MISAR In Agricultural Area By Developing Machine Learning Models (Case Study: Mango Farms In Sicily, Italy)

***Mohsen Pourmohammad Shahvar*[1], *Dario Scuderi* [2], *Giovanni Tripodo*[1], *Alfonso Collura*[3], *Salvatore Miccichè*[1], *Vittorio Farina* [2], *and Giovanni Marsella*[1]**

Email: mohsen.pourmohammadshahvar@unipa.it

[1] *Dipartimento di Fisica e Chimica "E. Segrè", Università degli Studi di Palermo, Italy.*
[2] *Dipartimento di Scienze Agrarie, Alimentari e Forestali, Università degli Studi di Palermo, Italy.*
[3] *Istituto Nazionale di Astrofisica, Osservatorio Astronomico di Palermo, Italy*

ABSTRACT

Agriculture plays a crucial role in the economy of Italy, particularly in the region of Sicily where it serves as a primary source of income. To ensure high yields, it is essential to enhance farmers' knowledge and awareness, especially in mitigating potential risks and damages caused by climate change and managing farming processes such as soil and water preparation, fertilizer, and pesticide management. To follow the MISAR (Climate Change Risk Management by Improving the Individual and Social Awareness of Risk in Sicily) targets, this paper focuses on the importance of Information and communication technologies (ICT) in the "Mango Farms Risk Management Plan" to foster stronger connections between stakeholders and farmers in Messina. Climate change poses various hazards such as temperature fluctuations, extreme events, soil salinity, and irregular rainfall, which are expected to increase in the future. Effective decision-making for stakeholders and farmers requires efficient analytical tools, particularly for handling large datasets. The paper introduces a new architecture called ADM, which combines Decision Support Systems (DSS), Agent-Based Modelling (ABM), and Machine Learning (ML) methods to develop a comprehensive risk plan for future agricultural challenges. The ADM model in MISAR incorporates empirical information collected during the ML phase, including the reactions of Mango plants to risks and determining factors like extreme temperature changes. To promote and safeguard mango cultivation and production, changes in temperature are estimated using advanced techniques such as Random Forest and Feed-Forward Neural Networks. Weather stations equipped with meteorological sensors are strategically placed within farms, providing direct measurements of hazards. Each station has its own credentials, allowing farmers access to the data. Furthermore, historical data analysis considers data from municipal meteorological stations and satellite sources. The model facilitates mutual communication between decision-makers and farmers, enabling farmers to monitor forecasts and report unexpected events in their respective farm areas.

INTRODUCTION

- The MISAR project aims to improve individual and social awareness of climate change risks in Sicily through a research design that utilizes advancements in risk analysis, modelling, behavioural theories, and social science.

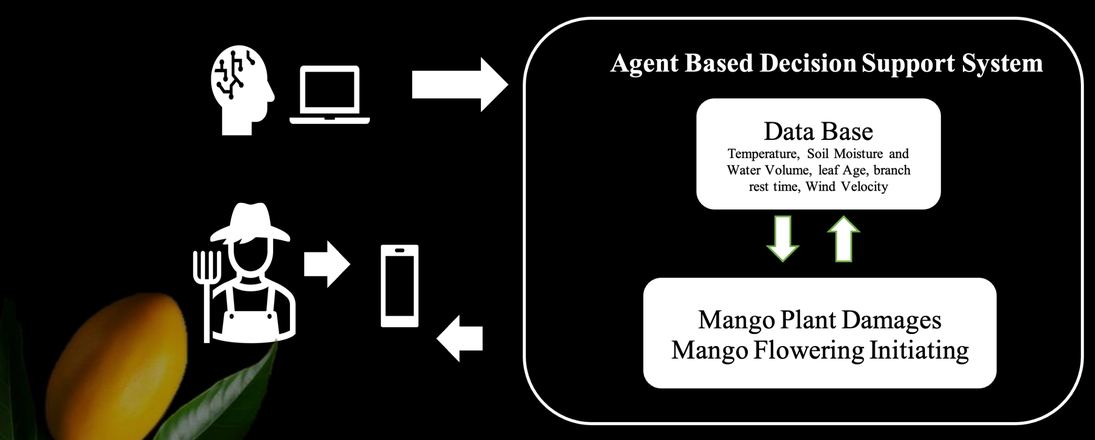
- Climate change is expected to have significant impacts on society and the environment, particularly in agriculture. The agriculture industry needs to address climate change concerns in the coming years.

- Sicily has approximately 55 hectares of mango orchards along the coastal area, where the temperature remains above 10°C for eight months a year. Various mango varieties are cultivated in Sicily, ranging in weight from 150g to 750g.

- The MISAR project focuses on analysing factors that may affect mango plants, such as temperature in the Messina region, using the novel ADM architecture (Agent-Based + Decision Support + Machine Learning). This architecture aims to warn farmers and decision makers about potential damages and ensure economic sustainability in rural areas.

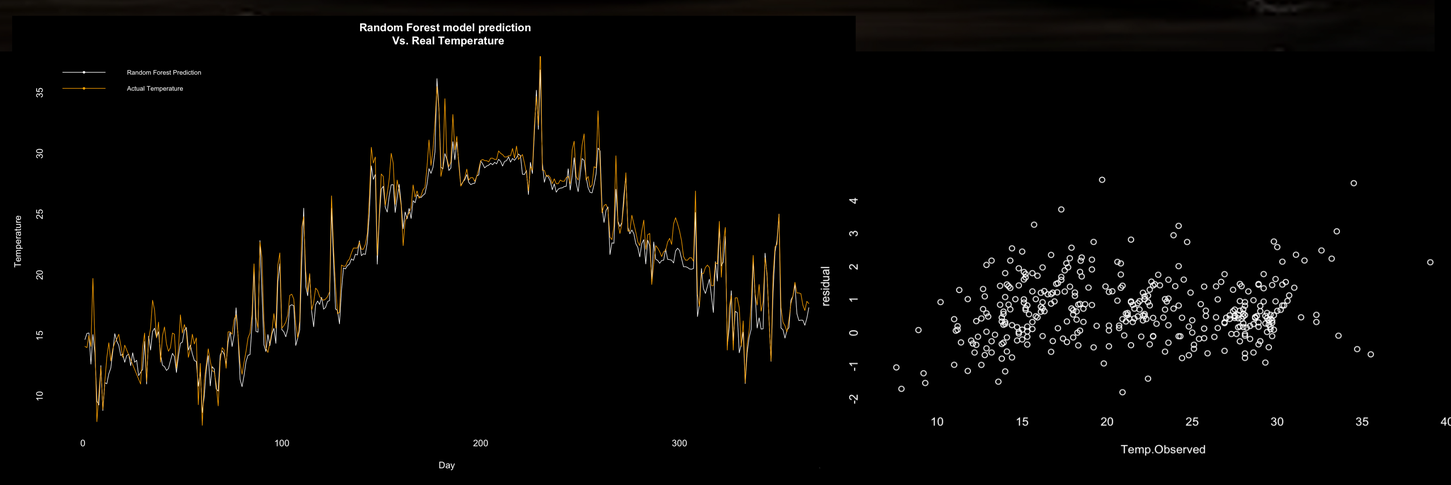
METHODOLOGY

- The new architecture aims to address the relationship between climate-related variables and damages in mango plants, as well as the cooperation between decision makers and farmers to avoid risks and damages.
- An agent-based model (ABM) is constructed, with meteorological factors as agents, to set rules for different decision scenarios. Temperature is a key factor in mango cultivation, with temperatures below 5°C and above 40°C causing damage.
- The ADM architecture uses machine learning methods (Random Forest and Feed Forward Network) to estimate and predict temperature. Other agents, such as soil moisture, water volume, leaf age, branch rest time, and wind velocity, are also considered.
- ICT (Information and Communication Technology) is utilized to cooperate with farmers, providing real-time information and alerts. A website or application is considered for farmers to monitor weather changes and extreme events.
- Historical meteorological data and satellite images are pre-processed for analysis. Correlation analysis is conducted to exclude highly correlated variables, simplifying the ML and ANN models' application.
- The Random Forest and Feed-Forward NN models require inputs such as maximum and minimum relative humidity, albedo, solar irradiance, surface air pressure, wind velocity and direction, and precipitation quantity to predict maximum (and minimum) temperature.

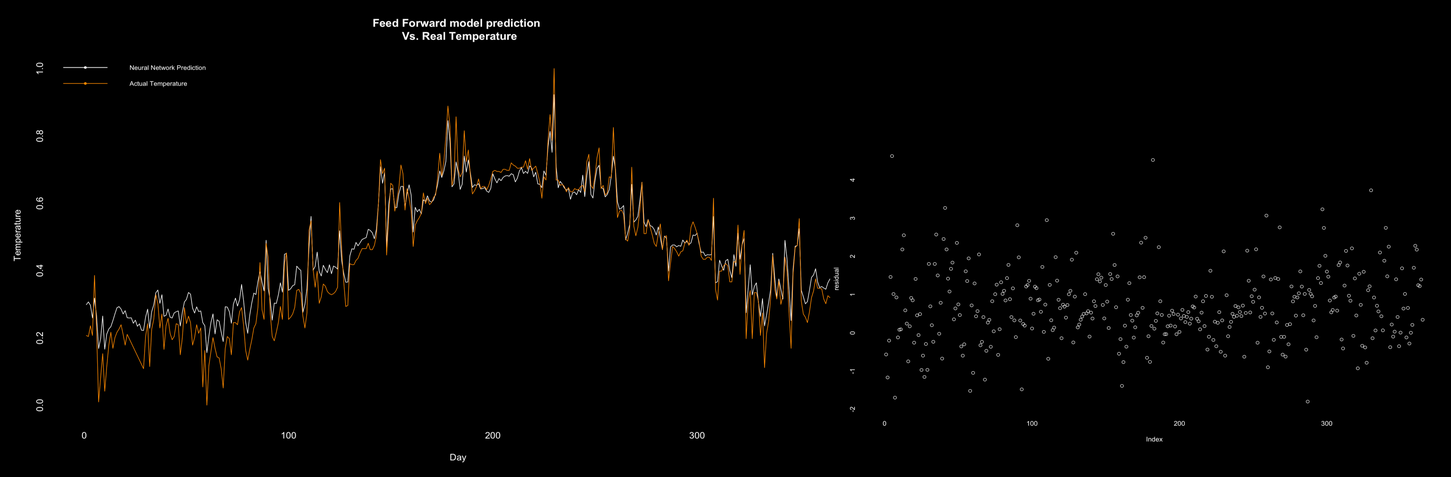


Results and Discussion

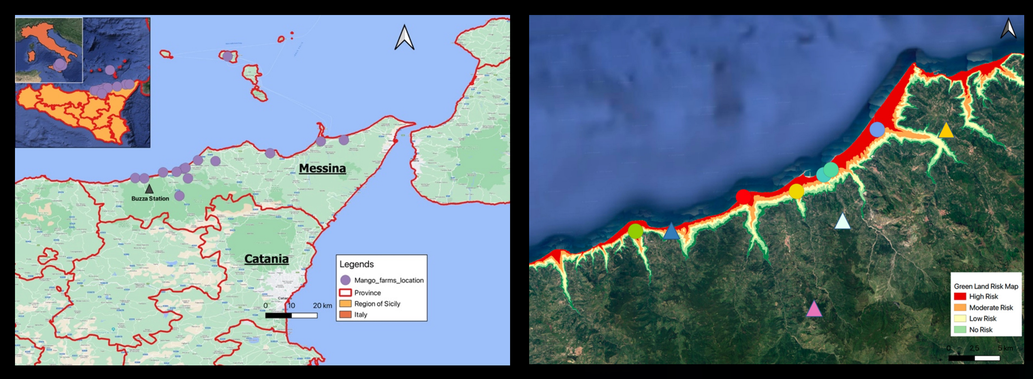
Random Forest:
- The RF algorithm is utilized for predicting future temperatures. It comprises an ensemble of decision trees that independently predict outcomes, with the final prediction obtained by averaging the tree predictions.
- The accuracy of the RF model is evaluated using the Root Mean Square Error (RMSE) metric, which quantifies the differences between predicted and actual temperature values.
- The dataset is divided into a training set (covering January 2009 to December 2020) and a test set (entire year 2021). The RF model is trained on the training set and then used to forecast temperatures for 2022.



Neural Network (Feed Forward):
- Neuron output in the FNN is calculated by applying an activation function to the weighted sum of inputs.
- Similar to the RF model, the FNN's performance is assessed using the RMSE metric, measuring the differences between predicted and actual values.
- Results from the FNN model align with those of the RF model, showing a low RMSE value and no discernible pattern in the residual analysis. This underscores the accuracy and reliability of the forecasting approach.



Mango Cultivation Management By using ICT



1. **Mango Cultivation and Climate Challenges**:
Mango cultivation faces climate challenges in coastal regions, and to address this, cutting-edge Information and Communication Technology (ICT) solutions are employed.
2. Risk Mapping and Assessment:
Geospatial technology, including Digital Elevation Models (DEM) and satellite data, is used to create a comprehensive risk map. Lands are categorized by risk level, enabling systematic assessment and mitigation of climate-related risks to mango crops.
3. MeteoSense 4.0 Station:
The introduction of MeteoSense 4.0, an advanced agrometeorological station, offers precise sensor measurements and real-time data accessible through the Cloud Live Data portal. It revolutionizes mango cultivation management by providing critical weather information.
4. Data-Driven Decision-Making:
The approach emphasizes data-driven decision-making. Stakeholders can adapt planting and harvesting schedules and implement protective measures in response to real-time weather data and risk map insights, enhancing mango crop resilience.

Conclusion

1. The MISAR project advances climate change risk management in Sicilian mango farms via ICT, emphasizing the ADM architecture for temperature prediction and sustainable rural development.
2. The interdisciplinary approach incorporates agent-based modelling, machine learning, and geospatial analysis to empower stakeholders, while acknowledging the need for more comprehensive data and research.
3. The project offers practical solutions to climate change challenges in agriculture, aiming to enhance global agricultural resilience through ongoing model refinement and expanded data sources.