BioLoop Water Efficiency Model (BWEM) – Pilot Study & Prototype Documentation

1. Overview

The BioLoop Water Efficiency Model (BWEM) Prototype v1.0 is a publicly deployed, planning-level digital decision-support tool designed to estimate farm-level water demand and irrigation efficiency in semi-arid agricultural regions.

The prototype integrates crop evapotranspiration modeling, livestock water demand estimation, and irrigation system efficiency factors into a structured assessment framework accessible through a web interface.

Deployment URL: bioloop.net/water-calculator

Release Version: 1.0

2. Core Functional Components

- The prototype allows users to:
- Input farm area (acres)
- Enter reference evapotranspiration (ETo)
- Select crop type (crop coefficient-based)
- Select irrigation method (flood, sprinkler, drip)
- Enter livestock type and population size
- The system then calculates:
- Crop daily water requirement (ETc = ETo × crop coefficient)
- Livestock daily water demand
- Total farm water demand
- Estimated irrigation efficiency
- Estimated irrigation inefficiency (water loss)
- Basic water management recommendations

3. Methodological Basis

The prototype uses standard agricultural water modeling principles, including crop evapotranspiration estimation using the formula ETc = ETo × Kc.

Where ETo represents reference evapotranspiration, and Kc represents the crop coefficient.

Livestock demand is estimated using species-based daily intake assumptions. Irrigation efficiency adjustments are based on generalized system performance benchmarks.

The model is designed for planning-level analysis rather than regulatory or engineering certification.

4. Calculations and Unit Conversions (BWEM Core Logic)

BWEM computes crop water demand using the FAO-56 crop coefficient method and converts water depth estimates into volumetric irrigation requirements based on irrigated area and irrigation system efficiency. Calculations are performed as follows:

1) Crop evapotranspiration (ETc)

BWEM calculates crop evapotranspiration using:

ETc (mm/day) = ETo (mm/day) × Kc

where ETo is reference evapotranspiration and Kc is the crop coefficient.

2) Convert irrigated area to square meters

BWEM converts irrigated area from acres to square meters using:

Area (m²) = Area (acres) × 4,046.86

3) Convert ETc depth to net crop water volume (liters/day)

Because 1 mm of water over 1 m² equals 1 liter, BWEM converts ETc to daily net water volume as:

Net crop demand (L/day) = ETc (mm/day) × Area (m²)

4) Convert liters to gallons (gallons/day) BWEM converts liters to U.S. gallons using:

Net crop demand (gal/day) = Net crop demand (L/day) ÷ 3.78541

5) Adjust for irrigation efficiency to estimate applied irrigation requirement

BWEM estimates the applied irrigation demand by adjusting for irrigation system efficiency (Ei, expressed as a decimal).

Applied irrigation (gal/day) = Net crop demand (gal/day) ÷ Ei

Examples used in pilot scenarios include: flood (Ei = 0.60), sprinkler (Ei = 0.75), and drip (Ei = 0.90).

6) Estimate irrigation loss (gal/day)

BWEM estimates loss as the difference between applied irrigation and net crop demand:

Irrigation loss (gal/day) = Applied irrigation (gal/day) − Net crop demand (gal/day)

7) **Livestock water demand**

When livestock demand is included, BWEM calculates:

Livestock demand (gal/day) = Intake rate (gal/day/head) × Headcount

8) Total estimated farm water demand (gal/day)

BWEM reports total daily farm demand as:

Total demand (gal/day) = Applied irrigation (gal/day) + Livestock demand (gal/day)

(If no livestock is included, total demand equals applied irrigation.)

Constants used:

- 1 acre = 4,046.86 m²
- 1 mm over 1 m² = 1 liter
- 1 gallon = 3.78541 liters

5. Demonstration of Operational Functionality

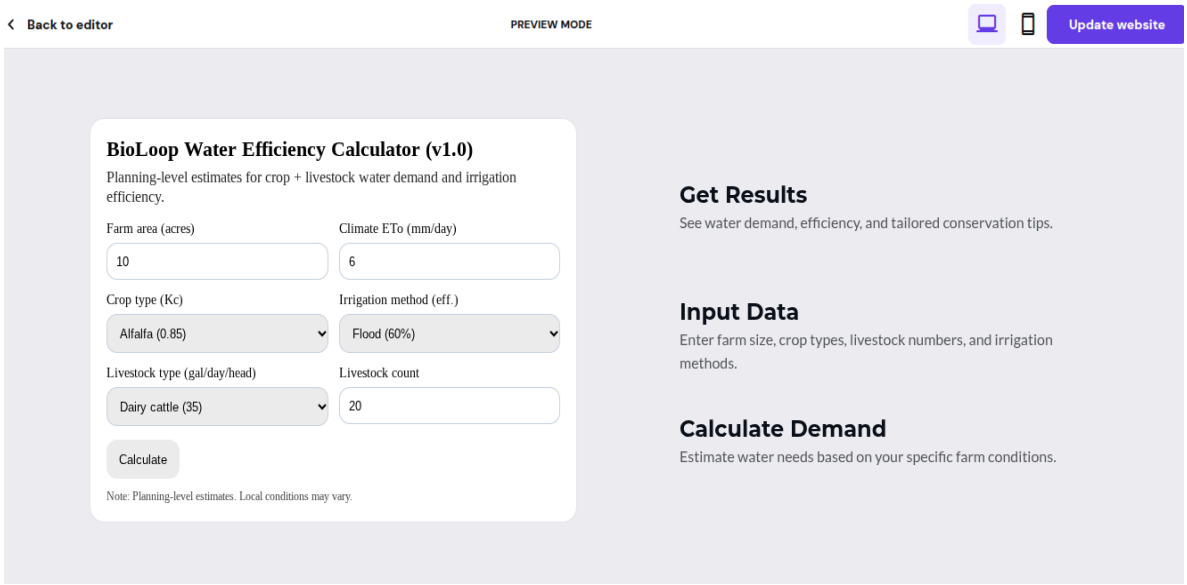
The deployed system performs real-time numerical calculations based on user inputs, adjusts outputs dynamically when irrigation efficiency changes, generates efficiency percentages and estimated water losses, and provides conditional recommendations based on climate and irrigation type.

The system has been tested on desktop and mobile interfaces to ensure usability and responsiveness.

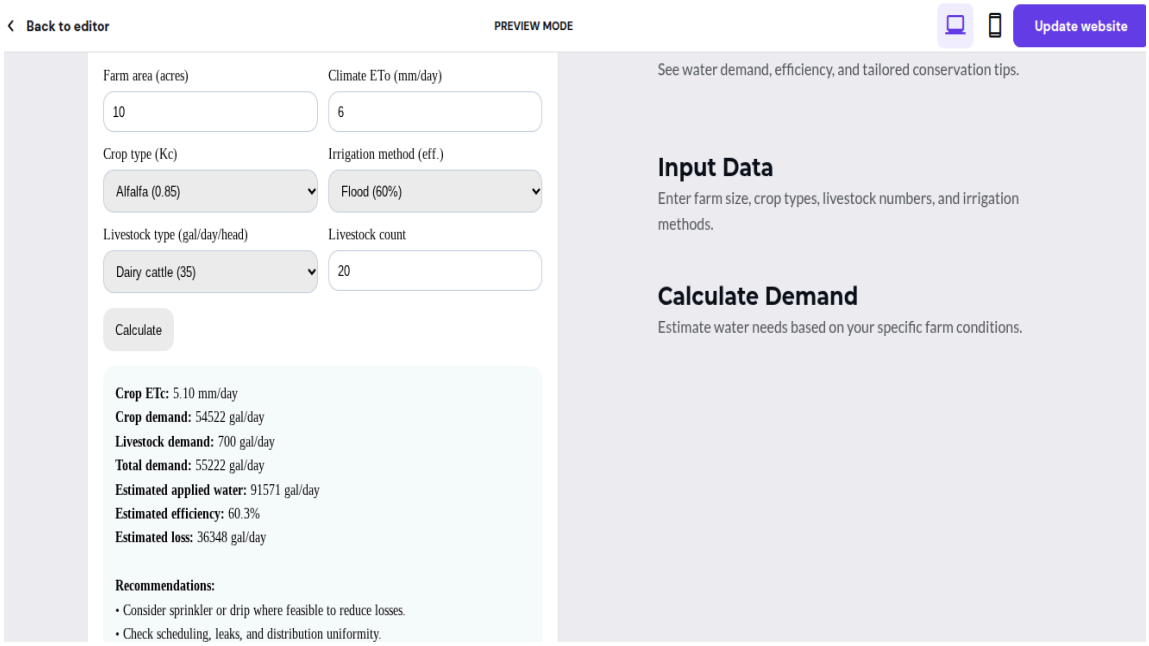
Pilot simulations demonstrating operational outputs are provided in **(Exhibits E1-E2)**

Screenshots of input interface and output results (Prototype v1.0):

- Screenshot of the input interface.



- Screenshot of output results.



6. Development Scope and Future Enhancement

Version 1.0 represents the foundational phase of the BioLoop framework.

- Planned enhancements may include:
- Integration of real-time weather APIs
- Incorporation of soil classification parameters
- Enhanced livestock temperature modeling
- Scenario comparison modules for irrigation transition analysis
- Expansion into broader circular agricultural optimization systems

The prototype demonstrates technical feasibility and establishes the operational foundation for scalable agricultural water efficiency modeling.

BWEM:

Link: https://bioloop.net/water-calculator