Swiss Re

The hidden risks of climate change: An increase in property damage from soil subsidence in Europe

Property damage from drought-induced soil subsidence has risen dramatically across Europe. In France alone, subsidence-related losses have increased by more than 50% within two decades, costing affected regions an average of EUR 340 million per year.

Climate change will further magnify the risks. As soil movements become more frequent and severe, communities will have to adapt to protect assets and limit financial losses. Insurance provides them with an important tool to do so.

One of the costliest but least known risks for property owners and insurers sits just a few feet below the earth's surface. Subsiding soil is to blame. In some regions of Europe, property losses from soil movements have eclipsed the costs of most other natural hazards and now reach the same damage levels as floods. Drought is one of the primary culprits. A long and intense dry spell can lower the ground so much that it creates fissures in the earth and tears apart the foundations of houses, bridges, industrial sites and other structures. In the worst case, shifting soil can cause whole buildings to collapse.

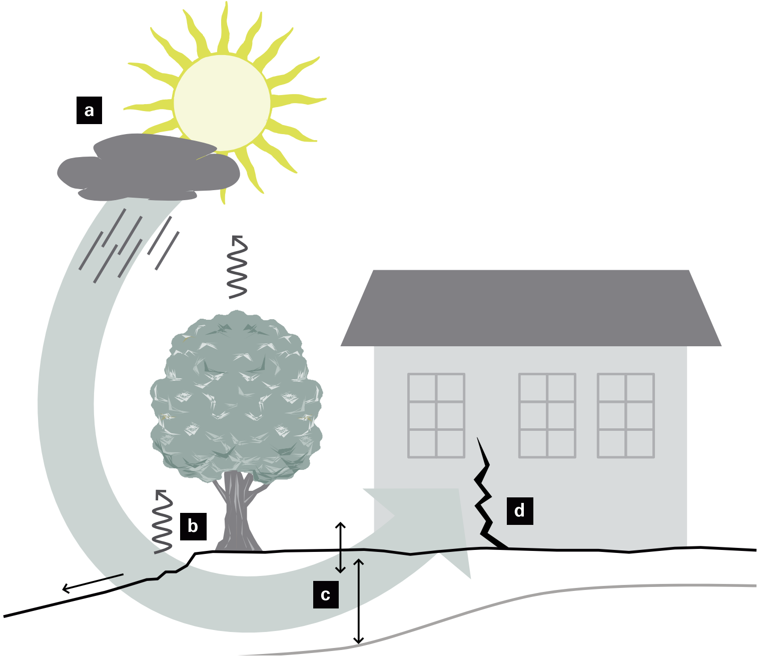
Climate change will magnify the risks. Rising average temperatures, combined with more erratic rainfall and higher levels of radiation from the sun, have already altered soil moisture conditions across Europe in recent years. As the trend towards drier weather continues, occurrences of drought and soil subsidence will become even more frequent and more severe. Affected communities will therefore have to adapt to increasing levels of risk. They can do so most cost-effectively by combining risk prevention and risk transfer measures as part of a broader adaptation portfolio.

Understanding soil subsidence risks

Over the past two decades, Europe has seen a marked increase in damage to buildings as a result of soil movements. A new loss model developed by Swiss Re and the Swiss Federal Institute of Technology (ETH Zurich) shows that in France alone, economic losses from soil subsidence have risen by over 50% since 1990, amounting to an average of EUR 340 million a year.[1] But despite the growing costs borne by homeowners, insurance companies and society at large, soil subsidence has not attracted much attention in the media or climate science.

The virtual absence of the issue in the general press is perhaps because soil subsidence is not a disaster event like any other. Although potentially destructive, it is usually a very slow and gradual process. With vertical movements of the ground typically just a few millimetres or centimetres, it is also unspectacular in scope and difficult to visualise.

Figure 1: Illustration of soil subsidence
A drought is primarily driven by unbalanced precipitation (a) and evaporation (b). Depending on its composition, the soil will swell and shrink with moisture changes (c). If the soil movements are very pronounced, they can cause serious damage to property structures (d).



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[1] Corti, T., Muccione, V., Köllner-Heck, P., Bresch, D., Seneviratne, S.I., 2009. Simulating past droughts and associated building damages in France. Hydrol. Earth Syst. Sci., 13, 1739–1747.

Subsidence, the downwards displacement of the ground, can cause significant damage to buildings. This subsiding house in London, UK is being supported against collapse by metal struts.

Incidents of subsiding soil stem from a process that regulates the amount of water in the soil. As clay in the soil swells and shrinks in dry and wet weather, the ground rises and falls naturally with it. When fluctuations in the soil's moisture content become too pronounced, these vertical land shifts can severely damage buildings and infrastructure. As illustrated in Figure 1, meteorology is the main factor behind the soil-water balance. It, in turn, determines the amount of water in the ground. This explains why changes in climate can significantly influence soil subsidence risks. Within the soil itself, properties such as the proportion of swelling clay minerals determine the extent of vertical soil movements, which in some cases cause serious damage to properties.

Soil subsidence risks are likely to increase in a changing climate. But the damage potential also depends on the stability of building structures and their foundations.

Yet the risks associated with subsiding soil are not linked to natural processes alone. They also depend on the stability of property structures. Consequently, not all buildings are affected equally by swelling and shrinking soils. A survey of damaged properties in the United Kingdom has shown that detached buildings are particularly vulnerable and that both the age of buildings and the depth of their foundations play a role.

Similar observations have been made in France and other regions across Europe. In France, soil subsidence was first observed after the drought of 1976, when severe structural failures occurred. In 1989, tens of thousands of buildings were again affected.[2] Following these events, soil subsidence was integrated into the country's natural catastrophe insurance system (Cat-Nat). Since then, subsiding soil has caused as much damage to residential properties across France as floods. Losses from drought-induced subsidence are expected to rise even further as the climate continues to change.

Defining a drought for insurance purposes

There are various definitions of a drought based on meteorological variables, soil moisture, river runoff and related factors which are used in different situations by farmers, hydropower providers and other agents. But whatever the context, a drought is not a single disaster event like a winter storm or an earthquake. Rather, it is a longer period or seasonal spell of dry weather. From an insurance perspective, this means that the typical definition of a natural catastrophe – such as a "named storm" or a 72-hour clause designating the maximum length of one event – does not apply. Instead, to assign claims and losses caused by a drought and soil subsidence, a whole season or year is used. This has very practical consequences. In France, for example, local administrators have the regulatory authority to declare a year as one in which households may place a claim based on local conditions but 'without an event'. A typical reinsurance product might therefore be an annual aggregate cover where the sum of natural catastrophe losses in a calendar year defines a reinsurance payout.

[2] Salagnac, J.L. Lessons from the 2003 heat wave: a French perspective, Build. Res. Informat., 35, 450–457, 2007.

Quantifying soil subsidence risks

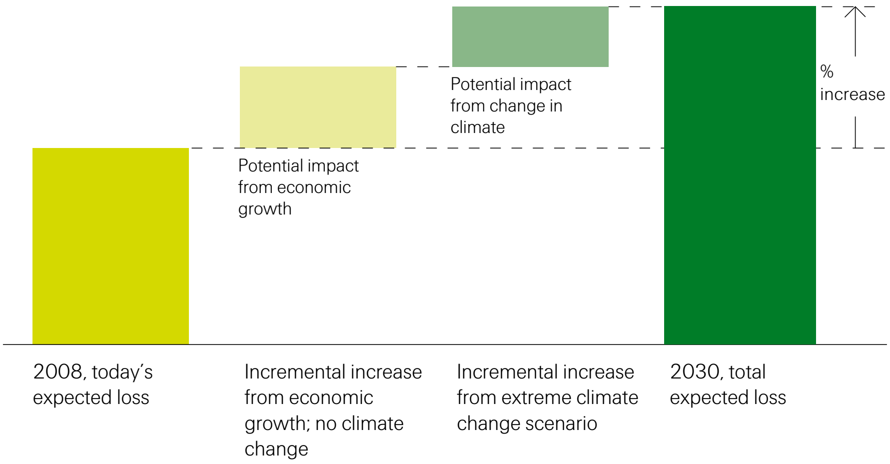
For property insurers across Europe, drought-induced soil movements are a major source of loss potential. Besides meteorological factors such as precipitation and soil moisture content, local geology and land use determine how vulnerable a region is to incidents of subsiding soil. In addition, the geographic distribution of properties and future development of asset values are important to consider when assessing the total losses that a community is likely to face today and in the future (Fig. 2).

Figure 2: Estimating total expected losses from climate risks

A total climate risk approach provides important guidance on assessing the total losses faced by a community from climate risks today and in the future, incl. storms, floods, drought and the impact of drought-related subsidence. It considers a continuation of today's weather patterns, projected asset values at risk and additional climate change.

Drivers of total climate risk

Illustrative



Source: Swiss Re, Economics of Climate Adaptation Working Group

To better quantify and more adequately price soil subsidence risks in various locations of Europe, researchers from Swiss Re and ETH Zurich developed a new loss model that weds Swiss Re's expertise in natural catastrophe modelling with drought-related data compiled by the Zurich-based Institute for Atmospheric and Climate Science.

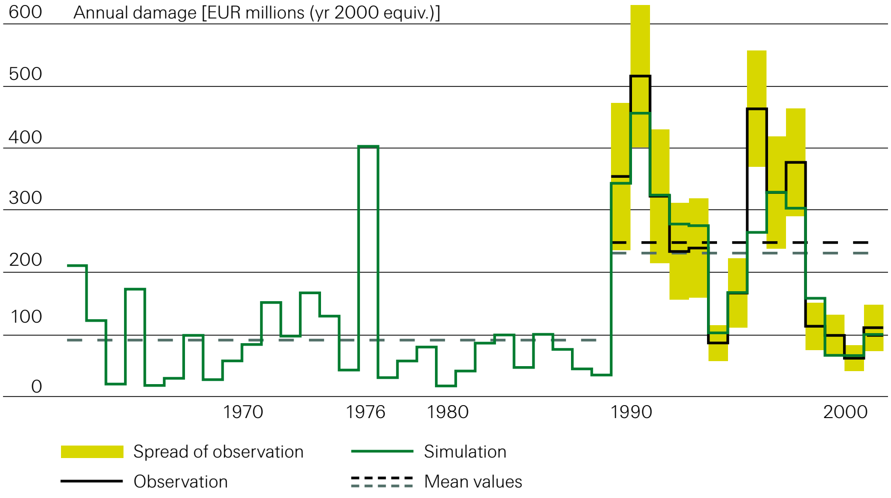
The newly designed loss model underpins a more comprehensive, systematic approach to analysing local subsidence risks. It was used in a recent research project to highlight the impact of climate change on local soil conditions in France and simulate expected losses under various climate scenarios. To derive these findings, the model-driven study compared data from the years 1987 – 2006 with past data from 1951 – 1970 and data for future climate scenarios covering the period 2021 – 2040. The years 1987 – 2006 served as the reference scenario for today's climate.

Loss models that integrate climate data in their damage estimates are powerful tools to quantify and accurately price the risks of drought-related soil subsidence.

As Figure 3 shows, the loss model's simulations approximate the damage history from drought-related subsidence with high accuracy for the years 1989–2002, a period for which robust loss reports are available. Such a comparison between simulated and actual losses underscores the model's capacity to reliably estimate future risks and calculate expected losses using probabilistic data sets.

Figure 3: Simulated vs. observed losses from soil subsidence

The model's simulated damage potential from soil subsidence in France between 1989 and 2002 closely mirrors actual observed losses for the same period (indexed to 2000).



Source: Swiss Re, ETH Zurich

Methodology of modelling soil subsidence risks

In order to quantify soil subsidence risks, Swiss Re and ETH Zurich developed a loss model compatible with and integrated in the Swiss Re in-house loss model framework. Such a loss model allows us to study the reported damages in scenarios, in regional granularity and also in the broader statistical context. We first looked at the history of subsidence losses. Because robust loss reports are available for France for the years 1987–2006, these years spanned the calibration period. The same period was defined as the 'current climate', which is always the convention in climate research due to the changing nature of climate patterns.

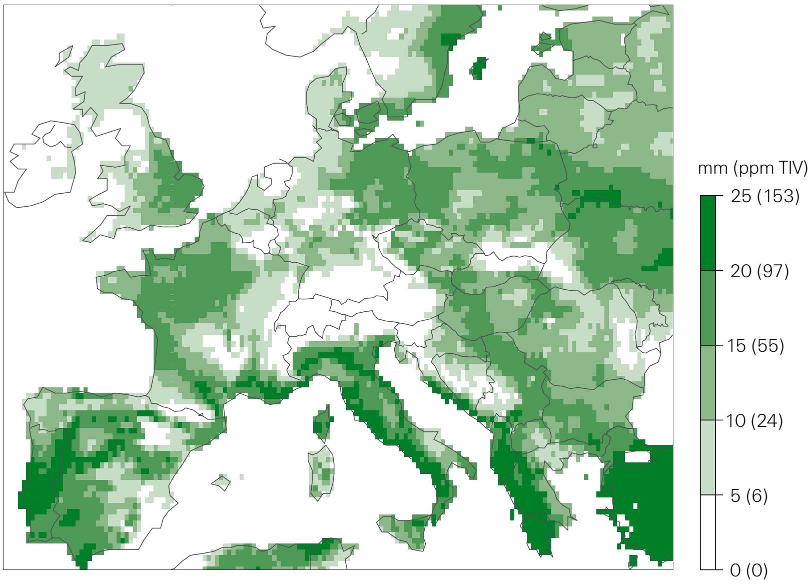
To prepare a set of historical droughts at high resolution in each country, we used the IPCC studies' regional climate models (RCM) and combined them with an extensive observational data-set (E-OBS). Their monthly meteorology determines whether a drought season happens and indicates the soil moisture deficit in a given year. As a result, multiple decades of soil moisture fields at high geographical resolution can be calculated.

Finally, to judge the current and future risk reliably, we created probabilistic drought hazard sets using the component re-sampling approach. This allowed us to simulate hundreds of years of activity in line with climatology. Because the study showed this methodology was able to represent the activity of the past and present climate, it was assumed to be compatible also with the future climate. The same methodology was therefore coupled with the regional climate models to estimate the future drought risk.

Increasing loss potential from soil subsidence in Europe

Assuming mean French conditions of geology, land use and construction standards, the model defines a region's soil subsidence loss potential in terms of vertical land movements (in millimetres) or mean annual loss as a ratio of the total insured value (TIV) of residential buildings. In today's climate (1987–2006), locations in France, the United Kingdom, the Mediterranean and Central and Eastern Europe are particularly exposed (Fig. 4).

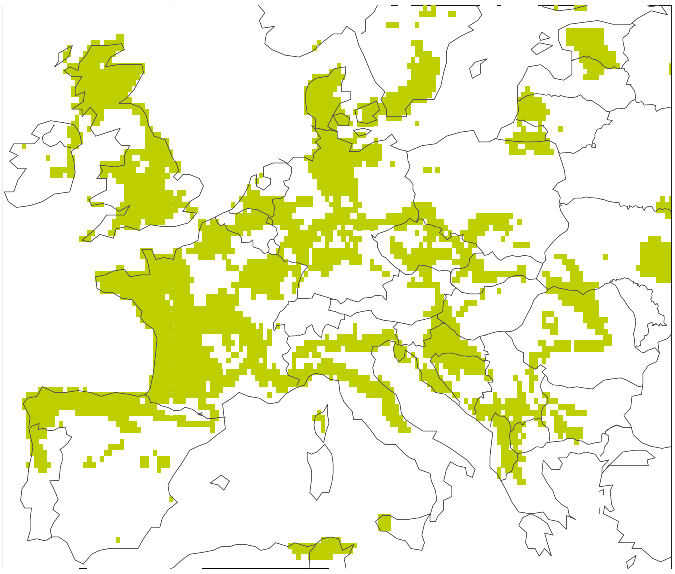
Figure 4: Loss potential from soil subsidence in Europe today
Loss potential from soil subsidence in Europe today is simulated using a base climate scenario for the period 1987–2006.



Source: Swiss Re, ETH Zurich

In the past, communities in these regions have undertaken efforts to reduce their exposure to shifting soil by taking potential land movements into account when planning and designing buildings. But in recent decades, climate change has led to a dramatic – and often unforeseen – rise in soil subsidence risks. The light green colour shades on the map below highlight those regions in Europe where the loss potential from drought-induced soil subsidence has increased by more than 50% compared to the period 1951–1970 (Fig. 5).

Figure 5: Increase in loss potential from soil subsidence since 1951–70
Loss potential from soil subsidence has been rising across Europe. Light green shades denote areas where today's simulated losses increased by more than 50% since the 1951–70 period.

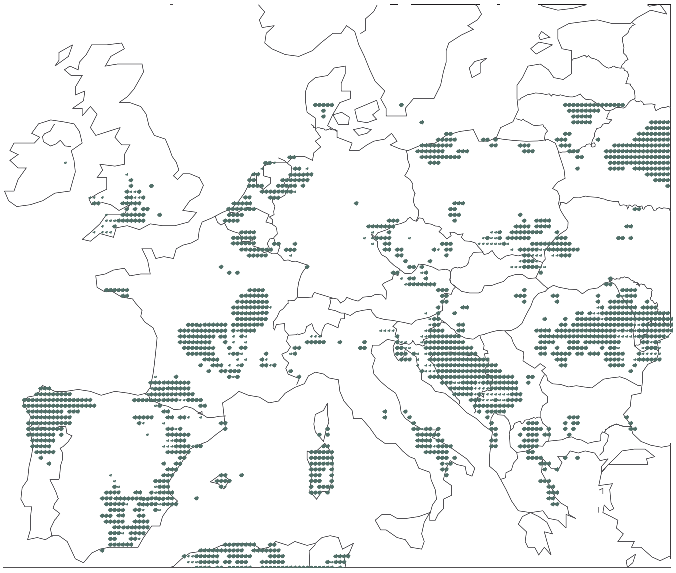


Source: Swiss Re, ETH Zurich

The findings show that large parts of France and the UK but also communities in Germany, Spain, Italy and Eastern Europe are affected by a very significant increase in subsidence risk. Many of these locations have not yet adapted to the heightened loss potential. Only newer houses built in the last two decades are the possible exception.

Climate change will further increase the frequency and intensity of drought-induced soil subsidence – and with it the risk of future damage to properties. As the new Swiss Re-ETH loss model shows, large parts of Europe will experience more sporadic rainfall and drier soils, and as a result face far greater losses from shifting soil. The grey shades on the map below highlight regions where the soil subsidence loss potential for the period 2021–2040 is expected to rise by more than 50% compared to today (Fig. 6).

Figure 6: Projected increase in loss potential from soil subsidence by 2021–40
Loss potential from soil subsidence is projected to rise further in a changing climate. Grey shades denote regions where future subsidence losses for the period 2021–2040 are estimated to increase by 50% or more compared to the period 1987–2006.



Source: Swiss Re. ETH Zurich

For those communities which have already experienced more occurrences of soil movements, this translates into a disproportionately high increase in drought risk within less than a century. For newly affected communities, the expected increase in loss potential means that they, too, will be impacted by rising temperatures and drying soils. The delay suggests that the risk of property damage from soil subsidence is not only increasing in some regions but is also spreading to new geographic areas in Europe.

As our climate continues to change, the risk of property damage from soil subsidence is not only increasing but also spreading to new regions across Europe.

The 2003 European heat wave: limitations of modelling peak risks

The summer of 2003 is remembered as one of the hottest on record in Europe, especially the months from June to August. Thousands of people died as a direct consequence of the heat, and losses to agriculture were tremendous. But a lesser known fact is that the heat wave also led to huge property losses resulting from soil subsidence. For 2003, the Caisse Centrale de Réassurance (CCR) reported damage estimates of around EUR 1.1 billion.

By contrast, simulations with Swiss Re's in-house loss model yield damages of EUR 530 million. The model, which uses a soil-moisture deficit indicator, thus underestimates the losses reported by CCR. There are several possible explanations for the inaccuracies of the model for 2003. Firstly, the damage could stem from physical mechanisms not included in the model, such as subsidence brought on by excessive ground water extraction. Secondly, varying construction standards might play a role, resulting in higher damages in regions that were affected by soil subsidence for the first time in 2003. Thirdly, the damages reported in 2003 could include reported damages actually caused by previous events. Such damage accumulation is a potential side effect of the French insurance system, which specifies that soil subsidence is officially declared as a natural disaster before individuals can report damages. And finally, the large public and media attention given to the 2003 heat wave might have prompted a higher rate of damage reports than previous events.

The summer heat wave illustrates the difficulties of accurately modelling peak losses, particularly when they are driven by factors not directly linked to the risk itself. But it also highlights the value of risk transfer in capping losses from low-frequency, high-severity disaster events.

Insuring soil subsidence risks

Soil subsidence is an insurable risk. But as climate change and shifting weather patterns over Europe expose more regions to soil movements, affected communities will have to develop new responses to protect properties and limit financial losses. Such efforts are most effective when they form part of a broader climate adaptation strategy that takes long-term climate impacts into account and engages local planning authorities, building contractors, regulators and re/insurers in finding appropriate solutions.

Once properly assessed, soil subsidence risks should be considered in local zoning plans and building codes. Governments should also incentivise homeowners to design or retrofit buildings so that these withstand the impact of greater soil movements. In France, for example, the builder of a new house can give a warranty for such initiatives under the so-called "décennale", a government-mandated policy that covers structural damages in the first ten years. A proposed reform of the natural catastrophe insurance system is currently under review, which would allow owners of buildings less than ten years old to receive compensation under the "décennale" for subsidence-related losses.

Yet as numerous adaptation studies show, it makes little economic sense for communities to try to prevent losses from every imaginable disaster.[3] Soil subsidence is no exception. Since losses can vary significantly from season to season, it is more economical to insure damage from the most extreme droughts and soil movements than to try to avert such losses at what would be a prohibitively high cost.

[3] Report of the Economics of Climate Adaptation Working Group 2009. Shaping climate-resilient development – a framework for decision-making. www.swissre.com/climatechange

Various risk transfer solutions are available to protect against losses from soil movements. Besides traditional, indemnity-based insurance, parametric covers and other index-based schemes could present a real alternative. These innovative solutions pay out whenever the index crosses a predefined threshold, such as a season's aggregate shortfall in precipitation. The main advantages of index solutions are their rapid disbursement and relatively low administrative costs.

Whichever solution is chosen, insurers must consider a range of issues when seeking to provide a commercially viable product. Firstly, they should examine whether and to what extent they already cover damage from soil subsidence. After a careful review of their portfolio, they may either decide to adjust existing offerings or develop new solutions altogether. Secondly, since loss experience is not a good indicator of future risks, insurers should develop a pricing strategy that takes into account the increase in subsidence risks using forward-looking estimates supported by risk models. Finally, insurers must cope with an accumulation of individual claims during very dry periods and the resulting volatility of annual earnings. Reinsurance is a proven way to tackle this problem, and parametric covers can be particularly effective in such instances.

But like other hazards, subsidence risks can only remain insurable at affordable rates if prevention measures are also put in place. Properly priced insurance premiums therefore reinforce investments in cost-effective initiatives. And when comparing the long-term impact of climate change, often spanning decades, to the replacement cycle of residential properties, insurance is also a very timely measure. Affected communities therefore have much to gain from integrating it into a broader adaptation portfolio.

Conclusion

As incidents of soil subsidence increase in frequency and severity with climate change, so does the need for systematically managing the risks through a combination of loss prevention and risk transfer initiatives, including insurance. Loss models are a key asset in efforts to tackle soil subsidence. By quantifying the risks involved, they provide decision-makers with the facts to make informed choices about those adaptation investments that promise to yield net benefits.

Much of the expertise needed to respond to soil subsidence risks already exists in drought-experienced regions, and innovative insurance solutions are available to protect against drought and other weather-related risks. Sharing this knowledge and redeploying tested risk solutions in other, newly affected regions should be a key objective of any local climate adaptation strategy.

Swiss Reinsurance Company Ltd
Mythenquai 50/60
P.O. Box
8022 Zurich
Switzerland

Telephone +41 43 285 2121
Fax +41 43 285 2999
www.swissre.com

Title:
The hidden risks of climate change: an increase in property damage from soil subsidence in Europe

Principal contributors:
Marc Wüest, David Bresch, Thierry Corti

Writing and editing:
Patrick Reichenmiller

Managing editor:
Esther Baur

Graphic design and production:
Swiss Re Media Production Zurich

Photographs:
Getty Images (Cover), Sciencephotolibrary (p 2)

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