Proposed Irrigation-Need Function

**Irrigation-Need = ET\_c - (P + SM\_avail)**

Where:

* **ET\_c**: Crop evapotranspiration demand, influenced by temperature, humidity, and solar radiation.
* **P**: Effective precipitation.
* **SM\_avail**: Available soil moisture in the root zone.

This calculates net irrigation need by subtracting precipitation and existing soil moisture from total water demand.

From Theory to Application: Deriving the Irrigation Need Formula

Directly computing ETc typically requires complex parameters like solar radiation, wind speed, and crop-specific coefficients — data that is often unavailable or inconsistent in field conditions.

To make this formula more practical and data-driven, we restructured it into a normalized model using readily available environmental variables as proxies. The resulting formula is:

**max(0, (1 - Soil\_Moisture\_% / 40) × (Temp\_C / 30) × (1 - Humidity\_% / 100) × (1 - Rain\_mm / 50))**

This adjusted formula captures the same core logic:

* Higher **temperature** increases water demand (acting as a proxy for ETc),
* Higher **rainfall** and **soil moisture** reduce irrigation need (representing P + SM\_avail),
* **Humidity** reduces evapotranspiration, acting as a dampening factor.

This simplification enables easier integration into machine learning workflows and automated irrigation systems while still aligning with fundamental agronomic principles.

Justification and Supporting References

1. **Evapotranspiration (ET) as a Core Metric**

* Evapotranspiration is the sum of water loss via evaporation + transpiration. Core to irrigation estimation.
* Colorado State University notes that irrigation is essential when ET exceeds rainfall and stored moisture.  
  <https://extension.colostate.edu/topic-areas/agriculture/effects-of-weather-on-irrigation-requirements-4-721/>

1. **Importance of Soil Moisture Monitoring**

* Soil sensors enable precise water scheduling based on real-time soil data.
* University of Minnesota Extension highlights sensors as highly effective tools for irrigation management.  
  <https://extension.umn.edu/irrigation/soil-moisture-sensors-irrigation-scheduling>

1. **Integration of Weather Data**

* Using weather forecasts (temp, humidity, rainfall) refines irrigation timing and quantity.
* SAI Platform discusses tools that use local weather data to optimize irrigation practices.  
  <https://www.saiplatform.org/uploads/Library/Technical%20Brief%206.%20Irrigation%20Scheduling.pdf>

1. **Data-Driven Approaches in Irrigation Management**

* Advanced models leverage sensor data to forecast soil moisture and optimize irrigation.
* A study on ScienceDirect details predictive modeling of soil moisture using real-time data.  
  <https://www.sciencedirect.com/science/article/pii/S2772375524002971>