FPI / PRACTICAL AGRICULTURAL RESOURCES

Sustainable Irrigation Guide 2026

Technical guide | Water-efficient agricultural production

Practical design, operation, scheduling and maintenance principles for smallholder, commercial and cluster-based farms.

2026 EDITION | Botswana and Southern Africa

Published for farmer training, extension, farm planning and agricultural systems integration. Adapt all recommendations to verified local conditions, water rights and professional advice.

1 Purpose and design principles

An irrigation system is sustainable when it delivers adequate water to the crop root zone while protecting water sources, soil health, energy resources and farm economics. Irrigation must be designed as a complete system: source, storage, treatment, pump, distribution, emitters, soil, crop and monitoring.

Begin with a water-resource assessment. Verify the abstraction permit or water-use rights, seasonal reliability, water quality, pumping constraints and the environmental needs of downstream users. Never size a farm solely around the nominal pump rating.

Match crop, planting density, root depth and seasonal water demand to the **dependable** water supply. Plan for hot, dry peak-demand periods and for equipment downtime.

2 Field survey and baseline assessment

Map field boundaries, elevations, slopes, soils, access, electrical supply, pump position, water storage, and the distance from source to each irrigation block. Record the proposed crops, row spacing, harvest cycles and soil texture.

Measure the source's sustainable flow under representative operating conditions. Test water for electrical conductivity (EC), pH, suspended solids and other locally relevant contaminants; assess sodium and salinity hazards with a competent laboratory.

Assess infiltration and drainage. Sandy soils generally require smaller, more frequent applications; heavier soils may require slower application and closer attention to runoff or waterlogging. Field verification takes precedence over generic rules.

3 Water requirement calculation

Reference evapotranspiration (ETo) represents atmospheric evaporative demand; **crop evapotranspiration (ETc)** is estimated as ETc = Kc x ETo, where Kc varies by crop and growth stage. Use locally validated weather data and appropriate coefficients; the revised FAO crop-water guidance is a useful technical basis.

Net irrigation depth (mm) = crop water requirement minus effective rainfall and usable stored soil water, with appropriate adjustment for root-zone conditions. **Gross application depth** = net depth / measured application efficiency (as a fraction). Site-specific leaching requirements may increase demand when salinity is an issue.

Volume (m3) = depth (mm) x area (ha) x 10. This identity is a unit conversion, not a crop-specific irrigation recommendation.

4 Worked example: one hectare

Illustrative only: assume ETo = 5.0 mm/day, Kc = 0.8, effective rainfall = 0 mm/day, irrigated area = 1 ha, and measured system application efficiency = 90%. ETc = 4.0 mm/day; gross irrigation = 4.0 / 0.90 = 4.44 mm/day; daily water volume = 44.4 m3.

If the available delivery rate to the field is 10 m3/hour, nominal daily operating time is 44.4 / 10 = 4.44 hours, before allowances for filtration backwashing, downtime and operational constraints. Divide this into zones according to hydraulics and crop needs.

Do not apply the illustrative 90% efficiency, ETo or Kc as a universal default. Actual scheduling must use local weather, crop stage, effective rainfall, measured system performance and soil moisture.

5 Choosing irrigation technology

Drip: targeted application with low wetted area, well suited to row crops and many orchards where filtration, flushing and maintenance are reliable. **Micro-sprinklers:** broader wetting patterns where crop geometry warrants them. **Sprinklers:** useful for uniform coverage, but wind and evaporation losses need management. **Surface systems:** can be appropriate on suitable graded land with strong water control.

Select on lifecycle cost and agronomic performance, not purchase price alone. Consider water quality, emitter clogging risk, pressure requirements, energy use, availability of replacement parts, technical support and the ability to inspect every zone.

6 Hydraulic design and component specification

Prepare a scaled layout showing mainlines, submains, laterals, valves, pressure regulators, filters, air-release valves, flush points, flow meters and pressure gauges. Design for acceptable pressure variation and emitter discharge uniformity across elevation changes and pipe friction losses.

Specify a filter appropriate to source water and emitter passages; use laboratory and manufacturer guidance. Provide isolation and flushing capability for every block. Use pump curves to confirm operating flow and total dynamic head rather than selecting equipment by horsepower alone.

Commission by measuring flow and pressures at representative points, testing leaks and flushing, and recording the installed configuration as an as-built drawing.

7 Irrigation scheduling and soil moisture

Schedule based on weather demand, rainfall, crop stage, soil water storage and root-zone observations. Tensiometers, capacitance sensors, gravimetric sampling and careful field inspection can each contribute; calibrate sensor interpretation to the local soil.

Record applied volume and duration by block. Reduce or suspend irrigation after effective rain when the root zone is adequately supplied; do not assume all measured rainfall infiltrates. Avoid prolonged saturation and investigate unexpected increases in runtime.

During establishment, roots are shallow and may require more frequent checks. As roots develop, revise the depth and frequency of wetting. In perennial cut-and-regrow systems, monitor water demand after each harvest and during canopy recovery.

8 Moringa and herb production considerations

For high-density moringa, design water distribution around the actual bed geometry, rooting pattern and harvest regime. Avoid assuming one emitter arrangement works for all spacings. Confirm wetted-strip continuity and uniformity before scaling to a commercial block.

For medicinal and aromatic crops, maintain hygienic irrigation practices, prevent water contamination of harvestable material, and document the water source, irrigation events and corrective actions for traceability.

Check the buyer's and certifier's requirements before using reclaimed water or applying inputs through irrigation.

9 Soil health, salinity and drainage

Mulch, organic matter and erosion-control measures can improve infiltration and reduce avoidable evaporation. Monitor soil EC where saline water or high evaporative demand presents accumulation risks. Salinity management requires a site-specific water balance and safe drainage route.

Excess irrigation wastes water, leaches nutrients and can create anaerobic root conditions. Ensure drainage does not contaminate neighbours' land or sensitive ecosystems. Keep fertilizers and chemicals away from open water sources and prevent backflow into the supply.

10 Energy and climate resilience

Compare grid, solar and hybrid pumping on total lifecycle cost, available solar hours, storage and operational reliability. Solar pumping does not make water extraction automatically sustainable: abstraction must remain within resource limits.

Provide contingency capacity for heatwaves, pump failure and delayed rainfall. Consider covered or otherwise protected storage where feasible, secure electrical systems, spare critical fittings and clear escalation responsibilities.

11 Maintenance and quality assurance

Daily: inspect leaks, pump alarms, filtration pressure difference, field pressure and obvious dry or saturated patches. Weekly: compare meter readings with planned demand, flush as required and inspect end-of-line discharge. Monthly: check emitter output distribution, service equipment and review water-quality trends.

Document flushing, repairs, water-quality tests, pump service, training and incidents. Investigate rising pressure differential across filters, reduced zone flow, uneven crop growth or abnormal power consumption promptly.

12 Management indicators and governance

Track water applied (m3/ha), crop yield per m3 of water applied, irrigation uniformity, pump energy (kWh/m3), downtime, soil salinity and the share of zones with verified records. These indicators need consistent measurement boundaries and should not be compared across dissimilar crops without context.

Assign named responsibility for permits, source monitoring, meter readings, maintenance, water testing and corrective action. At cluster scale, establish transparent allocation rules, conflict resolution and a shared maintenance reserve.

13 Field calculation and commissioning template

Design input	Measured / calculated value
Crop and growth stage	_____
Irrigated area (ha)	_____
ETo (mm/day) / source	_____
Kc / source	_____
Effective rainfall (mm/day)	_____
Net irrigation (mm/day)	_____
Measured application efficiency (%)	_____
Gross irrigation (mm/day)	_____
Required volume (m3/day)	_____
Source flow (m3/hour)	_____
System flow (m3/hour)	_____
Available irrigation hours/day	_____
Water EC / pH / test date	_____
Operating pressure / block	_____
Measured flow / block	_____

14 Commissioning acceptance checklist

Control	Verified by / date
Water rights and source reliability verified	_____
Water quality assessed and treatment selected	_____
Hydraulic design and pump curve checked	_____
Filters, gauges, meters and flush points installed	_____
Zone pressures and flows measured	_____
Leak test and uniformity assessment completed	_____
Operators trained and records issued	_____
Maintenance and emergency plans approved	_____

15 Irrigation operating log

Date / block	ET / rainfall	Run time	Meter start / end	Observation / action
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

16 Technical references and further reading

FAO, *Crop Evapotranspiration: Guidelines for Computing Crop Water Requirements*, revised edition (2025), catalogued by FAO AGRIS: https://agris.fao.org/search/en/providers/124943/records/6a32b9d6b9a0a56f302a5e20

FAO, *Small-scale Irrigation for Arid Zones*, Chapter 5, irrigation scheduling: https://www.fao.org/4/w3094e/w3094e06.htm

FAO, *Crop Evapotranspiration*, Paper 56, chapters on ETo, Kc and water balance: https://www.fao.org/4/X0490E/X0490E00.htm

FAO, *Climate-Smart Agriculture Sourcebook*: https://www.fao.org/4/i3325e/i3325e.pdf

Important: This guide provides technical education, not a stamped engineering design. Site-specific irrigation engineering, laboratory analysis, environmental permissions and local regulatory compliance are required before procurement or construction.