West Yorkshire Flood Innovation Programme Accelerator Project

Work Package 5: Opportunity Mapping Feasibility Study Report

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Executive summary

Work Package 5 of The West Yorkshire Flood Innovation Programme (WY FLIP) Accelerator Project, funded by the UK Government through the UK Shared Prosperity Fund, aims to address flood risks within the Calder catchment area. This focuses on Opportunity Mapping, utilizing the concept of a "social thalweg" to understand the socio-political dynamics of river systems. This approach integrates participatory GIS (PGIS) tools, specifically the Map-Me.org platform, to engage stakeholders in identifying flood risks and potential interventions.

Key activities included the design and implementation of the Map-Me survey, which gathered input from local stakeholders through online and face-to-face workshops. The survey captured perceptions of flood frequency, severity, and contributing factors, resulting in detailed heatmaps and sentiment analyses. Findings highlighted the significant impact of flooding on infrastructure, property, and community well-being, with climate change expected to exacerbate these issues.

The findings emphasize the significant disruptions caused by flooding, including road closures, property damage, and economic losses. Climate change is expected to worsen these impacts, increasing flood frequency and severity. The survey results underscore the need for enhanced stakeholder engagement, implementation of Nature-Based Solutions (NBS), improved data collection, and adaptive policy development to effectively manage flood risks and build community resilience.

Recommendations emphasize the need for enhanced stakeholder engagement, the implementation of Nature-Based Solutions (NBS), improved data collection, and the development of adaptive policies. The project underscores the importance of integrating local knowledge and participatory approaches in flood management, with implications for regional and national policy development. The Accelerator Project serves as a model for innovative, community-driven flood risk management strategies.

Background and rationale

While we may often regard river systems and their catchments as one-way systems – with upstream to downstream flows of water, sediment and pollutants – they are best regarded as two-way systems in the social, cultural and political context. What happens upstream affects those living downstream and so affected populations regularly look upstream to see what may have caused flooding or pollution in their local river; for example, recent flooding in Hebden Bridge being blamed on grouse moor management upstream, and poor water quality in the River Wye being blamed on intensive chicken farms located in the catchment. Whether these links are real or not is the object of scientific study, but from a socio-political perspective they can appear very real to those affected.

It is useful to adapt the concept of a river "thalweg" (German: tal = valley, weg = way) from its physical geography origins, to include the social, cultural and political aspects of the river and the complex picture of actors, scale, responsibilities, concerns and motivations. This enables better understanding of the views and relationships people have with their rivers, land and associated problems of flooding and water quality. Many of these may be regarded as "wicked problems" requiring closer scrutiny of upstream-downstream perspectives, conflicts and solutions that may be achieved through broader recognition of vested interests between the communities and stakeholders involved to identify compromise positions. The well-known DPSIR framework (Driving forces, Pressures, States, Impacts and Responses) can be applied throughout the 'social thalweg' (Figure 1) using participatory mapping approaches to capture the 'rich picture' of upstream-downstream views.

The aim of this Work Package is to apply the concept of a social thalweg and existing research experience in participatory GIS (PGIS) to develop an element of spatial collaborative working with stakeholders up and down the River Calder catchment.

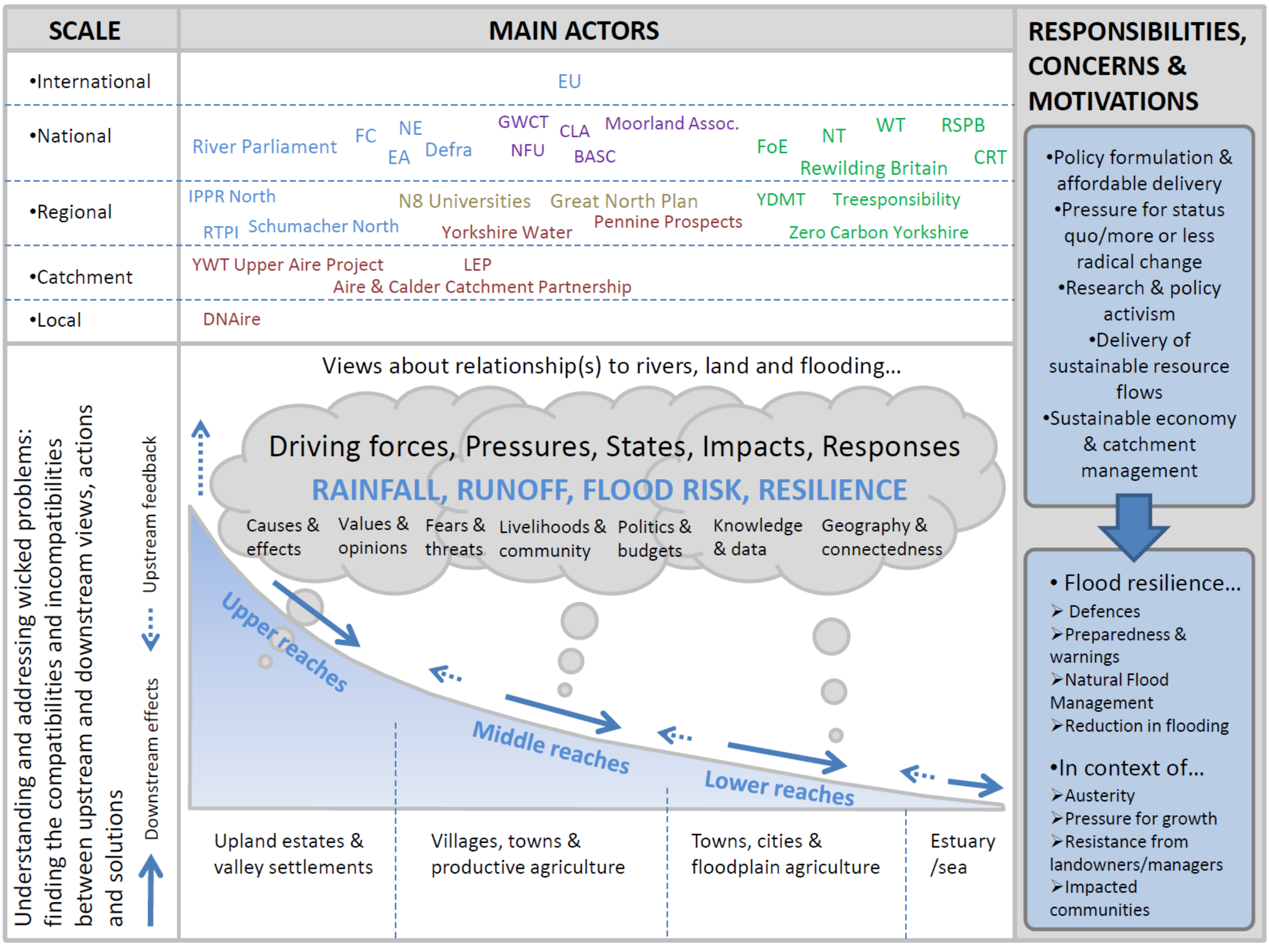


Figure 1. The Social Thalweg

Research methodology

The following activities have been undertaken within the Work Package:

A. Use of the social thalweg (Figure 1) model as a conceptual framework for developing and implementing a participatory GIS (PGIS) approach to facilitate upstream-downstream stakeholder dialogue.

B. Use of existing PGIS tools for both online and face-to-face workshops with stakeholders, practitioners and community representatives from within or representing interests within the Calder catchment. Ideally these would be located at all points along the social thalweg to provide a broad representation of variability in views and opinions looking both upstream and downstream as regards both the causes and the results of flooding relevant these locations over the next 2-3 decades.

C. Design and use of Map-Me.org online PGIS tool to facilitate stakeholder input to comment on/validate opportunity mapping regarding perceived causes and implications of flooding within the Calder catchment and identify possible actions/interventions for consideration including evaluation of land use strategies, hard and soft flood engineering such as Nature-based solutions, Natural Flood Management and Sustainable Urban Drainage proposals. Development of demonstrator Map-Me survey has included:

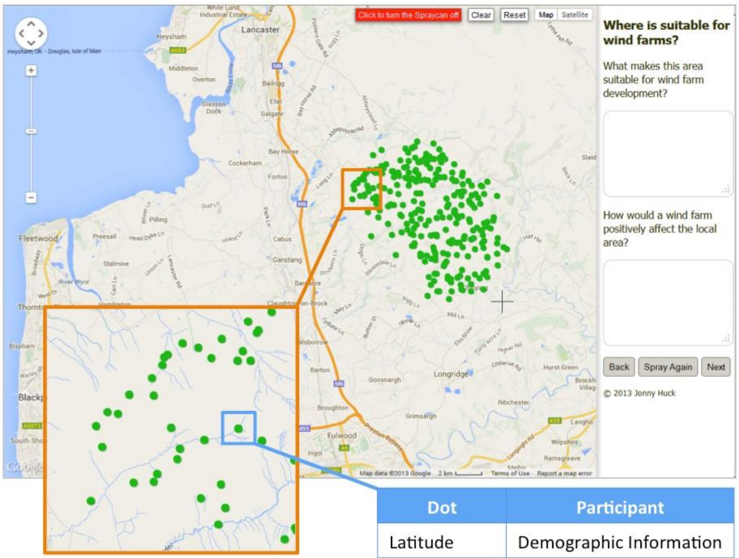
i. Preliminary talks with local agency/authority staff.
ii. Identification of key research questions.
iii. Writing of ‘spray’ (geographical) and ‘say’ (context/clarification) questions.
iv. Programming and testing of survey with local agency/authority staff.

D. Launch and testing of prototype survey including:

i. Run with local agency/authority staff at three locations (upper, middle, lower reach).
ii. Collate and analyse results.
iii. Create heatmaps and text/sentiment analysis.

E. Analysis of the results and key themes/patterns extracted and integrated with desk-based models for validation/confirmation and to identify commonalities and differences that need further consideration in the planning process.

The Map-Me software constitutes a Participatory GIS (PGIS) interface that permits participants to answer spatial questions by drawing onto a Google map (or satellite image) using a ‘spray can’ (or ‘airbrush’) tool, as opposed to using traditional map-based drawing tools such as points and polygons. Figure 2 illustrates what data are attached to each dot – “Participant” in blue indicates a link to all of the information that we have about the participant as well (so we can look, for example, at the differences between data generated by women and men, and so on).



Dot	Participant
Latitude	Demographic Information
Longitude	Timestamp
Timestamp	Browser
Zoom Level	IP Address
Participant	Free-Text Comments

Figure 2. the Map-Me data model

The significance of this approach to participatory mapping relates to the way in which members of the public typically think about the world around them, and how this contrasts with the way in which we typically store these places in GIS software. People tend to think about the world in terms of *places*, which are typically vaguely defined, in that universally accepted and unequivocal boundaries cannot be determined for them. This is because *places* are defined be the individual perceptions, experiences and cognition of the participants, and so the extent of an area will necessarily vary between them. To illustrate the flexibility of this approach for capturing complex socio-spatial phenomena, Figure 3 shows the results of Map-Me survey focused on perceptions of Catholic, Protestant and Mixed communities from the Belfast Mobility Project. The results from the mapping survey are shown together with an illustration of how the size of the dots change with the zoom level of the map, how the colour build up with greater density of spray, and how the colours blend together.

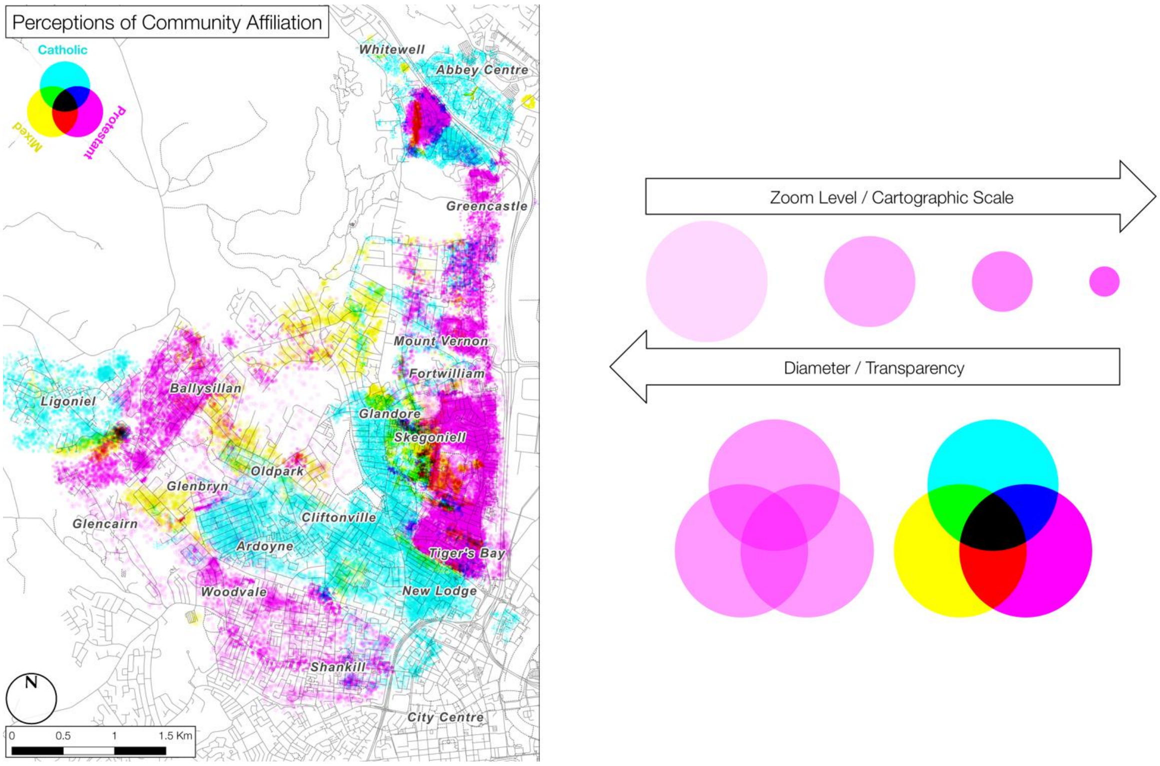


Figure 3. Example Map-Me results relating to perceptions of sectarian territory in Belfast

Place-based models contrast with the *space*-based approaches that are used in typical GIS software, which require precision in the location and boundaries of these places. The use of such *space*-based representations for vague *places* enforces an ‘artificial precision’ (after Montello et al., 2003) onto them, resulting in a poor representation of the *place* in question – which will impact upon any subsequent interpretation and analysis. It has also been shown that people find it difficult to convert their *place*-based thoughts and feelings into *spatial* representations in this way, meaning that the imposition of this ‘artificial precision’ also acts to reduce the quality of the data.

To avoid these negative effects, and the resulting challenges from incorporating findings into policy, we can use alternative map interfaces that are designed ‘for purpose’, of which the ‘Spray can’ is a prominent example. In this case, participants can add data to the map without consideration of precise boundaries, as well as allowing them to change the density of the ‘paint’ (denoting variation in strength of feeling, for example). This approach facilitates either qualitative (e.g. Huck et al., 2019) or quantitative (e.g. Huck et al., 2014) interpretation, and has been applied to a range of environmental and socio-cultural problems worldwide, by a variety of organisations, governments and universities.

More information about the software and its motivations can be found in the following publications:

Huck, J.J., Whyatt, J.D. Sturgeon, B., Hocking, B., Davies, G., Dixon, J., Jarman, N. and Bryan, D. (2018). Exploring Segregation and Sharing in a Divided City: a PGIS approach. Annals of the Association of American Geographers, 109:1, 223-241

Huck, J.J., Whyatt, D. & Coulton, P. (2014). Spraycan: a PPGIS for capturing imprecise notions of place. Applied Geography. 55, p. 229-237

Evans, A. J., & Waters, T. (2007). Mapping vernacular geography: web-based GIS tools for capturing “fuzzy” or “vague” entities. International Journal of Technology, Policy and Management, 7(2), 134-150.

Findings

A total of 36 individual responses were collected from the Map-Me survey. Two case studies are developed, one for WP4 (Wyke beck, Leeds) and one for this work package focusing on the Calder Catchment. These can be found here:

- Wykebeck: https://map-me.org/sites/wyflipdemo
- Calder: https://map-me.org/sites/calderdemo

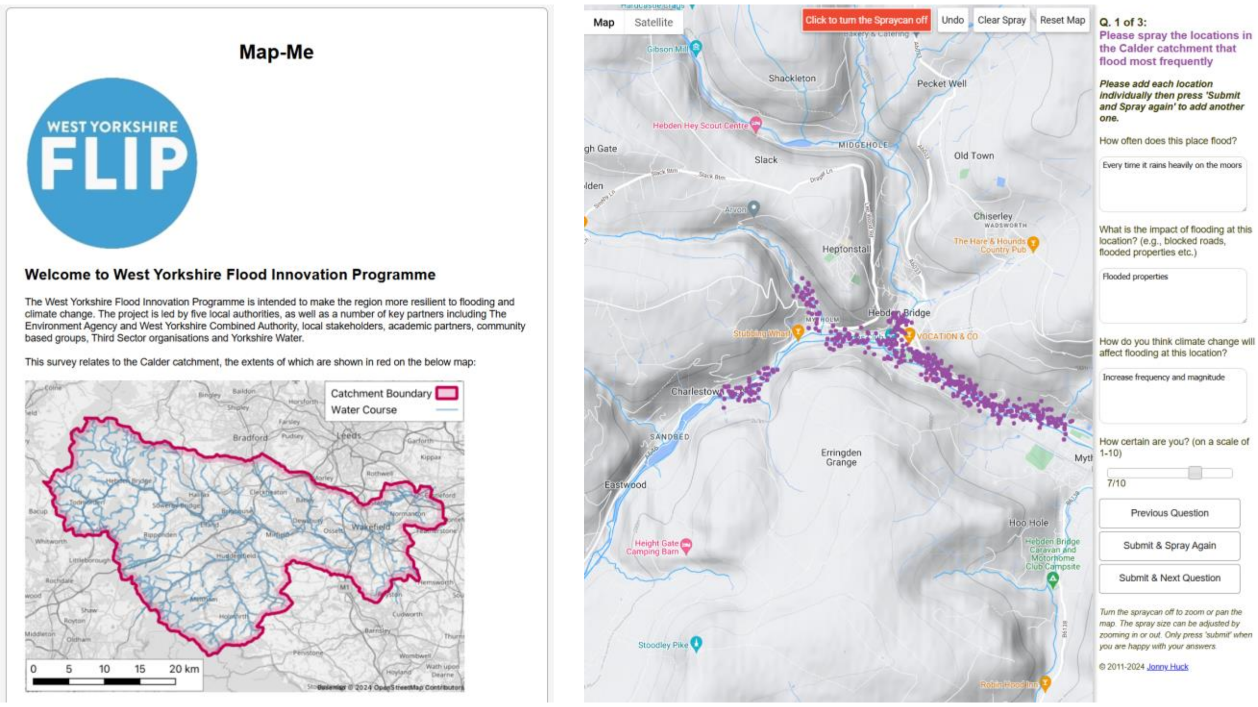


Figure 4. The map-Me interface and example user responses

This demonstrator project asks the survey respondents to spray on to the base map in response to three questions:

1. Please spray the locations in the Calder catchment that flood most frequently
2. Please spray the locations in the Calder catchment that see the deepest or most extensive flooding (even if you identified some of them in the previous question)
3. Please spray the key areas in the Calder catchment that cause flooding

Each of the combined users "spray" maps are shown with the associated spray questions below. These are presented as heatmaps showing the density of "spray painted" added to the base map. These are each accompanied by "say" questions wherein the respondent is asked to elucidate their reasons for spraying these areas on the map. These are summarised for each of the three spray questions here as follows:

1. Please spray the locations in the Calder catchment that flood most frequently

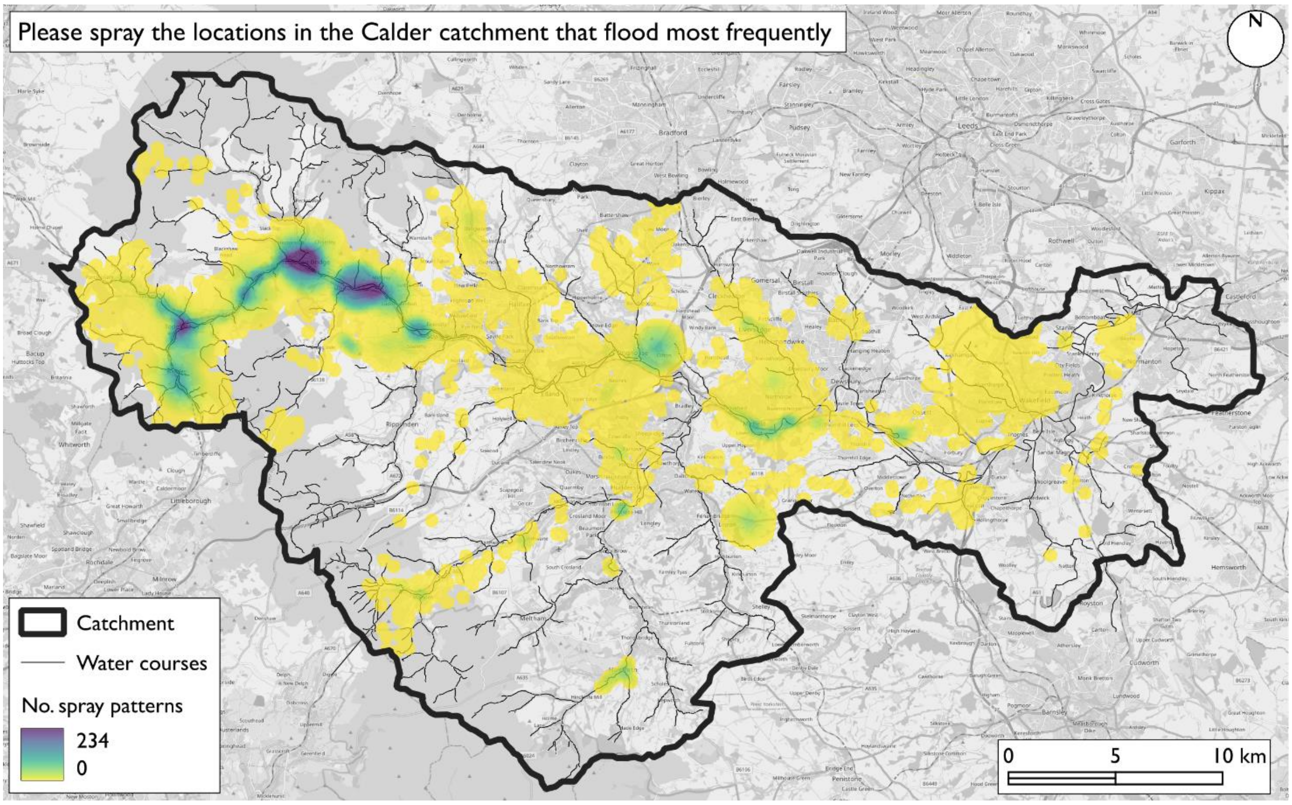


Figure 5. Question 1 spray pattern

Q1.1 How often does this place flood?

Flooding frequency varies significantly across locations, with some areas experiencing multiple floods per year and others only once every several years. Key patterns include:

- Frequent Flooding (Multiple Times Per Year): Some areas flood 3–5 times per year, especially during heavy rainfall or major storms.
- Moderate Frequency (Every 1–5 Years): Many places experience flooding annually or every 2–5 years, often linked to heavy rain or overloaded drainage systems.
- Less Frequent Flooding (Every 10+ Years): Some locations flood once every 10–30 years, typically due to extreme weather events.
- Flash Floods & Surface Water Issues: Even when rivers do not overtop, heavy rain can lead to flash floods, ponding, and drainage system failures.
- Unpredictability: Some responses indicate uncertainty about exact frequency, but flooding is often tied to severe or prolonged rain events.

Overall, flooding is a recurring issue, with some locations facing severe and regular impacts, while others experience sporadic but significant events.

Q1.2 What is the impact of flooding at this location?

The impact of flooding at this location is severe and multifaceted, with major disruptions to both infrastructure and daily life. Key consequences include:

- Road Closures & Traffic Disruptions: Roads, including vital routes like the A646, become flooded, leading to closures, dangerous driving conditions, and traffic jams. Cars get stuck, and abandoned vehicles further exacerbate the problem.
- Flooded Properties & Businesses: Residential properties and businesses experience flooding, causing property damage and loss of trade, particularly in areas with multiple flooded businesses. Cellars and lower-lying properties are often affected, with some businesses unable to recover.
- Infrastructure Damage: Flooding leads to blocked roads, damaged drains, and culvert blockages, causing further road damage and sludge accumulation. Areas like Elland Road and North Cut experience erosion, potholes, and debris buildup.
- Service Disruptions: Key services like train stations and schools may be closed, with businesses and residents facing interruptions to daily activities.
- Danger to Life & Property: Floodwaters present life-threatening conditions, especially when roads are impassable, and people are isolated due to lack of transport options.
- Economic & Social Impact: The local economy is disrupted as businesses close, and residents face increased hardship, including issues with insurance, property devaluation, and flood-related cleanup.
- Additional Risks: Sewage backflow and flash flooding from hillsides overwhelm drainage systems, further complicating flood management and leading to health risks and environmental damage.

In summary, flooding causes significant damage to property, disrupts transportation and business, and creates ongoing risks to safety. The economic, infrastructural, and social costs of flooding are high, requiring long-term mitigation and preparedness strategies.

Q1.3 How do you think climate change will affect flooding at this location?

The general consensus is that climate change will worsen flooding in this location by increasing its frequency, severity, and impact. Key concerns include:

- More Frequent & Intense Flooding: Warmer air holds more moisture, leading to heavier rainfall and more extreme weather events, which will increase both river and surface water flooding.
- Deeper Floodwaters: Flooding will likely reach greater depths, further affecting homes, businesses, and infrastructure.
- Worsening Drainage Issues: Existing drainage systems are already overwhelmed, and increasing rainfall will exacerbate blockages and runoff issues.
- Economic & Social Consequences: More frequent flooding may lead to business closures, reduced investment, property devaluation, and difficulties obtaining insurance, causing long-term community impacts.
- Infrastructure & Land Use Concerns: Poor land management, urbanization (e.g., increased tarmac and concrete surfaces), and deforestation are worsening flood risks by reducing natural water absorption.
- Potential for Mitigation: Some responses note that flood alleviation efforts (e.g., reservoir management, improved drainage) could help, but without further intervention, the situation will continue to deteriorate.

Overall, climate change is expected to make flooding more severe, frequent, and costly, requiring better land management, drainage improvements, and flood mitigation strategies to adapt to the increasing risks.

2. Please spray the locations in the Calder catchment that see the deepest or most extensive flooding (even if you identified some of them in the previous question)

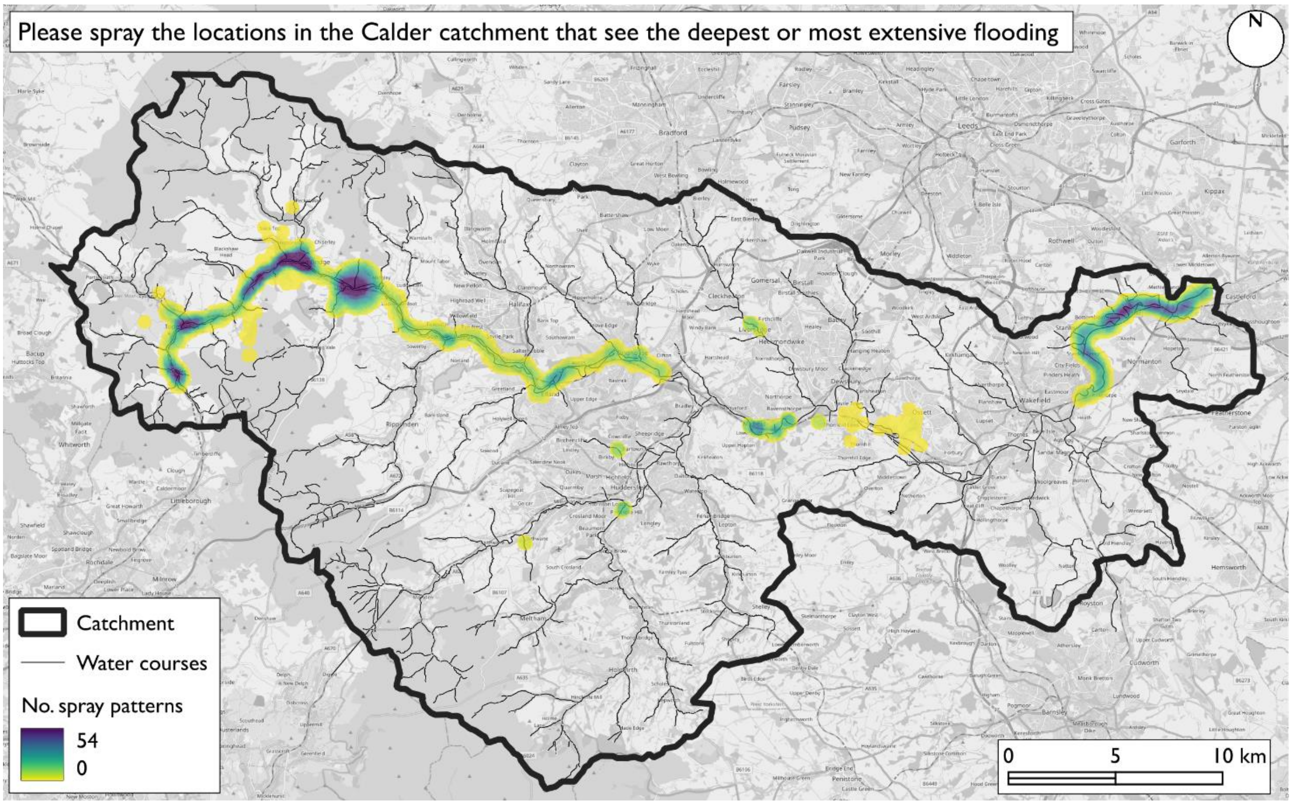


Figure 6. Question 2 spray pattern

Q2.1 What is the impact of flooding at this location?

The impact of flooding at this location includes **significant disruptions to homes, businesses, and infrastructure**, with key consequences being:

- **Property Damage:** Several **homes and businesses** are frequently **flooded**, leading to financial and structural damage.
- **Road Closures & Access Issues:** Roads become **dangerously deep** with floodwater, leading to **blocked roads**, **stranded vehicles**, and restricted access to homes and care facilities.
- **Business Disruptions:** Flooding forces businesses to **close temporarily** or even **permanently**, affecting the **local economy and community sustainability**.
- **Power & Utility Disruptions:** Some areas experience **power outages** alongside flooding.
- **Risk to Life & Safety:** The depth and force of floodwaters create **risks to life**, especially in heavily affected locations.
- **Varied Impact:** While some areas suffer **severe** consequences, others experience **minimal disruption** due to limited infrastructure or housing.

Overall, flooding poses **serious risks** to property, businesses, and community stability, with widespread **economic and safety implications**.

3. Please spray the key areas in the Calder catchment that cause flooding

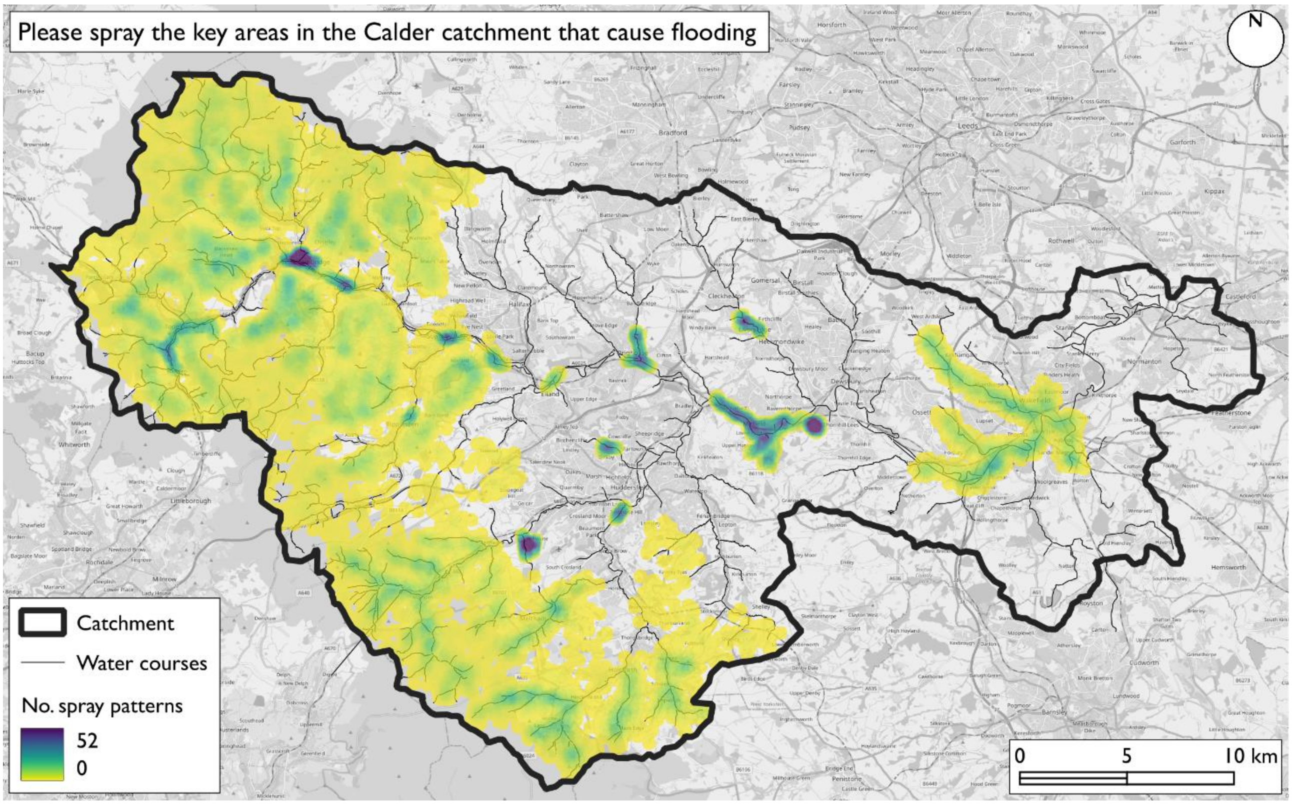


Figure 7. Question 3 spray pattern

Q3.1 How does this location contribute to flood risk?

The location contributes to flood risk due to a combination of river overtopping, surface water drainage issues, and rapid runoff from surrounding terrain. Key factors include:

- **River Overflow:** The **River Calder, Colne, and Spen** frequently overtop their banks, submerging gullies and surface water systems, leading to flooding.
- **Drainage Blockages:** Debris from rivers, woodlands, and surface water systems blocks screens and pipes, preventing proper drainage.
- **Surface Water Issues:** Flat or poorly maintained drainage systems struggle to clear water, leading to ponding, especially in road dips.
- **Topography & Runoff:** Steep valleys and large upland catchments generate significant runoff, exacerbated by past drainage modifications and moorland degradation.
- **Urban Impact:** Increased runoff from built-up areas (e.g., Wakefield) and narrow valley developments adds to river levels.
- **Historical & Regional Context:** Flood risk is longstanding (10-15 years) and affects multiple locations, including **Brighouse, Copley, Elland, Walsden, Todmorden, Hebden Bridge, and Mytholmroyd**.

The combined effect of these factors results in frequent and severe flooding, particularly following heavy rainfall.

Q3.2 What interventions at this location might reduce its contribution to flooding?

Potential interventions to reduce this location's contribution to flooding include:

- **Natural Flood Management (NFM):** Implementing **upland management**, **SuDS (Sustainable Drainage Systems)**, and **storage areas** to **slow the flow** of water before it reaches rivers and urban areas.
- **Improved Drainage & Surface Water Management:** Enhancing **surface water drainage**, removing surface water from the **sewer system**, and creating **sacrificial storage areas** to reduce flood peaks.
- **Debris & Culvert Maintenance:** Ensuring **culvert entrances** and **debris screens** remain clear to improve **water conveyance** and prevent blockages.
- **Infrastructure & Flood Defences:** Considering **flood alleviation schemes**, **weir removal**, and **defences in vulnerable areas**, while balancing potential downstream impacts.
- **Community Awareness & Resilience:** Increasing **preparedness** through a mix of **property-level resilience measures**, **early warning systems**, and **flood risk awareness initiatives**.

A **combination of these approaches**—including **NFM, drainage improvements, and infrastructure resilience**—could help mitigate **flooding impacts** while addressing both **urban and upstream flood sources**.

Word Clouds

A series of word clouds have been drawn using the data from the "say" questions to illustrate further patterns in user responses based on the most frequently mention word or phrase in the answers to the "say" questions. To produce these word clouds, the nouns were extracted from the text data, lemmatised (reduced to their root word) to facilitate thematic grouping and then weighted by frequency. The resulting word clouds are as follows:

Figure 8. Contributions to flood risk

Figure 9. Impacts of flooding

Figure 10. Reducing flooding

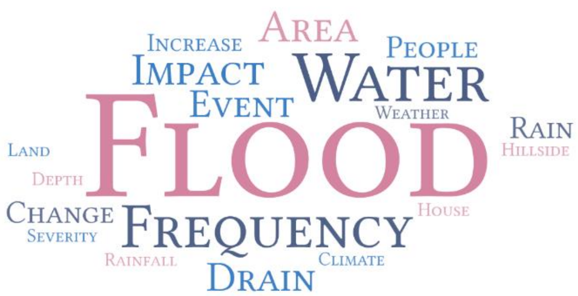


Figure 11. Climate change

Recommendations and proposed next steps

Recommendations for Extending the Map-Me Survey

1. **Enhanced Survey Scope**: Expand the Map-Me survey to cover additional aspects of flood risk, such as the impact of land use changes, infrastructure vulnerabilities, and community resilience measures. This will provide a more comprehensive understanding of the factors contributing to flooding.
2. **Incorporate Climate Change Scenarios**: Integrate climate change projections into the survey to assess how future climate conditions might affect flood risk and community vulnerability. This will help in planning adaptive strategies.
3. **Broader Stakeholder Participation**: Increase the number, range, and diversity of survey participants by engaging more stakeholders, including local businesses, schools, and healthcare facilities. This will ensure that the survey captures a wide range of perspectives and experiences.
4. **Real-Time Data Collection**: Implement real-time data collection capabilities to capture immediate responses during flood events. This could provide valuable insights into the dynamic nature of flooding and its immediate impacts.

Potential Deliverables from the Extended Map-Me Survey

1. **Detailed Flood Risk Maps**: Generate high-resolution flood risk maps that highlight areas of frequent and severe flooding, as well as potential future hotspots based on climate change scenarios. These maps can be used for planning and emergency response.
2. **Community Impact Assessments**: Produce detailed assessments of how flooding affects different community sectors, including residential, commercial, and public services. This will help in prioritizing interventions and resources as well as help better understandings of 'bottom up' perceptions of flooding impacts on local communities.
3. **Policy Recommendations**: Develop evidence-based policy recommendations for local and regional authorities, focusing on integrated flood management strategies that incorporate community input and climate resilience.
4. **Educational Resources**: Create educational materials and workshops based on survey findings to raise awareness about flood risks and promote community preparedness and resilience.

By extending the Map-Me survey, the project can deliver more comprehensive and actionable insights, ultimately leading to more effective flood management and community resilience strategies.