IHE DELFT Institute for Water Education under the auspices of UNESCO

Food and Agriculture Organization of the United Nations

Training plan for developing the capacities of government officials and technical staff on using geospatial technology to fill data gaps and support decision-making in the water and agricultural sectors, in water scarce contexts

The 6th Meeting of the High-Level Joint Water- Agriculture Technical Committee of the League of Arab States
16 October 2024

Summary

Project name/acronym	Training plan for developing the capacities of government officials and technical staff on using geospatial technology to fill data gaps and support decision-making in the water and agricultural sectors, in water scarce contexts
Donor/Programme/Funding Scheme	Food and Agriculture Organization (FAO) Regional Office for the Near East and North Africa (RNE)
Donor project/reference number	
Report being submitted by	IHE Delft Institute for Water Education Westvest 7 P.O. Box 3015 2601 DA, Delft The Netherlands
Contact Information	Elga Salvadore e.salvadore@un-ihe.org
Project Duration	August 2024 – September 2024

ii. List of abbreviations

BWP	Bio-physical Water Productivity
CLI	Command Line Interface
EO	Earth Observation
EOT	Earth Observation Technology
FAO	Food and Agriculture Organization
GEE	Google Earth Engine
GIS	Geographic Information System
HLJTC	High-Level Joint Water-Agriculture Technical Committee
IPA	Irrigation Performance Indicators
LAS	League of Arab States
LO	Learning Objective
ML	Machine Learning
NENA	Near East and North Africa
NDVI	Normalized Difference Vegetation Index
O	Objective
OCW	Open Course Ware
RNE	Regional Office for the Near East and North Africa
RS	Remote Sensing
SDG	Sustainable Development Goals
WA	Water Accounting
WP	Water Productivity

1. Project Summary

1.1. Overall Project Summary

A letter of agreement was signed between IHE Delft Institute for Water Education (IHE Delft) and the Food and Agriculture Organization (FAO), to develop a comprehensive training plan for the capacity development of government officials and technical staff in using geospatial technology to address data gaps for water and agriculture sectors in the Near East and North Africa (NENA) region.

This activity comes as a support for the League of Arab States (LAS) High-Level Joint Water-Agriculture Technical Committee (HLJTC) recommendation after the fourth meeting in 2022, to enhance the capacities in the Arab countries in the use earth observation data, geospatial information technology, and other relevant data sources and tools to address data deficiencies in the sectors of water and agriculture. This recommendation was supported by the FAO Regional Office for the Near East and North Africa (RNE).

1.2. Overview of the project objectives

The training plan reflects the background, objectives, expected outputs and is tailored to the target audience summarized in the concept note endorsed by the HLJTC. The overarching objectives of the training is to enhance the knowledge and skills among government officials working on water-agriculture crosscutting issues by focusing on data acquisition and analysis, including Earth Observation data and geospatial information technology, while shedding light on analytics and applications of remote sensing and geographic information systems in order to obtain useful information that contributes to enhanced water and agriculture resource management and coordinated policy coherence. In order to achieve this, guiding objectives were provided:

- Updating participants on the latest developments in Earth Observation data for agricultural monitoring and water management applications.
- Reviewing essential spatial information in support to the 2030 Agenda for sustainable development and national reporting, with a focus on SDG 2 (Zero Hunger) and SDG 6 (Clean Water and Sanitation)
- Demonstrating the optimal use of remote sensing and geoportals with global to local information on water and agriculture-related data and information, as well as providing guidance on accessing and using such data in support of agricultural monitoring, water management and food security national information systems.
- Reviewing and clarifying the potentials and functionalities of cloud computing platforms and relevant geographic information system tools, with a focus on their capabilities in geographical data and remote sensing analytics for applications related to the water and agriculture sectors.
- Introducing GIS/RS methods and spatial models for assessing and monitoring the vegetation, land cover, crop productivity, soil, land and water resources in agriculture.
- Introducing water accounting (WA) and monitoring concepts and frameworks using remote sensing data (including hands on training on the implementation of a WA assessment).

- Introducing water productivity (WP) concepts and the tools available for monitoring water productivity in agriculture at different scales (e.g. FAO WaPOR).
- Providing opportunities for participants to interact with experts in the field, as well as collaborate and exchange experiences with participants from other countries.

In order of achieve these objectives, this report provides a detailed training plan to build the capacities in the identified target group. Section 2 provides an overview of the training structure and the target audience, and Section 3 details the learning objectives of each module, highlights the training methods, and material/resources needed in order to achieve the learning objectives in each course.

2. Training structure and target audience

2.1. Training Program Learning Objectives and Structure

Upon successful completion of the proposed training program, participants will be able to:

1) Explain the basic principles and characteristics of different types of remote sensing and their suitability for agriculture and water management applications.
2) Select and acquire Earth Observation data for agriculture monitoring and water resources management.
3) Perform basic spatio-temporal analysis and extract information from Remote Sensing data through desktop application (using Python programming and Geographical Information Systems) as well as web-portals and cloud computing.
4) Utilize spatial information in support of the 2030 Agenda for sustainable development and national reporting.
5) Compile different remote sensing and other global datasets to analyze the water resources conditions in a river basin, identify possible issues and propose solutions in terms of management and monitoring.
6) Compile different remote sensing datasets to analyse Land and Water Productivity in irrigation schemes, identify possible issues and propose solutions in terms of management and monitoring.

To achieve these objectives, the training program provides both theoretical and practical activities. The teaching methods varies according to the topic and the delivery methods will range from online, blended and face-to-face (more details are provided in Section 3). The training program is based on problem-based learning principles and participants will have the opportunity to practice through guided case studies from their own countries.

Since the target participants are coming from both water and agriculture backgrounds, the proposed training structure have foundation modules common for all participants and two specialized tracks: the water track and the agriculture track. This structure allows for sufficient interaction between participants of different backgrounds as well as tailored specialized training in the field of water and agriculture. The proposed training structure is presented in Figure 1. Participants will have to successfully complete the foundation modules in order to move forward in the training.

Since one of the main objectives of the training program is to stimulate the interaction between participants (cross-discipline and cross-country joint learning), we proposed to end the training with a workshop session were participants join together to share the results of the specialized modules. This will give an opportunity to the participants to gain a holistic view of the use of Remote Sensing data for water and agriculture and reflect on the different type of RS-derived data needed for river basins vs irrigation schemes in terms of temporal and spatial resolution (use of global datasets vs developing own high-resolution data using pySEBAL or pyWaPOR). This joint session could potentially be open for a larger group and serve as an informative session as well as for receiving feedback on the training program.

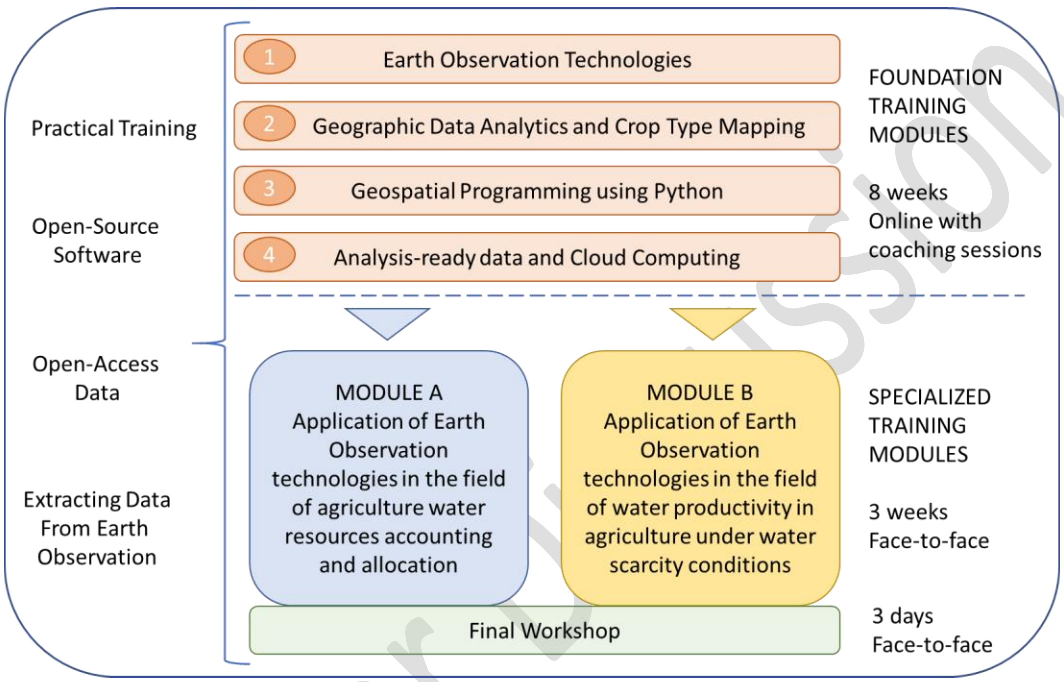

Figure 1: Graphical representation of the proposed training program

2.2. Target Audience

The concept note identifies the target audience for this training program. The target audience includes technical staff working in the governmental departments in the water and agriculture sectors. The target participant wishes to specialize in geospatial data acquisition and analysis for producing knowledge-based reports and products (indicators, maps, ...) to support decision-makers responsible for managing water and agriculture resources.

The qualifications required for candidates to join the training program are as follows:

- **Educational qualifications**: Candidates should have an academic background related to hydrology, hydrogeological, geographic information systems, irrigation, agriculture, plants, or any other relevant field.
- **Knowledge of earth observation technology**: Candidates should have an understanding of the basic principles of geographic information systems and remote sensing.
- **Language proficiency**: Candidates should have a good command of the English language.

- **Computer skills**: Candidates should have basic computer skills, including proficiency in using Microsoft Office programs, internet browsing, file management. Knowledge of computer programming is an advantage.
- **Availability**: Candidates should be committed to participate in both the basic and specialized training courses of the training program.
- **Practical experience**: Candidates should have practical experience in managing and analyzing spatial/ statistical data in the water and agriculture fields within their relevant ministries.

The selection of the participants will be carried out by the technical secretarial of the Arab Ministerial Water Council and the Arab Organization for Agriculture Development who will coordinate with the Arab countries to receive the nominations with a target of a total eight candidates (four from the water sector and four from agriculture) from each country. The candidates will be assessed and four will be selected to join the training (two from water and two from agriculture). For each training cycle, five countries will participate, with 20 participants for the foundation modules and 10 participants for the specialized modules. It is agreed that the joint technical secretariat of the HLJTC will invite FAO to participate in the selection process of participants.

3. Training Plan

This section focuses on detailing the training plan and is divided into three main parts: the foundation modules, the two specialized modules (track on water and track on agriculture) and the closing (workshop). Each section presents the learning objectives, training modality, the main topics and activities, training material and available resources, assessment method and study load for each course.

For every module (both foundation and specialized), topics should include a practical part with examples relevant to water and land management and data used for the practical components focuses on the countries of the participants.

3.1. Foundation Modules

The foundation modules as highlighted in the concept note focus on four main topics:

1- Earth Observation Technologies
2- Geographic Data Analytics and Crop Type Mapping
3- Geospatial Programming using Python
4- Analysis-Ready Data and Cloud Computing

Foundation modules are designed for 20 participants from five countries (two water and two agricultural experts per country). The modality of the foundation modules is online with coaching sessions. At the end of every topic a simple online evaluation (quiz, assignment, etc…) should be performed before the participant can continue to the next topic. The duration of each foundation module is two weeks (including practical parts). Two weeks is intended full-time (8 hours/day 5 days/week) as teaching load for both self-paced activities and synchronous activities and entails 8 hours or activities per day. These two weeks can be spread over a period of three to four weeks depending on the time availability of participants. We advise to set a strict time limit for participants to complete each foundation module. Every module is propaedeutic to the next, meaning each participant needs to complete the first module before being allowed to start the next.

3.1.1. Earth Observation Technologies

Learning Objectives (LO). Participants will be able to:

LO1: Explain the basic principles and characteristics of different types of remote sensing and their suitability for agriculture and water management applications.

LO2: Access open access Remote Sensing data from web platforms.

LO3: Perform basic analysis of Remote Sensing data for water and agriculture applications using open-access platforms.

LO4: Recognize the benefits and challenges of open data.

LO5: Discuss real-world case applications demonstrating the use of these technologies in water and agriculture.

Learning Objective	Topics/Activities	Online Resources	Modality	Course load
LO1: Explain the basic principles and characteristics of different types of remote sensing and their suitability for agriculture and water management applications	• Introduction to Earth Observation Technologies (EOT) in water and agriculture (basic theory and overview of available technologies) • Examples of applications • Introduction to key terminology • Data accuracy • Focus: optical RS, radar	Introducing NASA's NEW Earth System Observatory (youtube.com) Home | OCWGIS (gisopencourseware.org) ARSET - Fundamentals of Remote Sensing | NASA Applied Sciences https://business.esa.int/newcomers-earth-observation-guide#ref_4	Online moderated group discussions	2 days
LO2: Access open access Remote Sensing data from web platforms	• Introduction to Open Access Data • Key Open Access Data Sources for Water and Agriculture • Tools for Working with Open Access Data • Case study example	https://earthexplorer.usgs.gov/ https://land.copernicus.eu/en https://data.apps.fao.org/wapor/?lang=en https://dahiti.dgfi.tum.de/en/map/	Online with coaching sessions	1 day
LO3: Perform basic analysis of Remote Sensing data for water and agriculture applications using open-access platforms	• Basic analysis of Remote Sensing data using online platforms • Practical exercises: computing basic statistics of EO data for water and agriculture. • Country-specific case study		Online with coaching sessions	2 days

LO4: Recognize the benefits and challenges of open data	• In-situ v.s. remote sensing data • challenges and uncertainty in open data • group discussion		Online Moderated group discussion	1 day
LO5: Discuss real-world case applications demonstrating the use of these technologies in water and agriculture	• Simple country-specific case study using Remote Sensing data for water and agricultural water management • Data: open-access RS data, open-access statistical data • Limited analysis performed on web platform		Live case-study presentation Group project	4 days
Assessment	1- Groups of 4 each will get a scenario (drought management, water resources assessment, agriculture development...) they need to use the data and tools to develop and action plan on how to use EOT to address each their scenario. 2- How they could implement Earth observation technologies in their respective organizations or projects		1- Report submission 2- Oral presentation	

3.1.2. Geographic Data Analytics and Landcover/Crop Type Mapping

Learning Objectives (LO). Participants will be able to:

LO1: Perform basic geographic data analytics using Remote Sensing data.

LO2: Access, process and validate open-access satellite data for water and agricultural applications.

LO3: Apply remote sensing and machine learning (ML) techniques to identify different crop types.

LO4: Visualize and interpret the results of crop type mapping using GIS tools.

Software: QGIS and relevant GIS tools

Learning Objective	**Topics/Activities**	**Online Resources**	**Modality**	**Course load**
LO1: Perform basic geographic data analytics using Remote Sensing data	• Software installation (QGIS) • Recap on geospatial data types • Recap on QGIS and main GIS tools for water and agriculture • Basic Remote Sensing data processing using land and water examples Introduction to case studies	https://courses.gisopencourseware.org/ https://docs.qgis.org/3.34/en/docs/index.html	Online with coaching sessions	2 days

LO2: Access, process and validate open-source satellite data for water and agricultural applications	• Recap on RS data for water and agriculture • Data acquisition and processing • Introduction to validation and accuracy assessment of open access RS data Practical exercises		online with coaching sessions	2 days
LO3: Apply remote sensing techniques to identify different crop types	• Normalized Difference Vegetation Index (NDVI) • Calculation of NDVI using QGIS • Land cover mapping (basic algorithms) • Exercise land cover classification • Crop mapping theory and exercise	1- https://appliedsciences.nasa.gov/get-involved/training/english/arset-agricultural-crop-classification-synthetic-aperture-radar-and 2- Crop mapping | Water efficiency, productivity and sustainability in the NENA regions (WEPS-NENA) | Food and Agriculture Organization of the United Nations (fao.org) ARSET - Mapping Crops and their Biophysical Characteristics with Polarimetric SAR and Optical Remote Sensing | NASA Applied Sciences	online with coaching sessions	3 days
LO4: Visualize and interpret the results of crop type mapping using GIS tools	• Case study • Group work Group presentation		Online Moderated group discussion	3 days
Assessment	Group work on crop mapping and GIS data analytics		1- Report submission 2- Oral presentation	

3.1.3. Geospatial programming using Python

Learning Objectives (LO). Participants will be able to:

LO1: Manage files and folders using the Command Line Interface (CLI).

LO2: Use GDAL commands to convert GIS data.

LO3: Run existing Python codes for water and agricultural applications and make small adaptations for data manipulation.

LO4: Create simple plots to visualize data.

Software: Python (Mamba installation), Colab, relevant Python libraries (Pandas/GeoPandas, Matplotlib, Jupyter, xarray, rioarray).

Learning Objective	Topics/Activities	Online Resources	Modality	Course load
LO1: Manage files and folders using the Command Line Interface (CLI)	• How to use the Command Line Interface (CLI) • How files and directories (folders) are organised on your computer	Tutorial: Introduction to the Command Line Interface: Introduction | OCW IHE DELFT (un-ihe.org)	Online with coaching sessions	1 day
LO2: Use GDAL commands to convert GIS data	• Intro to GDAL. • Reprojections, conversions to different formats	https://ocw.un-ihe.org/mod/book/view.php?id=18442	Online with coaching sessions	2 days
LO3: Use and make small adaptation to existing Python codes for water and agricultural applications and data manipulation	• Basics of programming • Tutorials and exercises • Values, types and variables, functions, conditional executions, iterations, strings and data structures, • I/O from file, debugging • (hands-on exercises using Python Notebooks)	www.python.org www.wiki.python.org HackerRank Learn Python 3 | Codecademy Topic: Module 2 | Python for Geospatial Analyses using WaPOR Data | OCW IHE DELFT (un-ihe.org)	Online with coaching sessions	4 days
LO4: Create simple plots to visualize data	• Read geospatial data in Python • Compute basic statistics • Generate and save plots • Optional: automatic open-access data download using Python	https://ocw.un-ihe.org/course/view.php?id=272&section=5#tabs-tree-start	Online with coaching sessions	3 days
Assessment	Assessment in this module are included at activity level after topic cover to ensure the progress and capture of concepts by participants.			

3.1.4. Analysis Ready Data and Cloud Computing

Learning Objectives (LO). Participants will be able to:

LO1: Access and download WaPOR data using different approaches

LO2: Apply geospatial analysis using the WaPOR data

LO3: Explain the potential of Cloud Computing using Google Earth Engine (GEE) for land and water applications

LO4: Explain the potential of Cloud Computing using SEPAL

Topic	**Details**	**Resources**	**Modality**	**Course load**
LO1: Access and download WaPOR data using different approaches	• WaPOR Data components and portal overview • WaPOR Data format • WaPOR Data quality assessment • How to use the WaPOR Portal (its main components) • how to use WaPORDL? How to install and available tools	https://ocw.un-ihe.org/course/view.php?id=263&section=2#tabs-tree-start	online with coaching sessions	3 days
LO2: Apply geospatial analysis using WaPOR data	• WaPOR portal analysis tools • QGIS Spatial analysis tools • Crop yield and water productivity maps • Apply knowledge to calculate yield and water productivity in your own case study	Topic: WaPOR spatial analyses using GIS | WaPOR introduction (version 3) | OCW IHE DELFT (un-ihe.org)	online with coaching sessions	3 days
LO3: Explain the potential of Cloud Computing using Google Earth Engine (GEE) for land and water applications	• Introduction and demonstration of working on Google Earth Engine (GEE) platforms • Case study example	https://www.youtube.com/watch?v=_4o6sbOu5do&t=3s	online with coaching sessions	2 days
LO4: Explain the potential of Cloud Computing using SEPAL	• What is SEPAL and case study examples • Components and applications	https://www.youtube.com/watch?v=niOUVE8N7wo&embeds_referring_euri=https%3A%2F%2Fdocs.sepal.io%2Fen%2Flatest%2F&source_ve_path=OTY3MTQ https://sepal.io/	presentation	2 days
Assessment	Group work on crop yield and water productivity mapping using the WaPOR portal		1- Report submission 2- Oral presentation	

3.2. Specialised modules

The two specialized modules are the following:

1- MODULE A: Application of Earth Observation technologies in the field of water resources accounting and allocation for agriculture.
2- MODULE B: Application of Earth Observation technologies in the field of water productivity in agriculture under water scarcity conditions.

Each specialized module is designed for 10 participants from five countries (two water or two agricultural experts per country). The modality of the specialized modules is face-to-face with online recap of the foundation modules. The duration of each specialized module is three weeks (including practical parts). Three weeks is intended as a full-time week (8 hours/day lecture and independent work for 5 days/week).

3.2.1. Module A: Application of Earth Observation technologies in the field of Agriculture Water Resources Accounting and Allocation

Learning Objectives (LO). Participants will be able to:

LO 1: Explain what is water accounting, define main concepts, features, approaches and challenges in its application.

LO2: Explain the concept of rapid water accounting and identify elements for water budget application including data needs and gaps.

LO3: Understand the role (and challenges) of EOT in the application for water accounting for agricultural applications.

LO4: Apply (rapid) water accounting for a case study.

LO5: Understand the importance of stakeholder analysis and engagement and scenario development in water accounting and the linkage to water allocation and governance

Learning Objective	Topic/Activities	Online Resources	Modality	Course load
LO1: Explain what is water accounting, define main concepts, features, approaches and challenges in its application	• What is water accounting (benefits and challenges) • Important definitions and concepts and approaches to water accounting • Case studies and application examples	Topic: 1 - Introduction to Water Accounting | MOOC: Water Accounting and Auditing | OCW IHE DELFT (un-ihe.org)	face to face	1.5 day

Learning Objective	Topic/Activities	Online Resources	Modality	Course load
LO2: Explain the concept of rapid water accounting and identify elements for water budget application including data needs and gaps	• What is rapid water accounting and water budget • Data needs for conducting water budget • challenges in water budget calculations	Topic: 2 - Rapid Water Accounting | MOOC: Water Accounting and Auditing | OCW IHE DELFT (un-ihe.org)	face to face	1 day
LO4: Understand the role (and challenges) of EOT in the application for water accounting for agricultural applications	• What are the available EOT for water accounting and budget calculations including challenges and uncertainty • How can EOT/RS support the application of water accounting (data gap) • Water budget calculation using RS	Topic: 3A Introduction to WA+ | MOOC: Water Accounting and Auditing | OCW IHE DELFT (un-ihe.org)	face to face	2.5 day
LO5: Apply (rapid) water accounting for a case study	• Select a case study (set objective for the application) • Collect and process data • Understand soil moisture, get familiar with WaPOR Data and Python • Visualize and evaluate results	Topic: 4A Applying WA+ | MOOC: Water Accounting and Auditing | OCW IHE DELFT (un-ihe.org)	Face to face theory and hands on exercise	5 days
LO6: Understand the importance of stakeholder analysis and engagement and scenario development in water accounting and the linkage to water governance	• Importance of stakeholder engagement (stakeholder analysis) • how can we use water accounting for scenario development • Water accounting and policy making and governance	1- https://ocw.un-ihe.org/course/view.php?id=194&section=10#tabs-tree-start 2- https://ocw.un-ihe.org/course/view.php?id=194&section=14#tabs-tree-start	face to face	2 days
Assessment	• Group work on a case study to complete the WA analysis including scenarios and basic stakeholder analysis • presentation of results		Group work and final presentation	3 days

3.2.2. Module B: Application of Earth Observation technologies on Water Productivity in Agriculture under water scarcity conditions

Learning Objectives (LO). Participants will be able to:

LO 1: Explain the use of remote sensing in assessing water use in agriculture and the estimation of biomass production.

LO 2: Analyse remote sensing products for land use statistics.

LO 3: Apply remote sensing-based approach to estimate high resolution actual evapotranspiration and biomass production.

LO 4: Conduct a remote sensing-based application for an agricultural landscape using indicators such as water productivity.

Learning Objective	Topic/Activities	Online Resources	Modality	Course load
LO1: Explain the use of remote sensing in assessing water use in agriculture and the estimation of biomass production	• Theory of methods for deriving agricultural water use and biomass production data from remote • sensing (incl Surface Energy Balance Models and Penman Monteith method), Introduction to • PyWaPOR model, hands-on exercise on running PyWaPOR to estimate ET, biomass production	https://ocw.un-ihe.org/course/view.php?id=214&section=1#tabs-tree-start	face to face	3 day
LO2: Analyse remote sensing products for land use statistics	• Satellite data pre-processing; mapping and visualizing spatial data; hands-on exercise on deriving • Vegetation indices, zonal statistics using open source software	-	face to face	2 day
LO3: Apply remote sensing based approach to estimate high resolution actual evapotranspiration and biomass production	• Introduction to PyWaPOR model, hands-on exercise on running PyWaPOR to estimate ET, biomass production.	https://ocw.un-ihe.org/course/view.php?id=214&section=2#tabs-tree-start Hands on exercises	face to face	5 day

Learning Objective	Topic/Activities	Online Resources	Modality	Course load
LO4: Conduct a remote sensing based application for an agricultural landscape using indicators such as water productivity	• Convert biomass information retrieved from satellite data to compute crop water productivity and • irrigation performance indicators (IPA)		face to face	2 day
Assessment	• Group work on a case study to complete the WP and IPA analysis including scenarios and basic stakeholder analysis • presentation of results		Group work and final presentation	3 days

3.3. **Workshop**

Objectives (O):

O1: Support knowledge exchange between water and agricultural experts of participating countries

O2: Facilitate the interaction with experts in the field, collaborate and exchange experiences with participants from other countries.

O3: Discuss the usefulness of EOT for policy making in the field of water and agriculture

O4: Collect feedback

Learning Objective	Activities
O1: Support knowledge exchange between water and agricultural experts of the five selected countries	Presentation from each country on the case study worked on (2 presentation from each country – water and agriculture)
O2: Facilitate the interaction with experts in the field, collaborate and exchange experiences with participants from other countries.	Feedback and discussion between presenters of each case study (overview of results from the water and agriculture participants) Feedback and discussion between the different country participants (cross country interactions) Feedback from international experts on presentations
O3: Discuss the usefulness of EOT for policy making in the field of water and agriculture	Interactive session with policy makers