Guidelines on planning infrastructure and irrigation strategies to contrast saltwater intrusion

Deliverable D_5.2.4

Contributing partners:

LP – UNIPD DICEA

Table of contents

1. Criteria to identify actions

- Efficiency for crop growth
- Doable by the farmers
- Affordable by the farmers
- Suitable for the specific environment of the Veneto Region coastal areas
- Implementation of available technologies

2. The guidelines framework

Each action is described using the following scheme:

ACTION NAME	
DESCRIPTION AND OBJECTIVES	
HOW TO RREALIZE THE MEASURE	
WHERE TO REALIZE THE MEASURE	
ADVANTAGES	
DISADVANTAGES	
EFFICACY-COST-TECHNOLOGY-ENVIRONMENT-APPLICABILITY	
ACTORS INVOLVED	
NORMATIVE REFERENCES	

3. Guidelines: water management

3.1 Pre-planting or early stage irrigation with freshwater

DESCRIPTION AND OBJECTIVES	The germination and seedling stages are the most susceptible to salt injury. For this reason, an early-season application of freshwater designed to leach salts from the root zone may provide good enough condition for the crop
HOW TO RREALIZE THE MEASURE	The water can be applied with sprinkler irrigation systems such as hose reels
WHERE TO REALIZE THE MEASURE	The pre-plant irrigation should be performed in the farms where: • Irrigation water with ECw < 2.4 mS/cm is available. The limit of ECw < 1 mS/cm is applied for very sensitive crops • Irrigation water with low SAR; ECw and SAR should be evaluated together following the irrigation water quality guidelines
ADVANTAGES	• Reduction of germination failure • Reduction of irrigation events and water consumption
DISADVANTAGES	Early-stage irrigation with freshwater may be insufficient to guarantee successful crop growth during late stages depending on the weather conditions during the growing season
EFFICACY-COST-TECHNOLOGY-ENVIRONMENT-APPLICABILITY	
ACTORS INVOLVED	Farmers
NORMATIVE REFERENCES	DGR n. 1687 of 29 November 2021

3.2 Frequent irrigation with low water volume (surface or subsurface drip irrigation)

DESCRIPTION AND OBJECTIVES	Surface or subsurface high frequency irrigation with low water volumes keep the soil at high moisture content and prevent increasing the salt concentration in the root zone
HOW TO RREALIZE THE MEASURE	The water can be applied with surface drip irrigation or drip tape systems depending on the crop type. The salinity of irrigation water should be monitored to plan the crop water requirements: the more saline the water, the more water needed
WHERE TO REALIZE THE MEASURE	Farms where irrigation water is available during all the growing season. The water can be fresh or brackish and should be managed according to its salinity and SAR
ADVANTAGES	• Salt leaching to groundwater is avoided • High water use efficiency • Surface drip irrigation avoids wetting the leaves with salt water • High frequency irrigation can be performed with brackish water • Drip irrigation systems allow fertigation (i.e., the application of fertilizers through irrigation water) improving the fertilizers use efficiency
DISADVANTAGES	• Drip irrigation with saline water might increase the risk of salinization of upper soil horizons • Cost of the irrigation system • Plastic residues
EFFICACY-COST-TECHNOLOGY-ENVIRONMENT-APPLICABILITY	
ACTORS INVOLVED	• Land reclamation authority • Farmers
NORMATIVE REFERENCES	DGR n. 1687 of 29 November 2021

3.3 Subirrigation with freshwater

DESCRIPTION AND OBJECTIVES	Subirrigation by capillary rise from groundwater; groundwater level can be controlled by the land reclamation authority or by the subsurface drainage systems
HOW TO RREALIZE THE MEASURE	The depth to the water table may be increased or lowered depending on the crop needs. Subirrigation by capillary rise should only be performed if the groundwater is fresh; drainage pipes can be used to remove excess water and salts and, in turn, prevent salt/water stress
WHERE TO REALIZE THE MEASURE	Capillary rise from groundwater can be performed where the groundwater level is shallow and regulated by pumping systems; subsurface drainage systems must be available or can be installed ex-novo; natural features such as paleochannels can be exploited to recharge the groundwater level; freshwater sources must available
ADVANTAGES	• no evaporation during the distribution • low evaporation from soil • double use in case of subsurface drainage systems
DISADVANTAGES	• Impossibility to apply pre-planting or early-stage irrigation • Capillary rise from groundwater required a careful water management by authorities
EFFICACY-COST-TECHNOLOGY-ENVIRONMENT-APPLICABILITY	
ACTORS INVOLVED	• Land reclamation authority • Farmers
NORMATIVE REFERENCES	DGR n. 1687 of 29 November 2021

3.4 Precision irrigation

DESCRIPTION AND OBJECTIVES	Application of water where and when is needed considering spatial and temporal variability (e.g., weather conditions, soil salinity, soil texture, groundwater depth, groundwater salinity). Precision irrigation can also be scheduled according to soil sensor data
HOW TO RREALIZE THE MEASURE	Precision irrigation strategies require: Variable rate irrigation (VRI) systems: pivot or drip irrigation systems Field variability mapping (e.g., apparent electrical conductivity maps) and definition of management zones
WHERE TO REALIZE THE MEASURE	• Farms characterized by spatial variability • Farms in which VRI irrigation systems are already functioning → cost reduction
ADVANTAGES	• High water use efficiency • Possibility to apply site-specific leaching requirement • Possibility to perform fertigation
DISADVANTAGES	• Initial cost if irrigations systems are not present • Cost for spatiotemporal variability monitoring • Energy cost (pivot systems) • High expertise needed
EFFICACY-COST-TECHNOLOGY-ENVIRONMENT-APPLICABILITY	
ACTORS INVOLVED	Farmers
NORMATIVE REFERENCES	DGR n. 1687 of 29 November 2021

3.5 Percolation and groundwater drainage (leaching)

DESCRIPTION AND OBJECTIVES	Application of water in an amount greater than evapotranspiration causing a fraction of the applied water to flow through the root zone flushing away the excess salts. A drainage systems may be necessary to avoid excessive water table rise
HOW TO RREALIZE THE MEASURE	The fraction of water that must be percolated out of the root zone to prevent average soil salinity from rising above a specific level is called leaching requirement. The EC threshold of the soil solution should be defined depending on: • Crop parameters: sensitivity to salinity, crop phenological stage, crop status (if already stressed or not) • Irrigation water parameters: salinity and SAR Leaching soils may be performed using two different strategies: • Continuous flooding (e.g., rice cultivation) • Keeping water content near saturation (e.g., under low-intensity sprinkling or intermittent ponding)
WHERE TO REALIZE THE MEASURE	The measure can be applied where high amounts of irrigation water are available and in the farms where there is the possibility to exploit VRI technology; to be avoided in absence of an efficient drainage systems or in sensitive areas for water pollution
ADVANTAGES	• Salts leaching • Groundwater recharge
DISADVANTAGES	• Possible groundwater degradation (nutrients, agrochemicals, and salts leaching) • Reduction of nutrients use efficiency • Percolation must be optimized to avoid excessive water table rise (except for rice) • Flood irrigation with high SAR water may cause the break-down of soil aggregates

EFFICACY-COST-TECHNOLOGY-ENVIRONMENT-APPLICABILITY	
ACTORS INVOLVED	• Land reclamation authority • Farmers
NORMATIVE REFERENCES	DGR n. 1687 of 29 November 2021

3.6 Irrigation scheduling according to soil sensors data

DESCRIPTION AND OBJECTIVES	Irrigation scheduling according to soil sensor data (soil moisture, soil EC, ECa). Soil ECa, EC or moisture thresholds should be defined according to the salinity of irrigation water, crop tolerance and phenological stage, soil characteristics; new soil sensors estimate salinity in pore water and in turn osmotic potential; to be consider for dynamic moisture thresholds
HOW TO RREALIZE THE MEASURE	Installing a network of soil moisture and EC sensors whose number will depend on the soil variability. It is possible to develop a smartphone application connected with an array of wireless sensors for irrigation scheduling
WHERE TO REALIZE THE MEASURE	• Farms characterized by low spatial variability: few sensors needed, possibility of homogeneous water distribution • Farms characterized by high spatial variability if a VRI system is already implemented
ADVANTAGES	• Low cost if irrigation systems are already operating in the farm • The irrigation systems can be automated according to the sensor data
DISADVANTAGES	• Sensor costs • Sensor installation and maintenance (high expertise required)
EFFICACY-COST-TECHNOLOGY-ENVIRONMENT-APPLICABILITY	
ACTORS INVOLVED	Farmers
NORMATIVE REFERENCES	DGR n. 1687 of 29 November 2021

3.7 Farm ponds

DESCRIPTION AND OBJECTIVES	Water retention ponds are artificial basins built by farmers or farmer networks to guarantee the presence of water for irrigation during the periods of scarcity and thus a higher soil water content
HOW TO RREALIZE THE MEASURE	Water retention ponds are mainly built by excavation. If present, a clay layer can be used as bottom impermeable component, otherwise the waterproofing of the bottom may be needed to prevent the upward movement of salty groundwater. A pumping system is needed to: collect the water from the river and fills the pond collect the water from the pond for irrigation
WHERE TO REALIZE THE MEASURE	Farms where: • the availability of irrigation water is not guaranteed during the summer • the distance from the surface water network is suitable for water collection
ADVANTAGES	• European incentives • Retention ponds can be designed to improve ecological performance by creating buffer vegetation, and building floating islands that serve as refuges for wildlife and aquatic fauna (green ponds)
DISADVANTAGES	• The construction of water retention ponds requires the availability of some land ha. For this reason, the action is suitable for big farms only (> 100 ha) • Cost for excavation, waterproofing and perimeter fence: 12-14 €/m^3 of water stored • Cost for water pumping (fuel cost)
EFFICACY-COST-TECHNOLOGY-ENVIRONMENT-APPLICABILITY	
ACTORS INVOLVED	Farmers
NORMATIVE REFERENCES	Law n. 205 of 27/12/2017 art. 1 - DGR n. 1687 of 29 November 2021DGR n. 1687 of 29 November 2021

3.8 Measuring the amount and quality of irrigation water

DESCRIPTION AND OBJECTIVES	Measuring the amount and quality of irrigation water allows to optimize irrigation applications and evaluate risk of salinization due to low quality waters
HOW TO RREALIZE THE MEASURE	Installing flowmeters and salinometers at the irrigation pumps
WHERE TO REALIZE THE MEASURE	In each farm
ADVANTAGES	• Increase of water use efficiency • Reduction of water pollution • Reduction of energy consumption
DISADVANTAGES	• Device cost • Expertise required for installation and functioning
EFFICACY-COST-TECHNOLOGY-ENVIRONMENT-APPLICABILITY	
ACTORS INVOLVED	Farmers
NORMATIVE REFERENCES	D. Lgs n. 152/2006 - Directive 2000/60/CE - DGR n. 2240/2016 - MIPAAF Guidelines 31/057/2015 - DM 39/2015

3.9 Subsurface barriers

DESCRIPTION AND OBJECTIVES	Precluding or limit the saltwater wedge intrusion in shallow aquifers through physical barriers (subsurface dam or cut-off wall)
HOW TO RREALIZE THE MEASURE	By bentonite injection or realizing a dig filled by natural material with low hydraulic conductivity (clay)
WHERE TO REALIZE THE MEASURE	Along the coastline or at the farmland side of the river levee
ADVANTAGES	• Limit the saltwater intrusion • No maintenance required
DISADVANTAGES	• Device cost • The device must be established before the salinization starts • Risk related to the subsurface dam to lead an irreversible salinization if overpassed by saline water
EFFICACY-COST-TECHNOLOGY-ENVIRONMENT-APPLICABILITY	
ACTORS INVOLVED	Land and water authorities
NORMATIVE REFERENCES	D. Lgs n. 50 of 18/4/2016 for the public work assignment - State, Regional, and Local regulations

3.10 Surface barriers across the river

DESCRIPTION AND OBJECTIVES	Limit the seawater encroachment close to the river mouth by means of mobile barriers
HOW TO RREALIZE THE MEASURE	Construction of mobile dam by a proper system of gates
WHERE TO REALIZE THE MEASURE	Nearby the river / channel mouth
ADVANTAGES	• Reduction of seawater contamination of the river • Enhancing the freshwater storage in upstream river during drought periods • Limit the later dispersion in the subsurface from the riverbed
DISADVANTAGES	• Device cost • Expertise required for installation and functioning • Limitations of ships / boat mobility
EFFICACY-COST-TECHNOLOGY-ENVIRONMENT-APPLICABILITY	
ACTORS INVOLVED	National, Regional, and Local authorities - Superintendence for archeology and landscape - Italian army - Private people
NORMATIVE REFERENCES	D. Lgs n. 50 of 18/4/2016 for the public work assignment - National, Regional, and Local regulations

3.11 Optimize the management of reclamation systems

DESCRIPTION AND OBJECTIVES	Enhance the storage of the freshwater in the reclamation channel network
HOW TO RREALIZE THE MEASURE	Optimal management of the pumping stations
WHERE TO REALIZE THE MEASURE	In any area served by a reclamation system
ADVANTAGES	• Increase of water use efficiency • Increase the freshwater intrusion in the soil
DISADVANTAGES	• Expertise required for installation and functioning • Not always suitable
EFFICACY-COST-TECHNOLOGY-ENVIRONMENT-APPLICABILITY	
ACTORS INVOLVED	Land and reclamation authorities
NORMATIVE REFERENCES	-