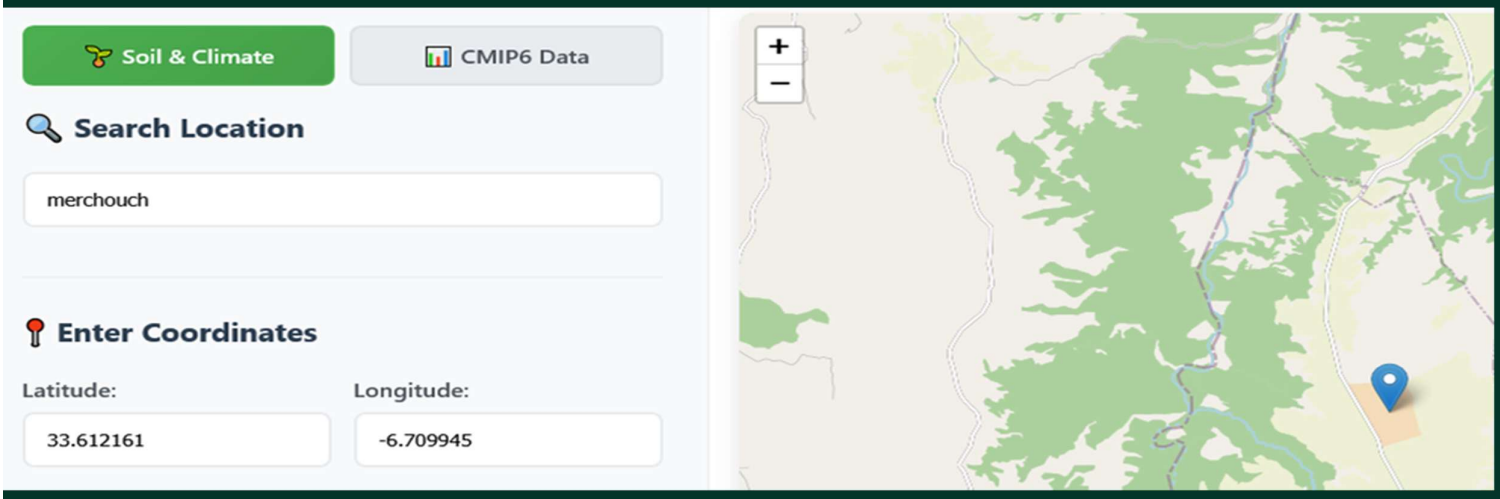
CGIAR SUSTAINABLE FARMING

"Dashboard of Datasets (Soil and Climate)" Required for Crop Modeling for MENA Region

December, 2025

Technical Report



ICARDA

Science for resilient livelihoods in dry areas

CGIAR

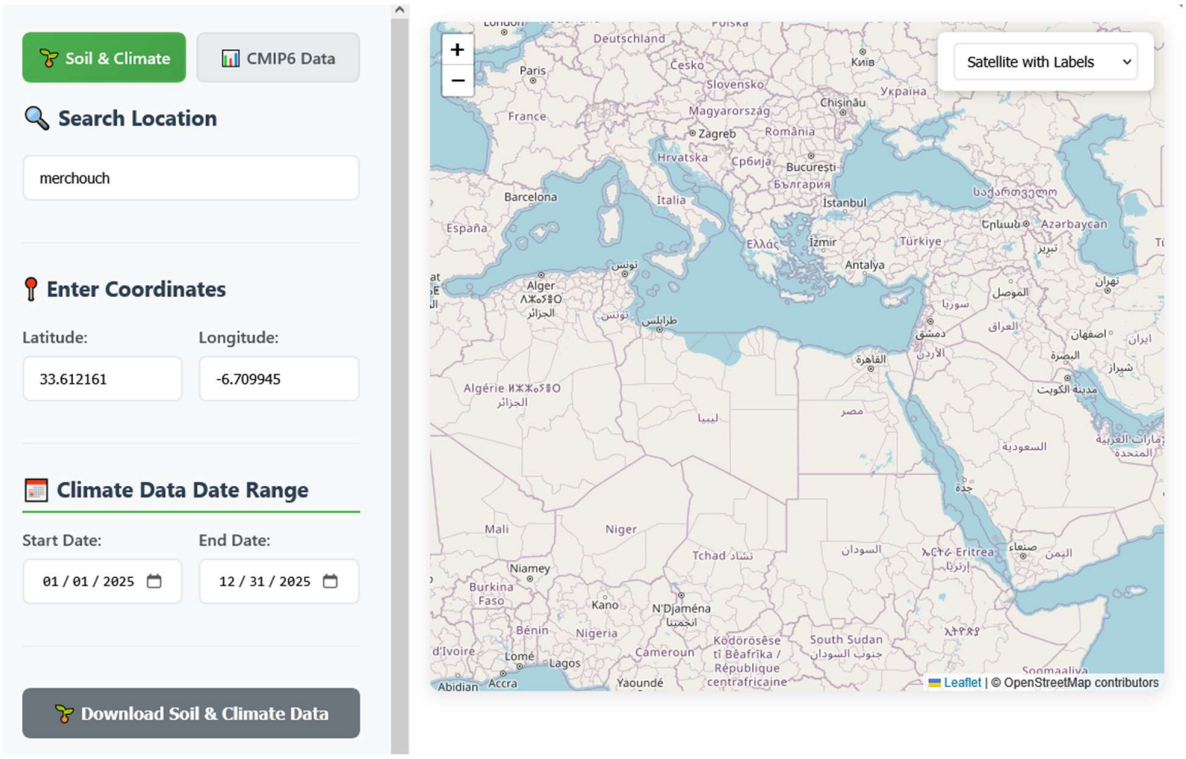
Report Prepared by Krishna Devkota and Abdelkrim Bouasria

Abstract

The Crop Modelling (Soil, Climate, and Crop) “Dashboard of Database” Application is a specialized web-based platform developed to support crop modeling research in the Middle East and North Africa (MENA) region. This application provides streamlined access to essential environmental datasets specifically curated and processed for agricultural research in water-scarce environments. Designed to facilitate climate change impact assessments and sustainable agricultural planning, this tool eliminates the need for complex GIS software and programming expertise while ensuring data compatibility with major crop growth models.

1. Introduction

Wheat The Crop Modelling (Soil, Climate, and Crop) “Dashboard of Database” Application is a specialized web-based platform developed to support crop modeling research in the Middle East and North Africa (MENA) region. This application provides streamlined access to essential environmental datasets specifically curated and processed for agricultural research in water-scarce environments. Designed to facilitate climate change impact assessments and sustainable agricultural planning, this tool eliminates the need for complex GIS software and programming expertise while ensuring data compatibility with major crop growth models.



1. Application Overview

Target Audience

- **Crop Modelers** (DSSAT, APSIM, AquaCrop, STICS users)
- **Agricultural Researchers**
- **Climate Change Impact Analysts**
- **Precision Agriculture Practitioners**
- **Agricultural Extension Specialists**

Core Purpose

To simplify the data acquisition process for crop modeling by providing:

1) **Standardized data formats** compatible with major crop models
2) **Spatially explicit soil and climate data** for any global location
3) **Future climate scenarios** for climate change impact studies
4) **Time-saving automation** for data processing and formatting

2. Key Functionalities

A. Soil Data Extraction

Data Sources:

- **OpenLandMap Soil Properties Database** (global coverage, 250m resolution)
- Multiple soil layers and depths (0-200cm)
- Scientifically validated soil mapping products

Extracted Soil Parameters:

Parameter	Units	Description	Crop Model Relevance
BD	g/cm³	Bulk Density	Affects root growth, water movement
CLAY	%	Clay Content	Water retention, nutrient holding
SAND	%	Sand Content	Drainage, aeration
OC	%	Organic Carbon	Nutrient cycling, soil structure
PH	pH	Soil pH in H_2O	Nutrient availability, microbial activity
WC33kPa	m³/m³	Water Content at 33kPa	Field capacity, available water

Soil Depth Layers:

- 0-5cm (surface layer)
- 10-15cm
- 30-35cm
- 60-65cm
- 100-105cm
- 200-205cm (deep soil profile)

Output Format:

- **Excel file** with depths as rows and parameters as columns
- Structured format ready for import into crop models
- Metadata sheet with units and descriptions

B. Historical Climate Data

Data Source:

- **NASA POWER Database** (Prediction of Worldwide Energy Resources)
- Daily meteorological data from 1981 to present
- 0.5° × 0.5° spatial resolution (~50km at equator)

Climate Parameters:

Parameter	Units	Crop Model Parameter	Importance
Tmin	°C	TNMIN	Minimum temperature for growth
Tmax	°C	TNMAX	Maximum temperature stress
Solar Radiation	MJ/m²/day	SRAD	Photosynthesis, biomass accumulation
Precipitation	mm/day	RAIN	Water balance, irrigation scheduling

Parameter	Units	Crop Model Parameter	Importance
Wind Speed	m/s	WIND	Evapotranspiration, crop stress
Relative Humidity	%	RHUM	Disease pressure, evapotranspiration

Date Range Flexibility:

- Customizable start and end dates
- Full historical coverage available
- Daily resolution data

C. Future Climate Projections (CMIP6)

Climate Scenarios Available:

- **Historical** (1850-2014): Baseline climate conditions
- **SSP2-4.5** (SSP245): Middle-of-the-road scenario
- **SSP3-7.0** (SSP370): Regional rivalry scenario
- **SSP5-8.5** (SSP585): Fossil-fueled development

Climate Variables:

Variable	Code	Units (Output)	Crop Modeling Application
Precipitation	pr	mm/day	Water balance, drought analysis
Solar Radiation	rsds	MJ/m²/day	Photosynthesis modeling
Maximum Temperature	tasmax	°C	Heat stress analysis
Minimum Temperature	tasmin	°C	Frost risk, growing degree days

Data Processing:

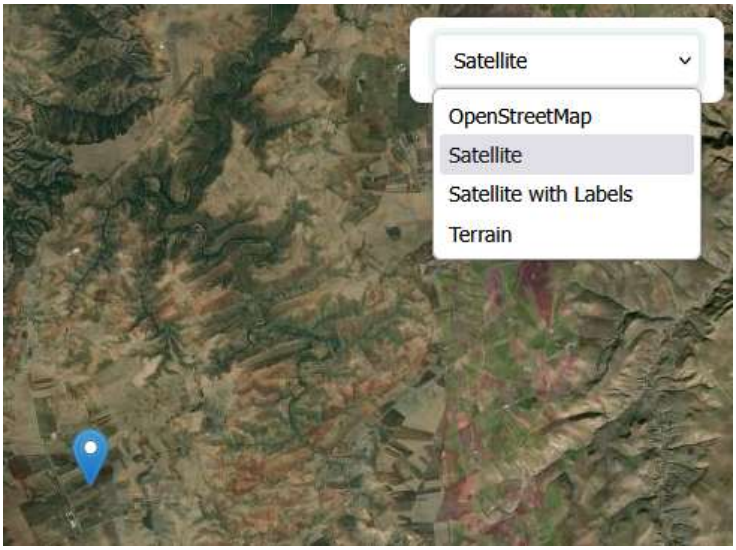
- **Automatic unit conversion** (K → °C, W/m² → MJ/m²/day)
- **Time-series extraction** at point locations
- **Statistical summaries** (mean, min, max, quartiles)
- **Metadata preservation** for traceability

3. User Workflow

Step 1: Location Selection

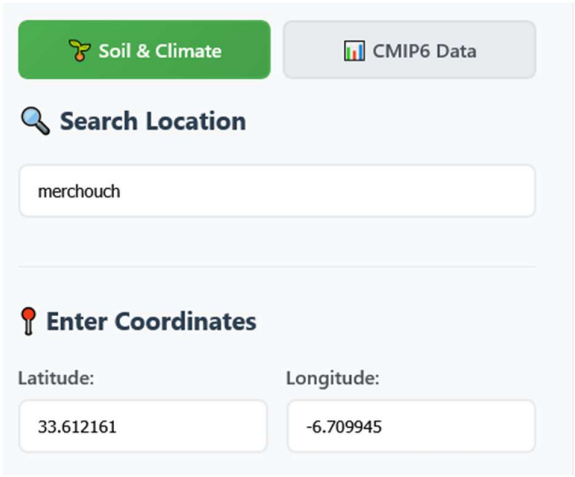
The user has three methods available for selecting or specifying the target location:

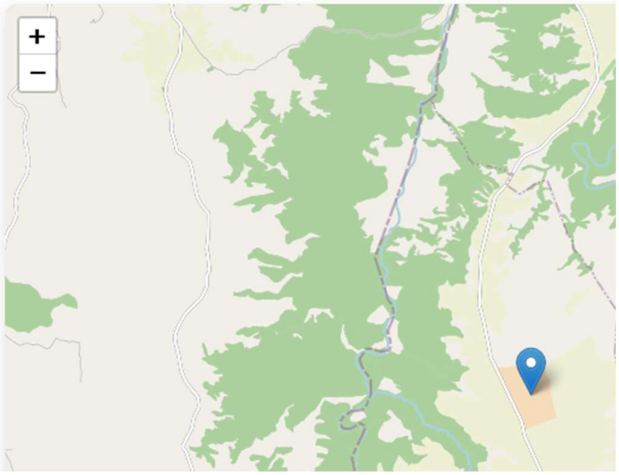
1. **Map Click**: Interactive global map with multiple basemaps



2. **Geocoding**: Search by place name (city, region, country)

3. **Coordinate Input**: Manual latitude/longitude entry





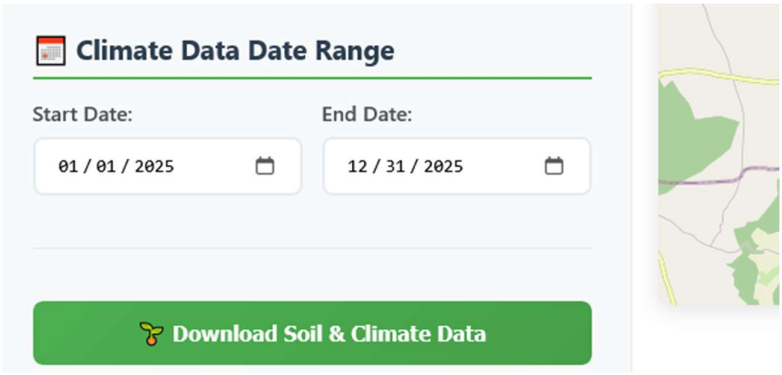
Step 2: Data Type Selection

After selecting a location, the map adds a marker and zooms to the point. Users retain this location and its coordinates as they toggle between two analysis options:

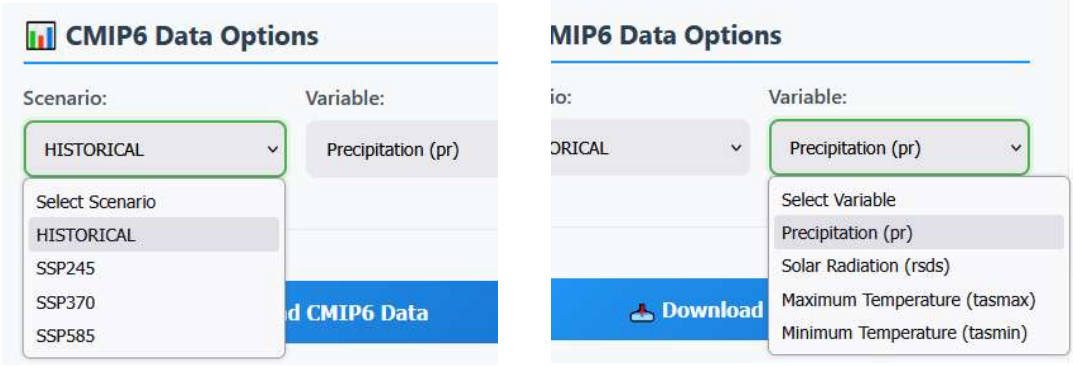
- **Option A**: Access soil properties and historical climate records.
- **Option B**: Explore future climate scenarios using CMIP6 projections.

Step 3: Parameter Specification

- **For Soil & Climate**: Select date range

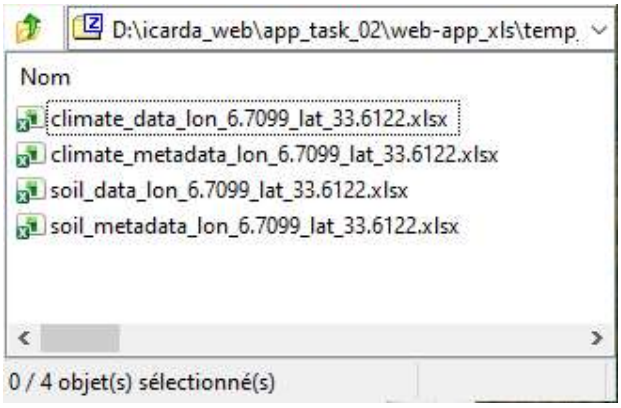


- **For CMIP6**: Choose scenario and variable



Step 4: Data Processing & Download

- **Automatic processing** in background
- **ZIP file download** containing:
  - Processed Excel files
  - Metadata sheets
  - Statistical summaries
- **File naming convention**: lon_XXX_lat_YYY.zip



4. Technical Specifications

Data Quality & Validation

Aspect	Soil Data	Climate Data	CMIP6 Data
Spatial Resolution	250m	0.5°	Model-dependent
Temporal Resolution	Static	Daily	Daily
Validation	Global soil sampling	Satellite/station	Model evaluation
Update Frequency	Periodic	Daily	Scenario-dependent

Output Format Details

- **Excel 2010+ format** (.xlsx)
- **Multiple worksheets** per file
- **Auto-formatted columns** for readability
- **Metadata sheets** for data provenance
- **Statistical summaries** for quick analysis

Geographic Coverage

- **Global coverage** (except polar regions)
- **Land areas only** (ocean areas excluded)
- **No country restrictions** (open access)

5. Scientific Applications

A. Baseline Studies

- **Site characterization** for field experiments
- **Model calibration** with local soil/climate data
- **Yield gap analysis** using historical climate

B. Climate Change Impact Assessment

- **Future yield projections** under different scenarios
- **Extreme event analysis** (droughts, heat waves)
- **Climate risk mapping** for agricultural planning

C. Adaptation Planning

- **Crop suitability analysis** under future climates
- **Irrigation requirement projections**
- **Planting date optimization** studies

D. Policy Support

- **Carbon sequestration potential** from soil OC data
- **Climate-smart agriculture** planning
- **Food security assessments**

6. Advantages Over Traditional Methods

Time Savings

Task	Traditional Method	This Application
Soil data collection	Field sampling + lab analysis	2-3 minutes
Climate data download	Manual website navigation + format conversion	1-2 minutes
CMIP6 data extraction	Complex GIS software + programming	2-3 minutes
Data formatting	Manual Excel editing	Automatic
Total time	Days to weeks	**3-8 minutes**

Data Consistency

- **Standardized extraction** methods
- **Uniform units** across all outputs
- **Consistent file formats**
- **Reproducible results**

Accessibility

- **No programming skills** required
- **No GIS software** needed
- **Web-based interface** (accessible anywhere)
- **No data licensing** issues (open access data)

7. Limitations & Considerations

Spatial Resolution

- Soil data: 250m (may not capture field-scale variability)
- Climate data: 50km (coarse for microclimate studies)
- CMIP6 data: Model grid resolution (100-300km)

Temporal Limitations

- Historical climate: Available from 1981
- CMIP6 projections: Typically 2015-2100
- Soil data: Static (does not account for soil degradation)

Accuracy Considerations

- **Soil maps** are predictive models with inherent uncertainty
- **Climate data** may have biases in complex terrain
- **CMIP6 projections** include model uncertainty
- **Local validation** recommended for critical applications

Recommended Best Practices

1. **Field validation** for soil data in experimental sites
2. **Bias correction** of climate data for local conditions
3. **Multi-model ensemble** for climate projections
4. **Uncertainty quantification** in model simulations

8. Conclusion

The Crop Data Collector Application represents a significant advancement in streamlining data preparation for crop modeling. By integrating multiple data sources into a single, user-friendly platform, it addresses a critical bottleneck in agricultural research: the time-consuming and technically challenging process of acquiring and formatting environmental data.

Key Benefits for Crop Modelers:

1. **Increased Efficiency**: Reduces data preparation time from days to minutes
2. **Improved Accuracy**: Standardized methods reduce human error
3. **Enhanced Reproducibility**: Consistent outputs facilitate comparison
4. **Greater Accessibility**: Makes advanced data accessible to non-specialists
5. **Future-Proofing**: Includes latest climate projections for impact studies

Scientific Impact:

- **Accelerates research** by eliminating data barriers
- **Facilitates multi-model comparisons** with standardized inputs
- **Enables large-scale studies** with consistent methodology
- **Supports capacity building** in developing regions

Recommendation:

We recommend this application for:

- **Graduate students** learning crop modeling

- **Researchers** conducting multi-site studies

- **Extension specialists** providing climate adaptation advice

- **Policy analysts** assessing agricultural impacts

By democratizing access to critical environmental data, this application has the potential to accelerate agricultural research, improve climate adaptation planning, and contribute to global food security efforts.

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Citation

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The CGIAR Sustainable Science Program (SFP) and Climate Action Science Program (CASP) forms a part of CGIAR's new Research Portfolio, addressing key challenges in agri-food systems by fostering efficient production of nutritious foods and safeguarding the environment to create fair employment opportunities, as we simultaneously tackle climate change, soil degradation, pests, diseases, and desertification. Its research is being implemented by CGIAR researchers from International Center for Agriculture Research in the Dry Areas (ICARDA), Rabat, Morocco. We would like to thank all funders who supported this research through their contributions to the CGIAR Trust Fund: https://www.cgiar.org/funders/

About CGIAR Sustainable Science Program Report

This research was conducted as part of the CGIAR Sustainable Farming Science Program. This research is being implemented by CGIAR researcher from *International Center for Agriculture Research in the Dry Areas (ICARDA), Rabat, Morocco*. CGIAR is a global research partnership for a food-secure future. Its science is carried out by 15 Research Centers in close collaboration with hundreds of global partners. www.cgiar.org

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Key Words:

Climate Change; Locally led-Adaptation; Mitigation; Crop Simulation Modeling, Cropping System Design

About CGIAR Sustainable Farming Science Program

The CGIAR Sustainable Farming Science Program will address key challenges in agrifood systems by fostering efficient production of nutritious foods and safeguarding the environment to create fair employment opportunities, as we simultaneously tackle climate change, soil degradation, pests, diseases, and desertification.