Closing the Mesh

The Hungarian Plain Is a Storage Problem, Not a Rainfall Problem

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1. What is on the table

A reportage from the Hungarian lowland gives a set of numbers. They are worth reading as measurements, not as atmosphere.

At Kiskunmajsa, on the sand ridge between the Danube and the Tisza, a landowner digs a pit each summer to find the water table. Last year he reached it at 6.5 metres. This year at 8 metres. That is a drop of 1.5 metres in twelve months at one point.

The trees on the same ground sort themselves by root depth. The tall ones still reach water. The lower ones stand bare. Nothing is being observed there except the depth of the water and the depth of the roots.

Central Hungary is warming roughly fifty per cent faster than the rest of Europe. The plain sits inside the Carpathian ring. Heat does not leave it easily.

The Danube fell far enough this summer that the Paks nuclear station had to reduce output. Paks normally supplies about forty per cent of Hungarian electricity. Households and firms were asked to cut consumption.

The grain harvest fell more than anywhere else in the Union, against last year and against five years ago. In severe drought the loss runs past half the crop. The OECD puts the economic damage near six billion euro.

One farmer near the Serbian border lost fifteen per cent. His neighbour on the same soil, in the same weather, lost more than half. The difference between them is the subject of this article.

The national hydrological view is that the plain is past its tipping point. The claim is worth taking seriously and worth taking apart. It is true of one layer and false of another. Which layer is which decides whether a government invests or resigns itself.

2. The net, in eight lines

The frame used here is the one developed in earlier work. It is stated compactly so this article stands on its own.

1. There is one strand, not two things interacting. What appears as separate objects are windings of the same strand at different depths.
2. A knot is a winding that closes. Only what returns in phase stays.
3. A mesh is the open space a closed winding encloses. The mesh is not empty. It is the state.

4. Tension is what a mesh holds before it discharges.
5. Discharge is not caused. It is what happens when closure fails and the tension has nowhere left to sit.
6. Delay is a valve. Held tension does not vanish. It returns enlarged.
7. Context sets which forms are permitted. Constants are state functions, not fixed background.
8. Description at the right winding depth replaces explanation.

For a landscape this reads directly. Rain arriving is not the state. Rain held is the state. A catchment that returns its water to itself has closure. A catchment that passes water through has none. What passes through is not available to return.

The fishnet image applies without translation. Cut the mesh and the net still exists. It just holds nothing.

3. The category error

Three things are being confused in the Hungarian debate. They sit at different depths and have different response times.

Rainfall. How much water arrives. Set by the circulation over the continent, which is set deeper still. Nothing done on the plain changes it.

Storage. How much of what arrives is retained in soil and aquifer. Set entirely by what is done on the plain.

The mesh. Whether the retained water is returned to the local atmosphere as evapotranspiration, or exported as runoff and drainage. Also set entirely by what is done on the plain.

The reportage treats all three as one thing called drought. The hydrologist's tipping-point claim is then ambiguous. Past the tipping point in rainfall is probably true and is not actionable. Past the tipping point in storage is a claim about arithmetic and can be checked.

Section 5 checks it.

4. The mesh was cut deliberately

The plain did not dry by accident, and it did not begin drying in 2022.

From 1846 the Tisza was regulated. Meanders were cut off. The river was shortened by roughly a third of its length. Its floodplain, which had spread across a large part of the Alföld each spring, was confined between dikes.

That work was successful on its own terms. It converted marsh into arable land. It is the reason the plain became grain country at all.

It also converted a retaining landscape into a conveying landscape. The canal network that followed was built to move water off the land and into the rivers, and the rivers out of the country.

That network is still there and still works. It is doing in a drought exactly what it was built to do in a flood.

This is not a causal story about blame. It is a ledger entry. The infrastructure that exports water was installed, and nothing has since been installed that retains it. The volunteers who dammed a channel with planks last autumn were closing a mesh that was cut in the nineteenth century.

5. The storage arithmetic

Here is the calculation in full. Every step is in the text.

Area. The sand ridge between the Danube and the Tisza — the Homokhátság — covers roughly 10,000 square kilometres. That is 1 million hectares, or 10^{10} square metres. This is the zone at risk of desertification.

Storage coefficient. In sand, the fraction of soil volume that fills and drains with the water table — the specific yield — is between 0.15 and 0.25. Take 0.20.

Volume for one metre. To raise the water table by one metre across that area requires

$0.20 \times 1\ \text{m} \times 10^{10}\ \text{m}^2 = 2 \times 10^9\ \text{m}^3$ = 2 cubic kilometres.

What two cubic kilometres is. Lake Balaton has an area near 592 km^2 and a mean depth near 3.25 m. Its volume is therefore about 1.9 km^3. Raising the ridge's water table by one metre takes roughly one Balaton.

That sounds prohibitive until the flows are put next to it.

What passes through. The Tisza at Szeged carries a mean discharge near 800 m^3/s. Over a year that is

$800 \times 86{,}400 \times 365 \approx 2.5 \times 10^{10}\ \text{m}^3 = 25\ \text{km}^3$.

The Danube at Budapest carries near 2,350 m^3/s, which is about 74 km^3 per year.

So the volume needed to lift the aquifer one metre is about eight per cent of one year's Tisza flow. It is under three per cent of one year's Danube flow.

The water is not absent from the region. It is passing through it.

What retention would have to deliver. Annual precipitation on the ridge is around 520 mm. Potential evapotranspiration there is around 700 to 750 mm. The structural deficit is therefore roughly 200 mm per year. That deficit is the reason the ridge is a ridge and not a marsh.

Suppose retention works hold back an additional 50 mm per year across the million hectares. That is

$0.05\ \text{m} \times 10^{10}\ \text{m}^2 = 5 \times 10^8\ \text{m}^3 = 0.5\ \text{km}^3$ per year.

Against the 2 km^3 needed per metre, that is **four years per metre of recovery.**

Check against the observed drop. The pit at Kiskunmajsa fell 1.5 m in one year. At 0.20 specific yield that is a local storage loss of 300 mm of water in that year. A 50 mm per year retention gain does not stop a 300 mm loss year. It changes the multi-year slope, not the worst summer.

That is the honest result. It is also the useful one. It says recovery is a decade-scale programme with a measurable annual slope, not a rescue.

The conclusion on the tipping point. Fifty millimetres per year is two per cent of the Tisza's annual throughput. Nothing about the arithmetic is impossible. The plain is not past a physical limit in storage. It is past the point where a single season fixes it.

6. The latent lever

Storage is one half. What the held water then does is the other half, and it is larger than the current climate debate assumes.

The latent heat of vaporisation of water near 20 °C is 2.45 megajoules per kilogram. One millimetre of evapotranspiration per day over one square metre is one kilogram per day. In flux terms

2.45×10^6 J ÷ 86,400 s = **28.4 watts per square metre.**

That is per millimetre per day. Compare it to the global radiative forcing that the entire climate policy apparatus addresses, which is about 2.7 W/m².

One extra millimetre of local evapotranspiration per day moves about **ten times** the global forcing figure, locally.

Across the million hectares of the ridge, one millimetre per day is

28.4 W/m² × 10^{10} m² = 2.84×10^{11} W = **284 gigawatts** of latent flux redirected.

For scale, the Paks station's four reactors total about 2 gigawatts of electrical output. The lever available in the landscape water balance is more than two orders of magnitude larger than the country's principal power station.

This is the reason the mesh matters more than the screen. Energy that leaves the surface as latent heat does not heat the air above it. Energy that leaves dry ground as sensible heat does. The plain's fifty-per-cent-faster warming is not only an atmospheric import. Part of it is locally produced, and the locally produced part is settable.

No causal claim is needed here, and none is made. This is a budget. The energy arriving is fixed. How it is partitioned is set by whether there is water at the surface to take it.

7. What the two neighbouring fields actually measured

The farmer at Ferencszállás lost fifteen per cent. His neighbour lost over half. Same rain, same heat, same soil type, adjacent parcels. The difference is the closure of the mesh at field scale. It can be accounted for in millimetres.

Organic matter. Take the top 30 cm at a bulk density of 1.4 g/cm³. That is

0.30 m × 1,400 kg/m³ = 420 kg per square metre, or 4,200 tonnes per hectare.

One percentage point of soil organic matter is therefore 42 tonnes per hectare. Organic matter holds roughly two to four times its own mass in water. That gives 84 to 168 tonnes of water per hectare, which over 10,000 m^2 is

84,000 to 168,000 kg ÷ 10,000 m^2 = **8 to 17 mm** of additional plant-available water per percentage point of organic matter.

Cover. Bare soil in a Hungarian summer loses a substantial share of its stored water to direct evaporation before a root ever reaches it. Straw and weed cover suppress a large part of that. The order of magnitude recoverable over a growing season is a few tens of millimetres.

Fallow and grazing. Resting a field and returning manure to it rebuilds the organic fraction. That is what makes the first term above grow year on year instead of holding constant.

Total. Twelve years of this practice plausibly buys somewhere near 50 mm of effective growing-season water relative to the neighbouring parcel.

Why 50 mm decides a harvest. Yield is not linear in water near the wilting point. It is a threshold. The last fifty millimetres are the difference between a crop that closes its cycle and a crop that does not. The neighbour was not fifty millimetres worse off in general. He was fifty millimetres short at the point in July where the seed either sets or does not.

Selection by fit, not causation. Only what closes its cycle remains. The two fields are the experiment, already run, at no cost, with a control.

And the limit. Fifty millimetres is not two hundred. Field practice closes the mesh within the season. It does not refill the aquifer. The pit at Kiskunmajsa keeps getting deeper whatever the neighbours do with their straw.

This is the point on which honest advice differs from enthusiasm. Regenerative practice and landscape retention are two different depths of the same net. Each is insufficient alone. Together they are a programme.

8. The cost ceiling is already known

The damage figure sets the budget without any need to estimate the works.

Six billion euro of damage, spread over the million hectares of the affected ridge, is

€$6 \times 10^9 \div 10^6$ ha = €**6,000 per hectare, per damage year.**

That is the amount that may be spent per hectare per bad year before restoration costs more than compensation. It is not an estimate of what the works cost. It is the ceiling above which the argument stops being economic.

Two further comparisons make the position clear.

Hungarian GDP is on the order of two hundred billion euro. Six billion is therefore near three per cent of GDP in a bad harvest year. The budget deficit is eight per cent of GDP. The drought damage is a substantial fraction of the deficit that is said to prevent addressing it.

And compensation is a recurring cost with no terminal value. Retention is a capital cost with a rising asset behind it. The compensation regime as currently run purchases the same bad year again every few years.

The plank across a canal is the cheapest intervention in the entire ledger. The volunteers found this without a budget line.

9. One instrument

A programme needs a single number that goes up or down. Otherwise every ministry measures its own thing and nothing is settled.

The instrument proposed is a **closure index** for a defined catchment block, read annually, built from four readings that are all already collectable in Hungary.

Reading one — storage slope. The mean annual change in water table depth across the national monitoring wells inside the block, in metres per year. Sign matters more than magnitude. Falling is negative closure.

Reading two — export fraction. The volume leaving the block through gauged canal outfalls, divided by the volume of precipitation falling on the block. A conveying landscape scores high. A retaining one scores low.

Reading three — evaporative fraction. The share of available surface energy leaving as latent rather than sensible heat, taken from thermal satellite retrieval over the growing season. This is the direct reading of section 6, in the field, at no marginal cost.

Reading four — persistence. How long green cover is maintained through July and August, from the standard vegetation index. Not peak greenness. Duration.

The index is the composite. Its purpose is not precision. Its purpose is that a minister, a hydrologist and a farmer are looking at the same dial.

Three of the four readings exist for the whole plain retrospectively. The index can be computed backwards to the 1980s before a single plank is laid. The baseline is free.

10. What to do, ordered by depth

Not a phased plan. An ordering by response time, because the layers respond on different clocks and must be started in the reverse order of how fast they pay.

Deepest and slowest — the canal network. The export infrastructure is the mesh cut. Closing it is the only intervention that changes the storage slope. It is also the cheapest per unit effect and the one already demonstrated by volunteers with planks. What is needed is not invention but authority: a legal instrument allowing controlled retention on the existing network, and a rule for who bears the wet field.

The reportage contains the obstacle in one line. One landowner refused to join the flooding, and the boundary of his refusal is visible in the grass. Retention is a catchment property. It cannot be bought parcel by parcel. This is the political problem, and it is the real one.

Next — the shape of the land. Where the ridge is sand, water moves down fast and sideways slowly. Small works that hold water where it falls — swales, sunken fields, restored oxbows, controlled winter inundation of grassland — extend the time water spends in the mesh. Winter is when the water is available. The volunteers already understood this. Their channels run in autumn and winter.

Next — land use. Maize and sunflower on the driest sand are a crop choice made when the water table was two metres higher. Converting the worst of that ground to grass is not a loss of production. It is a recognition that the production already stopped. Grass with grazing rebuilds the organic fraction, which is the term calculated in section 7.

Fastest and last — field practice. Cover, residue, rotation, fallow, animals. Fifty millimetres, three to ten years, and it works on land the farmer already controls without waiting for anyone. It is listed last not because it is least important but because it is the only item that does not require a decision from anyone else. It will happen on its own now that a neighbour has shown a fifteen per cent loss against fifty.

What is not on the list. Importing water from the Danube by pump is a conveying solution to a retention problem. It buys the surface and not the aquifer, at recurring energy cost, from a river that was itself too low to cool a reactor this summer.

11. Five dated commitments

Stated as probabilities against base rates, so that the frame can be scored rather than believed.

C1. In any catchment block where canal export is materially reduced from autumn 2026, the mean water table slope turns positive within three growing seasons. **65 per cent.** Base rate for a random block on the ridge over the same period: near 20 per cent, given the trend. Measured from existing monitoring wells.

C2. Growing-season evaporative fraction over treated blocks exceeds untreated controls by at least 0.10 in July–August of 2027, 2028 or 2029. **60 per cent.** Measured from thermal satellite retrieval, no new instruments required.

C3. In the next severe drought year on the plain, the yield gap between established regenerative operations and conventional neighbours on comparable soil is at least twenty percentage points. **55 per cent.** This year's observed gap was near thirty-five. If it collapses below ten, the field-scale term in section 7 is wrong.

C4. Fifty millimetres per year of additional retention yields a water table rise of at least 0.20 m per year at block scale. **50 per cent.** This is the direct test of the specific-yield assumption in section 5. If retention is achieved and the table does not respond, the storage coefficient on that sand is lower than 0.20 and every timescale in section 5 lengthens proportionally.

C5. Mean summer maximum temperature over a treated block runs 0.5 to 1.5 K below an adjacent untreated block, in at least two of the summers 2027 to 2030. **45 per cent.** This is the local test of section 6. It is the one most likely to fail, because block scale may be too small for the signal to separate from advection. If it fails at block scale it should be retested at county scale before the latent lever is discarded.

The lowest-confidence claim is listed with its most likely failure mode. That is deliberate. A frame that cannot lose is not a frame.

12. Status ledger

Established, independently of this frame. The latent heat figure of 28.4 W/m² per mm/day. The volume arithmetic in section 5. The organic matter water-holding calculation in section 7. The historical fact of the Tisza regulation. The observed yield gap between the two farms. The €6,000 per hectare ceiling.

Model-dependent. The reading of drought as delayed discharge rather than as absence. The claim that description at the correct depth substitutes for causal explanation. The ordering in section 10.

Assumed and checkable. Specific yield of 0.20. Ridge area of 10,000 km². Structural deficit of 200 mm. Each of these is a published Hungarian figure and each should be replaced with the national value before any works are costed.

Open. Whether block-scale retention produces a detectable temperature signal. Whether the political instrument for catchment-wide participation exists in Hungarian law. Whether the aquifer under the ridge is hydraulically connected enough for local retention to raise it, or whether it drains laterally to the rivers faster than it fills.

That last one is the single question that would most change the arithmetic. It should be asked first and it can be answered from existing well records.

13. What this is for

A hydrologist said the plain is past its tipping point and that returning would cost a great deal.

The first half is true of the rainfall and false of the storage. The second half is true and the amount is smaller than the damage already being paid.

A landowner dug a pit and found the number. A farmer let weeds grow and kept his harvest. A group of volunteers put planks in a canal and turned a field green.

Three measurements exist on that plain that no ministry commissioned. The work now is to read them at the right depth, put a dial on them, and hand it to people who can lay planks across ten thousand square kilometres instead of ten.

References

1. Kabel, D. (2026). "Een woestijn in het hart van Europa: vruchtbare Hongaarse landbouwgrond verandert in dorre vlakte." ***Het Financieele Dagblad*****, 19 August 2026.** Why read? It is the source of every field observation in this article: the pit at 6.5 and 8 metres, the two neighbouring sunflower fields, the planks in the canal, the refusing landowner, the Paks reduction. Reading advice: read it as a set of measurements someone happened to write down as a story.

2. Pálfai, I. (various, 1990s–2010s). Work on the water balance and groundwater decline of the Danube–Tisza Interfluve, and the PaDI drought index. Why read? The groundwater deficit on the ridge was documented from the 1980s onward, decades before it became news. Reading advice: go here for the national values of specific yield, ridge area and structural deficit that section 12 says should replace the assumed ones.

3. Somlyódy, L. (ed.) (2011). ***Magyarország vízgazdálkodása: helyzetkép és stratégiai feladatok*****. Hungarian Academy of Sciences.** Why read? The standing national water strategy volume. It contains the institutional map — who controls canals, who controls wells, who compensates whom — which is where section 10's political obstacle actually lives.

4. Lóczy, D. (ed.) (2015). ***Landscapes and Landforms of Hungary*****. Springer.** Why read? For the Tisza regulation as a landform event: the meander cutoffs, the shortening, the confinement of the floodplain. Reading advice: read the Alföld chapters and note how recent the current landscape is.

5. Ripl, W. (2003). "Water: the bloodstream of the biosphere." ***Philosophical Transactions of the Royal Society B*****, 358, 1921–1934.** Why read? The closest existing statement of the argument in section 6 by someone who worked on real catchments. Landscapes are read as energy dissipation structures, with water as the dissipating medium and irreversibility measured by what is exported. Reading advice: this is the single most useful reference on this list.

6. Kravčík, M., Pokorný, J., Kohutiar, J., Kováč, M. & Tóth, E. (2007). ***Water for the Recovery of the Climate — A New Water Paradigm*****.** Why read? Central European, practitioner-written, and directly about small-catchment rainwater retention as climate intervention. These authors built the works before they wrote the theory. Reading advice: the arithmetic is looser than section 5 requires, but the programme in section 10 is essentially theirs.

7. Seneviratne, S.I. et al. (2010). "Investigating soil moisture–climate interactions in a changing climate: A review." ***Earth-Science Reviews*****, 99, 125–161.** Why read? The standard reference for the partition between latent and sensible heat as a function of soil moisture, which is the mechanism-free budget used in section 6.

8. Miralles, D.G. et al. (2014). "Mega-heatwave temperatures due to combined soil desiccation and atmospheric heat accumulation." ***Nature Geoscience*****, 7, 345–349.** Why read? Quantifies how a dry surface raises its own air temperature over successive days. This is the enlarged-return-after-delay pattern in a form that a meteorological audience already accepts.

9. Teuling, A.J. et al. (2010). "Contrasting response of European forest and grassland energy exchange to heatwaves." ***Nature Geoscience*****, 3, 722–727.** Why read? Two adjacent land covers, same weather, different energy partition — the continental-scale version of the two sunflower fields in section 7.

10. Basche, A.D. & DeLonge, M.S. (2019). "Comparing infiltration rates in soils managed with conventional and alternative farming methods: A meta-analysis." ***PLOS ONE*****, 14(9).** Why read? Puts a number on what cover and residue do to infiltration across many sites. Reading advice: use it to check whether the 50 mm figure in section 7 is generous or conservative for sandy soil.

11. IPCC (2021). ***Sixth Assessment Report, Working Group I*****, Chapter 11 and the regional Atlas, Central and Eastern Europe.** Why read? For the Carpathian Basin's projected drying and the observed warming rate against the European mean. It is the source behind the fifty-per-cent figure quoted in the reportage.

12. IPCC (2022). *Sixth Assessment Report, Working Group III*. Why read? Diána Ürge-Vorsatz, quoted in the reportage, is a vice-chair of this working group. Reading advice: read the demand-side and land chapters to see what she means by cheap interventions.

13. Cook, E.R. et al. (2015). "Old World megadroughts and pluvials during the Common Era." *Science Advances*, 1(10). Why read? The tree-ring drought atlas for Europe. It shows that the Carpathian Basin has had multi-decade dry episodes before industrial forcing. Reading advice: this is the argument against panic and for persistence measurement.

14. Tapley, B.D. et al. (2019). "Contributions of GRACE to understanding climate change." *Nature Climate Change*, 9, 358–369. Why read? Total water storage from satellite gravimetry. It is the independent check on section 5's storage arithmetic at basin scale, without a single well.

15. Fisher, J.B. et al. (2020). "ECOSTRESS: NASA's next-generation mission to measure evapotranspiration from the International Space Station." *Water Resources Research*, 56. Why read? The instrument behind reading three of the closure index in section 9. Reading advice: check revisit frequency over Hungary before committing the index to it, and hold Copernicus thermal products in reserve.