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Valuing high density sensing on local watercourses: reflections on extreme rainfall responses at a UK lead local flood authority

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Abstract

Lead local flood authority Central Bedfordshire Council (CBC) faced an overwhelming emergency response following unprecedented rainfall (up to 148mm/day) in September 2024. In a changed climate, we can read CBC as "any lead local flood authority" and the lessons drawn from two weeks of 24-hour emergency response as widely applicable.

In this paper we evaluate the response to the back-to-back storm events which occurred between 21-29 September 2024 and delivered rainfall totalling 396% of the monthly average, overwhelming watercourses and infrastructure and flooding over 200 homes. We present the key findings from interviews with emergency responders from a range of partner organisations conducted within weeks of the emergency occurring.

CBC was in the unusual position of having one highly sensored catchment, as a result of its participation in a government-funded flood innovation pilot programme. Flood risk managers' experience of having access to this data was positive, highlighting the benefits of sensor-driven flood monitoring and prediction systems for emergency responders.

Key results highlight challenges in handling public enquiries, limitations in current flood warning systems, and the potential of sensors and a streamlined flood reporting platform to enhance response efficiency. Recommendations include expanding sensor coverage and integrating a centralised public reporting framework.

Highlights

- High density monitoring provides valuable live insights for real-time response teams.
- Resources are stretched by high public enquiry volumes and atomised reporting mechanisms.
- A centralised flood reporting system and increased sensor deployment are recommended.

Introduction

"We were tested. The intensity and the scale were beyond anything that has happened here before." (CBC Flood Risk Manager).

The flooding in the region of Central Bedfordshire, north of London, UK, during September 2024 was a surface water-driven event resulting from intense downpours following a period of dry weather. It was characterised by a slow-moving front which included embedded thunderstorms that brought intense and prolonged rainfall which surpassed historical records. The flooding led to mobilisation of a 24-hour multi-agency response which lasted over two weeks.

The experience of this prolonged emergency response offered Central Bedfordshire Council (CBC), the Lead Local Flood Authority (LLFA), an opportunity in the aftermath to review its response coordination.

CBC is the lead authority in the aforementioned multi-agency project, called ResilienTogether[1], investigating opportunities for enhancing flood warning and prediction using localised sensors. The University of Exeter is an academic partner in the project. The project case study catchment is the 16km^2 Pix Brook. Following work in 2022 and 2023 to deploy a series of water level sensors, rain gauges, cameras and other asset instrumentation, this location is now thought to be one of the most intensively sensored ordinary watercourses in the UK, with data shared on a portal available to project partners.

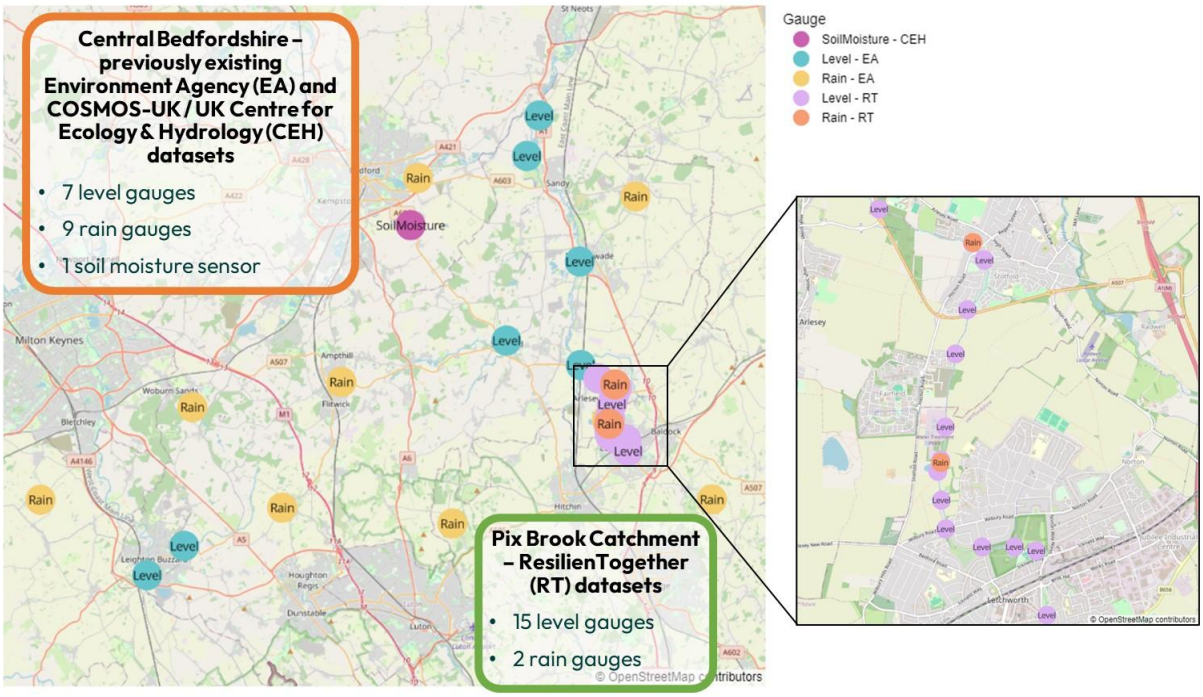

Figure 1. Illustration of sensor locations in the Pix

Researchers at the University of Exeter were invited to conduct interviews with key personnel, all of whom played a direct role in the emergency response, to evaluate response effectiveness, assess the value of having a highly monitored catchment and hypothesise possible technological solutions. In addition, the university examined some of the available weather and sensor data from the event.

Methodology

All interviews lasted approximately an hour and followed the same questions. Invitations were sent to personnel at CBC, the local Environment Agency (EA) team, the local Internal Drainage Board (IDB), and the local water company. All interviews were conducted within 12 weeks of the emergency occurring.

Steps taken to gather information evaluated here included:

1. Gathering names and contact details of relevant personnel from the LLFA flood manager.
2. Gathering information about individuals' roles, what they did during the emergency, and their reflections on the emergency response using a Microsoft form and Teams interviews.
3. Reviewing the information generated, grouping it into themes and highlighting the most relevant quotations and feedback.
4. Contextualising the feedback alongside the data from local sensors installed in 2022-2023.

Seven interviews were conducted to enable insights to emerge and be shared to the Flood Risk Manager. Interviews were conducted with people in the following job roles from three agencies: Emergency Planning Manager, Service Director for Public Protection and Transport, Flood Risk Engineer, Flood Risk Manager (all CBC), Operations Manager (IDB), Area Partnerships and Strategic Overview Team Manager (EA).

Results and Discussion

Reflections gathered fell broadly into the categories of handling enquiries from residents; (in)effectiveness of warnings; making use of innovative sensor deployments; and the need for a centralised flood reporting system. Further information on each, including key quotations from participants, is provided in the following sections.

Handling residents' enquiries

Staff at CBC received at least 1,000 emails, as well as calls direct to their mobile phones and other calls diverted to them from the CBC helpline. Responders were also assessing information from 37 community Whatsapp groups, in addition to information from volunteers, councillors, other emergency responders, and the UK Meteorological Office (Met Office) web portal Hazard Manager.

However, often information from the public was partial or incomplete, including basic descriptive elements such as flooding locations. Interviewees noted that where they had additional sensors, particularly cameras, they were better able to 'ground truth' information from residents.

Despite significant efforts from staff, emergency partners and associated contractors, the volume of public contacts was overwhelming and respondents to this study agreed that the experience represented an opportunity for implementation of more structured public reporting mechanisms. These findings coincide with the conclusions of a review of local flood risk management arrangements carried out by the Government in 2021[2].

Effectiveness of warnings

While the UK's Flood Forecasting Centre provided a five-day risk analysis, local authority partners described a flood warning system that was insufficiently localised for detailed resource deployment. In addition, the storm front unexpectedly changed course and the first downpours landed in the south of the area rather than the north as expected. Previous false alarms impaired preparedness, while sensor outages on main river gauges operated by the Environment Agency reduced the amount of river level data available to the emergency response team.

Making use of innovative sensor deployments

"Real-time telemetry on the Pix Brook was useful...it gave us the ability to know what to expect and where to expect it." (CBC Flood Risk Engineer).

The sensor data from the Pix Brook case study area as shown in Fig 2 enabled flood risk managers to rapidly be assured that in this particular flooding hotspot water was not going to go out-of-bank, and enabled them to focus instead on other priority areas. This demonstrates the advantages of sensor-informed platforms.

Figure 2 shows the Pix Brook level data that was available to CBC in near-real-time during the latter stages of the flood event. Further information was available from two nearby rain gauges. A further seven level gauges and nine rain gauges from the Environment Agency provided lower spatial resolution data for the wider CBC area (as shown in Figure 1); however, not all of these were available to responders during the event.

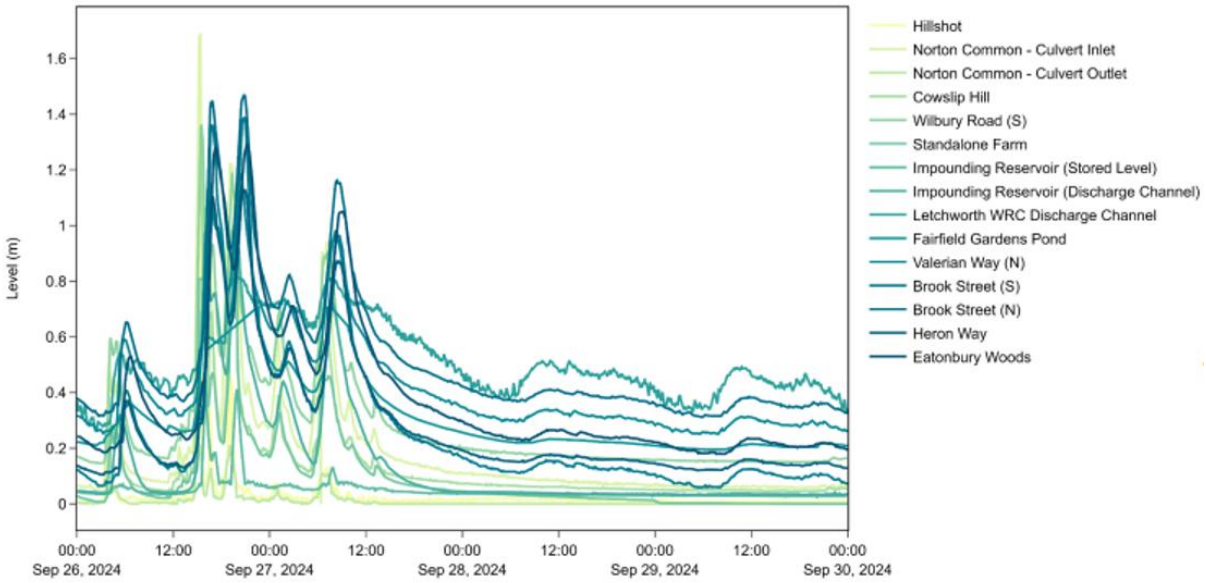

Figure 2. Illustration of water levels in the Pix Brook during the second band of rainfall in September 2024

With an industry that has built its understanding of watercourse modelling based on historical data, staff observed that the impacts of climate change will likely exacerbate prediction difficulties, emphasising the need for updated models linked to real-time data as described by Zolghadr-Asli et al (2024)[3] and Rubio et al (2019)[4].

Scoping a Flood Reporting System

Existing public reporting methods led to inefficiencies. A centralised flood reporting system could streamline data collection, triage vulnerable cases, and enhance communication with responders. Integrating such a system with CBC's homepage and emergency planning tools would improve response times and accuracy.

Conclusion & Future Work

The work described here exposed the scale of the emergency response challenge for UK local flood authorities. It suggests that lead local flood authorities would benefit from enhancing sensor coverage in ordinary watercourses liable to flooding, adopting a centralised flood reporting platform, and refining public communication strategies. Future work will focus on implementing these systems in CBC and evaluating their efficacy during subsequent events.

Acknowledgement

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References

1. ResillienTogether (n.d.) *Home*. Available at: Home - ResillienTogether (Accessed: 18 July 2025).
2. FD2680 (2023) *Evaluation of local arrangements for FRM*. Available at: 14016_FD2680_Evaluation_of_local_arrangements_for_FRM_Final_Report.pdf (Accessed: 18 July 2025).

3. Zolghadr-Asli, B., Ferdowsi, A. and Savić, D. (2024) 'A call for a fundamental shift from model-centric to data-centric approaches in hydroinformatics', *Cambridge Prisms: Water*, 2, e7. doi:10.1017/wat.2024.5.
4. (n.d.) *Urban and river flooding: Comparison of flood risk management approaches in the UK and China and an assessment of future knowledge needs*. Available at: Urban and river flooding: Comparison of flood risk management approaches in the UK and China and an assessment of future knowledge needs (Accessed: 18 July 2025).
5. GOV.UK (n.d.) *Flood and coastal innovation programmes*. Available at: Flood and coastal innovation programmes - GOV.UK (Accessed: 18 July 2025).