Earth Observation Based Digital Twin for Resilient Agriculture Under Multiple Stressors

ESA Living Planet Symposium

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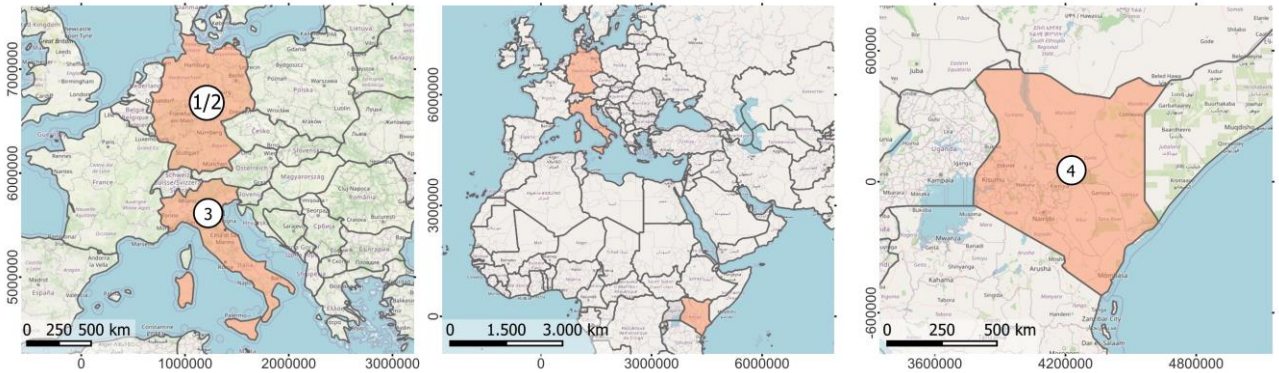
INTRODUCTION

To create a comprehensive **virtual replica of agricultural systems,** at multiple scales, with a focus on agriculture under **multiple stressors,** and to deliver **Digital Twin** to support monitoring of crop condition, simulation of growth dynamics and production under different conditions and stress factors.

Project Duration: November 2024 - November 2026

WHAT-IF SCENARIOS



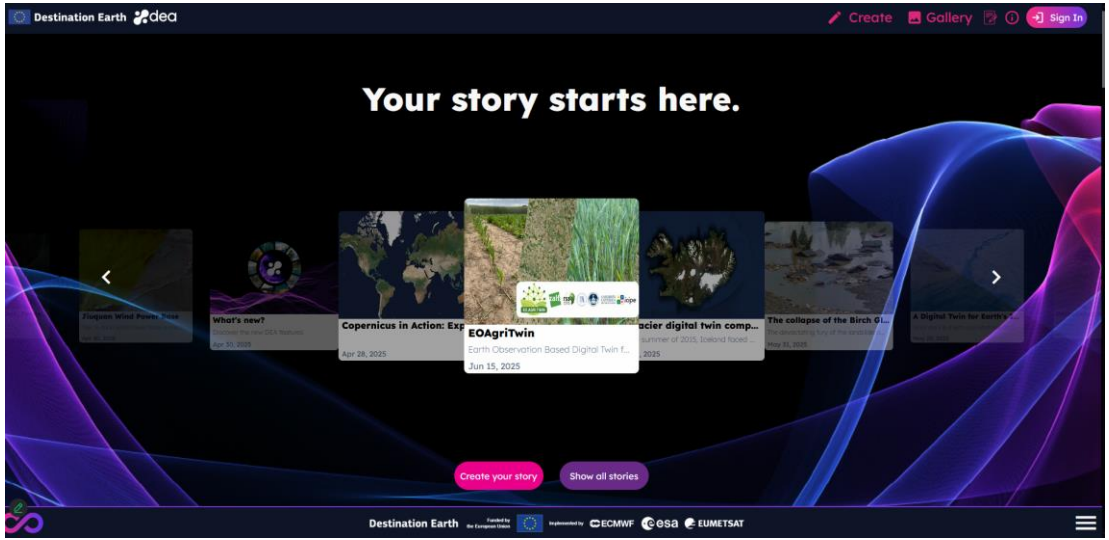
1. Crop specific drought and heat risk
2. Field-level crop water consumption
3. Drought and disease impact assessment
4. Push-pull and alternatively controlled cereal-based cropping systems

What if

Rainfall patterns and dry spells affect disease spread and yield?
Irrigation is applied?

Heat waves occur earlier?

Stakeholder needs, feedback, and integration drives the development.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Thematic focus

- Drought and Heat Stress impact monitoring and modeling
- Pest and Disease Assessment
- Drought impact under different management (e.g. irrigation)
- Impact of stressors on yield, resilience and sustainability

DROUGHT AND HEAT STRESS MONITORING AND MODELING

PEST AND DISEASE ASSESSEMENT

DROUGHT IMPACT UNDER DIFFERENT MANAGEMENT

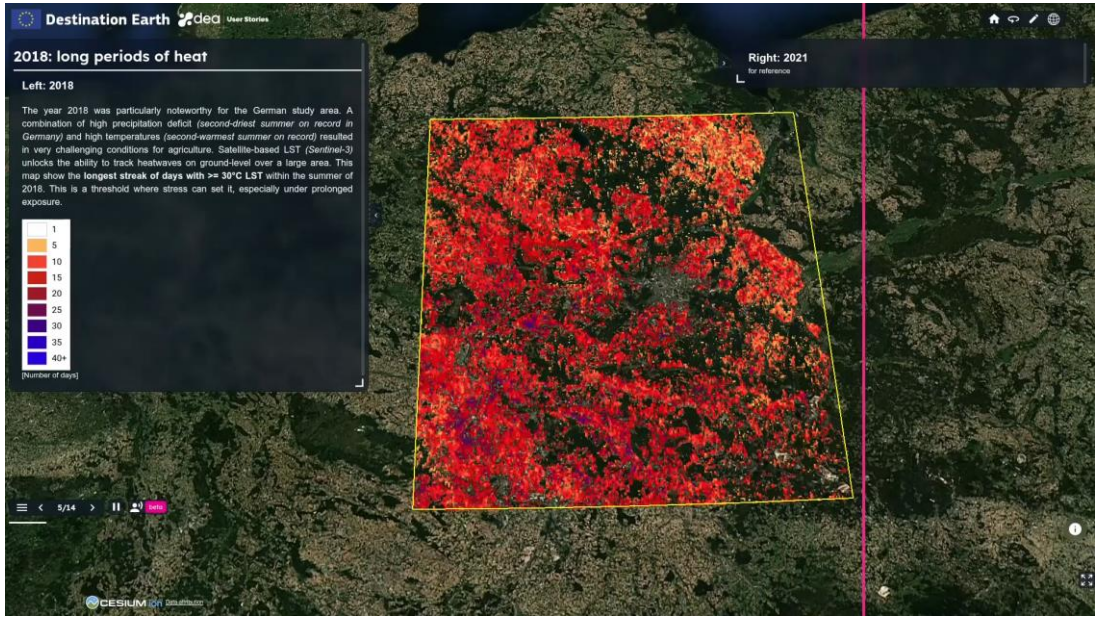
RESILIENCE AND SUSTAINABILITY

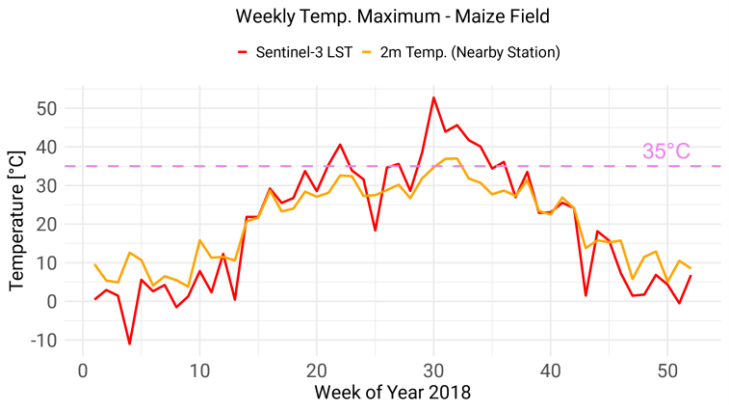
ARTIFICIAL INTELLIGENCE

SATELLITE | EARTH OBSERVATION DATA

PROCESS BASED MODELS

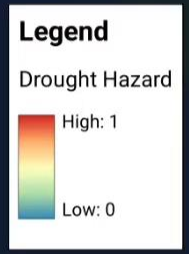
HEAT STRESS ASSESSMENT AND WATER USE

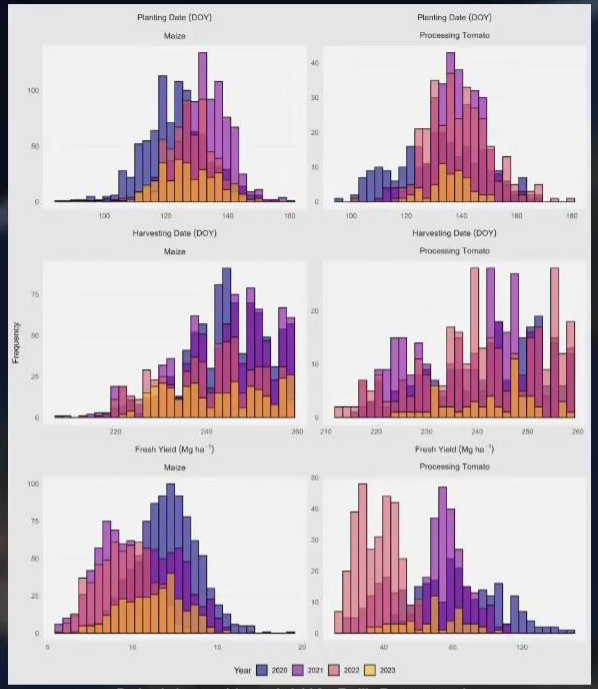




2023 Germany drought hazard

A drought hazard modelling framework has been developed using over 20 years of MODIS, Sentinel-3, and precipitation data, enabling the recognition of regional drought patterns and the identification of high-risk areas through time-series analysis. Designed to support early warning systems, climate-resilient decision-making, and drought-based agricultural insurance, the framework also highlights the increasing risk of drought conditions driven by climate change.

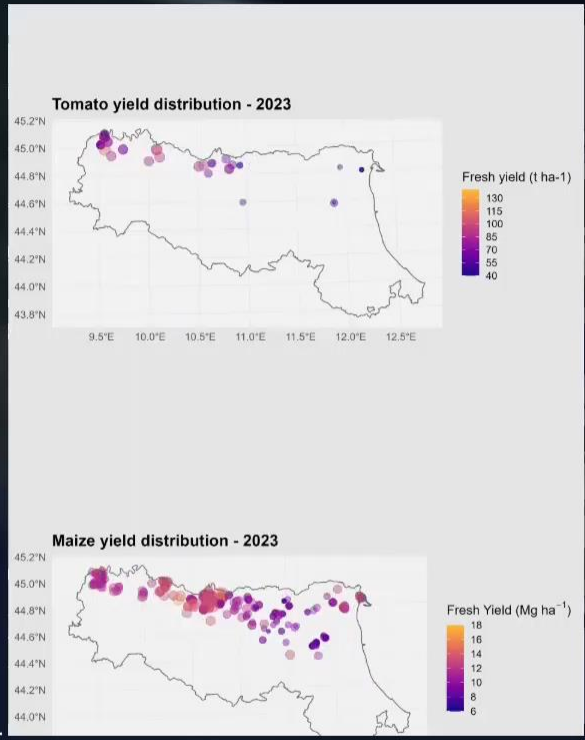




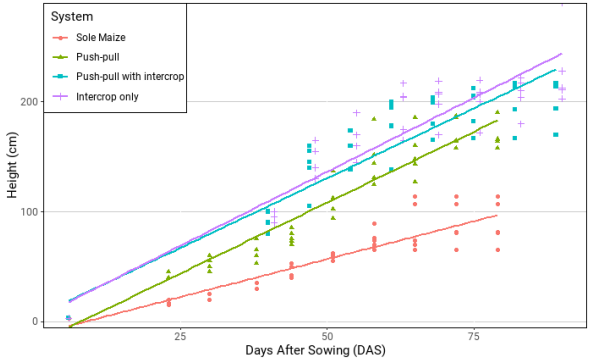
Derived phenometrics and yield for Emilia Romagna region

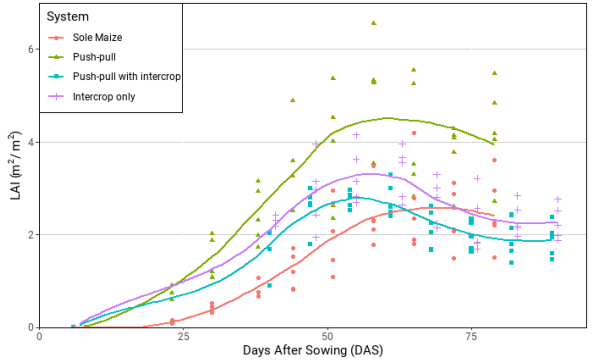
Sowing and harvesting dates (expressed as Day of Year) for maize and processing tomato were derived from Sentinel-2 vegetation index time series. Marketable fresh yield (Mg ha-1) was estimated using a Light Use Efficiency (LUE) model that integrates Sentinel-2 imagery with meteorological data from ERA5-Land.

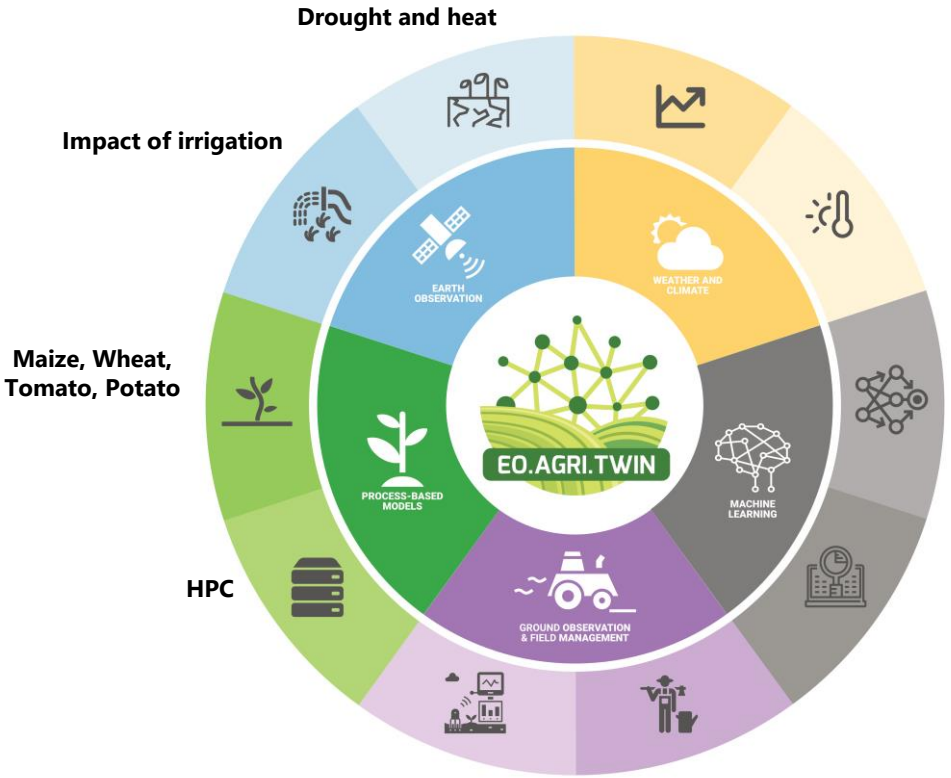
Yield across the Emilia-Romagna region



PUSH-PULL CROPPING SYSTEMS AND ASSESSMENT OF PESTS IN KENYA






Drought and heat
Impact of irrigation
Maize, Wheat,
Tomato, Potato
HPC
Impact of management: intercropping
EARTH OBSERVATION
WEATHER AND CLIMATE
PROCESS-BASED MODELS
MACHINE LEARNING
GROUND OBSERVATION & FIELD MANAGEMENT
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Next steps:

DeltaTwin

THANK YOU FOR YOUR ATTENTION.

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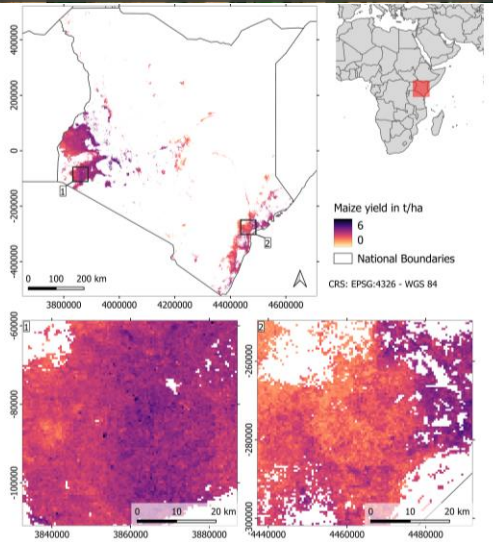
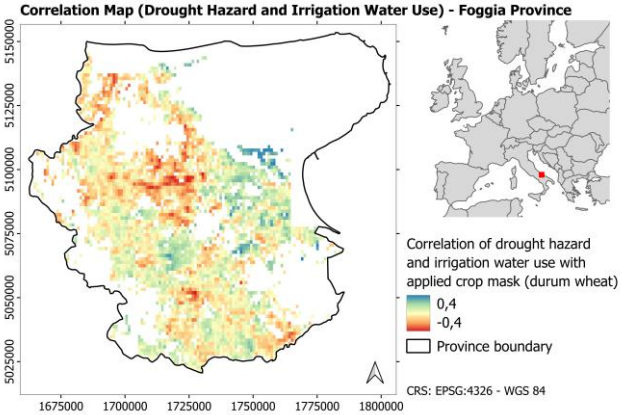
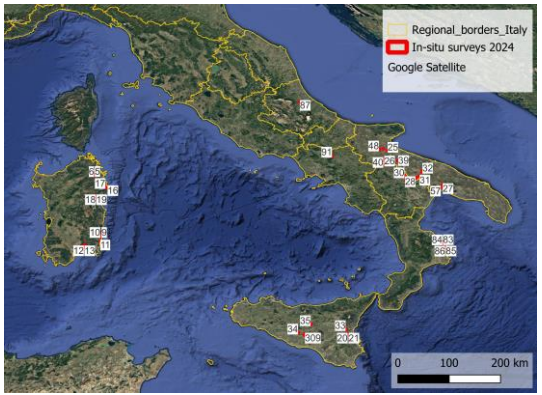
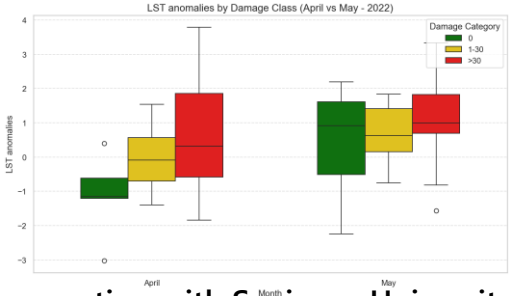
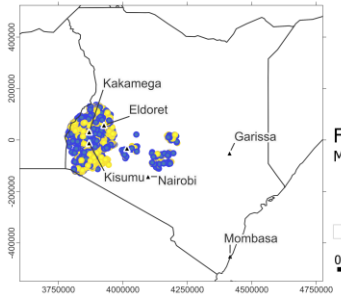
COLLABORATIONS











ONE ACRE FUND

Field Data Kenya 2016-2020
Maize field data
- No intercropping
- Intercropping
- Cities
- National Boundaries

0 100 200 km

DTE-Hydrology

DTE-Hydrology Next

Cooperation with Sapienza University (Filippo Bocchino) PhD program *Italian National PhD in Earth Observation*