ERASMUS-EDU-2023-CBHE
Project number: 101129032

Duration: 36 months
(01/01/2024 – 31/12/2026)

LESLIE
LAND MANAGEMENT
ENVIRONMENT &
SOLID-WASTE

MICRO-CREDENTIAL

CLIMATE CHANGE FOR SUSTAINABLE LAND MANAGEMENT IN CENTRAL ASIA

6. – Agriculture, Food Security and Rural Livelihoods

Soil Health, Salinization and Climate Resilience

CC-W06-V23

Co-funded by the European Union

Bukhara State Technical University
(***prev. "TIIIAME" NRU BINRM***)

Learning objectives

1. 
Understand why soil health is central to productive and climate-resilient land management

2. 
Explain how heat, drought, erosion and water management affect soil functions

3. 
Distinguish soil salinity from sodicity and understand how secondary salinization develops

4. 
Identify management and monitoring options for improving soil resilience in Central Asia

→ **Healthy soils are essential for food security, climate adaptation and sustainable development in Central Asia.**

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Soil health: the functional basis of resilience



→ **Climate resilience depends on maintaining soil functions, not simply short-term fertility.**

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Central Asian soils: why vulnerability is high



Dry climate

- Low and variable rainfall
- High evaporative demand
- Sparse cover increases erosion risk



Irrigation dependence

- Large irrigated areas in major river basins
- Drainage performance is critical
- Shallow groundwater can mobilize salts



Land-use pressure

- Intensive cultivation in irrigated zones
- Loss of cover accelerates degradation
- Tillage can reduce structure and carbon



Natural constraints

- Many soils are naturally salt-prone
- Closed basins favor salt accumulation
- Wind erosion is important in drylands

→ **In Central Asia, soil degradation is shaped by climate, hydrology and management together.**

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Climate stress can amplify soil degradation



Higher temperature

- Faster drying of surface soil
- Possible loss of soil organic matter
- Greater evaporative concentration of salts



Drought

- Lower plant cover and root inputs
- Reduced biological activity
- Greater wind-erosion exposure



Intense rainfall

- Runoff and water erosion
- Surface sealing or crusting
- Loss of fine particles and nutrients



Vegetation loss

- Less protection against erosion
- Lower carbon inputs
- Reduced recovery capacity

→ **Climate stress often intensifies pre-existing management and hydrological problems rather than acting alone.**

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What is soil salinization?

Salinization is the accumulation of soluble salts in the root zone to levels that impair soil functions and plant growth.

SALINE SOIL



Dominant issue	High concentration of soluble salts
Typical indicator	Electrical conductivity (EC)
Main plant effect	Osmotic stress reduces water uptake; specific ions may also become toxic

SODIC SOIL



Dominant issue	Excess exchangeable sodium
Typical indicators	SAR / ESP
Main soil effect	Clay dispersion can reduce aggregation, infiltration and hydraulic conductivity

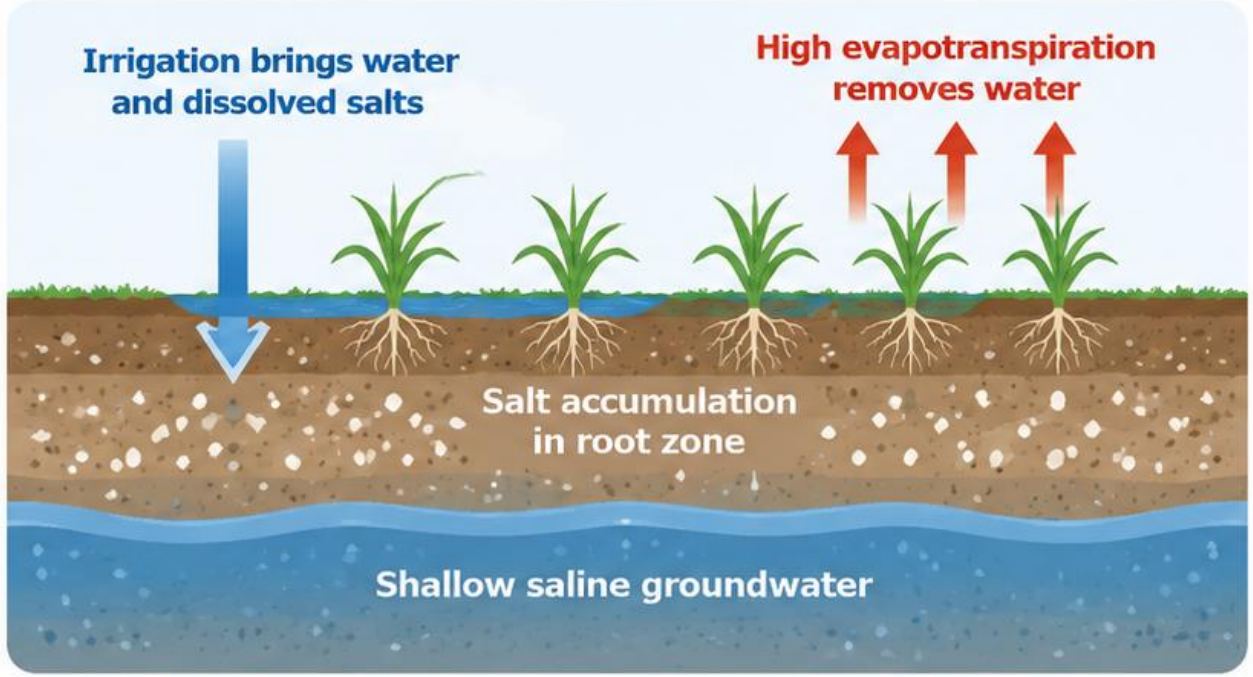
Why the distinction matters

Salinity and sodicity may occur together, but diagnosis determines the correct management response. EC alone does not characterize sodicity.

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How secondary salinization develops in irrigated drylands

The critical mechanism is a salt-balance problem coupled with insufficient drainage.



Salt accumulates in the root zone when leaching and drainage are inadequate

Typical reinforcing factors

1. High evaporation / transpiration
2. Poor drainage or waterlogging
3. Shallow saline groundwater
4. Inefficient irrigation or excess application
5. Saline irrigation or drainage water

→ **Effective salinity control depends on irrigation quality, leaching, drainage and groundwater management together.**

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Salinity in Central Aisa: scale and consequences

Official evidence

1.9 million ha

of Uzbekistan's area equipped for irrigation is reported as saline — **about 46%**

FAO and regional assessments also report widespread salinity and waterlogging problems across irrigated Central Asia, especially in downstream Aral Sea regions.



Main consequences

Plants

osmotic stress, ion toxicity, reduced nutrient uptake

Soil

structure decline where sodicity is high, lower infiltration

Water

greater leaching requirement, saline drainage loads

Farms and livelihoods

yield loss, higher costs, risk of land abandonment

Salinity is both a soil problem and a water-management problem; climate warming can intensify both.

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Prevent – Diagnose – Manage: a salinity strategy

Salt-affected soils require diagnosis first; management depends on the type and severity of the problem.

1 PREVENT
Avoid new salt accumulation



Match irrigation to crop and soil needs



Maintain drainage and safe groundwater depth



Monitor irrigation-water quality

2 DIAGNOSE
Confirm salinity and/or sodicity



Measure soil electrical conductivity (EC)



Assess sodium hazard where relevant



Map spatial variability and root-zone depth

3 MANAGE
Use targeted interventions



Leach salts only where drainage permits



Apply calcium amendments for sodic soils when justified



Use adapted crops and agronomic measures

4 MONITOR
Check whether the soil is recovering



Track EC and sodicity indicators over time



Monitor infiltration, crop response and groundwater



Avoid transferring salts to downstream waters

→ **No single reclamation recipe is valid for all salt-affected soils.**

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Management must match the diagnosis

Salinity and sodicity affect the soil differently, so corrective measures are not interchangeable.



SALINE SOIL

Excess soluble salts in the soil solution

Primary objective	Remove excess soluble salts from the root zone
Core measures	Adequate drainage; controlled leaching; appropriate irrigation-water management; salt-tolerant crops where needed
Key caution	Leaching is ineffective if salts cannot leave the system



SODIC SOIL

Excess exchangeable sodium affecting soil structure

Primary objective	Replace exchangeable sodium and restore structure
Core measures	Calcium amendments such as gypsum when appropriate; subsequent leaching and drainage; organic matter and structure-supporting practices; avoid sodium-rich irrigation water
Key caution	Amendments should follow diagnosis, not precede it

→ **A technically correct diagnosis prevents ineffective interventions and reduces unnecessary water, amendment and energy use.**

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Building soil resilience beyond salinity

Soil resilience depends on maintaining water, carbon, structure and biological activity together.



Protect soil cover

- Crop residues
- Cover crops where feasible
- Wind-erosion protection



Build organic matter

- Return organic residues
- Use compost or manure appropriately
- Reduce unnecessary disturbance



Improve water entry

- Maintain aggregation
- Avoid compaction
- Promote infiltration rather than runoff



Support biological function

- Maintain roots in soil for longer periods
- Avoid severe physical and chemical stress
- Support diverse soil biota

→ **Soil-health practices improve resilience when they are adapted to local climate, soil type, water quality and farming system.**

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Monitoring soil health and salinity

Monitoring should combine physical, chemical, biological and hydrological indicators rather than relying on one measurement.



Physical



Soil structure / aggregate stability



Bulk density and compaction



Infiltration or hydraulic conductivity



Bare ground and erosion



Chemical



Electrical conductivity (EC)



pH



SAR / ESP where sodicity is suspected



Soil organic carbon and nutrients



Biological



Root growth



Soil fauna or microbial indicators



Residue decomposition



Vegetation / crop response



Hydrological



Groundwater depth



Groundwater salinity



Irrigation-water EC



Drainage volume and salinity

→ **Use repeated measurements at comparable locations and depths. Trends are more informative than isolated values, especially in highly variable dryland environments.**

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Regional example: irrigation, drainage and salinity in Uzbekistan

The case illustrates why soil salinity cannot be separated from irrigation and drainage management.

Current challenge



1.9 million ha

of Uzbekistan's area equipped for irrigation is reported as saline — approximately 46%.

This is not only a soil issue. Irrigation efficiency, drainage capacity, groundwater levels and the disposal of saline drainage water all interact.



Management response



Modernise irrigation

Reduce avoidable conveyance and field losses



Improve drainage

Control waterlogging and shallow groundwater



Monitor salinity

Track soil EC, groundwater and drainage-water quality



Target remediation

Prioritise severely affected areas and suitable crops

→ **Regional lesson: salinity control requires coordinated soil, irrigation, drainage and groundwater management.**

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Key Messages

1. 
Soil health is a functional concept: water regulation, structure, carbon and biology matter together.

2. 
Climate stress can intensify existing soil degradation, especially in dry and sparsely vegetated landscapes.

3. 
Salinity and sodicity are different problems and require different diagnostic indicators and management responses.

4. 
In irrigated drylands, salinity is fundamentally linked to water quality, drainage and groundwater control.

5. 
V24 moves from diagnosis to integrated climate-smart and circular practices across crops, livestock, soils and resources.

→ **Next: CC-W06-V24 – Climate-Smart Agriculture and Circular Practices**

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Check your learning

1. Why is electrical conductivity useful for salinity diagnosis but insufficient for diagnosing sodicity?
2. Why can leaching fail if drainage is inadequate?
3. Which indicators would you combine to monitor soil recovery in a salt-affected field?
4. How can climate warming increase salinity risk even if irrigation-water salinity does not change?

Closing thought

Healthy soils are not only more productive; they are better able to absorb shocks, regulate water and support long-term land resilience.



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