# Climate adaptation is becoming the new edge in Europe's fruit sector

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*Europe's fruit sector is adapting to a changing climate. While established production regions remain central, shifting temperatures, water availability, and seasonal patterns are changing how and where different crops perform best. This report explores what these changes mean for citrus, pome fruit, and stone fruit and how adaptation can support more resilient and competitive supply chains.*

## Summary

- Climate change is increasing volatility across European fruit production. Rather than threatening overall supply, it is making yields, quality, and harvest timing less predictable.
- The main risks vary by crop and region. Citrus is most exposed to heat and water scarcity. Pome fruit remains sensitive to false springs and late frosts, while heat waves are becoming an increasingly important risk for fruit size and quality. Stone fruit is particularly exposed to declining winter chill, which can disrupt flowering and fruit set.
- Adaptation is possible but capacity varies across growers, regions, and production systems. Producers with reliable access to water, capital, knowledge, and technology are better positioned to manage climate pressures than those operating under more constrained conditions. As adaptation becomes more capital- and knowledge-intensive, well-invested growers may strengthen their position, while smaller, older, or less profitable farms face increasing pressure to consolidate, switch crops, or exit production. Scale alone will not be enough for growers to remain competitive. Advantages will increasingly depend on technical capabilities and investments that support resilient production.

## Climate change is making fruit production less predictable

Climate change is reshaping production outcomes across the fruit sector, increasing risk through more volatile yields and more frequent production shocks, while also increasing variability in fruit quality, including fruit size, grading, and storability. At the same time, shifting temperature and precipitation patterns are redistributing production across regions and reshaping trade flows.

Recent harvests across Europe illustrate how these risks are already materializing. Late frosts in 2020 contributed to one of the smallest EU apple harvests in nearly two decades, while widespread drought and heat drove major citrus losses in 2022. In 2024, apple production fell by 11% following late frosts in Poland, Germany, and Austria, and easy peeler volumes declined by 10% due to adverse winter and flowering conditions in Spain. In 2025, frost, heat waves, and excess rainfall affected production and quality across multiple fruit sectors and regions, illustrating the growing prevalence of overlapping climate shocks within a single year. Weather events thus far in 2026 look set to continue this trend.

While climate change is not the only challenge facing the sector, this report focuses specifically on climate risk and adaptation. It examines how changing climatic conditions are affecting European fruit production, how regional suitability is shifting, and how adaptation capacity differs across crops, regions, and producers.

## Climate risks are already reshaping fruit production

Climate risk materializes where climate hazards overlap with concentrated production systems and sensitive crops, particularly when adequate adaptation measures are not in place.

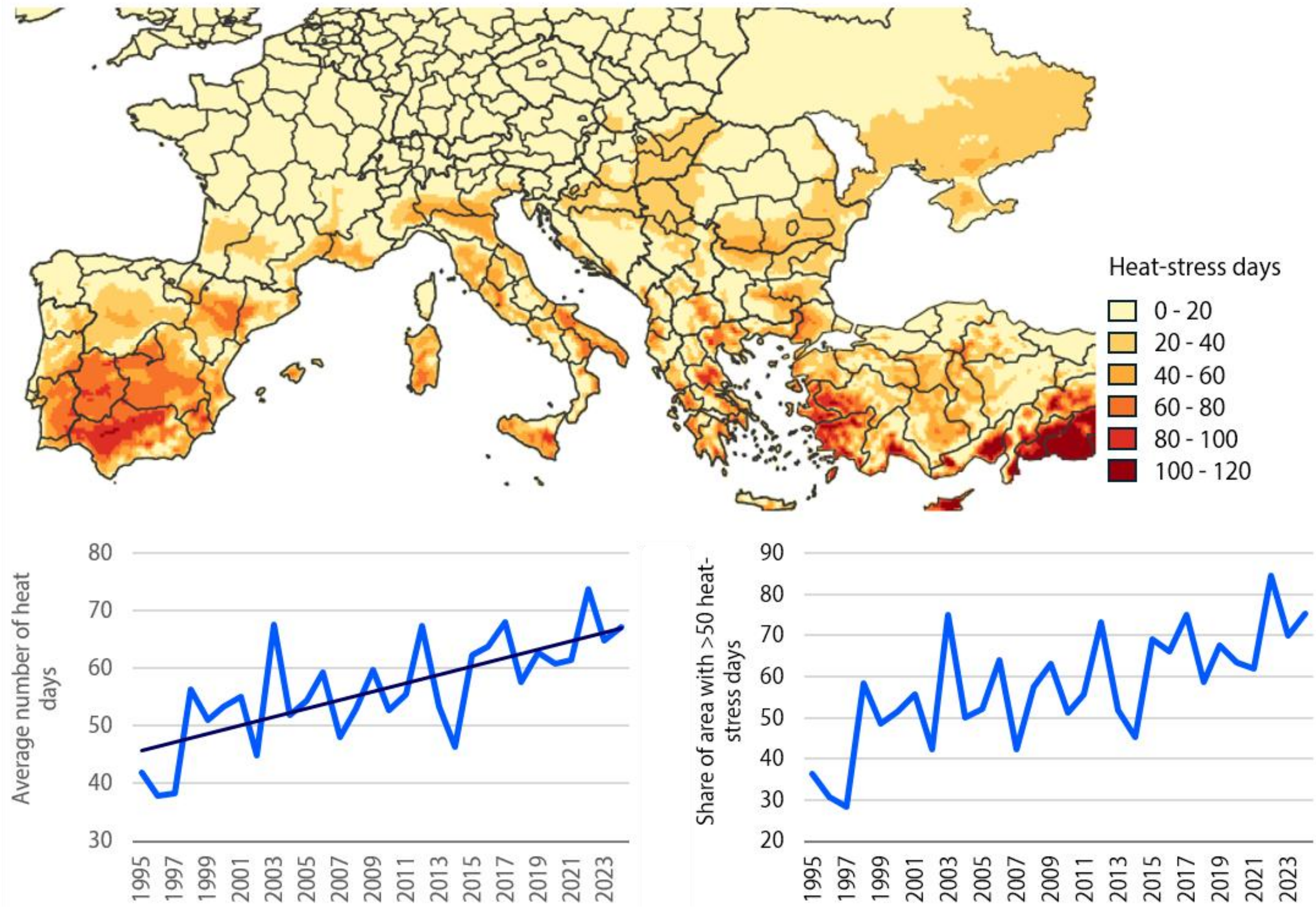
While many fruit trees face similar hazards – including heat waves, drought, and spring frost – the relative importance of these risks differs by crop. For citrus, the main constraint is increasing heat and water stress in the Mediterranean production core. For pome fruit, the key vulnerability remains the timing mismatch between earlier flowering and late spring frost. And for stone fruit, declining winter chill is emerging as a structural challenge because it directly affects flowering and fruit set. These are the primary climate risks facing each fruit category, although additional risks also affect individual crops.

### *Citrus is under growing heat and water pressure*

Europe's citrus sector faces growing climate pressure, with production heavily concentrated in the Mediterranean core. Spain accounts for around 55% to 60% of EU citrus production, followed by Italy (roughly 20% to 25%) and Greece (about 10%), leaving the sector highly exposed to a region that is warming faster than the global average and experiencing greater temperature and rainfall variability. According to the Spanish ministry of agriculture (MAPA), Spanish citrus fruit production declined by over 10% if we compare the 2023 to 2025 average with the average of 2013 to 2015. As a result, production is becoming more volatile and suitability is gradually shifting away from some traditional growing areas toward more northern regions.

Heat exposure is already high across the Mediterranean citrus belt, with many producing areas experiencing more than 80 to 100 heat-stress days per summer, reflecting structurally high baseline heat risk (see figure 1). Since the mid-1990s, the regional average number of heat-stress days has increased by around 15 to 20 days, while the areas exceeding critical thresholds have expanded. More frequent and persistent heat waves increase the risk of sunburn, fruit damage, and premature fruit drop.

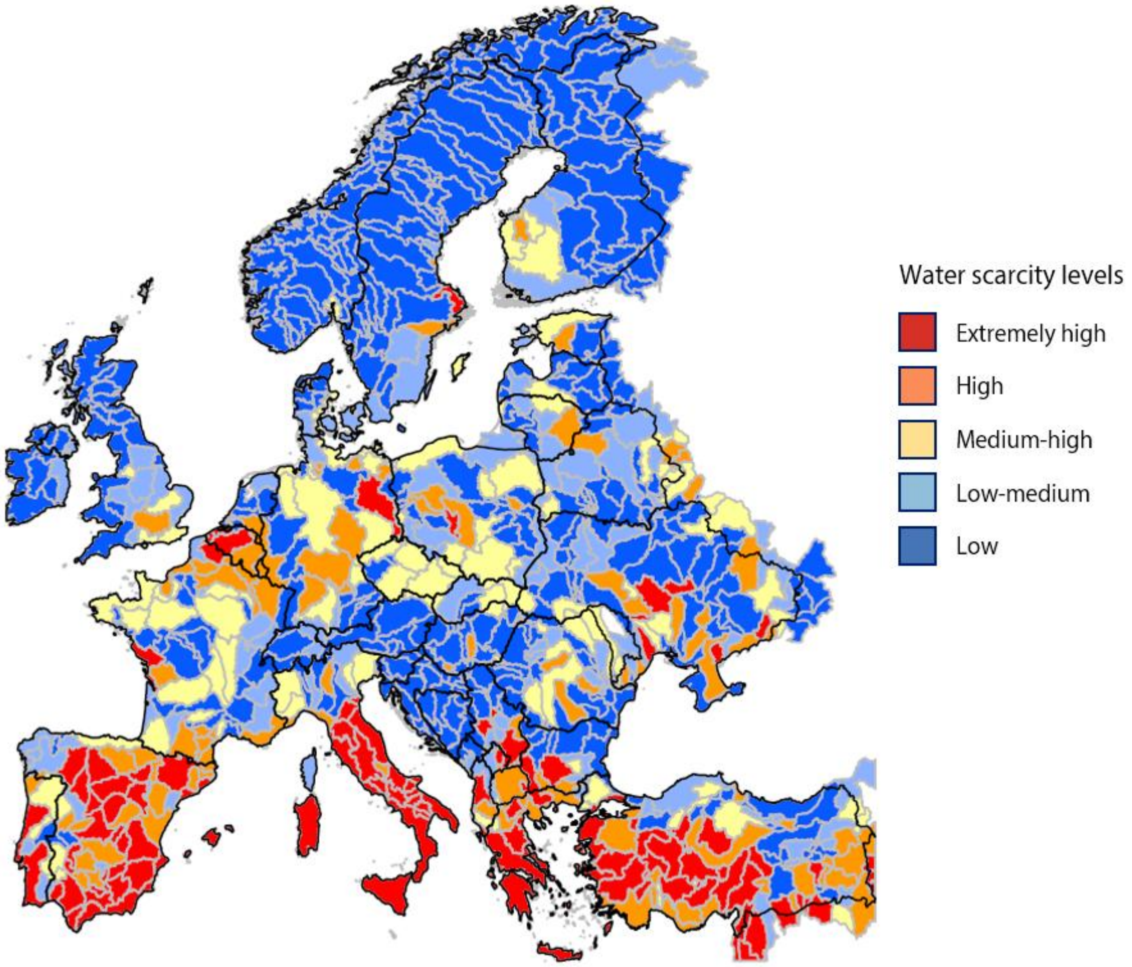
*Figure 1: Heat-stress exposure is increasing across Europe's citrus-producing regions, 1995-2024*




Note: The map shows the average annual number of heat-stress days during June to September, defined as days with a daily maximum temperature above 30°C, calculated over 1995 to 2024 and displayed for major citrus-growing areas. The bottom-left chart shows the evolution of the average number of heat-stress days across citrus-producing regions over time. The bottom-right chart shows the share of citrus-growing area experiencing at least 50 heat-stress days per year. Together, the indicators illustrate both the intensity and spatial extent of heat exposure in European citrus production regions.
Source: Copernicus, Spatial Production Allocation Model (SPAM), RaboResearch 2026

In addition, more uneven rainfall patterns and longer rain-free periods increase the frequency of intraseasonal water deficits, resulting in faster soil moisture depletion, greater dependence on irrigation, and higher exposure to combined heat and water stress during flowering and fruit development. These pressures are compounded by the Mediterranean basin's already dry summer climate and rising water scarcity risks (see figure 2). World Resources Institute projections indicate further expansion of water-scarce areas by mid-century, with the largest required reductions in water use concentrated in southern Europe.

*Figure 2: Projected water scarcity in European fruit-producing regions by 2050*




Note: Water scarcity is calculated as the gap between projected water demand and available supply.
Source: World Resources Institute, RaboResearch 2026

Conversely, intense rainfall can waterlog soils, damage root systems, and increase disease pressure during a critical stage of the growing season. In extreme cases, heavy rainfall can trigger flash flooding, causing significant damage to crops and infrastructure. The floods that affected Valencia in October 2024 illustrate this risk. Attribution studies suggest that climate change increased the severity of the event, as warmer air and sea-surface temperatures allowed the atmosphere to hold and release more moisture. While climate projections do not indicate a clear increase in the frequency of such events, they consistently point to greater rainfall intensity. As a result, the associated impacts of extreme precipitation events are expected to become more severe.

Taken together, increasing heat stress, water scarcity, and more intense rainfall events are making citrus production more volatile and costly while gradually reducing suitability in the most exposed Mediterranean growing regions.

## *Pome fruit is exposed to increasingly complex climate risks*

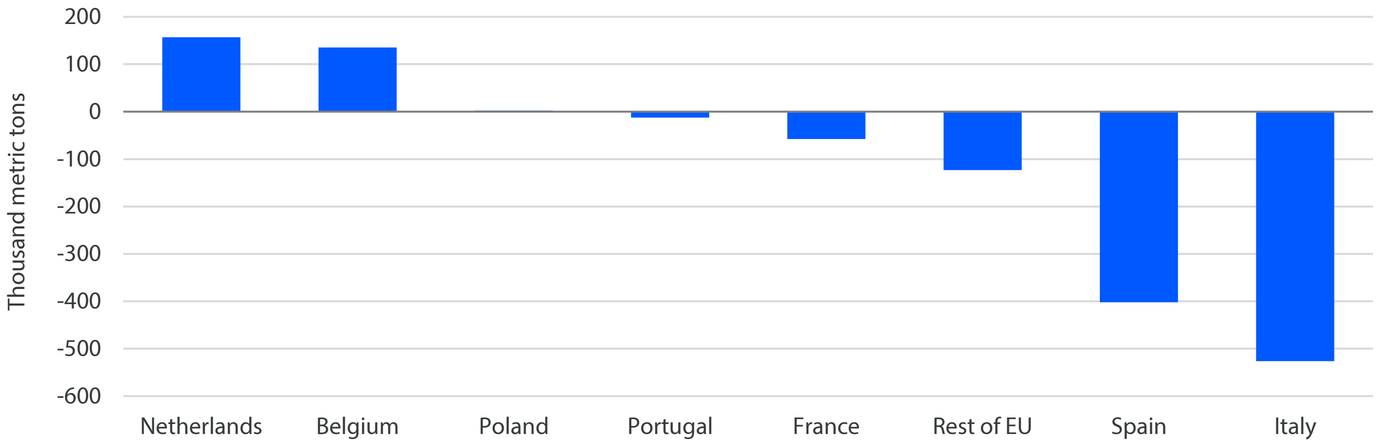
Europe's pome fruit sector is more geographically dispersed than citrus production, but it remains highly sensitive to weather conditions at key biological stages. Poland, Italy, and France lead apple production, while pear production is more concentrated in Italy, the Netherlands, and Belgium.

Spring frost and false springs remain the dominant climate risks, largely determining yield potential and, in extreme cases, severely reducing harvests where effective adaptation measures are not in place. Spring frosts in 2021 significantly affected

European pome fruit production, reducing fruit set in apple orchards and contributing to a markedly smaller pear harvest across Europe. In Italy, frost-related losses resulted in the smallest pear crop in 30 years. However, climate pressures are becoming more diverse. Heat waves during the growing season are increasingly affecting fruit size and quality, as well as increasing year-to-year production variability. In addition, declining winter chill is emerging as a concern in some pear-producing regions, particularly in Italy, where insufficient chilling can affect flowering consistency and fruit set.

Together, these pressures are gradually altering regional suitability. Warmer southern regions face increasing heat constraints, while cooler and more continental regions are gaining relative suitability. In pears, this shift is already visible in the widening production gap between northern and southern Europe (see figure 3). The Netherlands and Belgium continue to benefit from cooler growing conditions, strong sector expertise, and relatively well-developed orchard systems, while Italy and Spain are under increasing pressure from heat, water stress, and declining winter chill. The recent decline in pear production in Italy and Spain reflects both lower yields and shrinking cultivated area. These trends can reinforce each other: Repeated poor yields reduce grower confidence and profitability, which can lead farmers to stop producing pears or postpone orchard investment. Lower investment, in turn, can further weaken yields and accelerate area decline. At the same time, lower pear consumption in Europe has likely placed additional pressure on production volumes by weakening incentives for orchard renewal and expansion.

*Figure 3: Change in EU pear production, 2023-2025 average vs. 2003-2005 average*



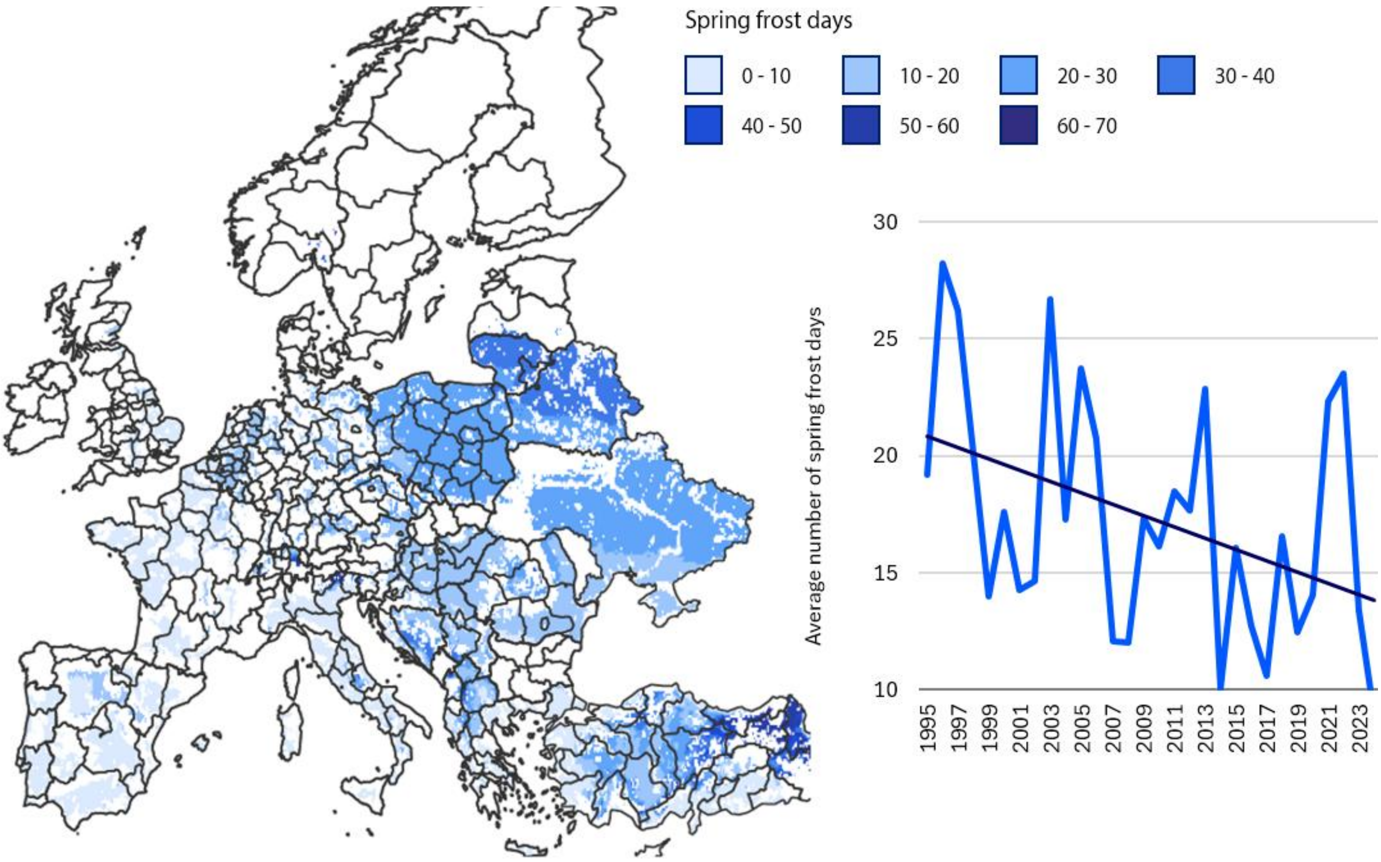

Note: Production changes are calculated as the average for 2023-2025 compared with the average for 2003-2005.
Source: Eurostat, RaboResearch 2026

## Spring frost remains the key risk

Pome flowering has advanced [by around 10 to 15 days] in recent decades, increasing the likelihood that sensitive growth stages coincide with late frost events. Frost exposure remains highest across central and eastern Europe, where continental climates have greater temperature variability (see figure 4). At the same time, [false spring risk is increasing], as early warm spells accelerate flower development before a return to colder conditions.

As a result, frost risk is becoming less a question of frequency and more one of timing. Even as the number of frost days declines in most regions, exposure during critical flowering stages remains high, contributing to year-to-year production variability.

*Figure 4: Spring frost exposure and its evolution in European pome fruit-producing regions, 1995-2024*




Note: Spring frost exposure is measured as the annual number of March and April days with a minimum temperature below 0°C.. The map shows the long-term spatial distribution of this risk, while the time series shows how their frequency has evolved since 1995. Together, they capture both direct frost exposure and the increasing risk of premature crop development followed by damaging cold conditions.
Source: Copernicus, RaboResearch 2026

## Summer risks are becoming more important

High temperatures reduce fruit quality and increase sunburn risk, while water deficits limit growth, increase fruit drop, and amplify yield variability. Orchard-level evidence suggests impacts can be substantial. A study in Spain and Portugal found that sunburn alone can reduce yields by 10 to 50%, depending on climate, cultivar, and crop management. Evidence from France also shows that while moderate warming has historically benefited production in some areas, rising heat stress is increasingly offsetting these gains in warmer regions. Combined summer heat and water stress is most pronounced in southern and southeastern Europe, where exposure and heat wave intensity are increasing. Together with ongoing spring frost risk, these trends are increasing year-to-year production variability, widening performance differences between regions, and underscoring the importance of adaptation measures such as frost protection, irrigation, canopy management, and varietal selection.

### *Industry insight: Warmer conditions are increasing pest and disease pressure*

Warmer and more variable growing conditions are not only increasing abiotic risks, but also changing pest and disease pressure in pome fruit systems. Industry stakeholders point to diseases such as *Stemphylium*-related leaf spot in pears and emerging pest challenges such as stink bugs as examples of problems that are becoming more difficult to manage under changing climatic conditions. Control is complicated by limited chemical options, increasing regulatory pressure, and the need for more knowledge-intensive crop management. Ongoing collaboration among growers, advisors, and research institutions will therefore be important, but effective solutions may take time to scale.

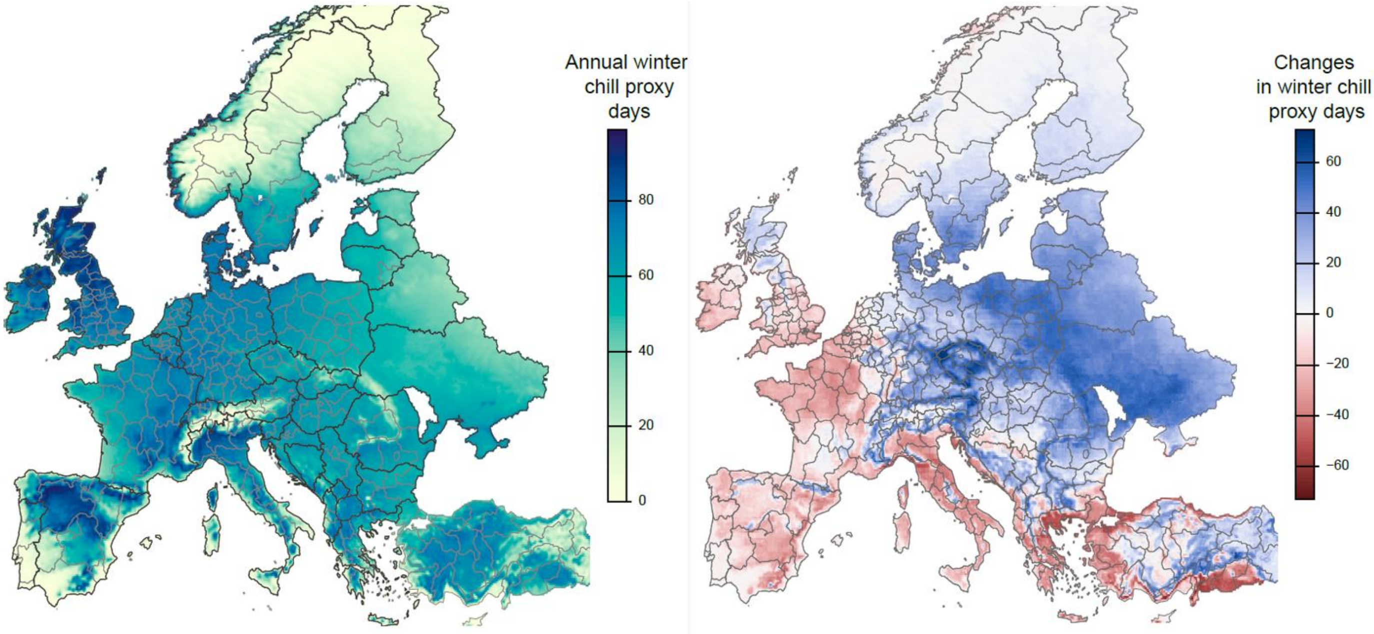
## *Stone fruit faces declining winter chill*

Europe's stone fruit sector is concentrated in the Mediterranean region. Production is dominated by Spain, Italy, and Greece, which together account for more than 90% of EU peach and nectarine output, while southern France is also a significant producer. Cherry and plum production is more geographically dispersed, with important production areas in Poland, Romania, and Hungary.

Like other fruit crops, stone fruit is exposed to heat, drought, and spring frost. However, its defining climate challenge is declining winter chill, as stone fruits require sufficient cold exposure during dormancy to ensure normal budbreak, flowering, and fruit set. Warmer winters are already reducing chill accumulation across parts of southern Europe, and projections suggest further declines by mid-century. Beyond insufficient chilling, warmer winters may also increase the frequency of abnormal heat events during dormancy, further disrupting flowering and reducing fruit set.

A simple chill-day analysis conducted for this report confirms strong regional differences in winter chilling across Europe. Mediterranean production areas consistently record the lowest chill accumulation, and recent trends suggest further reductions in several southern regions. In contrast, parts of central and eastern Europe show stable or increasing chill-day counts, highlighting the potential for shifting regional suitability within Europe's stone fruit sector (see figure 5).

*Figure 4: Winter chill accumulation and recent change in Europe's stone fruit regions, 1995-2024*




Note: Winter chill is measured using a simple chill-day proxy: the number of days during November to February when the daily mean temperature is between 0°C and 7°C. The map on the left shows the average number of chill proxy days across winters from 1995 to 2024. The map on the right shows the change in chill proxy days between 2025 and 1995. This is a simplified chill indicator and does not represent crop- or variety-specific chill-hour requirements.
Source: Copernicus, RaboResearch 2026

# Climate change is redrawing Europe's fruit map

Climate change is not only increasing production volatility. It is also gradually reshaping the geography of fruit production across Europe. Rising temperatures and changing precipitation patterns are altering the climatic conditions that have historically supported different fruit crops.

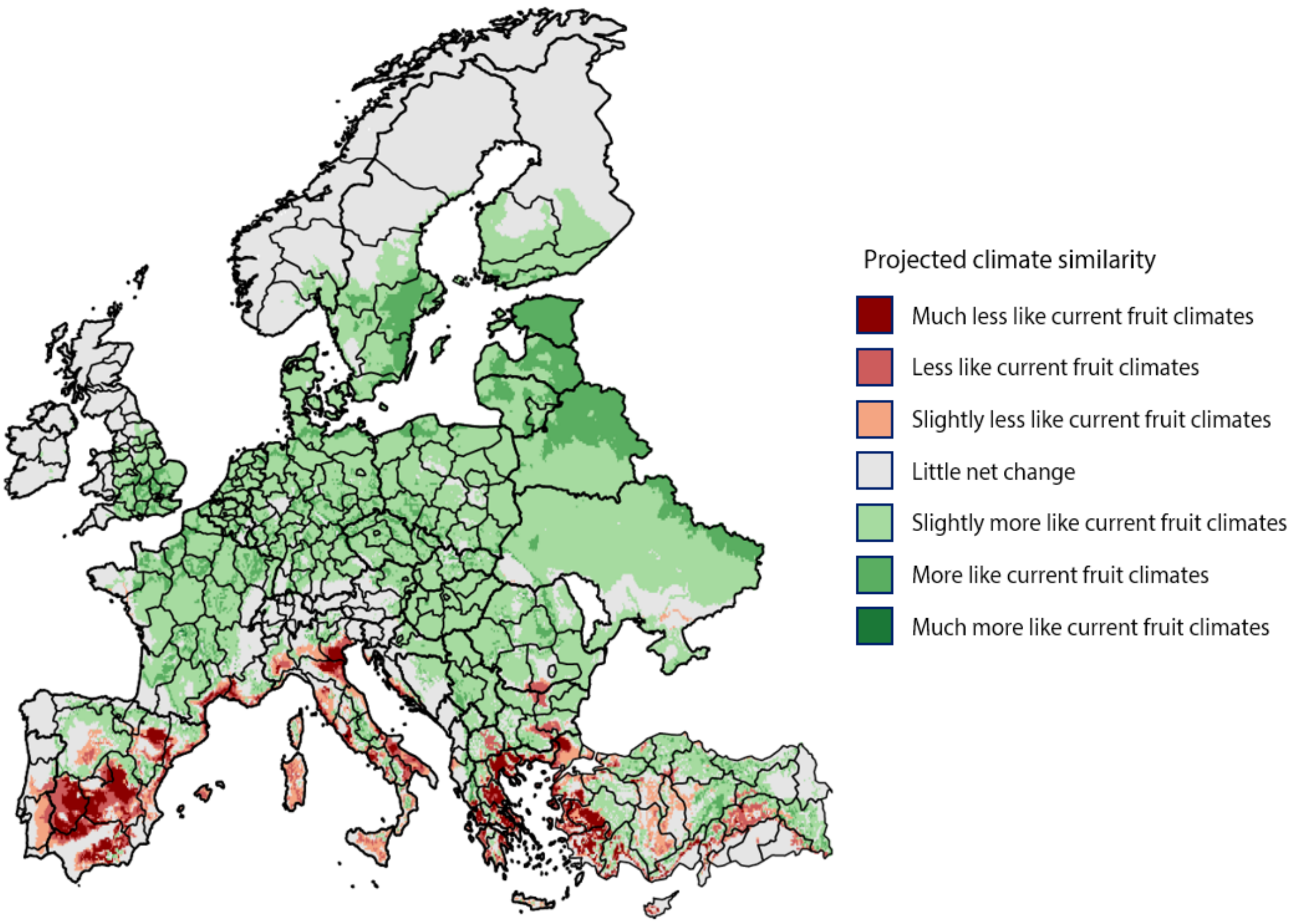
To illustrate these shifts, we mapped where the climatic conditions currently associated with major fruit-producing regions are projected to occur in the future. The combined analysis indicates a broad movement of these climatic analogues away from parts of the Mediterranean basin toward cooler northern and more continental regions of Europe (see figure 6). We project that areas of central and eastern Europe will increasingly resemble today's fruit-production climates, while parts of southern Europe will move further away from the climatic conditions that have historically supported fruit production.

Importantly, this does not imply that current production regions will become unsuitable for fruit cultivation, nor that production will automatically relocate to newly suitable areas. The analysis identifies changes in climate conditions, not future production locations. Producers can adapt through investments in irrigation, varietal selection, orchard design, frost protection, and shade systems, as well as through other management practices. Likewise, suitable climatic conditions alone are insufficient to support commercial production without adequate infrastructure, water resources, grower expertise, labor availability, logistics, and market access.

Industry feedback suggests that some of these shifts are already visible in investment patterns. Parts of eastern Europe, including Poland, Serbia, and Slovakia, are attracting investment in modern apple orchards, supported by lower labor costs and opportunities to develop protected, large-scale production systems. In western Europe, the response has focused more on premium production, strong local varieties, and branding. In regions with small farms and less consolidation, declining profitability and uncertain farm succession may contribute to orchard abandonment or conversion to other crops.

As a result, climate change is more likely to drive a gradual redistribution of future investment and production growth than a rapid relocation away from established fruit-producing regions. Traditional production areas in southern Europe are expected to remain important, but may face rising adaptation costs and increasing production risks. At the same time, some cooler regions may gain new opportunities as climatic conditions become more favorable for a wider range of fruit crops.

*Figure 5: Projected shift in climate similarity for European fruit production by 2050*




Note: The map combines climate-similarity analyses for citrus, pome fruit, and stone fruit. For each fruit group, current production climates were defined using the 5th to 95th percentile range of selected climate indicators in today's main growing areas. These climate profiles were then applied to projected mid-century climate conditions using a range of climate-model projections. Green areas indicate a net increase in the number of fruit groups for which future climate resembles today's production climate; red areas indicate a net decrease. The map shows climate similarity only, not future production potential. It does not account for soils, water rights, irrigation infrastructure, labor availability, investment capacity, varieties, pest pressure, or adaptation.
Source: WorldClim, SPAM, RaboResearch 2026

## Climate adaptation is becoming a competitive necessity

Adaptation can reduce climate exposure in Europe's fruit sector, but opportunities differ across crops and regions. For citrus, adaptation is constrained primarily by water availability. For pome fruit, the main challenges are spring frost and increasing summer stress, while stone fruit must contend with frost, heat, and declining winter chill. Across all crops, climate resilience depends on combining farm-level measures with investment, diversification, and value-chain support (see table 1).

*Table 1: Operational, structural, and supply-chain responses to climate risk*

| *Level* | *Main objective* | *Examples* |
|---|---|---|
| **Operational adaptation** | Reduce exposure within existing orchards | Irrigation management, frost protection, shading, integrated pest and disease management, sunburn prevention, postharvest quality protocols |
| **Structural adaptation** | Increase long-term resilience | New varieties, rootstocks, orchard renewal, relocation, crop diversification |
| **Supply chain adaptation** | Spread and manage risk across the value chain | Sourcing diversification, long-term contracts, retailer support, coinvestment, risk sharing, shared investment in storage, forecasting, quality data, and climate-risk monitoring |

Source: RaboResearch 2026

Operational adaptation remains the first line of defense. For citrus, this means improving irrigation efficiency through precision irrigation, soil moisture monitoring, and decision-support tools. For pome and stone fruit, frost protection remains critical as flowering increasingly overlaps with late frost events. Sprinkler irrigation remains the most effective frost-protection measure, although its use is often constrained by water availability, infrastructure requirements, and cost. Heat and sunburn risks can be reduced through shading, canopy management, reflective particle films, and targeted cooling, although these measures generally protect quality more than they increase yields.

Water is becoming the main constraint behind many adaptation choices. Irrigation supports drought resilience, heat mitigation, and frost protection, but it also increases dependence on a resource that is becoming less reliable in several production regions. Adaptation therefore depends not only on farm-level measures, but also on broader investments in water storage, infrastructure, and governance. Regions with secure and diversified water supplies are likely to be better positioned to manage increasing climate pressure.

### *Industry insight: Climate risk continues after harvest*

Climate change also affects fruit performance after harvest. Heat stress, sunburn, poor fruit size development, and disease can reduce storability and shorten shelf life. This means that adaptation cannot stop at orchard protection. Postharvest management, cooling capacity, and storage protocols are likely to become more important as climate-related quality variability increases. For value chain actors, this raises the importance of aligning orchard-level adaptation with storage, logistics, and marketing strategies.

Structural adaptation will also play an important role, although it is inherently slow in perennial crops. Varietal change, rootstock selection, and orchard renewal can improve resilience to climate hazards. In some regions, changing climatic conditions may also create opportunities for crop diversification, including the introduction of selected subtropical and tropical fruits. However, orchards remain productive for decades, replanting is costly, and growers often require years to recover production after renewal. As a result, this type of adaptation tends to be gradual and requires producers to balance climate resilience with market opportunities and consumer demand.

The biggest adaptation gap is not technical but financial and organizational. Many adaptation tools already exist, yet adoption remains uneven because producers vary in scale and in their access to capital, infrastructure, knowledge, and risk-management tools. Larger and more diversified businesses can spread climate exposure across crops, regions, and sourcing windows, while smaller producers are often more vulnerable to local climate shocks. The economics of adaptation vary strongly by crop value, farm size, and the expected frequency of climate risks. Measures such as hail nets, sprinkler systems, and improved water infrastructure can protect yields and quality, but they require substantial upfront investment. As a result, the business case is generally stronger for high-value, well-branded, or export-oriented fruit than for lower-margin commodity varieties. This could widen the gap between well-capitalized growers and smaller or older farms that are less willing or able to invest.

As climate risks become more frequent and geographically uneven, traders, processors, retailers, and input suppliers can help reduce exposure across the value chain. Long-term commercial relationships can improve the business case for investments in climate adaptation. Coinvestment, improved forecasting, climate-risk monitoring, and risk-sharing mechanisms can also help distribute adaptation costs, reducing the burden on growers.

Ultimately, the key divide may not be between those exposed and those not exposed to climate risk, but between those able to adapt and those unable to do so. As a result, climate resilience is expected to become an increasingly important differentiator across Europe's fruit sector.

## Authors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