Smart Irrigation and Innovation Integration :Transforming Smallholder Farming for a Climate-Resilient Kenya

By

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Introduction

The East Africa FEW Nexus Conference is a timely and critical intervention in response to increasing climate variability , resources scarcity and population growth in the region

(Temp increase projection by 2050 2.0-2.5°C (IPCC,2022)

With the Food-Water and Energy increasingly interdependent, FEW Conference provides a structured platform for co-creating systemic solutions

(Multi-disciplinary stakeholders to explore models like Solar-powered irrigation, off-grid energy for agriculture, smart water harvesting, and digital crop management)

FEW Conference outcome will guide evidence-based Policy reforms research and scalable innovations across EA .

(Emphasis on AI, IoT & Automation and Entrepreneurship position the conferences as a launchpad for the next generation Innovation and private-sector investment in FEW nexus)

Water Scarcity Scenario in Kenya.

- Water availability in kenya stands at ~494 m^3 per person per year (2023) below the water-scarcity threshold of 1,000 m^3 and rapidly approaching the absolute scarcity level of <500 m^3 (UNEP, 2023; World Bank, 2022).
- Over 80% of agriculture is rain-fed, and only 3% of total arable land is under irrigation (MoALD, 2022)
- Current National Demand: Estimated at ~24 billion m^3/year, Current Supply: ~20.2 billion m^3/year
  By 2030, demand is projected to rise to ~32 billion m^3/year, increasing the water gap by over 50% if no interventions are made (Kenya Water Master Plan, 2030).

KALRO MANDATE(BROAD)

The Kenya Agricultural and Livestock Research Organization (KALRO) has a broad mandate to undertake, streamline, coordinate, and regulate agricultural and livestock research in Kenya.

KALRO has 51 centers and sub-centers spread across the country

The institutes are classified broadly into livestock, crop, NRM, and socio-economics, and policy research.

The organization conducts various types of research ie basic, applied, and validation

Challenges Faced by Small Holder Irrigators

- Limited access to affordable and appropriate irrigation technologies
- High input costs, including energy
- Poor infrastructure and market access
- Low institutional support
- Land tenure systems
- Land Degradation

KALRO- IRRIGATION RESEARCH ACTIVITIES

To develop and disseminate technologies on efficient usage of water, soil properties related to irrigation, drainage, and problematic soils, and fertilizer use under irrigation.

Operates a practical training field for irrigation technologies and OFFERS ADVISORY SERVICES to irrigators

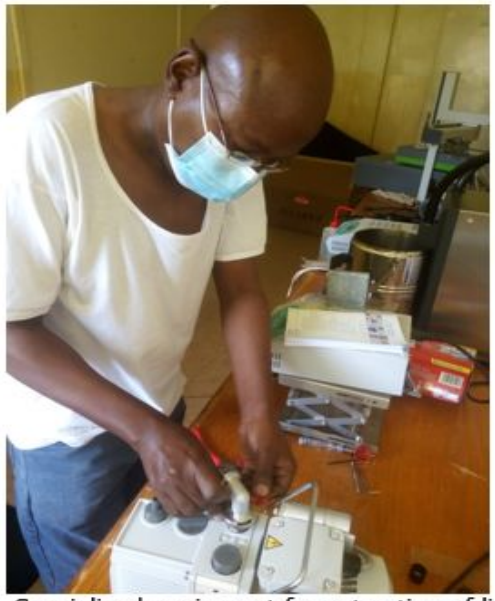
Soil physics laboratory and specialized nuclear application facilities for the separation of Evaporation and Transpiration (E & T) using the oxygen and hydrogen isotopes in water (^{18}O & ^{2}H).

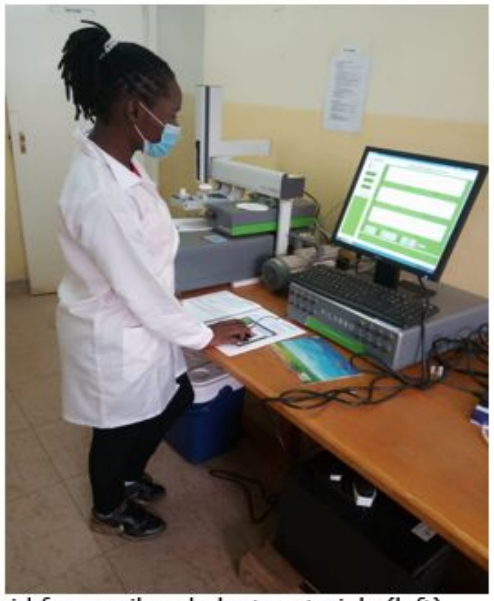
Collaborates and hosts Scientists and Technicians from African countries on International Atomic

Irrigation Water Management (IWM)

Farmers use this to determine how much water is in their fields .

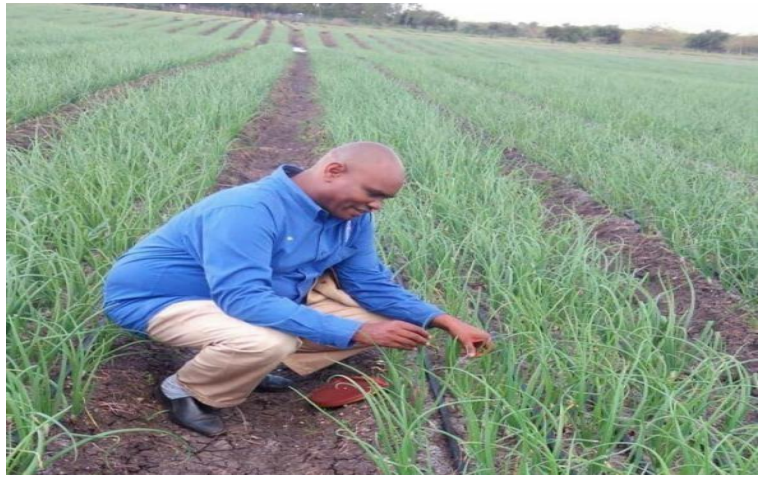
SOIL SAMPLING
(neutron probe



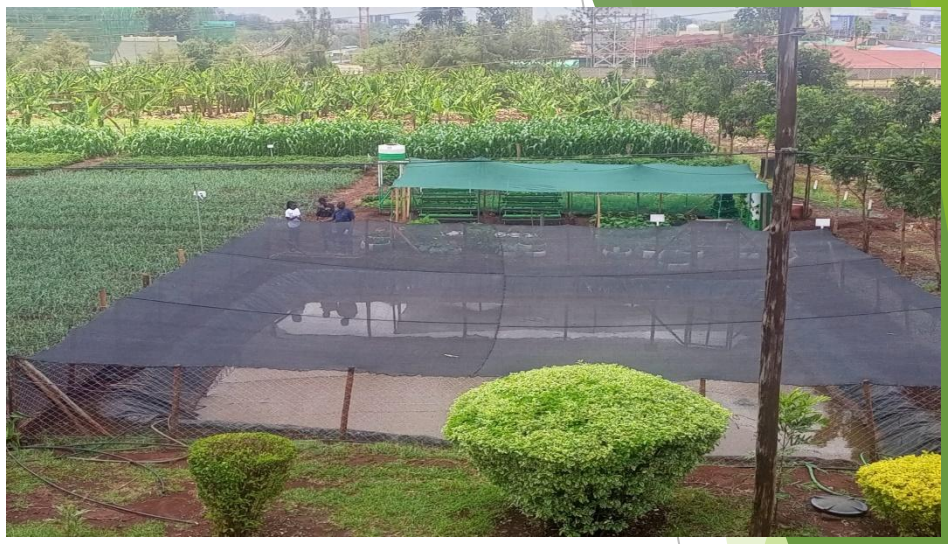


Specialised equipment for extraction of liquid from soil and plant materials (left) and for separation of Oxygen and Hydrogen Isotopes from the samples (Picarro)

ALUM Application

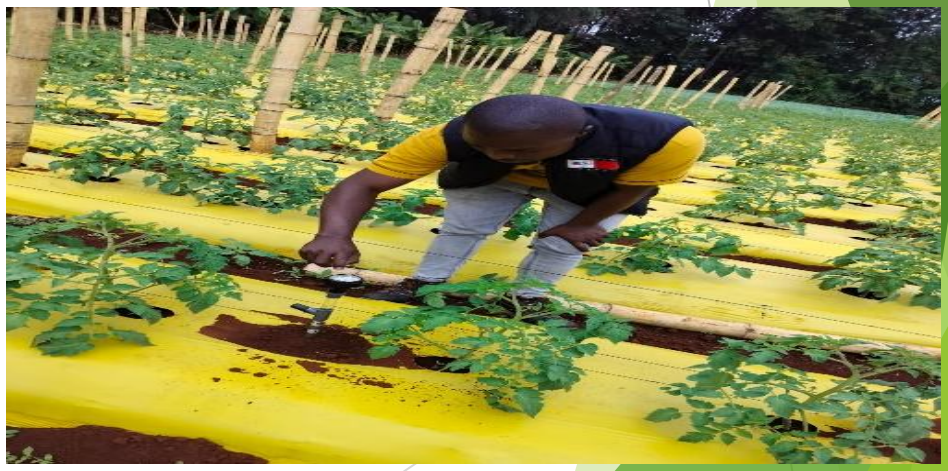


Drip Irrigated onion crop



Smart Water Pan

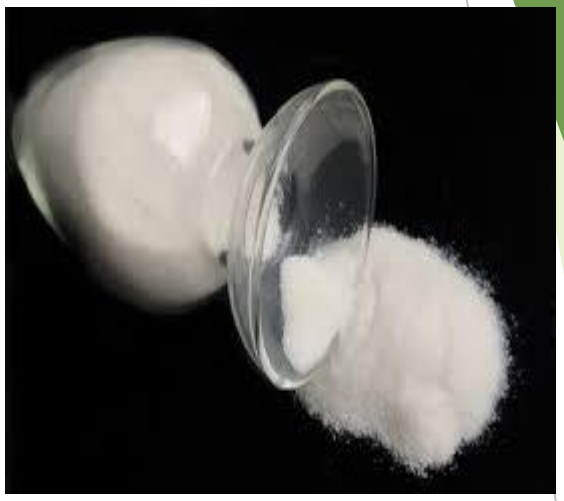
Solar Pumping in Operation

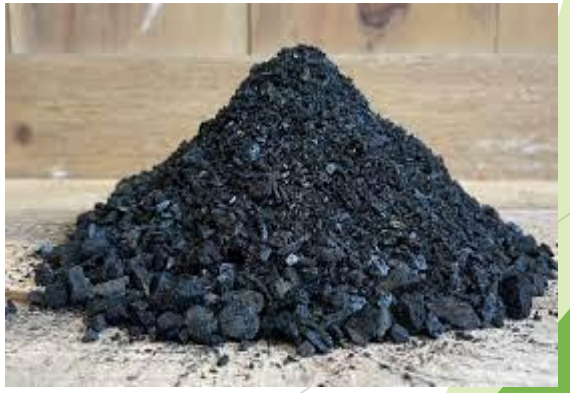


Reading Tensiometer

Soil moisture retention Materials

- SAP(Superabsorbent polymers synthentics 500 to 1000 times the weight . 1g/1kg of soil
- Organic materials/inoganic films
- Mineral amaendments, vermiculite
- Biochar , charcoal dust like





Technology and Innovation-Based Interventions

Solution	Function	Resilience Benefit
Automated Drip Irrigation	Delivers water directly to root zones with minimal waste	Reduces water use by 40–60%, stabilizes yields during dry spells
Soil Moisture Sensors	Monitors soil conditions for optimal irrigation timing	Prevents over-irrigation and reduces water stress on crops
Solar-Powered Irrigation Systems	Uses solar energy to pump and distribute water	Reduces dependence on rain and fossil fuels, cuts irrigation costs
Rainwater Harvesting (farm ponds)	Collects and stores runoff for later use	Enhances water availability during dry periods
Drought-tolerant Crop Varieties	Crops bred for heat and moisture stress tolerance	Ensures some harvest even under climate stress
Mobile Apps for Weather Alerts	Provide timely forecasts and irrigation advice	Helps farmers make informed decisions and reduce crop failure risk

Roles of KALRO in promoting climate resilience

- Research and innovation in smart water use and irrigation technologies (solar -powered Automated drip irrigation systems- Kiboko, Katumani in Makueni county that has reduced water use by up to 60% while improving yields of tomato, capsicum and maize production

- Soil Moisture sensors for irrigation efficiency – in corroboration with JICA , USAID and KALRO have implemented various sensor-based irrigation systems that schedule water based on the soil moisture data bosting water efficiency and prevent crop water stress.

- **Case Study – Katumani5,000 smallholder farmers have been train on drip irrigation and climate-smart irrigation with beneficiaries reporting up to 3x yield increases30–50% reduction in water use (KALRO Progress Report 2024)**

CONTD

- Development of NEW CROP VARIETIES –drought resistant, and short maturity period. Ukamez, WEMA maize , Mituki pigeon peas, shangi potatoes cooking energy reduced by 50% , NERICA Rice maturity period reduced (8-3) Months
- Promotion of SMART water harvesting and pumping
- WUE in Irrigation kits for small irrigators, green houses/net houses
- Urban and peri urban intensive crop production, hydroponics, aeroponics (SAVE 80% of WATER)

maturity period reduced from(8-6months), drought tolerance(cooking energy saved by 50%) , NERICA Rice

KALRO developed technologies for Advancing climate smart resilience

- Promotion of SMART water harvesting
- Irrigation kits for micro and small irrigators **WUE Application efficiency-90%**

Urban Hydroponics Tower Garden

Smallholders Farmers in Kenya

In Kenya , Smallholders schemes account for 162,000 hectares of irrigated land (12%) out of potential 1.3 million hectares (MoALD,2024)

Pilots in Makueni, Kitui, Embu, have introduced solar-powered irrigations mart pumps and low-pressure drip systems., but the adoption remains low due to cost and technical literacy

Smart irrigation gaps: High cost of irrigation technologies, low access to financing for irrigation infrastructure, weak extension services and Fragmented water governance structures

Innovations to Bridge Gaps and Enhance Productivity

- 🌱 IoT-Enabled Moisture Sensors: Low-cost sensors for precise irrigation scheduling.
- 💧 Water-Saving Irrigation Systems: Gravity-fed drip kits, mini-sprinklers.
- 📲 Mobile Apps for Irrigation Alerts & Water Budgeting
- 📚 Community-Based Training Hubs: Peer-led demo sites showcasing smart irrigation.
- 💼 Green Credit Facilities: Targeting water-smart agriculture

With appropriate support, smallholder irrigation can transform from a vulnerability to a climate resilience and food security accelerator across Kenya and East Africa.

Unlocking Potential for Smallholder Farmer (Opportunities)

Renewable Energy for Agriculture: Solar-powered irrigation , Off-Grid cold storage, Biogas Systems

Agri-Tech and Digital Solutions: Mobile Apps for irrigation schedules – based Moisture Sensors, Drones and Satellite imagery

Access to climate Finance & Impact Investment: Green Financing Programs and Climate-Smart credit , Donor-funded initiatives

Public Private Partnerships (PPPs): Collaborations between government, research institutions, NGOs and Agri-tech companies

Agri-entrepreneurship Models – Value addition using renewable energy

The Role of AI and IoT in Building Climate Resilience Through Smart Agriculture

Summary: Impact and Potential

Benefit	AI & IoT Contribution
Improved water-use efficiency	Real-time sensor data and predictive analytics
Reduced crop failure	Smart alerts and automated irrigation during dry spells
Increased yields and incomes	Precision irrigation and input optimization
Enhanced farmer decision-making	Weather forecasts, soil data, market analysis
Climate shock preparedness	Drought early warnings and pest detection

THANK YOU