CIHEAM
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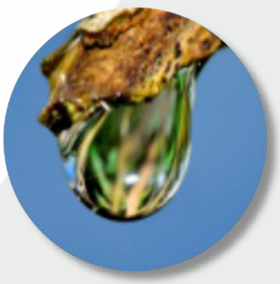
MASTER COURSES
2021-22

Master in
Sustainable Water and Land Management in Agriculture



Academic Year 2021 - 2022

DESCRIPTION

The Master aims at preparing a new generation towards professional and academic careers, and to enable their effective contribution to the sustainable management of water and land resources in agriculture, and to the socio-economic development thereof, in view of important challenges that include water scarcity, land degradation, demographic pressures, and climate change. A major focus is on the increase of cross-sectoral coherence between Sustainable Development Goals, and the application of modern technologies and tools that integrate agronomic, engineering, environmental and socio-economic aspects of water and land management in agriculture.

Students follow theoretical and practical sessions that aim at framing improved management of water and land resources, at increasing food production using less water, and reversing land degradation. The programme presents the basic principles, and the latest scientific and technological achievements in irrigation systems at farm and large-scale level, taking into consideration the application of innovative "green" management solutions.

At the end of the programme, students will acquire the skills to apply integrated approaches of water and land management for sustainable agriculture and food systems, under significant challenges of climate change, resource scarcity, societal changes and food insecurity. Specifically, they will acquire the following competencies:

- management of water resources in agriculture with a view to land conservation and water use efficiency increase in Mediterranean agroecosystems,
- management of a range of alternative water resources including saline and reclaimed water, and water harvesting systems for irrigation purposes,
- planning and evaluation of irrigation projects, at farm and large-scale level to optimize water/land/nutrient use, considering societal/institutional aspects and economic criteria,
- knowledge of the latest technologies and tools for a sustainable management of water resources at different scales and in different agroecosystems.

The program is organized in 8 Units, awarding 60 credits in total (see details in the table below). Unit I and Unit II are implemented in distance learning modality.

Units	Credits	Calendar
Unit I - Sustainability in agriculture and food systems	6	4 – 29 October 2021
Unit II – Climate “smart” agroecology	6	1 – 26 November 2021
Unit III - Basic concepts of sustainable land and water management	4	6 – 17 December 2021
Unit IV - Sustainable on farm water management	8	20 – 31 December 2021 3 – 14 January 2022
Unit V - Irrigation planning, design and management	8	24 January - 25 February 2022
Unit VI - Use of smart tools in agriculture	4	28 February – 11 March 2022
Unit VII - Use of Alternative Water Resources in Agriculture	8	14 March – 8 April 2022
Unit VIII - Water Economics and Governance	8	11 – 15 April 2022 26 April – 16 May 2022
Unit IX - Irrigation project design: an integrated approach	8	17 – 21 January 2022 16 May – 10 June 2022

UNIT I – SUSTAINABILITY IN AGRICULTURE AND FOOD SYSTEMS

Food systems encompass all elements (environment, people, inputs, infrastructures, institutions, etc.) and activities relating to the production (cf. agriculture), processing, distribution, and consumption of food. They include the supply and consumption features as well as the food environment that has an influence on food access. Over the last decades, food systems have been central in the debate on sustainable development (cf. Sustainable Development Goals - SDGs). Indeed, food systems are under an unprecedented confluence of pressures and lie at the centre of a global nexus of environmental, social and economic problems, as humanity faces the challenge of achieving sustainable food security in the face of ecosystem degradation and biodiversity loss, resource scarcity, human population growth, and climate change. On the one hand, food systems are among the main contributors to sustainability challenges such as land degradation, climate change, biodiversity loss, etc. On the other hand, they are dramatically affected by these challenges facing humanity. Moreover, the dysfunction of modern food systems is a major cause of several societal issues such as food insecurity and malnutrition, rural poverty and livelihoods vulnerability, social inequality. This has all culminated in different calls for the transformation of food systems and their transition towards sustainability. Transition to sustainable agri-food systems is the objective of many policies, strategies, and initiatives. While some initiatives focus on single stages of the food chain (e.g. sustainable agriculture, sustainable diets), others are more systemic and holistic (e.g. short food supply chains, alternative food networks). Food-related challenges are particularly pressing in the Mediterranean where there is an urgent need for action.

Aims

- Explaining the concepts of sustainability and sustainable development and the way of applying them to agriculture and food systems (cf. sustainable agriculture, sustainable diets, sustainable food systems),
- Exploring environmental, social, economic, and health-nutritional challenges affecting the sustainability of agriculture and food in the Mediterranean area and worldwide,
- Introducing examples of sustainability assessment approaches and showing how they have been used in agriculture and food systems,
- Presenting policies, strategies, and initiatives to foster transition towards sustainability in agriculture and food systems in the Mediterranean, European Union and worldwide.

Learning outcomes

By the end of the Unit, students will be able to:

- ✓ Understand the concepts of sustainability and sustainable development and apply them to agriculture and food systems,
- ✓ Explain sustainability challenges regarding agriculture and food in the Mediterranean area and worldwide,
- ✓ Know how sustainability assessment approaches are used in agriculture and food systems with practical examples,
- ✓ Understand strategies, pathways, and actions for transition towards sustainability in agriculture and food systems.

UNIT II – CLIMATE SMART AGROECOLOGY

Agroecology is a relative new discipline that studies the ecological complexity and functioning of the agroecosystem. It is therefore a key discipline to drive the transition of agriculture towards sustainable paths, facing the challenges posed by climate change. It focuses on biological processes and on how they interact and influence the functioning of agroecosystems and farming systems, to propose sustainable agricultural practices. Concepts of biodiversity, natural capital and the provision of ecosystem services will be analyzed and the agroecosystem will relate to the use of natural resources, health of soil, plant, environment and ecosystems in relation to abiotic and biotic threats under a changing climate.

Aims

The course aims to provide a widely applicable knowledge base to increase agroecosystems' resilience and production in a changing climate scenario.

- Explaining agroecosystems functioning,
- Examining the agroecosystems' complexities and challenges,
- Reviewing agroecological practices which enable a more sustainable production,
- Understanding how climate change affects agroecosystems functioning,
- Identifying sustainable management solutions to mitigate and adapt to climate change and other global drivers of change,
- Understanding the value of agroecological approach for improving rural livelihood and promote social equity.

All along the course, practical sessions are promoted to provide and improve skills, knowledge, and abilities of students, to use specific tools and technologies that enable proper analysis of agroecosystems and biodiversity at different scale and support rational management of natural resources at multiscale levels.

Learning outcomes

At the end of the Unit students will:

- ✓ become knowledgeable on principles of agroecology and related practices,
- ✓ acquire practical skills on integrated multi scale agroecosystem analysis,
- ✓ achieve basic knowledge on nature-based solutions for biodiversity and ecosystem service provision,
- ✓ understand how climate change affects agroecosystems and sustainable management practices for adaptation and mitigation across energy-food-ecosystem nexus.

UNIT III – LAND AND WATER RESOURCES: BASIC PRINCIPLES OF SUSTAINABLE MANAGEMENT

The unit will deepen the main challenges that land, and water resources are facing in Mediterranean environments and beyond, including climate change impacts. Nevertheless, the focus will be on land and water use in agriculture. In more detail, the key concepts of soil genesis, pedologic features, soil resources classification and survey will be debated and integrated with hands-on practices of soil profile studies. The interaction between soil moisture and temperatures regimes and how they influence soil properties, land degradation, desertification, drought, and land use planning will be discussed. The most prominent practices for sustainable land and water management to reverse and mitigate land degradation in various Mediterranean ecosystems will be illustrated.

AIMS

The main objective of the Unit is to increase the knowledge base of students on:

- soil, land, and water resources and their primary role in biomass production including food and ecosystem services.
- land degradation and desertification processes and the best management practices to mitigate their negative impacts.

The Unit will provide basic knowledge on the following:

- Soil genesis
- Soil survey
- Soil classification systems
- Geo-referenced soil information systems
- WOCAT[1] methodology for sustainable land and water management
- Out-scaling and upscaling the best management practices

LEARNING OUTCOMES

At the end of the Unit, students will acquire:

- ✓ Comprehensive knowledge on characteristics and diversity of soil, land, and water resources with major focus on the Mediterranean region.
- ✓ Basic concepts of integrated natural resources management including both bio-physical and socio-economic indicators.
- ✓ Overwhelming experience to assess land degradation process in a landscape context.
- ✓ Principles of implementing sustainable land and water management and its out-scaling
- ✓ Knowledge on factors that govern land and water management in an ecosystem-based approach and with multi-stakeholder involvement.

[1] *World Overview of Conservation Approaches and Technologies* (*WOCAT*) is a network of Sustainable Land Management (SLM) specialists from all over the world.

UNIT IV – SUSTAINABLE ON-FARM IRRIGATION MANAGEMENT

Sustainable on-farm irrigation management integrates various agronomic and engineering aspects of the most relevant bio-physical and hydrological principles, laws governing soil-plant-atmosphere continuum processes, and optimization of crop growth under different environmental conditions and management limitations.

Through theoretical and practical sessions, this Unit provides the basic and advanced knowledge to determine soil physical and hydro-pedological characteristics, elaborate agro-meteorological data, optimize irrigation scheduling, and model crop growth for a sustainable on-farm irrigation management.

Aims

Providing theoretical knowledge and explaining basic and advanced concepts and relations on the topics of interest to practical application of sustainable on-farm irrigation management practices. Hence, the Unit focuses on:

- understanding soil physical properties and processes,
- collecting and interpreting agro-meteorological data,
- investigating complex interactions of the Soil-Plant-Atmosphere Continuum,
- estimating crop water requirements and crop response to water,
- optimization of irrigation scheduling,
- Resource use efficiency and crop water productivity,
- Crop growth modelling,
- Smart on-farm irrigation management practices and tools.

Learning outcomes

Students enhance their theoretical understanding of the above topics and acquire practical skills and capacity to use:

- ✓ field and laboratory equipment/procedures for acquisition/analysis of soil samples, agro-meteorological data, and crop physiological status/parameters,
- ✓ irrigation-scheduling tools based on the soil water balance under different environmental conditions, management limitations and irrigation methods,
- ✓ crop growth modeling to simulate development, growth, and yield as a function of the soil-plant-atmosphere dynamics and management practices,
- ✓ a practical smart irrigation tool (app) for on-farm irrigation management.

UNIT V – IRRIGATION SYSTEMS DESIGN, PLANNING AND MANAGEMENT

The scientific understanding combined with new technology leads to better development, maintenance, and management of durable and efficient delivery systems that convey irrigation water from its source to the land and provide reliable services to users. This Unit explores an integrated approach that fosters an efficient management of surface and ground water in agriculture, and a resilient design of irrigation systems, in a performance-oriented perspective. Students learn about advances, technologies, and innovations in farm irrigation technologies, multi-objective planning, design, and management of large-scale irrigation systems, use of renewable energy in water systems, and management practices and approaches towards an integrated groundwater management applied to agricultural environments. They also acquire knowledge on how a system would react to fluctuations of its input (supply and/or demand), and thus an understanding, through a problem-solving approach, of the location of bottlenecks, of the importance of failures and, consequently, of actions to be built in. This curriculum is built on the key supporting sciences of hydrology, hydraulics, soil and plant science, and economics.

Aims

- developing the theoretical, conceptual, and practical knowledge about the processes that contribute to surface and groundwater sustainability and resilience
- providing the general overview and systems level knowledge on the technical and engineering aspects of irrigation water equipment and infrastructure,
- familiarizing students with the latest insights, concepts, and theories of irrigation technologies for sustainable development,
- planning, designing, operating, maintaining, controlling, and managing water resources and irrigation-related infrastructure, emphasizing the modernization of irrigation.

Learning outcomes

On conclusion of the Unit, the student:

- ✓ acquires knowledge on surface and groundwater management in agricultural settings,
- ✓ fully understands the delivery processes, structural components, function and performance of irrigation systems and the interaction of scales,
- ✓ masters different types of irrigation systems, techniques, and technologies, and is able to use the most appropriate, under different conditions,
- ✓ builds technical background for system level planning, operation, maintenance, control, and management.

UNIT VI – SMART TOOLS FOR THE MANAGEMENT OF NATURAL RESOURCES IN AGRICULTURE

Nowadays, the sustainable planning and management of agriculture rely a lot on a range of SMART tools that make possible the fast collection and analysis of large geo-spatial data. Remote sensing, Geographic Information Systems and Global Position Systems, are commonly applied to a variety of fields that include farming systems analysis, water and irrigation management and are used for the acquisition, management, processing, analysis and display of spatial data and information.

The use of these technologies requires the access to software (open licenses) and devices, often combined and integrated.

Aims

The main objective of the Unit is to present how SMART tools may help support decisions in agriculture towards a sustainable management of natural resources, using modern approaches and tools available in geomatic, geoscientific and computer science environments.

In particular, the Unit provides basic knowledge for the use and applications of the following technologies:

- Remote sensing
- Geographic Information System
- Cartography and Geographic Positioning System

Learning outcomes

At the end of the Unit, students will acquire:

- ✓ basic concepts, principles, methods, and practical applications of the Geographic Information System (GIS), Cartography and Geographic Positioning System (GPS).

fundamental concepts of remote sensing for the management and sustainability of the territory, the agricultural system, and the water resources.

UNIT VII – USE OF ALTERNATIVE WATER RESOURCES IN AGRICULTURE

Pressures from population growth and climate change have widened the gap between the availability and the demand for water in agriculture, reaching unsustainable levels in some regions, especially in the Mediterranean region. Thus, it is imperative to re-orientate the best water management practices in agriculture towards Alternative Water Resources (AWR) use, such as drainage water, treated wastewater, rainwater harvesting, and desalinated water with varying levels of treatment. It has been argued that the safe use of AWRs in irrigated agriculture provides numerous socio-economic benefits. However, processes in water treatment are complex and capital-intensive and produce additional environmental and economic impacts for ensuring appropriate water quality.

This Unit offers a holistic approach towards AWR management and practices in agriculture as a sustainable, safe, innovative, and cost-effective way of improving community access to water in water-scarce areas. This contributes to climate change adaptation and preserves soil and crop quality, ensuring crop productivity to match current population growth. The major focus is on:

- the reuse of low-quality waters, the treatments, methods, and processes,
- salinity control and its impact on soils and crops,
- drainage systems design and management,
- rainfed agriculture techniques.
- impact assessment of AWRs reclamation and use: a holistic point of view

Aims

Explaining the main techniques, strategies, technologies, and assessment tools related to the use of AWR in agriculture.

- examining the role of AWR as a potential contributor to water and food security,
- reviewing agricultural practices adoption with alternative sources of water in supporting farming sustainability,
- proposing irrigation and agriculture management practices and monitoring techniques to control deep percolation fluxes and limit soil and groundwater contamination.
- evaluating the holistic environmental, costing, and social impacts of different AWRs reclamation and reuse practices.

Learning outcomes

Students will:

- ✓ acquire a better understanding of the role of AWR use in water scarcity alleviation and irrigation management,
- ✓ develop knowledge on the water treatment techniques for safe and proper management and use of AWR in agriculture,
- ✓ discuss irrigated agriculture and techniques suitable for the use of AWR and assess its impact on soil and crop production,
- ✓ highlight the regulation related to the use of AWR in agriculture and its management,
- ✓ implement sustainable water management in agriculture projects using AWR.

- ✓ develop working knowledge of applying life cycle thinking methods in water management (both from conventional and non-conventional resources).

UNIT VIII – WATER ECONOMICS AND GOVERNANCE

Basic concepts of economics applied in irrigated agriculture and water management at farm, district and basin level are explored for an efficient water allocation and irrigation projects' planning. By considering the major institutional dimensions of the Mediterranean irrigation sector, the following main topics are addressed:

- ❖ technical and allocative efficiency in multi-input and multi-output farm production process,
- ❖ agro-economic mathematical programming models,
- ❖ analysis of the main farm accounting balance sheet and income statement components,
- ❖ Cost Benefit Analysis to evaluate the economic and financial feasibility of investment projects,
- ❖ main institutional models of water governance with a particular focus on participatory approaches and water pricing policies in Mediterranean countries.

Aims

Explaining:

- ❖ how to plan the optimal allocation and use of water resources at farm and irrigation district scale,
- ❖ how to assess the economic feasibility of irrigation project,
- ❖ the environmental and economic impacts of economic tools and policies adoption in irrigation water management,
- ❖ the guiding principles and challenges of participatory approaches in irrigation management (PIM) and transfer (IMT) with a focus on the Mediterranean countries.

Learning outcomes

Students will:

- ✓ understand the role of economic parameters and criteria in the water management decision making process at farm and basin scale,
- ✓ acquire knowledge on quantitative methods used to support agricultural policies decision making,
- ✓ develop skills to comparatively assess the effectiveness of water policies and water governance models in irrigation sector,
- ✓ learn how to implement simple Cost/Benefit Analysis in irrigation projects.

UNIT IX – IRRIGATION PROJECT DESIGN: AN INTEGRATED APPROACH

An irrigation project at district level is designed, capitalizing on the knowledge acquired in the different Units. It integrates the environmental, agronomic, engineering, and socio-economic dimensions.

This process includes a comprehensive analysis of climatic, soil and crop data, the identification of the optimal cropping pattern, and the hydraulic design of a large-scale pressurized distribution network under different scenarios of water availability and quality, and energy sources. This Unit integrates the use of GIS tools, simulation, and optimization models.

Aims

The Unit aims at developing a comprehensive logical approach to the design and management of irrigation systems. It also aims at developing the analytical skills and abilities of trainees to observe, research and interpret complex problems and solutions.

Learning outcomes

Students will be able to:

- ✓ use and interpret climate, soil, crop data,
- ✓ determine the crop response to water and soil hydrological behaviour,
- ✓ optimise water allocation for irrigation at farm and district level,
- ✓ design and model the energy and hydraulic operation and management performance of irrigation systems in a service-oriented perspective,
- ✓ evaluate the economic feasibility and environmental impacts of irrigation projects.