WATER USE EFFICIENCY

University introduces smarter way to manage agricultural water in arid regions through new app

As droughts intensify and pressure on South Africa's scarce water resources grows, smarter irrigation has never been more important. A new satellite-based water use efficiency (WUE) application developed by Sol Plaatje University's Arid Region Water Research Centre, in partnership with the Water Research Commission, puts powerful scientific insights at users' fingertips. Article by Dr Morena Mapuru and Prof Mohamed AM Abd Elbasit from the Arid Region Water Research Centre (ARWRC) at Sol Plaatje University.

Water scarcity is one of the greatest challenges facing agriculture worldwide, and South Africa is no exception. Increasing temperatures, prolonged droughts and changing rainfall patterns continue to place enormous pressure on the country's limited water resources. As the demand for food increases, farmers must find ways to produce higher yields while using less water. This has made water-use efficiency one of the key priorities for sustainable agriculture and climate change adaptation.

To help address this challenge, the Arid Region Water Research Centre (ARWRC), which was established at Sol Plaatje University in partnership with the Water Research Commission (WRC), has developed an innovative Water Use Efficiency (WUE) and Crop Water Requirement (CWR) application.

Developed using Google Earth Engine, the application combines satellite-derived climate information with scientific modelling to provide rapid estimates of crop water requirements and irrigation performance. Designed as a practical decision-support tool, the application enables users to evaluate water productivity and make informed irrigation decisions using freely available climate data.

Why water use efficiency matters in South Africa

South Africa is one of the world's most water-scarce countries, receiving an average annual rainfall of approximately 465 mm, which is nearly half the global average. Climate change, population growth, expanding agricultural activities and increasing competition among different water users continue to place significant pressure on the country's already limited freshwater resources. Agriculture accounts for approximately 60% of South Africa's freshwater consumption, making efficient irrigation essential for improving water security and ensuring sustainable food production.

Improving water-use efficiency enables farmers to produce more food with less water while reducing production costs and minimising pressure on rivers, dams and groundwater resources. Reliable information on crop water requirements is therefore essential for improving irrigation scheduling, increasing agricultural productivity and strengthening resilience to drought. The WUE application was developed to support these goals by providing users with an accessible, science-based tool to evaluate irrigation performance and promote sustainable water management.

How does the app work?

The WUE application is an interactive decision-support tool that estimates WUE and CWR using satellite-derived climate information and user-supplied agricultural data.

The application calculates how efficiently crops use irrigation water by combining climate variables with crop-specific information. It estimates the amount of water required by a crop, compares the actual water use with benchmark values, and classifies irrigation performance as either Optimal or Below Optimal.

Unlike many conventional irrigation tools that require specialised software or extensive field measurements, this application operates entirely within Google Earth Engine, making advanced geospatial analysis accessible through a simple and user-friendly interface.

How was it developed?

The application was developed using Google Earth Engine, a cloud-based geospatial analysis platform that processes large volumes of Earth observation data efficiently. The application integrates the ERA5-Land Daily Aggregated climate dataset with the internationally recognised FAO-56 Penman–Monteith

equation to calculate Reference Evapotranspiration (ET_0), the foundation for estimating crop water requirements.

The application automatically retrieves daily climate variables, including air temperature, relative humidity, wind speed, and net solar radiation. Users provide additional information such as crop type, crop coefficient (Kc), cultivated area, irrigation water applied, and crop yield.

- Using these inputs, the application calculates:
- Reference evapotranspiration (ET_0)
- Crop water requirement (CWR)
- Water use efficiency (WUE)
- Benchmark water use efficiency
- Irrigation performance (optimal or below optimal)

The application also generates interactive time-series graphs displaying changes in ET_0, crop water requirement, temperature, humidity, and wind speed throughout the selected period, allowing users to better understand the climatic factors influencing crop water demand.

What is the purpose of the app?
The primary purpose of the application is to improve irrigation water management by providing users with a practical, science-based tool for evaluating water-use efficiency. It enables users to estimate crop water requirements under current climate conditions, calculate WUE in kg/m^3 for different crops, and compare irrigation performance against established benchmark values.

The application also supports improved irrigation scheduling and enhanced water productivity, contributing to climate-smart agriculture and the sustainable management of water resources. By integrating Earth observation and climate data into an easy-to-use platform, it promotes informed decision-making and simplifies complex scientific calculations, effectively bridging the gap between research and practical agricultural management.

Who can use the app?
The application has been designed for a broad range of users involved in agriculture and water resource management, including farmers and irrigation managers, agricultural extension officers, water resource managers, researchers and university students, government departments responsible for agriculture and water resources, agricultural consultants, and non-governmental organisations working in climate adaptation and sustainable agriculture. By using freely available Earth observation and climate datasets, the application can be applied across South Africa and readily adapted for use in other regions experiencing similar water scarcity challenges, making it a versatile tool for improving agricultural water management and supporting sustainable decision-making.

How can one use the app?
The application has been designed to be intuitive and requires only a few simple steps outlined below to execute a task, as set out in Figure 1.

Within seconds, the application automatically calculates and displays:
- WUE (kg/m^3)
- CWR

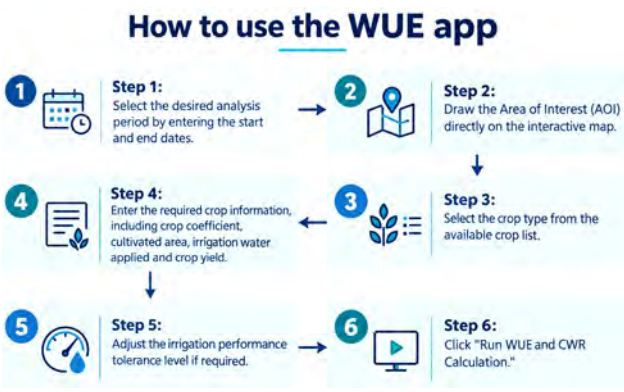


Figure 1. The six steps to follow for the effective use of the application.

- Benchmark WUE
- Irrigation performance assessment
- Mean ET_0 map
- Time-series graphs of ET_0, Crop Water Requirement, Temperature, Relative Humidity, and Wind Speed

These outputs provide valuable information for irrigation planning, water allocation, and improving agricultural productivity.

Benefits of the application
The application offers several practical advantages for improving agricultural water management. It enables the rapid estimation of crop water requirements, supports more effective irrigation planning and scheduling, and helps reduce water wastage while increasing agricultural water productivity.

The application also provides easy access to satellite-derived climate information through a user-friendly interface that requires minimal technical expertise, making it accessible to a wide range of users. By supporting evidence-based decision-making for sustainable agriculture and being freely accessible through Google Earth Engine, the application provides a practical and cost-effective solution for enhancing water-use efficiency.

Looking ahead
Digital technologies are transforming agriculture by making scientific information more accessible to farmers and decision-makers. As climate change continues to intensify water scarcity, tools that combine satellite observations, climate data and cloud computing will play an increasingly important role in improving agricultural resilience.

The Water Use Efficiency application demonstrates how modern Earth observation technologies can be translated into practical solutions that help users optimise irrigation, improve water productivity and strengthen climate resilience. By providing timely and scientifically robust information, the application supports sustainable agricultural development and contributes to more efficient management of South Africa's scarce water resources.

To read more about the ARWRC's activities, visit: https://bit.ly/4ifsofX

To access the app, visit: https://aridregionwaterresearchcentre.users.earthengine.app/view/water-use-efficiency