Cloud-to-Coast Adaptation: Enabling a climate resilient future

Concept Note v2

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`Would you tell me, please, which way I ought to go from here?' said Alice
`That depends a good deal on where you want to get to' said the Cat.
Alice's Adventures in Wonderland, Lewis Carroll (1865)

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1. Background

Motivation

Two-thirds of European citizens are expected to be at particular risk from climate change and weather-related events by the year 2100 (Krona et al., 2019). Countries with significant coastal populations will be particularly affected, including The North Sea Region (NSR), where communities are vulnerable to changes in sea level and added storminess. Inland, increased rainfall intensities and volumes will increase localised fluvial and pluvial flood risks. Estimates of the expected annual damages in Europe by the 2080s from coastal flooding are €17.4 to 25.4 billion (currently €1.9 billion) and from fluvial flooding, €97.9 billion (currently €5.5 billion), unless strong prevention and adaptation policies are implemented (EU, 2014). Vulnerabilities are especially intense for parts of the NSR, such as cities and seaports, which comprise some of the most active global transport and commerce hubs. Hence, flood protection is vital for the NSR, with investments potentially yielding a benefit-cost ratio between 7:1 and 10:1 (World Bank, 2014).

The conventional response to these challenges has been to develop flood protection infrastructure, but increasingly it is recognized that a 'defence' paradigm alone is unable to manage risk whilst continuing to promote ecosystem health and social well-being. A new approach is required.

Cloud-to-Coast: A new approach to climate change adaptation

The aim of the C5A project is to enable greater integration and innovation in the adaptation to the physical, economic and social impact of flooding taking into account climate change. To help achieve this aim C5A develops an approach that promotes the adoption of a whole-system and long-term perspective to climate change adaptation that is purposeful, collaborative and builds on the principles of social justice, ecosystem health and resilience; an approach we call **Cloud-to-Coast (C2C) adaptation**.

Co-creating the Cloud-to-Coast (C2C) approach

The C5A project is exploring and developing the basis of this new C2C approach through a combination of knowledge exchange and pilot studies. The early concepts underlying this approach build upon a Survey of project partners, the collective experience of seven founding EU Interreg NSR projects, the review of scientific and professional literature, and a series of case studies that are designed to test and refine the approach through a process of co-creation between science and practice.

2. Cloud-to-Coast: Barriers to progress

There is a general acceptance that climate change, socio-economic development and adaptation can only be addressed successfully through collective action. Within the water sector, integrated coastal zone management (ICZM) and integrated water resources management (IWRM) approaches have both emerged in an attempt to enable this integration. The experience over the past decades show that, in many respects, these approaches have failed to achieve meaningful integration in practice (as evident from the continued siloed planning processes across the multiple domains of water management and development, FAIR, 2019). In part, this is because these approaches tend to be process-focused and presume perfect alignment of plans and the organisations that deliver them. In doing so, such approaches fail to address uncertainty 'head-on' and limited support is given to how to meaningfully address issues of climate change and adaptation.

More recently strategic approaches have been developed that accept the complexity and uncertainty of current and future decision making and to provide a more practical long-term focus in order to address the highly uncertain issue of climate change (e.g. Fuerth, 2009; Sayers et al., 2015; Quay, 2010; Boyd et al., 2015). There is now an urgent need to build upon the insights provided by these initiatives and develop a new approach that will address these challenges and contribute to Sustainable Development Goals (SDGs) more broadly and in particular improving human and institutional capacity to act, a key target under the SDG13 (UN, 2015).

In the Interreg North Sea Region, recent projects have sought to further advance this vision of an integrated and strategic approach (see Box 2-1). Although these projects have been successful, a survey to project partners outlined here (further detailed see Box 2-1) confirms that several common barriers to progress persist:

- **Institutional barriers:** including (i) siloes and the challenge to build synergies across different organisations to cope with uncertainty on policymaking; (ii) cross-boundaries responsibilities between the province, regional water authority, and municipality.
- **Actor related barriers:** including contesting responsibilities between different actors, governmental bodies and individual landowners; that lead to conflicting goals and priorities and ineffective governance of climate change adaptation.
- **Barriers concerning regulations**: including policies and regulations that are highly regulated at the regional level, challenges of conducting the implementation of climate change adaptation across different stakeholders, and enforcement of climate policies as a voluntary measure.
- **Barriers around climate information and communication:** including (i) climate science communication and communicative information from science to policymaking and practitioners, and political commitment for long-term objectives; (ii) case studies have considered different timescales (short, medium, and long-term planning) for future adaptation planning.
- **Planning barriers:** including (i) evaluation between long-term and short-term adaptation planning, (ii) understanding of long-term costs and benefits of adaptation, relevant tools and capabilities to support 'future-proofed' decision making, and funding for perceived 'additional' costs or 'future' investments.

The C2C approach seeks to build on lessons learned from these earlier frameworks that have been applied in different Interreg NSR projects. This new approach will also reflect on the emerging concept of climate resilience to provide a framework that enables collaborative processes to overcome these barriers and encourages a whole system and multi-scale approach to increasing challenges in undertaking climate change adaptation. The new approach will facilitate a whole-system, long-term and collaborative approach in order to respond to the highly complex issue of climate change.

Box 2-1 C2C building upon seven EU Interreg NSR projects

The C2C approach builds upon and supports the application of the whole system approaches for managing water-related risks, including building upon the findings of seven EU Interreg NSR projects:

- Adaptive flood protection asset management (FAIR), see for example "A perspective on the future of asset management for flood protection policy brief" (FAIR, 2019)
- Integrated coastal zone management (BWN, Ringkobing, Esens, het Swin), see for example "Building with nature for flood resilience policy brief" (BWN, 2020).
- Integrated river management (Coevorden). Add ref
- Integrated flood risk management (FRAMES, Dordrecht), see for example "FRAMES: Increasing flood resilience beyond borders newsletter" (FRAMES, 2017).
- Integrated approaches to stormwater management (BEGIN), see for example "Blue Green Infrastructures through Social Innovation Approach" (BEGIN, 2020).
- Integrated approaches to urban water management and climate change adaptation (CATCH), see for example "Water Sensitive Cities Framework" (CATCH, 2020).
- Regional governance on groundwater flooding, see for example "TOPSOIL Roadmap: How to improve regional governance on groundwater flooding" (TOPSOIL, 2019)

3. Cloud-to-Coast: Framework

The C2C approach recognises that opportunities to build resilience to water related hazards in general, and flooding in particular, starts from the moment the rain falls (clouds) to flow through the rural catchment and cities, before interacting with coastal storms (coast). These constituent systems are interconnected and interact, the change in one influencing the flood risk in another. This means that slowing the flow in the upper catchment can act to reduce flood risk downstream, and building a flood defence in one area may reduce the risk locally but may increase flood risk elsewhere. The identification of water related hazards, such as floods, as a challenge cannot be addressed in isolation but should be shared by local, regional and national authorities across the NSR. In doing so, the C2C adopts a whole system approach that addresses both physical assets to protect against floods and the capability of individuals, communities and organisations to cope with the occurrence of floods.

To bring these aspects together in C2C, five fundamental aspects deliver a resilient society and underpin the overall concept. These are illustrated in the Figure below. Three aspects are discussed in this chapter: an adaptive approach, an inclusive process and a whole system response that works with natural processes are prerequisites for of a resilient society (outcome). The five, cross-cutting requirement, is for an ongoing 'continuous dialogue' to make it happen.

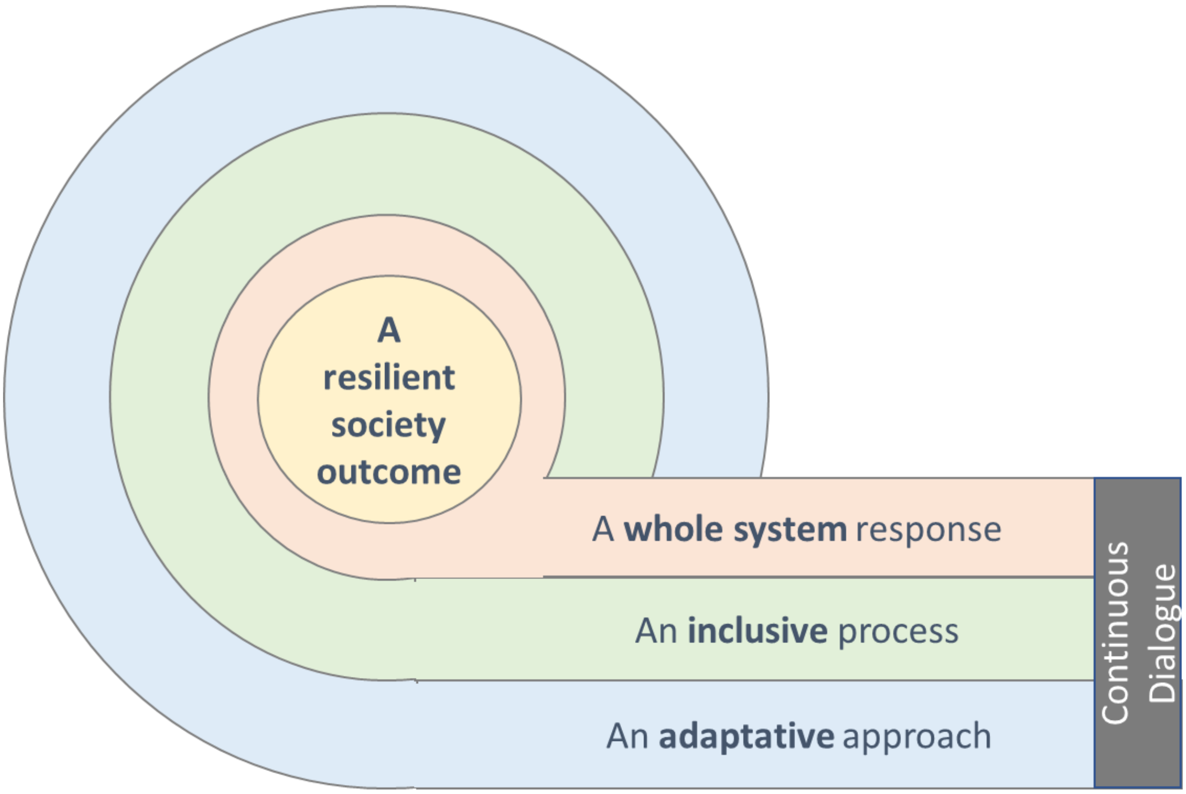


Figure 1 Cloud-to-Coast Framework

A resilience outcome

A resilient society is core goal of the Cloud-to-Coast approach (Figure 1). In support of this 'resilience' is used here to provide the management lens that underpins the C2C approach – the goal of a *resilient society*. 'Resilience' however is an emergent property of the system. This means it can not be measured or delivered by directly but places the focus on the management 'approach' to ensures this outcome. The required qualities of such an approach have been summarised by Arup with support from the Rockefeller Foundation in their 'observable qualities of resilient city planning' (Box 3-1); qualities that are applicable elsewhere, not only for city planning. These qualities are not outcomes (as the degree of resilience society can only be measured through proxies such as risk), but rather characteristics of the decision process and the actions implemented.

Box 3-1 City Resilience Framework (Arup, 2014)

Resilient cities demonstrate a range of observable qualities through their stakeholders and urban systems:

- *Reflective* - People and institutions systematically learn from experience, with an adaptive planning mindset that accepts unpredictable outcomes. They have mechanisms to continuously modify standards based on emerging evidence, rather than seeking permanent solutions based on an assessment of today's shocks and stresses;
- *Robust*- Robust city systems are designed and managed to withstand the impacts of extreme conditions and to avoid a catastrophic collapse of the city from the failure of a single element. A robust system anticipates system failures and makes provisions to maximize predictability and safety;
- *Redundant* - Redundancy is to deliberately plan capacity to accommodate for increasing demand or extreme pressures--if one component of the system fails, other pathways or substitutable components can meet essential functional needs;
- *Flexible* - Flexibility is a city with systems that can change, evolve and adopt alternative strategies (in either the short or longer term) in response to changing conditions. These systems tend to favour the decentralization of conventional infrastructure with new technologies;
- *Resourceful* - People and institutions should invest in capacity to anticipate future urban conditions, set priorities, and mobilize and coordinate the resources (human, financial, and physical). Resourcefulness prepares a city to respond quickly to extreme events, modifying organizations or procedures as needed;
- *Inclusive* - An inclusive approach is one that includes the consultation and engagement of communities, particularly those who are vulnerable. A city cannot build resilience in isolation of others. Resilience needs collective ownership and joint vision from various groups within the city;
- *Integrated* - City systems, decision making, and investments should be mutually supportive of a common outcome. Resilient system integration has evidence of systems that exist across different scales of operation. Integration requires ongoing feedback system for collection of information and response.

In the C5A, these qualities are reflected in our four fundamental aspects of the Cloud-to-Coast approach: . (i) an inclusive approach; (ii) and adaptive approach and (iii) a whole system approach based on a continuous dialogue that is reflective and flexibility.

Delivering the C2C adaptation will require a substantial change in our approach to the management of water-related climate risks; one that is more than simply a rebranding of conventional concepts and approaches. For example:

- The ability to 'resist' is often adopted as the primary response and unhelpfully propagates the status quo paradigm of 'flood protection' under a different guise.
- The ability to recover is however often mistakenly considered to be synonymous for resilience– but this is only part of the resilience lens.

Further detail on 'resilience' is given in Appendix 1.1.

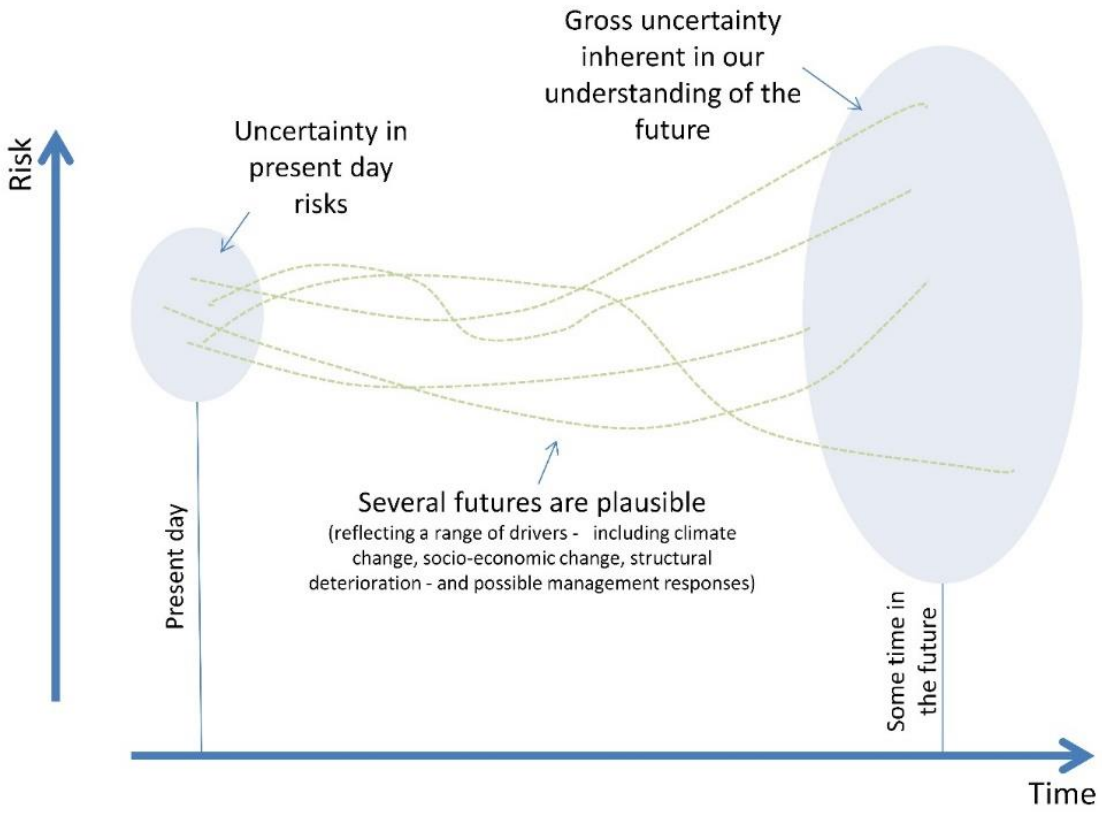
Adaptive approach

'Decisions taken today will have a profound impact on the size of flood risks that future generations will need to manage. They will also strongly influence the options available for managing those risks' (Foresight Future Flood Study, Evans et al., 2004a,b).

The world around us is always changing (Figure 2). Water management has always faced the challenge of decision-making in the face of multiple uncertainties. This lack of forethought has often led to the need for future unplanned adaption that takes place in response to future events (as either greater storm events are experienced or other requirements come to the fore).

Figure 2 The context of flood management is always changing

More recently the uncertainty has been addressed more directly, often by adopting a precautionary approach to strategy development and scheme design (often referred to as planned adaptation, e.g. Brisley *et al.,* 2015). In such an approach, a single plausible worst-case or most-likely view of the future is often developed and used as the basis of design (examples include precautionary allowances for sea level rise, optimism bias applied to costs *etc*.). A single linear future trajectory however remains the basis of conventional approaches and give little or no scope for more radical changes if the future is different from that envisaged (as it inevitably will be – Figure 3).



Source: Sayers et al., 2014

Figure 3 The future is deeply uncertain

The shortcomings of this approach are widely acknowledged (potential for lock-in to designs that are maladapted to the reality of the future and/or unnecessarily costly) and the advantages afforded by *managed adaptation* increasingly acknowledged (e.g. Brisley *et al.,* 2015). In such an approach, multiple futures are considered and strategies developed to maximise the potential opportunity and avoid costly maladaptation.

A recent workshop considered how to 'make adaptation happen in practice' supported jointly by the UK Environment Agency and the EU INTERREG FAIR project. This included the discussion of the four ingredients needed to support planned adaptation (Figure 4) and the challenges and the important changes needed to make progress towards meaningful adaptation (Box 3-4).

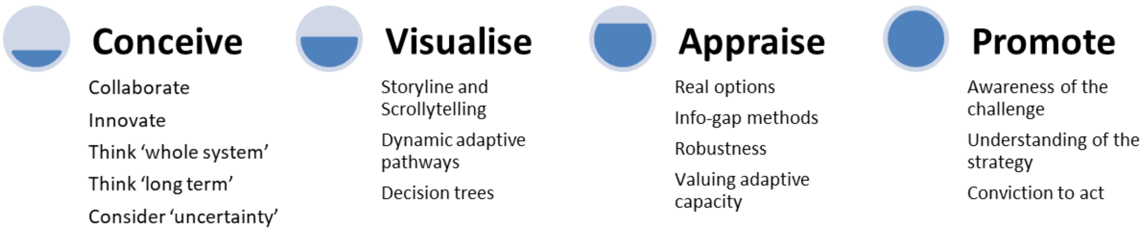


Figure 4 Making adaptation happen in practice – four core ingredients

Further details on adaptation – what it means, and the example applications are given in Appendix 1.2.

Box 3-2 Making adaptation happen in practice: Workshop findings

A Workshop (co-convened by the FAIR project and Environment Agency, UK) held in Oxford in February 2020 grappled with issue of adapting to an uncertain future in practice. Although no single sliver point was identified there was significant consensus on the urgency of the issues to be addressed and what was needed to make real progress.

Building upon four Policy Recommendations from the FAIR project (ref), namely: (i) **Break-free of the silo:** Align multiple planning processes within, and beyond, flood management; (ii) **Mind the gap:** Link strategic planning and operational processes through a tactical handshake; (iii) **Prepare for change**: Develop flexible strategies and asset designs that can be adapted to meet changing requirements in future; (iv) **Make space for innovation**: Embrace and manage risk to support the development of innovative solutions.

To **make adaptation happen** it was agreed that adaptation is more than simple modifying a flood defence asset – it is a process that requires innovative, whole system, long-term thinking. Achieving this relies on recognising: (i) **'Our world is changing faster than our thinking'** – we need to catch up; (ii) **Adaptation is a 'people thing'** – including individuals, communities, politicians, planners and engineers; (iii) **Uncertainty is driven by more than climate change alone** – development (local and remote), funding, societal preferences an all have profound implications for the choices we make; (iv) **Change starts with you!** Flood management is in a pivotal (although perhaps not leading) position to influence change - we must 'break free of our silo – we all have to reach out

To **make progress** we must be better at: (i) **Envisioning and visualising the future** - Storylines can be powerful agents in supporting buy-in to an alternative course of action. (ii) **Addressing the hard choices** - Adaptation 'at the edges' is easy but to address the hard choices (from realignment, to food security) is much more difficult but are central issues; (iii) **Recognising adaptation as a purposeful process** – not kicking the can down the road - 'own (not make) future choices today'; (iv) Accepting adaptation is not a free lunch – how much are we willing to pay for future flexibility/reduced lock-in; (v) **Avoiding bear trap of 'paralysis by analysis'**: We have many of the tools. We have a lot of information. New data is not always needed (sometimes it may be) – but we can use the information we have to make better choices today. (vi) Delivering adaptation as a continuous process - you can't get 'adaptation done'; adaptation is an ongoing process that balances the dual masters of ambition and practicality.

Source: Sayers, Barlow and Vonk (2020) – Workshop findings[1]

Box 3-3 An adaptive approach as an enabler for building resilience

The focus of an adaptive approach is on how adaptation measures feedback, either positively or negatively, into the system as a whole through time and space. It recognizes that the decisions of the past influence the available adaptation options in the present; and that decisions in the present have implications for the flexibility of which options can be implemented in the future. Such adaptation options, therefore, need to be conceived as part of adaptation pathways (Appendix 1.3). This approach contributes to resilience by anticipating (unforeseen) future conditions. It seeks to maximise robustness by designing actions that perform well in multiple plausible futures, and flexibility by avoiding 'lock-ins' and keeping options open where and when possible (Ranger et al. 2013).

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[1] http://www.sayersandpartners.co.uk/uploads/6/2/0/9/6209349/co-convened_flood_adaptation_-_meeting_notes.pdf

Inclusive process

To identify and embrace complexity, we should not merely look at the physical components of the system. People, with their livelihoods, jobs and leisure activities, are inseparable parts of the system, while they have diverse needs, interests, perceptions and knowledges regarding climate change. Taking this social diversity may increase complexity, whilst at the same time provides opportunities for climate change adaptation. To address decisions, we both need specialists and local governments, but in developing climate change resilience we should also value local wisdom and public knowledge as a credible source of expertise. Their input in the process stretches our thoughts and paradigms to flood protection, so that we can come up with solutions that fit both the people and the environment.

This makes inclusivity is one of the key concerns to achieve resilience in building climate change adaptation. It is about:

- A shared language to support a cloud-to-coast approach,
- Looking beyond siloes and connecting them in a non-sectoral way, and
- Including all stakeholders from public and private domains
- In a continuous dialogue with each other.

Inclusive climate change adaptation is a collaborative process in reducing the effects of climate change while at the same time, ensuring that the benefits and burdens of climate change adaptation are equitably distributed. Inclusivity is a central in governing climate change adaptation, where the process involves a wide range of stakeholders from public to private to civil society in designing policies and actions that are fair and accessible, and equitably distributing the climate policy impacts.

Inclusivity in climate change adaptation should be understood as a process, rather than an output. It occurs at different forms of spatial scales and multi-level governance, from an international, national, regional and local level. Moreover one should be aware of the fact that there is no "one size fits all" type of collaborative planning towards an inclusive climate change adaptation.

Figure 5 Adaptation is a 'people thing' – Relying upon all the talents and everyone's actions, not only professionals, but also wider stakeholders and community groups

Box 3-4 An inclusive process as an enabler for building resilience

Climate change will affect different groups of stakeholders and communities differently. However, the effects of climate change will likely and disproportionately affect the disadvantaged and vulnerable communities at a higher risk. Hence, climate change adaptation should be implemented on the basis of an inclusive process, which is organised as a continuous dialogue on multiple levels of scales and governance to ensure that no one is left behind and social inequalities are addressed. This "leaving no one behind" is of one of the key principles for achieving sustainable development targets outlined in the Sustainable Development Goals (SDGs).

An inclusive process is one of the key elements in the C2C approach in order to achieve societal resilience. Implementing an inclusive process requires that social equity, transparency and representation are considered to contribute to building resilience. As an instrumental framing, an inclusive process should also be maintained at all three elements of inclusivity: process, policy and impact (see Appendix 1.3 for further explanation). The C2C approach will provide guidance on how to accomplish these outcomes to ensure that interconnectedness, meaningful participation, avoiding siloes and connection with local knowledge and expertise are sustained to build societal resilience.

Whole system approach

One important aspect of climate resilience, is the adoption of a whole of system approach to climate change adaptation. A whole system response requires us to all think in 'whole system' terms. In doing so, it is necessary do develop a broadly based understanding of how water-related risks and opportunities are generated (in the short and longer term) and how they manage can be managed to achieve resilience. To be successful this requires us all to challenge the status quo adopt the basic principles of 'system thinking' – Figure 6[2].

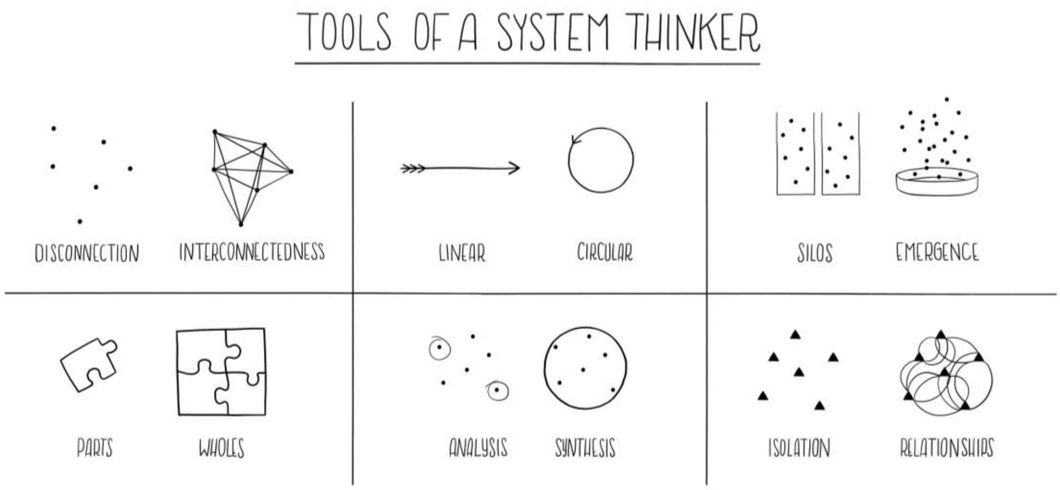

Figure 6 Tools and system thinker

To make the definition of the whole system is tractable (and avoid the pitfall over complication - "*if I try to pick out anything by itself, I find it hitched to everything else in the universe*." John Muir) appropriate boundaries need to be defined based on an ambitious approach to the sphere of influence of a stakeholder, where:

[2] Acaruglo (2017) Tools for Systems Thinkers: The 6 Fundamental Concepts of Systems Thinking. Image courtesy Disrupt Design. Via https://medium.com/disruptive-design/tools-for-systems-thinkers-the-6-fundamental-concepts-of-systems-thinking-379cdac3dc6a

- System - Spatial limits: The geographic and social limits of the 'system' that the decision-at-hand may influence (Figure 7);
- System - temporal limits: the timescale over which those decision will be influential.
- Drivers of system change: The external influences that may influence the behaviour of the system over time, such as sea level rise or development that may influence the decision-at-hand;

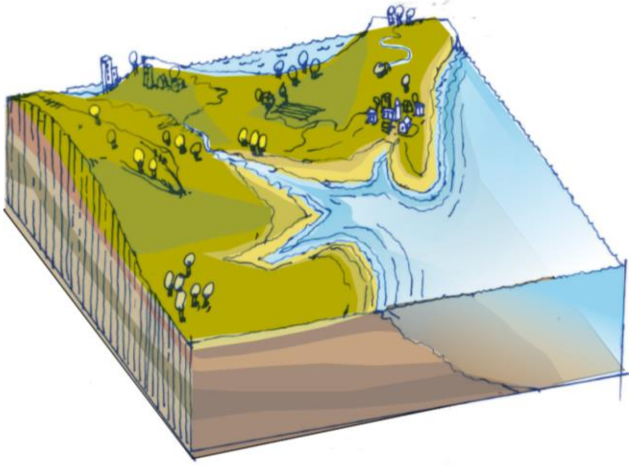

Figure7 Defining the spatial limits of the system is an important first step

The hydrological and hydraulic functioning of the system (during frequently and rarely occurring storm conditions), the socio-economic vulnerabilities and how alternative adaptations may influence risks will all be of interest. Climate change, socio-economic changes, land use change and infrastructure development and communities themselves all change the behaviour of the system and the associated water-related risks.

There is as yet no single view or model of a whole system approach or any of the variants on managing the water cycle as a whole (USEPA, 2012) and one that provides the guidance required by practitioners or those responsible for managing aspects or the entirety of the water system. Various initiatives have been put forward to better manage the water cycle in an integrated way. In a city planning context, the concept of Water Sensitive Urban Design (WSUD) is often adopted, derived from pathfinding research and practitioner development in Australia (Wong and Ashley, 2006) and now promoted in a number of countries worldwide, including the NSR countries (in EU INTERREG Catch). WSUD seeks to manage interconnections and utilise water whenever and wherever it occurs in urban areas, integrating with urban planning and design. This concept provides inspiration for maximizing the value and use of water, with an increasing consideration of flood resilience. Ashley et al. (2013) proposed a vision for WSUD to include flood resilience (Box 3-5) that is applicable beyond city planning only.

Box 3-5 A vision for Water Sensitive Urban Design (WSUD) includes resilience

A vision for WSUD to include flood resilience includes 4 principles (Ashley et al., 2013b):

1. Manage water to deal with both water scarcity and water excess (managing both water quantity and quality and system resilience) concurrently and in an integrated way;
2. Manage and utilise the water cycle as locally as possible as all aspects/occurrences of water are potential opportunities (exploit local opportunities); including source control measures and managing local topography to route flows into safe areas.
3. Deal with water appropriately and synergistically within urban environments; including ecosystems, and across urban services, design and planning processes (maximise wider value

opportunities, flexibility and resilience, and more effective integration and utilisation in urban areas);

4. Integrate water management effectively into the wider systems, services and utilities that provide human needs in cities and other areas by taking a systems-based approach and deal with the interdependencies in a planned way.

The principles require an emphasis on the risks (flooding and drought) as well as opportunities to be gained from the water cycle and good urban design and management. All added-value opportunities to improve societal, environmental and ecological systems should be considered in the planning and design of adaptation measures and taken advantage of throughout the process.

The C2C approach promotes a multi-scale vision of the whole system – bringing together actions at a local scale, and individual stakeholder, with more strategic actions and planning processes. Accepting the role of local project scale activities to address local challenges, alongside catchment scale management. In doing so, opportunities for one scale to contribute to the other and maximise opportunities and create synergies. This process will not be easy; but a whole system approach enables barriers and inherent conflicts to be identified (early) and addressed. Answering these questions will help to develop adaptation measures at the right scale.

Box 3-6 Whole of system approach as an enabler for building resilience

Adopting a whole of system approach is one of the steps to work towards resilient communities and environments. To explore the systems at hand and their interconnectedness with other systems (e.g. cities, infrastructure or nature), it helps to assess key components of resilient systems:

- Resistance: how robust is the system at hand to flooding?
- Recovery: are systems and communities able to bounce back from a flood?
- Adaptation: is the system flexible and able to adapt to change before, during or after a flood?
- Transformability: is the system (both natural and human) able to transform to a new system?

Working with natural processes as part of a whole system approach

The concept of working with natural processes has gained significant momentum in recent years and natural infrastructure (and infrastructure that works with natural processes) are increasingly recognized as desirable options (Working With Natural Processes, WWNP, 2018). Such approaches are more generally referred to as Nature-Based Solutions (NBS). NBS approaches are inspired and supported by nature and work with, or mimic, natural processes to deliver multiple co-benefits. An NBS can involve conserving or rehabilitating natural ecosystems and/or establishing natural processes in modified ecosystems.

In addition to supporting conservation and restoration objectives, working with natural processes provides infrastructure planners multiple opportunities, including (i) lower cost material choices (e.g. low carbon, recycled, reused); (ii) innovative biomimicry designs (based on adapting natures designs or functions such promote infiltration of rainfall into urban landscapes or regular heat and natural light within buildings, e.g. Kenny *et al.,* 2012); (iii) Lower cost construction and maintenance by harnessing the natural processes (for example using tidal currents to disperse sand nourishment, Stive *et al.,* 2013); (iv) reducing the need for built infrastructure by slowing the flow through the basin (catchment) to encourage aquifer recharge, improve water quality or buffer variability of flows and storage (Figure 8).

Table 1 Working with natural processes provides a range of opportunities (from Sayers et al., 2020)

Opportunity working with natural processes provides	Description
Safeguarding existing natural processes: **Conversation**	Ensuring infrastructure choices safeguard healthy species and places of ecological value at local and landscape scales.
Restoring degraded ecosystem structures and functions: **Restoration**	Adding ecological value by assisting the recovery of ecological structure and function of a freshwater ecosystem by replacing lost, damaged or compromised elements and re-establishing the processes necessary to support the natural ecosystem and to improve the ecosystem services it provide (for example by slowing the flow through re-establishing wetlands and river meanders, natural infiltration *etc*).
Choosing low cost renewable materials: **Sustainable materials**	Seeking to design in the use of recycled or renewable materials.
Developing innovative biomimicry design: **Designs inspired by nature**	Designing built infrastructure to replicate natural processes to reduce cost and impact on the natural processes – for example reducing urban run-off through artificial infiltration and storage systems. Such approaches can provide biodiversity benefits (e.g. using urban ponds or swales) by do not necessarily do so (for example plastic cellular urban storage may have no additional benefit).
Using the forces of nature to lower construction and maintenance cost: **Natural value engineering.**	Low carbon (e.g. solar, wind) and low-cost construction methods that use natural processes to help construct infrastructure or maintain performance/
Adding biodiversity through details: **Bio-detailing**	Choosing materials and design details to encourage local biodiversity

Many opportunities exist to work with natural processes throughout the basin – from local project (reach) scales to landscape scale strategies (Figure). Working with natural processes throughout the basin (from headwaters to terminal outflow) underpins a whole system approach to protecting headwaters, retaining water in the landscape by *'slowing the flow'* and maintaining (or re-establishing) connectivity (both vertically with aquifers, laterally with river floodplains and longitudinally) throughout the basin. Developing solutions that work with natural processes through the system embeds restorative and regenerative processes into infrastructure planning and design choices. In doing so, SWI provides a natural counterpart to the concepts of *green growth* and the sustainable use of natural resources and processes to that underpin Sustainable Development. Working with natural processes also widely agreed to generate multiple social and environmental co-benefits (including providing meaningful jobs, recreational opportunities as well as protecting and enhancing biodiversity). The value of such co-benefits can be substantial (such as for sustainable urban drainage, Ashley *et al.,* 2018 to across landscape scale benefits, Opperman *et al.,* 2018).

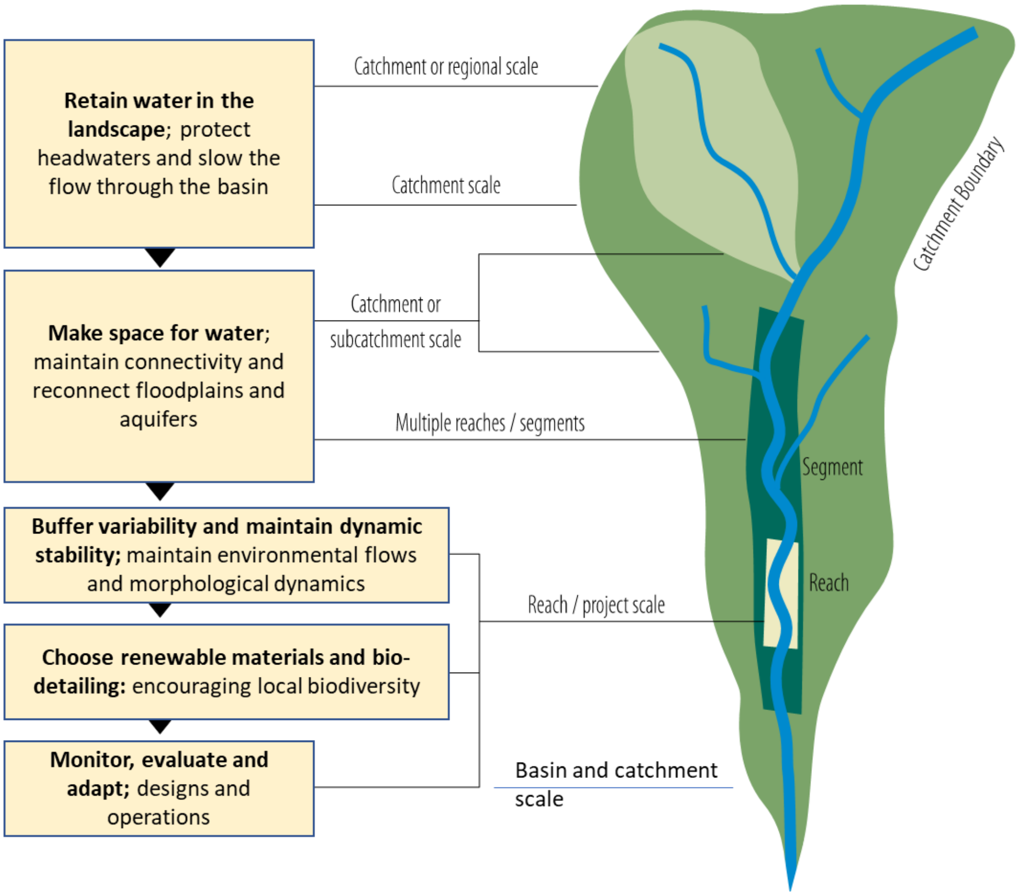

Figure 8 Cloud-2-Coast provides together opportunities work with natural process (after Sayers et al., 2020)

Despite the growing acceptance of the need to work with natural processes and the benefits it provides many water resources policy and management fail to promote NBS options (and may embed active barriers against their use – see Chapter 1). Cloud-to-coast provides a practical framework upscaling NBS into mainstream, multi-sectoral, practice. In doing so, C2C moves working with natural processes and NBSs away from an 'add-on' to a central tenet of good infrastructure planning that blends natural and built infrastructure (alongside non-infrastructure) responses to deliver multiple outcomes.

Continuous dialogue

Transnational or regional cooperation is an effective way of preparing for, mitigating and ideally preventing flooding and the associated impacts. Such cooperation is facilitated by a dialogue among stakeholders involved in the management of the water-related risks. The challenge for the dialogue is that each of the disciplines is a bubble of thoughts and information. This leads to a Babylonic situation where the professional or scientific disciplines, if they try to interact at all, misinterpret or misunderstand the realities of the others. This is depicted in Figure 9.

To avoid this Babylonic situation, the stakeholders should be prepared to look at the world from a different angle, one that may stretch their original thoughts and paradigms. The dialogue should, therefore, be geared towards mutual learning among stakeholders, an iterative process of deliberation, supported by an inclusive decision-making process. During the dialogue the complexity and behaviour of the whole system is discussed by the stakeholders, which includes local communities. Stakeholders will also share their respective knowledge and explore the barriers and opportunities for a resilient future.

The continuous dialogue is elaborated in the following chapter

Figure 9 A depiction of the tower of Babel. The individual disciplines are separated in their work to build the tower.

4. Guidance on the continuous dialogue

The dialogue consists of three stages: preparing the dialogue, conducting the dialogue and addressing the barriers and opportunities. Guidance is provided here for each stage.

Stage 1: Preparing the dialogue

Stakeholders will need to be proactive in understanding their contribution to the C2C dialogue. This is facilitated by answering following questions in preparation of the dialogue:

- **Motivation:** What is your motivation for engaging in the dialogue? Is it an issue or threat that cannot be addressed in isolation, but that requires a shared response? Or is it an opportunity to create or enhance value that may arise from multi-functional solutions? It could also be the start of an actual project, such as the reinforcement of a flood defence.
- **Stakeholder analysis:** Which stakeholders would you like to involve in the dialogue? Undertaking a stakeholder analysis to determine who is affected or can contribute to the (shared) response will make it clear who should be involved in the dialogue. The mapping of the power and interest space is a core element of this analysis.
- **Knowledge base:** What minimum information do you need to conduct the dialogue? There are different attributes of climate knowledge that can be integrated into the dialogue. This climate knowledge should be complemented by an understanding of the local context of the case study. This may be in the form of (local) policy developments or maintenance programmes. With regard to preparing the dialogue, there is the risk of 'paralysis by analysis', whereby one spends too much time on acquiring new data and not taking enough time for the dialogue and its follow-up. New data is not always needed (sometimes it may be). It will often suffice to use readily available knowledge and information to start the dialogue.
- **Creative and participatory approach:** What is an effective approach for the dialogue? The dialogue can be conducted in the form of a working session, brainstorm or simply as a conversation. The participatory approach should trigger the stakeholders to participate actively in the dialogue and challenge their creativity. There are different tools available to facilitate brainstorming and critical thinking (see Appendix 2).

Stage 2: Enabling a constructive dialogue

This stage starts with defining the concrete goal(s) for establishing a C2C dialogue; building upon the motivation that is explored in the preparatory stage. The goal(s) will be case specific, and there are different goals at different decision making levels (Box 4-1).

Conducting the C2C dialogue is a collaborative and iterative stage. During the process it may be necessary to repeat one or more steps. The following steps (in random order) are typically involved in conducting the dialogue:

- Identifying interactions between constituent systems;
- Looking for new or additional information;
- Creating a sense of urgency for action;
- Reaching consensus on the vision, plan or design.

Only when the involved stakeholders are aligned as much as possible, the dialogue can be rounded up. Each stakeholder, therefore, has the responsibility to make their voice heard. The design of the C2C dialogue should accommodate any issues (barriers and opportunities) arising, for example siloes among organisations, conflicting perceptions or contested responsibilities. It should also encourage sharing information, iterative learning and consensus building.

Box 4-1 Goals for establishing a C2C dialogue

Goals for establishing a C2C dialogue include:

- Obtaining a structured understanding of the behaviour of the whole system. This also enables interactions between constituent systems to be understood, and the way flood risk may cascade and escalate through those systems. (strategic context)
- Making strategic choices about the management of the whole system. Adaptation 'at the edges' (e.g. creating local storage) is easy; to address the hard choices (from coastal realignment to diverting rivers flows) is much more difficult, but these choices are central to dealing with (more extreme) climate change. (strategic context)
- Developing an integrated vision for a coastline, catchment or city, where flood and coastal risk management is integrated into strategic spatial planning. This could for example be a vision to develop green-blue corridors between city and catchment, where the surrounding rural area serves as (excess) water storage. (strategic context)
- Exploring opportunities to connect an adaptive plan / implementation agenda for flood and coastal risk management with implementation agenda's in other sectors, such as spatial planning or ecosystem restoration. (tactical context)
- Ensuring that operational decisions to manage flood risk and beyond (in other sectors) will not be maladaptive under climate change and climate change adaptation at higher scales (operational context)
- Exploring opportunities to create or enhance social, ecological or cultural values that may arise from multi-functional solutions. (operational context)

Stage 3: Act upon the outcomes

The final stage is to round off the C2C dialogue and work towards an outcome. The decision making level will determine the specificity of the outcome. At the operational level, the stakeholders can make concrete agreements about adaptation measures (responsibilities, financing and planning). At the strategic level, the agreements may be procedural, such as an intention to jointly work toward an integrated vision. Such a vision will often involve long-term solutions, although this might be in combination with short-term measures.

Rounding off the dialogue is mainly about establishing agreements about what each stakeholder can do and wants to do to address the barriers and opportunities , including:

- Documenting the dialogue. The inputs and outputs should be well described and (where possible) quantified: which risks have been reduced, of which values have been created? It should be noted here that the actual documentation starts from stage 1 of the dialogue; but is translated into an output in this stage.
- Making joint agreements to ensure identified barriers and opportunities are addressed. It helps to deliver follow-up if there is a clear actionable perspective for the stakeholders involved.
- Providing room for adjustment where new learning and/or circumstances are recognized.

The outcomes of the dialogue feed into decision making processes at various levels, from the strategic to the operational level. It is of note here that the C2C adaptation dialogue is an iterative process and never really completed. There will always be new information and changes in flood risk that call for a continuation of the dialogue. For instance, the EU Floods Directive requires that its 3 key stages must be repeated on a cyclical basis (every 6 years) to ensure that flood risk is managed effectively. Nevertheless, it is important to go through the stage of rounding up the dialogue to ensure (continued) commitment for the follow-up process.

5. Summary messages

Water-related risks are context specific and as such any attempt to prescribe a stepwise assessment and management procedure would inevitably fail. Without intending to be prescriptive, the C2C approach provides an 'actionable framework' to identify adaptation and transformative pathways (refer to Appendix 1.2) that enable a water resilient future. It also helps to manage water-related risks and to create a sustainable environment. This framework is designed to be applicable to all contexts. It, therefore, intends to mirror the strengths of a risk-based approach; risk provides a common framework that can be interpreted and translated to add value to any decision context. Similarly, the C2C framework should have utility for all those involved in the management of the water-related risks by encouraging a common approach—rather than providing a prescriptive procedure or (software) tool. This does not imply C2C requires no supporting tools or evidence; it does. But such tools can be bespoke to the decision at hand without compromising the C2C framework. The C2C framework is actionable in that it helps to manage interactions between sectors, organisations and processes involved with managing the water-related risks. This is facilitated by providing guidance for a continuous dialogue around adaptation and transformation.

To deliver C2C in practice five characteristics help shape a practical whole-system approach:

#1 '**Mesh' the theory and practice**: We recognise that integrated approaches routinely fail because they assume a prefect processes; sequential and aligned decisions across domains; shared knowledge and politics. In practice this is not the case. The C2C recognizes this and seeks to encourage collaboration where opportunities exist for mutual benefit and enhanced outcomes.

#2 'Balance' ambition and practicality: We recognize the need to be practical but still ambitious. Without ambition innovation is difficult and the status quo is difficulty to break free from. Aspirations that are too ambitious may fail to gain support and may simply remain on the shelf. Getting this right is central to the success of C2C – and why we are engaged in a process of **co-creation** through C5a.

#3 A shared language: We recognize that language can be a barrier to progress; placing unnecessary division between groups and discouraging outreach beyond one's own domain. The typical response is to provide simplistic definitions to complex terms, such as adaptation, resilience, risk, uncertainty, whole system etc. – but this simply diminishes their strength. Within the C2C framework we set out the most significant characteristics; characteristics that good management will need to reflect.

#4 Link strategic and operational choices: This includes securing the 'tactical' handshake that enables a meaningful connection between (i) Strategic planning *with* operational planning; (ii) Asset management (natural and conventional assets) processes *with* spatial planning processes *and* biodiversity management processes.

#5 Initiate and maintain dialogue: We recognize that the dialogue never ends, because the climate and social-ecological systems continually change. Rather, the dialogue is (part of) an ongoing process at various levels: (a) from the strategic to the operational level by encouraging (a) from transnational or regional cooperation. It also enables a common understanding of the important behaviours of the whole system to be developed and the barriers and opportunities for a resilient future to be identified. For this to be successful the C2C approach demands all stakeholders to be proactive in making their contribution to the dialogue and enacting their contribution to the management of risk across all stages of the C2C dialogue: preparing the dialogue, conducting the dialogue, and addressing the barriers and opportunities.

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Appendices

Two Appendices are provided covering:

Appendix 1 – Common language

- Resilience
- Adaptation
- Inclusivity
- Whole system

Appendix 2 – Supporting

- Stakeholder engagement
- Whole system analysis
- Whole life costing
- Visualizing and appraising alternative futures
- Measuring resilience outcomes
- Learning lessons and evaluation

Appendix 1: Common understanding and language

The survey of partners confirms there is a diversity of understanding regarding the detailed definitions of adaptation, adaptive plan, adaptation thresholds, resilience, whole system, and system interdependencies. A common language is however emerging in the literature and guidance (for example the IS0 140090: 2019 on Adaptation to climate change – Principles, requirements and guidelines). These standard definitions however are only partly useful and the should not be over interpreted requiring critical evaluation and consensual agreement in the context of any application.

To be useful a common language needs to developed locally in a way that facilitates an empirical understanding and inclusive learning process in local contexts where these terms will be applied. We are aware that these common language will need to be translated into local language and recognize the challenges of translation process in different socio-cultural contexts. As such C2C focuses on developing a common cognitive translation. The C2C framework supports this but to help core terms are discussed below:

- Resilience
- Adaptation
- Inclusivity
- Whole system

Appendix 1.1 Resilience

Despite the term 'resilience' becoming increasing widely used and intuitively understood, a formal definition and understanding remains elusive. In recent years, its application expanded from ecology, engineering, psychology, economy, security studies to nation building (Folke, 2016), and more recently on urban planning as exemplifies from Arup's City Resilience Framework in earlier section. It is however agreed that resilience has four aspects: (e.g. Sayers et al., 2012; Twigger-Ross et al., 2014 and echoed in ISO 14090:2019, 3.14), namely:

(i) **Resistance** (an ability to resist);
(ii) **Recovery** (the ability to bounce back);
(iii) **Adaptation** (ability to adjust to changing conditions in a timely manner);
(iv) **Transformation** (change in the fundamental attributes of natural and human systems).

The aspects of resistance and recovery determine whether the system is able to remain functioning under a wide range of flood waves, or whether it might be affected beyond recovery. This is captured by the term 'ecological resilience' or 'system robustness'. Mens and Klijn (2015) explain how system robustness can be analyzed in a response curve as the sum of the resistance range and the resilience range. A response curve depicts the flood impacts as a function of a range of disturbances, like river discharge (Figure XX). The resistance range is quantified by those discharges that cause no impact to the system. It ends where the impacts become greater than zero. The resilience range is quantified by those discharges that cause limited impact from which the system is able to recover. This range ends where the impacts exceed the recovery threshold, which is the maximum impact from which the system can still recover.

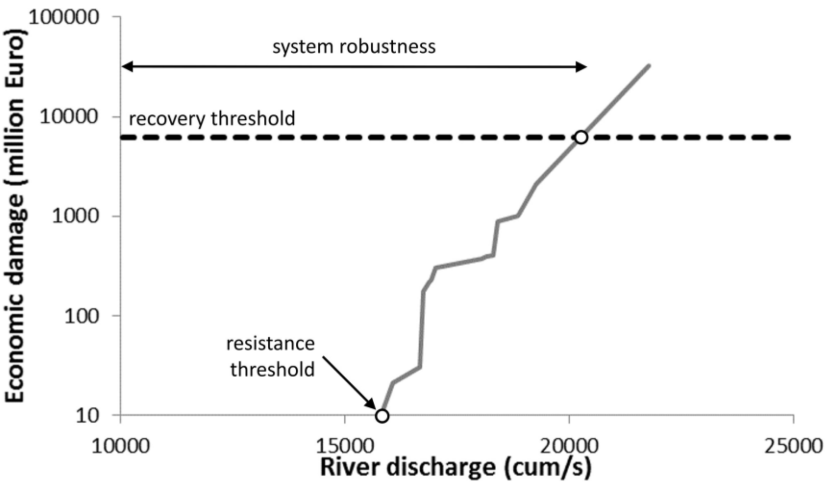


Figure A response curve of a flood risk system (adapted from Mens et al. 2011)

Essential to resilience is a balance in the system. The systems are very diverse: it is not only about ecosystems, but also socioeconomic and political systems. Social conditions can affect nature development and the other way around. For example, the presence of nature can be beneficial to peoples' health. The C2C adopts a whole-system approach, which is elaborated in the Appendix 1.1.

Box A1-1: Example - Flood Resilience

Flood resilience is the capacity of a system to not only withstand flooding, but also to rebuild after a flood and to deal with changes in flood risk. When a flood happens to a city, a resilient city will be able to remain functioning and rebuild quickly.

To focus on **resistance** to flooding means to implement infrastructural measures to reduce flooding such as barriers. Measures to promote **recovery** are effective forecasting mechanisms, affordable insurance and functioning emergency response. A focus on **adaptation** makes sure that the plans can be modified to be ready for future developments, such as building a flood defence so that it can be heightened easily. **Transformation** means a radical change to the approach, departing from the current strategy. Decision makers can decide to no longer protect a certain area because it becomes too costly.

Adaptation and Transformation: Ready for the future

Climate change can make it difficult for systems to remain resilient. Effects such as sea level rise and the increased frequency of rainfall and storms make the it more likely that a flood will happen. When changes happen, the system needs to adapt order to remain functioning. Sometimes, adaptation is no longer possible and the entire system needs to be transformed. Adaptive capacity and transformability are necessary for a system to remain resilient.

Box A1-2 Selected definition (Based on ISO 14090:2019)

Adaptive capacity: “ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences" (ISO 14090:2019, 3.2)

Transformability: “The capacity to transform (…) in order to become different kind of system, to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable.” (Folke et al. 2010: 20)

Through adaptation, actors make changes to the system to deal with future changes. For example, adaptation can help ski resorts to remain open with less snow, by installing snow machines or building snow reservoirs. The previous section gives an overview of how to organise adaptation and adaptive decision making.

Transformation occurs when the system can no longer function as is. This happens either through big events (such as disasters) or gradual changes. In the example of the ski resort, snow machines or reservoirs could be become too costly or impossible to maintain due to rises in temperature. The resorts can then transform to find another source of income (such as wellness or agriculture).

Adaptation thresholds: when to transform

Every system has a number of thresholds or tipping points which can affect resilience. Thresholds are the limits at which the system can no longer function, because there have been too many changes which are too difficult to reverse or irreversible. For example, a change in water quality can lead to an abundance of growth, which makes it impossible for certain species to survive. Thresholds can be climate-related, ecological, socioeconomic, or political (van Ginkel et al. 2018). It can be a matter of political choice to no longer invest in certain measures.

Indicators of resilience

The thresholds can function as indicators for resilience. By making an assessment of the adaptation thresholds and the distance to these thresholds, actors can plan to steer away from the threshold and in this way improve the resilience of the system. How to conduct **threshold analysis** is explained in ISO 14090:2019:

1. Characterise the system: describe the key features of the system;
2. Research possible climate changes: find trends in climate change;
3. Identify thresholds: what are the thresholds to the system?
4. Assess resilience: what do we need to do to avoid crossing the thresholds?
5. Identify suitable indicators: decide what to monitor.

Box A1-3: example threshold analysis

"(…) a coastal city has flood resilience infrastructure in place to a threshold of 0,7 m sea level rise. At that point, strengthening the existing tidal barrier and raising associated sea defences to a specification resilient to 2,3 m of sea level rise will be undertaken. A range of further pathway options with trigger points have been identified to provide resilience to a threshold of 4 m sea level rise. Inevitably, sea levels will rise such that further extension of the defences will become unfavourable. It will be necessary to retreat from the coastal area. If the planning and implementation of the retreat begins early enough, it becomes a process of transformation such that costs are minimized and benefits maximized." (ISO 14090:2019, B.2.5)

Appendix 1.2 Adaptation

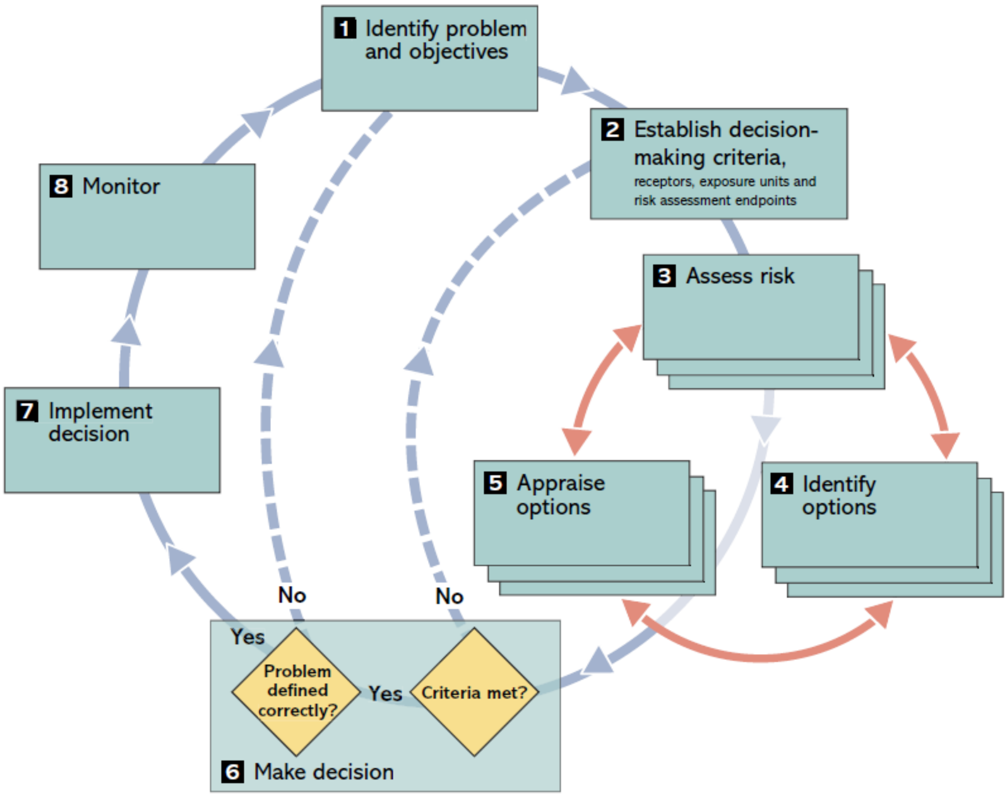
Recognising the future as deeply uncertain does not prevent decisions being made. In fact, it is a key requirement for appropriately embedding adaptive capacity into choices made today. Only by quantifying and acknowledging uncertainty are we better placed to decide how best to manage it, a position articulated well by John Maynard Keynes, 1937:

"By 'uncertain' knowledge, let me explain, I do not mean merely to distinguish what is known for certain from what is only probable. The game of roulette is not subject, in this sense, to uncertainty … Even the weather is only moderately uncertain. The sense in which I am using the term is that in which the prospect of a European war is uncertain, or the price of copper and the rate of interest twenty years hence, or the obsolescence of a new invention…… About these matters there is no scientific basis on which to form any calculable probability whatever. We simply do not know. Nevertheless, the necessity for action and for decision compels us as practical men to do our best." John Maynard Keynes, 1937

Developing 'adaptive capacity' is increasingly recognized as a central response to any uncertainty future associated with climate change, development and funding etc. In turn this has promoted the move away from conventional linear models of plan development, which based upon a more certain view of the future, towards approaches that are capable of adapting to an unknown future. Various approaches to decision making under conditions of uncertainty have emerged to support this transition (*e.g.* Chen and Yin, 2016; Vermeulen *et al.,* 2013, Wilby and Dessai, 2010; Sayers *et al.*, 2008, 2012, 2014 and many others). Such approaches typically presented 'adaptation' as either or a combination of these different framework:

- **A planning framework:** setting out sequential decisions and roadmap of (potential) future activities.
- **A learning framework:** setting out the process of 'adaptive management' through a learning cycle.
- **A driver of transformational change:** focusing on the socio-institutional, governance, policy domains and the way society innovates, collaborates and perceptions and decisions structures change.

All of these framing of adaptation share common attributes - they all promote a continuous process of monitoring and action that reinvigorates the classical engineering control loop of data acquisition, decision making, intervention and monitoring. These framing recognize that climate change adaptation as "a process of socio-political transition and transformation" that involves adaptive learning, refining current governance and re-defining political economy in the process (Pelling, 2011, p.5). Consider for example the decision-making framework proposed by Willows and Connell (2003) that considers adaptation as both a planning and learning framework. This approach establishes adaptive management as a continuous process of defining objectives, assessing risks, appraising options, implementation and monitoring. Conditions of uncertainty and change imply a commitment to on-going adjustment in the context of a constantly changing system and evolving set of objectives.



Source: Willows and Connell (2003)

Figure Framework for adaptive decision making

Recent decision-oriented adaptation approaches are framed within a “pathways” metaphor to emphasise the processes change and inter-temporal complexity (e.g. Sayers *et al,* 2008; Ren *et al.,* 2011; Fazey, *et al.,* 2016). Adaptation pathways approaches applied to date however mostly focus on contexts with clearly identified decision-makers (for example a given infrastructure provider/utility company, or government agency) and well defined (and unchanging) goals; as a result, they generally constrain the nature of the responses considered to those that are largely in control of the defined decision-makers and hence often fail to provide the multi-actor adaptation that may be necessary to provide a whole system response. This broader conceptualisation (recognised by Wise *et al.,* 2016 as *‘pathways thinking’)* is an approach that recognises interactions between sectoral adaptation plans, vested interests, and situations where values, interests, or institutions constrain societal responses to change).

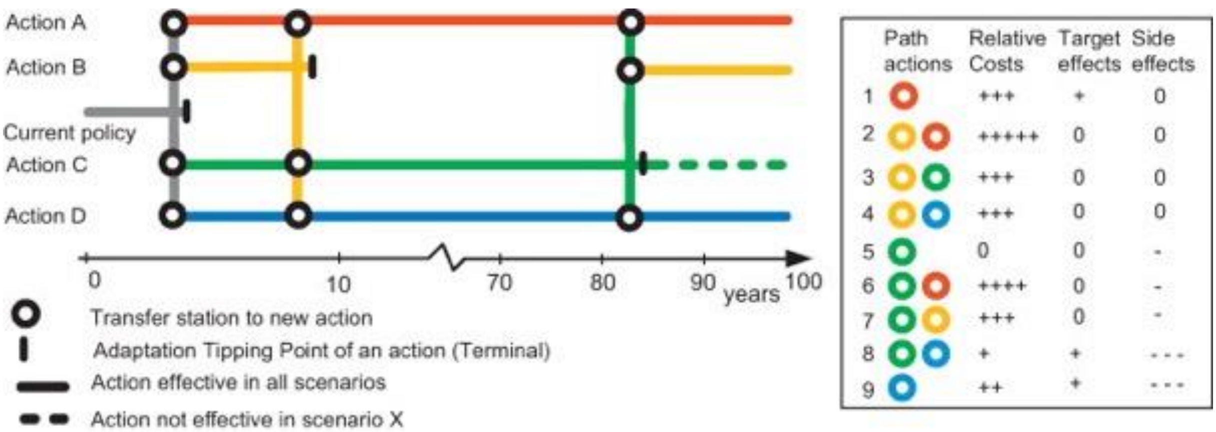
A single linear future trajectory however remains the basis of conventional approaches and give little or no scope for more radical changes if the future is different from that envisaged (as it inevitably will be). The shortcomings of this approach are widely recognized (potential for lock-in to designs that are maladapted to the reality of the future and/or unnecessarily costly) and the advantages afforded by *managed adaptation* increasingly acknowledged. Many significant scientific and methodological advances have emerged in recent years to help assess and visualise this process (e.g. Hall *et al.,* 2003; Phillips *et al.,* 2008; McGahey and Sayers, 2008; Haasnoot *et al.,* 2013; Brisley *et al.,* 2015; Hino and Hall, 2017). Most importantly perhaps, accepting the future as unknown has several profound implications that contrast with the linear model of strategy development (based upon a more certain view of the future that is characteristic of traditional flood control decisions). This is not to imply that an adaptive approach requires more or less information on the performance of the physical and socio-economic system, simply that the uncertainty in that understanding is managed in a different way within the decision process (table A1-1).

Table The recognition of uncertainty has a profound impact on strategy development

Stages of strategy development	Traditional (certain) model of strategy development and decision making	Adaptive (uncertain) model of strategy development and decision making
Deciding what is needed	Pre-defined system of goals, objectives and desired outcomes. Defined set of activities and resource demands.	Emerging pattern of goals, objectives and desired outcomes. Flexible configuration of resources and priorities.
Deciding how to achieve it	Sequential process of planning, programming and implementation. Top-down strategy development.	Continuous alignment of plans, programmes and implementation activities with the changing world. Continuous reconciliation of the bottom-up initiatives and top-down strategies.
Understanding the external and internal influences	Stable system of decision making. Predictable (deterministic) future change – climate, demographics, deterioration, preferences *etc.*.	Monitoring, evaluating change Changing decision processes, strategies and priorities. Unknown future change - climate, demographics, deterioration, preferences *etc.*.

Source: Sayers *et al.,* 2013

Various tools and techniques are available to help make this case (from visualising adaptive pathways - as decision points McGahey & Sayers, 2008 or potential pathways Haasnoot et al., 2013, Figure below - to formally valuing adaptive capacity - Brisley et al., 2015). Such approaches can be used to underpin the identification of tipping points (such as in the Thames Estuary 2100 studies, Tarrant & Sayers, 2012 – see Boxes A1-1). Using these tools and approaches can help asset managers balance performance, risk and cost over the short and longer term by maximising societal value and avoiding solutions that may be unsuitable for future conditions.



Adaptation Pathways Map **Scorecard pathways**

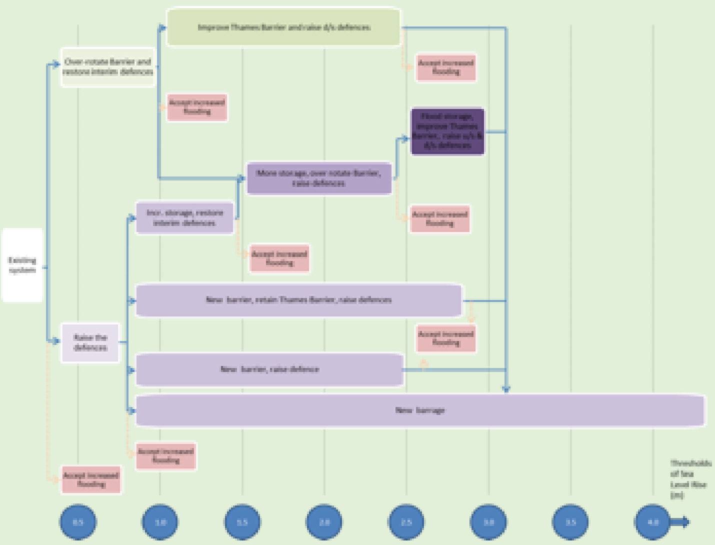
Source: Haasnoot et al, 2013

Figure Adaptation pathways map

Box A1-1 Adaptive strategy developed for the Thames Estuary, UK

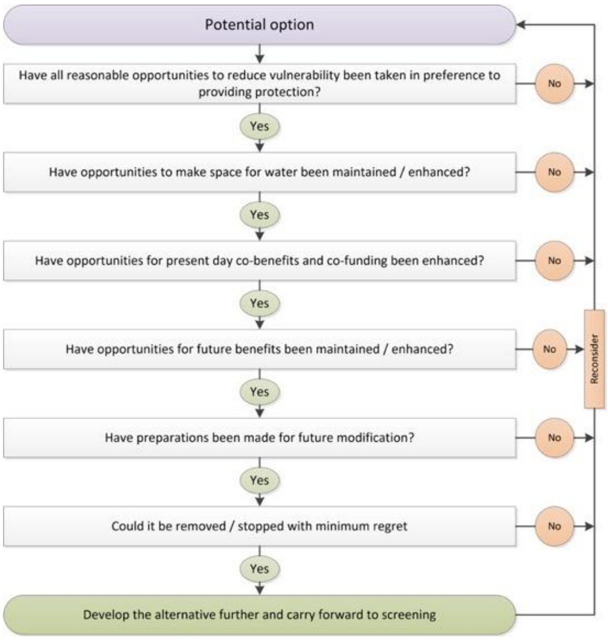
The Thames Estuary 2100 project (TE2100) was established in 2002 with the aim of developing a long-term tidal flood risk management plan for London and the Thames estuary. To reflect this goal of an adaptable strategy, a flexible strategy was developed around the concept of a decision pipeline (McGahey and Sayers 2008), that presents potential actions in the form of a decision tree. The figure below shows the decision tree developed for the Thames Estuary flood defence system, highlighting the choices to be made as sea levels rise. Depending upon the degree of sea level rise that materialises as the future unfolds, the nature of the defence system required may be distinctly different. The decision tree (see below) supported decision makers deciding when and how to invest. In particular it reveals that major investment to improve the defence system is not immediately required. Innovations in the operation of the Thames Barrier (through over-rotation) extends the life of the defence system, enabling potentially high regret decisions regarding the development of a major new barrier to be delayed until more is known.

The TE2100 plan also includes a monitoring and continuous process of re-evaluation. The monitoring process provides the triggers (discussed in Tarrant and Sayers, 2010) for the decisions within the pipeline. For example, if monitoring reveals that climate change is happening more quickly (or slowly) than predicted, the strategy can be reappraised in light of the new information, and options can be brought forward (or put back). Some decisions, once made, require a considerable lead time to implement. This lag time between deciding to act and delivering that action is allowed for in the plan (*e.g.* the completion of the Thames Barrier took 30 years to plan, design and deliver). The resulting TE2100 Plan[i] sets out a management strategy that can be adapted in response to future change including climate and socio-economic change.



Source: Tarrant and Sayers, 2012 after Environment Agency 2009
Thames Estuary 2100 Plan presented as a decision tree

In considering the measures to promote adaptive capacity, the role of flood protection should be considered as a support to actions that reduced vulnerability and exposure as a priority (where possible) and where required are implemented in such a way as to maintain room for the river or coastal dynamics in response to sea level rise. Figure A1-3 presents a flow chart to aid the decision process and promote the creation of an adaptive strategy.



Source: Sayers et al., 2015

Figure Flow chart to help guide the development of adaptive management measures

Supporting definitions from ISO 14090:2019 on Adaptation to climate change – Principles, requirements and guidelines are included in Box A1-2

Box x Selected definitions (based on ISO 14090:2019)

Adaptation: process of adjustment to actual or expected change and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention can facilitate adjustment to expected climate and its effects.

Adaptive capacity: ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences

Adaptive management: process of iteratively planning, implementing and modifying strategies for managing resources in the face of uncertainty and change. Adaptive management involves adjusting approaches in response to observations of their effects and changes in the system brought on by resulting feedback effects and other variables.

Threshold: the point at which a system is deemed to be no longer effective (economically, socially, technologically or environmentally) as a result of the average or extreme climatic conditions.

Appendix 1.3 Inclusivity

Inclusivity is one of the key concerns in order to achieve resilience in building climate change adaptation (Cities IPCC, 2018; Dodman et al, 2018). There is a clear concern that climate change will disproportionately affect groups of communities in a different way. However, it is the disadvantaged and vulnerable communities that are disproportionately at higher risk from the effects of climate change, such as sea level rise, drought and flood hazards, as reported in the Intergovernmental Panel on Climate Change (IPCC) Special Report on the Impact of Global Warming 1.5° C. Most concerning is that social inequalities could be worsened with the effects of climate change.

At the international level, there is a clear principle of "leave no one behind" to adapt to climate change and, more broadly, to contribute to achieving sustainable development targets under the Sustainable Development Goals (SDGs) Agenda. This principle means an inclusive approach for planning and governing climate change adaptation should shift away from a managerialist, technical-rational and top-down approach to a more deliberative engagement that places stakeholders' knowledge, opinions and aspirations to be central (Few et al, 2007). In this sense, public participation in climate change adaptation has the potential to avoid "empty ritual of participation" (Arnstein, 1969, p.216) and provide "a forum for proactive deliberation" (Few et al, 2012, p.57). Social justice and fairness should also be considered when targeting climate change adaptation options, especially for the most socially vulnerable groups of population (Sayers et al, 2017). An inclusive climate change adaptation should avoid the marginalization of specific groups of communities, siloes among different agencies, and covert participation during all the process – planning, implementing, and evaluating current and future climate change adaptation options.

What does an inclusive climate change adaptation mean?

An inclusive climate change adaptation is a collaborative process in reducing the effects of climate change while at the same time, ensuring that the benefits and burden of climate change adaptation are equitably distributed. Inclusivity is a central core in governing climate change adaptation, where the process involves a wide range of stakeholders from public, private to civil society in designing policies and actions that are fair and accessible, and equitably distributing the climate policy impacts.

Inclusivity in climate change adaptation should be understood as a process, rather than an output. This means building climate change adaptation should invest in efforts to co-produce "a process of dynamic, collective learning involving for whom an issue is of particular concern" (Lane et al, 2011, p.18). The process should support the role of 'concerned groups', e.g. stakeholders and/or groups of communities that will be affected by a specific adaptation option, to involve not only on the problem-solving and analysis but more importantly to have meaningful participation in the decision-making process. An inclusive climate change adaptation clearly values a citizen-science process. Building climate change adaptation should also value local wisdom and public knowledge as a credible source of expertise. Moreover, three key components on inclusivity in climate change adaptation should consider:

1. Social equity: a call for equitable distribution of benefits and burdens to communities from the effects of climate change.
2. Transparency: the goal and outcomes of climate change options should be made transparent, and the process should build legitimacy from all stakeholders and groups of communities.
3. Representation: the process must ensure meaningful participation with active involvement and representation from a wide range of stakeholders and communities in taking decisions.

Why is inclusive climate change adaptation important?

Climate change is a social problem. It is recognized that the negative effects of climate change commonly experience more frequently and severely by marginalized and disadvantaged populations, while the benefits are often distributed unequally. In order to avoid wider inequalities as the effect of climate change adaptation options, efforts to build a C2C approach should address both climate change and socioeconomic inequalities.

When should inclusive climate change adaptation occur?

Inclusive climate adaptation will occur at different forms of spatial scales and multi-level governance, from an international, national, regional and local level. It also involves an array of heterogeneous stakeholders, from governments, non-governmental organizations, business, and local communities to participate in planning and policy intervention.

There are three elements of inclusivity which are widely used as an instrumental framing to build climate change actions especially by the C40, an international network of world cities committed to addressing climate change (USAID, 2019):

1. Inclusivity of process: engagement of a wide range of stakeholders and groups of communities.
2. Inclusivity of policy: fairness and accessibility in design and delivery of climate adaptation options.
3. Inclusivity of impact: wider benefits of adaptation action, distributed as equitably as possible.

How can inclusive climate change adaptation be achieved?

Collaborative planning is an important mechanism to build an inclusive climate change adaptation. While it is a context-specific, and there is no "one size fits all" type, collaborative planning towards an inclusive climate change adaptation typically engage to (USAID, 2019):

1. Identity interconnectedness between multiple benefits that integrate social and economic equity and future climates.
2. Ensure meaningful participation from all stakeholders and groups of communities as well as mediate siloes among agencies during consultation, planning, implementing, and evaluating process.
3. Avoid maladaptation and develop opportunities to implement climate change adaptation actions that directly benefit underrepresented, disadvantaged and vulnerable groups of communities.
4. Establish tangible forms of collaboration, partnership and cooperation among stakeholders, e.g. governments, non-government organization (NGOs), and business as well as diverse groups of communities or population.
5. Offer just environmental planning and sustainable actions to implement climate change adaptation options.

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Appendix 1.4 Whole system

Achieving a whole system approach can be a daunting task. The use of Source-Pathway-Receptor framework[3] can be a useful and practical aid to this process (as adopted in FAIR). This framework provides a practical means of separating the basic components of environment risk into its constituent components (DETR, 2000). The SPR framework helps exploring the 'whole system' that influences flood probability, probability that flood waters will reach a location and the consequences for the affected system. This structured understanding of the system also enables interactions to understood, and the way risk may cascade and escalate through systems.

The Source-Pathway-Receptor framework has three system state descriptors:

1. The **source** of a flood (rainfall, storms, high river discharge);
2. The **pathway** of flood water: taking account of the performance of the intervening system of wetlands, channels, dams, levees, gates, floodwalls and other structures;
3. The **receptors** that are exposed: reflected by both the vulnerability of the receptors and the chance that a given receptor will be exposed to the flood when it occurs (figure below).

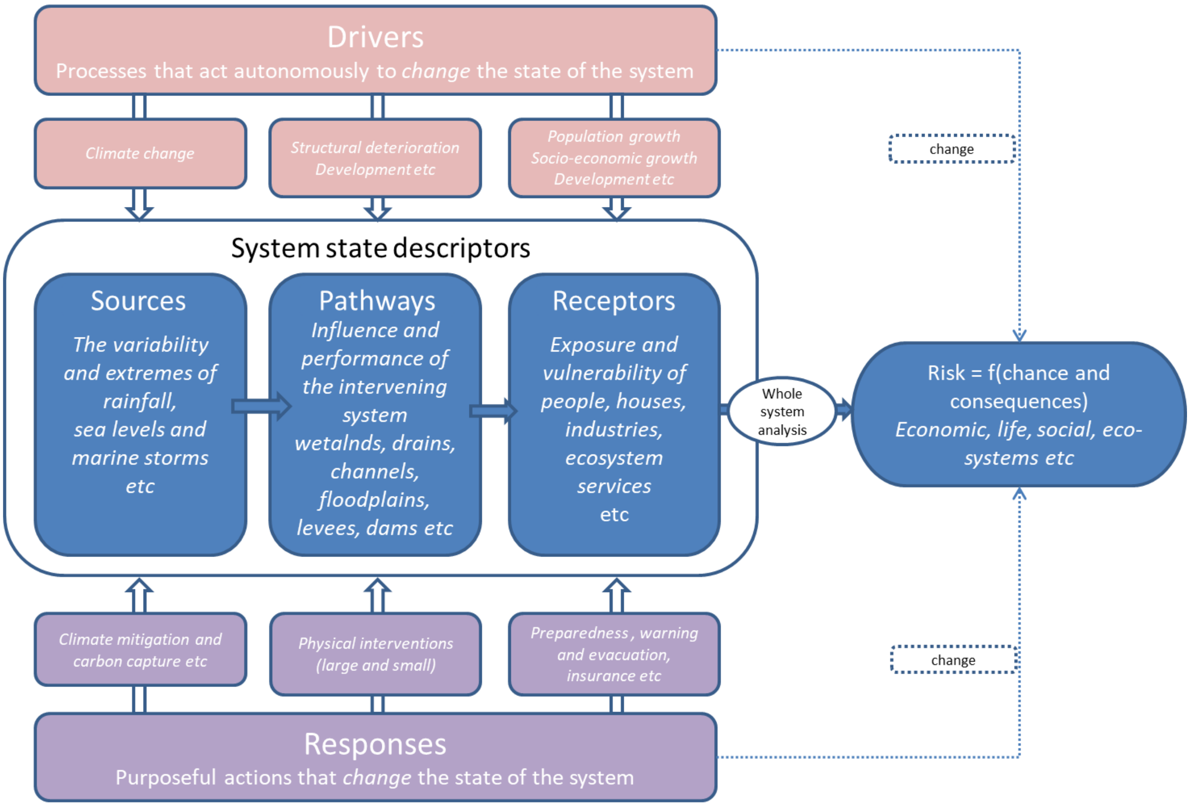

Figure Drivers and responses include different aspects of the SPR framework[4]

Cascading effects

The strong linkages between components in complex systems can mean that failure in one or more components can lead to cascading, and potentially escalating, impacts in space or time. Typically there are three broad categories of interactions (as elaborated in Sayers et al., 2014):

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[3] Sayers PB; Hall JW; Meadowcroft IC (2002). Towards risk-based flood hazard management in the UK. Civil Engineering 2002, 150(5), 36-42.

[4] P. Sayers, Y. Li, G. Galloway, E. Penning-Rowsell, F. Shen, K. Wen, Y. Chen, and T. Le Quesne. Flood Risk Management: A strategic approach (2013). Published in 2013 by the United Nations Educational, Scientific and Cultural Organization 7, place de Fontenoy, 75352 Paris 07SP, France © UNESCO 2013 in association with Asian Development Bank, WWF-International and the GIWP, China. ISBN 978-92-3-001159-8.

- ***Cascading impacts*****:** a disruption in one infrastructure causes a disruption in a second infrastructure, or disruption to one aspect of the supply chain can have impacts to reliant business up and down the chain (with potentially global reach). Such cascading risks can, on occasion, have a greater impact than the initial flood water. For example, a lack of access to safe drinking water and sanitation during a flood can generate secondary public health impacts.
- ***Escalating impacts*****:** a disruption in one infrastructure, or to one element of the supply chain, exacerbates disruption to another.
- ***Coherent impacts*****:** a disruption of two or more infrastructures at the same time because of a common cause (e.g. directly affected by initiating natural disaster for example or indirectly where reliant on the same, failed, supply chain). Such interactions can be generated through many different types of linkages as illustrated by Rinaldi and his colleagues (2001) in Figure X.

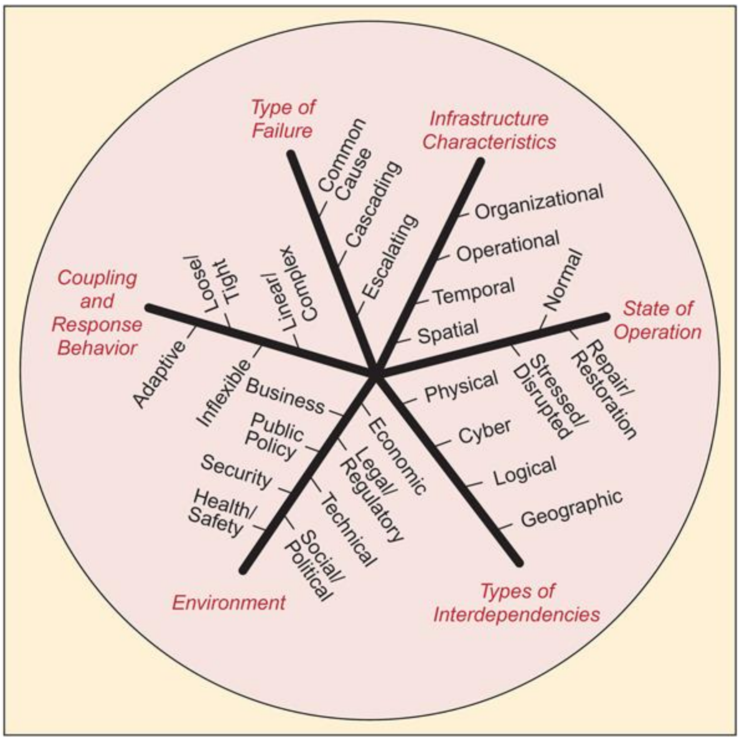

Figure Dimensions for describing infrastructure interdependencies (Rinaldi et al, 2001)

Understanding systems performance

Every system has their own dynamic, behaviour and performance. When multiple systems are relevant for a resilient environment, each system needs their goals and indicators. These goals are agreed upon by its stakeholders and describe the desired state of a system (see text box ‘example of systems performance’). This provides the ways to increase the resilience of the ‘whole system’ as you can set a base line for the system (what is the current state) and what are the goals for the system (desired resilient state)? If the system doesn’t reach its desired state, measures can be defined to reach the desired state. Moreover, measures to increase resilience can reside within other systems. This is true for the whole water system, as opportunities for flood resilience can be found in the water system itself, but also in other interconnected and interdependent systems, for example in the context of housing, infrastructure or energy system.

Box A4-1 example of systems performance

The functioning of the Dutch highway system is being measured by the availability and level of safety. Different parts of the highway network have different requirements and goals of availability they have to meet. For example, ring roads must meet the highest category. These requirements are agreed upon in 'service level agreements' with the Ministry of Infrastructure and Water Management. If the availability of the system drops under the agreed level of service, the system isn't functioning as desired and measures have to be taken. Measures can be defined in the infrastructure system itself, for example by broadening a highway, or by adapting adjacent systems, like smart mobility measures such as Truck Platooning which is part of the bigger mobility system.

Box A4-2 Selected definitions (based on ISO 14090:2019)

Systems Thinking: climate change adaptation processes include an understanding of cross-cutting (systemic) issues of the organisation by examining internal and external interdependencies and linkages, for example through case and effect relationships.

Appendix 2: Supporting tools

The supporting projects have developed a plethora of the tools that may be useful to support the Cloud-to-Coast approach. Selected tools are summarised below with links to more detail.

Stakeholder engagement

Name and type	Description	Link
Software, guidance, etc		

Whole system analysis

Name and type	Description	Link
Software, guidance, etc		

Whole life costing

Name and type	Description	Link
Software, guidance, etc		

Visualizing and appraising alternative futures

Name and type	Description	Link
Software, guidance, etc		

Measuring resilience outcomes

Name and type	Description	Link
Software, guidance, etc		

Learning lessons and evaluating

Name and type	Description	Link
Software, guidance, etc		