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EXECUTIVE SUMMARY

Peri-urban are at risk from multiple climate change and extreme weather hazards. Equally, peri-urban development and land use change can both moderate and intensify climate change risks locally and in surrounding urban and rural areas. These issues, which sit at the heart of the Peri-cene project, remain under-researched and deserve greater attention. Peri-urban areas have a crucial role to play in transitioning to more climate resilient futures. The companion Peri-cene deliverable to this report (D.4.1) analysed these issues and challenges in the context of the Manchester region, and highlighted that peri-urban areas are also facing multiple socio-economic and biophysical pressures that interact and, in some cases, intensify those linked to the changing climate. This report moves from problem analysis to solution development, focusing on adaptive pathways for the Manchester region that can support peri-urban climate, and broader socio-economic and biophysical, transitions.

Existing research and policy priorities demonstrate that flooding is perceived as the greatest extreme weather and climate risk in the Manchester wider region. Through in-depth qualitative research, we examine issues linked to the implementation of natural flood management (NFM) schemes in the Irwell catchment as a response to this risk. It is through targeted in-depth cases studies such as this that the themes central to the Peri-cene project, namely peri-urban areas and climate change risk and adaptation, can be uncovered and better understood. Attention is paid to existing flood risk governance (considering themes related to policy and administrative arrangements at different spatial scales), the nature of existing NFM schemes in the Irwell catchment and barriers to the wider implementation of NFM. Adaptive pathways to encourage the uptake of NFM as an element of a complementary suite of flood risk management responses are presented and discussed. These are supported by discussion of adaptive pathways for the Manchester region's peri-urban areas more broadly. The complex dynamics of integrated peri-urban and urban areas (and river catchments such as the Irwell) are at the heart of this deliverable, which looks to better understand how the peri-urban can play a stronger role in adapting and building resilience to climate change.

2 INTRODUCTION

The Peri-cene project

The Peri-cene project is creating the first ever global assessment of the peri-urban, with a particular focus on relevant climate change risks and adaptation themes. It explores forward pathways, in a Policy Lab with 18 city-regions from around the world, together with two in-depth case studies in India and the UK.

These case studies focus on the ***Chennai region*** (India) and the ***Manchester region*** (UK). Each has a very different historical background, series of development pressures, underpinning socio-economic trends and projected climate risks.

Overall, the Peri-cene project aims to:

- Provide a state of the art analysis of climate impacts and vulnerabilities in the peri-urban / rural areas.
- Provide models for adaptive / collaborative governance for climate / peri urban interactions, by facilitating stakeholder dialogue & co-design.

Scope of this report

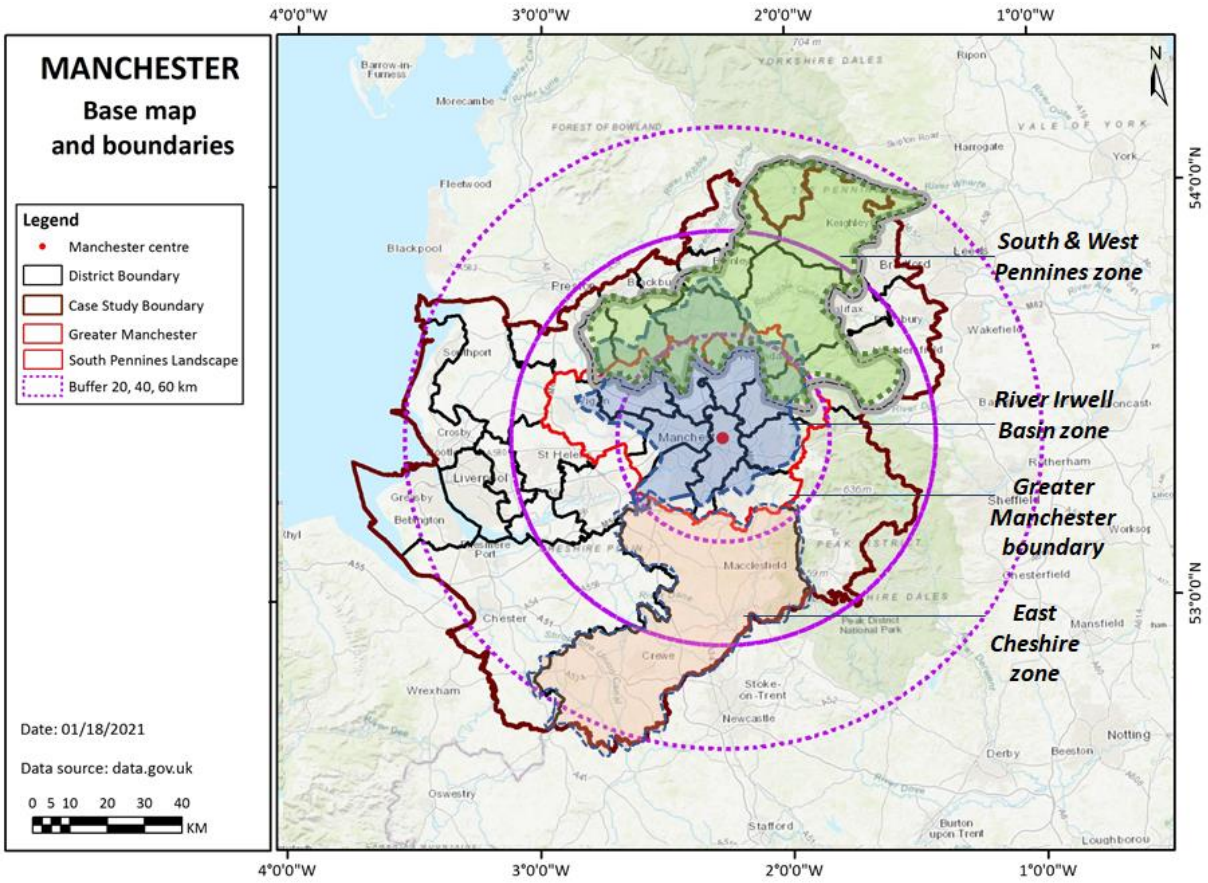
This deliverable focuses on the Manchester region case study (Figure 1), and builds on Deliverable 4.1b (D4.1b) which reports on peri-urban themes, climate change risks and climate change adaptation responses in the Manchester region. Whereas D4.1b concentrates on a providing a problem analysis, D4.2b explores potential solutions. Specifically, this deliverable concentrates on adaptive pathways to help address the challenges posed by climate change in the Manchester region. Here, flooding is the key focus given the prominence of this risk locally. The scope of this deliverable is further refined though its focus on natural flood management (NFM) as an element of the flood risk management response. This issue is explored at the scale of the river Irwell catchment, which is located in the Manchester region. Framed by these issues, D4.2b focus on the following principal objective:

- To explore adaptive pathways to reduce flood risk in the Manchester region, with a particular focus on natural flood management in peri-urban areas.

The Manchester region case study approaches this objective from two perspectives, each of which concentrates on different geographical areas, aspects of climate change risk and adaptation response approaches. The Manchester region case study considers the wider peri-urban hinterland zone surrounding the city centre, particularly the South & West Pennines. The focus here is on adaptive governance from the perspective of peri-urban climate change risk, adaptation and resilience themes from a broad perspective. Secondly, specific attention is paid to natural flood management (NFM) responses to reduce fluvial flood risk in the river Irwell catchment. A key focus

of this deliverable is therefore on outlining challenges associated with expanding NFM provision within the Irwell catchment, and highlighting adaptive pathways that could support the realisation of this vision.

Figure 1: Manchester Region base map and boundaries



Report caveats

Peri-urban development and land use change, and relationships to climate change risk and adaptation, are complex and often controversial involving a range of stakeholder groups and multiple visions for the future of peri-urban areas (and connected urban and rural areas) playing out across various interconnecting spatial scales. This Manchester region case study does not therefore aim to describe all possible interactions between peri-urban land use and development and climate risk and adaptation, with consideration of relationships to surrounding urban and rural areas, in a large and complex region. Further, stakeholder and organisational arrangements and relationships are diverse and changeable, and challenging to untangle. Although this report does not claim to be fully comprehensive, the adaptive pathways explored within it offer a valuable understanding of

current issues and future opportunities linked to climate change risk and adaptation in the peri-urban.

Report Structure

This report is structured according to the following sections:

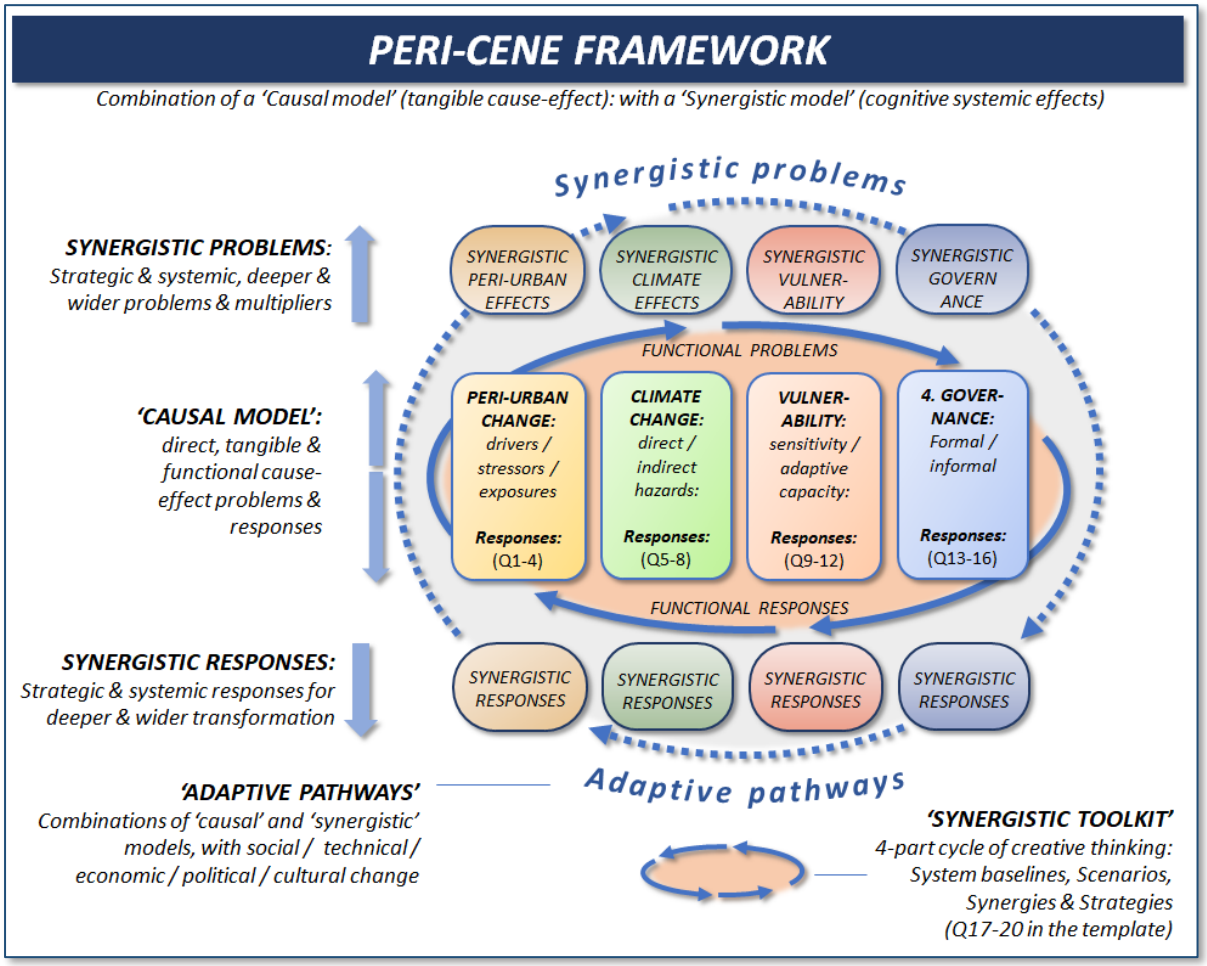
- ***3. Methods:*** This section provides details of the overarching Peri-cene Framework, and concentrates in particular on the adaptive pathways dimension. Adaptive pathways (as applied within the Peri-cene project) are introduced, and approaches taken to developing adaptive pathways within the project are outlined. The second element of the methods section provides an overview of approaches (including literature and policy reviews, interviews and workshops) applied within the Irwell catchment NFM study to explore challenges and related governance issues and opportunities linked to enhancing NFM as a constituent element of flood risk management responses within the catchment.
- ***4. Peri-urban adaptive pathways for the Manchester region:*** This section focuses on introducing Manchester's adaptive pathways 'menu', developed with input from the Peri-cene global city network following the approaches outlined in the methods chapter. Particular attention is paid to the core Peri-cene agenda of climate change risks and adaptation responses. The South Pennines provides a specific focus for this discussion.
- ***5. Progressing natural flood management in the Irwell catchment: exploring challenges and governance opportunities:*** A key element of the Manchester region case study is a detailed investigation of flood risk and NFM responses within the river Irwell catchment. This section draws on insights gained from a targeted academic literature and policy review, and a series of interviews and workshops with relevant policy makers and practitioners. The key focus is on developing a richer understanding of issues and challenges associated with embedding NFM measures more widely across the peri-urban landscapes of the Irwell catchment. The discussion turns to existing governance approaches that frame efforts to implement NFM in the catchment. It also looks towards alternative adaptive pathways that could offer a way forward for this crucial peri-urban agenda, which embraces themes from land ownership and development pressure through to natural processes and long term climate change adaptation responses.
- ***6. Capturing key themes and lessons learnt from the Manchester region case study:*** This section brings together the findings of the Manchester region case study, presenting key conclusions and highlighting transferable insights and findings for peri-urban regions facing climate change pressures and the need to adapt.

3 METHODS

This section provides details of the overarching Peri-cene Framework and concentrates in particular on the adaptive pathways dimension. Adaptive pathways (as applied within the Peri-cene project) are introduced, and approaches taken to developing adaptive pathways within the project are outlined. The second element of the methods section provides an overview of approaches (including literature and policy reviews, interviews and workshops) applied within the Irwell catchment NFM study to explore challenges and related governance issues and opportunities linked to enhancing NFM as a constituent element of flood risk management responses within the catchment.

Peri-cene has the challenge of working with a multiplicity of complex causes, effects and responses. To provide a theoretical structure and practical tools for such complexity, we have developed the ***Peri-cene Framework***, with a set of tools and templates (Figure 2) (for details see D1.2).

Figure 2: Peri-cene Framework



This combined Peri-cene Framework is a combination of two main 'Models':

- The '***Causal Model'*** follows a mainly functional picture of cause and effect, in direct problems and responses, between four main factors: peri-urban / climate / vulnerability / capacity.
- The ***'Synergistic Model'*** addresses wider systems with deeper complexity and potential for transformation via collective intelligence, with strategic level problems and responses.

The Peri-cene framework incorporates adaptive pathways, which are a central focus of this deliverable. Both the Peri-cene framework, and adaptive pathways as a constituent element of this framework, are shaped by a range contextual factors that influence how the issues sitting at the heart of the Peri-cene project are framed.

- Deeper complexity effects, in both peri-urban and climate change systems
- Major uncertainties, boundary questions and value-conflicts: major gaps between evidence, discourse, policy and reality on the ground (e.g. climate impacts and policy);
- Inter-connection of ***problems*** between peri-urban-climate / other domains (social, economic etc).
- Inter-connection of ***responses*** and forward pathways between peri-urban-climate / other domains (social, economic, political etc).

The following section provides an overview of how adaptive pathways are understood and implemented within the Peri-cene project.

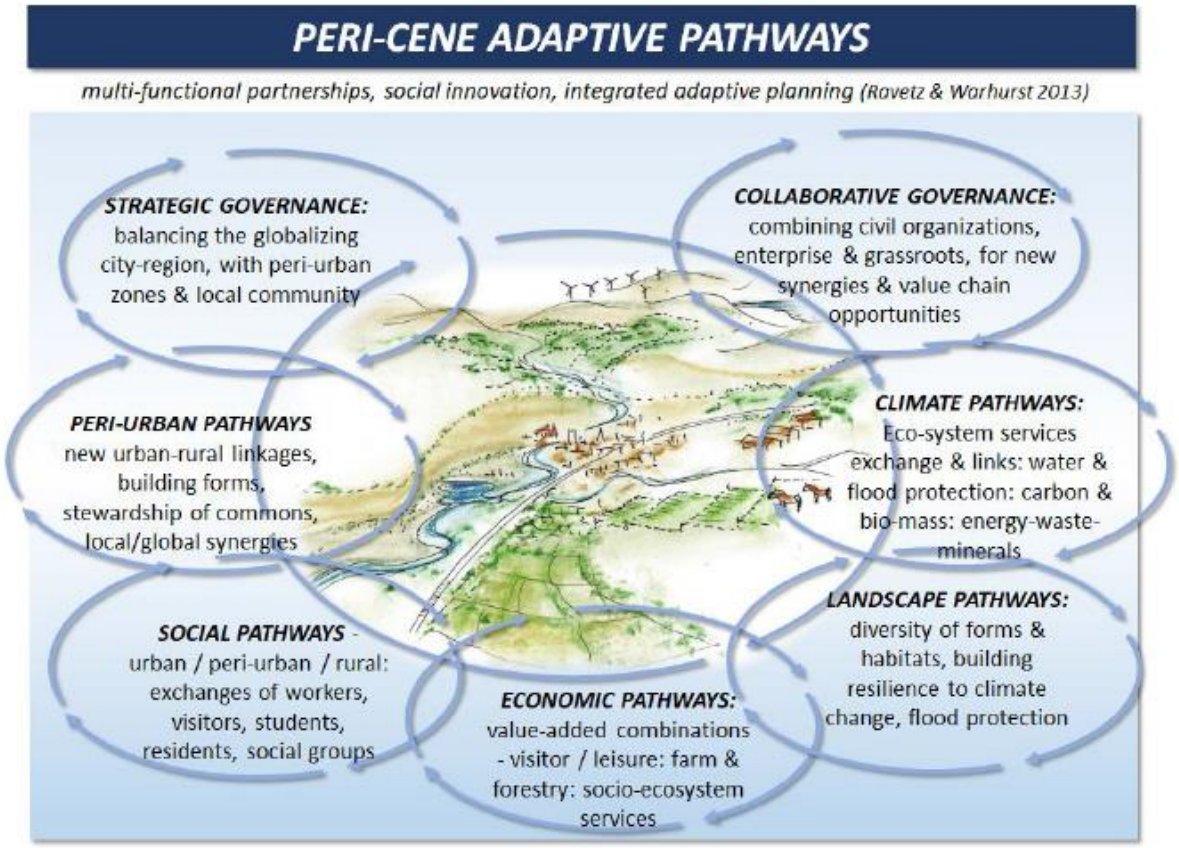
3.1. Adaptive Pathways

The challenge of peri-urban development and climate change is huge, complex, controversial: not easily solved by simple technical fixes. This calls for the adaptive pathway approach – where all stakeholders can co-produce new synergies and combinations – peri-urban development, land use, climate adaptation and resilience. These adaptive pathways are likely to be combinations of many actions (social, technical, ecological, economic, political, cultural etc), which can overcome multiple challenges, and lead towards transformation. Figure 3 provides a visual representation of the Peri-cene adaptive pathways approach.

Definitions of key terms linked to the adaptive pathways approach include:

- A ***pathway*** (in this context) is a coordinated set of actions and knowledge, which over time can move towards a desired goal of transformation.
- A ***functional pathway*** is about tangible problems with direct solutions: e.g. building a flood defence wall for a known extreme event: or, changes in energy generation technology.
- An ***adaptive pathway*** is about more real-life challenges: risks and uncertainties, controversies and conflicts, events and contingencies, corruption and other structural barriers: and whatever is needed to manage these. Here the 'adaptive pathway' title includes for the *'synergistic'* potential of collective intelligence (social, technical, economic etc). This includes mutual learning, co-creation and co-production: between a wider community, with a further scope of cause-effect, and with deeper layers of value and meaning.

Figure 3: The Peri-cene adaptive pathways approach.



A portfolio of adaptive pathways, which are general enough to be global and specific enough to be useful, has emerged from a series of international workshops involving representatives from cities across the world. These can be organised into four main themes based on the structure of the Peri-cene cause-effect model, and also bringing in the deeper layers of social, technological, economic and cultural systems, all essential in one way or another:

- Peri-urban pathways
- Climate-environment pathways
- Vulnerability-resilience pathways
- Governance pathways

Within the Peri-cene project, these pathways have been tested, expanded and refined in different locations around the world. This deliverable presents the adaptive pathways that are most closely connected to the Manchester region and the flooding challenges that it faces, concentrating on the South Pennines.

In addition to the adaptive pathways developed through the Peri-cene international workshops, a series of interviews and workshops was undertaken with stakeholders working on flooding and natural flood management in the Irwell catchment, and more broadly at regional and national levels, to arrive at adaptive pathways specifically connected to expanding NFM as part of a wider flood risk management strategy for the Irwell catchment. In total 18 people were interviewed, who represented public, private and third sector organisations engagement in NFM and flood risk

management. The interviews focused on drivers behind, barriers to and strategies for advancing NFM within peri-urban areas and wider river catchments. The interviews were followed by two workshops where interviewees were brought back together to explore approaches to advancing NFM as part of catchment-scale flood risk management approaches in more detail. The outcomes of the interviews and workshops have been used to create a further series of adaptive pathways linked to progressing this particular agenda. The Irwell catchment case study was also informed by an academic literature review of sources linked to NFM, and a review of policy at national, regional and local scales linked to flooding and NFM.

4 ADAPTIVE PATHWAYS FOR THE MANCHESTER REGION

This section focuses on introducing Manchester's adaptive pathways 'menu', developed with input from the Peri-cene global city network following the approaches outlined in the methods chapter. Particular attention is paid to the core Peri-cene agenda of climate change risks and adaptation responses. The South and West Pennines provides a specific focus for this discussion.

4.1. The changing climate of the Manchester region

Climate change is projected to generate significant shifts in temperature and precipitation patterns and extremes in the Manchester region. Future projections here assume a relatively mainstream 'worst case' scenario, (based on the IPCC's RCP 8.5 scenario), which points towards a 3-4 degree average temperature rise. These are the headlines from the national UKCP18 climate projections for the 2070s (for locations typical of central England):

- summer precipitation change: between 57% drier and 3% wetter
- winter precipitation change: between 2% drier and 33% wetter
- summer temperature change: up to 5.80C warmer
- winter temperature change: up to 4.20C warmer

While these averages are very significant the greater risks are from extreme events:

- extreme rainfall events
- extreme heat / drought episodes

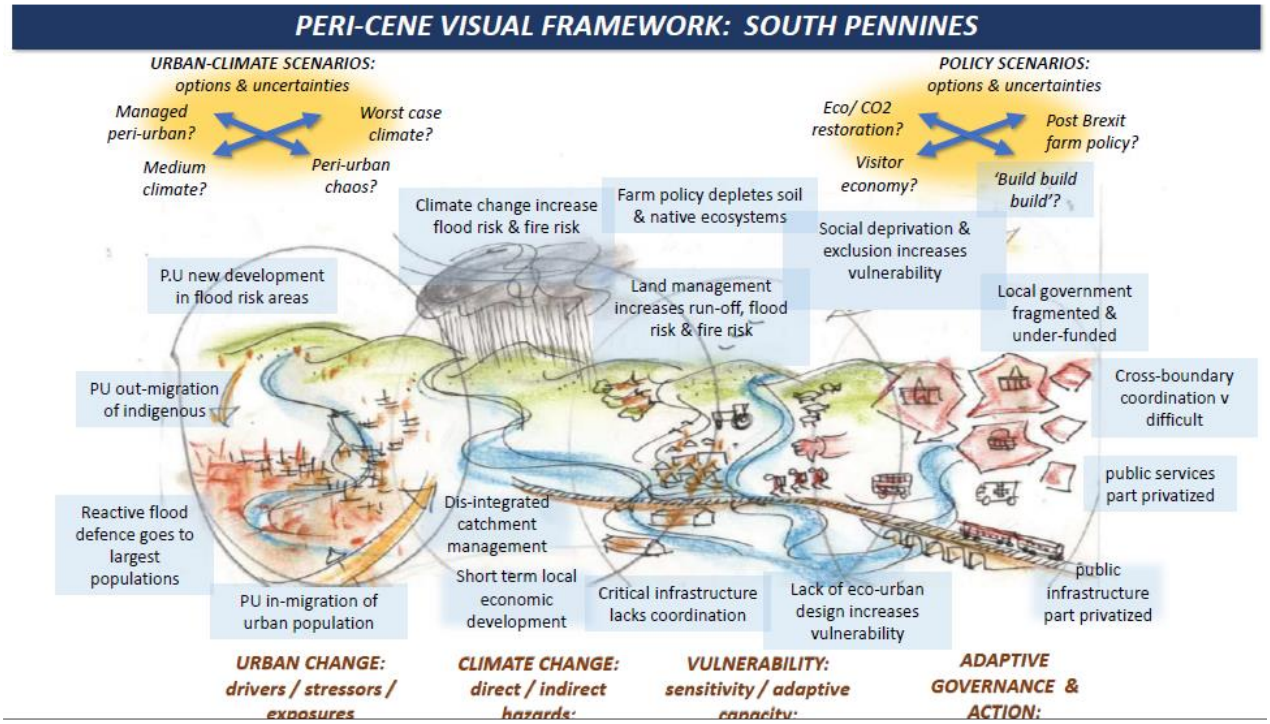
It is the extreme events that have the potential to cause the most significant impacts for people, communities and ecosystems across the Manchester region. Here, projected changes to rainfall are the biggest concern. Rainfall volumes during the wettest day in winter are projected to increase by 14.6% by 2050 (under the central estimate for the high greenhouse gas emissions scenario). This will increase pressure on flooding infrastructure and potentially increase the risk of flooding. D4.1b provides a more detailed overview of climate change risks to the Manchester region, paying particular attention to flooding which stands out as the key risk facing the area.

4.2. Exploring peri-urban and climate change interactions in the South and West Pennines

Figure 1 situates the South and West Pennine zone, which sits to the north of the Manchester region. This area is one of low hills (<500m) with moorland peat bogs, upland hill farming, steep valley sides, former industrial towns in the valley bottoms, overlaid with newer suburban type developments. D4.1b provides an overview of the South and West Pennine zone, highlighting issues and challenges linked to the relationship between climate change risks and adaptation in the

context of peri-urban characteristics and processes. Figure 4 provides a visualisation of related issues, structured around the Peri-cene framework. This image, created collaboratively with stakeholders during a Peri-cene workshop, indicates that the area is under considerable pressure from multiple socio-economic, governance and biophysical drivers operating from local to global scales, which are contributing to the generation of negative impacts from social deprivation to soil depletion.

Figure 4: Visualising peri-urban issues and challenges in the South Pennines



Despite this challenging context, peri-urban areas such as the South and West Pennines remain vitally important from the perspective of climate change. This is for two key reasons; the first is about the local conditions in the peri-urban, and the second from the perspective of seeing the peri-urban as part of a whole city-region system.

Addressing the first point, local conditions place peri-urban areas in the South and West Pennines at risk from certain climate change hazards. Significant risks include:

- Fluvial & surface flooding, particularly in the river valleys where former industrial towns and infrastructure are sited. This is partly a result of factors such as land management practices in the surrounding uplands including over grazing, and also due to degradation of peat bog habitats (which provide water attenuation capacity when healthy).
- Drought conditions are becoming more common (from a low baseline), with effects on ecosystems, landscapes, water supply and local farming.
- Wildfires become a greater risk under drought conditions, with impacts on upland ecosystems. Peri-urban wildfires in the Pennines scrub land and peat bogs have increased.

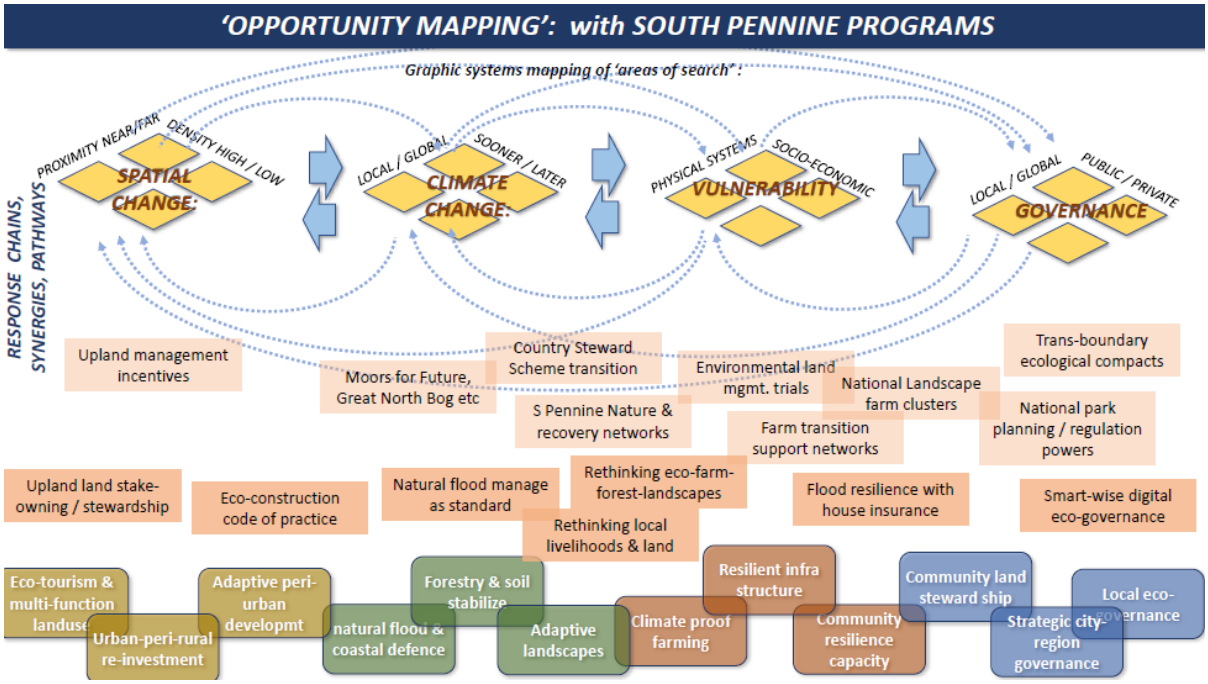
During significant events, fires casts smoke across the entire conurbation, generating impacts on human health and transport disruption.
- Extreme heat, which affects vulnerable social groups (e.g. the young and elderly, outdoor workers, people with per-existing health conditions) especially in more urbanised areas.

Secondly, the peri-urban areas of the South and West Pennines are also highly inter-connected to their surrounding urban and rural areas. From the perspective of climate change risks and adaptation, this has both positive and negative implications. These include:

- Landscape management in the peri-urban have effects on the water environment and hydrology, for example where upland land ownership and land use practices contribute to water quality and downstream flooding. Equally, this points towards the opportunity to promote more sensitive land management to help alleviate this impact.
- Land management and farming practices in the peri-urban create problems of run-off, water pollution, soil erosion and compaction and the loss of habitats and biodiversity. Again, although these are currently negative impacts, this does point towards the peri-urban as an opportunity space for approaches that can support climate and ecosystem resilience.
- Housing development in the peri-urban is a direct effect of pressure for urbanisation and related housing growth. Knock-on impacts of urban intensification in the peri-urban include the creation of urban heat island and pressure on habitats and biodiversity.

Figure 5 takes forward this notion of peri-urban areas in the South and West Pennines as an opportunity space. This Figure was created with input from the South Pennines Park organisation, a collaboration between public, private and third sector organisations working towards progressing a nature-led and people-centred vision for the South Pennines area. It emphasises that a range of socio-economic and biophysical measures and approaches can be directed towards generating peri-urban landscapes and urban environments that can respond positively to the challenges they face and capturing the opportunities they can help to realise. These issues are taken forward as a series of broad adaptive pathways in the next section.

Figure 5: Opportunity mapping visualisation for the South Pennines.



4.3. Adaptive pathways for the South and West Pennines

There follows a number of adaptive pathways developed through a series of international workshops involving representatives from cities across the world. These are high level and generic in nature, and global in origin, but provide an insight into broad approaches that could be taken to transition peri-urban areas in the South and West Pennines to a state where they are better adapted and more resilient to climate change whilst also addressing other socio-economic and biophysical challenges (as outlined in Figure 4).

PERI-URBAN PATHWAYS	
Urban-rural linkages in the peri-urban	Urban & rural areas are highly inter-dependent, in resources, infrastructure, housing, travel, leisure, ecosystems services etc. The peri-urban adds another dimension to that mix. The aim of the 'PURL' is to maximize opportunities and minimize negative impacts on each kind of territory. 'Sprawl repair' & similar ideas aim to mobilize the local synergies wherever possible.
Peri-urban stewardship of land & commons	Many peri-urban territories include large areas of leftover 'lost space', and much of this (in some countries) is in common / public ownership. The community-based stewardship of marginal land on edges or corridors, can be a powerful way to generate social synergies, e.g. by local food democracy, which can then manage ecosystems for resilience and adaptive capacity.

CLIMATE PATHWAYS	
Water / flood / storm adaptation	Short term: we need ways to manage rising floodwaters and extreme events, via sustainable urban drainage (SUDS), NFM, flood barriers etc. Longer term: (in some areas) we need to rethink – where are the settlements, how can the dominant urban forms and landscape surroundings evolve to enhance climate resilience, how can low impact eco-design manage a transformation towards a climate-friendly co-existence.

VULNERABILITY / RESILIENCE PATHWAYS	
***PHYSICAL:* Landscape diversity & resilience**	A wider agenda is for sustainable / adaptive / resilient landscapes, soils, forests, water bodies & wetlands etc, both within / without formal designations. Policies for forestry, farming, infrastructure, housing, business, leisure & tourism etc, can steer towards adaptive planning & design for housing, industry, farming etc. These approaches may be strengthened by eco-systems markets, green finance, carbon offsets etc.
***SOCIAL:* Demographic shifts & new forms of eco-housing**	While much peri-urban expansion is in middle-upper income suburbs & gated communities, some areas see an influx of alternative lifestyle, ex-urban small-holders, local eco-entrepreneurs etc. This brings new opportunities for eco-housing, housing with small-holdings, low impact development etc. This can change the social mix & increase the local diversity & resilience.
***ECONOMIC:* Ecosystems markets & green finance**	From the 'Economics of Ecosystems & Biodiversity' agenda, there are many variations of economic approaches being developed across different countries. Payment for ecosystem services, local carbon markets, green / long finance, developer contributions, precautionary bonds / escrow accounts, and social return on investment are some of the emerging options.
***TECHNOLOGY:* Digital platforms & monitoring**	A digital approach sees potential to enhance climate adaptation, flood defence, ecosystems management & markets. Indicators & metrics for systems change, adaptation and resilience can be defined & monitored by local stakeholders in combination with experts.

GOVERNANCE PATHWAYS	
Market-led governance, finance & enterprise	Beyond the limits of formal government, market-led approaches may enable innovation, forward investment, and enterprise of all kinds. Ecosystems markets, green finance, impact investment, or social return on investment are approaches that may bridge the gap between ecological social & economic values. Public services and public procurement can also have a powerful effect, such as local / organic food policies or ecosystems reinvestment.
Collaborative governance, civil partnerships	As the peri-urban agenda crosses many boundaries & involves many sectors, new forms of civil society partnerships, networks, forums, dialogues can emerge. These may be based on water catchments, bio-regions, or terrestrial eco-regions, as well as economic zones, commuting patterns etc. Government can enable these with round table structures, deliberative processes, core subsidies, rules for transparency & accountability.

5 Progressing natural flood management in the Irwell catchment: exploring adaptive pathways

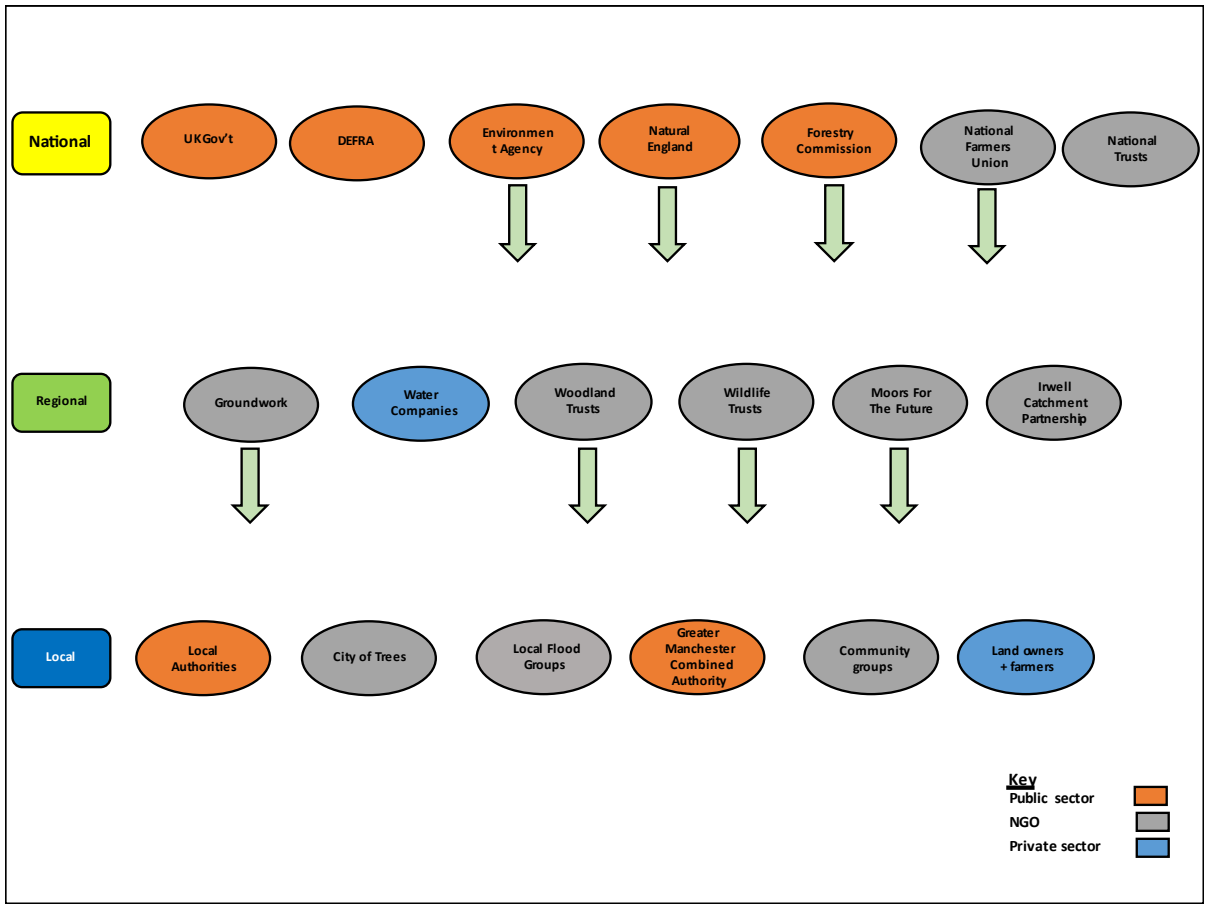
This section provides an exploration of issues linked to flood risk and related NFM responses in the Irwell catchment. A companion Peri-cene deliverable, D4.1b, looked at exposure to fluvial flooding and NFM opportunity in the Irwell catchment from a spatial perspective. The focus of this section is on themes linked to existing NFM activity and governance, and adaptive pathways that could enhance NFM activity in the Irwell catchment. A related Peri-cene deliverable, D5.2, explores adaptive governance principles in the context of NFM in the Irwell catchment.

5.1. Current Flood Risk Management Policy Frameworks and Governance Structures

Figure 6 introduces key organisations engaged in flood risk management, NFM and the development and implementation of NFM schemes in the Irwell catchment. This is not an exhaustive stakeholder map but aims to reflect key organisations and groups driving forward, and with a stake in, NFM. These stakeholders are also involved in other water-related agendas, including those connected to water quality and biodiversity, in addition to a wide range of other environmental themes. Figure 6 emphasises the wide range of organisations involved in NFM, and the complexities linked to governing this agenda.

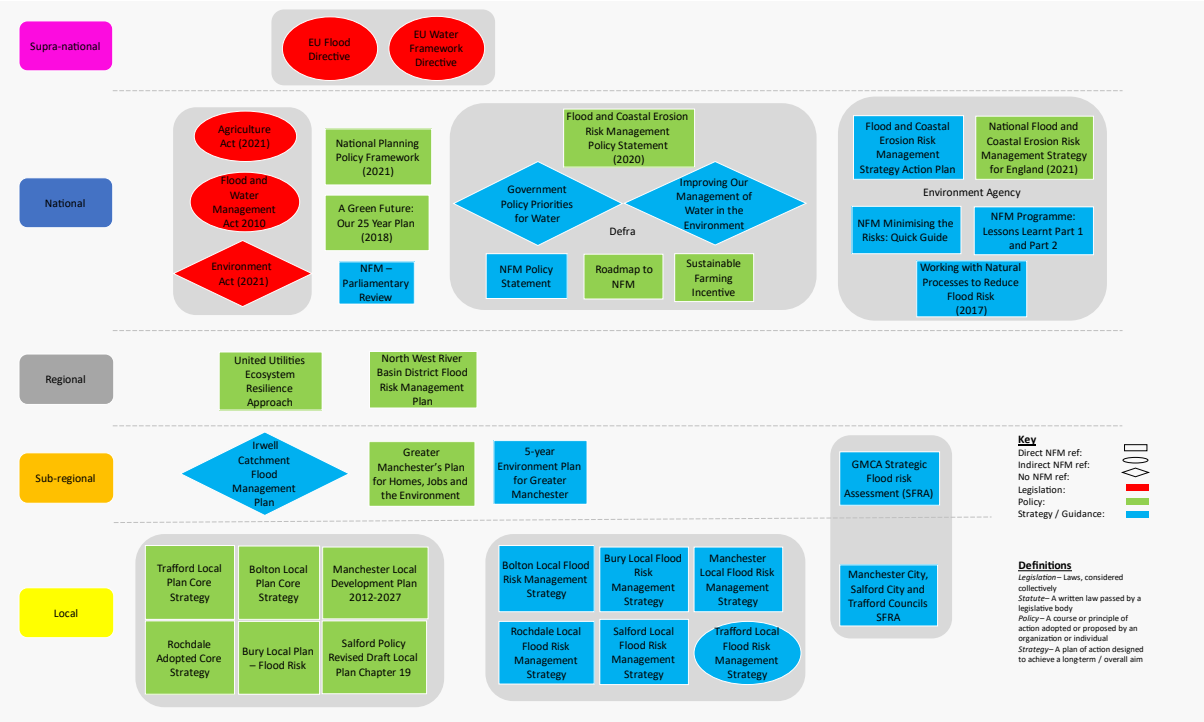
The Irwell catchment is sub-regional in scale. It crosses multiple local authorities (or municipalities) and is situated partially within the administrative boundary of Greater Manchester. Local and regional stakeholders, representing public, private and NGO sector organisations, are therefore involved in flood risk management activity across the catchment. National level organisations, some of which have remits that extends downwards to regional scales, influence the agenda at the Irwell catchment scale through the development of policy and guidance, and by taking resourcing decisions. The relationships between these organisations are complex, with the extent of engagement and connections depending on the initiative or action considered.

Figure 6: Stakeholders involved in flooding and NFM in the Irwell catchment



A number of the stakeholders represented in Figure 6 are responsible for developing and maintaining an evolving framework of legislation, policy and strategy that has an influence on NFM activity (and the water and natural environment more broadly) in the Irwell catchment. A range of key documents were reviewed within the Peri-cene project to better understand this framework from the perspective of NFM. Figure 7 visualises the reviewed documents, distinguishing them according to their spatial scale of focus and the extent to which NFM themes are featured. Whether a document makes direct or no reference to NFM is straightforward to determine. Direct reference is where a document incorporates flood risk management principles and actions that are described using NFM terminology. Indirect reference to NFM is where nature-based interventions are highlighted that could potentially deliver flood risk management benefits (e.g. restoring ecosystems, tree planting), but the link to flooding is not specifically made. Box 1 includes examples of statements and policies from the reviewed documents where direct reference to NFM is made.

Figure 7: Legislation, policy and strategy that has an influence on NFM activity (and the water and natural environment more broadly) in the Irwell catchment.



Broad conclusions that can be drawn from the policy review include:

- Across the different spatial scales considered within this review, the majority of documents make direct reference to NFM (that is they include statements and policies that are supportive of NFM). It is clear that NFM is working its way into the governance landscape that influences flood risk management activity within the Irwell catchment.
- Some key national level legislation and strategy that provides an overarching structure for the development of responses to flooding makes no reference to NFM. This indicates that NFM currently lacks clear and consistent national policy direction, and at present is therefore discretionary in nature.

Despite this, regional and local scale documents generally do refer to NFM. It is particularly encouraging that local plans, which set out policies guiding the development and use of land in the districts (municipalities) falling within the Irwell catchment, recognise and in some cases actively promote NFM.

Box 1: NFM statements and policies from key documents informing the flood risk management response in the Irwell catchment.

Document	NFM extract
Defra, 2020. A Green Future: Our 25 Year Plan to Improve the Environment.	"We will work with nature to protect communities from flooding, slowing rivers and creating and sustaining more wetlands to reduce flood risk and offer valuable habitats." (p. 7) "Natural flood management can play an important role in flood and coastal risk management" (p. 53)
Environment Agency. 2020. National Flood and Coastal Erosion Risk Management Strategy for England.	'"Alongside flood and coastal defences, we need a broader range of actions for achieving climate resilient places. This includes avoiding inappropriate development in the floodplain and using nature-based solutions to slow the flow of or store flood waters." (p. 13)
Ministry of Housing, Communities & Local Government .2021. National Planning Policy Framework	"Planning policies and decisions should: [...] recognise that some undeveloped land can perform many functions, such as for wildlife, recreation, flood risk mitigation, cooling/shading, carbon storage or food production." (p. 35)
Greater Manchester Combined Authority. 2020. Greater Manchester's plan for homes, jobs and the environment.	"An integrated catchment-based approach will be taken to protect the quantity and quality of water bodies and managing flood risk, by: [...] Working with natural processes and adopting a natural flood management approach to slow the speed of water drainage and intercept water pollutants" (p. 85).
Greater Manchester Combined Authority. 2019. 5-year environment plan for Greater Manchester.	"There will need to be a shift to more nature-based solutions (e.g. natural flood management) to support traditional flood alleviation schemes and catchment-wide approaches in upland and more rural areas" (p. 64).
Salford City Council. 2019. Salford Revised Draft Local Plan Chapter 19: Water.	Policy WA1 - "Supporting a catchment-wide approach to managing water resources and flood risk, including natural flood risk management measures where suitable."
Bolton Council. 2013. Bolton's Flood Risk Management Strategy.	"Bolton Council will be creating an asset register that identifies manmade and natural features that perform a flood defence function." (p. 6)

5.2. NFM activity in the Irwell catchment

Figure 8 visualises a range of completed, ongoing and planned NFM projects situated within the Irwell catchment. The locations of these projects are approximate, with some encompassing a number of smaller initiatives taking place over a wide area (e.g. the Clough Woodlands in the South Pennines scheme). This figure focuses on identifying schemes that are specifically driven by NFM or include a significant NFM component. It does not pick up projects linked to sustainable urban drainage or green roofs for example, which are also 'nature-based' measures and can offer benefits linked to reducing flood risk. Figure 8 does suggest that NFM schemes appear to be more prevalent to the north of the Irwell catchment, which is peri-urban and rural in nature. These locations are characterised by their upland moorland landscapes with steeply incised river valleys that feed into towns situated in the peri-urban fringe of the Greater Manchester conurbation. Figure 9 indicates that it is the built environment landscapes of these towns, including Rochdale, Bury and Bolton,

that are at greatest risk of flooding from the river Irwell and its tributaries. Given that these towns are surrounded by upland landscapes with the potential to house NFM schemes to attenuate water to reduce downstream flood risk (see D.4.1), NFM is increasingly being explored as an element of the flood risk management response in these locations. Indeed, the policy review highlighted that the local plans and flood risk management strategies prepared by these towns make direct reference to NFM and include policies that are supportive of related activity. Other factors driving the siting of NFM scheme in the upland and peri-urban fringes of the Irwell catchment include:

- Availability of land that is not allocated to other uses (e.g. productive agriculture or building development).
- High levels of rainfall due to prevailing wind direction and topography that NFM schemes have the potential to capture.
- High capacity of the landscape to hold water, for example within peat bogs.
- Availability of existing studies detailing the effectiveness of upland NFM interventions.
- Limited opportunity to obtain funding for traditional 'hard' flood defences to protect smaller upland and peri-urban settlements in the vicinity of these areas.

Figure 8: NFM schemes taking place across the Irwell catchment.

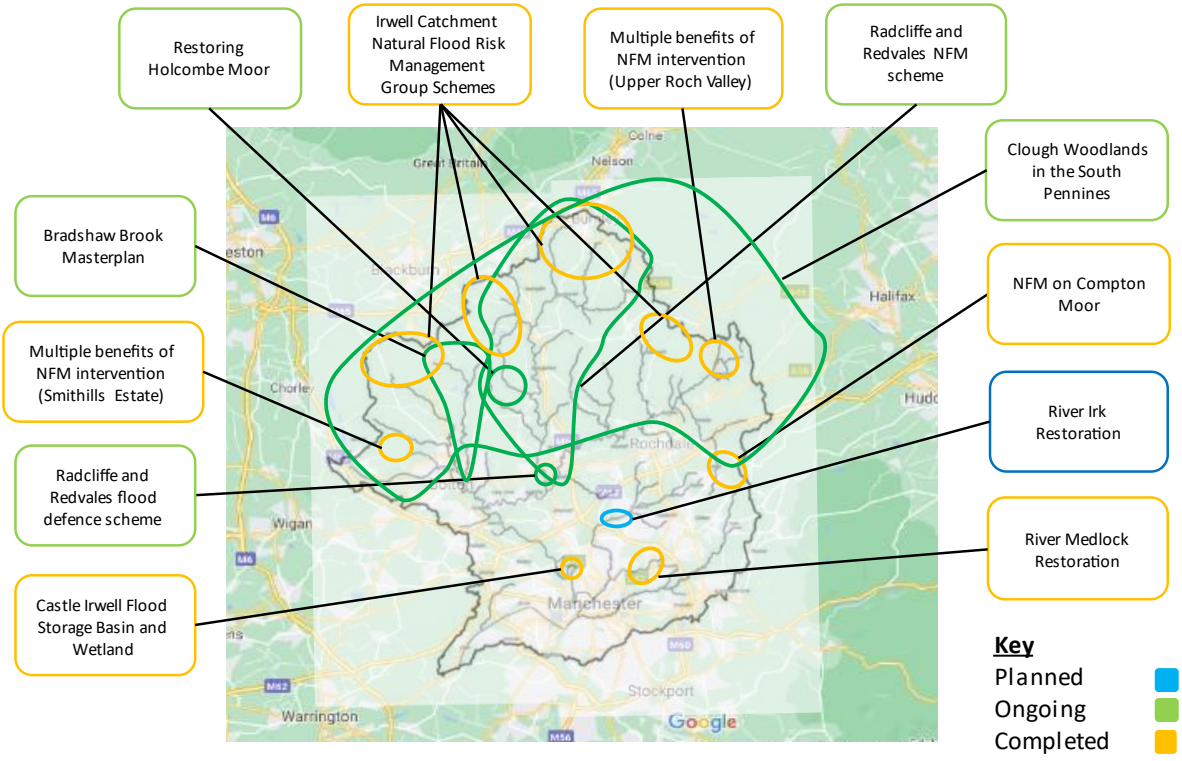


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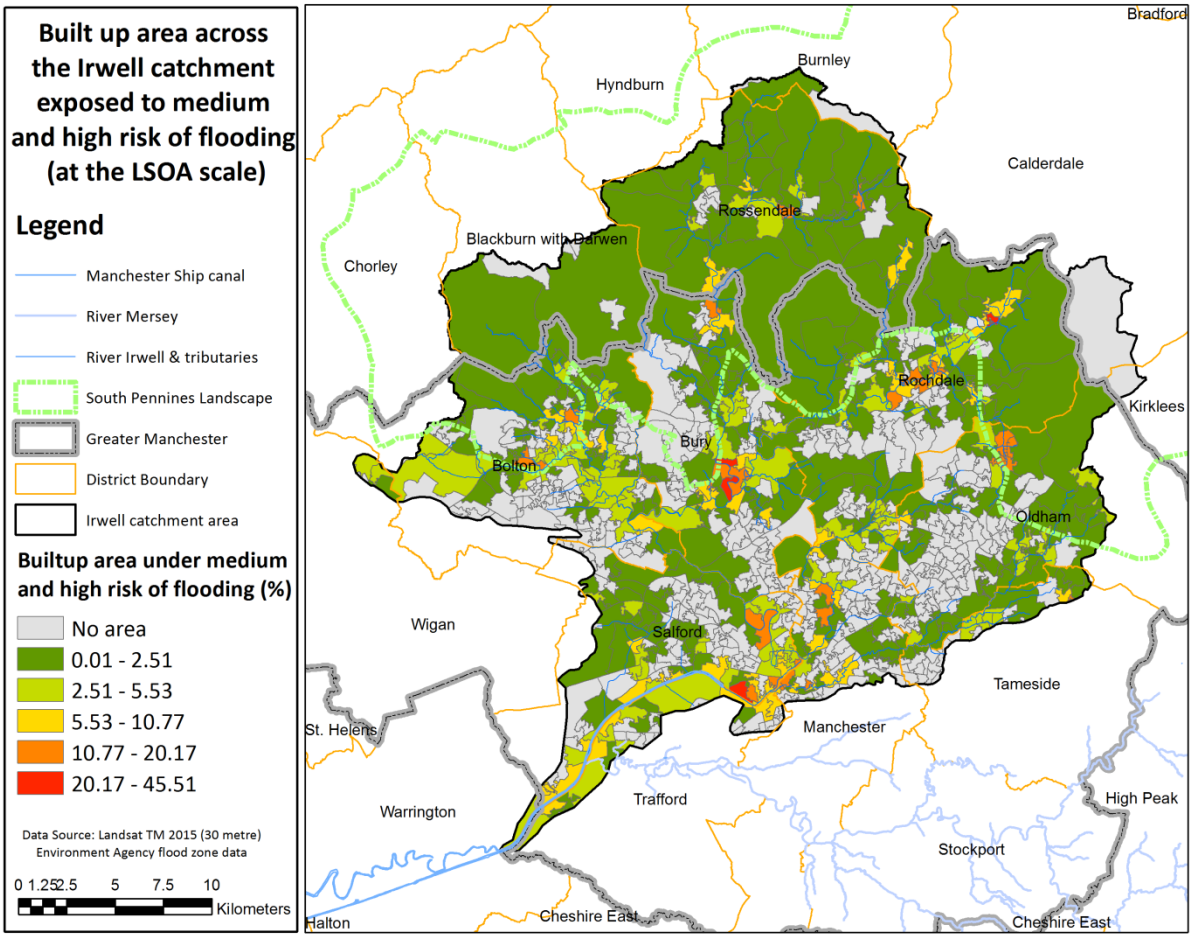
Figure 9: Built up area across the Irwell catchment exposed to medium and high risk of flooding.



Looking at two Irwell catchment NFM schemes in more detail, Figures 10 and 11 summarise the actions linked to the Holcombe Moor and Multiple Benefits of NFM interventions schemes NFM schemes (see Figures 12, 13 and 14 for related images). Both of these schemes are situated in the uplands to the north of the Irwell catchment. The Strategic Flood Risk Assessment data for Greater Manchester identifies certain areas within the Irwell catchment with the potential to be exposed to intensified flooding under projected climate change due to uplift in river flows (see Figure 15). This map highlights that locations around Rochdale along the river Roch, one of the main Irwell tributaries, are projected to experience increased exposure to flood risk hazards under climate change. This area is close to the South & West Pennine uplands, an area that has the potential to house NFM interventions (as highlighted in the Peri-cene deliverable D4.1b) that can help to take pressure off downstream hard flood defences by reducing flow levels within river. Figures 10 and 11 also highlight the stakeholders involved in the Restoring Holcombe Moor and Multiple Benefits of NFM interventions in the upper Roch valley. In each case a range of national, regional and local organisations and groups were engaged to enable project deliver, emphasising the importance of engagement and network development for NFM implementation.

Figure 10: Stakeholders involved in the Restoring Holcombe Moor NFM project.

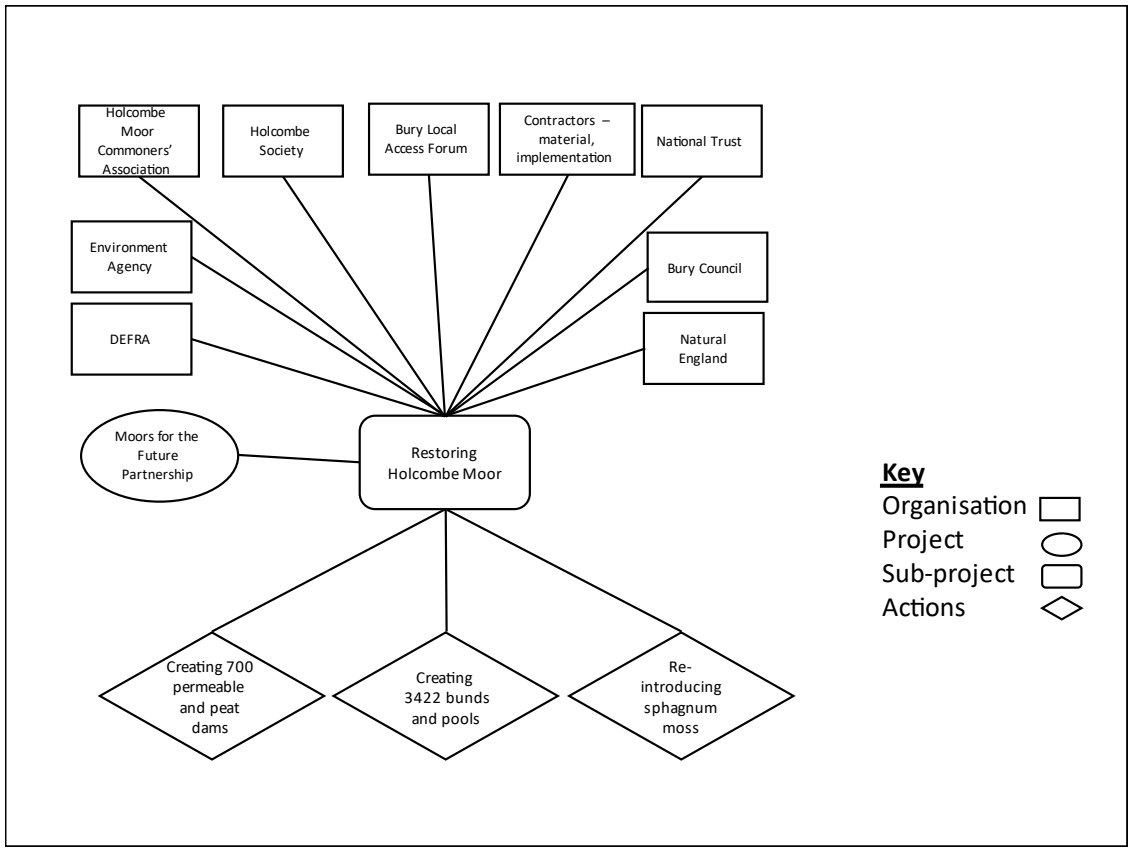


Figure 11: Stakeholders involved in the Multiple Benefits of NFM project (Upper Roch Valley).

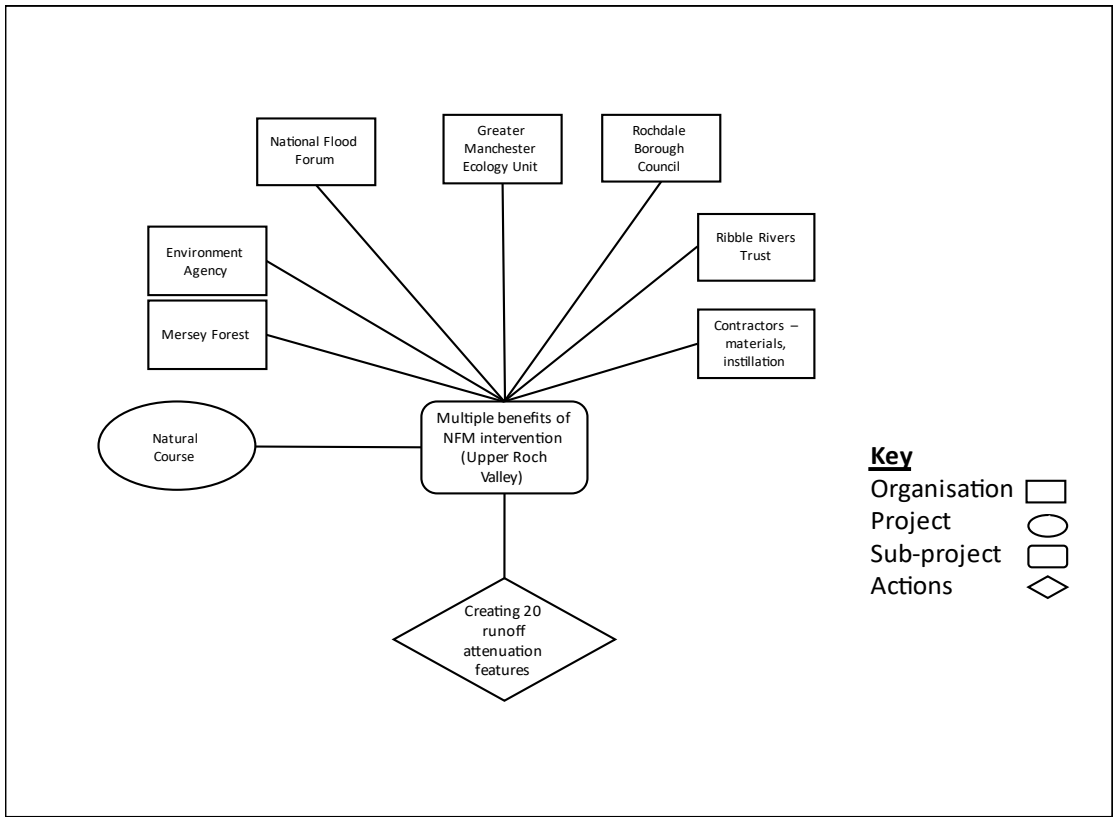
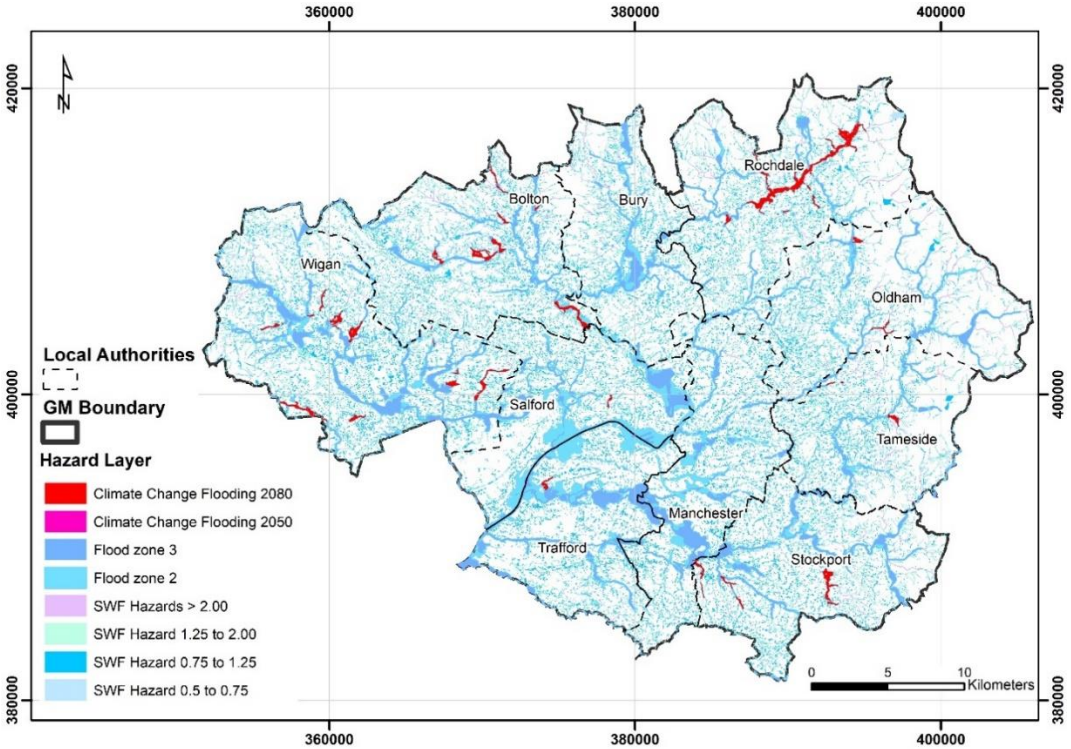


Figure 12: Aerial image of peat bunds and pools created as part of the Restoring Holcombe Moor project to attenuate rainwater (Source: Google Maps).

Figure 13: Peat bund and pools on Holcombe Moor (Source: National Trust).

Figure 14: 'Leaky dam' on private land developed as part of the Multiple Benefits of NFM interventions in the upper Roch valley scheme (Source: Rochdale Natural Flood Management Project, Rochdale Borough Council and National Flood Forum)

Figure 15. Flood Hazard across Greater Manchester. (Image source: Carter et al 2018; Data source: Greater Manchester Combined Authority, Strategic Flood Risk Assessment, 2018.)



5.3. NFM drivers and barriers

Within the river Irwell catchment NFM is becoming gradually more widespread. An emerging framework of policy and guidance, and networks including the Irwell Catchment Partnership, are in place and are helping to underpin current and potential future activity. There is scope for NFM to become more firmly established in the Irwell catchment, and other river catchments globally, to support adaptation to current and future flood risk. Indeed, this is one of the key drivers behind NFM. NFM should be perceived as one element of a broader flood risk management, or flood resilience, response. With the projected increase in the frequency and water volumes associated with extreme rainfall events, NFM is seen as a way of reducing the volume of water reaching streams and rivers and flowing downstream to potentially generate flood events. This, in turn, can lessen pressure on downstream flood defences and infrastructure including combined sewage systems that take rainwater runoff and domestic and industrial sewage.

Beyond climate change adaptation and resilience, other key drivers include that NFM schemes can support the achievement of a range of co-benefits including ecosystem and landscape restoration, biodiversity conservation, carbon sequestration and water quality enhancement. With increases in flood events, within the Irwell catchment and beyond, public awareness of this hazard is increasing channelled by media coverage. This is in turn increasing pressure on politicians and decision makers to respond and to develop measures to reduce flood risk to properties and communities. There is a recognition that traditional 'hard' defences alone are not enough to manage this hazard, particularly in the context of climate change, with attention therefore turning to alternative approaches including NFM. Further, some locations may simply not be suitable for traditional hard engineering solutions due to factors such as location or topography, in addition to challenges associated with accessing funding, with NFM therefore providing a potentially viable option in these circumstances.

Despite the drivers behind, and potential of, NFM in this context, interviews undertaken with stakeholders involved in the Restoring Holcombe Moor and Multiple Benefits of NFM interventions in the upper Roch valley NFM schemes, and with stakeholders with NFM experience locally, regionally and nationally, identified several key barriers holding back the wider implementation of NFM as an element of broader flood risk management initiatives within river catchments such as the Irwell. These include:

Resistance from landowners and farmers: Although there is a significant amount of land within upland peri-urban zones of river catchments such as the Irwell that could be utilised for NFM, obtaining the agreement of landowners and farmers to implement NFM measures can be challenging. Key factors underlying this resistance include concerns over the impact of NFM schemes on farm productivity and conflicts with existing land uses. More generally, there appears in some cases to be a lack of understanding of landowner and farmer circumstances and concerns, which can increase division and lessen engagement in NFM programmes.

NFM maintenance and liability: There a lack of understanding of who is responsible for maintaining NFM schemes, how this maintenance activity should be funded and who is liable should NFM measures generate problems downstream (e.g. if bunds or barriers fail during high flow conditions). This is another factor contributing to landowner and farmer resistance to implement NFM on their

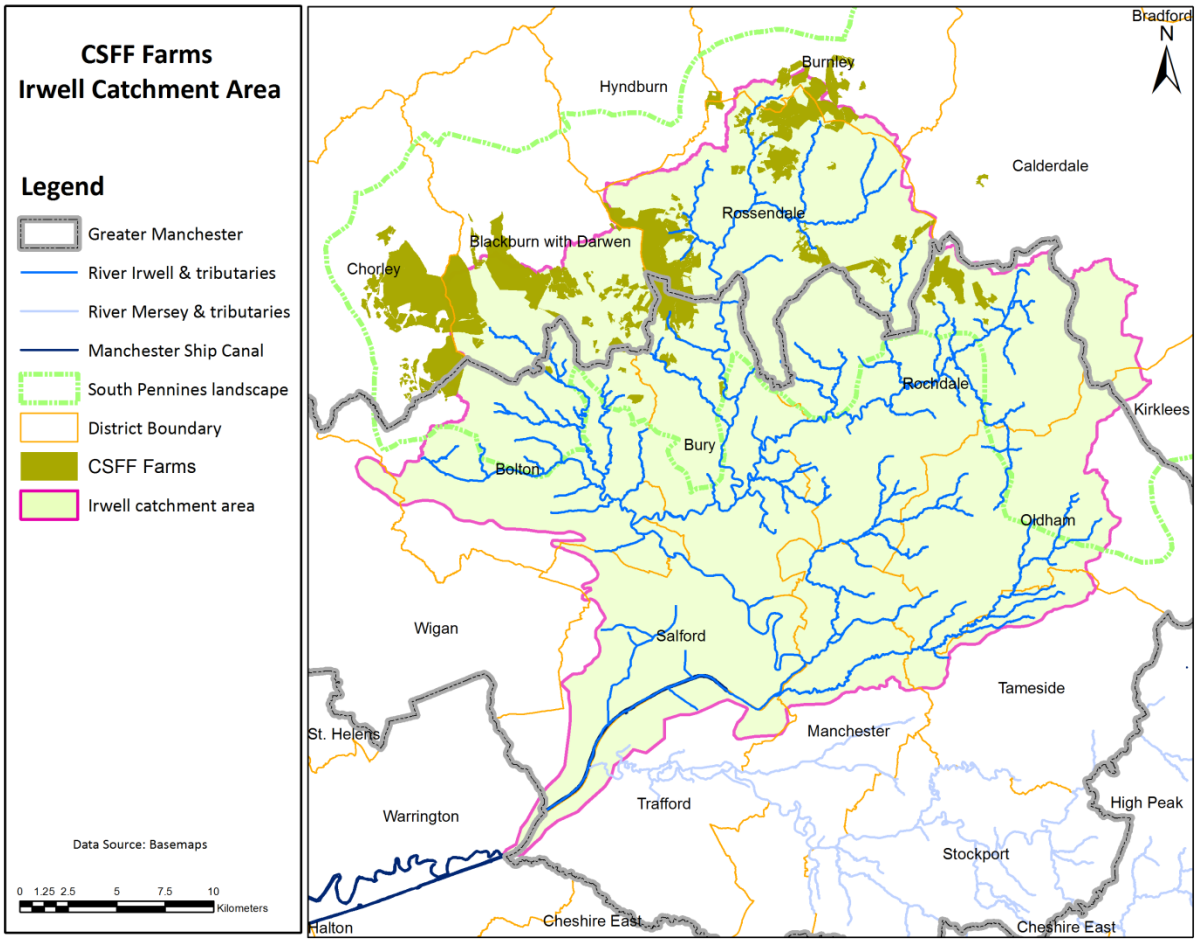
land. This is a common barrier limiting the uptake of green infrastructure and nature-based solutions more generally.

Challenges in obtaining funding for NFM: In England, current approaches to allocating public funding to flood reduction projects often limits the scope of options to measures that can evidence reduction in flood risk to specific communities and properties. Further, schemes that take larger numbers of communities and properties out of the highest levels of risk are given additional weight. In addition, assessments of the economic benefit of proposed measures are also often required. This approach works against obtaining funding for NFM measures, particularly smaller schemes and those schemes requiring longer term funding commitments (e.g. linked to landscape restoration).

Lack of evidence of NFM benefits: Although research on NFM effectiveness is increasing (ref), there remain significant gaps in the evidence base. This is particularly the case concerning measuring and modelling NFM effectiveness larger scales (e.g. across catchments and between upstream and downstream areas), where related issues and hydrological dynamics are beyond the scope of many research initiatives at present. This issue compounds problems linked to accessing funding for NFM, where data on the effectiveness of proposed schemes may be required to secure funding. This results in available funding being channelled into traditional flood defence schemes, often in downstream urban areas, as associated benefits can be more readily quantified.

Absence of strategic flood risk management planning: NFM activity is increasing, yet schemes are often opportunistic in nature taking place where there may be willing landowners and favourable funding sources. However, these schemes may not be occurring in locations where optimum flood risk management benefits can be achieved. This is symptomatic of a lack of strategic flood risk management strategy and planning, where catchment scale perspectives are lacking due to mismatches between natural hydrological systems and administrative units (e.g. local authority boundaries). This issue is exemplified by Figure x, which highlights that the Irwell catchment is segmented into several administrative units. District (or municipality) boundaries and the Greater Manchester boundary cut across the catchment, complicating governance responses. Figure x highlights a specific case study, the Countryside Stewardship Facilitation Fund (CSFF), allocated by the UK Government's Department for Environment Food and Rural Affairs to bring together land managers to collaboratively deliver positive environmental outcomes at landscape scales. Figure 16 demonstrates that farms enrolled in this scheme in the upper Irwell, which focused on flood risk management, are generally located beyond Greater Manchester's boundary. This generated problems when looking to communicate and collaborate with administrators within Greater Manchester, hampering progress towards a catchment-based approach. This example demonstrates the challenges faced where strategic catchment-based flood risk management strategies are lacking, and those stakeholders delivering and deriving benefit from NFM measures are located in different administrative jurisdictions.

Figure 16: Countryside Stewardship Facilitation Fund (CSFF) farms located within the Irwell Catchment.



Academic research has also highlighted barriers constraining NFM uptake. Interviews with policy actors in Scotland revealed three main broad challenges: allocating resources, evidence and uncertainty, and coordination and communication (Waylen et al. 2018). Interviews with practitioners in the UK found 25 barriers, of which three were most prevalent: "economic constraints for land managers, the current lack of scientific evidence to support NFM and current lack of governance over long-term responsibility for NFM, which hinders future monitoring and maintenance" (Wells et al. 2020, pg. 1). These themes chime with the NFM barriers uncovered within the Peri-cene project.

5.4. Adaptive pathways for enhancing NFM in river catchments

Interviews and workshops held with a range of stakeholders enquired into the potential of different approaches for delivering more effective NFM outcomes in integrated peri-urban and urban river catchments settings. The interviews informed the development of adaptive pathways linked to expanding NFM across the Irwell catchment, addressing the barriers to wider NFM implementation and enabling NFM to play a stronger role within broader and more holistic approaches to flood risk management. These can be presented as a series of adaptive pathways that can support the transition towards peri-urban (and urban and rural) areas that are better adapted and more resilient to climate change. Given the multiple biophysical and socio-economic benefits that can be secured through NFM, this should not be purely seen a response to climate change but as part of a wider sustainability transition. Although the following adaptive pathways are presented individually, it is important to emphasise that they are not mutually exclusive and are instead potentially complementary.

Natural systems pathway: Perceiving river catchments as natural systems, that are shaped and driven by natural processes, opens opportunities for embedding NFM as an integral element of flood risk management strategies. The goal of a natural systems pathway is to understand catchment dynamics and the role that restoring natural functions can play in moderating flood risk (in addition to other socio-economic and biophysical functions). The natural systems pathway would be based around river catchments and sub-catchments, and encourage an evidence-based strategic approach. Here, a mosaic of natural (and engineered) measures contribute to flood risk management goals through restoring and enhancing natural habitats and ecosystems.

Finance and markets pathway: Current approaches to funding measures to reduce flood risk to people and communities do not support the wider implementation of NFM measures and instead encourage the development of engineered 'hard' or 'grey' measures. Enhancement and expansion of NFM, and natural systems approaches more generally, will not be achieved without new funding mechanisms that support these approaches and incentivise landowners and farmers to take action. Breaking out of the funding-related constraints that are holding back NFM will require innovative approaches linked to a broader push for nature recovery and the restoration of natural functions. Potential opportunities highlighted during Peri-cene interviews and workshops include blended finance approaches that build on capturing the co-benefits offered by NFM to multiple beneficiaries, obtaining funding directly from communities at risk (particularly those smaller communities that are struggling to finance measures through current approaches) and securing finance from insurance companies. Emerging funding schemes in the UK, including environmental land management (ELM) and the drive for 'public money for public goods', may help to incentivise alternative approaches to using farmland for uses beyond food production (which in the uplands is often a marginal endeavour dependant on subsidies). More fundamentally, a broadening of the assumptions and expectations that inform decisions over the allocation of funding for flood measures, and land management more generally, is needed.

Co-benefits pathway: Promoting co-benefits can help to increase engagement and leverage funding for NFM schemes from multiple organisations who are driven by different but complementary agendas. The reality is that flooding is not always the primary driver behind

schemes that display characteristics of NFM. Reducing flood risk is often a co-benefit amongst other target outcomes, including enhancing water quality, habitat and landscape restoration and carbon sequestration. As multiple benefits will generally be an outcome of NFM schemes, moving away from flooding-related terminology towards restoring natural processes could be a useful step. The goal here is to progress collaborative projects bringing in different stakeholders focused on achieving various co-benefits from NFM measures. Organisations including Natural England and Groundwork currently aim to work in this way. The challenge remains moving towards securing funding and implementation of measures in practice based around collaborative approaches. A scheme on the river Wyre in northwest England developed of a special purpose vehicle to enable multiple beneficiaries to engage together and fund an NFM project, and provides a useful example of innovative practice (link). Similarly, the restoring Holcombe Moor scheme accessed national government peat restoration funding, and garnered support from organisations looking to enhance upland habitats to conserve threatened bird species, to deliver a NFM-related scheme that also helped to reduce downstream flood risk.

Partnership and engagement pathway: Developing partnerships and encouraging engagement with appropriate stakeholders will be at the heart of any expansion of NFM activity. Partnership working connects to delivering on a co-benefits approach to driving forward NFM. Early dialogue and engagement with landowners, farmers and land management organisations is essential to generate support for and willingness to implement NFM measures. Landowners and farmers also have the best knowledge of how the landscape behaves under extreme rainfall conditions, and can provide valuable insights to support hydrological modelling. Indeed, each NFM scheme will be bespoke and location specific. This requires sufficient time and allocation of resources to be effective. Without receptive landowners, there will be no broad expansion of NFM measures across river catchments such as the Irwell. Securing support from senior decision makers and politicians is also needed. A single catchment plan, focused on water quality and quantity issues at a minimum, could provide a nexus for partnership working.

6 CAPTURING KEY THEMES AND LESSONS LEARNT FROM THE MANCHESTER REGION CASE STUDY

This deliverable has addressed issues connected to climate change risk and adaptation in the peri-urban areas of the Manchester region. Given that it is the prominent climate change hazard facing the region, particular attention has been paid to flooding and flood risk management within the South and West Pennines and the Irwell catchment. Certain flood risk management responses have a clear resonance with the peri-urban. Peri-cene has highlighted that there is potential to expand the implementation of NFM schemes in peri-urban landscapes to the north and west of the Manchester region. However, barriers stand in the way of realising this potential in practice. These barriers cover themes including inadequate landowner engagement, evidence base gaps and unsupportive funding schemes, highlighting problems with current flood risk approaches within and beyond the Manchester region and pointing towards the need for new approaches.

An important message running through this report is the need to view the peri-urban as an opportunity space that provides an important range of functions in the context of climate change adaptation and resilience. Given their scale, many river catchments (and sub-catchments of larger river systems) encompass peri-urban areas. Locations within these peri-urban areas can be at risk of flooding themselves, and equally rainwater runoff from peri-urban natural landscapes and built environments can contribute to elevating flood risk in downstream areas. Hence, the development of peri-urban NFM schemes can act to reduce flood risk locally and in other areas of river catchments which may be more densely populated and developed. Indeed, this is the case on the Irwell catchment. This offers peri-urban areas an opportunity to act as providers of adaptation functions locally and to areas in their vicinity. This is not only the case regarding flooding. Peri-urban areas can also provide climate change adaptation functions linked to other agendas. These include biodiversity conservation through provision of green and blue migration corridors, transference of cool air to urban centres via greenspace corridors under heatwave conditions and encouraging land management practices that can enhance water quality.

The key question is how can this transition, which peri-urban areas have the potential to help realise, be supported? In the UK, national level strategy and guidance is increasingly recognising the role of NFM as an element of wider flood risk management responses, setting a framework for action at local scale. This is encouraging. Yet the nature of the barriers holding back wider NFM implementation, needed in response to climate change induced uplift in flood risk and to encourage other co-benefits, are such that new approaches are needed. A series of adaptive pathways have been proposed within this report covering a range of socio-economic and biophysical themes. These can encourage the incorporation of NFM within flood risk management strategies, and broader peri-urban transitions centred on ecosystem, societal and economic resilience. Further research is needed into these pathways, involving collaboration with stakeholders and decision makers, to evaluate the extent to which they are achievable in practice and to understand how the adaptive pathways and the themes that they cover can drive forward a positive and proactive future for peri-urban areas.

7 ANNEX

7.1. Reference list

(TBC)

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