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Tidal Flooding on the Clyde

Options analysis and scoping of adaptation pathways study – summary report

May 2022

For full report prepared by Rivelin Bridge for ClimateXChange and Clyde Mission see https://www.climatexchange.org.uk/research/projects/tidal-flooding-on-the-clyde-options-analysis-and-scoping-of-adaptation-pathways/

1 Climate adaptation and the Clyde

1.1 Project aims

Adaptation pathways is a decision-making tool employed to adapt to climate change and the inherent uncertainties of future risk. The research this summary is based on set out to explore the evidence base to help design and apply adaptation (investment) pathways to the tidal reach of the Clyde drawing on international practice and UK guidance.

At a national level the research can support the delivery of the Second Climate Change Adaptation Programme (SCCAP)[1] by **informing development of a credible climate adaptation plan for the tidal reach of the river Clyde,** and provide practical insights that can be shared with other regions.

At a regional and local level, the findings are designed to support the Clyde Mission[2], which is working across public and private sectors to ensure the Clyde is adaptable and resilient to the effects of climate change; and achieve the grand challenge **"to make the Clyde an engine of sustainable and inclusive growth"**.

1.2 The river and the region

Over the last 200 years the Clyde has experienced significant adaptation and transformation. As the region looks ahead, this continued transformation will be essential to addressing future climate shocks and stresses (including tidal flood risk), alongside socio-economic and environmental ambitions; to meet the needs and aspirations of both current and future generations.

[1] https://www.gov.scot/publications/climate-ready-scotland-second-scottish-climate-change-adaptation-programme-2019-2024/

[2] Clyde Mission is a cross-sector collective of those with the knowledge, resource and levers that can help to achieve the Grand Challenge. It comprises five interlinked Missions, that seek to deliver benefits for the environment, businesses and communities. Those five Missions are: Create new, good and green jobs and a workforce with the skills to secure those jobs; Use vacant and derelict land for the benefit of the economy, the environment and communities; Adapt to climate risks, especially flooding; Accelerate Scotland's progress to net zero; and Use the river to create better places for people and communities.

Building on this history of adaptation, stakeholders have expressed a desire to re-imagine the current relationship between the river, people and place; to create a vibrant connected river corridor and waterfront, and make the river *"an asset to be proud of".* The approach to adaptation for the Clyde will therefore need to be transformation-orientated, with place making and resilience at the heart of investment decision making and future pathway design.

1.3 Sea level, climate change and adaptation

With climate change it is plausible for mean sea levels in the Clyde to rise by 1.5m to 2.5m over the next 120 years, and higher still in the future. The consequence, if adaptation actions are not taken, is areas that are currently exposed to occasional flooding from coastal storms and tidal surges will become inter-tidal or permanently under water.

Within the context of traditional planning timeframes, which are typically 5-25 years, sea level rise may appear to be *"non-urgent"* to decision makers. However, considering today's investments will shape the infrastructure and land-use well into the next century, planning for sea level rise and tidal flood risk becomes *"important"* in the short-term.

The practice of adaptation pathways is flexible enough to be used as an investment decision making framework and/or as a project planning tool. For the Clyde, the practice has most to offer, in the short-term, as a decision-making framework. This will enable the approach to work alongside established governance arrangements and delivery routes (public and private), to embed resilience and adaptation within existing and near-term plans; and inform shared ambitions and plausible investment pathways.

2 Designing for resilience

2.1 Adaptation measures

The research identified a range of opportunities that are available for the Clyde Estuary today and into the future. Common for the opportunities is that they combine different adaptation measures to *anticipate; resist and absorb; respond and recover; and adapt and transform*.

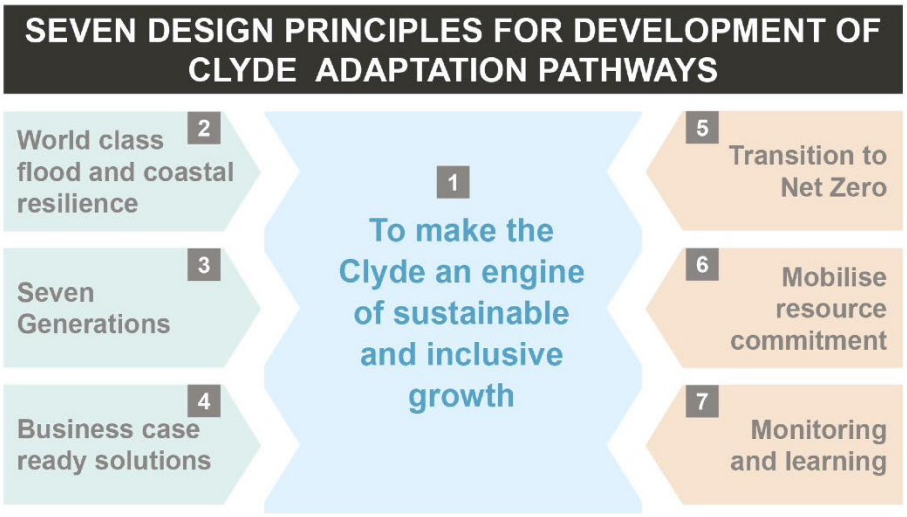
Adaptation measures include non-structural *soft* measures, natural and nature based *green* measures, and physical engineered *grey* measures.

Together this provides a portfolio of opportunities for the Clyde. To deliver long-term resilience it is important that future investments adopt a portfolio of measures that address both physical interventions and wider interventions to deal with emergency response and transformation. This approach can deliver both coping capacity and adaptive capacity.

2.2 Design principles

A wide range of strategic options and choices for the application of adaptation pathways, and tactical options for starting the process and route-map development and actions, is available for the Clyde. The future choices will be dependent on the framing of the adaptation ambitions. It is important that the ambitions and associated objectives and outcomes are co-designed with stakeholders right from the start. Figure 1 sets out seven design principles that draw on existing policies, plans and stakeholder insights; and provide a starting point for future development.

Figure 1: Design principles for development of Clyde adaptation pathways



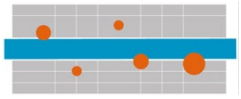
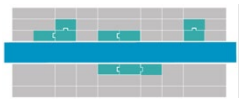
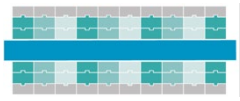
3 Investment options and pathways

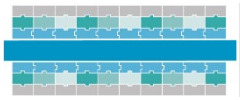
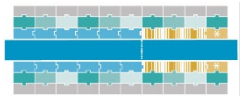
3.1 Strategic approaches

New infrastructure investments, due to their long asset life and the potential cost and complexity of replacement, need to be designed for uncertainties; and consider long-term sea-level rise implications on business case decisions.

The research has identified a number of strategic approaches to option development for the Clyde, described in table 1 below.

Table 1 Strategic Investment Choices for the Clyde

Strategic Choice	Description
Business as Usual 	Continue decision making based on national prioritisation of hot-spots and risk within a rolling 6-year investment programme. Impacts: Reach and/or neighbourhood scale. Example: The Clyde and Loch Lomond Flood Risk Management Plan.
Strategic Wins 	In combination with Business as Usual, invest in options that deliver system-wide adaptation benefits, maximise future choices and/or actively shape and inform pathway design. Impacts: System-wide and/or reach. Examples: Creation of new tidal wetlands, and adaptation of critical road and rail infrastructure.
Blue-Green Units 	Establish Blue-Green Spatial Units that enable development choices and implementation at the reach/neighbourhood whilst fostering system-wide integration. Impacts: System-wide, reach and neighbourhood scale.

	Examples: Shoreline Management Plans, San Francisco Bay Shoreline Adaptation Atlas (Operational Landscape Units)
Blue-belt 	In combination with Blue-Green Spatial Units invest actively in an accessible and resilient waterfront along the length of the Clyde. Impacts: System-wide, reach and neighbourhood scale. Examples: The Big-U New York City[3]
Blue-belt + Barrage 	In combination with Blue-Belt invest in a multi-functional inner Clyde barrage. Impacts: System-wide, reach and neighbourhood scale. Examples: Tees Barrage and Tawe Barrage.

Building on these strategic choices we have developed five plausible adaptation investment pathways for the Clyde. These pathways are described in *Table 2* below.

Table 2 – Five plausible adaptation investment pathways for the Clyde

ID	Pathway Name	Description of the investment journey	Main driver for the Business Case
A	Reactive	Rolling programme of Business-as-Usual flood risk management investments at the reach and/or neighbourhood scale.	Value at Risk
B1	Delayed Adaptation	Business as Usual in the near future, followed by a managed transition of strategic wins and blue-belt development, followed by development of a multi-functional barrage in the next century.	Value at Risk
B2	Managed Transformation	A managed transition applying the strategic choices as adaptation steps: Business as Usual, Strategic Wins, Blue-Green Unit and Blue-Belt this century, backed-up with the planned possibility for a Clyde Barrage in the next century.	Value at Risk
C1	Mission-based One	System wide development of an accessible and resilient waterfront based on no physical restriction to tidal movement and river flows; starting with strategic wins in the short-term, Blue-Green Unit development within the next two decades, and incremental development of a system-wide masterplan accommodating flexible land use policies.	Value Potential

[3] https://www.youtube.com/watch?v=GEmVETFPR3c

C2	Mission-based Two	System wide development of an accessible and resilient waterfront including an inner Clyde multi-functional barrier; starting with strategic wins in the short-term, Blue-Green Unit development within the next two decades, and multi-functional barrage implementation mid-century onwards.	Value Potential

3.2 IInvestment practice shift

Adaptation to tidal flood risk on the Clyde is unlikely to satisfy stakeholder ambitions unless it is supported by a shift in appraisal and investment practice that unlocks wider sources of funding and finance.

The shift will need to drive public and private investment, and sustain a working portfolio of projects that collectively realise multiple (societal, economic and environmental) benefits to enhance the resilience of the Clyde today and in the future.

The research used best practice in adaptation pathways[4] and builds on previous ClimateXChange research[5] in discussing investment options.

3.3 Resource commitment

Adaptation pathway approaches will assist decision making and development of solutions for the *"non-urgent but important"* impacts of sea level rise and tidal flood risk. Existing flood risk management investment practices and mindsets will however be insufficient to foster the public-private collaboration and innovation to deliver transformation-orientated adaptation. For adaptation to succeed, it will be necessary to embrace new ways of working and build multidisciplinary team(s) supported by dedicated resources and early investment.

4 A Mission-based approach

One of the challenges to future decision making and investment on the Clyde is how best to align and co-ordinate the application of adaptation pathway practices within the landscape of initiatives, strategies and plans that already exist. Adopting a Mission-based approach will provide a strong operational framework to drive ambitions, action and investment in the immediate future, and a platform for creating the enabling environment to deliver system-wide resilience and meet the needs of future generations.

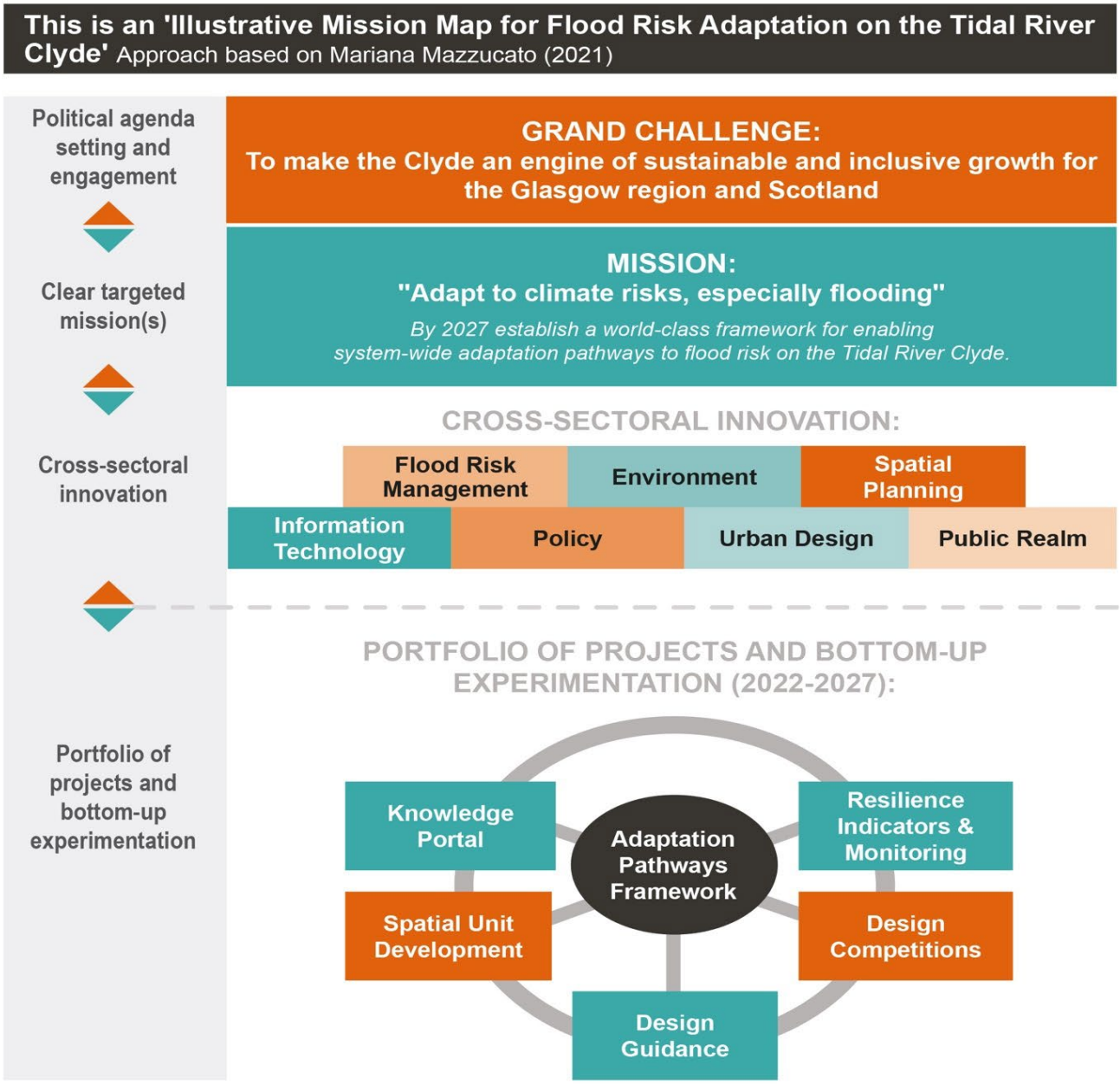
A key aspect of Mission-based approaches is stakeholder collaboration in the co-design of mission maps, narratives, visualisation and SMART goals aligned to opportunities for cross-sectoral innovation, and a clear and actionable portfolio of projects to enable bottom-up action and experimentation. It is not the place of this research to prescribe a Mission Map. However, to provide a starting point for exploration, *Figure 2* provides an illustration of what this could look like for the Tidal River Clyde based on the approach of Marianna Mazzucato[6] (2021).

[4] as set out in BS8631:2021 'Adaptation to climate change – Using adaptation pathways for decision making – Guide' https://shop.bsigroup.com/products/adaptation-to-climate-change-using-adaptation-pathways-for-decision-making-guide/standard

[5] https://www.climatexchange.org.uk/research/projects/international-practice-on-assessing-investment-needs-and-securing-investment-to-adapt/

[6] Mission Economy: A Moonshot Guide to Changing Capitalism, Penguin Random House UK, 2021

Figure 2: Illustration of a Mission Map for adaptation



Project Descriptions:

Adaptation Pathways Framework. Establish process and governance for driving adaptation and learning on the River Clyde

Knowledge Portal. Develop and promote an accessible knowledge portal to support cross-sector collaboration, adaptation engagement and capacity building.

Spatial Unit Development. Develop operational spatial units to support integrated decision making between system, reach and neighbourhood scales.

Design Guidance: Co-create design and investment guidance for a future Blue-belt on the Clyde (for built environment and infrastructure investments).

Design Competitions. Collaborative design competitions to explore strategic opportunities and enable or pilot new solutions.

Resilience Indicators & Monitoring: Develop place-based indicators to monitoring changes in resilience accounting for climate change and adaptation investments.

5 Options for Clyde adaptation pathways

5.1 Developing a framework

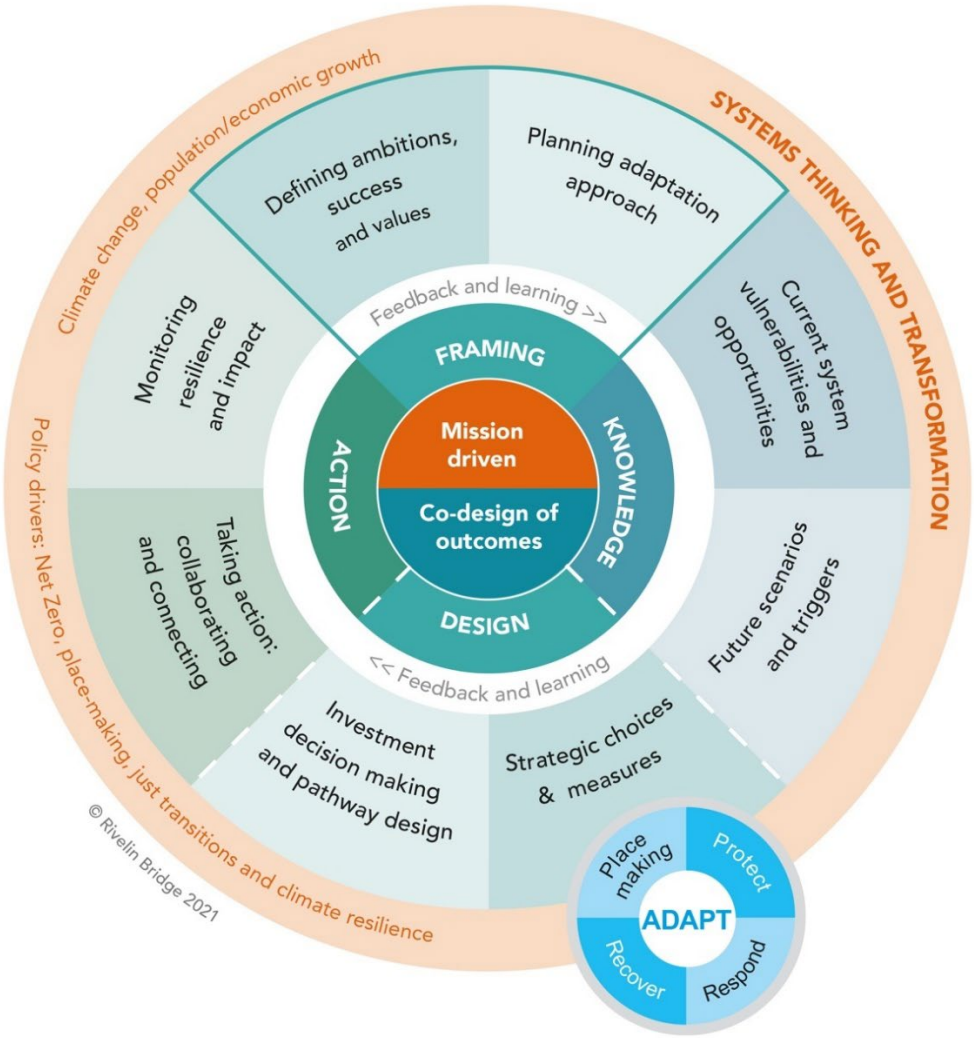
To progress the practice of adaptation pathways for the Clyde, it is important *"not to rush to solutions"*, but instead focus time, money and resources on: creating a shared vision of desirable futures and framing ambitions; establishing working practices for collaborative decision-making, innovation and learning; and developing a system-wide understanding of resilience and adaptation choices at a strategic level.

These are core foundations for enabling an adaptation pathways approach to be implemented for the Clyde, providing the 'framing' for future: knowledge, design and action stages.

Building on the practices explored in this report, *Figure 3* illustrates a starting point for a Clyde specific framework for adaptation pathways design, framed around:

- 2 principles: systems thinking and transformation
- 2 core aspects to the process: mission-based and co-design of outcomes
- 4 core inter-dependent pillars: framing, knowledge, design and action, and
- 8 procedural steps connected by feedback and learning.

Figure 3: A framework for adaptation pathways design for the Clyde



5.2 Building adaptation capacities and competence

Central to tackling the adaptation challenge for the Clyde is building and sustaining adaptation capacities and competence over the next decade to successfully foster systems thinking, collaboration and co-design of outcomes and solutions. Fulfilling four key design roles within the process will be important to success. These roles will support a more design-led approach which can flexibly respond to both risks and opportunities.

Table 3 Key Design Iroles / competencies (source Design Council 2021)[7]

Four key design roles / competencies	
Systems thinker	Someone who has the ability to see how everything is interconnected in a bigger picture and zoom between the micro and macro and across silos.
Leader and storyteller	Someone who can tell a great story about what might be possible and why it is important, get buy-in from all levels and have the tenacity to see the work through.
Designer and maker	Someone who understands the power of design and innovation tools, has the technical and creative skills to make things happen, and put these to work early in the process.
Connector and convenor	Someone who has good relationships, can create spaces where people from different background come together, and joins the dots to create a bigger movement.

5.3 Recommended first steps for adaptation on the Clyde

- R1.1 agree a *framework* for the application of adaptation pathways for the Clyde that fosters systems-thinking and a process for place-based decision making;
- R1.2 agree what "a resilient Clyde" means, to inform *design principles* for investment and pathway development, and shape indicators for monitoring and evaluation;
- R1.3 establish a '*resilience zone'*, a geographic boundary for decision-making;
- R1.4 build an action plan (*Mission Map*) for the first five years of investment; and
- R1.5 scope and develop a knowledge portal to support innovation, collaboration and long-term monitoring and evaluation.

These recommendations are demanding and will require stakeholders to think in new ways and commit time and energy to the process. The potential reward, in terms of addressing tidal flood risk and achieving the grand challenge *'to make the Clyde an engine of sustainable and inclusive growth'* is locally, regionally and nationally compelling.

The full research report [link] includes further detail on implementing these recommendations and also further step.

[7] https://www.designcouncil.org.uk/resources/guide/beyond-net-zero-systemic-design-approach

Glossary

Adaptation – The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate of exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustments to expected climate and its effects. (*Source: Intergovernmental Panel on Climate Change 2014*)[8]

Incremental adaptation: Adaptation actions where the central aim is to maintain the essence and integrity of a system of process at a given scale.

Transformational adaptation*:* Adaptation that changes the fundamental attributes of a system in response to climate and its effects.

Adaptive management - process of iteratively planning, implementing and modifying strategies for managing resources in the face of uncertainty. Note – 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. (*Source: BS8631:2021*[9]*)*

Adaptation Pathways (APs) – series of adaptation choices involving trade-offs between short-term and long-term goals and values (Note: These are processes of deliberation to identify solutions that are meaningful to people in the context of their daily lives and to avoid maladaptation). (*Source: BS8631:2021*)

Mission – a concrete target, achievable step towards a grand challenge that contextualises projects. (*Source Mazzucato, M and Dibb, G. (2019). Missions: A beginner's guide. UCL Institute for Innovation and Public Purpose, Policy Brief series (IIPP PB 09*)[10])

Resilience – The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning and transformation. (*Source: Intergovernmental Panel on Climate Change 2014*)

System – A set of elements or parts that is coherently organised and interconnected in a pattern or structure that produces a characteristic set of behaviours, often classified as its "function" or "purpose" (*Source: Donella H. Meadows, "Thinking in Systems" 2008, Sustainability Institute)*

Systems thinking – is a set of synergistic analytic skills used to improve the capability of identifying and understanding systems, predicting their behaviours, and devising modifications to them in order to produce desired affects. These skills work together as a system. (*Source: Ross D. Arnold, Jon P. Wade, 2015*[11])

[8] https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-TS_FINAL.pdf
[9] https://standardsdevelopment.bsigroup.com/projects/2019-00219#/section
[10] https://www.ucl.ac.uk/bartlett/public-purpose/sites/public-purpose/files/iipp_policy_brief_09_missions_a_beginners_guide.pdf

[11] https://doi.org/10.1016/j.procs.2015.03.050

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