

GEAVET TRAINING PROGRAMME FOR CSA

GEAVET TRAINING PROGRAMME FOR CLIMATE-SMART AGRICULTURE (CSA):

KENYA

UNIT I.3 DRIP IRRIGATION SYSTEMS

ENGLISH VERSION

GEAVET Project n° 101129027



Open Educational Resources



Disclaimer: Co-Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

PART I – LEARNING MATERIAL

1. Introduction

In the face of increasingly unpredictable rainfall and frequent droughts in Kenya, efficient water use is no longer an option but a necessity for smallholder farmers. Traditional irrigation methods, such as flood irrigation or watering cans, are highly inefficient, leading to significant water loss through evaporation, runoff, and deep percolation. Drip irrigation is a climate-smart technology that delivers water directly to the root zone of plants, drop by drop. This document provides a hands-on guide to understanding, installing, and maintaining a low-cost drip irrigation system. By adopting this practice, farmers can significantly increase water efficiency, boost crop yields, and build resilience against climate variability, all while contributing to sustainable water resource management.

2. Knowledge

2.1. The Principles and Benefits of Drip Irrigation

Drip irrigation is a water-efficient method that applies water slowly and directly to the plant root zone through a network of pipes, lines and emitters. It relies on three core principles: precision application, low flow rates, and distribution uniformity.

Benefits include:

- Significant water savings (30–60% vs flood irrigation)
- Increased yields and crop quality
- Reduced weed growth and foliar diseases
- Labour savings and time efficiency
- Possibility for fertigation (nutrient application through the irrigation system)
- Better integration with soil moisture monitoring for precision agriculture

2.2. Components of a Simple Drip Irrigation System

Table 5. Components of a simple drip irrigation system, their function and common types in Kenya

Component	Function	Common Types in Kenya
Water Source	Supplies water to the system	Rainwater tank, borehole, river, dam

Head Unit	Filter and pressure regulator; optional fertilizer tank for fertigation	Disc/screen filter; pressure regulator; Venturi injector or small pump with injector
Mainline (HDPE)	Carries water from source to field	High-density polyethylene pipes (20–50 mm)
Sub-main/Laterals	Distribute water along rows	LDPE pipes, drip lines or tape (12–20 mm)
Emitters/Drippers	Meter water to plants	Pressure-compensating drippers, turbulent-flow drippers, or dripline with pre-spaced emitters
Fittings & Valves	Connection and flow control	Tees, elbows, connectors, end caps, ball valves
Tools & Accessories	Installation and maintenance	Punch tool, scissors, flush caps, spare emitters

2.3. System Layout and Water Pressure Basics

Designing a layout requires plotting the water source, head unit, mainline route, sub-mains, and laterals. Consider slope, crop spacing and future expansion. Water pressure must be considered: small-scale systems typically work best at 0.5–1.5 bar. Gravity-fed systems use elevated tanks (1–3 m) to create head; pumps require pressure regulators. Too high pressure can damage drip tape; too low pressure reduces emitter flow. Use pressure-compensating emitters on sloping fields to ensure uniformity.

3. Skills

3.1. Planning and Designing a System Layout

Practical steps:

1. Sketch the plot (scale 1:100 if possible).
2. Mark water source and elevation changes.
3. Measure row lengths and plant spacing to estimate lateral lengths.
4. Calculate total flow and select mainline diameter.
5. Consider future needs (fertigation, filters, additional rows).

3.2. Assembling and Installing a Drip System (Practical Steps)

Step-by-step:

1. Install the head unit: attach filter, pressure regulator and valves to the water source outlet.
2. Lay the mainline along the designed route and anchor it.
3. Branch off sub-mains to field beds using tees and connectors.
4. Lay laterals along rows, secure with stakes.
5. Punch holes and insert emitters or unroll dripline with in-built emitters.
6. End cap the laterals and fit a flush valve at the far end for maintenance.
7. Commission the system: flush lines, then operate at working pressure and check for uniform emission.

3.3. Routine Maintenance and Troubleshooting

Maintenance schedule:

- **Daily/weekly** - inspect filters, check for leaks, and observe crop wetting patterns.
- **Monthly** - open flush valves and flush laterals; inspect and clean emitters; check tank cleanliness.
- **Seasonal** - disassemble and deep-clean filters; replace worn sections of dripline; inspect UV damage to tapes.

Table 6. Problems, possible causes and solutions to problems with drip irrigation

Problem	Likely Cause	Solution
Dry patches under certain emitters	Clogged emitter, kinked lateral	Clean or replace emitter; check for kinks
Entire row dry / low flow	Blocked filter or closed valve; pump issue	Check filter, open valves, test pump
Water pooling near plants	Leak at connector or broken lateral	Repair or replace damaged section; tighten fittings
Uneven distribution on slope	No pressure compensation	Use pressure-compensating emitters or pressure regulator

3.4. Calculating Water Requirements

Basic calculation steps:

1. Identify crop water use (L/plant/day). Use local agronomic data (e.g., tomatoes 3–5 L/plant/day).
2. Multiply by the number of plants to obtain daily crop water needs.
3. Divide by emitter flow rate to obtain operation hours per day.

Example: Tomatoes (4 L/plant/day) x 100 plants = 400 L/day.

If emitters flow 2 L/hr, the system needs 200 hr total / number of emitters in use; practically, run for e.g., 4 hours if multiple emitters supply plants.

Include hands-on exercises with sample plots and calculator apps.

4. Attitudes

Learners should develop:

- Valuing precision and efficiency – every drop counts.
- Proactive stewardship – schedule and perform regular maintenance.
- Innovation and adaptation – improvise with local materials where appropriate.
- Long-term investment thinking – initial costs return in water and yield gains.

5. Case Study – Kibri Chia, Mount Kenya

Background: Smallholder farmers in Kibirichia shifted from rain-fed vegetables to year-round production using gravity-fed drip kits and rainwater harvesting. Over 300 farmers received 1000-L tanks, filters and 50 m drip lines, plus training.

Implementation: Training focused on installation, cleaning filters, simple fertigation and crop scheduling. Farmers adopted rainwater harvesting gutters and storage tanks.

Results: Water use reduced by 60–70%; tomato yields rose from 5 to 15 t/acre; household incomes increased by ~40%. The project demonstrated that low-cost systems plus training yield high returns.

6. References

Food and Agriculture Organization of the United Nations (FAO). (2013). *Small-scale drip irrigation – A promising technology for smallholder farmers*. Rome: FAO.

Kenya Agricultural and Livestock Research Organization (KALRO). (2020). *Technical Guide on Small-Scale Irrigation Technologies for Kenya*.

Mt. Kenya Trust. (2021). *Kibirichia Smallholder Irrigation Project: Impact Assessment Report*. Unpublished internal report.

Netafim. (n.d.). *Drip Irrigation Design & Installation Manual*. Retrieved from: <https://www.netafim.com/en/agriculture/drip-irrigation/>

PART 2 – CURRICULUM

Learning Objectives:

KNOWLEDGE	SKILLS	ATTITUDES
<p><i>Students will know:</i></p> <ul style="list-style-type: none"> ● Principles and benefits of drip irrigation ● Components of a simple drip irrigation system ● System layout and water pressure basics ● Water Requirements Calculation 	<p><i>Student will be able to:</i></p> <ul style="list-style-type: none"> ● Plan and design a system layout ● Assemble and install a drip system ● Perform routine maintenance and troubleshooting ● Calculate water requirements for crops 	<p><i>Student will develop the following mindset:</i></p> <ul style="list-style-type: none"> ● Valuing precision and efficiency. ● Proactive system Stewardship ● Innovation & adaptation ● Long-term investment thinking
<p>TRANSVERSAL SKILLS INTEGRATED:</p> <ul style="list-style-type: none"> ● Critical Thinking & Problem Solving: Analyse field conditions, calculate water needs, troubleshoot system problems, and adapt designs to local contexts. ● Adaptability & Innovation: Modify standard kits for irregular plots, use locally available materials for repairs, and adjust systems for different crops. ● Entrepreneurship & Efficiency Mindset: Calculate cost-benefit of drip irrigation, explore business opportunities in system installation/maintenance, and value long-term savings. ● Collaboration & Community Learning: Work in teams to install systems, share knowledge about maintenance, and organize group purchases of irrigation kits. 		
<p>DIGITAL SKILLS INTEGRATED:</p> <ul style="list-style-type: none"> ● Digital Literacy / ICT for Agriculture: Use smartphones to access tutorial videos and irrigation scheduling apps. ● Mobile-Based Advisory Tools: Use SMS services for weather data to inform irrigation scheduling. ● Digital Communication & Collaboration: Share system photos and troubleshooting questions via WhatsApp groups. ● Data Management & Interpretation: Use simple calculator apps for water volume and flow rate calculations. ● Cyber-awareness & Digital Responsibility: Safely access and use agricultural 		

apps and online resources.

GREEN SKILLS INTEGRATED:

- **Water Resource Management:** Implement highly efficient irrigation to conserve water resources.
- **Climate Resilience:** Maintain crop production during drought periods through efficient water use.
- **Sustainable Land Management:** Prevent soil erosion and nutrient leaching through controlled water application.
- **Energy Efficiency:** Reduce pumping needs through efficient water use, especially with gravity-fed systems.

Implementation plan of pedagogical activities - Scheme of work

Duration: 3 hours				
Target: TVET students, farmers, extension officers				
No. of Activity	Duration	Training Methods / Activity	What the trainers do	What the participants do
1.	30 min	Design for a dry Ssason (PBL)	<ul style="list-style-type: none"> ● Present scenario ● Mentor group designs ● Prompt critical questions. 	<ul style="list-style-type: none"> ● In groups, create layout and water calculations ● Present design
2.	40 min	Assembly line challenge	<ul style="list-style-type: none"> ● Distribute kits ● Time exercise ● Supervise and score 	<ul style="list-style-type: none"> ● Assemble kits ● Peer review other groups' work
3.	40 min	Maintenance relay	<ul style="list-style-type: none"> ● Set up fault stations ● Guide diagnosis 	<ul style="list-style-type: none"> ● Rotate and fix faults ● Fill maintenance checklists
4.	1 hour	Drip demo plot	<ul style="list-style-type: none"> ● Oversee installation and safety 	<ul style="list-style-type: none"> ● Install and commission demo plot

			<ul style="list-style-type: none"> • Demonstrate compaction and staking 	<ul style="list-style-type: none"> • Collect baseline data
5.	20 min	Cost-benefit workshop	<ul style="list-style-type: none"> • Provide sample costs and yields • Facilitate calculations 	<ul style="list-style-type: none"> • Calculate payback period and discuss financing options
<p>Materials (What trainers need to have prepared):</p> <ul style="list-style-type: none"> • Complete drip irrigation kits per group (mainline, laterals, emitters) • Filters, pressure regulators, spare emitters and connectors • Tools: punch tool, scissors, clamps, stakes • Measuring tapes, plot stakes, markers • Water source (bucket or tank), ladder to elevate tanks • Printed job-cards, checklists and spreadsheets • PPE: gloves, eye protection, gumboots • Sample failure stations and replacement parts 				
<p>Other notes:</p>				

PART 3 – ACTIVITY GUIDE

DESCRIPTION OF THE ACTIVITIES

1. Problem-Based Learning: Design for a Dry Season

Learners are presented with a farmer profile: 'Mwangi' has a 10 m x 10 m plot of tomatoes and a 1000-L rainwater tank. Groups must design a drip layout, choose components, calculate emitter count and operation time to conserve the tank water across a specified cropping period. Trainers circulate and ask probing questions on emitter spacing, filtration and slope effects. Each group presents the design and receives feedback. This activity develops planning, calculation and teamwork skills and encourages resource-efficient solutions using local materials.

- 1. Aim of the activity:** To develop learners' ability to design a water-efficient drip irrigation system under realistic resource constraints.
- 2. Duration:** 30 min
- 3. Material required:**
 - Farmer profile handout
 - Graph paper and markers
 - Drip irrigation component samples

- Calculator
- Flipchart or whiteboard

4. Step-by-step instruction of the task/practical exercise/case study:

- Present the farmer profile and explain the design challenge
- Divide learners into small groups
- Analyse plot size, crop spacing, and water availability
- Select components and calculate emitter numbers and run time
- Prepare a simple system layout diagram
- Present group designs to the class
- Receive feedback and discuss improvements

References/Sources/Further materials:

No further references.

2. Hands-On 'Assembly Line' Challenge

Teams receive identical small-scale kits and a checklist. A timed event challenges groups to assemble a working system and commission it. Judges score based on correctness, safety, and speed. After assembly, each group inspects another team's system and completes a fault checklist, promoting peer learning and critical appraisal.

- 1. Aim of the activity:** To strengthen hands-on skills in assembling and commissioning drip irrigation systems.
- 2. Duration:** 40 min
- 3. Material required:**
 - Small-scale drip irrigation kits
 - Assembly checklist
 - Basic tools
 - Stop-watch or timer
 - Fault inspection checklist
- 4. Step-by-step instruction of the task/practical exercise/case study:**
 - Divide learners into teams and distribute kits
 - Explain rules, scoring criteria, and time limit
 - Begin timed assembly challenge
 - Inspect completed systems for functionality
 - Exchange systems between teams for peer inspection
 - Complete fault checklists
 - Conduct group reflection and feedback

References/Sources/Further materials:

No further references.

3. Maintenance & Troubleshooting Relay

Stations simulate common issues: clogged emitter, kinked lateral, low pressure, leaking connector. Teams rotate through stations and must diagnose and fix issues under time pressure. Trainers facilitate reflection on preventive maintenance and record common mistakes to emphasize.

1. **Aim of the activity:** To develop learners' ability to diagnose, repair, and prevent common drip irrigation faults.
2. **Duration:** 40 min
3. **Material required:**
 - Drip system fault stations
 - Spare connectors and emitters
 - Basic tools
 - Maintenance guide sheets
4. **Step-by-step instruction of the task/practical exercise/case study:**
 - Explain relay rules and safety considerations
 - Assign teams and starting stations
 - Diagnose and fix the fault at each station
 - Rotate teams at timed intervals
 - Observe and record solutions
 - Conduct group reflection on lessons learned

References/Sources/Further materials:

No further references.

4. Drip Demo Plot Establishment

The full group collaborates to install a functioning drip plot. Trainers guide site selection, marking beds, measuring spacing, and installing the mainline and laterals. After commissioning, learners agree on a monitoring calendar to record water used, crop growth and any faults. This demo plot becomes a local learning hub after training.

1. **Aim of the activity:** To build collective experience in installing and managing a real drip irrigation system.
2. **Duration:** 60 min

3. Material required:

- Full drip irrigation kit
- Measuring tape and stakes
- Tools
- Monitoring record sheets

4. Step-by-step instruction of the task/practical exercise/case study:

- Select and prepare the site
- Mark beds and measure spacing
- Install head unit and mainline
- Lay laterals and install emitters
- Flush and commission the system
- Agree on monitoring and maintenance schedule

References/Sources/Further materials:

No further references.

5. Cost-Benefit Calculation Workshop

Participants use provided cost templates to calculate initial setup costs (tanks, filters, pipes, emitters, labour) and estimate water and labour savings. Using conservative yield increases, they compute payback period and discuss options: group purchasing, microcredit, or input subsidy programs. Trainers discuss maintenance costs and realistic adoption barriers.

- 1. Aim of the activity:** To build learners' capacity to assess the financial viability of drip irrigation systems.
- 2. Duration:** 20 min
- 3. Material required:**
 - Cost calculation templates
 - Calculators
 - Example price lists
- 4. Step-by-step instruction of the task/practical exercise/case study:**
 - Distribute cost templates
 - Calculate setup costs
 - Estimate savings and yield benefits
 - Compute payback period
 - Discuss financing options and risks

References/Sources/Further materials:

No further references.

Additional material

1. Annex A: Assessment and Certification

➤ **Assessment methods:**

- Practical assessment: assemble and commission a working small-scale system.
- Written/Oral test: short quizzes on components, maintenance and calculations.
- Group presentation: design and defend a drip layout for a sample plot.

➤ **Certification:** Participants who pass practical + one other assessment receive a GEAVET CSA module completion certificate.

2. Annex B: Installation Checklist (Trainer Job-Card)

- Head unit installed and sealed
- Filter fitted and clean
- Mainline laid and fixed
- Sub-mains connected correctly
- Laterals unrolled and staked
- Emitters installed and tested
- End caps and flush valves fitted
- System flushed and commissioned
- Maintenance schedule noted

3. Annex C: Sample Equipment Cost Worksheet

Item	Unit Cost (KES)	Quantity	Total (KES)
1000-L tank	6,000	1	6,000
Filter (disc/screen)	3,500	1	3,500
Mainline HDPE (50 m)	2,000	1	2,000
Dripline (50 m)	3,000	1	3,000
Emitters (100 pcs)	1,500	1	1,500
Fittings & valves	1,200	1	1,200
Labour/installation	1,500	1	1,500

4. Annex D: Maintenance Schedule (Sample)

Frequency	Task	Responsible
Daily	Check pressure gauge; look for leaks	Farmer/Operator
Weekly	Clean primary filter; inspect emitters	Farmer/Operator
Monthly	Flush laterals; inspect dripline for damage	Trainer/Farmer
Seasonal	Service pump; replace worn sections	Technician/Farmer

5. Glossary:

- **Emitter:** A device that meters water from the lateral to the plant.
- **Fertigation:** Application of fertilizer through the irrigation system.
- **Head Unit:** Assembly at the water source including filters and pressure regulation.
- **Pressure-compensating emitter:** An emitter that delivers a constant flow over a range of pressures.