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Flooding Has Become Fast. Flood Risk Management is Still Slow

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Introduction

The gap between the timescale of the hazard and the timescale of our response is now the binding constraint on climate adaptation — and closing it is a data problem more than a modelling problem.

When a cloudburst hits a city, rain becomes flood in minutes. The catchment is small, sealed and steep; there is no river channel to absorb the storm and usually no gauge to record it. Yet the instruments we manage this hazard with — statutory maps, design events, review cycles — run on timescales of years. Under the EU Floods Directive, flood assessments, hazard maps and management plans are reviewed on a six-year cycle [1]. The hazard now has a tempo of minutes; the response has a tempo of years. That mismatch, not the size of the floods, is what now limits climate adaptation, and closing it is less a modelling problem than a data problem.

The Target is Moving

The usual frame of climate change and flooding is one of magnitude: more rain, bigger floods. That part is well established. Heavy precipitation has intensified and will intensify further as the atmosphere warms [2], and the short-duration extremes that drive urban flooding are intensifying fastest of all [3]. For the Nordic region, convection-permitting climate simulations show clear increases in design precipitation [4].

The more corrosive effect is on the method, not the magnitude. Flood management rests on the return-period event: read the historical record, fit a distribution, design to the 200-year flood. That works only if the statistics of the record are stable. They are not. Stationarity is no longer a safe basis for water management under a changing climate [5], which means the design event has become a moving target estimated under deep uncertainty rather than a number read from a stable record. Norway's response — a climate allowance of 40 to 50 per cent on short-duration design rainfall — is an honest admission, written into the design rule itself, that the past no longer describes the future. It patches the number. It does not restore the premise.

Met on the Wrong Timescale

A moving target could still be managed if we were fast enough. We are not. Traditional flood practice was built for large rivers that integrate weather slowly: a storm is absorbed, routed and released over hours to days, and a long-gauged record gives the model something to calibrate against. Pluvial and flash floods are different objects. They respond to the weather almost directly, in small catchments that are typically ungauged — and prediction in ungauged basins remains one of hydrology's openly acknowledged unsolved problems [6].

The conventional workflow — monitor, build a model, run it, decide — completes comfortably inside a fluvial response window of hours to days. Against a pluvial window of minutes to a few hours it simply overruns: by the time the model is built and run, the flood has happened. And the failure is not confined to the model. Data that are not current when the event arrives, institutional decision cycles slower than the hazard, uncertainty that compounds along the way — the whole chain was calibrated to slow water, and a chain calibrated to slow water cannot simply be sped up to serve fast water. The assumptions are wired into each step.

Prepare Slow, Decide Fast

The way out is not a faster model. It is moving the expensive work out of the event. Hydroinformatics is already reorienting from model-centric to data-centric practice [7], and the operational implication is a division of labour: detailed physics-based simulation belongs to the time before and after an event, where there are hours or days to spend, while the live job — the one with minutes — falls to hazard layers computed in advance and simply read off, or to learned models that answer in the time a query takes. Machine learning now predicts extreme floods in ungauged catchments at multi-day lead times with reliability comparable to established physically based systems [8], precisely where calibration fails for want of a record.

This is practical today, not hypothetical. In recent work, colleagues and I showed that a machine-learning susceptibility index computed in advance at building level, carried on a discrete global grid, can serve pluvial flood risk assessment at any scale a decision requires, from a single property to a whole city [9]. Nothing about the approach is bound to one country. What it requires is unglamorous: curated terrain, rainfall, land-use and damage data, kept analysis-ready so that when the rain starts, the answer already exists.

The Map is a Product. The Pipeline is the Capability

There is a quieter argument underneath the speed one. A statutory hazard map is a product: drawn once, valid until redrawn. Under a stationary climate that was tolerable, because the map aged slowly. Under a moving target it starts ageing on the day it is published. The data-centric alternative is not a better map but a different kind of deliverable: an automated, reproducible pipeline that regenerates the map whenever its inputs change — new terrain data, a recorded flood, a revised climate allowance. Reading flood-risk work as a chain that carries data through to knowledge and services is an established position in hydrology [10]. The practical consequence is that hazard information stops being a periodic report and becomes a maintained system — and the fixed climate allowance can become an adaptive margin that tightens as the chain learns.

No Single Fix

Here is the part that gets missed. None of these advances — better data, faster models, sharper maps — is sufficient on its own. A hazard map nobody uses changes nothing. Risk information that never reaches the market leaves exposed housing overvalued, and the eventual correction falls hardest on those least able to bear it [11]. And a system that never learns from the floods that actually occur will drift as the climate does. What makes flood risk management operational at the timescale of the hazard is the integration of the whole chain, from deciding what to monitor, through data and hazard characterization, to the maps, warnings and valuations people act on — with a feedback loop that carries each event back to the start and recalibrates. The six-year statutory cycle contains that loop in embryo. But it runs on a cycle measured in years against a hazard measured in minutes.

The adaptation debate fixates on building higher and holding water back. Both matters. But the faster the water gets, the more adaptation becomes a question of deciding faster — and deciding faster is, at bottom, a question of having done the data work before the rain starts. Climate change has changed the speed of the hazard. Flood risk management has to change speed with it.

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