CLIMATE CHANGE IMPACT ON RADIOACTIVE WASTE MANAGEMENT: KEY FINDINGS FROM WP11 CLIMATE

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WP11 CLIMATE - OBJECTIVES

EURAD-2 WP11 CLIMATE aims to **identify knowledge gaps** and **provide recommendations** for future research on the **impacts of climate change** on radioactive waste management facilities and sites.

Facility types

- Surface
- Near-surface
- Deep Geological Repositories

Lifecycle phases

- Construction
- Operation
- Post-closure

WP11 CLIMATE - OUTCOMES

White Paper

Challenges
R&D priorities
Call to action

Outcomes to Member States

Key findings
Practical implications
Member State perspective

Synthesis Report

Technical evidence base across facility types, phases and national cases

Domain Insight

Knowledge synthesis
Topic introduction
Long-term preservation

Training

Practical messages
Knowledge transfer
Interactive learning

Civil Society Workshops

Societal perspective
Uncertainty & scenarios
Increased outreach

Climate change must be considered across the full lifecycle

CONSTRUCTION AND OPERATION

Mainly concerned with **extreme weather** and infrastructure performance: disruption of operations, impacts on surface barriers and site access, and worker safety.

- Heavy rainfall
- Flooding
- Heatwaves
- Desertification
- Erosion
- Coastal hazards

POST-CLOSURE

Focus on **system evolution**, barrier performance and exposure pathways, ultimately affecting the safety case.

- Infiltration
- Groundwater flow
- Landscape evolution
- Sea-level change
- Permafrost/glaciation

CONSTRUCTION & OPERATION

The main concern is exposed systems under **changing extremes**

Main Pathways

- Infrastructure performance
- Operations and access
- Surface barriers and drainage
- Worker safety and support systems

Decision focus

- Design basis
- Operational limits
- Monitoring
- Adaptation
- Licensing

Compound and cascading events matter: the combined response can be more important than any single hazard considered in isolation.

POST-CLOSURE

Climate matters through long-term **system evolution**.

Main Pathways

- Hydrogeological boundary conditions
- Barrier performance and geochemistry
- Landscape / erosion processes
- Future exposure pathways

Decision focus

- Scenario development
- FEPs
- Long-term system evolution
- Safety case robustness.

Near-surface Disposals

Have stronger links to infiltration, erosion, cover degradation and shallow groundwater over post-closure.

Deep Geological Disposal

Buffered from direct weather, but sensitive to long-term hydrogeological and geological evolution.

Climate information becomes useful only when it is translated into decision-relevant inputs.

Climate science
projections · observations

Climate scenarios
timescales · states · extremes

Safety-relevant parameters
recharge - sea level - rainfall

System response
FEPs - barriers - hydrogeology

Safety decisions
design - licensing - review

Where CLIMATE repeatedly found the methodological gap

WHERE METHODOLOGICAL GAPS REMAIN

Scale & extremes

Climate-model output exists, but safety assessment often needs different spatial and temporal scales, especially for infrequent extremes.

Century to millennium gap

Near-term projections and geological timescale scenarios are stronger than the intermediate time window for some concepts.

Uncertainty propagation

The key is not to eliminate uncertainty, but to make assumptions traceable and carry uncertainty into system response and decisions.

Construction and operation gaps

Site-specific extreme-event data
Spatial and temporal downscaling
Compound and cascading hazards
Monitoring during infrequent extremes

Post-closure gaps

Century-to-millennium scenarios
Coupled climate–hydrogeological response
Local boundary conditions for long-term models
Long-term erosion / landscape evolution

Harmonise the logic. Common language and proportionality improve transparency and comparability.

Shared European framework

1	**Scenario logic**	How climate futures are selected and bounded
2	**Translation rules**	How climate variables become safety inputs
3	**Uncertainty treatment**	How uncertainty is documented & propagated
4	**Monitoring & review**	How new observations trigger reassessment

Proportionate national implementation

A	**Facility type**	surface - near-surface - DGR
B	**Climate context**	Climate - coast
C	**Programme maturity**	screening → structured scenario assessment
D	**Regulatory context**	national requirements and licensing stage

PRIORITY AREAS FOR FURTHER DEVELOPMENT

Climate & site evidence

- Site-specific monitoring and characterisation
- Downscaling and extreme-event statistics
- Better information for intermediate and long timescales

Assessment methods

- Compound and cascading hazards
- Translation of climate information into safety-relevant inputs
- Scenario-based treatment of uncertainty

System understanding & modelling

- Coupled climate–hydrogeological models
- Erosion and landscape evolution
- Long-term barrier and material performance

Harmonisation & adaptive management

- Common methodological guidance and benchmarking
- Monitoring, thresholds and review triggers
- Dialogue with regulators and stakeholders

Strengthen the evidence, methods and frameworks used to make robust climate-informed decisions.

TAKE HOME MESSAGES

Climate change must be integrated across the full lifecycle from near-term programme decisions to long-term safety assessment.

1 The climate question changes

Dominant processes and risks vary with facility type, climate context, lifecycle phase and timescale.

2 Short- and long-term concerns differ

Near-term safety is driven mainly by extremes and exposed systems; post-closure safety by evolving environmental and hydrogeological conditions.

3 Robust decisions need a stronger method

Shared assessment logic, stronger site evidence, clearer translation to safety inputs and explicit uncertainty treatment improve confidence.

Climate science → TRANSLATE → **Safety-relevant system understanding** → INTEGRATE → **Robust programme decisions**

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