Training course packages targeting food operators on the adoption and management of the technological innovations

PRECISION IRRIGATION SYSTEMS

A step-by-step guide for the installation of the Open Smart Irrigation Platform

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1. FoodLAND technical innovation for local food supply chains: concepts and approaches

The FoodLAND project has the ambition to impact on a large number of supply chains and communities, hence the process of food operators' capacity development has to be tailored and as much participative as possible. Accordingly, one of the assumptions of FoodLAND is that sustainable and nutrition-responsive farming systems can be achieved basically by strengthening the capacity development, and specifically by **a)** empowering farmers and processors through the implementation of capacity building processes and concrete opportunities; **b)** creating or consolidating cooperation and shared knowledge to overcome the lack of coordination among food operators; **c)** addressing the inefficient use of resources; **d)** trying to address and build resiliency to the high vulnerability of food systems to climate change; **e)** enhancing the integration of supply chains by creating commercial and stakeholders' networks; **f)** improving the responsiveness of the production sector to the market demand.

To implement these elements of capacity development, FoodLAND proposed the adoption of specific innovations, among which the organizational ones, to create strong and responsive links between producers and encompassing all the intermediate actors along the food value chain, such as researchers, SMEs, NGOs, local and national authorities. In order to ease the creation of those links and guarantee the sustainability over time of the results, 14 Food Hubs will be created in 6 countries as part of the organizational innovations. Food Hubs are conceived as multi-actors centers of innovation where to develop or enhance the organizational and operational conditions enabling local food supply chains (D3.6).

Functional to the implementation of the Food Hubs and of the innovations, the training courses were designed – in form of capacity development activities – as a two-phase process. Firstly, a training session focused on general, preparatory topics was provided to farmers as described and reported in D3.5 ("Group Introductory Training", GIT). According to the project GA, GIT broad set of goals were: to enhance the knowledge of consumers' nutritional needs and market opportunities, and to boost the notions about climate change, sustainability, resilience, and food culture. Secondly, a specific training session were organized to provide food operators with practical information on the adoption and management of the innovations tested at lab / small scale level and to contribute to validating them at appropriate scale.

However, as the whole approach has been designed by FoodLAND to ensure the inclusion of the local actors from the first moment, both the training sessions were set up accordingly. Indeed, yet in the inception phase of the project, an assessment on participatory methods has been run and Participatory Learning and Action (PLA) approach has been eventually assessed as the best one to ensure the inclusion of multiple perspectives. The main purpose of PLA is to support people within communities to analyze their own situation, rather than have it analyzed by outsiders, and to ensure that any learning is then translated into action (Gosling and Edwards 2003). In addition, a gender-sensitive approach has been applied to the trainings that have been designed considering gender roles and power relations; they have provided equal opportunities to participate in the process by caring to times, venues and use of local languages.

The GITs have been conceived as the first step towards the innovation validation and aim at involving the producers, yet from the inception phase. They are just the first step in a sequence of 6, summed up in **Table 1**. After the GITs, where farmers and processors meet and share their vision and goals for the Food Hubs and exchange information about specific topics, the Food Hubs were created and the innovation tested (first in pre-test, then in pilot phase). The constant iteration between researchers and local actors is a key feature of the project: specifically, the practical trainings focused the single innovations (step 5) are aimed at validating the innovations at adequate scale and planned to trigger feedback loops of control and improvement involving developers and adopters.

Table 1. Activities with farmers and food processors (SMEs) and participatory approach

Step	1	2	3	4	5	6
Task	T3.3	T3.3	T3.4	T4.1¸T4.5	T5.1¸T5.5	T5.1¸T5.5
Activity	Group introductory training	Food Hubs creation	Innovation undertaking	Innovation tests	Individual and group practical training	Innovation pilot and validation

2. FoodLAND practical training: aims and scope

According to the project bottom-up and participatory approaches, following the courses on introductory topics GIT organized in the early project phase (T3.3), and as component creating / strengthening the Food Hubs as local innovation centres, FoodLAND has organized a second set of training activities with food operators based on active learning methods and gender equality principle (Task 5.1-5.9). In this regard, specific mechanisms (being aware of the gender roles and power relations; providing equal opportunities to participate in the process by putting attention to the times, venues, use of local languages, etc.) will be lifted to ensure women's participation. These training packages are aimed at providing the local farmers and food processors with operational instructions on the adoption and management of the validated innovations.

This second set of training activities has been organised – triggering PLA approach – as individual and group practical (demonstration/capacity building) activities to be conducted in parallel to the implementation of the technological research (where relevant) and of the innovation pilots and validation. These technology-centred trainings aim at strengthening the participants' understanding of novel production and post-harvest techniques, innovative tools and systems (e.g., climate smart/precision agriculture, hydroponics, and integrated aquaculture), new technologies for primary and secondary processing, and supply chain management. Thus they aim at fostering knowledge and operational capacity to deploy, manage, and maintain the validated technological innovations – documented by the released guidelines D4.1 ÷ D4.11 (e.g., training pamphlets, user manuals, flow diagrams, and operational recommendations) and practice abstracts D6.5 – validated jointly at appropriate scale.

3. Second training packages on the adoption and management of the tested innovations: an overview

The second training course aimed at consolidating the food operators' knowledge and practical skills to adopt, manage and validate the project innovations and complement the related guidelines. Specifically, the realized training materials provide local farmers and food operators with a set of notions and concrete information on a series of innovative tools and systems as per the following **Table 2**. It is clear that both the contents and formats of the learning packages widely differ across technologies as well as Food Hubs (when the same type of innovation must be validated in different contexts). The diversity that emerges from the proposed solutions reflects the different needs highlighted by farmers and stakeholders as well as the conditions and opportunities characterizing the local communities. Nevertheless, in order to take into due account the existing heterogeneity inside the local communities, the developed learning materials have been let available on the project intranet so as to be used for further training initiatives across the network of Food Hubs.

4. Second training packages on practical information on the adoption and management of the tested innovations

Precision irrigation systems

A step by step guide for the installation of the Open Smart Irrigation Platform

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Introduction

With agriculture accounting for 70% of global freshwater withdrawal(World Bank, 2021), improving water use efficiency is essential for sustainable food production, especially in regions vulnerable to climate change. Smart irrigation systems offer a promising solution by integrating modern technology to optimize water use while boosting crop productivity. Agroscope conducted field trials in Uganda using smart irrigation components, combined with nationwide farm surveys. The trials demonstrated a potential 30% productivity increase compared to conventional methods but also highlighted key challenges to adopting complex technologies in resource-constrained farming contexts. These insights led to the development of a requirement catalogue tailored to smallholders' needs, emphasizing accessibility and robustness. Building on this foundation, Agroscope introduced the “Open Smart Irrigation” platform to provide affordable, practical solutions for farmers in emerging economies. The platform includes both software and educational resources, supporting the setup of smart irrigation systems adaptable to diverse environments. The system architecture (Figure 1) uses LoRa radio technology to establish a low-power wide-area network (LPWAN) that connects sensors and actuators. At its core is a “Raspberry Pi” central unit running open-source software (Customized Chirpstack Gateway OS), which handles local data storage, LoRa communication, and irrigation scheduling. Designed to operate offline and with minimal power consumption, it addresses rural challenges like unreliable electricity and internet access.

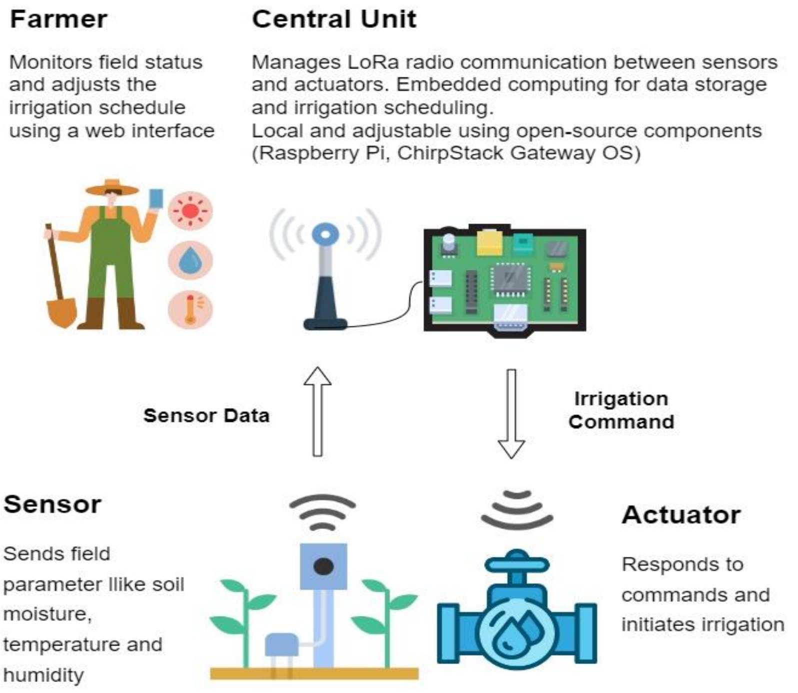

Figure1. System architecture of the “Open Smart Irrigation” platform

The present manual provides step-by-step instructions for installing the central unit and setting up a sample smart irrigation system using a tested smart valve and soil moisture sensor. For guidance on additional components, updated training materials, and the required software, please visit the project website.

Installation manual

1. Required Hardware Components

Component	**Description**	**Purpose**	**Advice & Tested Example**
Raspberry Pi	A small computer serving as the system's central unit.	Runs the irrigation software, stores data, and manages LoRa communication.	**Tested Example:** Raspberry Pi 4 Model B (2GB RAM) **Advice:** Supported models include Raspberry Pi 3, 4, and Compute Module versions. More RAM improves performance for larger systems.
MicroSD Card	Memory card for the Raspberry Pi.	Stores the operating system, software, and data.	**Tested Example:** Samsung Pro Endurance 16GB **Advice:** Use "Endurance" cards for reliability, e.g., Samsung Pro Endurance, SanDisk Max Endurance, Transcend High Endurance. Larger sizes offer greater durability.
LoRa Gateway Module	Device enabling long-range wireless communication between sensors and the central unit.	Facilitates long-range communication (LPWAN).	**Tested Example:** Seeed WM1302 LoRaWAN Gateway Module + WM1301 Raspberry Pi LoRa HAT **Advice:** Supported gateways include models like WM1302. Ensure compatibility with Raspberry Pi and ChirpStack.
Power Supply for Raspberry Pi	Power adapter for the Raspberry Pi.	Ensures continuous power to the central unit.	**Tested Example:** Official Raspberry Pi Power Supply (5V/3A) **Advice:** For added reliability, use an optional UPS HAT (Uninterruptible Power Supply) with 2x 18650 batteries to protect against power outages. A PV module can be integrated for solar, off-grid power supply
LoRa Antenna	Antenna for long-range wireless communication.	Improves LoRa communication range and signal strength.	**Tested Example:** 3 dBi antenna for testing **Advice:** For longer ranges, use antennas with 5 dBi or higher. Ensure the LoRa module and antenna match the frequency (e.g., 868 MHz). A U.FL to SMA connector is required.

Component	Description	Purpose	Advice & Tested Example
Soil Moisture and Environmental Sensor	Monitors soil moisture, temperature, humidity, and light conditions.	Provides environmental data to optimize irrigation decisions.	**Tested Example:** TEKTELIC KIWI Agriculture Sensor (868 MHz) **Advice:** Connect up to 2 external Watermark sensors and thermistors. The KIWI sensor integrates seamlessly into LoRaWAN networks and provides robust field performance.
Smart Valve	Valve that automatically opens or closes based on irrigation needs.	Controls the flow of water to the field.	**Tested Example:** STREGA Smart Valve (Solenoid Version, 868 MHz) **Advice:** Select a valve that matches the system's frequency and supports low-power operation. STREGA valves are ideal for long-range control via LoRa.
Tools for Setup	Basic tools required to install and secure components.	Helps connect, mount, and prepare the system for operation.	**Required:** Philips T10 screwdriver and, if needed, a wire cutter for cable preparation and sensor installation.
Protective Casing	Enclosure for protecting sensitive hardware.	Protects the Raspberry Pi, LoRa HAT, and other components from dust and unintended user interference.	**Tested Example:** HighPi Pro Case **Advice:** Choose a case with enough clearance for the LoRa HAT and good ventilation. The **HighPi Pro Case** fits the Raspberry Pi 4 with HAT attachments while ensuring proper airflow.

2. Software Requirements

ChirpStack Gateway OS: Full installation required. Select the version corresponding to your Raspberry Pi model.

Resource: ChirpStack Gateway OS Install Guide

SD Card Flashing Utility: For flashing the ChirpStack Gateway OS.

Recommended for Windows: Win32 Disk Imager

Open Smart Irrigation Software:

Resource: Open Smart Irrigation

STREGA Smart Valve SV_SE Reader: For configuring the valve.

Resource: STREGA Utilities

Video Tutorials: Recommended for new users and updated regularly to new versions of the system.

Resource: Video Series

3. Step-by-Step Installation Guide

Step 1: Central Unit Setup

Connect the Hardware:

Attach the LoRa Gateway Module to the HAT and to the Raspberry Pi using the 40-pin connector.

Connect the LoRa antenna to the HAT.

Flash the Gateway OS:

Use Win32 Disk Imager (or your preferred utility) to flash the ChirpStack Gateway OS onto the SD card.

Power Up the Central Unit:

Insert the SD card into the Raspberry Pi and connect the power supply.

Refer to the ChirpStack Getting Started Guide for first-time setup.

Initial Wi-Fi Setup:

Connect your computer to the Wi-Fi network **ChirpStackAP-XXXXXX** (default password: ChirpStackAP).

Open a web browser and enter the IP address (e.g., http://192.168.0.1).

Default Login:

Username: root

Password: (leave blank)

Configure the LoRaWAN Concentrator:

Navigate to **ChirpStack > Concentratord**.

Set the chipset (e.g., **SX1302**), antenna gain (e.g., 3 dBi), and channel plan (e.g., **EU868**).

Save and apply settings.

Configure the LoRaWAN Network Server:

Open the ChirpStack web interface.

Navigate to **Gateways > Add Gateway**, provide a name, and enter the Gateway ID.

Step 2: Smart Valve Configuration

Install the Valve:

Follow the STREGA manual (STREGA Smart Valve Manual) and installation video.

Connect the Valve to the computer (Video)

Use a USB cable to connect the valve.

Open the STREGA SV SE Reader and read the **Device EUI**, **APPEUI**, and **APPKEY**.

Save these values for later use.

Step 3: Sensor Configuration

Connect Watermark and Thermistor Sensors:

Refer to the TEKTELIC KIWI Manual (pages 17-20).

Open the case and pass the sensor wires through the cable gland.

Connect the wires as follows (for one watermark):

Thermistor: White wire (3A), Black wire (4A)

Watermark: Green wire (3B), Green-white wire (4B)

Close the case securely.

Record Sensor Identifiers:

Locate the **Device EUI**, **APPEUI**, and **APPKEY** on the device.

Step 4: Adding Devices to ChirpStack

Create Device Profiles:

Go to **Device Profiles** and add profiles for both the sensor (TEKTELIC) and valve (STREGA).

Set the region to **EU868** and adjust for the KIWI sensor the MAC versions to LoRaWAN 1.02.

Register Devices:

Add a new application with a suitable name, e.g. open smart irrigation

Add the devices under the application in ChirpStack.

Enter the **Device EUI**, **APPEUI**, and **APPKEY**.

Wait for Activation:

It may take time for devices to be recognized. Monitor uplink events under **LoRaWAN Frames**.

Step 5: Configure Open Smart Irrigation Software

Open Node-RED:

Access Node-RED from the ChirpStack Gateway OS interface.

Import the Open Smart Irrigation software by clicking on "Import Code" and selecting the downloaded JSON file.

Install Additional Packages:

Go to the **Manage Palette** section within Node-RED.

Search for **node-red-dashboard** and install it.

Repeat the process for other required packages, such as **node-red-contrib-cron-plus**.

Configure the Node-RED Flow:

Link the nodes within the imported irrigation flow to match your devices.

Set the input nodes to connect to the MQTT broker using the device IDs from the LoRaWAN frames.

Adjust MQTT Settings:

Ensure that the application and device IDs are correctly configured in the Node-RED flow, a green "Online" label must show.

Double-check that the uplink and downlink messages are properly routed in the Debug monitor.

Training Material and Troubleshooting:

Consult the comprehensive Open Smart Irrigation Training for additional instructions.

For new users, refer to Node-RED Beginner Guides to familiarize yourself with adjusting the system.

References

World Bank, 2021. World Development Report 2021: Data for Better Lives [WWW Document]. URL https://wdr2021.worldbank.org (accessed 6.22.24).