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Risk Alert Briefing: Clay shrink– swell property damage and the increasing protection gap in Europe

*A climate-driven risk for public authorities, insurers and
property owners*

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1 Introduction

Clay shrink–swell (CSS) processes pose an under-recognised but increasingly material risk to buildings and infrastructure across Europe. These processes occur when clay-rich soils contract during dry periods and expand again when moisture returns, causing ground movement that can lead to cracking and structural damage to buildings and infrastructure.

Climate change is projected to significantly increase the frequency and severity of deep-soil drought across large parts of Europe. Climate model projections indicate that by 2050, severe drought episodes affecting deep soil layers may occur approximately three times more often.ⁱ These conditions are strongly associated with CSS events.

Despite the growing hazard, CSS risk remains poorly visible in national climate adaptation planning and insurance arrangements in many EU Member States. At the same time, CSS property damage is typically excluded from standard private insurance contracts – and the protection provided by any state natural catastrophe mechanism (where these exist) is uncertain. This creates an increasing protection gap.

The purpose of this Briefing is to draw attention to this CSS risk and increasing protection gap. Extending our initial analysis of the issue in France to a further five EU countries – Finland, Germany, Italy, Luxembourg and Spain – this Briefing highlights evidence showing a consistent pattern of increasing CSS risk combined with inadequate insurance cover for homeowners.ⁱⁱ Through highlighting this evidence, the Briefing aims to support informed discussion among policymakers, regulators, insurers and public authorities on the implications of climate-driven CSS property damage for housing resilience, insurance markets and climate adaptation.

2 CSS property damage is projected to increase with climate change

CSS property damage can affect buildings and infrastructure constructed on clay-rich soils. During prolonged dry periods clay soils contract as moisture decreases and expand again when moisture returns. Repeated shrink–swell cycles can generate ground movement, placing stress on building foundations and structures. Some of the most frequent property damage caused by CSS events are cracks in the foundations, subsidence of the structure and deformation of walls and floors.

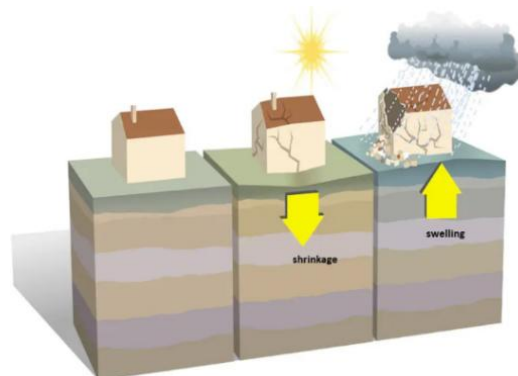


Figure 1: Illustration of clay shrink swell event causing property damageⁱⁱⁱ



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Climate projections based on multi-model global climate simulations indicate a clear drying trend in deep soil layers (60–100 cm) across most of Europe during summer and autumn months. These soil depths are particularly relevant, as previous research has shown a strong correlation between deep-soil drought and CSS property damage. In most areas of Europe, the soil invariably becomes wet and swells back to its original volume in winter. Therefore, it is the dry periods in summer and autumn that pose the largest risk of building damage.

By 2050, severe deep-soil drought events – defined relative to historical baseline conditions – are projected to occur significantly more frequently across multiple European regions. A drought event that occurred approximately twice in 50 years during the late 20th century is projected to occur around five to seven times in 50 years under a medium emissions scenario.^{iv}

While the magnitude of change varies between climate models, there is strong agreement on the overall direction of change: deep soils are becoming drier, and severe drought episodes are becoming more frequent. Although uncertainties remain regarding the precise scale and spatial distribution of future impacts, CSS property damage is expected to become more frequent and more severe over time in many parts of Europe.

3 Exposure, vulnerability and awareness of CSS risks

Large areas in Europe are exposed to CSS property damage through having clay-rich soils that are sensitive to moisture variation. Many residential buildings are in these areas. Economic exposure to drought-induced soil subsidence affecting buildings and infrastructure is already substantial and is projected to increase significantly. This exposure is unevenly distributed but affects all countries examined in this Briefing.

In addition to soil characteristics (exposure) the risk level of CSS property damage depends on vulnerability. The vulnerability of any building depends on factors such as building type, foundation depth, proximity to vegetation, drainage infrastructure and local construction practices. Older buildings with shallow foundations are generally more susceptible, while newer construction techniques might reduce – but not eliminate – the risk. CSS property damage may remain hidden until structural cracks appear, complicating early detection and management.

The level of awareness of CSS risks is also a significant factor. The IPCC Sixth Assessment Report (AR6) identifies CSS events as a risk that can affect the stability of buildings and infrastructure and result in substantial damage costs.^v However, awareness of CSS risks varies across Europe, both among homeowners and within public authorities, creating significant potential for under-preparedness.

Finland: Clay-rich soils in southern and western regions are particularly sensitive to moisture fluctuations, and past events (such as the extreme nine-month drought in 2002–2003) have caused measurable structural damage. While municipal authorities and construction professionals are generally aware of CSS risks, awareness among homeowners is limited. Soil surveys and engineering assessments are recommended for new construction, but proactive measures to manage CSS risk across the wider housing stock seems to remain rare. The National Climate Change Adaptation Plan (**NAP**) of Finland does not explicitly address risks related to CSS events.



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Germany: Historical examples such as the Massenheim Evangelical Church in Hessen demonstrate long-term damage accumulation and indicate moderate CSS vulnerability. Ground movement risks are typically understood within construction and civil engineering sectors, but general awareness about CSS seems to be limited. The NAP of Germany does not explicitly address risks related to CSS events.

Italy: Vulnerability is documented in regions such as Emilia-Romagna and Veneto, where fluvial plains and urban expansion interact with naturally compressible soils. Studies indicate that thousands of buildings are at risk of structural damage. While engineering and municipal authorities generally recognise subsidence risks, explicit consideration of CSS processes, particularly in the context of climate-driven drought, is limited. The NAP of Italy does not explicitly address risks related to CSS events although subsidence events are mentioned.

Luxembourg: CSS vulnerability is particularly pronounced in the southern Gutland region, where shallow foundations of individual residential buildings are common. CSS risks are frequently underestimated or misunderstood. There is no appropriate legislation or risk maps in Luxembourg related to CSS events. Technical solutions are known to specialists, but these are rarely applied proactively, and homeowner awareness is low. The NAP of Luxembourg does not explicitly address risks related to CSS events.

Spain: CSS vulnerability is documented in areas such as Murcia, Valencia, Granada and parts of southern Madrid. While public authorities in regions such as Catalonia monitor land movements, CSS is not consistently addressed as a specific hazard in climate adaptation strategies. The NAP of Spain does not explicitly address risks related to CSS events.

Across all five countries, a consistent pattern emerges: while technical expertise in engineering and construction sectors may often recognise CSS risk, national adaptation plans seldom address it explicitly and awareness of the issue can generally be assumed to be low. Information available about CSS events and related damage to buildings seems to be limited (although there is more information available about subsidence). The combination of factors increases the potential for widespread and under-recognised CSS property damage as climate-driven droughts become more frequent.

4 Insurance frameworks and the emerging protection gap

CSS property damage presents conceptual challenges for insurance markets. The damage can be difficult to attribute to a specific event and may even be considered predictable in high-risk areas as climate conditions change. These characteristics sit uneasily with traditional insurance principles based on sudden and unforeseen events. As climate change increases the frequency of drought conditions conducive to CSS, these challenges are likely to intensify.

CSS insurance cover in France

CSS events probably receive most attention in France where it is estimated that 48% of the national territory and around 10.4 million single-family homes are at medium or high risk of this phenomenon, representing 54% of all single-family homes.^{vi}

When it comes to insurance cover, a state mechanism called Cat Nat is a compensation scheme for homeowners, companies and local authorities for damage caused by natural disasters such as CSS events. The Cat Nat scheme is based on a dual-guaranteed system: insurance companies offer insurance policies to cover properties, and they are reinsured by the Caisse Centrale de



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Réassurance (**CCR**) for payouts when a natural catastrophe has been declared; and the CCR benefits from a full government guarantee and in return for this guarantee pays the State around €100 million per year (even if there is no payout).

Despite the fact that the Cat Nat mechanism enables better provision for natural catastrophe cover in France, there are a number of concerns in relation to how this applies to CSS events. In recent years an average of 50% of requests for official recognition of a CSS event as a natural catastrophe under the Cat Nat scheme have been unsuccessful.^{vii} And as the frequency and severity of CSS events increases, there are concerns as to long term viability of the Cat Nat scheme regarding CSS. It is estimated that the cumulative cost of drought claims between 2020 and 2050 would be €43 billion which represents a threefold increase compared to the previous three decades. In the face of these significant increases in the cost related to CSS event, there are concerns, in the insurance world and at the national level, that the Cat Nat scheme would no longer be able to generate sufficient reserves to cover claims by 2040.^{viii}

Across the five EU countries, insurance cover for CSS property damage across Europe reflects different legal frameworks, state compensation mechanisms and market practices. CSS events are not reliably recognised as a natural catastrophe and standard private home insurance policies generally exclude cover for gradual soil movement. This leaves homeowners exposed to a growing protection gap as climate change increases CSS risk.

Finland: There is no state compensation mechanism for natural disasters and property insurance is voluntary. Standard policies generally exclude ground movement, including CSS, unless the event is sudden and unpredictable. There is no common market practice to offer CSS-specific cover, and homeowners cannot easily request tailored protection.

Germany: Cover relies on voluntary private insurance, without a centralised natural catastrophe scheme. Soil movement insurance exists only through voluntary add-ons, typically excluding drying-related subsidence relevant to CSS. Even extended policies define subsidence narrowly and exclude gradual ground movement caused by drought. While homeowners may negotiate cover on a case-by-case basis, uptake is low, and public awareness of CSS-related insurance limitations is limited.

Italy: There is a largely discretionary system for natural disaster compensation, providing exceptional state intervention only in select circumstances. Standard fire and ancillary risk home insurance excludes damage from subsidence and soil swelling, meaning CSS is not automatically covered. Homeowners can request additional coverage, but it often requires higher premiums, geological surveys and individualised underwriting. Implementation of mandatory coverage under recent legislation is inconsistent, leaving many households without reliable protection.

Luxembourg: There is no state natural catastrophe mechanism; all insurance coverage is via private contracts. Standard home insurance excludes CSS, although specific cover can sometimes be requested on a case-by-case basis with higher premiums. Market practice is rare, and homeowner awareness of CSS insurance options is low.

Spain: Spain combines private insurance with a public compensation mechanism for extraordinary risks (the Insurance Compensation Consortium, CCS). However, CSS is generally excluded from CCS coverage unless triggered by extraordinary flooding events. Standard private policies are contract-specific and frequently exclude CSS-related damage. While homeowners may negotiate tailored cover for expansive soils, premiums can be high, and uptake is uneven. Even with a public mechanism in place, CSS remains a largely unprotected risk for most homeowners.



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Across all five countries, CSS damage is typically excluded from standard insurance. Homeowners may sometimes request cover, but this is rare and costly. Spain represents a partial exception with a public compensation scheme, but practical coverage for CSS remains limited. Overall, there is a systemic misalignment between growing CSS risk and existing insurance frameworks, increasing exposure for homeowners and potentially creating financial strain on households and public authorities alike.

5 Implications for policymakers and stakeholders

The combination of increasing CSS risk and insurance protection gaps has broader implications beyond individual homeowners. These include:

- Growing financial exposure of households to climate-related property damage.
- Potential pressure on public authorities to provide ad hoc support following damage.
- Challenges for insurance markets in maintaining coverage as risks become more frequent.
- Gaps between climate science, adaptation planning and risk transfer mechanisms.

CSS property damage represents an increasing climate-driven risk across Europe. Climate change is increasing the conditions under which such damage occurs, while insurance cover for homeowners remains limited and uncertain in many Member States. The combination of growing CSS risk and insurance protection gaps may lead to increased financial exposure for homeowners and potential systemic challenges for insurance markets and public authorities. Awareness of this risk among policymakers, regulators, insurers and homeowners is an essential first step toward informed planning and risk management.

ⁱ Ruosteenoja, K. (2026). Projections of deep and near-surface layer soil moisture for Europe: long-term mean changes and occurrence of severe droughts. [Unpublished manuscript]. Finnish Meteorological Institute.

ⁱⁱ This briefing draws on a targeted analysis of five EU Member States and uses climate model outputs at a continental scale. It does not provide a comprehensive assessment of CSS risk across all EU countries, nor does it propose policy or regulatory responses. The objective is to raise awareness of an emerging risk trend and highlight the need for further attention, data integration and dialogue among relevant stakeholders.

ⁱⁱⁱ Image copied from: Gruslin, Steve, Hennebaut, Tiffany, & Tirone, Mattia. (2022). How to ensure better consideration and mitigation of the shrinkage–swelling risk of clays?. *European Geologist*, 53, 20–28. <https://doi.org/10.5281/zenodo.6882354>

^{iv} Ruosteenoja, K. (2026). Projections of deep and near-surface layer soil moisture for Europe: long-term mean changes and occurrence of severe droughts. [Unpublished manuscript]. Finnish Meteorological Institute.

^v Intergovernmental Panel On Climate Change (IPCC). AR6. (2023). *Climate Change 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (1st edn)*. Cambridge University Press. <https://doi.org/10.1017/9781009325844>

^{vi} Sénat. (2023). Rapport d'information La sécheresse ébranle les fondations du régime CatNat. Retrieved from https://www.senat.fr/rap/r22-354/r22-354_mono.html

^{vii} Cour des Comptes. (2022). Sols argileux et catastrophes naturelles. Retrieved from <https://www.ccomptes.fr/sites/default/files/2023-10/20220215-sols-argileux-catastrophes-naturelles.pdf>

^{viii} Sénat. (2023). Rapport d'information La sécheresse ébranle les fondations du régime CatNat. Retrieved from https://www.senat.fr/rap/r22-354/r22-354_mono.html

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