CLIMATE CHANGE AND AGRICULTURE

From drought to data: How precision tech is future-proofing the pomegranate sector

As climate change tightens its grip on South Africa, agriculture sits on the frontline of rising temperatures, shrinking rainfall and increasing water pressure. Building resilience is no longer optional; it is essential. In the Western Cape, pomegranates are emerging as a climate-smart alternative, supported by new research that combines on-farm measurements with cutting-edge drone technology. Together, these innovations point to a future where farmers can produce more with less water, strengthening both livelihoods and water security. Article by Theresa Volschenk.

South Africa is recognised as being vulnerable to climate change impacts (World Bank Group, 2021). The country is warming by c. 0.2°C per decade, contributing to climate impacts including extreme heat, drought, sea level rise and flooding (Johnston et al., 2024). Climate change predictions for parts of the Western Cape foresee increased minimum and maximum temperatures, more hot days and heat waves, reduced average rainfall and more evaporation from soil and water surfaces by 2030 compared to the current climate (Midgley et al., 2021). This is disconcerting for a province which relies on rainfall and surface runoff as its main water source and where 75% of all the water used (government schemes, own surface supplies or groundwater) is for agriculture (World Bank, 2030 WRG, Pegasys, EDP, 2022). According to the Western Cape Climate Change Response Strategy (Birch et al., 2023) the agricultural sector will address the challenges posed by climate change by implementing the SmartAgri plan (WCDoA, WCDEA and DP, 2016). To become more resilient to climate change, one of the recommendations of this plan is to plant more drought-tolerant crops (DEA, 2016).

In addition to being a prime deciduous fruit-producing area, the Western Cape also harbours pomegranate (*Punica granatum* L.) – a climate-smart crop. Pomegranate is world-renowned for its health benefits (Cheng et al., 2023). It is versatile as it can be marketed fresh or processed into ready-to-eat convenience foods, juices and other beverages, or used in pharmaceutical or cosmetic products. Their resistance to drought and adaptability to climates with hot summers and cold winters make them especially valuable in arid regions (Galindo et al., 2014). The South African pomegranate industry, having plantings of about 1 168 hectares (Viljoen and Hurter, 2024), is small compared to the 12 850 hectares of pears and more than 25 000 hectares of apples (Hortgro, 2024). About 79% of pomegranate plantings are in the Western Cape, 11% in the Northern Cape, 9% in Limpopo, with the remainder in KwaZulu-Natal and the Eastern Cape (Viljoen and Hurter, 2024).

In addition to planting drought-tolerant crops, resilience to climate change can also be achieved by adopting water-efficient production practices, such as optimal irrigation, using the right irrigation systems, applying mulch and implementing water-saving irrigation strategies. Proper irrigation scheduling can conserve water, allowing its use in other sectors during drought and benefiting the environment through efficient use of limited water resources and reducing fertilizer leaching into groundwater. Effective irrigation improves crop production and fruit quality, leading to higher production for local and export markets that support increased income, create sustainable job opportunities and strengthen food security. Advances in technology, such as precision agriculture using drones, digital farming solutions (e.g., mobile applications and cloud-based platforms), progressive data analysis and the use of smart irrigation systems, can further enhance water use efficiency, profitability and farming sustainability (Obaideena et al., 2022, Alazzai et al., 2024). Drones can support irrigation management by detecting potentially stressed areas in orchards to find, diagnose and correct underlying problems; to estimate orchard water use through evapotranspiration models or to derive crop coefficients to estimate water use for irrigation scheduling (Niu et al., 2020; Zhang et al., 2021, Ahansal et al, 2022).

To schedule irrigation accurately, information is required on the water use of the crop in question. The Alternative Crop Fund of the Western Cape Department of Agriculture, the Pomegranate Producers Association of South Africa (POMASA) and the Water Research Commission (WRC) initially funded a scoping study undertaken by the Agricultural Research Council (ARC) to provide a baseline understanding of pomegranate orchard water use in selected production areas (Volschenk and Mulidzi, 2020). The study confirmed that pomegranate trees, despite being drought-tolerant, require irrigation during the dry summer for optimal commercial production and that potential exists for some production areas to improve yield and fruit quality

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A grove of pomegranate trees.

through improved irrigation scheduling. However, no local information on the evapotranspiration of pomegranate orchards was available, and a practical means to derive crop coefficients for different orchards for irrigation scheduling purposes and catchment water management was required.

Accurate irrigation scheduling may improve yield and quality while reducing electricity consumption, thereby enhancing economic water productivity and export earnings for the country.

This research gap was addressed by two projects funded by the WRC, the National Research Foundation (NRF Grant no. 138129) and the ARC. The research was conducted in the Western Cape and focused on water use and water productivity of pomegranate orchards (WRC project no. C2020/2021-00404, unpublished) as well as water use estimation of pomegranate orchards using drone technology (**WRC Report No. 3217/1/25**, Volschenk et al., 2025). The multidisciplinary research team included researchers and students from the ARC, the University of the Free State and Stellenbosch University. POMASA supported research site selection, while the University of Pretoria: Department of Plant and Soil Sciences, which provided specialised equipment and expertise without monetary compensation, conducted a heat ratio sap flow method calibration in potted pomegranate trees.

The water use and water productivity research project aimed to measure water use, tree and fruit growth, yield and fruit quality in irrigated pomegranate orchards with varying canopy sizes and to determine several water use indicators. A practical method to estimate crop coefficients for calculation of individual orchard water requirements was also investigated. The second research project proposed to refine pomegranate orchard irrigation management by using the water use data generated by the first project, together with drone technology. It assessed whether drone-technology derived attributes for individual pomegranate trees can be related accurately to in-field measured tree dimensions and light interception. In addition drone-determined tree geometric traits and several vegetation indices were correlated with actual water use and crop coefficients at both tree and orchard scales. Orchard homogeneity for the two orchards was compared using the drone technology derived tree attributes.

The first project generated information on pomegranate orchard water use efficiency, biophysical and economic water productivity, seasonal water use, transpiration coefficients and crop coefficients. This local information can guide producers in on-farm irrigation management decisions and support catchment water management and policy making. A method to determine crop coefficients from fractional light interception in pomegranate orchards has been tested but requires refinement. Previously, no local water use information existed for pomegranate orchards of different ages and sizes. Such information was determined over two seasons for a young (four years old) and a full-bearing (thirteen years old) orchard of an economically important cultivar 'Wonderful' – filling an important knowledge gap.

Drones played an important role in this project.

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The usefulness of drones to assist in the estimation of crop coefficients for orchards differing in canopy size and location was evaluated through drone surveys conducted earlier and later during the canopy development stage, at full canopy, during ripening, before harvest and after harvest, and by using selected tree and water use data from the water use and water productivity project. Linear regression relationships were obtained between drone image-derived spectral band reflectance, tree geometrical canopy characteristics, six vegetation indices (including Normalized Difference Vegetation Index) and thermal infrared temperature, and in-field measured tree canopy properties (dimensions, fractional interception, leaf area index); selected tree physiological parameters and tree water use (transpiration, evapotranspiration and crop

A full bearing pomegranate orchard. Their resistance to drought and adaptability to climates with hot summers and cold winters make pomegranates especially valuable in arid regions.

coefficients). Regressions were conducted at two scales: (1) the individual tree scale – combining data of orchards/ surveys per site/ trees per survey per site, and (2) the orchard averaged scale – combining data of orchards/ surveys per site (Volschenk et al., 2025).

For the young orchard, orchard-averaged tree height could be estimated from the orchard-averaged blue spectral band reflectance with a low standard error of the estimate. Fractional light interception and orchard leaf area index could also be estimated from regression relationships with RedEdge spectral band reflectance, although with lower accuracy. Transpiration or crop coefficients for irrigation scheduling of a young orchard could be estimated from orchard-averaged drone image-derived RedEdge and near-infrared reflectance, respectively.

It must be emphasised that additional data collection is recommended to improve and to validate the above-mentioned regression relationships. Orchard water use homogeneity for the young pomegranate orchard was evaluated by estimating individual tree transpiration and crop coefficient values for different growth stages using the regression relationships obtained. Considerable between-tree water use variability was apparent for the c. 7 ha orchard and precision irrigation is therefore highly recommended to improve water use efficiency.

The knowledge generated by this research can support the formation of a water-wise agriculture sector that promotes sustainable and optimal agricultural production and thereby improves water security. Users and beneficiaries of the research include producers, the Pomegranate Producers Association of South Africa, the Water Research Commission, the Western Cape Department of Agriculture and National Department of Agriculture and science councils.

The references to this article are available on request.