

Climate risks in Hungary, 2026–2035

National risk assessment for senior civil servants,
with an outlook to 2050

TEN-YEAR WINDOW

OUTLOOK

2050



2026

2035

*An accessible summary based on the detailed background document
· Courtesy translation*

József Feiler · Csaba Nemes · Péter Kardos · Péter Szabó

October 2026

Climate risks in Hungary, 2026–2035

National risk assessment for senior civil servants, with an outlook to 2050

An accessible summary based on the detailed background document · Courtesy translation · October 2026

AUTHORS	József Feiler · Csaba Nemes · Péter Kardos · Péter Szabó
THE DETAILED BACKGROUND DOCUMENT	<i>Climate risks in Hungary over the coming decade.</i> A risk profile for 2026–2035, with an outlook to 2050. Background document for senior civil servants. Budapest, October 2026. DOI 10.5281/zenodo.23430763
NOTES	The blue superscripts point to the source list in Annex C; they are clickable in the PDF, and the arrow (↔) at the end of each note leads back to the text.
ENGLISH VERSION	Courtesy translation of the Hungarian original, produced by machine translation (DeepL) and checked against the Hungarian text; not professionally edited. The Hungarian text is authoritative. The figures carry Hungarian labels; their captions are in English.

CONTENTS

01	Key findings and their confidence levels	3
02	What this assessment is about	6
03	How to deal with uncertainty	7
04	The hazard is emerging earlier than planning anticipates	8
05	The water system is where the country is most vulnerable	10
06	The main driver of drying is evaporative demand	12
07	Risk and consequences: from hazard to damage	14
08	Summer 2026: the compound event turns into an operational disruption	16
09	Outlook to 2050: what to design for	17
10	Risk bands applied	20
11	Policy decisions	21
A	Annex A – Glossary	23
B	Annex B – Methodology	24
C	Annex C – Sources	24

01

Key findings and their confidence levels

1 **The four most important climate indicators are changing at a faster rate than predicted.** For average temperature, the number of hot days, spring frosts and the vapour pressure deficit – which enhances evaporation – none of the available domestic model forecasts show the rate of change already indicated by our latest meteorological measurements. We must therefore adopt a new approach to these climate indicators: rather than relying on forecasts, we should treat the measured data as the planning minimum, as the lower limit of the model forecast range can no longer be regarded as a safe starting point, but at best as the theoretical minimum value.



2 **Water is at the centre of domestic climate risks in the coming decade.** East of the Danube, water levels are falling in 98 per cent of our wells, even though precipitation during the winter half-year has not decreased. Our country’s water reserves are now only able to regenerate to any significant extent during winters that bring abundant rainfall. The cyclical recovery that was previously typical has essentially ceased since 2014; water levels no longer return to their previous typical levels even after winters with abundant rainfall. In August 2026, 79 per cent of the wells in the national network of monitoring wells were at their lowest recorded levels.



3 **The deeper confined groundwater,³² which accounts for around a third of the drinking water supply, has been falling since 2019.** This decline has brought an end to two decades of stability, but we do not know whether this is caused by the drought itself or by the increased extraction associated with it, as a significant proportion of water abstraction remains unmeasured to this day. As a mistake over the drinking water supply would come at a very high cost, putting the missing measurement in place is one of the most urgent steps.

■ ■ ■ □ □
Medium for the decline,
low for its cause

4 **The main reason for our climate becoming drier is the increase in evaporative demand, which was not captured by the forecasts.** The vapour pressure deficit, which is the main driver of evaporative demand, has increased by 39 per cent in summer since the 1970s. None of the 28 domestic model runs predicted this increase. The duration of dry spells did not increase up to 2025, but 2026 brought the longest in the 125-year record. One year does not, of course, constitute a trend, but the extreme summer of 2026 has become the baseline for the design of reservoirs and irrigation systems.

■ ■ ■ ■ □
High for the drying
trend, low for the turn-
ing point

5 **In the summer of 2026, drought, heatwave and low flows occurred simultaneously, leading to operational disruption.** According to public statements, a full unit at the Paks power station was shut down for the first time due to low flows; water flows in the Danube, the Körös rivers and the Maros fell to the lowest levels on record, the average winter wheat yield was 4.3 t/ha, down from 5.5 in 2025, while the maize yield was estimated at around 3 t/ha, below the 3.4 recorded in 2022. The risks share a common cause and therefore occur together; so preparations must be scaled to cope with two consecutive poor years.

■ ■ ■ □ □
Medium

6

We have no official domestic data on excess mortality caused by heat. Heat-related mortality cannot be tracked in cause-of-death statistics, and we have only ten years’ worth of data even on the two components of the risk. In 2024, around 2,300 deaths can be attributed to the heat, while cause-of-death statistics listed heat as the cause of death in only 27 cases. According to a European estimate, the burden is borne almost entirely by those aged 75 and over. The heat burden for this age group – that is, the product of the number of extremely hot days and the population – was 3.2 times the 1991–2020 level in 2021–2025. The most recent officially available vulnerability dataset is based on data from 2005–2014.

■ ■ ■ ■
Medium in terms of magnitude, high in terms of data obsolescence

7

Planning must account for global warming of at least 2 °C by 2050, with a 2.5 °C stress test. A continuation of the measured rate of warming alone would result in a 2 °C increase by 2050. In Hungary, the 2 °C level corresponds to an annual mean temperature approximately 1.9 °C warmer than the 1991–2020 average, while the 2.5 °C level corresponds to an annual mean temperature 2.5 °C warmer. Stabilising at a more favourable level cannot be counted as a saving, because the associated carbon budget would be exhausted within a few years at current emission rates. The Alpine ice reserves feeding the Danube will have fallen by about half by 2050, so low flows during hot, dry summers could become increasingly extreme.

■ ■ ■ ■
Medium

8

We do not have comprehensive information on domestic climate-related damage. There is no official Hungarian damage assessment, and we do not know who bears the costs of such damage. According to European damage figures, between 1980 and 2024, domestic weather and climate-related damage amounted to 12.8 billion euros at 2024 prices; 78 per cent of this occurred in just five years, and only 4.8 per cent was insured.

■ ■ ■ ■
High in terms of the data gap, low in terms of scale

The meaning of the confidence levels is explained on the following page.

02

What this assessment is about

This assessment is based on domestic measurement series, the two domestic climate projections and the international literature published since the IPCC's Sixth Assessment Report.¹ It is not a scientific report, but a risk assessment. It examines which of the measurable hazards have changed and to what extent, and which decisions rely on this information. It follows established practice in public administration risk assessment, that is, it considers the reasonable worst-case scenario, after ruling out highly improbable scenarios.² It does not state exactly what will happen. However, it does indicate what we need to prepare for, and which mistakes will prove more costly.

The three questions of the assessment

1. Which climate hazards deviate from the planning assumptions over the next decade, and in what direction?
2. Where is the country most vulnerable, and how are society and the economy harmed?
3. Where is data currently lacking that would enable the risk to be quantified at all?

Confidence levels

High: a finding based on measured data, confirmed by several independent lines of measurement. The source data is public, the calculation is reproducible, and it has been verified by an independent re-calculation; however, blind spots arising from a common methodological approach may not necessarily be revealed by the re-calculation. Examples include the rate of domestic warming, the decline in groundwater levels and the increase in the vapour pressure deficit.

Medium: a measured indicator based on a short time period, a single event, or partly on preliminary data or expert assessment. The trend is well-established, but the frequency or magnitude is not. Examples include the lessons learnt from the 2026 compound event and the 2050 planning level.

Low: the phenomenon is measurable, but its cause or magnitude cannot be identified from domestic data because the necessary time series is missing. Examples include the cause of the decline in confined groundwater levels and the national economic magnitude of climate-related damage.

THREE BASIC CONCEPTS

Planning minimum: the level below which planning cannot go. For those indicators where the models fall short of the measurements, this is the value already observed.

Reasonable worst-case scenario: the worst possible outcome remaining after the exclusion of highly improbable scenarios. It forms the basis for proportionate preparedness.

Compound event: a combination of several interrelated hazards, such as a summer heat-wave and low flows following a dry winter. Planning that treats hazards separately regularly underestimates such events.

The full glossary can be found in Annex A.

03

How to deal with uncertainty

British and other national security assessments work with a fixed set of probability terms. This assessment, however, deliberately does not use this approach. The most serious identified domestic outcomes and combined events are: groundwater levels failing to recover due to a winter with low rainfall, accompanied by summer heat and low flows. The combined probability of these events cannot be reliably estimated from the available data, and as the hazards share a common cause, assuming their independence would underestimate the likelihood of their combined occurrence. The findings are therefore assigned a reliability rating, without a probability classification.

There are two ways to make a mistake. One can prepare for something that does not happen, or one can fail to prepare for something that does happen. In a planning context, failure to prepare is the more costly mistake, because the consequences of a missed investment span decades and are, in part, irreversible, while the cost of unnecessary preparation is one-off and visible. This carries particular weight for confined groundwater, as anyone who ignores the decline after 2019 by citing the previous stagnation may take a decision on the drinking water supply that will take decades to rectify. Weighing up these two errors is clearly a matter of value judgement, which we openly acknowledge.

The ‘planning minimum’ rule. Where domestic climate models fall short of measured data, the measured value serves as the starting point, while the lower limit of the model range represents the smallest conceivable value – not the best-case scenario. We have verified this rule separately for each indicator and apply it only where it can be justified. For the dura-

tion of dry spells, the level of intense rainfall and the number of extremely hot days reaching 35 °C, the models do not fall short of the measured values; in these cases, this rule does not apply.

THE FOUR INDICATORS OF THE PLANNING MINIMUM			
Indicator	What the domestic dataset measured	What the domestic model provides	What the rule applies to
Annual mean temperature	9.9 °C (1971–1990) → 11.5 °C (2006–2025)	the median of the runs reaches the measured level 13–16 years later; none of the 28 runs reaches it	both domestic projections
Number of days reaching 30 °C	the measured value exceeds the range of the official projection in 16 out of 20 counties and 136 out of 173 districts	the official four-run projection remains below the measured value	both domestic projections
Spring frost	bud burst occurred twelve days earlier, while the date of the last spring frost remained unchanged	none of the 14 runs of the moderate emission scenario reaches the measured value	one set; the official projection does not report this
Vapour pressure deficit (the driving force behind evaporative demand)	in summer +73 Pa/decade (1971–2025); in 2021–2025 +39 per cent compared with the 1971–1980 average	none of the 28 runs reproduces this, on any emission pathway	one set; the official projection does not report this

Source: Chapters II.2 and IV of the background document.¹

04

The hazard is emerging earlier than planning anticipates

The global framework has shifted. Warming in the decade 2016–2025, measured against the 1850–1900 baseline, is 1.26 [1.13–1.36] °C, with the rate of anthropogenic warming at 0.27 °C per decade – the highest value recorded in the instrumental record to date.³ The Earth’s energy surplus – that is, the amount of heat remaining in the system – has more than doubled over two decades. According to one study, the models give half the 2023 value; according to another, the observed annual values remain within the model range; the background document concludes from these two that the majority of models underestimate the rate of increase.^{4,5} The global picture serves as a boundary condition for domestic findings, while domestic claims are based on domestic measurements.

The Carpathian Basin is warming faster than the global average, and at an uneven rate across the seasons: winter and summer are warming the fastest, while spring is warming the slowest. Comparing two 20-year periods of equal length, the annual mean temperature rose from 9.9 °C in 1971–1990 to 11.5 °C in 2006–2025. During the same period, the number of extremely hot days with temperatures of at least 35 °C rose from 0.3 to 4.9 per year, while the number of tropical nights rose from 0.4 to 3.6; over the last five years, there have been an average of 8.5 extremely hot days and 6.6 tropical nights per year.⁶

For the first time, a forecast based on measured initial conditions has been produced for the coming decade. The international system used gives +1.7 °C for the annual mean and +1.9 °C for the summer mean for 2025–2034, measured against its own 1991–2020 reference period, with the number of extremely hot days increasing most in the southern third of the country.⁷ The system's retrospective runs track summer temperatures well, but this skill derives largely from the warming trend, and no skill can be shown for precipitation, and none of the products have a separate skill score for the Carpathian Basin. The +1.7 °C deviation can be used as a planning value, but the figure may also fall towards the upper end of the range. However, the system already estimates the number of extremely hot days for the baseline period at three times the measured figure; therefore, only the trend and the spatial pattern can be taken from it.

The domestic regional models fall short of the observed values for four indicators. For temperature, the number of days reaching 30 °C and the vapour pressure deficit, none of the models in the 28-run domestic model ensemble⁸ reaches the observed value; similarly, for spring frost, none of the 14 runs under the moderate emissions scenario does so. For temperature and days reaching 30 °C, HungaroMet's official four-run projection shows the same pattern: in the county and district-level layers published in 2026, this applies to the majority of counties and districts, while for summer daily maximum temperatures, it applies to all of them.⁹ Both domestic datasets are based on the previous generation of global models, whereas the range of the newer generation is wider and has shifted upwards. The domestic projections should therefore be regarded as lower-bound estimates, and the test of the planning minimum must be repeated using the new generation.

2026: THE LIMITS OF MEASURED EXTREMES HAVE SHIFTED

During the summer, only 36 per cent of the normal rainfall fell; this was the driest and the second-hottest summer since records began in 1901.¹⁰ In the same year, temperatures as low as -18.3°C and as high as $+42.0^{\circ}\text{C}$ were recorded, so it is too early to scale back preparations for cold weather. The longest dry spell during the growing season averaged 30.2 days across the ten weather stations that have been recording data since 1901; in Szeged, it was 53 days, 12 days above the previous local record.⁶ The Danube's water level at the Budapest gauge fell below zero in September, while the summer flow of the Körös and Maros rivers was the lowest since 2000.¹¹ In a warming climate, records are broken by larger margins, so design standards must be adapted to such years, not to an average year.

05

The water system is where the country is most vulnerable

Precipitation during the winter half-year has not decreased, yet ground-water levels are falling. Comparing two twenty-year periods (1972–1991 and 2006–2025), winter half-year precipitation increased from 226 to 255 mm, while summer precipitation changed from 351 to 355 mm, and fell appreciably only in the last five years (2021–2025: 312 mm).⁶ The ground-water level is falling in 721 of the 763 wells in the national monitoring network that have a quarter-century record. East of the Danube, 98 per cent of the wells are showing a decline, with a median rate of half a metre per decade; in Transdanubia, the decline is slower, while in Western Transdanubia there is no consistent downward trend.¹¹ Satellite gravimetry, which measures the combined volume of soil, groundwater and surface water, shows the same trend: June 2026 is the month with the lowest value in the series dating back to 2002.¹²

The explanation lies in the nature of the recharge process. Reserves increase during a few winters with abundant rainfall; an average winter barely raises the groundwater level; and, in terms of groundwater levels, an average winter following a drier one does not ensure replenishment. The other climatic factor is evaporation: according to a not yet peer-reviewed estimate of the water balance between the Danube and the Tisza, the recharge resulting from the difference between precipitation and evaporation has fallen to a fraction of what it was in the 1950s; however, researchers' opinions differ on the weight of evaporation.¹ Previously, the decline caused by dry years was consistently offset by abundant winters;

however, this cycle has been disrupted: east of the Danube, water levels in 84 per cent of the wells with long records have not returned to the 2001–2013 peaks since 2014, even though in the previous decade abundant winters had still restored them. The most important measure is therefore to retain winter half-year precipitation in the landscape, in a sequence set region by region.

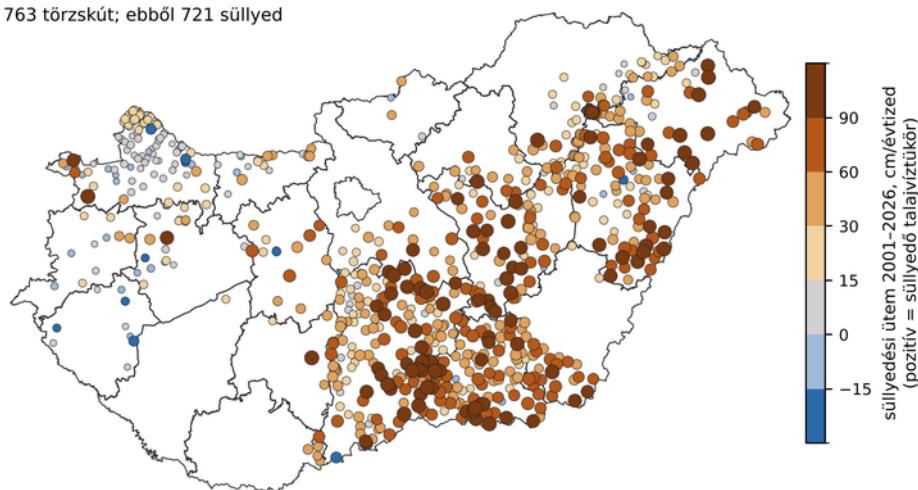
Deeper confined groundwater paints a different picture. Based on an analysis of a national well dataset comprising 102 wells and covering twenty-six years, the water level remained stable between 2001 and 2019; however, between 2019 and 2026, it fell at a rate of 1.67 metres per decade, with 85 of the 102 wells moving in the same direction.¹¹ There are two possible explanations for this decline. One is the spread of drought to the deeper layers; the other is an increase in confined groundwater abstraction following the depletion of shallower reserves. However, without an abstraction time series we are unable to separate these two processes, as a significant proportion of water abstraction remains unmeasured to this day.

The two major rivers diverge. Days of third-level flood alert on the Tisza have virtually disappeared since 2013 (falling from 12 days a year to 1.5 days in Szolnok), while on the Danube they have remained essentially unchanged; in September 2024, the Danube experienced one of the greatest floods of the century in the same month that the Tisza suffered prolonged low flows. The Danube is also fed by snow and ice from the Alps, while the Tisza is fed by precipitation from the Carpathians; consequently, preparedness measures differ from river to river.

FIGURE 1

Rate of decline in the groundwater table at 763 wells in the national network of observation wells, 2001–2026 (cm/decade). Brown shades indicate a falling groundwater level, while blue shades indicate a rising one; some of the blank areas represent gaps in the data.

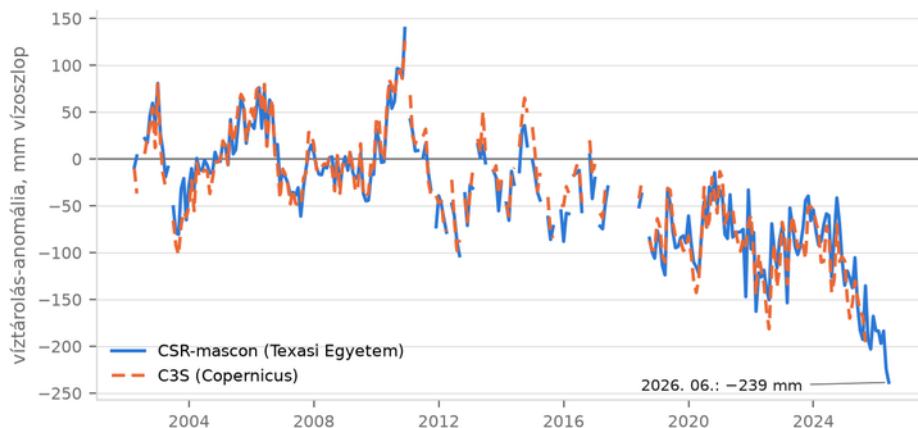
763 törzskút; ebből 721 süllyed



SOURCE own calculations based on public monitoring well data from the National Water Authority.¹¹

FIGURE 2

Terrestrial water storage across Hungary has been declining in stages since 2014. Monthly water storage deviation, mm water column, relative to the 2004–2009 average; two independent analyses. 100 mm water column corresponds to approximately 9 km³ of water across the country.¹²



06

The main driver of drying is evaporative demand

The increase in the vapour pressure deficit is the strongest observed signal. The vapour pressure deficit indicates how much more water vapour the air could hold in addition to what is already present. In other words, it reflects the air's capacity to hold water vapour, which is also the main driving force behind evaporative demand. Between 1971 and 2025, its summer value increased by 73 Pa per decade, and in 2021–2025 it exceeded the 1971–1980 average by 39 per cent, while the number of days with values above 1,500 Pa – which already place a strain on plants – rose from 19 to 57 per year over the same periods.⁶ This is significantly faster than the increase in evaporative demand calculated using the standard method, and none of the 28 domestic model runs reproduce this trend. The runs estimate air humidity indirectly, based on temperature; consequently, on dry soil or during a heatwave, they are only able to predict half of the actual increase.⁸

Actual evaporation no longer keeps pace. In dry air, evaporation is rapid provided there is something to evaporate. On parched soil, actual evaporation falls short of the evaporative demand, and plants suffer a water deficit. According to measurements from MATE's Bugac eddy covariance station, which are due to be published, actual evaporation has long since ceased to keep pace with the increase in evaporative demand. Nation-

wide, model-estimated actual evaporation increased between 1981 and 2020, but at a slower rate than evaporative demand; between 2000 and 2022, it even decreased in parts of the Great Plain.¹ Atmospheric drying is therefore primarily evident in the water deficit experienced by plants, while the volume of water actually evaporated is growing more slowly.

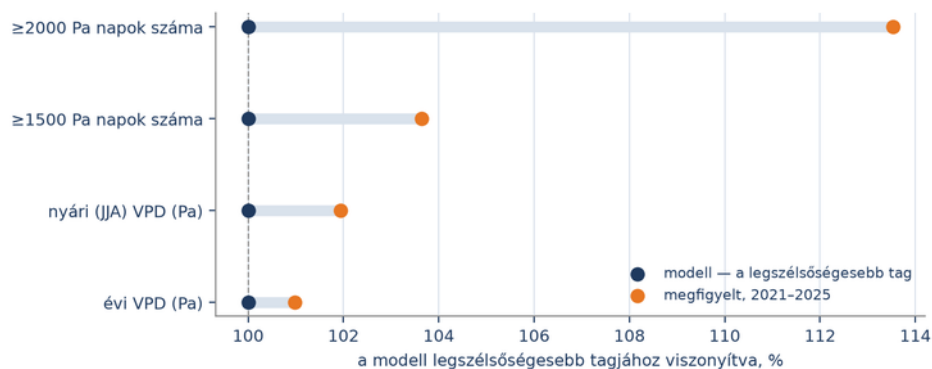
The duration of dry spells did not increase up to 2025. No detectable trend was observed in the longest dry spell during the growing season up to 2025; however, in 2026, the average across the ten stations that have been recording data since 1901 was 30.2 days, which is the highest value since records began, although it exceeded the 1992 peak by only 1.2 days.⁶ A single year does not indicate a trend, so it cannot yet be determined whether we are seeing a one-off spike or a turning point. If the figure reaches 28 days again in at least two years between 2027 and 2031, then we can speak of a turning point in this parameter as well.

The same amount of rainfall, in fewer and heavier events. The annual total rainfall has not decreased, but the number of days with at least 20 mm of rainfall is approximately 20 per cent higher in the 1996–2025 period than in the 1971–2000 period. This is a comparison of two time periods and therefore cannot be described as a trend, but in small catchment areas it nevertheless points towards an increased risk of flash floods.

The risk of frost is not disappearing, but is changing. The number of frost days fell from 96 to 80 per year between the 1971–1990 and 2006–2025 periods; however, this decrease stems from late autumn and early spring days; the number of frosts in April–May has remained unchanged, while bud burst – calculated from the heat sum – has occurred twelve days earlier. The period of exposure between bud burst and the last frost was longer on average over the five-year period 2021–2025 than in any previous decade; however, this is merely an indication and not a confirmed trend.¹

FIGURE 3

The vapour pressure deficit has now exceeded the most extreme value in the domestic model ensemble. The observed value for 2021–2025 is expressed as a percentage of the most extreme member of the 28 runs, across four vapour pressure deficit indicators (VPD: vapour pressure deficit; JJA: summer). For all four indicators, the observation lies outside the model range.



SOURCE own calculations.^{6,8}

WHY SNOW MATTERS

As well as the amount of winter precipitation, the length of time it remains on the surface as snow is also important, because a slowly melting snow cover gives the water time to infiltrate. At the water authority network's stations on the Great Plain, the median number of days with a snow cover fell from 22 to 6 between 2003–2014 and 2015–2026, and is decreasing at all seventeen stations studied.¹¹ At the wells in the Homokhátság region, the winter half-year precipitation below which the groundwater level does not rise in net terms over the winter is approximately 185 mm; the average winter precipitation (239 mm) is above this threshold but barely raises the level. The threshold required for recharge varies by region and must be measured separately.

07

Risk and consequences: from hazard to damage

Risk is composed of three factors. Hazard refers to the physical event: heatwave, drought, low flows. Exposure refers to who and what is present where the hazard occurs. Vulnerability refers to the extent of the harm caused if the hazard occurs. Domestic risk is carried by the chains linking the hazard to socio-economic consequences, and these chains can reinforce one another. Where the discussion below is brief, this indicates a lack of data, not a lower level of risk.

Heat and health	The impact of heat on mortality is immediate, and most of it is not merely death brought forward. Between 2011 and 2023, the annual excess mortality averaged 814, with extremes of 28 and 1,741. ¹³ In 2024, approximately 2,300 deaths were attributable to the heat, while cause-of-death statistics listed heat as the cause of death in only 27 cases. ¹⁴ The burden falls almost entirely on those aged 75 and over; the number of cases in emergency care rises by 2 per cent on heatwave days, and by a third to a half more than this in districts with a shortage of GPs. ¹⁵ According to a 2019 survey, 88 per cent of social care homes had no air-conditioned room. A 2026 European study found that more than half (56 per cent) of heat-related deaths in Hungarian cities are a consequence of human-induced global warming; in Budapest, the figure was 76 per cent in 2025. ³³
Urban heat island	The heat island effect is most pronounced at night. Between 2016 and 2025, there were an average of 31 tropical nights per year in the inner city of Szeged and 9 in the outskirts; by early October 2026, these figures had risen to 41 and 18 respectively. ⁶ In dense urban districts, the situation is worse than the national grid shows.
Agriculture	Maize is the most sensitive of the major crops. Since 1990, its average yield has fallen more than 20 per cent below the seven-year rolling median in six years, all with unusually hot summers; however, the average yield is just as closely linked to rainfall during the growing season as it is to summer heat. ¹⁶ In Békés County, the yield fell from 6.7 t/ha in 2010–2019 to 4.6 t/ha for 2021–2025, while in Zala County it increased over the same period. In 2026, the drought went beyond even this picture: in Békés, the preliminary county average was 1.4 t/ha, while nationally, the average maize yield was estimated at around 3 t/ha, following 3.4 in 2022 and 5.3 in 2025. The national average for winter wheat was 4.3 t/ha, following 5.5 in 2025, while that for sunflower was around 1.6 t/ha, 20 per cent below the five-year average. ³⁴ The value of the crop losses for six major arable crops during the 2022 drought amounted to approximately 2.4 billion euros, calculated at 2022 peak prices, which is not the same as the loss of income. ¹⁷ Loss compensation payments totalled 162.8 billion forints between 2012 and 2024; in 2022, only 80 per cent of eligible claims were paid out. The area at risk of secondary salinisation is in the region of 400,000 hectares, and the process will not reverse itself; this figure is known from secondary sources.
Forestry	The climate zones used in Hungarian forestry have already shifted, and the two assessments end in 2010; the warming that has occurred over the past decade and a half is not reflected in them. Planting and the selection of tree species must be adapted to the drier climate zones.
Drinking water and irrigation	The depletion of water resources is also affecting the drinking water supply. Of the 1,746 operational water sources, 208 are highly vulnerable and a further 113 are vulnerable; those situated on shallow, porous aquifers are the most vulnerable. ¹ The expansion of irrigation relying on groundwater cannot be justified until water abstraction has been measured. Irrigation is an expensive, after-the-fact summer measure that does not replenish water supplies.
Energy	Low river flows trigger restrictions on both cooling water and navigation, while hot, dry summers increase demand for electricity. There are no aggregate figures on the proportion of capacity dependent on cooling water, nor on the impact on imports and prices.
Settlements and infrastructure	Heavy rainfall causes flash floods in small catchment areas; the majority of the damage is uninsured. The official geographic information system classifies 2,120 mountain and hilly catchment areas according to flash flood risk, of which 367 are at high risk. ¹ The majority of the building stock will still be standing in 2050, but there is currently no requirement on summer overheating.

Economy and public finances	There is no official Hungarian damage assessment; the only identified official macro-level estimate dates from 2010. ¹⁸ According to a model calculation commissioned by the Hungarian National Bank in 2021, the gradually intensifying impacts will reduce GDP by approximately 1 per cent by 2050 under a warming scenario of less than 2 °C, and by 4.25 per cent under a scenario of 3.5–4 °C, excluding damage from extreme events. ¹⁹ Part of the risk lies in the allocation itself. The Water Management Act sets out the order of priority for water demands; restrictions are imposed in the reverse order, with no compensation provided except for water use for subsistence purposes; however, investment planning does not align with this order. ²⁰
-----------------------------	--

08

Summer 2026: the compound event turns into an operational disruption

The risks arise simultaneously due to a common cause. In the summer of 2026, heatwaves, drought, low flows and power station output curtailment occurred at the same time. Such combined events are regularly underestimated by planning approaches that treat hazards separately. The damage also occurs in just a few exceptional years. According to the European damage series, between 1980 and 2024, domestic weather- and climate-related damage amounted to 12.8 billion euros at 2024 prices; 78 per cent of this occurred in just five years, and only 4.8 per cent was insured.²¹ A reserve calculated for an average year is therefore insufficient.

The deterioration is proceeding at two speeds. Slow erosion – such as the quarter-century-long decline in the water table – is not conspicuous in any single year, particularly when measured against the recent past; the sudden turn, however, hits a system that has already been weakened. Before 2026, the decadal average of the longest dry spell was below normal; recent experience has therefore pointed in exactly the opposite direction.

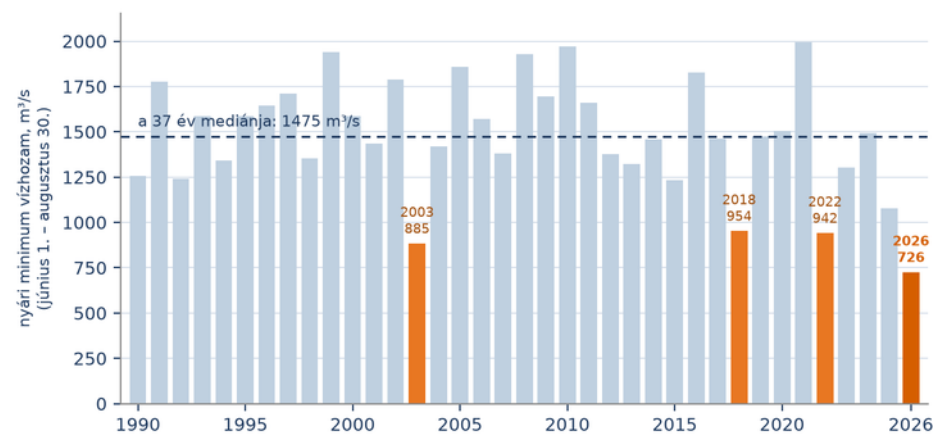
Ninety-six per cent of our water resources come from abroad, so droughts in upstream countries have a direct impact on us. Derailment risk is particularly dangerous: a series of damaging events and crisis management divert funds and attention away from prevention, pushing us towards less favourable trajectories.

Funding is not pre-arranged either. According to a European model, in the event of a flood with a 1 per cent annual probability (referred to in the source as a ‘once-in-a-century’ event), domestic reserves would cover approximately 175 million euros and the EU Solidarity Fund approximately 196 million euros, leaving some 936 million euros uncovered.²² The uncovered portion currently awaits an ad hoc budgetary decision.

CASE STUDY: LOW FLOWS AND A NUCLEAR POWER STATION, SUMMER 2026

Due to record-low flows in the Danube and the temperature limit on discharged cooling water, the output of the Paks Nuclear Power Station had to be reduced from 27 July 2026. On 29 July, according to public announcements, a whole unit was shut down for the first time in the power station’s history due to low flows; on 1 August, total output fell to 476 MW.²³ At Paks, the lowest summer water flow was 726 m³/s – the lowest summer value in the 37-year record – and on 8 October, the daily average fell to 613 m³/s.¹¹ There is a gap in accountability on the institutional side of the chain. In the environmental permit for the Tiszaújváros power station, the water authority states that, due to uncertain low-flow conditions, it makes no statement on a fully reliable water supply,²⁴ while energy planning treats this same capacity as firm.

FIGURE 4
The minimum summer flow of the Danube at Paks in 2026 was the lowest value in the 37-year series. Water flow, m³/s; the lowest daily average of the year between 1 June and 30 August, 1990–2026.



SOURCE own calculations based on the Paks water flow series from the National Water Authority.¹¹

09

Outlook to 2050: what to design for

Beyond the decade, domestic measurements no longer provide a direct benchmark; therefore, the 2050 scenario must be treated as a risk management issue. In other words, it provides guidance on what to design for and what to monitor. If the measured decadal rate continues, global warming will reach 2.0 °C by 2050. If the faster rate observed in five data-sets since 2013–2014 persists, this would result in a rise of 2.2–2.4 °C; statistically, this acceleration currently rests on the record year of 2024. Both are simple extrapolations, not forecasts.^{3,25} The IPCC gives 2.0 °C for the

2041–2060 average under the medium emissions pathway,²⁶ while the UK Climate Change Committee regards a 2 °C rise by 2050 as a minimum planning assumption.²⁷

Stabilising at a more favourable level cannot be counted as a saving. Under one of the most favourable emission scenarios included in the assessment (if all commitments and net-zero targets are met), warming peaks at around 1.8 °C, while the most stringent scenarios, starting in 2025, have a 50 per cent chance of peaking at 1.6–1.8 °C.²⁸ The carbon budget for the 1.5 °C target would be exhausted in three years at current emission levels, while that for the 1.7 °C target would be exhausted in twelve years. These three figures are global values and cannot be converted into national figures by applying a multiplier. The background document therefore estimates, based on regional warming from global models and measured domestic amplification, that compared with the 1991–2020 average, the 2 °C level corresponds to an annual mean temperature in Hungary that is approximately 1.9 °C warmer, the 2.5 °C level 2.5 °C warmer, and the 3 °C level 3.3 °C warmer. Measured on the same basis, the region is warming 1.4–1.5 times faster than the global average. This is lower than the amplification observed in the past, partly because the reduction in sulphur pollution – which accelerated past warming in Europe – has largely already taken place; however, as these same models underestimated past warming in Europe, the figures should be regarded as lower-bound estimates. The domestic regional runs give 7.7 extremely hot days per year at the 2 °C level, fewer than the 8.5 already recorded in 2021–2025; in planning for 2050, going below the measured average is unjustified.¹

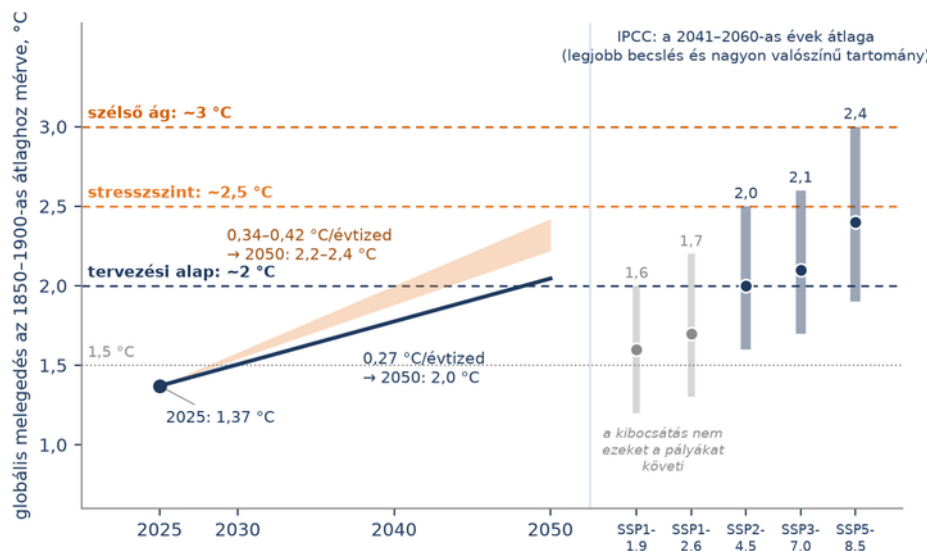
The flow regime of the Danube will change by 2050. According to model calculations, the volume of the Alpine glaciers will decrease by 47–52 per cent by 2050 compared with 2017 levels, essentially regardless of the emissions pathway; moreover, the melting measured since 2022 is running at roughly twice this rate.²⁹ Winter water flow will increase, while the trend in average summer flow is uncertain; however, low flows may become increasingly extreme, as meltwater provides the reserve during hot, dry summers. By 2050, there is little difference between the 2 °C and 2.5 °C scenarios in terms of the Danube's ice reserves, as most of the ice will melt in any case due to the warming that has already occurred; after 2050, however, the temperature level becomes decisive, and at 3 °C, Alpine ice will virtually disappear. When planning for cooling water, navigation and drinking water supplies, the measurement data from the summer of 2026 should therefore be regarded as the base case for stress testing.

The tipping points will affect Hungary via atmospheric circulation, the flow of the Danube and the acceleration of global warming. Of the seven tipping points affecting Hungary, the best estimates for the thresholds of

five fall within the 2–2.5 °C range or below it.³⁰ According to the literature from 2025–2026, a shutdown of northern deep convection by 2050 is a realistic risk, rather than a complete collapse of the circulation, and there is no consensus on whether the circulation is already weakening. A weakening of the Atlantic deep-water current will not halt domestic warming; however, according to one modelling study, it may lead to a reduction in winter precipitation in Central Europe, while a collapse of the current could result in more severe winter cold extremes. These are the background document's own conclusions.

FIGURE 5

Around 2050, even a continuation of the measured rate gives 2 °C of global warming. Left-hand side: extrapolation of the observed trend from the 2025 value. Right-hand side: the average for the 2041–2060 period across five emission pathways; the two low-emission pathways assume an immediate, steep reduction in emissions, which has not materialised.



SOURCE own calculations.^{3,25,26}

Planning level	Global warming around 2050	Role
Planning basis	~2 °C	Reference point for all facilities and standards that will remain in operation after 2050
stress test	~2.5 °C	mandatory sensitivity analysis for long-lived facilities
extreme branch	~3 °C	scenario, not a basis for design

10

Risk bands applied

For chronic, systemic risk, the probability framework alone is insufficient. The assessment therefore describes three observable risk bands for the coming decade and assigns indicators to be monitored for each. The indicators can only be used if it is established in advance for each one which decision crossing it triggers; otherwise, the signal remains merely an observation.

Risk band	Description	Role in planning
Favourable band	Abundant, replenishing winters recur more often than at present, while the summer heat burden remains in the lower half of the forecast. The depletion of reserves comes to a halt.	Not a planning basis.
Planning-basis band	The central scenario of the forecast is realised: an annual deviation of +1.7 °C and a summer deviation of +1.9 °C, with more extremely hot days. Abundant winters will not be more frequent than at present, so reserves will continue to decline slowly.	This is the band with the greatest weight; planning must start from here.
Compound stress band	In two or more consecutive years, winter precipitation falls below the replenishment level, compounded by summer heat, power station output curtailment due to low flow and spring frost damage.	Not the most likely scenario, but reasonably possible: preparations must be scaled to cope with this.

What would weaken this assessment

If the groundwater level at wells east of the Danube begins to rise persistently over the next five years, even with average winters, the main finding regarding the water system will be weakened. If a new generation of models reproduces the observed evaporation and temperature trends, the ‘planning minimum’ rule will be weakened, and the centre of the model range will regain its role in design. If excess mortality data follow the 2026 pattern over several years alongside a rising heat burden, the weighting of the health risk should be adjusted downwards, as the effects of early warning and adaptation prove lasting.

WARNING SIGNS, 2027–2031

1. winter half-year precipitation relative to the recharge level measured by region, over three consecutive years, and the frequency of abundant winters – this is where the favourable band and the planning basis diverge;
2. the August low points in the national network of monitoring wells, and whether abundant winters will raise the level back to previous peaks;
3. an explanation for the decline in confined groundwater levels after 2019, provided that extraction data is available by then;
4. the excess mortality in weeks with extremely hot days, i.e. whether the effect of adaptation is waning or is long-lasting;
5. the longest dry spell during the growing season, i.e. whether the 2026 record was a one-off spike or a turning point;
6. whether the decadal prediction proves accurate, i.e. whether the actual data for 2026–2030 remain within the predicted range;
7. as an institutional indicator, whether the vulnerability data layers are being updated and whether a five-day resolution soil moisture series is being established for the root zone.

11

Policy decisions

The assessment does not set out to take investment decisions, nor does it provide cost estimates or timetables for such decisions. It indicates only where decisions need to be taken and on what evidence. The following three basic principles should be followed in every sector:

- (1) **For the four main climatic parameters, measurements must be taken as the basis for design.** For temperature, days reaching 30 °C, spring frost and vapour pressure deficit, the lower limit of the model range must be treated as the minimum conceivable value, and not as a safe design basis
- (2) **Design is for the unfavourable but realistic case, namely two consecutive drought years with heat, low flows and frost damage, rather than on the mean values of climate projections.** The summer of 2026 is to be regarded as the design event for dry periods and also serves as a stress test for capacities dependent on cooling water.
- (3) **Facilities operating beyond 2050 must be designed for at least 2 °C of global warming, with a 2.5 °C stress test, and this level should be laid down in law so that all sectoral plans and standards refer to the same**

benchmark. In January 2026, France laid down its own reference scenario in a decree.³¹

The table below summarises the key actions required in each sector. A detailed list can be found in the background document; for several of these actions, working practice in other European countries provides a model.¹

Sector	Key action	Nature
Water management	Ensuring that water abstraction is measured even where it is not currently measured, as this is the least costly step and a prerequisite for all further water management decisions. Winter half-year water must be retained in the landscape; areas changing land use – those not economically viable as arable land in the long term – are the primary locations for this.	data; rule
Agriculture and forestry	The vapour pressure deficit, the driving force of evaporative demand, should be included among the indicators for agricultural planning and subsidy conditions. Compensation for losses must be linked to the suitability of the growing site, and where arable farming is not justifiable in the long term, a change in land use must be supported. Afforestation should be targeted at drier climate zones.	rule
Energy	The reduction in output due to low flows must be incorporated into system design using the frequencies from the measured flow series, and the assumptions used in water licensing must be aligned with energy planning.	Operation
Health and social care	Preparations for heatwaves should be based on four target groups: the elderly, the chronically ill and bedridden, pregnant women and young children, and outdoor workers. The primary indicator for heatwave alerts should be the heat burden on those aged 75 and over; the alert system must not be dismantled.	Operation
Buildings and settlements	Mandatory summer overheating protection requirements for new and significantly refurbished buildings, with priority given to those providing care for the elderly. In settlements at risk of flash floods, rainwater drainage systems must be reinforced; in inner-city areas, less paving and more green space and water surfaces.	rule; investment preparation
Finance	An official national economic damage account, a budgetary reserve for rare years of major damage, and pre-determined damage financing arrangements specifying who pays for major damage and from what sources. Compulsory disaster damage insurance with state reinsurance should be examined.	data; rule
Data and measurement	Updating vulnerability data layers is a quick and cheap data task. Expanding the measurement of air humidity; establishing a national soil moisture monitoring network covering the root zone with a designated data manager; grading the quality of the data series of existing sectoral networks; and ensuring the long-term maintenance of stations measuring actual evaporation.	data
Governance	In addition to the adaptation strategy, a five-year implementation programme with a budget and designated owners, a national climate risk report every five years, and an annual assessment of warning signs by a designated owner.	rule

Annex A – Glossary

Decadal prediction: a model run initiated from measured oceanic and atmospheric initial conditions, for the next ten years. This is not the same as the end-of-century projection, which is based on an emissions pathway.

Winter and summer half-years: October–March and April–September respectively. Groundwater recharge occurs in the winter half-year.

Hot day and extremely hot day: a hot day is a day on which the daily maximum temperature reaches 30 °C; an extremely hot day is one on which it reaches 35 °C.

Tropical night: a night on which the temperature does not fall below 20 °C.

Vapour pressure deficit (VPD): the difference between the amount of water vapour the air could hold and the amount it actually contains; in other words, the air's capacity to absorb water vapour. It is the main driving force behind evaporative demand, a quantity calculated from measurements, rather than the water that has actually evaporated.

Evaporative demand: the atmosphere's capacity to remove moisture, an indicator calculated for a standard, well-watered grass surface. On dry soil, actual evaporation no longer follows this value.

Actual evaporation: the water that actually evaporates from the soil and vegetation, measurable using the eddy covariance method. Under water-limited conditions, it increases more slowly than evaporative demand, or does not increase at all.

Confined groundwater: groundwater stored in deeper, typically confined aquifers; one of the main sources of drinking water. Groundwater is shallower than this and is directly linked to precipitation.

Model range: the range of values for a given indicator produced by model runs.

Risk: the combination of hazard, exposure and vulnerability. Exposure refers to the population, agricultural land, building stock and infrastructure exposed to the hazard, while vulnerability refers to the extent to which the hazard causes harm if it occurs.

Derailment risk: the risk that repeated damage and crisis management divert funds and attention away from prevention, thereby pushing the system towards more adverse trajectories.

Tipping point: an element of the climate system which, once a threshold is crossed, undergoes a self-sustaining change of state and, on a human timescale, does not revert even if warming ceases.

Annex B – Methodology

The assessment summarises the findings of the detailed background document and does not perform any new calculations.¹ The background document is based on four main datasets: the HungaroMet homogenised daily grid from 1971 to 2025; runs of international decadal prediction systems launched at the end of 2024; the national groundwater monitoring network of the National Water Authority for the period 2001–2026, with time series extending back to 1975 for the analysis of cyclical patterns; and daily data from water gauges. The calculations were made from the source data with AI support and were subjected to independent re-calculation, which does not necessarily reveal blind spots arising from the common methodological approach. Where a figure is another author’s, the reference list names the source.

The authors have assigned confidence levels to the findings based on the nature of the evidence base – that is, according to how many independent measurement series support them, the length of the series, and whether the data are preliminary. The 2050 finding is based on modelling and expert assessment; therefore, its confidence level is at most medium. The basis and time period are stated alongside each figure, as a climate figure cannot be interpreted without these two elements. The mortality, precipitation and river discharge data for 2025 and 2026 are preliminary and subject to change.

The assessment does not provide estimates of drought damage to the national economy, return periods, the total water balance, the climatic attribution of individual events, or an aggregate ‘cost of inaction’. These are not included in the background document either; its limits are listed in a separate annex.

Annex C – Sources

1. Feiler J., Nemes Cs., Kardos P., Szabó P. (2026): Climate risks in Hungary over the coming decade. A risk profile for the period 2026–2035, with an outlook to 2050. Published by the authors, Budapest, 20 October 2026. DOI [10.5281/zenodo.23430763](https://doi.org/10.5281/zenodo.23430763). ↵
2. HM Government / Cabinet Office (2025): National Risk Register 2025. London. ↵
3. Forster, P. M. et al. (2026): Indicators of Global Climate Change 2025. Earth System Science Data 18, 3889–3933. ↵
4. Mauritsen, T. et al. (2025): Earth’s Energy Imbalance More Than Doubled in Recent Decades. AGU Advances 6, e2024AV001636. ↵

5. Bimpiri, K., Hocking, T., Mauritsen, T. (2026): Climate models with moderate climate sensitivity best simulate the magnitude of Earth's energy imbalance. *Earth System Dynamics* 17, 877–892. ↩
6. HungaroMet Open Data Policy portal (odp.met.hu): homogenised daily grid database 1971–2025, daily time series from the ten stations that have been operating since 1901, and observations from the inner-city and outlying stations in Szeged; own calculations. ↩
7. National Observatory of Athens: Decadal prediction downscaled to Hungary (CMIP6 DCP, HadGEM3-GC31-MM, November 2024 run); own calculations. ↩
8. Kern, A. et al. (2024): Seamlessly combined historical and projected daily meteorological datasets for impact studies in Central Europe: The FORESEE v4.0 and the FORESEE-HUN v1.0. *Climate Services* 33, 100443. ↩
9. HungaroMet: KLIMADAT geoinformation system, version 2.0 (14 July 2026), gis01.met.hu/klimadat; county and district data tables, downloaded on 10 October 2026; own calculations. ↩
10. HungaroMet (2026): assessment of temperature and precipitation conditions in the summer of 2026, 7 September 2026, preliminary data. ↩
11. National Water Authority: water data service (data.vizugy.hu), groundwater wells 1960–2026, snow depth, water level and discharge data from gauges; own calculations. ↩
12. Save, H., Bettadpur, S., Tapley, B. D. (2016): High-resolution CSR GRACE RL05 mascons. *Journal of Geophysical Research: Solid Earth* 121, 7547–7569; Copernicus Climate Change Service: terrestrial water storage anomalies derived from satellite gravimetry. ↩
13. Páldy A., Bobvos J., Rudnai T. (2024): Review and development of the heatwave warning system. *Health Sciences* 67(1): 36–52. ↩
14. Hungarian Central Statistical Office (KSH): Demographic Yearbook 2011–2024, daily mortality and causes of death; HungaroMet daily grid; own calculations using a distributed lag model (Gasparini et al. 2010, *Statistics in Medicine* 29: 2224–2234). European estimate by age group: Janoš, T. et al. (2025): Heat-related mortality in Europe during 2024. *Nature Medicine* 31: 4065–4074. ↩
15. Hajdu, T. (2025): Heterogeneous impacts of climate change on morbidity. *Economics & Human Biology* 58: 101517. ↩
16. KSH STADAT 19.1.1.18. and 19.1.1.12.: average yield and harvested area of the main arable crops; county-level average yield; own calculations. ↩
17. Pinke, Zs. et al. (2024): Hotspots in the EU-27 and Economic Consequences of the 2022 Spring–Summer Drought. *EuroChoices* 23(1): 28–33. ↩
18. VAHAVA Report (2010): Climate Change and Hungary: Mitigating Risks and Preparing for Impacts. Hungarian Academy of Sciences – Ministry of Environment and Water Management. ↩
19. Fazekas, D., Goldman, M., Kórműves, Zs., Pavelka, A. (2021): Climate impact assessment: Impacts of climate change scenarios on the Hungarian economy. Cambridge Econometrics for the Hungarian National Bank, Budapest. ↩
20. Act LVII of 1995 on Water Management, Section 15. ↩
21. European Environment Agency (2025): Economic losses from climate-related extremes in Europe, 1980–2024. ↩
22. World Bank, European Commission (2021): Economics for Disaster Prevention and Preparedness: Financial Risk and Opportunities to Build Resilience in Europe. Washington DC – Brussels. ↩
23. Press releases from MVM Paks Nuclear Power Plant Ltd., July–August 2026; Hungarian Atomic Energy Authority data as reported in the press. ↩
24. Borsod-Abaúj-Zemplén County Government Office: Decision No. BO/32/02197-47/2025 (integrated environmental permit, Tiszaújváros), April 2025. ↩

25. Foster, G., Rahmstorf, S. (2026): Global warming has accelerated significantly. *Geophysical Research Letters* 53, e2025GL118804. [↔](#)
26. IPCC (2021): Summary for Policymakers. In: *Climate Change 2021: The Physical Science Basis*. Cambridge University Press. [↔](#)
27. Climate Change Committee (2026): A Well-Adapted UK: The Fourth Independent Assessment of UK Climate Risk. London. [↔](#)
28. UNEP (2026): Limiting Overshoot: Navigating exceedance of 1.5°C and pathways towards return. Nairobi. [↔](#)
29. Zekollari, H., Huss, M., Farinotti, D. (2019): Modelling the future evolution of glaciers in the European Alps under the EURO-CORDEX RCM ensemble. *The Cryosphere* 13: 1125–1146; Cook, S. J. et al. (2023): Committed Ice Loss in the European Alps Until 2050. *Geophysical Research Letters* 50(23), e2023GL105029; GLAMOS (2026): mass balance of Swiss glaciers 2025/26, 1 October 2026. [↔](#)
30. Armstrong McKay, D. I. et al. (2022): Exceeding 1.5°C global warming could trigger multiple climate tipping points. *Science* 377(6611), eabn7950; Lenton, T. M. et al. (eds.) (2025): *Global Tipping Points Report 2025*. University of Exeter. [↔](#)
31. Decree No. 2026-23 of 23 January 2026 on the reference warming trajectory for climate change adaptation. JORF, 25 January 2026. [↔](#)
32. Drinking Water Quality 2011. Public Health Report, on the website of the National Centre for Public Health (nnk.gov.hu/attachments/article/726/Ivóvízminőség_2011.pdf): 46 per cent of domestic drinking water is bank-filtered, 35 per cent is confined groundwater, 11 per cent is protected karst water, and 8 per cent is surface water. [↔](#)
33. Barnes, C., Masselot, P., Xi, D. et al. (2026): Heat-related urban mortality attributable to human-induced climate change in Europe from 2000 to 2025. *Nature Health*, published 14 October 2026. DOI [10.1038/s44360-026-00209-8](https://doi.org/10.1038/s44360-026-00209-8). The figures for Hungarian cities are taken from Table 2 of the paper (Hungarian cities included in the sample, 2.8 million inhabitants; annual average of 393 deaths, of which 217 are attributable to global warming), while the 2025 figure for Budapest is taken from Supplementary Table 4 (210, proportion 0.76). The model does not account for adaptation. [↔](#)
34. Preliminary crop yields for 2026: AKI: Information report on summer agricultural work, as at 13 August 2026 (winter wheat 4.235 million tonnes, 4.3 t/ha); information from the Ministry of Agriculture and Food and the National Association of Cereal Growers, 23 September 2026 (maize, sunflower); data from the Békés County Harvest Committee as at 29 September 2026 (BEOL, 30 September 2026). Previous years: KSH STADAT 19.1.2.5. All 2026 figures are provisional. [↔](#)