Opportunities for Positive Tipping Points in NHS digital systems resilience

Summary

Positive Tipping points are about creating i*ntention* and *agency* for organisational change to become more resilient in the face of increasingly unstable Earth systems.

This research examines how positive tipping can be triggered in NHS digital systems to be more resilient to climate change and quicker to respond to, and recover from, climate incidents.

The concept of systems tipping points derives from research into 'negative' Earth systems tipping points, which provides a key context for this investigation of climate resilience. Negative feedback loops in Earth systems are amplifying, tipping towards abrupt nonlinear system change, such as the collapse of the Atlantic meridional overturning circulation (AMOC). This sudden shift, a strong possibility in current projections, would radically undermine global food and water security and plunge northwest Europe into prolonged severe winters.

A series of systemic challenges were identified as opportunities for positive tipping points in NHS digital systems where climate resilience can be enhanced through innovation:

Non-technical/institutional Positive Tipping Points

NT1. Decision makers prioritise resilience and long term thinking amidst day-to-day working

NT2. If climate resilience viewed as essential and a shared responsibility by staff and suppliers

NT3. If we had a more effective response to incidents and better learning from them

NT4. If we reduce 'cognitive debt' of outsourcing systems and services

NT5. If we had a reciprocal resilience network with institutional partners

NT6. If we had nature based resilience networks with local partners

Technical Positive Tipping Points

T1. If investment and procurement balance resilience with complexity and cost

T2. If we knew the likely impact of climate change (medium/long term) and climate incidents (immediate term)

T3. If we understand the risk and resilience of the existing system

Managing risk and resilience in Earth systems and NHS digital systems

The work concludes that the most powerful leverage points for positive tipping are around system goals and the mindset of the people in the system.

The research includes proposals for how methods such as *Three Horizons Framework* and *Alternative Capitals* that fit together with the PTP methodology, can be combined to create conditions within organisations to be more resilient:

- Longer term thinking
- Seeing big pictures, the entire system and out role within it, and finding fresh perspectives
- Understanding how systems change abruptly, and how extremes matter most, not averages
- Finding approaches that enable tipping points

The positive tipping points model and it's related methods and practices, are a comprehensive, intelligent and masterful way to understand organisational transformation in response Earth system instability.

1 Introduction

This paper presents the findings of an investigation into the applicability of Positive Tipping Points to the resilience of NHS digital systems to climate change, responding to the question:

"How can we ensure our digital service is less likely to fail, and quicker to recover when climate risks occur?"

1.1 What are Positive Tipping Points?

Not every change is a tipping point. Tipping points are changes in the state of a system when this change:

- is self-reinforcing through feedback loops
- builds momentum towards widespread impact

Tipping point change is often abrupt, and non-linear. The impact of tipping points is often irreversible, as the system has changed state.

Positive tipping points refer to the amplification of positive feedback loops (such as economies of scale or social contagion), supported in some instances by the dampening of negative feedback loops (cost pressures, political will etc), to change the system state.

Positive tipping points tend to happen abruptly, and can manifest as a rapid phase-in of a desired, sustainable innovation (idea, social practice, or technology), or as a rapid transition away from an undesired, unsustainable incumbent.

It's possible to imagine tipping points by considering the effort required to shift from one state to another as analogous to a ball being nudged along a curve, with basins representing alternative system states.

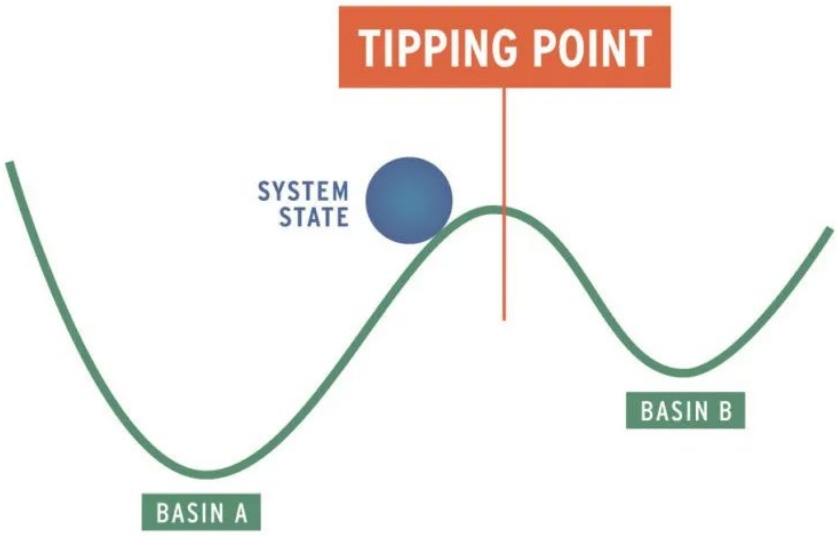

Figure 1 - Tipping Point Illustration, PTP Toolkit

In this way, you can sense the difficulty in changing the state of a system, due to negative feedback loops. Without a sustained attempt to push the ball along the curve, over the tipping point, most nudges displace the ball momentarily before it returns to the bottom of the basin.

Key characteristics of a tipping point:

1. A meaningful and significant change from one system state to another
2. Positive feedback that acts as momentum to amplify the change
3. Non-linear change, including change happening very quickly compared to the usual speed of progress
4. Irreversible change that cannot be easily or quickly undone

History provides countless examples - from the invention of the electricity grid to the abolition of slavery - in which change happened slowly at first, then all at once —due to the existence of positive feedback causing an initially gradual change to gain momentum and become self-reinforcing after a threshold was reached.

Modelling and empirical studies have that found that tipping in social networks is possible with a range of 10-43% adoption in the population, most commonly around 25%. This level is influenced by factors in the population such as trust, social proximity and the structure of social networks.

These social networks exist within institutional (NHS organisations, supply chain businesses etc), place and technical contexts (professional groupings, technical infrastructure etc). Here, policy and other interventions can create the enabling conditions for tipping to occur by weakening balancing feedbacks and/or strengthening reinforcing feedbacks.

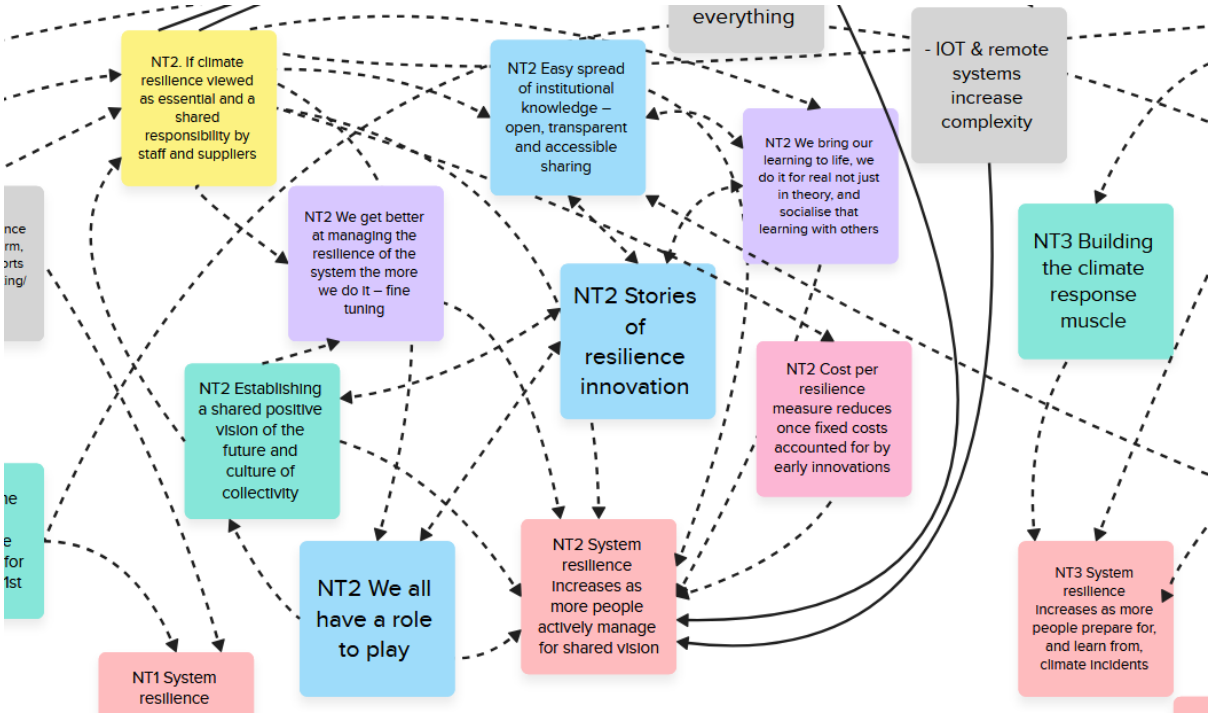

Figure 2 - Mapping Digital Systems Feedback Loops

1.2 Positive Tipping Point Methodology

Positive tipping points emerged from work led by Prof Tim Lenton and the Global Systems Institute at Exeter University which examined 'negative' environmental tipping points in global systems - triggered by climate change, biodiversity loss and other anthropogenic trends in natural systems.

To counter this negative tipping, the team at Exeter began to address the opposite contention –

"C*an we create positive tipping points within systems to reduce the scale or likelihood of negative tipping?"*

The resulting Positive Tipping Point methodology outlines a series of stages to investigate positive tipping points in systems, such as NHS digital systems.

Stages in Positive Tipping Points methodology

Step 1: Notice your starting point

- What is your context? What challenges are you facing?

Step 2: Imagine an alternative future

- Imagine the **Stories of Change** you could tell about a new reality and the **Indicators** that would signal you had passed, or were close to, a tipping point.

Step 3: Identify what would make that alternative future more possible?

- Identify the **Enabling Conditions** required for a positive tipping point to become a realistic future.

Step 4: Understand how to strengthen those enabling conditions

- Identify the **Feedback Loops** that strengthen enabling conditions.

Step 5: Take action

- Consider the **Triggers** required to pass the Positive Tipping Point. How might these triggers be noticed, cultivated and triggered?

This inquiry examines the potential for triggering positive tipping points that can shift the state of NHS digital systems, so they are less likely to fail, and quicker to recover when climate incidents occur.

This work covers Steps 1 to 4 in the PTP methodology, along with a proposal for Step 5.

2.0 The context for Positive Tipping Points in systems

The tipping points approach, summarised in the report Global Tipping Points for COP30 in Belem, Brazil, describes findings in relation to both positive and negative tipping points.

This report describes both the non-linear nature of complex systems change, and how this will unfold in Earth systems as cascading change and collapse. This provides a medium to long term perspective and challenges our assumptions about the predictable linear predictions of the pace of climate change. This provides a profound context for this enquiry into resilience to climate change.

2.11 Abrupt, non-linear system change

Tipping points research developed our understanding of how climate change is likely to play out, moving us on from the linear thinking of climate change modelling, which assumes that change will happen in a predictable manner that can be reliably forecast by a trend analysis.

Far from a predictable progression, the analysis shows how tipping points within systems are usually abrupt, and often irreversible.

It demonstrates, too, that tipping point risks are interconnected and the interactions between them are usually destabilising, meaning tipping one part of a system makes tipping another more likely.

Take away - *This is how systems change, very slowly, and then all at once – both the boiling frog and the black swan, all at the same time.*

2.12 A method for understanding non-linear change - Complex and complicated systems

Systems are dynamic environments that change and adapt through feedback loops, in which significant shifts in the system state are abrupt and non-linear events. So, it is important to reflect what this tells us about the nature of systems and their behaviour.

If we want to change a system, we need to think like a system.

Typically, we fail to appreciate how systems really behave and, in trying to reduce them to something 'knowable', we fail to appreciate the nature of complex behaviour.

The PTP methodology uses the example of a bicycle to demonstrate this. A bicycle is a complicated system. It's not easy to understand, but it is understandable. If you have enough knowledge, you can take it apart and put it back together again. It is predictable, you know what will happen if you pull a lever or turn a pedal. There is a correct answer to how this system works, and it is controllable.

If you put a cyclist on the bike, however, it becomes a complex system. It is no longer static. It is unpredictable. You might know some things about how they will act, but not everything. Knowledge is useful, but it is not enough. We need multiple perspectives to have a better understanding of how this system is functioning. There is no correct answer, and we cannot control this system, only influence it.

Complicated system

Not simple, but understandable
A correct answer exists
Predictable
About things
Requires expertise

Complex system

Not fully understandable
No correct answer exists
Only partially predictable
About relationships
Requires perspective

Figure 3 – Complicated and complex systems, from PTP Toolkit

The NHS digital system is a complex system. We cannot fully understand it, but we can develop new methods to scope, measure and comprehend it holistically as a functioning whole, not just a series of reductive elements.

Whilst we can begin to predict how the system will function, this will only ever be a partial, due to internal system dynamics (we can't predict or model all the parts within the digital system) and the relationship between NHS digital and the social, institutional, technical and environmental systems it is nested within.

Take Away – *We can't 'know' the NHS digital system given it's complexity. We need to find a perspective, such as a new story or a new way of assessing value, that allows us to understand the relationships within the system in a way that encompasses the bigger picture and/or the longer term.*

2.21 Negative tipping points in Earth systems

2024 was the first calendar year when average global temperatures exceeded 1.5°C above pre-industrial levels. Critical carbon sinks, such as the Arctic tundra and Northern boreal forests, are now shifting to become carbon sources, amplifying global warming. Additionally, unusual ocean heat extremes signal nonlinear response in Earth's systems and recent observations put in question the previously assumed linearity of temperature changes.

This is the fundamental finding of the Global Tipping Points work; that global warming increases the risks of Earth system tipping points.

Global warming will soon exceed 1.5°C with current policies on track for at least 3 degrees of warming. This is likely to trigger four of the six most likely Earth systems tipping points; Coral reef die off, the melting of mountain glaciers, collapse of the West Antarctic ice-sheet and collapse of the Subpolar Gyre Convection.

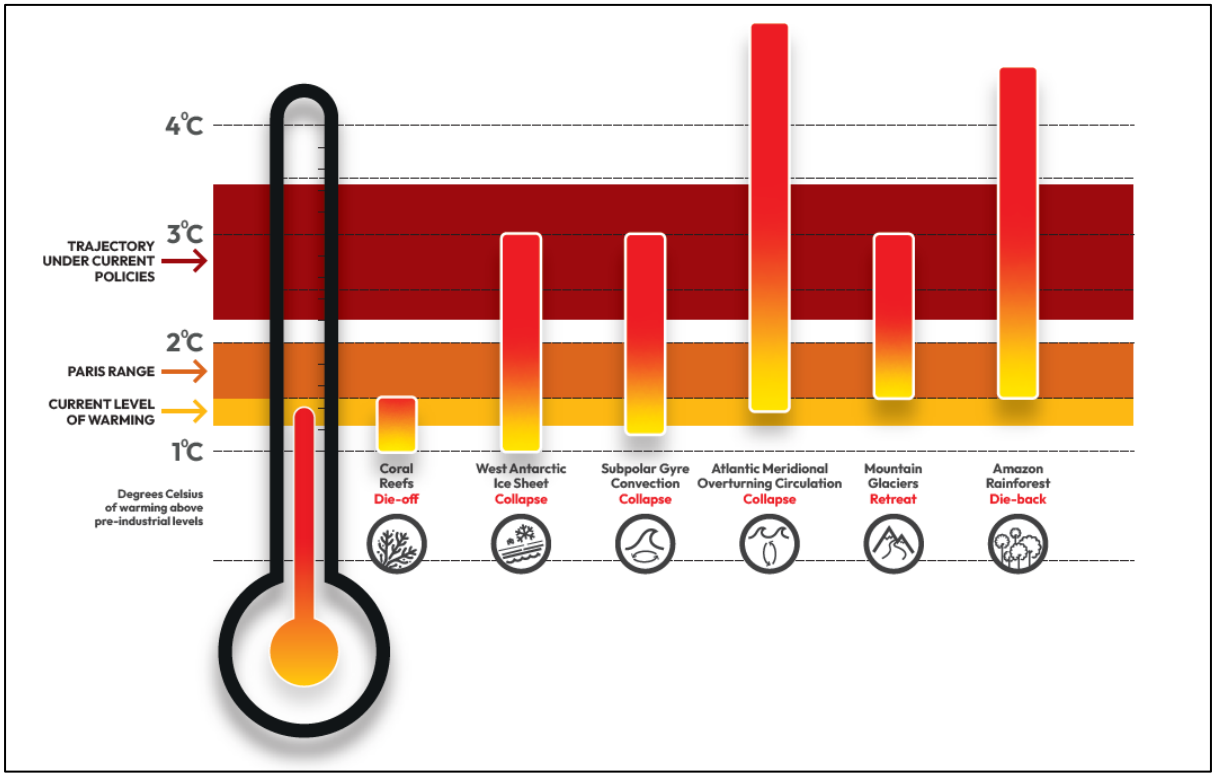

Figure 4 - Global Tipping Point risks increase with global warming

Every fraction of additional warming increases the risk of triggering additional tipping points. These include a collapse of the Atlantic Meridional Overturning Circulation (AMOC) that would radically undermine global food and water security and plunge northwest Europe into prolonged severe winters, along with widespread dieback of the Amazon rainforest, threatening incalculable damage to biodiversity and impacting over 100 million people who depend on the forest.

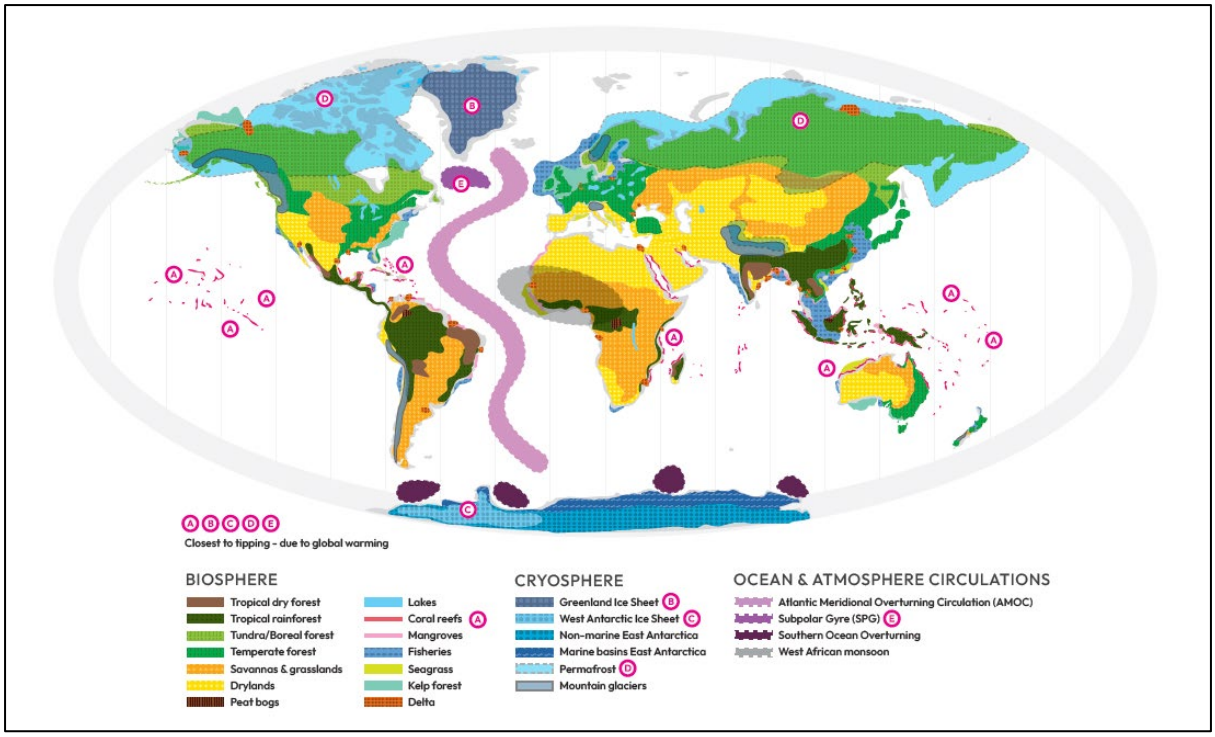

Figure 5 – Earth Systems Tipping Points

Together, these tipping points put humanity in the danger zone where multiple Earth systems tipping points pose catastrophic risks to billions of people, risks which will, ultimately, be measured in their impact on human health.

Take Away – *We should expect that Earth systems change will be abrupt. As such, we should plan for extremes not averages and for the impact of a change, not the likelihood.*

2.22 A method for creating change in unstable systems – the Three Horizons Framework

The *Three Horizons Framework* is a simple and intuitive way of thinking about the future and how we can create change within systems that are under strain or collapsing.

At its simplest we can see it as describing three patterns of activity, or Horizons as they are called, and how their interactions play out over time:

- **Horizon 1** is the dominant system at present. It represents 'business as usual'. We rely on these systems being stable and reliable. But as the world changes, so aspects of business as usual begin to feel out of place or no longer fit for purpose. Eventually 'business as usual' will always be superseded by new patterns of activity.
- **Horizon 3** is the long-term future, the eventual successor to business as usual, the vision of where we'd like change to take us. This future grows from fringe activity in the present that introduce new ways of doing things which turn out to be much better fitted to the world that is emerging than business as usual (Horizon 1).
- **Horizon 2** is the bridge between the present and the future, Horizon 1 and Horizon 3, it is brought to life when people try new things out and innovate in response to the ways in which the system is changing or needs to change.

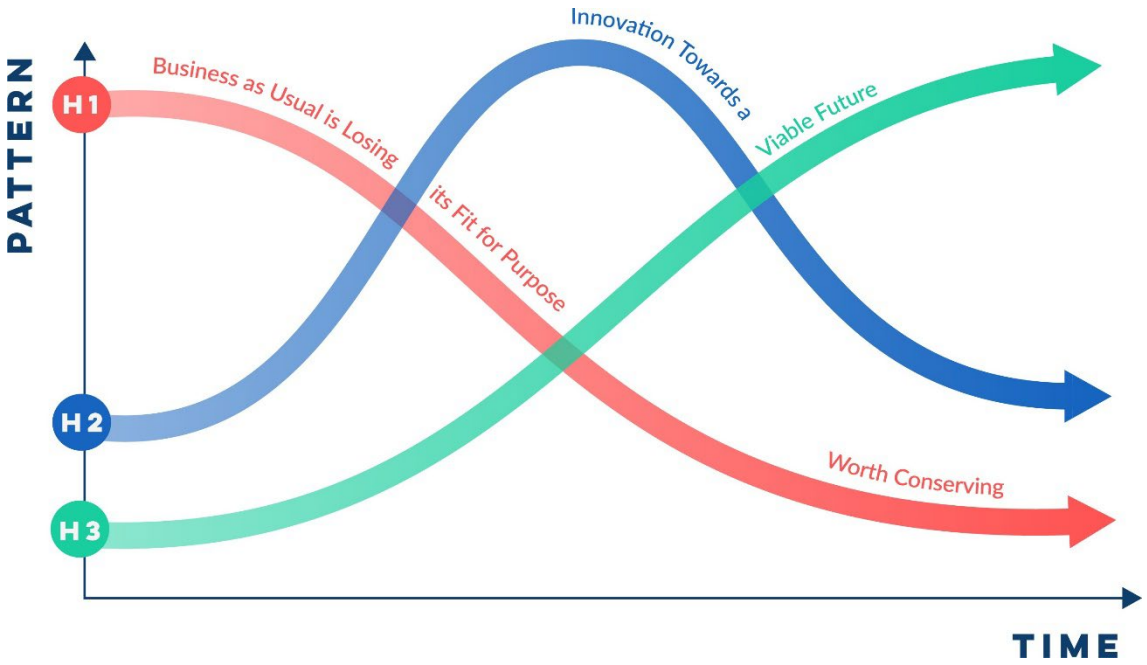

Figure 6 - The Three Horizons Framework

The Three Horizons Framework helps us see the bigger picture and observe a much longer timeframe than we are used to in our day-to-day work.

More than this, however, the central idea of Three Horizons, and what makes it so useful, is that it draws attention to the three horizons as existing always in the present moment, and reveals glimpses of the future in how people are behaving now.

The outcome of engaging with a Three Horizons exercise is a new understanding of transformational potential which enables us to act with more skill, freedom and creativity in creating that change, both individually and collectively.

Take Away – *The Three Horizons Framework can help us step into the process of system change and provides the long-term big picture perspective needed for creating change in an unstable world.*

2.31 Understanding how systems change - Leverage points

To aid our prediction of how systems work, we turn to the work of renowned systems thinker Donella Meadows, who identifies a progressive scale of leverage points in a system.

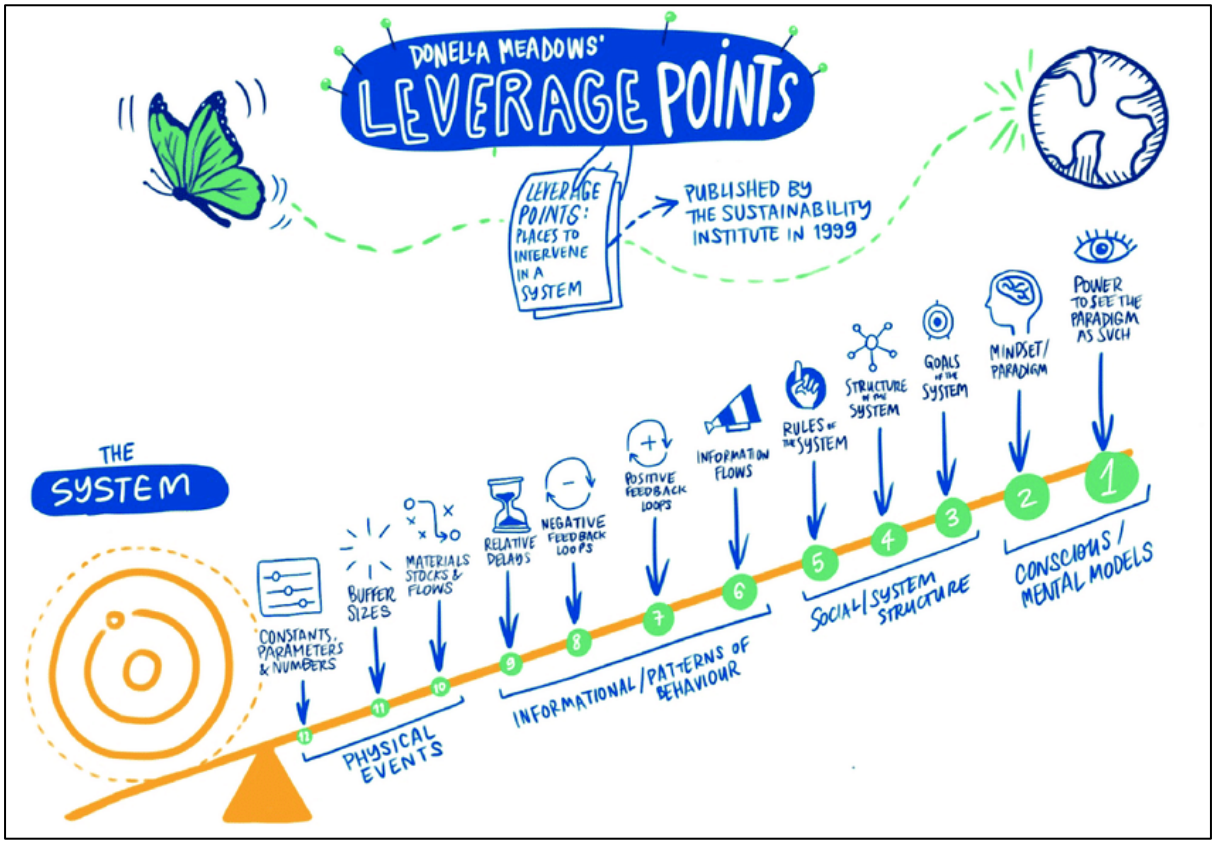

Figure 7 - Donella Meadows 12 Leverage Points

Some levers are much more powerful than others. The most powerful points of leverage are mindsets and mental models, such as a shared understanding that we can and should respond to climate risk, followed closely by system structure, goals and rules, such as balancing resilience with cost and complexity.

However, most interventions focus on the less powerful levers such as physical events - replacing an aging air-conditioning unit for example - and information flow, such as new training and guidance.

Take Away – *working on system goals, such as baking in resilience, and developing the mindset of responding to climate risk are the most powerful places to intervene in NHS digital systems resilience.*

2.32 A method for working with powerful systems levers – Theory U awareness-based system innovation

Understanding the importance of mindset is core to the awareness-based system innovation model *Theory U* by Prof Otto Sharmer. The approach blends systems thinking, innovation, and leading change, with awareness practices and allows us to update our mental and organizational operating systems for effecting change.

The success of an intervention depends primarily on the internal condition of the intervenor

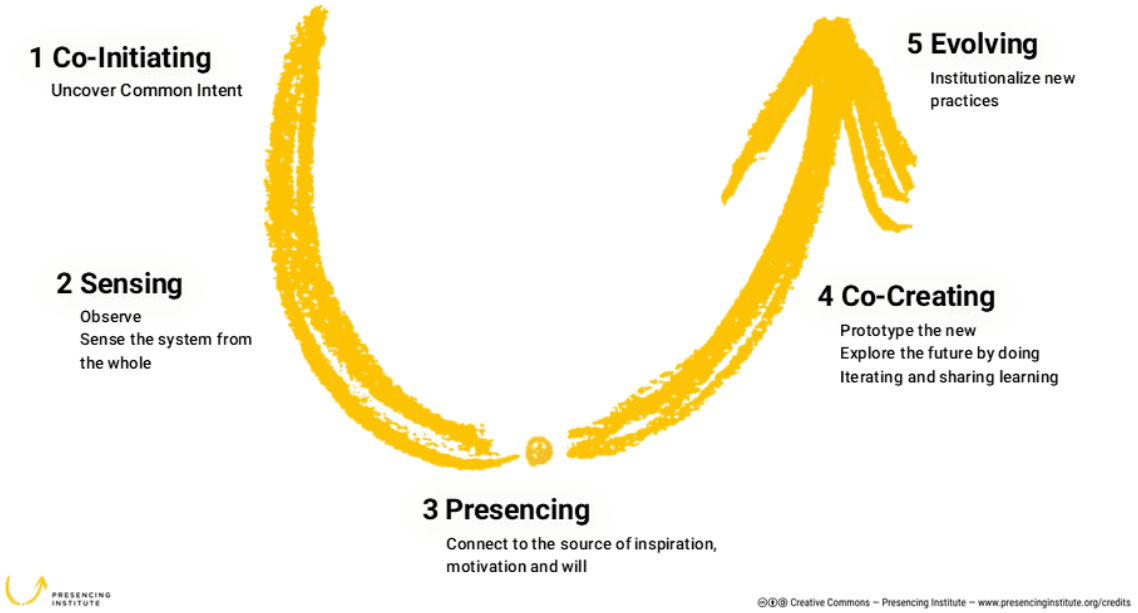

Figure 8 - The Theory U model of system innovation - Presencing Institute

The ability to shift from reacting against the past to leaning into and bringing forth, or presencing, an emerging future is probably the single most important leadership capacity today. The approach enables this through taking participants on a collective journey along the U:

- Uncovering common intent
- Observing and sensing the system from within – how does it feel?
- Connecting to the source of inspiration to make the future more present in the now
- Co-creating prototypes of the future with which to iterate and learn
- Institutionalising emerging practices

In 2022, the *Theory U* team worked with the World Health Organisation leaders to reimagine healthcare. Their conclusion was that change can be triggered by anyone, at any level of a health system. The message for decision makers and leaders is that by turning inwards and creating opportunities for the "system" to see itself and feel itself, the stimulus and impetus for change is ignited from the inside out.

Take Away –*Theory U demonstrates how to connect people's mindset with the system in which they are situated.*

3.0 Resilience

Resilience is the capacity of a system, be it an individual, a forest, a city, or the NHS digital system, to deal with change and continue to function or recover quickly.

Resilience and efficiency are fundamentally in tension, with resilience often compromised for cost savings, productivity, or some other immediately recognisable system property as resilience is less tangible in the short term.

For example, just-in-time deliveries of products has reduced inventory stocks and brought down costs in many industries. At the same time, the just-in-time model also has made the production system more vulnerable to perturbations in fuel supply, traffic flow, computer breakdown and labour availability. For this reason, resilience is often not obvious without a whole-system view, long term view.

3.1 Resilience Principles

Resilience operates across six reinforcing principles:

- Redundancy
- Diversity
- Dispersity
- Autarky
- Adaptability
- Transformability

Whilst each principle can be described discretely, like any aspect of systems they are strongly connected and bleed into each other, which warns against applying a narrow, reductive lens.

> **Redundancy** is spare capacity built into the system so that fluctuations can be absorbed, the opposite of just-in-time. A hospital with reserve beds or a grid with backup capacity for example. Typically, the provision of these stocks is in direct tension with productivity or efficiency, which is measured in the immediate or short term, and fails to take account of the whole system or long-term costs of buffer stocks. During day-to-day operation redundancy looks like a cost. It is only through taking a longer term perspective, such looking back at an event, that we can observe the costs of savings of buffer stocks.
>
> **Diversity** is the variety of components that comprise a system. The diversity, or homogeneity, of a system has a direct determinant on it's resilience. Where diversity is reduced, such as in mono-crop agriculture, the risks of losses are dramatically higher as contagion spreads rapidly through the system. In a digital system, this lack of diversity looks like over reliance on certain forms of technology or providers, such as the ubiquity of Amazon Web Hosting underpinning a wide range of digital services. In social contexts, a lack of diversity often shows up a group-think which amplifies the perspectives of those involved whilst remaining blind to external perspectives, losses here occur in the efficiency of the system to meet diverse needs, such as the disproportionate impact of Covid-19 on vulnerable populations.
>
> **Dispersity** is the spread of critical functions across geographies and scales, so that a single disruption cannot take everything out at once. The more centralised a system is - such as a strongly hierarchical decision making process, or a critical reliance on a

limited number of features, such as reliance on fossil fuels in an oil crisis - the less resilient it is.

Autarky is the capacity of parts of the system to function independently, it's self-sufficiency, when cut off. The higher the level of self-sufficiency within a system, the more resilient it is. This comes to the fore in the work-around, when part of a system fails, how effectively can this failure be responded to? The paper hospital is a great demonstration of autarky within NHS systems.

Adaptability is the capacity to reconfigure in response to a disruption without losing core function. In this context, scenario planning, flexible contracts, investment horizons that allow for adjustment are key to enabling adaptability and this resilience

Transformability is the deepest form of resilience, the capacity to use a crisis as an opportunity to rebuild with new characteristics when existing conditions become untenable. Not bouncing back to what was, but bouncing forward to something better. Here a process that animates and enables shared learning and reflection, and couples that with agency, is key.

Take Away – *To steward resilient systems, we must take a long term, whole systems view and accept higher short-term costs in exchange for the buffers, diversity, and redundancy that are invaluable in providing system resilience.*

3.2 A method for balancing resilience and efficiency - Alternative Capitals

Most modern socio-economic systems and institutions, including the NHS, are organized and controlled primarily through the flow of financial capital, money, to pay wages, procure goods, services and invest in infrastructure.

However, financial capital is just one form of value that is exchanged when goods, services and products change hands. Alternative understandings of value exchange have demonstrated up to eight different forms of capital, with businesses such as Yorkshire Water and environmental accountancy practices such as Accounting for Sustainability, using six different forms.

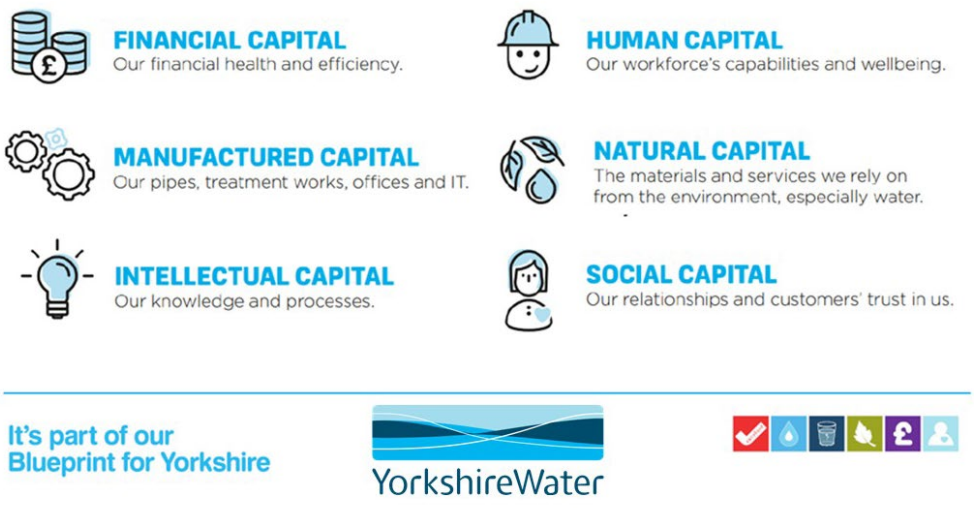

Figure 9 - Yorkshire Water's Six Capital Accounting

These alternate forms of capital include:

- ***Social Capital -*** Mutual social connections that help us be more resilient, more efficient and more effective
- ***Manufactured capital -*** Non-living physical objects such as products, buildings, and infrastructure along with tools, computers and other technology
- ***Intellectual Capital -*** The sum of our knowledge, the things we know and the things we know how to do
- ***Natural Capital -*** The natural entities and systems of the living world
- ***Cultural Capital -*** The unnoticed weave that threads communities together, through arts, media and culture, with shared experiences, perspectives and values.
- ***Experiential Capital -*** A uniquely personal combination of social and intellectual capital that forms the nature of our being; how we experience the world.
- ***Spiritual Capital -*** A sense of connection to self and universe, which includes aspects of intellectual and experiential capital, but is something deeper, more mysterious, more personal.
- ***Financial Capital -*** Value exchange in the form of market determined financial values for goods, services, assets and finance.

Each of these alternate forms of capital provides a different lens through which we can observe the value exchange that happens through procurement, contracting and investments, and uncover overlooked sources of resilience.

Take Away – *the tension between resilience and efficiency is due to a narrow understanding of the value exchange that occurs when people are employed for their labour or services are procured. A broader view based on an alternative capitals model, allows other forms of value to balance out apparent tensions by revealing additional forms of value.*

4. Risk and vulnerability

As observed in *The UK Government Resilience Framework,* December 2022, the starting point for resilience is understanding risk.

4.1 Emerging climate risk

Climate change will create disruption to health and social care services due to both direct and indirect impacts. Direct impacts include the effects of floods, heatwaves and other extreme weather on hospitals and other health and care settings, which may damage buildings or disrupt the ICT and transport infrastructure upon which services rely. Indirect impacts will happen due to the detrimental effect of extreme weather on people's health and wellbeing, which will increase demand for services.

These impacts will be felt not only within institutional settings, such as hospitals, residential and nursing homes for older people, or respite centres for disabled people, but will also affect people who receive care services in their own homes, and may prevent people from accessing critical services, such as GPs.

More and longer hot summers

Projections for the UK show increases in average summer temperatures and increases in the number of hot days and heatwave events. All regions in the UK will experience more frequent and more severe extreme daily high temperatures.

As temperatures increase, the frequency and intensity of heatwave events is projected to increase. The Met Offices estimates that a 'hot' summer such as 2018 had a probability of approximately 10% in the period 1981 to 2000, which is now somewhere between 10% and 20%, but this will increase to probabilities of the order of 50% by mid-century irrespective of emissions scenario.

The 'heatwave' season will increase in length, meaning that heat risks may become significant in early summer and spring. Night-time urban heat island effects are also expected to be more intense, leading to more 'tropical nights' in major cities.

The warming climate will impact UK regions differently, with increases in heat-related mortality likely to be greatest in the Southeast Region.

Although heatwaves are the primary projection for the impact of climate change, flooding is also expected to rise, with indirect impacts on demand, staffing, transportation and supply chains and direct impacts on healthcare: approximately 10% of hospitals are situated in areas of significant flood risk in the UK ~1000 premises with around 40% (2,500) of GP Surgeries at risk of flooding.

Violent storms associated with floods are also forecast to become more frequent, with severe localised disruption and devastation likely.

Take Away - *Coupled with the medium to long term risk of Earth systems tipping, our changing climate will have an increasing impact on NHS digital systems. We must get better at anticipating and preparing effectively for the impact of climate change and disruption due to climate incidents.*

4.2 Emerging climate related digital systems risk

The summer operation of some digital infrastructure is already being affected by climate change, and this will be exacerbated by projected increases in summer temperatures. The CCRA assesses the magnitude of risk as low at present, rising to medium by the 2050s across the UK.

However, recent research conducted to support the CCRA has indicated that the vulnerability of interconnected systems may be significantly underestimated. The risk of network failures is already high, potentially affecting hundreds of thousands or millions of people per year, particularly in urban areas. Telecommunications are an integral part of this interconnectedness, they are the glue which holds the network together. As such, the failure of telecommunications is the second highest cascading risk of failure within NHS digital systems.

There is an essential connection between telecoms and the energy sector given that all ICT and telecoms systems are reliant on electricity supply. Energy supply is thus the prime cascading risk that is likely to affect all others.

There is an ongoing increase in dependence on digital systems and services, which is likely to increase as technological reinforcement as the use of AI, health-tech and the Internet of Things continues to increase.

Coupled with this increase, there is a corresponding a gap in knowledge around the location of ICT infrastructure and the criticality of its function, and a longer chain of agency – it's not always clear what levers NHS staff can pull or what the response will be. As a result of such analysis, the CCRA assessed risk of cascading failures in digital systems as high, both now and in future.

Take away – *Digital systems are the backbone of modern healthcare. They make it vastly more efficient to operate but in the process they compound the risk of climate incidents.*

4.3 Risk management and resilience in NHS systems

The Covid-19 Inquiry provides valuable intelligence on how effective the NHS is at understanding and managing risk and is a good insight into the culture and mindset of risk and resilience in NHS systems.

It found that the approach of decision makers to risk assessment was flawed, resulting in inadequate planning to manage and prevent risks, and respond to them effectively. Whilst this refers specifically to pandemic planning, it is equally applicable to high impact, low frequency events that are difficult to account for as part of day-to-day operations, such as climate incidents.

The inquiry found that the policy and institutional context of the NHS complicate resilience planning. Policy documents are often outdated, involve complicated rules and procedures which can cause long delays and are full of jargon and overly complex. Emergency planning is further complicated by the many institutions and structures involved. There is also a failure to fully learn from past civil emergency exercises and incidents.

Emergency planning failed to put enough consideration into existing health and social inequalities and local authorities and volunteers were not adequately engaged. Advisers lacked freedom and autonomy to express differing opinions, which led to a lack of diverse

perspectives. Their advice was often undermined by “groupthink” - a phenomenon by which people in a group tend to think about the same things in the same way

Looking at other research on managing health risks in the context of climate change, the Heatwave Plan has been shown to be useful for healthcare managers in preparing for emergencies as it prompted them to take actions when alerted to do so. However, the messages do not appear to reach all those working at the frontline with patients, as many nurses report they are unaware of the Heatwave Plan.

However, the Covid-19 inquiry was clear that they system copes because of the tenacity and resilience of the people working in the NHS.

Take Away – *In hard-pressed decision-making environments with multiple and competing pressures, situated in extensive and long-established institutions, it is difficult to make space for big pictures or long-term thinking required to understand the gradually increasingly vulnerability to new emerging risks such as climate change and digital systems prevalence. And yet this skill will be increasingly important as the changes lying over the horizon shift into our daily lives.*

4.4 Key messages on managing climate risk and resilience in NHS digital systems

It is essential for leaders and decision makers to recognise risk and the changing nature of Earth systems, and that the systems thinking that informs this is equally applicable to resilience in NHS digital systems.

This approach, however, demands a different way of thinking that recognises the difference between complicated and complex systems.

A shift away from likelihood to risk severity

Governance needs to develop a stronger future orientation through diverse methods of collective future engagement, such as participatory scenario development or serious gaming, to generate and inform proactive measures.

Decision makers need to understand the deep uncertainties of (negative) environmental tipping points and shift away from managing risk based on likelihood to risk severity as the primary driver for action.

Longer term thinking

Longer term thinking is essential, with governance time horizons expanding beyond political cycles, to make decisions with long-term impact horizons.

Governance can create the enabling conditions for positive tipping, including easing access to finance, providing the necessary infrastructure to support rapid deployment and cultivating sufficient stakeholder engagement for policies to be approved and implemented.

Extremes matter most, not averages

While economic modelling has traditionally linked damages to changes in global mean temperature, societies and markets experience climate change through local and regional extremes, such as heatwaves, floods and droughts, which drive the bulk of economic and financial disruption while often barely registering in global averages.

Uncertainty rises sharply with warming

With temperatures trending towards a 2°C future, experts stress that impacts become increasingly unpredictable, as tipping points and tail risks increase. Even as models continue to produce precise-looking point estimates, climate risks will likely undermine the assumptions of continuous growth fundamental to many economic models. Policymakers should be wary of climate scenarios extending beyond certain temperature levels and take a 'broad spectrum' approach to tail risks.

The impacts of Earth system tipping points demand governance action

Societies need governance efforts that anticipate and prepare for the specific impacts of Earth system tipping points before tipping points are crossed – these impacts differ from the observed and expected impacts of other aspects of climate change.

New risk assessment approaches are needed for tipping points

Traditional risk assessment fails for Earth system tipping points: Conventional impact-probability matrices capturing individual climate impacts are inappropriate for tipping point risk analysis, due to uncertainty, nonlinear dynamics and the systemic scale and scope of interactions between impacts and their cascading effects.

Assessing tipping point risks can benefit from specialized approaches including risk registers that translate Earth system changes into policy-relevant "risk currencies" while capturing cascading effects and system interactions.

5.0 Application of Positive Tipping Points Methodology

5.1 Starting Point

The start point for this enquiry was to review the literature NHS literature on climate resilience, particularly the work emerging in Somerset around digital resilience, along with past incidents investigations, particularly the loss of twin data centres at Guys & St Thomas during the unprecedented 40oC heatwave in 2022.

A broader healthcare context was provided by the findings of the UK Covid-19 Inquiry, which examined the resilience and response of the NHS to the global pandemic.

This healthcare specific literature was complimented with advice to Government from the Climate Change Committee, the UK's third Climate Change Risk Assessment (CCRA3) in June 2021. The climate change context is further described in sections *2.21 Negative tipping points in Earth systems* and *4.1 Emerging climate risk*.

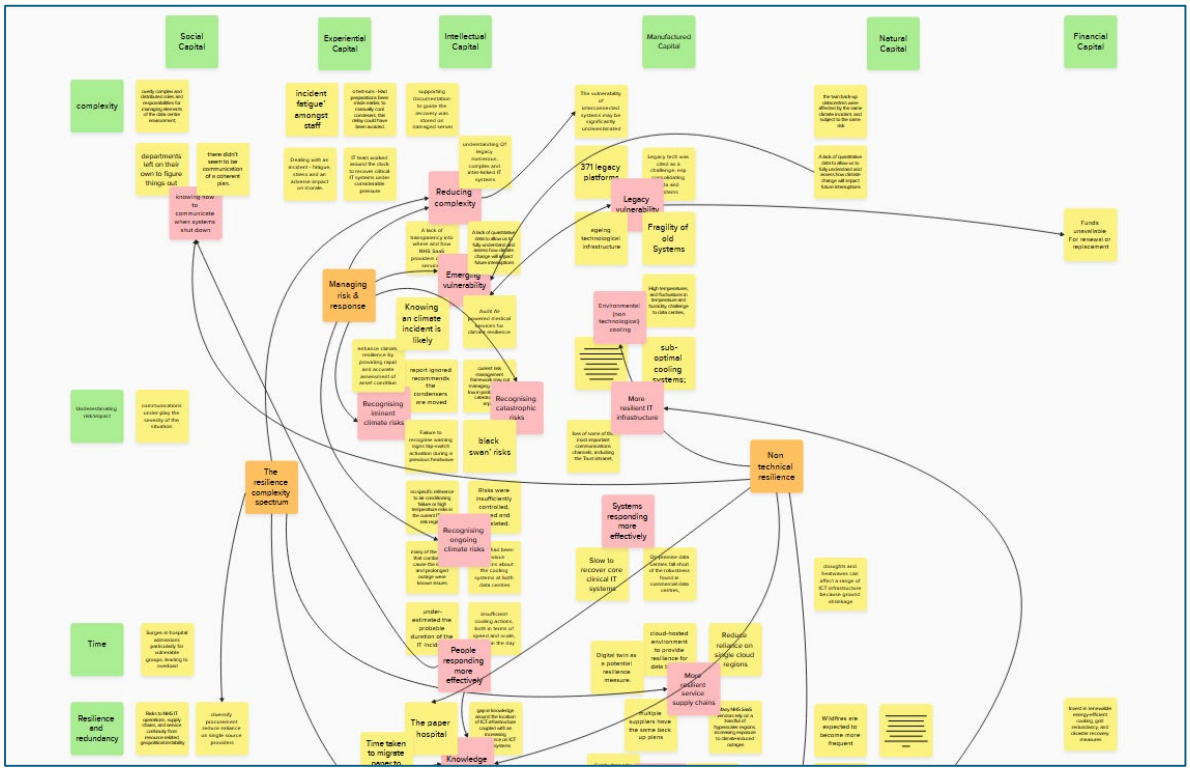

Figure 10-NHS Digital System challenges pattern analysis

5.12 Risk and resilience grouping

A pattern analysis of the risks to NHS digital systems as documented in the literature, identified nine defined opportunities to intervene to create positive tipping:

Non-technical/institutional Positive Tipping Points

NT1. Decision makers prioritise resilience and long term thinking amidst day-to-day working

NT2. If climate resilience viewed as essential and a shared responsibility by staff and suppliers

NT3. If we had a more effective response to incidents and better learning from them

NT4. If we reduce 'cognitive debt' of outsourcing systems and services

NT5. If we had a reciprocal resilience network with institutional partners

NT6. If we had nature based resilience networks with local partners

Technical Positive Tipping Points

T1. If investment and procurement balance resilience with complexity and cost

T2. If we knew the likely impact of climate change (medium/long term) and climate incidents (immediate term)

T3. If we understand the risk and resilience of the existing system

5.2 Understanding Enabling conditions

For each of these tipping points, we examined the Enabling Conditions, ie what would it take for this tipping point to be passed. Enabling Conditions include aspects such as cost, desirability, convenience and clarity:

Enabling condition	**Explanation**	**Example**
Clarity of and access to information	Is it clear to enough people what the change means and what it involves?	Adding nutritional information to food packaging
Reduced cost	Is the change affordable, compared to the cost of not changing?	Providing free litter pickers for a beach clean event
Desirability	Is the change attractive, or symbolic? Does it come with status?	Endorsements by celebrities or other influential figures
Convenience	Can people easily find the new behaviour, or tool?	Having healthy food available in the shops used by a community

We mapped the Enabling Conditions for tipping point and assessed the these to understand what it might take to achieve tipping. For example:

NT1. Decision makers prioritise resilience and long-term thinking amidst day-to-day working

Clarity	**Cost**	**Desirability**	**Convenience**
If decision makers know and *feel* we need to manage climate risk	If the benefits can be shown to outweigh the costs	• If we use language effectively ie 'resilience innovation' • If climate resilience was viewed like cyber resilience	If there is political support and mandate

5.3 Understanding Feedback loops

Feedback loops are the complex relationships between policy, technological and behavioural change (e.g. in terms of social norms, availability, prices and political support) that lead to tipping points.

Positive feedback loop	Explanation	Example
Social contagion	An idea or behaviour spreading from one person to the next	People being influenced by their friends or neighbours installing solar panels
Percolation	The abrupt change of a network from locally to globally connected, allowing change to spread more widely	The rapid increase of a contagious virus from contained to widespread
Investment pathways	Investment begins to increasingly flow towards the desired objective	As the cost of solar panels reduces and more people install them, new financing mechanisms develop to reduce up-front costs
Reinforcement	As a new technology or behaviour gains momentum, other new developments are created that reinforce it	The creation of apps to reinforce our use of smartphones
Learning by doing	The more we do something, the better at it we get	Listening to feedback on a workshop or project and taking action to improve the next one
Economies of scale	The more of something you produce, the cheaper it gets	Bulk-buying ethical products, or renewable energy, making it more attractive to others
Economies of networks	The value of a product or service increases the more people use it,	The more people using a social media platform, the more attractive it becomes to others

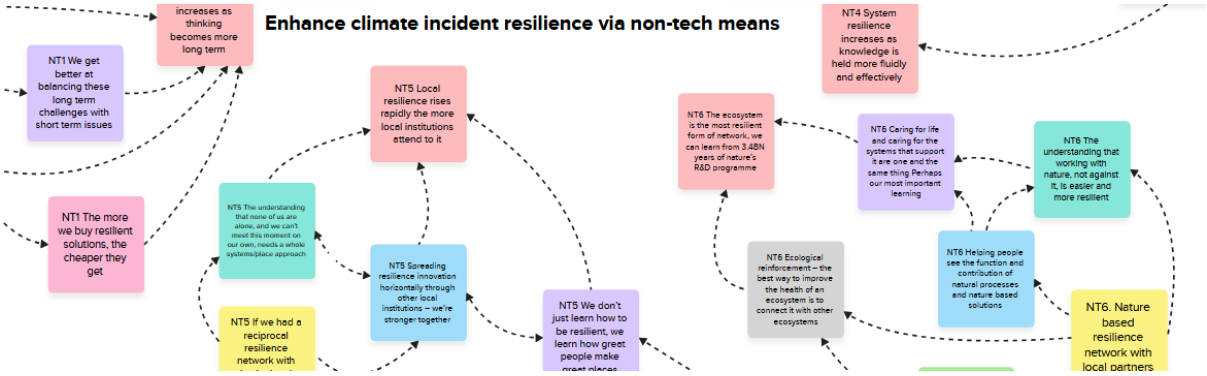

Figure 11 - Feedback loops in Non-technical tipping points

Again, we mapped the feedback loops for each tipping point to understand what loops might trigger tipping. These are visualised on our Mural whiteboard, and described in the table below (continuing the with the previous example):

NT1. Decision makers prioritise resilience and long-term thinking amidst day-to-day working

Social contagion	Taking the long view becomes the cultural norm for leaders in the 21st Century
Percolation	Examples of resilience being prioritised (ie Somerset) stimulate others to follow
Investment Pathways	Investment prioritises long term resilience based on extremes not averages
Reinforcement	When resilience becomes the norm, more tech supports resilience reporting/monitoring
Learning by doing	Each time we make a resilience intervention we get better at balancing long term challenges with short term issues.
Economies of scale	The more we buy resilient solutions, the cheaper they get
Economies of networks	System resilience increases (S- curve) as thinking becomes more long term as resilience innovation rolls out (bell curve)

Full details of each Tipping Point, and the related Enabling Conditions and Feedback Loops, can be found in the closing Appendix which comprises tipping point tables for each tipping point.

5.4 System Indicators

To understand the changing nature of a system, and whether progress is being made towards positive tipping, the methodology uses Indicators for each Positive Tipping Point.

These show the state of the system, what is happening, and whether things have changed, or stayed the same.

We have suggested new indicators as guides for areas where the methodology has pointed to the need for resilience innovation, in the Appendix tables

5.41 Indicators in the Transform model

The development of the *Transform mode*l will offer unparalleled ability to understand the complex relationships in NHS digital systems.

As part of this work, we compared the data sources and metrics for the Transform model. Understandably, the model leans towards technical resilience, and has less reach into nontechnical resilience such as mindset and culture.

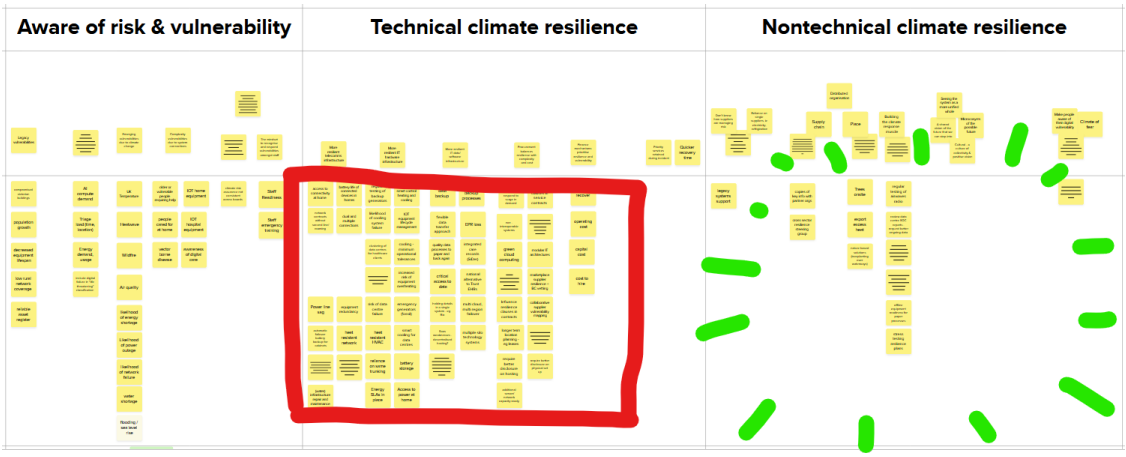

Figure 12 - Resilience 'blind spots' - most interventions are technical

This shows that both approaches to understanding NHS Digital Systems have value and contribute to each other. We would recommend the use of Transform model for testing the types of decision making suggested by the tipping point process. The two processes would work well together in the Holdfast programme allowing participants to discover agency in their role which the model helps bring to life.

5.5 Cornerstone Indicators

Whilst indicators can clearly tell us something about a system, this reductive analysis – breaking the system down into it's many parts - can make it difficult to understand the whole system state in a way that is comprehensible. For this reason, the Positive Tipping Points methodology proposes the use of Cornerstone Indicators, a framework for evaluating the system in a more holistic manner, connecting disparate parts of the system together in a way that is more deeply understood such as by finding ways to tell stories about the system.

To bring this rather abstract concept to life, we can think of a project examining the quality of life in a city region. The typical approach to creating a basket of indicators for this would be to compile metrics that articulate quality of life, say Life Expectancy, Amount of Green Space, Level of Employment, Size of the Economy, Educational Attainment etc.

When these input based system indicators are brought together, however, it can be difficult to articulate a narrative around that the indicators mean. Along with the inevitable problem of apples and pears – green space with grade scores.

The Cornerstone Indicators approach turns this on it's head, and takes an outcome-based approach, establishing indicators that help us understand the experience of living somewhere. In Skultana, Sweden, for example this meant developing cornerstone indicators which included:

- **Feeling positive** - the number of people who are feeling positive about the week ahead on Sunday evenings – a good indication of how people feel about their work life balance.
- **Recommend Skultana** – number of people who would recommend Skultana as a place to move to – a great metric for the quality of life.
- **Leisure activities** - the number of people who are regularly doing a leisure activity with people you don't cohabit with – a way of scoping the social capital of the place.
- **Not owning a car** – the number of households who enjoy not owning a car – a measure of how accessible the city is, with a sensed element added in "people who *enjoy* not owning a car".

- **Planning the future** – the number of people who have a dream, plan OR goal that stretches more than one year into the future – is this a place where people feel they have a future?

6.0 Narrative Re-authoring

6.1 New narratives that embrace system dynamics

> ***Humans think in stories, and we try to make sense of the world by telling stories.*** Yuval Noah Harari

Working with systems requires a new approach to how we tell stories, such as we find in Cornerstone Indicators. When we think about the past, present, or future with a beginning, middle and end, we can miss important details and limit our learning or imagination. This is linear thinking, we are trying to know the unknowable by reducing it from a complex situation to a complicated one.

Narrative Reauthoring is a creative approach used in the PTP methodology to start telling different stories that can reveal the bigger picture of the system we are working with, or better define the complex dynamics of change.

As Cornerstone Indicators have to be co-created by people with lived experience of the system being worked with, they have not been developed in this stage of the research. However, the research did begin to articulate some narratives about the system, which we have developed using the PTP methodology of Narrative Re-authoring.

Just like the distinction between Indicators and Cornerstone Indicators, working with systems requires a new approach to how we tell stories. When we think about the past, present, or future in strictly linear terms, with a beginning, middle and end, we can miss important details and limit our learning or imagination. Narrative Reauthoring is a creative and personal way to start telling different stories. The technique can create new language around existing stories, by reframing them in a non-linear way that builds on our sensory memories, intuitions, and feelings.

6.2 What does it cost to outsource services?

The PTP methodology is about establishing a systems thinking approach to cultivate intention of the system and agency within the system.

Intention and agency are also core concepts in the procurement of digital infrastructure and services for healthcare, such as hosting, clinical systems, patient records, telecoms, healthcare apps etc.

By thinking of this as ‘buying’ goods and services, we narrow our perspective to simply view the value exchange in terms of financial capital. However, if we take a broader perspective, we can see there are many other forms of value exchange happening.

The concept of Alternative Capitals (see XX) and the notion of being in debt, specifically cognitive debt (intellectual capital) and technical debt (manufactured capital) are useful techniques for broadening our perspectives here.

Cognitive debt is a concept coined by John Willshire in relation to the rapid rollout of AI, which itself is highly pertinent to digital healthcare systems, but it has a broader application to all digital systems outsourcing. *"Cognitive Debt is where you forgo the thinking in order just to get the answers, but have no real idea of why the answers are what they are."*

Similar to this, and potentially happening alongside it, technical debt is *"the implied cost of additional work in the future resulting from choosing an expedient solution over a more robust one"*.

In both cases, we can see how the over-riding demands of cost, productivity and efficiency, perhaps driven by a political environment or leadership pressure, have incurred a debt which must be repaid at some point, either in the form of further financial investment to repay the debt, or sub optimal operating – in this case less resilient systems.

Using an alternative capitals matrix allows a broader perspective of this value exchange, and includes aspects such as the potential loss of control (agency) over outsourced infrastructure and services, which can mean we now longer have access to as many levers of influence within the system as when it was in-house.

The experience of outsourcing, particularly in the healthcare setting, can be further complicated, as the ultimate concern for wellbeing is retained by staff within the institution. Even with a system to run things, staff cannot outsource the concern for patients and whether their needs are being met.

This approach can even reveal a lack of fulfilment, when meaningful parts of roles once fulfilled by NHS staff are outsourced elsewhere, leaving the in-house role as an administrative one.

Clearly, effective operation demands that goods, services and infrastructure are outsourced, we can't do everything in-house. But this approach does allow us to understand the hidden aspects in this exchange.

Alternative Capital	**What do we buy**	**How do we pay?**
Financial		Cost
Manufactured	Service delivery Infrastructure	Complexity Technical debt
Intellectual	New solutions	Cognitive debt
Social	Supply chains connections Professional connection	
Natural	Reduced emissions	Scope 2/3 emissions Earth systems vulnerability
Experiential	Increased productivity	Reduced agency Reduced Fulfilment Continued concern for care
Cultural	The stories we tell each other	The stories they tell about us

6.3 What if we didn't trust digital?

Much of the digital systems literature reflects the importance of healthcare users learning to trust the system, the Somerset Climate Resilience Strategy makes repeated reference to the need to *"Ensure staff are trained in and trust digital systems"*.

But what if we didn't trust digital systems?

What if we remember that systems fail all the time, and that our response to this failure will likely involve some adaptive problem solving and creative thinking as we dredge back up from our individual and institutional memories what is it that the systems are doing for us and how they achieve this?

This understanding builds on the notion of cognitive debt "*where you forgo the thinking in order to get the solution"*, and is particularly relevant as our workforce ages and is increasingly populated by digital natives with no legacy knowledge of *"how things used to be done"*.

During the course of this research, we heard from one NHS leader who was asked by a staff member when digital patient records had gone down *"So how do I know the patients history?"*

They were so used to calling up this information from digital records that they had forgotten that the patient, or their family and carers, would have this history lodged in their analogue memory, from where it could be retrieved and written down with pen and paper to enable effective treatment.

Clearly, this will take longer and perhaps be a less comprehensive record, yet the point is there is a non-digital solution in many instances, but we have reached the point where prevalence of digital systems has reached the point where we no longer think about what is happening within the black box.

In the context of resilience, this is about the Autarky or self-sufficiency of the system, a system which includes human actors as well as digital agents. At the organisational scale, this human intelligence scales to create institutional knowledge.

Clearly, it would not be possible to build out entire analogue manuals for every system and service. Where these have existed, such as in Guy's & St Thomas', when they were used in an incident the priorities failed to match the on the ground needs and priorities of clinical staff. In Somerset, the trust are moving away from extensive manuals for what to do in the event of an incident. They are focussing instead on creating a more agile form of adaptive learning institution, which is capable to responding to a situation and recreating what it needed in an analogue manner.

The development of adaptive learning organisations demands a fundamental shift to a more dispersed and distributed approach to leadership, decision making and management in an increasingly unstable world.

6.4 Healthcare professionals are our last line of defence

If asked to picture the public sector responding to a climate incident, it's likely that most people would imagine lines of soldiers filling sandbags, or Fire & Rescue services paddling through flooded streets towing a dinghy full of flooded householders.

It's rare for us most people, the general public, to imagine healthcare professionals being on a similar footing in response to climate incidents, and yet given the complexity of systems and their impact on our health and wellbeing, it is doctors and nurses who are increasingly deployed into complex situations of which they are last line of defence.

We even measure the impact of many climate incidents in the quantifiable metrics of healthcare, hospital admissions, mortality rates etc, whilst failing to recognise the role of the

professionals involved. Whether it's a powerful storm uprooting trees and causing injury on the highways, a flooded town causing long term psychological distress or a heatwave increasing the baseline level of mortality, we measure the impact of climate incidents in terms of their healthcare impact as much as we do their economic impact.

As cascading and connected crises impact many global systems, not just the climate, governments are committing to defence spending at levels not seen since the Cold War. And yet the same logic, that resilience requires investing in buffers, redundancy and collective capacity even when it is inefficient in the short run, is nowhere to be found when it comes to the welfare state, to public health systems, to the social infrastructure that keeps societies together under pressure.

7.0 Triggers

Having mapped out Tipping Points and examined how the system can be influenced to support positive tipping, the methodology moves on to identifying Triggers, by which we might create change in the enabling conditions and feedback loops.

It might be expected that policy windows, created by focusing events such as crises (e.g. extreme weather, pandemics, financial crisis), political shifts, or other factors, can create opportunities for policy entrepreneurs to overcome institutional frictions and introduce new items onto the agenda. However, it's also clear that all institutions have strong balancing feedbacks that sustain the status quo. This is what makes them institutions.

In this context, recent work by Exeter team suggests that sequencing triggers so that benefits are realised early and often can increase subsequent support for more ambitious climate policy.

8.0 Next steps - Holdfast

We'd like to suggest a way of bringing this methodology to life, and triggering the tipping points by cultivating the intention and agency that the method focuses on, by intervening in the goals and mindsets of decision makers and teams working in or using NHS digital systems.

We propose an immersive exercise for NHS staff and suppliers which uses methods and insights from the positive tipping points methodology to connect them with what is happening in Earth systems through their day to day roles – cultivating the intention and agency the methodology envisions through the *Holdfast Resilience Exercise*.

Appendix 1 - Enhancing climate incident resilience by addressing key technical vulnerabilities							
Positive Tipping Point	**Enabling conditions**						**Indicators**
	What are the conditions required for the systems change you are working towards				**Which conditions are already in place? How can they be strengthened?**	**Which conditions are not yet in place? What is your role in creating them?**	
	Positive statement	**Cost**	**Desirability**	**Convenience**			
T1. If we understand the risk and resilience of the existing system	If we knew how much trust to place in the system's climate resilience	We could remove costly weakspots and bottlenecks	By being clear on role responsibilities and rewarding risk management If it were easier to gauge resilience	Easy to access data, mapping, info etc If it was easy to understand infrastructure resilience If it was easy to monitor hardware performance	Asset registers Performance reporting	• Map out vulnerable assets and interdependencies • Stress test to climate extremes • A model to predict cost savings from resilience • A resilience rating approach to judge trust in the system • System Firebreaks	(Modelled) reduction in cost of climate incident Date of last risk and resilience register review Resilience ratings •
T2. If investment and procurement balance resilience with complexity and cost	If we weighted investment more towards resilience If procurement and delivery through supply chains increased	If there was an 'invest to save' infrastructure program If procurement priced in resilience	If a long term view was given weighting in personal objectives If the supply chain became less	If a dedicated investment vehicle was established If it was easier to strike the balance between	Green Book guidance	• Investment decision making process • Invest to save program • Procurement appraisal process • Embed climate resilience into procurement	• Climate resilience data provided by suppliers • Low/zero emission services ie Green cloud hosting • Circular materials in supply chain

	resilience not complexity		work to manage	complexity and resilience		• Guidance/manual on trade-offs and win:wins • System/supply chain Firebreaks • Resilience scores for suppliers • Complexity rating for the supply chain • Resilience/long term view in personal objectives	• Value of funds invested via 'invest to save' • Climate resilience rating for hardware
T3. If we knew the likely impact of climate change (medium/long term) and climate incidents (immediate term)	If we knew the scale and pace of climate change, overall and for our place (ie regional climate risk varies) If we knew the scale of imminent climate incidents	We could prioritise resource use during incident	We could change priorities in response to changing risk	If we had a clearer understanding of the factors that influence emerging risk If we knew how risks interacted and cascade	A map of system interactions and cascading vulnerabilities to highlight critical vulnerabilities (Transform model)	A model to predict cost savings from resilience	(Modelled) reduction in cost of climate incident

Enhancing non-technical climate incident resilience							
Positive Tipping Point	**Enabling conditions**						**Indicators**
	What are the conditions required for the systems change you are working towards				**Which conditions are already in place? How can they be strengthened?**	**Which conditions are not yet in place? What is your role in creating them?**	
	Positive statement	**Cost**	**Desirability**	**Convenience**			
NT1. Decision makers prioritise resilience and long term thinking amidst day-to-day working	If decision makers know and feel we need to manage climate risk	If the benefits can be shown to outweigh the costs	• If we use language effectively ie 'resilience' and innovation not adaptation • If climate resilience was viewed like cyber resilience Resilience and agility for institution (desirable to decision makers)	If there is political support and mandate	• Risk registers • Accountable Emergency Officer • Directors of resilience • Emergency planning • NHS Sustainability Leadership programme	• A model to predict cost savings from resilience • Guidance on language • Make positive connections to tech ie digital is part of the solution not part of problem • Quantified climate risk assessment • Climate resilience workshop • Appoint a local/Trust climate lead • Develop local/Trust working groups • Make space/process for more distributed working	• Modelled cost savings of resilience • Date risk registers last updated • Level of climate risk awareness (survey)

NT2. If climate resilience viewed as essential and a shared responsibility by staff and suppliers	If everyone feels we need to respond to climate risk effectively, and knows how to do so	If we have time to work collectively and with longer term view	If we create pride in contributing by connecting in-role action to the bigger picture of the changing world	• If there is a clear, defined, way to contribute to change • Decision makers prioritisation • Climate working groups • Individual goals • Manuals, guidance	• Sustainability teams • Business continuity plans	• Climate resilience workshop ('Holdfast') • Climate resilience working groups • Climate resilience innovation knowledge sharing process/platform	• Number of participants in process • Proportion of time learning in nature • Level of climate risk awareness (survey) • Presence of climate resilience working groups
NT3. If we had a more effective response to incidents and better learning from them	If we anticipate risk and prepare more actively	Cultivate alternative forms of capital social, natural, cultural etc	People's resilience celebrated inc but not limited to awards	• If we make it worth the effort • If we capture and share our leaning	NHS colleagues are already doing the work	• Bring our understanding to life through practice story & games • A process to enabled shared learning from incident response	
NT4. If we reduce 'cognitive debt' of outsourcing systems and services	If we understand how much knowledge of and control over digital systems we have	If we view cognitive debt as a cost comparable with the financial cost of outsourcing	If there was more cultural and social capital from people and institutions holding onto knowledge	If we make it easy to share knowledge and understanding	Long standing staff retain knowledge of 'how we used to do this' from before systems implemented	• A means of understanding the hidden costs of outsourcing • Process to capture and retain institutional knowledge	

NT5. If we had a reciprocal resilience network with institutional partners	If we support partners to be resilient whilst they support us		If we see working with others as an opportunity not a burden	If relationships were more established across and between organisations and places	There are many existing partnerships between local public sector institutions	Staff objectives and incentives	• Proportion of staff time spent with partner organisations • Proportion of staff time spent in community
NT6. If we had nature based resilience networks with local partners	If we work with each other, and with natural systems and processes to make better more resilient places	If we could account for value across different organisations by looking at the place If we could account for the value of nature based solutions	If we make better places in the process of making institutions and systems more resilient	If we had place based pools of funds & support for resilience	Nature based solutions are emerging in many places	• Shared benefit systems ie local heat network, green data centres • Pooled local infrastructure investment pool • Nature North	• Natural based cooling projects • Nature based water flow management (SUDs, sponge cities) projects

Appendix 2 - Enhancing climate incident resilience by addressing technical vulnerabilities Positive Feedback Loops							
	Social contagion	**Percolation**	**Investment pathways**	**Tech reinforcement**	**Economies of scale**	**Economies of networks**	**Learning by Doing**
T1. If we understand the risk and resilience of the existing system	The idea that resilience is something we can see and has value	Understanding of weakspots (ie co-located data centres) enables remediation	Invest to save resilience innovation fund (ie £360k resilience investment saves £1.4m recovery – 3.8x)	Less parts to fail means less cascading failures Software carries and enables trust within a system Resilience data increases trust/resilience - Apps increase complexity System resilience reporting becomes 'Baked in'		System resilience increases as legacy vulnerabilities are reduced The 'backbone' of digital systems becomes more resilient preventing cascading collapse System resilience increases as 'trust' increases	We get better at predicting how trustworthy parts of the system are
T2. If investment and procurement balance resilience with complexity and cost	Resilience becomes viewed as a norm in investment/procurement decisions	Resilience spreads vertically through supply chains	Resilient infrastructure investments tap into new resilience funding Resilient services become more competitive in	We can give the system a score of resilience and complexity (using AI?)	Once resilience is priced in it becomes more cost effective for suppliers to manage and the standard for purchasing When	System resilience increases when finance priorities long term and resilience is more visible and valued	We get better at understanding how to balance resilience with complexity We get better at creating models and vehicles to bring forward future value

			procurement process		resilience becomes a norm, it is provided as matter of course, not an extra As more resilient hardware is purchased, manufacturing costs per item reduce		into present day decision making
T3. If we understand likely impact of climate change (medium/long term) and climate incidents (immediate term)	A culture that links managing our local place and systems better with big picture of climate change A clear understanding that Storm X or Heatwave Y is imminent and it's impact when it occurs	'The climate is changing and so are we' story telling	Pricing in resilience to extremes not averages	Better climate modelling Increasing use of remote sensing - Increasing use of digital solutions (ie remote care, IOT, sensors, app based healthcare) - Changing climate increases risk - Power is the big cascading risk - Telecomms next cascading risk		System resilience increases the more parts of the system that are prepared for, and informed about, climate change and climate incidents	The more we understand climate risks the more we can improve our resilience

Enhancing non-technical climate incident resilience Positive Feedback Loops							
	Social contagion	**Percolation**	**Investment pathways**	**Reinforcement**	**Economies of scale**	**Economies of networks**	**Learning by Doing**
NT1. If NHS decision makers prioritise resilience and long term thinking amidst day-to-day working	Taking the long view becomes the cultural norm for leaders in C21st	Examples of resilience being prioritised (ie Somerset) stimulate others to follow	Investment prioritises long term resilience based on extremes not averages	When resilience becomes the norm, more tech supports resilience reporting/monitoring	The more we buy resilient solutions, the cheaper they get	System resilience increases (S-curve) as thinking becomes more long term as resilience innovation rolls out (bell curve)	Each time we make a resilience intervention we get better at balancing long term challenges with short term issues.
NT2. If climate resilience viewed as essential and a shared responsibility by staff and suppliers	Establishing a shared positive vision of the future and culture of collectivity – "We can't hide from this, and we can't do it on our own" Make resilience how we do things Celebrate those making a contribution	Easy spread of institutional knowledge – open, transparent and accessible sharing Stories of resilience innovation		'Bake in' system resilience reporting, AI? - IOT & remote systems increase complexity - Increasing reliance on digital for everything	Cost per resilience measure reduces once fixed costs accounted for by early innovations	System resilience increases as more people actively manage for this end	We get better at managing the resilience of the system the more we do it – fine tuning

NT3. If we had a more effective response to incidents and better learning from them	Building the climate response muscle					System resilience increases as more people prepare for, and learn from, climate incidents	We bring our learning to life, we do it for real not just in theory, and socialise that learning with others
NT4. If we reduce 'cognitive debt' of outsourcing systems and services	The idea that institutions can and should retain and share knowledge and not outsource it	Sharing of ways to hold onto knowledge through open learning				System resilience increases as knowledge is held more fluidly and effectively	
NT5. If we had a reciprocal resilience network with institutional partners	The understanding that none of us are alone, and we can't meet this moment on our own, needs a whole systems/place approach	Spreading resilience innovation horizontally through other local institutions – we're stronger together				Local resilience rises rapidly the more local institutions attend to it	We don't just learn how to be resilient, we learn how great people make great places
NT6. If we had nature based resilience networks with local partners	The understanding that working with nature, not against it, is easier and more resilient	Helping people see the function and contribution of natural processes and nature based solutions	Grow stocks of natural capital - working with nature is a low entropy, low long-term resource use option	Ecological reinforcement – the best way to improve the health of an ecosystem is to connect it with other ecosystems		The ecosystem is the most resilient form of network, we can learn from 3.4BN years of nature's R&D programme	Perhaps our most important learning, that caring for life and caring for the systems that support life are one and the same thing