	10%	12%	200K/mm
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	1001	102	25-01-02	4	25 Kg	155	10%	12%	200K/mm
Animal 1002	1002	103	25-01-02	7	30 Kg	94	10%	12%	200K/mm
	1002	103	25-01-01	7	15 Kg	93	10%	12%	200K/mm
Animal 1003	1003	102	25-01-02	5	20 Kg	204	10%	12%	200K/mm
	1003	102	25-01-01	5	15 Kg	204	10%	12%	200K/mm
Animal 1004	1004	103	25-01-02	4	35 Kg	115	10%	12%	200K/mm
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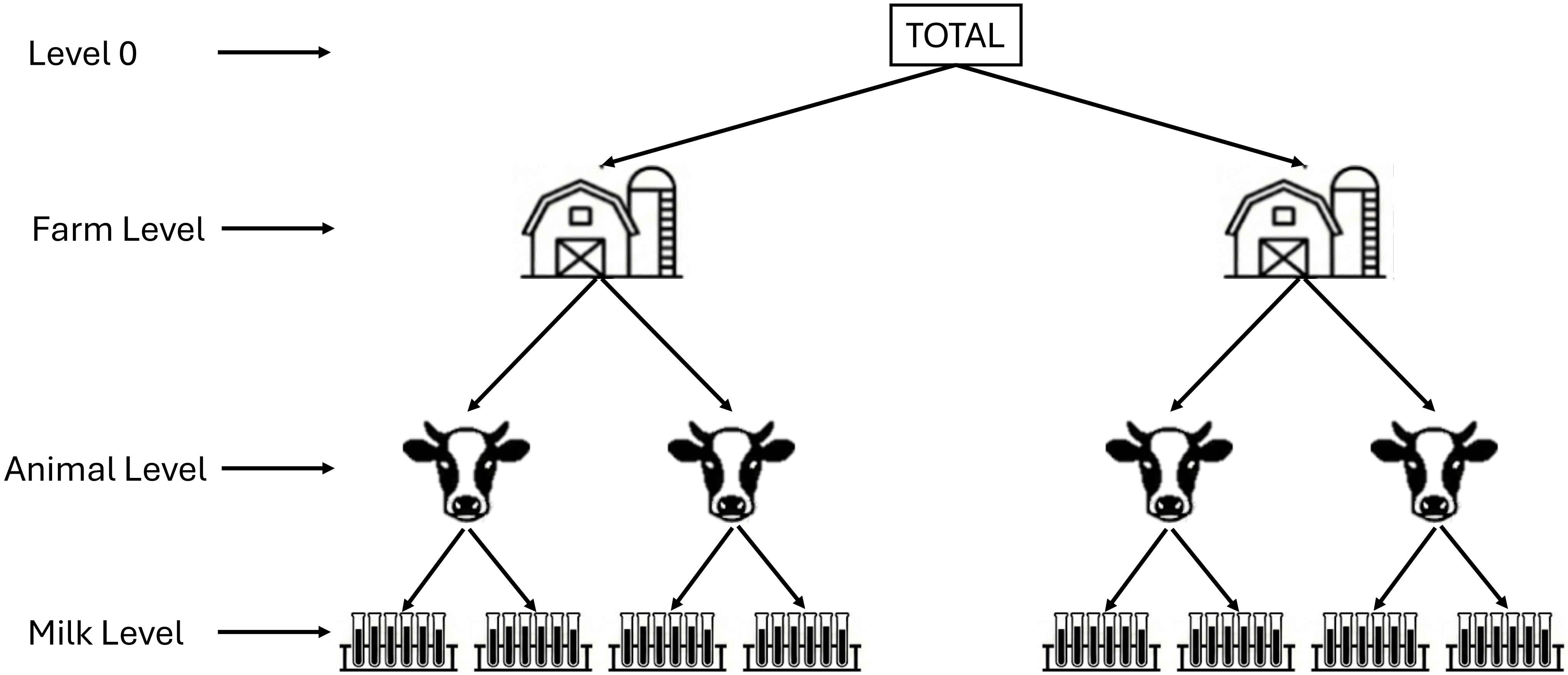
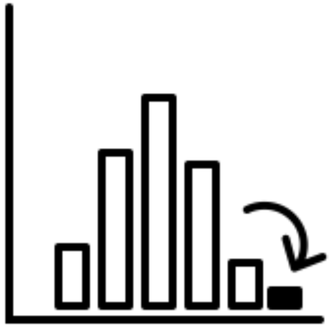
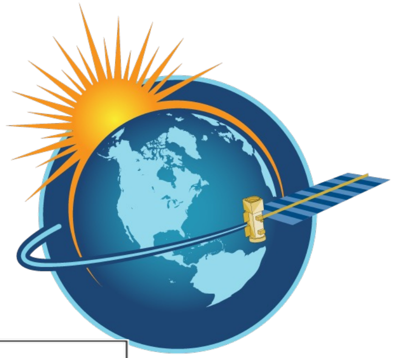
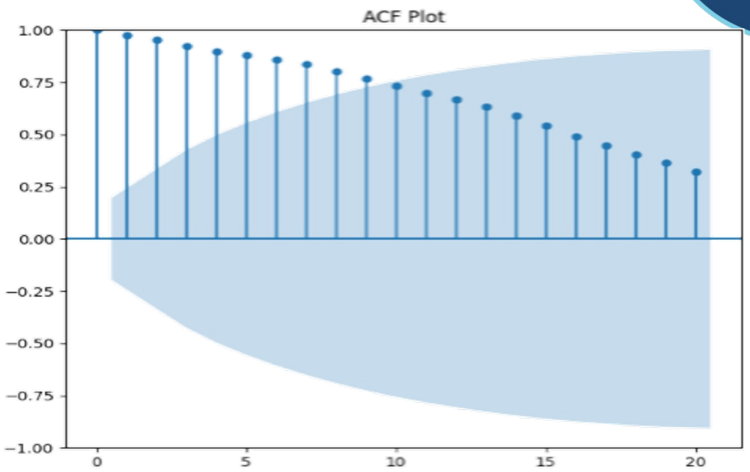


Preprocessing

- Removing Outliers and null values
  - Time Series Decomposition. [8]
  - Statical methods like normal distribution.
- Integrating climate data. [3,5]
- THI Compose
  - Avg of 2 days before and after [3]
- Lag Features
  - Captures the effect of past days

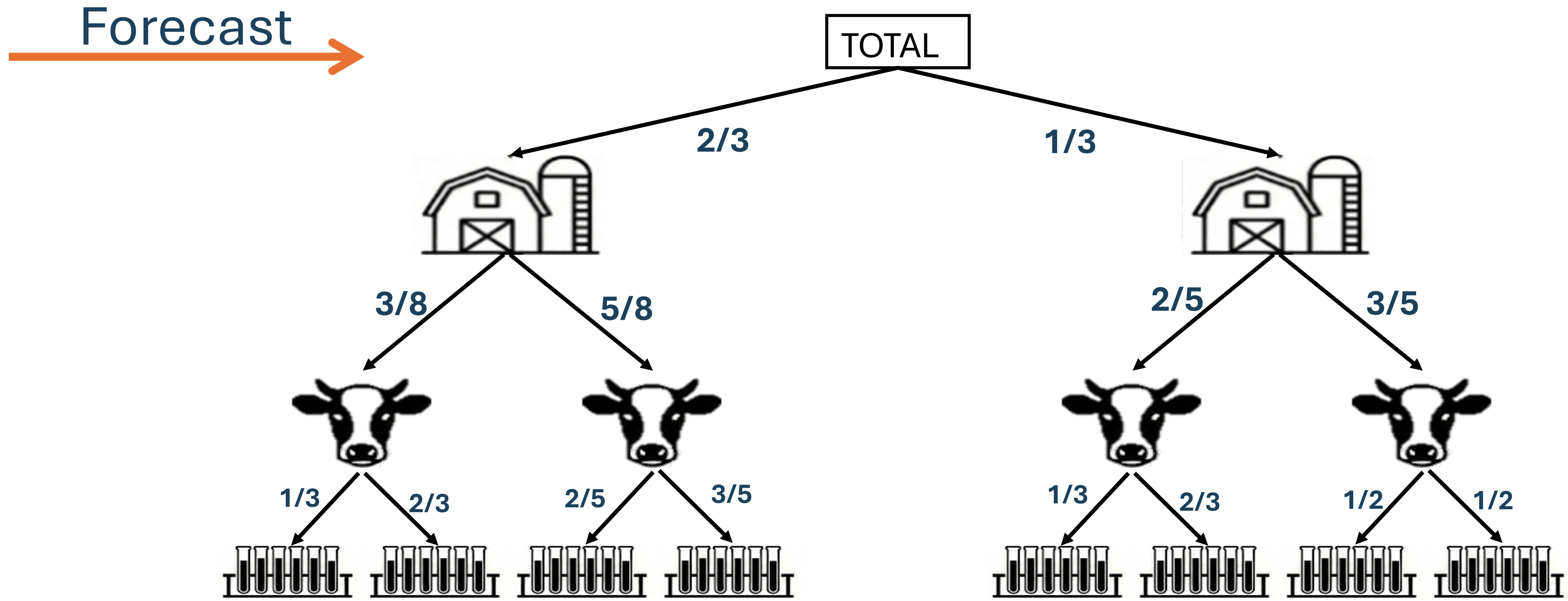






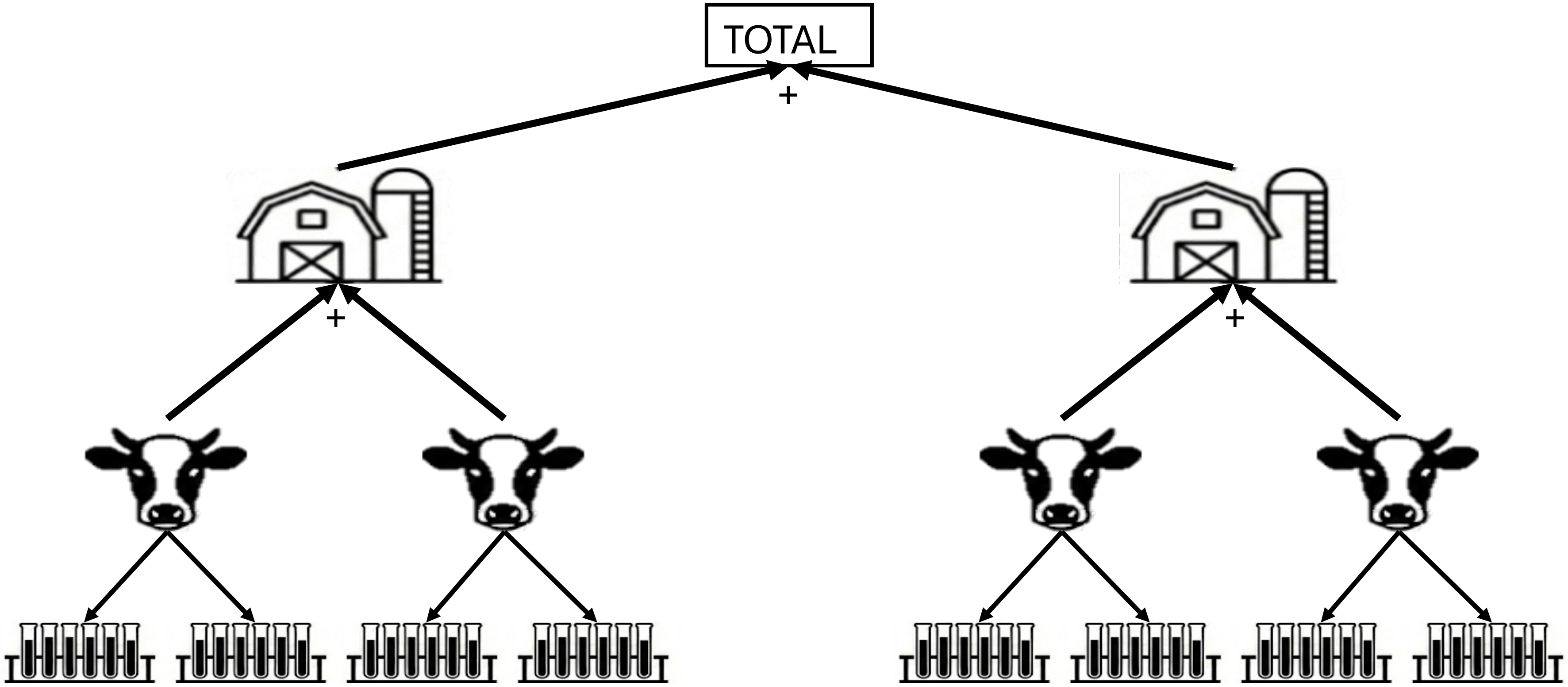
geeksforgeeks.org/machine-learning/what-is-lag-in-time-series-forecasting/

Approaches of Implementation [9] : Top Down



Approaches of Implementation [9]: Optimal

Forecast

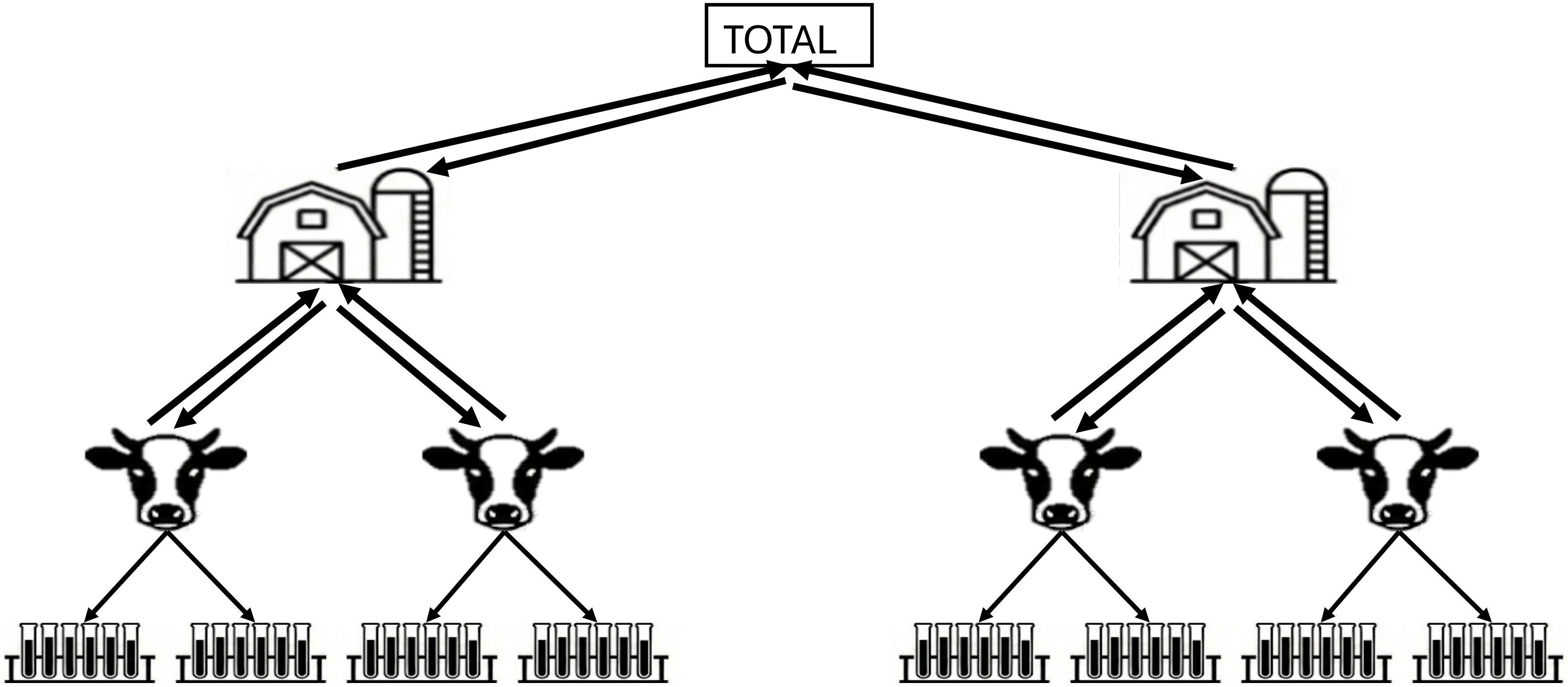


Approaches of Implementation [10] : Optimal Solution

Forecast

Forecast

Forecast

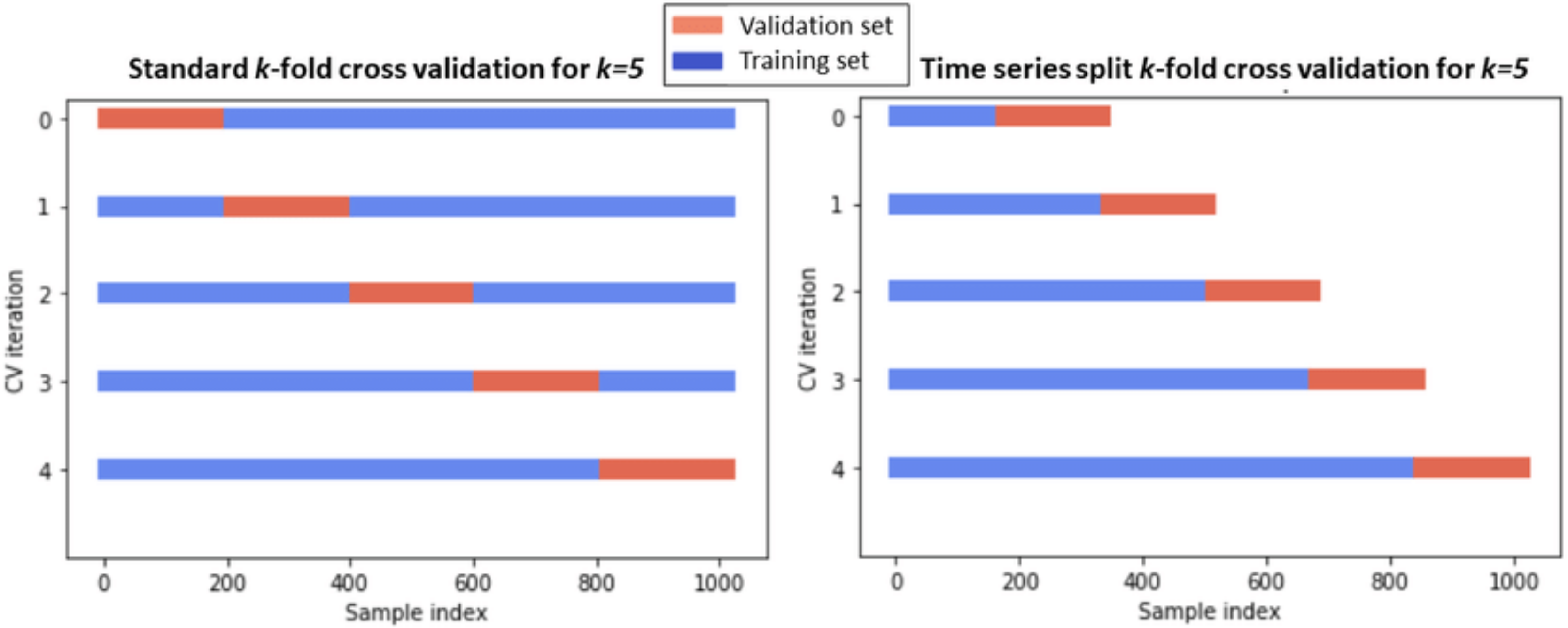


Hierarchical Reconciliation [10]

- A model will be trained on the data[XGBoost, ...].
- Forecast on the data using current model.
- Reconcile the predicted values using statistical approaches:
    - MinT : minimize the variance between reconciled values and base forecast error.

Evaluation and Metrics

- Cross-Validation
- Global model
  - We can use both
- Individual model
  - We can use time series cross validation



https://www.researchgate.net/figure/Classical-k-fold-cross-validation-vs-time-series-split-cross-validation_fig1_355889701

Evaluation and Metrics

- R-squared

$$R^2 = 1 - \frac{\sum_i (y_i - \hat{y}_i)^2}{\sum_i (y_i - \overline{y})^2}$$

- Root mean squared Error

$$RMSE = \sqrt{\sum_{i=1}^{n} \frac{(\hat{y}_i - y_i)^2}{n}}$$

$\hat{y}_i$ Predicted Value

y_i Actual Value

$\overline{y}$ Mean of Actual Value

n Number of samples

Potentials of this Project

- Utilizing online Climate Data.
- Buffalo-Specific prediction Model.
- Computing Farm’s milk loss with HTS Structure.

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[2] - Dash, S.; Chakravarty, A.K.; Singh, A.; Upadhyay, A.; Singh, M.; Yousuf, S. Effect of Heat Stress on Reproductive Performances of Dairy Cattle and Buffaloes: A Review. Vet. World 2016, 9, 235–244. [Ref]

[3] - M.F. Hasan, N. Celik, Y. Williams, S.R.O. Williams, L.C. Marett,An effective way to incorporate temperature–humidity index to study effect of heat stress on milk yield by an XGBoost machine learning model,[Ref]

[4] - Hyndman, Rob J., and George Athanasopoulos. *Forecasting: Principles and Practice*. 3rd ed. Melbourne, Australia: OTexts, 2021. [Ref]

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[6] - Jae-Woo Song, Mingyung Lee, Hyunjin Cho, Dae-Hyun Lee, Seongwon Seo, Wang-Hee Lee, Development of individual models for predicting cow milk production for real-time monitoring, [Ref]

[7] - Hansika Hewamalage, Christoph Bergmeir, Kasun Bandara,Global models for time series forecasting: A Simulation study, [Ref]

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[9] – Rob J. Hyndman, Roman A. Ahmed, George Athanasopoulos, Han Lin Shang,Optimal combination forecasts for hierarchical time series [Ref]

[10] - Shanika L. Wickramasuriya,George Athanasopoulos,Rob J. HyndmanOptimal Forecast Reconciliation for Hierarchical and Grouped Time Series Through Trace Minimization [Ref]

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[12] - Kim, M., Kim, H. & Moon, J. (2025). Beginner-Friendly Review of Research on R-Based Energy Forecasting: Insights from Text Mining. [Ref]

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