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Flexible Adaptation Pathways

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1. Key Points

Flexible adaptation pathways:

- **Focus on recognising and addressing the long-term and uncertain nature of climate change** by enabling the systematic adjustment of adaptation strategies in response to new information and changing circumstances, in ways that are as efficient and transparent as possible;
- **Use a risk-based decision framework based upon acceptable and unacceptable levels of risk** for different issues; and work on the basis that if flexible adaptation is pursued, then risk will be kept at an acceptable level;
- **Set limits and decision criteria (triggers) for risks** which identify when critical thresholds or tipping points are likely to be reached leading to very severe impacts and potentially irreversible consequences; identify alternative adaptation pathways for risks should thresholds be approached;
- **Utilise pathways consisting of *robust* adaptation actions** that work reasonably well across a wide range of circumstances both now and in the future (as opposed to those that are optimised for present-day conditions or a single future outcome that ignores uncertainty);
- **Incorporate low and no regrets actions,** usually with the implication that these can be implemented now, whilst further research is conducted to enable informed flexible pathways to be established for longer-term aims;
- Are sometimes referred to explicitly, but the term is used interchangeably with **'decision pathways'** and **'route-map approaches'**;
- **Were first and most prescriptively used** (according to the literature scoped in this study) in work by the Environment Agency **in developing a long-term tidal flood risk management plan for London and the Thames Estuary**; but have also been applied more widely in the City of London and by the Greater London Authority, by New York City and New York State. They are also being piloted in Australia and are referred to in adaptation guidance produced by the New Zealand government;

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- **Have been used mainly to plan adaptation** in situations which are quantifiable and for which there is a relatively strong evidence base. Where it has been applied e.g. Thames Estuary, there is little published information available on how this planning has occurred and its success in informing the decision-making process;
- **Have so far been applied at a relatively small spatial scale** i.e. at a particular location, community, or local authority level, rather than at a national or multi-state level;
- **Consider time-frames as short as next 8-10 years and as long as 90 years.** There is however very little information on timescales within the documentation.

In Scotland:

- **It seems feasible that the flexible pathway approach could be applied**. Its conceptual and practical application however need further exploration to better understand how it could best be utilised for a range of risks, sectors and spatial scales. The context-specific nature of adaptation would need to be carefully considered; as would the availability of tools and evidence;
- **It may well be possible to identify some form of threshold for most risks in most sectors**; it is perhaps easier however to identify and quantify thresholds for options in relation to engineering strategies;
- **It may be possible for the approach to be implemented at a number of concurrent levels** i.e. local and regional level strategies and thresholds alongside national level actions and policies with national level thresholds.

2. Introduction

This brief summarises a short piece of research that explored the concept of 'flexible adaptation pathways'. The work aimed to:

- Define the flexible adaptation pathways approach;
- Provide practical examples of how it is being used and in what context;
- Show how low-regret and no-regret options relate to the approach;
- Consider modifications to the approach;
- Offer ClimateXChange's opinion as to whether and where the approach might be applied in Scotland.

The work arose from ClimateXChange's comparative analysis of adaptation strategies (Low, Martin and Moss, 2012) which identified the flexible adaptation pathway approach being used to address adaptation in New York. The Scottish Government wanted to understand the approach in greater detail and whether it might be used to address climate change adaptation in Scotland.

3. Approach

The research involved the following stages:

- **Discussions with Adaptation Scotland** to identify the critical questions surrounding the approach, examples of its application and key contacts.
- **Scoping of literature** to understand how the flexible adaptation pathway approach has been defined and used in practice.
- **Email correspondence** with those involved in utilising the approach so as to gain further detail on its definition and its practical application.
- **A desk-based assessment** of whether and how the approach may be used in Scotland.

4. What are flexible adaptation pathways?

Climate change uncertainties are particularly problematic for planning large-scale, long-lived projects, such as public infrastructure and sector-level development programmes. These investments tend to be difficult or costly to reverse and their design is dependent on what assumptions are made at the start of the project about the climate over the lifetime of the investment. There are two main strategies to deal with this (Reeder & Ranger, 2011):

- **Incorporate flexibility in the adaptation measure from the start.** This can incur additional cost, but the benefit from the flexibility can outweigh this. However, this may not be practicable or the additional cost incurred may be difficult to justify.
- **Build the flexibility into the adaptation strategy** (rather than the individual measures) by sequencing the implementation of different measures over time. In this way, the system adapts to climate over time, but options are left open to deal with possible different future climates, via the selection of an appropriate pathway. This is regarded as a 'flexible adaptation pathway' approach.

'Flexible adaptation pathway(s)' is a relatively loose term but in general it refers to adaptation approaches that focus on the uncertain and long-term nature of climate change by employing a risk-based decision framework involving thresholds and trigger points that enable the systematic adjustment of adaptation strategies in response to new information and changing circumstances.

The approach is thought to have its roots in financial risk management, and takes three guidelines from monetary policies and applies them to climate change policies (Yohe & Leichenko, 2010):

- Keep long-term target options open as long as possible by setting decision-triggering thresholds,
- Aim to minimise adjustment costs of regularly implemented adjustment periods,
- Minimise administrative complexity by making adjustments as transparent and predictable as possible.
- In particular, flexible adaptation pathway approaches are based around ideas of **acceptable and unacceptable levels of risk** and the understanding that if flexible adaptation (as opposed to inflexible adaptation or no adaptation) is pursued, coupled with climate change mitigation, then risk will be kept below an unacceptable level (see Figure 1).

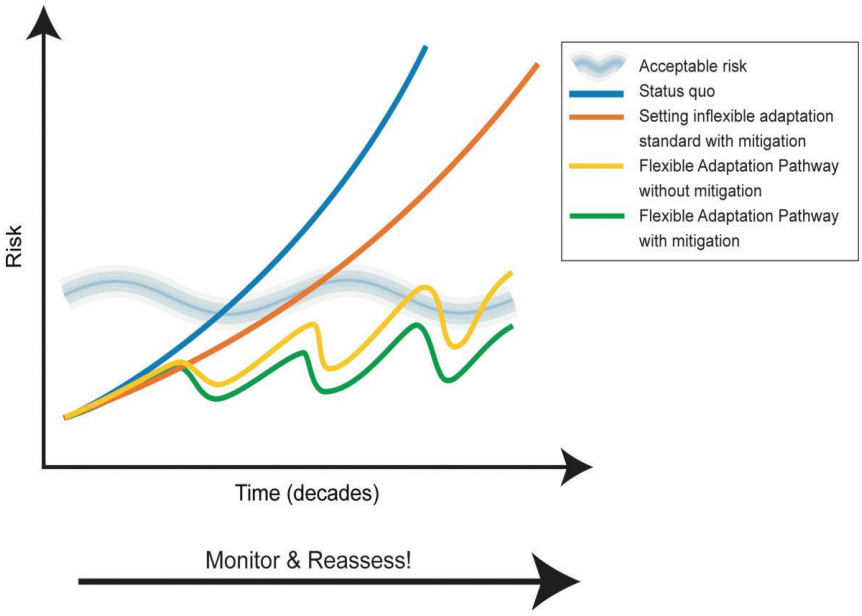

Figure 1 Changing risk in response to a Flexible Adaptation Pathway (adapted from Lowe *et al*, 2009)

The **pathways consist of a sequence of adaptation strategies and interim targets** that are related to long-term adaptation goals. The strategies and targets, however, evolve as knowledge of climate change develops and in ways that are as efficient and transparent as possible (Yohe & Leichenko, 2010). Systematic revisions are made through the use of **'trigger points'** which identify when **critical thresholds** are approached for irreversible or deleterious impacts and therefore when adaptation strategies should be adjusted. In some instances the alternative pathway is pre-planned, in others, a range of pathways are initially identified. The choice of pathway is kept flexible depending on resources available, acceptable level of risk and the availability of new information.

Flexible adaptation pathways therefore consist of adaptation measures that '**perform reasonably well now and in the near future** and can be modified or alternative complementary options introduced such that they perform reasonably well as the future unfolds' (Yohe & Leichenko, 2010). In other words they are based upon the idea that responses to uncertain circumstances that work reasonably well across a wide range of circumstances are more robust even if they do not work optimally well for any single outcome.

This differs from **a neo-classical economic approach** that would seek to define optimal adaptation solutions based on an accurate description of current and predicted future climates. This approach is not well suited to climate change which contains many layers of uncertainty relating not only to climate change and associated hazards but also to adaptive capacity (e.g. the availability of new knowledge and new technologies) and social and economic circumstances (e.g. changed attitudes about acceptable levels of risk). It is for these reasons that scenario analysis and scenario-based planning is commonly used in climate change adaptation.

Often flexible adaptation pathway approaches also incorporate **cost-benefit analysis (CBA) or multi-criteria analysis** to help identify preferred adaptation pathways and set decision-based thresholds. For example, the point at which cost of inaction outweighs the cost of taking adaptation action; or the point at which the relative benefit of continuing with one action is outweighed by another. This can have advantages in explicitly identifying the most appropriate decision criteria related to a range of benefits.

Monitoring and evaluation is essential to flexible adaptation pathway approaches so as to 'track and analyse the trajectories of change for key climate variables, impacts and the efficiency of existing adaptation processes in the context of evolving scientific knowledge' (Yohe & Leichenko, 2010). Also, to ensure that adaptation strategies should be reviewed and adjusted to remain within an accepted (safe) level of risk . This is particularly important given the potentially non-linear nature of climate change impacts.

Whilst the flexible adaptation pathway approach appears to have many advantages, it is worth adding a cautionary reminder that 'there are limits to the advantages of having a flexible policy – flexibility can incur additional costs for example, building deeper flood wall foundations to enable increased height to be added later, which need to be weighed against efficiency gains' (NPCC, 2010a).

5. How have flexible adaptation pathways been used?

From the scoping conducted as part of this work it appears that the term 'flexible adaptation pathway' is not widely used. In addition to those situations where the term is explicit, **a number of adaptation processes were identified which might be regarded as involving 'flexible adaptation pathways' but they were not referred to as such**. Other terminology potentially used interchangeably with 'flexible adaptation pathways' includes: 'decision pathways' and 'route-map approach' (Reeder & Ranger, 2011). The concept of 'route-maps' has also been used in other policy domains, notably climate change mitigation, although here the identification of a specific greenhouse gas emissions target provides the rationale (in this case related to defining a safe limit to avoid 'dangerous climate change'). Table One provides an overview of the use of flexible adaptation pathway approaches.

The first and **most precise and prescriptive use of the approach** has been by the Environment Agency in developing a long-term tidal flood risk management plan for London and the **Thames Estuary.** A flexible adaptation pathway approach has also been applied more widely in the **City of London** (NB whilst the adaptation strategy of the **Greater London Authority** also identifies the need to "develop flexible adaptations pathways for each climate risk" and lays out a comprehensive list of actions, with some associated timetabling for completion, the explicit nature of the intended flexibility of the strategies is not demonstrated (GLA, 2011)). Drawing upon the process used in the Thames Estuary as its inspiration, **New York City** (and subsequently **New York State**) then utilised the approach.

Flexible adaptation pathway approaches are also currently being piloted in **Australia** to address the risk of climate change induced coastal flooding (some as part of the national government's Coastal Adaptation Decision Pathways Project). **New Zealand** has also proposed guidance for local authorities on 'pathways to change' in relation to coastal adaptation to climate change. One approach set out by the guidance appears to be a flexible adaptation pathway approach, but a lack of detailed information prohibits us from making a complete appraisal of its uptake in New Zealand.

Overall it is possible to see that the flexible adaptation pathway approach tends to have been applied in situations that are **well understood, which are quantifiable and for which there is a reasonably strong evidence base**, including a high level of quantitative data availability. It also appears to have only been used in circumstances where clear decision frameworks can be applied, and where risks, thresholds and suites of solutions can be identified and understood. As such, it has mainly been applied in relation to **hard infrastructure and the physical environment** where engineered solutions are likely to play a role, for example in relation to flooding. The approach has also been mainly used to plan adaptation, and in some instances the utility of the approach being explored via pilot projects (which have yet to report). Where it has been applied e.g. Thames Estuary, there is little information available on how this process has occurred and its success to-date.

The complexity of the natural environment has meant that the preferred approach has been a more general adaptive management strategy[1], rather than to develop specific alternative pathways based upon certain decision

[1] Adaptive management strategies are structured iterative processes that focus on making robust decisions in the face of uncertainty. The aim is to reduce uncertainty over time via monitoring and evaluation. They focus on learning about the situation in question not just initiating change. As such they are cyclical process which moves from setting goals and understanding uncertainties, to designing and

criteria. However, the decision criteria are often apparent in the need to meet international obligations (e.g. EU Directives) and these could be used to scope flexible adaptation pathways.

Spatially, application of the approach tends to be relatively small-scale – i.e. at a particular location, community, or local authority level, rather than at a national or multi-state level. This may relate to the greater ease at which decision criteria can be defined at these levels (i.e. adaptation strategies depend on local context). However, whilst not being at a national level, the New York State report covers an area approximately two thirds the size of Scotland, with a population four times as big (though 40% reside in New York City). This wider spatial application (regional and landscape scale) was also seen as being relevant in Australia.

implementing actions to meet these goals. Monitoring and evaluating actions to understand their effectiveness and wider changes in circumstances enables objectives and actions to be revised in light of learning and changed circumstances.

Table 1: Overview of 'flexible adaptation pathway' approaches

Where	Key characteristics of the approach	Context	Spatial scale	Temporal scale	Stage
Thames Estuary, London	Overall policy & risk level set for each area, with associated portfolios of adaptation actions. Thresholds, lead times and decision points are used to inform & plan changes. Clearly defined potential pathways for major infrastructure.	Tidal flood risk management plan.	Thames Estuary and London.	Short term (25 years), medium term (40 years) and long term (till 2100).	Implemented.
City of London	Clear actions are identified and categorised as 'no regrets', 'low regrets', 'win-win' and/or 'flexible'.	City planning to manage risks from flooding, limited water resources and heat. Focused on all sectors, dependent upon assessed risk level.	City of London Corporation jurisdiction area.	No timescale apparent, though some deadlines for individual actions identified.	The 2010 revision document (CLC, 2010) refers to the 2007 version having been 'adopted' by the Corporation , with various actions detailed as already having been put in place in response.
New York City	Emphasises need for tipping points & impact triggers. Incorporates mitigation actions. A prioritisation framework is used to assess costs and timings. Priority to near term, low cost actions are identified. Emphasises the importance of mainstreaming.	City wide planning to limit risks to critical infrastructure from sea level rise, high temperatures, extreme events and changing precipitation.	Infrastructure in and around the city.	Planning guided by climate change scenarios, with focus on the 2020s, 2050s and 2080s.	New York City plans published in 2010.
New York State	Largely based on the methodology adopted for New York City.	State wide planning for all climate risks across 8 specified sectors (similar to Scotland).	State.	Goals for 2050 set.	Original planning was under a former Governor. The current leadership has halted further development or implementation.
Queensland, Australia	Emphasises different adaptation options and use of trigger points to identify acceptable levels of change before particular adaptation options must be implemented. Suggests generic trigger points.	Coastal land use planning in response to flood risk.	State guidance for use at community and local authority level.	No timescales specifically mentioned but infers the need to consider the year 2100 and beyond.	Adaptation planning guidance being tested via the Townsville pilot project.
Victoria, Australia	Identifies decision pathways and optimal adaptation measures to deal with uncertainty and/or long-timescales. Development of tools to help with the zoning of capacities and the identification of thresholds and trigger points .	Coastal land use planning in response to flood risk.	Community and local authority level.	Not referred to.	Adaptation planning pilot project.
New Zealand	Flexible adaptation process with use of adaptation tipping points as one possible approach. An 'adaptive management process' with regular monitoring and reviews to identify when these additional stages need to be implemented.	Coastal land use planning in response to flood risk.	National guidance for local authority use.	General references to 'long-term' decisions.	Adaptation planning guidance.

The case studies below provide further detail on the use of FAP in the Thames Estuary, London; New York City; and Victoria, Australia. Further case studies (New York State, Queensland Australia, and New Zealand) are available in Appendix One.

Case study: Thames Estuary, London

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. The project, lead by the Environment Agency, covers the Tidal Thames from Teddington in West London, through to Sheerness and Shoeburyness in Kent and Essex. A key driver for the project was **the need to develop an adaptable long term plan in the context of a changing estuary**. It was acknowledged that the Thames was changing in relation to its climate, people and property in the floodplain and an underlying essential but ageing flood defence system (Environment Agency, 2010). The TE2100 Plan contains recommendations on what actions the Environment Agency and others will need to take in the short (next 25 years), medium (the following 15 years) and long term (to the end of the century).

Each zone within the flood risk area was assigned one of 5 policies (e.g. 'No active intervention', 'Take further action to reduce the risk of flooding'). The policies set the strategic direction of flood risk management in each part of the Estuary. **The strategy is to then manage the flood risk according to risk level set by the policy, via a number of 'options' (portfolios of various adaptation actions)** (Environment Agency, 2009).

The plan identifies **ten key indicators** of the changes which will affect flood risk management. These "triggers for change" will be monitored throughout the life of the TE2100 Plan. The outputs from this monitoring will inform regular reviews and they will also trigger decision-making if rapid change occurs in one or more of the indicators. When one intervention ceases to be effective, another will be implemented; however the planning for this intervention may well have started decades earlier (Figure 2).

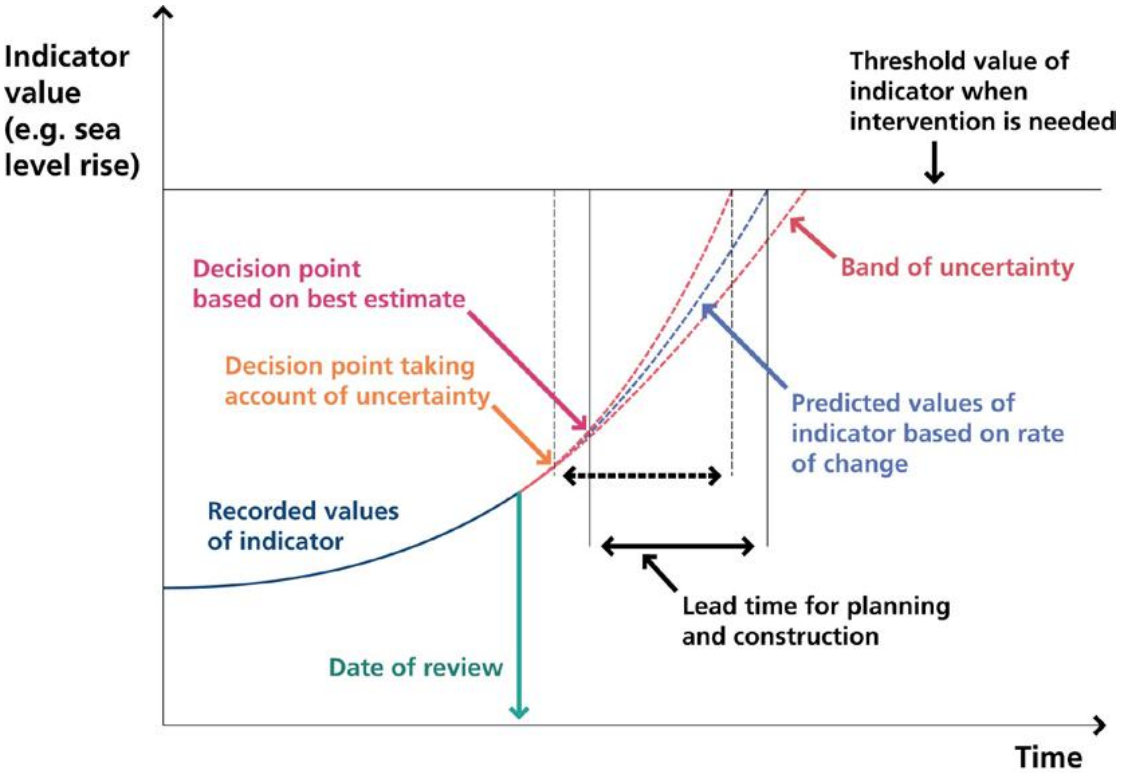

Figure 2 Schematic diagram of the thresholds, lead times and decision points approach from TE2100 (Reeder & Ranger, 2011)

The Environment Agency report (2009) identifies 5 main ways in which the Plan is/will be flexible:

- **Changes to the timing of new intervention:** If rates of change increase, interventions will be brought forward. If the rates of change are slower, then these interventions will be delayed.

- **Ability to change between options:** If the rate of change of a critical factor is significantly different from the expected rate of change, it may be necessary to switch to an alternative option which can cope more efficiently with these new conditions.

- **Adaptation of engineering responses:** Structures should be designed so that they can be adapted to changing circumstances. For example, providing foundations for new defences that can take higher future flood water loadings, or designing barriers and other control structures that can be modified in the future.

- **Safeguarding land for future options:** Each flood risk management option will require land for new defences, enlarged defences, new barriers, new areas of habitat creation, and in some cases flood storage.

- **Allowing adaptation to new infrastructure:** New infrastructure on the Thames estuary could have a major impact on flood risk management arrangements. For example, ports will require free access for navigation. Also, new transport links could provide the opportunity to combine a new crossing of the estuary with a new barrier.

Out of all the strategies reviewed for this study, TE2100 is the only one with already clearly defined potential pathways, with associated trigger points.

Case study: New York City

As part of **PlaNYC**, New York City's long-term sustainability plan, the New York City Panel on Climate Change (NPCC) was convened by Mayor Michael Bloomberg in August 2008. The city-wide strategy for adapting to climate change has been laid out in a major report and three related workbooks intended to guide the adaptation process (NPCC 2010a; 2010b). The work of the NPCC perhaps provides **one of the clearest examples of the intended application of 'Flexible Adaptation Pathways'**, as this is identified within the report as being the methodology the city will adopt wherever possible.

The London Thames project is cited as being the inspiring model for their approach. However, it is not apparent from the available documents to what extent the concept is being applied in a similar structured way. It is in relation to responses to low probability, high consequence events (as opposed to near/medium term incremental changes) that the report specifically identifies as requiring:

- Understanding of nonlinear tipping points and impact triggers;
- Decision pathways that suggest when and how to adopt different adaptation measures ;
- Dynamic evaluation.

(Yohe and Leichenko, 2010)

The New York City strategy identifies the necessity to **incorporate mitigation actions** alongside adaptation actions in order to maximise the ability for a strategy to reduce risk to within acceptable levels (Figure 1): "To make a risk management approach to climate change adaptation operational, we must craft iterative and flexible adaptation plans whose relative efficacy can and will be influenced by investment in mitigation" (NPCC, 2010a)

The plan identifies a number of key elements for a Flexible Adaptation Pathway approach:

- Guiding framework
- Stakeholder engagement
- Expert knowledge providers

- Recurring assessment process
- Action Plans by decision-makers
- Vertically/horizontally integrated projects with on-going evaluation

(NPCC, 2010a)

Like the London framework, New York City also utilises an 8-step framework (Figure 3). It does however differ to the London framework in the extent to which the flexible mechanism is identified: the London framework a) builds in (Step 2 – conduct inventory of infrastructure and assets) the establishment of criteria by which decisions will be made, and b) identifies smaller feedback loops (Figure 3). The 8 steps are designed to be incorporated into general planning and operations within an organization so that climate hazards are considered in all capital projects, repairs and operations.

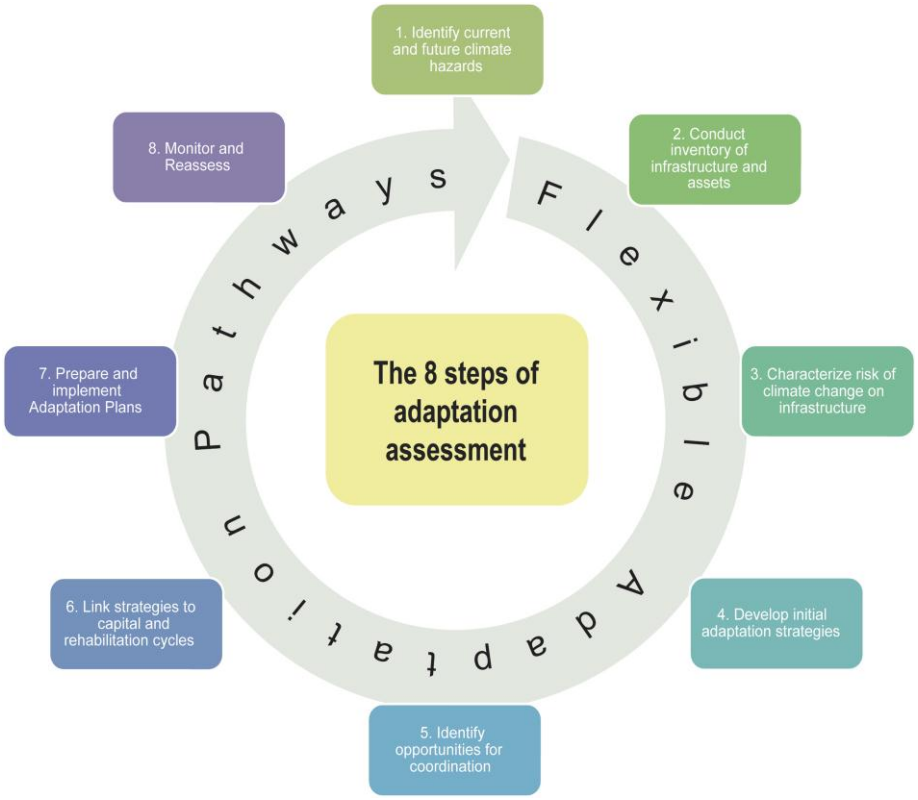

Figure 3 Adaptation Assessment Steps developed for New York City (NPCC, 2010b)

Under Step 4 (develop initial adaptation strategies), the plan identifies flexible adaptation pathways as just one consideration in selecting a strategy, implying an assumption that not all risks will be managed in this way (NPCC, 2010b).

The Executive Summary of the report (NPCC, 2010a) acknowledges the need for further studies to facilitate this approach, specifically to "identify, characterize, and understand nonlinear tipping points, triggers, and decision pathways". We have sought clarification from PlaNYC regarding the extent to which flexible adaptation pathways, involving identified thresholds and associated actions, have been implemented in their strategy.

Case study: Victoria, Australia

In Australia the national government has set up and funded a **Coastal Adaptation Decision Pathways Project** (www.climatechange.gov.au/en/government/initiatives/coastal-adaptation-decision-pathways.aspx). Consisting of 12 pilot projects (due to complete at the end of 2012), one focus of the project is on demonstrating the utility of

flexible pathways that incorporate future climate risk and adaptation actions into decision-making. Suggested issues for exploration within pilot projects are: flexible decision making, the use of thresholds and trigger points in decision-making, the identification of alternative decision pathways for on-going investment and relocation over decadal time-frames, and the costs, benefits and trade-offs of investment to build resilience at different time points in the life of an asset.

Of the pilot projects, the **'Deciding for the Coast'** project taking place in **Victoria, South-East Australia**, takes what might be regarded as a flexible adaptation pathway approach to land use planning in response to the risk of coastal zone flooding. The project aims to compile a comprehensive list of questions and answers and decision pathways, supported by tools to guide decisions about what adaptation option to implement to achieve optimal adaptation measures where costs and benefits may be uncertain and/or occur over a long time frame. Tools suggested include those helping to establish zoning capacities, overlays setting thresholds and trigger points beyond which actions might ensue, and when environmental, engineering or social responses should be considered. A list of assessment criteria for adaptation options will also be produced. The work focuses on the local community of West Port and will be applied within the local authority coastal hazard assessment and land use planning process. However, it is noted that the work may have application at regional and landscape scales. It has not been possible to obtain any further information on the project.

Other pilot projects within the Coastal Adaptation Decision Pathways Project may be taking a flexible adaptation pathway approach however it has not been possible to obtain sufficient information on them to make such a judgement. For example in Tasmania the **Tasmanian Coastal Adaptation Decision Pathways Project** is seeking to take a 'flexible community adaptation planning pathway' for four vulnerable coastal areas (Kingston beach, Roches beach / Lauderdale, St Helens and Port Sorell) (Tasmania Climate Change Office, 2012)).

The approach being taken does not prescribe a 'one-size fits-all' solution, but is a process to achieve adaptation responses. It involves a 'strategic options assessment' with preferences being made between pathways such as: 'Let nature take its course' and 'Protect existing and permit future development to the maximum possible extent for as long as possible'. Each strategy sets out 'how things might be with this scenario', 'options likely to be adopted for this scenario', actions over 0-10 year, 10-40 year and 40+ year time-scales, and 'things to think about and explore', including for example 'what if ': Sea levels don't rise? Rise faster?; It becomes stormier and erosion increases?; There is some major technology trend or innovation? It is not clear however how flexibility to accommodate such changes will be incorporated into the strategy.

6. How do low-regrets and no-regrets options relate to flexible adaptation pathways?

Flexible adaptation pathway approaches incorporate low and no regrets actions usually with the implication that these can be implemented now, whilst further research is conducted to enable informed flexible pathways to be established for longer-term aims. The flexible adaptation pathway process can therefore be beneficial in identifying shorter term low- and no regret options, in addition to longer-term benefits. The approach also has some interesting similarities with climate change mitigation planning (including 'transition pathways' to the low-carbon economy) which could help build synergies and help identify low- and no-regret options.

Of the three London approaches, **it is within the strategy developed by the City of London that low and no regret options (and 'win-win' options) are integral to the plan**. The adaptation options identified within the plan are grouped into research and monitoring, policy and practical actions, which are then categorised as either 'no-regrets', 'low-regrets', 'win-win' or 'flexible'.

However, despite its inclusion as a category, only 2 out of 34 of the subsequently identified actions were categorised as 'flexible' (see below) (both are from the 'Cross-cutting issues' section), and how this flexibility is to be achieved is not apparent:

- The City of London Corporation should develop Supplementary Planning Guidance for the LDF that focuses specifically on climate change adaptation, in the event that that the GLA's guidance does not adequately cover issues relevant to the City of London.
- The City of London Corporation should ensure that resourcing and delivery of waste management services is appropriate to cope with the added threats from climate change.

(City of London Corporation, 2010)

Identification of low-cost, near-term and easily implemented options forms part of the guidance document for the New York City strategy (NPCC, 2010b). The implication is that these can be implemented now, whilst further research is conducted to enable informed flexible pathways to be established for longer-term aims. The New York State proposed strategy utilises the same assessment framework, therefore, whilst not apparent, it is assumed that options were also categorised in a similar way.

In Queensland guidance (Department of Environment and Resource Management, 2012) (See Appendix One) **refers to the possible need for 'nuisance management'** as well as adaptation actions to address the longer-term impacts of climate change. Nuisance management includes minor adaptation measures to address low-level temporary impacts such as short-term flooding events during extreme weather, or wave over wash at high tides.

In **New Zealand guidance** (NIWA, 2011) (See Appendix One) suggests 'aiming for robust rather than optimal adaptation' and choosing **'low regrets options that will allow flexibility rather than the best possible options for an uncertain effect'**.

7. How do flexible adaptation pathway approaches fit with wider adaptation decision frameworks?

Flexible adaptation pathway approaches are compatible with, and usually have at their core, the adaptive management cycle (see for example Figures 3 & 4 of this report). In the New Zealand guidelines it is stated that the adaptation tipping point/scenario neutral approach simply considers how much climate change existing communities or infrastructure can cope with, leaving aside the timing of when it might happen to be 'addressed independently through an adaptive management process coupled with regular monitoring and reviews'. Flexible adaptation pathways can therefore provide additional clarity on the **timing** of particular decisions related to target outcomes, in the context of the **rate** of climate change. This includes shifts in the frequency of extreme events and interactions with wider socio-economic drivers of change.

Any monitoring programmes and policy schedules will need to synchronize with relevant risk timescales in order to enable the strategy to remain flexible. TE2100 identifies actions for the following time frames: short – next 25 years, medium – following 15 years, and long-term – to 2099, and in Tasmania, the adaptation pathways and associated strategies work to 8 - 10 year, 10 - 40 year and 40+ year periods. Aside from this, there is very little information on timescales within the documentation.

There is also an increasing awareness that in order for adaptation programmes to be actionable and sustainable they need to be '**mainstreamed**' with existing frameworks. Mainstreaming refers to the incorporation of climate change considerations into established or on-going development programs, policies or management strategies,

rather than developing adaptation initiatives separately. Both the New York and London strategies identity the benefit of this approach:

- The Greater London Authority Act 2007 commits the Mayor and London Assembly to a climate change 'duty', where the Mayor and London Assembly must mainstream climate change adaptation across their plans and strategies (Bulkeley & Schroeder, 2008). The GLA's subsequent guidance emphasises the need for pro-active risk management of climate issues via conventional business strategies- a view supported by the Association of British Insurers who state that 'it is time to bring planning for climate change into the mainstream of business life' (ABI, 2004).

- The NPCC (2010b) Guidebook emphasises the economic advantage of integrating climate change adaptation planning into infrastructure management and operations with capital and operating budgeting.

8. Could the approach be applied in Scotland and elsewhere?

In the context of climate change the flexible adaptation pathway approach – both its fully prescriptive use or looser application - is recognised as having value, particularly to decisions with long-term implications which are costly or difficult to adjust. However to make more refined judgements of its usefulness and practicality, further evidence is required on how the approach has been implemented and its success. In this case, measuring 'success' is difficult as some of the benefits of the flexible adaptation pathway approach only become more apparent in the future through its flexibility to respond to unexpected events.

Some generally useful aspects of the flexible adaptation approach for adaptation planning are the focus on:

- **Developing appropriate decision criteria and thresholds** based upon acceptable levels of risk and the rate of climate change. This may help to engage stakeholders that have so far been poorly engaged with adaptation beyond the 'wait and see' stage, and help them to identify no-regret and low-regret actions.
- **Long-term decisions** and identifying costly and/or irreversible decisions that need to be assess for climate change impacts.
- **Monitoring, evaluation and flexibility** – exploring adaptation options and adjusting in light to changing circumstances and lessons learned.
- **Linking climate change adaptation with climate change mitigation** policies and strategies.

It seems feasible that the approach could be applied in Scotland at a local scale but also perhaps at a regional and national level. Its conceptual application and practical implementation however need further exploration so as to better understand how the approach could be utilised for a range of risks, sectors and spatial scales. This would explore, for example, to what extent the evidence and information, tools and processes required to implement the approach are already in place or available. Additionally, it would investigate the potential costs, efficiency and usefulness of the approach.

Whilst it is, perhaps, easier to identify and quantify thresholds for options in relation to engineering strategies such as the TE2100 project, **it may be possible to identify some form of threshold for most risks and sectors**. The approach also has some compatibility with the identification of adaptation indicators for each sector.

Whilst within a sector, or at a local level, it can be possible to plan a single flexible pathway approach for an identified risk, **at national level simultaneous flexible adaptation pathways will inevitably be needed. Figure 4** illustrates how the management of a climate change risk (in this example, flood risk to homes) to an acceptable level in the long term will require simultaneous adaptation strategies at national level. This figure also highlights the influence of both national level strategy changes as well as the **effect of sectoral or local level** actions on the overall risk trend.

Figure 5 illustrates how it may be possible to identify multiple simultaneous flexible adaptation pathways and associated thresholds at a national level. In this example, initially a number of low regret and/or mainstreamed strategies are followed. However, as uncertainty diminishes and the risk increases to defined thresholds, some of these strategies become increasingly ineffective and it becomes necessary for the pathways to switch to more stringent and/or costly measures. In this example, **whilst it would be effective to instigate major capital projects at the outset, such a strategy may not be *cost* effective until there is certainty that risk levels will considerably exceed those controllable by other measures**.

Whilst it has not been possible within the timescales of this project to develop examples for other risks and sectors and to discuss their potential application with stakeholders, this would be feasible. It might, for example, be useful to initially develop examples for the transport and forestry sectors, both of which are used to working with relatively long-time frames, before moving on to sectors whose decision making timescales are shorter, for example, the emergency and rescue services. It may also be possible to identify some case study areas where strategic approaches to adaptation are being applied and where the potential application of the flexible adaptation pathway approach could be evaluated.

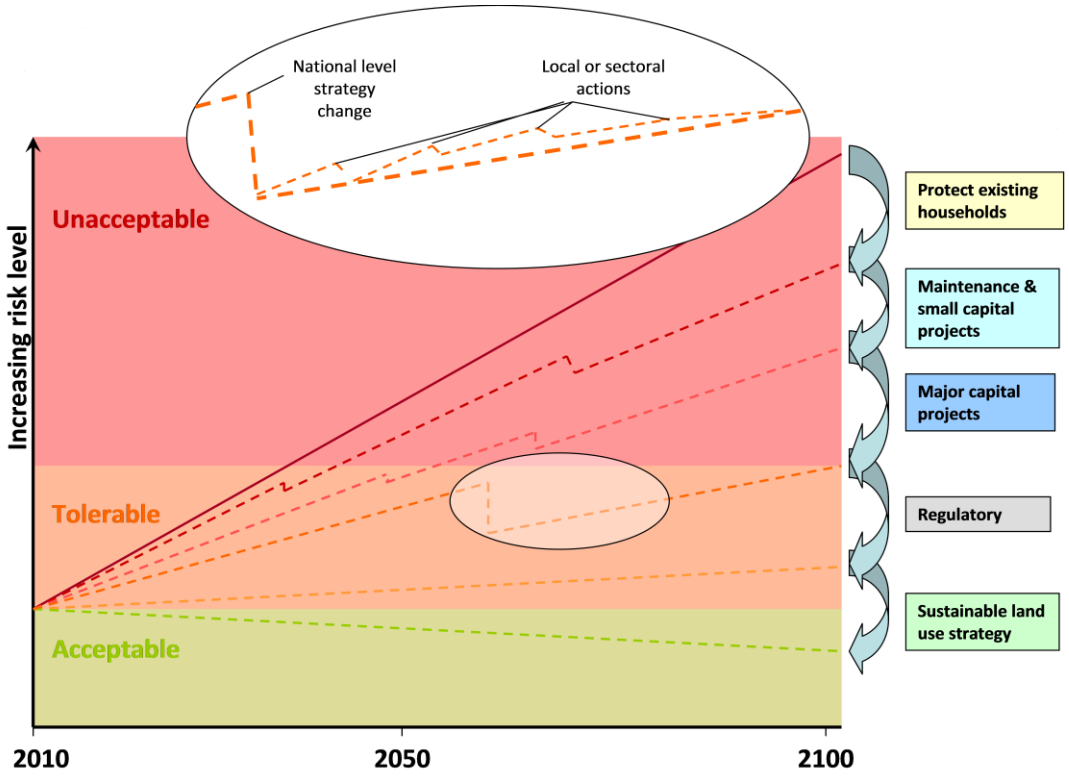

Figure 4 Example of how simultaneous adaptation strategies can manage flood risk to acceptable levels. Inset illustrates the relationship between national, local and sectoral strategies (national level strategy changes can result in potentially large changes in risk, but local or sectoral strategies will impact upon the overall rate of change) (adapted from GLA, 2011).

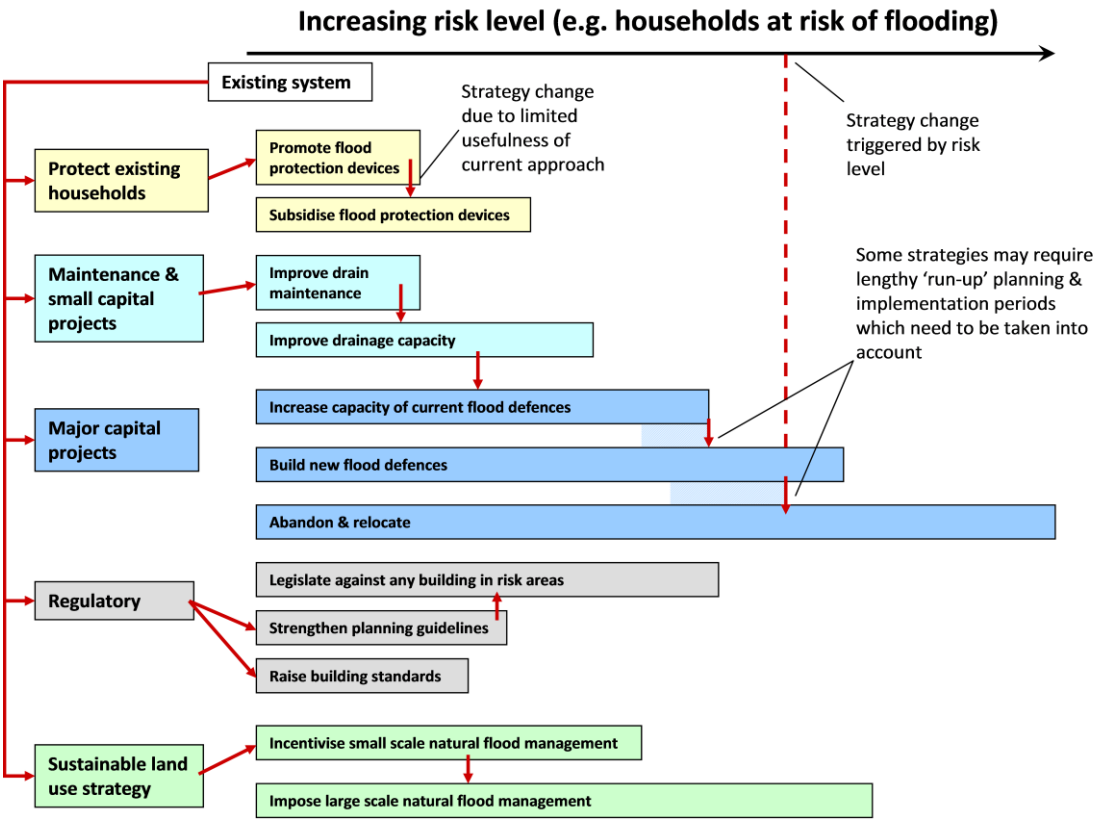

Figure 5 An example of how national level strategies for managing flood risk could involve multiple flexible pathways (actions and policies included in the diagram, along with relative lengths of effectiveness are for illustrative purposes only).

9. References

ABI (2004) *A Changing Climate for Insurance*. Available online at: http://www.abi.org.uk/Publications/24800.pdf

Bulkeley, H & Schroeder, H (2008) Governing Climate Change Post-2012: The Role of Global Cities – London, Tyndall Centre for Climate Change Research Working Paper 123

City of London Corporation (2010) *Rising to the Challenge - The City of London Climate Change Adaptation Strategy*. Available online at: www.cityoflondon.gov.uk/Corporation/LGNL_Services/Environment_and_planning/Sustainability/Climate_change

Department of Environment and Resource Management (2012) *Queensland Coastal Plan: Guidelines for Preparing Coastal Hazard Adaptation Strategies.* The State of Queensland Government, Brisbane, Australia.

Environment Agency (2009) TE2100 *Plan Consultation Document: Managing flood risk through London and the Thames estuary*. Available online at: www.environment-agency.gov.uk/research/library/consultations/106100.aspx

Environment Agency (2010) www.environment-agency.gov.uk/homeandleisure/floods/104695.aspx (accessed 01/06/12)

Greater London Authority (2011) *Managing risks and increasing resilience: The Mayor's climate change adaptation strategy OC TOBER 2011*, London

Low R., Martin S. and Moss A. (2012) *Comparative Review of Adaptation Strategies*. Sniffer on behalf of ClimateXChange.

Lowe, J., Reeder, T., Horsburgh, K. and Bell, V. (2009) *Using the new TE2100 science scenarios*, United Kingdom Environment Agency.

Lowery, M. (2012) Personal Correspondence*, Office of Climate Change, New York State Department of Environmental Conservation.*

NIWA (2011) *Coastal Adaptation to climate Change – Pathways to Change*. November 2011.

NPCC (2010a) Climate Change Adaptation in New York City: Building a Risk Management Response: New York City Panel on Climate Change 2010 Report. *Annals of the New York Academy of Sciences Vol. 1196*

NPCC (2010b) Climate Change Adaptation in New York City: Building a Risk Management Response: New York City Panel on Climate Change 2010 Report (Appendix B Adaptation Assessment Guidebook). *Annals of the New York Academy of Sciences Vol. 1196*

NYSCAC (2010) *New York State Climate Action Council Interim Report 11-9-10*, Chapter 11 Adapting to Climate Change. Available online at: http://nyclimatechange.us/InterimReport.cfm

NYSCAC (2012) http://www.nyclimatechange.us/background-nycac.cfm (accessed 31/05/12)

New York State Adaptation Technical Work Group (2010) *Full Descriptions of Adaptation Recommendations* . Available online at: http://www.nyclimatechange.us/ewebeditpro/items/O109F24268.pdf

New York State Energy Research and Development Authority (NYSERDA) (2011) *Climate Adaptation Guidebook for New York State: Annex II to the ClimAID Integrated Assessment for Effective Climate Change Adaptation Strategies in New York State*. Available online at: http://www.nyserda.ny.gov/Publications/Research-and-Development/Environmental/EMEP-Publications/

Reeder, T. & Ranger, N. (2011) *How do you adapt in an uncertain world? Lessons from the Thames Estuary 2100 project*. World Resources Report, Washington DC

Tasmanian Climate Change Office (2012) *Tasmania Coastal Adaptation Decision Pathways Project*. Available at www.dpac.tas.gov.au/divisions/climatechange/adapting/_tasmanian_coastal_adaptation_decision_pathways_project (accessed July 2012)

UKCIP (2003) *Climate adaptation: Risk, uncertainty and decision-making*. UKCIP Technical Report. UKCIP, Oxford.

Yohe, G. & Leichenko, R. (2010) Chapter 2: Adapting a Risk-Based Approach. In: *NYC Panel on Climate Change (2010) Climate Change Adaptation in New York City – building a risk management response*.

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Appendix One: Further case studies illustrating the use of the flexible adaptation pathway approach

Case study: City of London

The **City of London's Climate Change Adaptation Strategy**, which identifies itself as the first of its kind by a UK local authority, aims to identify the priority risks associated with climate change and proposes adaptation measures which are designed to ensure that the City's infrastructure and services cope under a changing climate (City of London Corporation, 2010).

Its development drew on the UKCIP (2003) risk-based climate adaptation decision-making framework (Figure. 3).

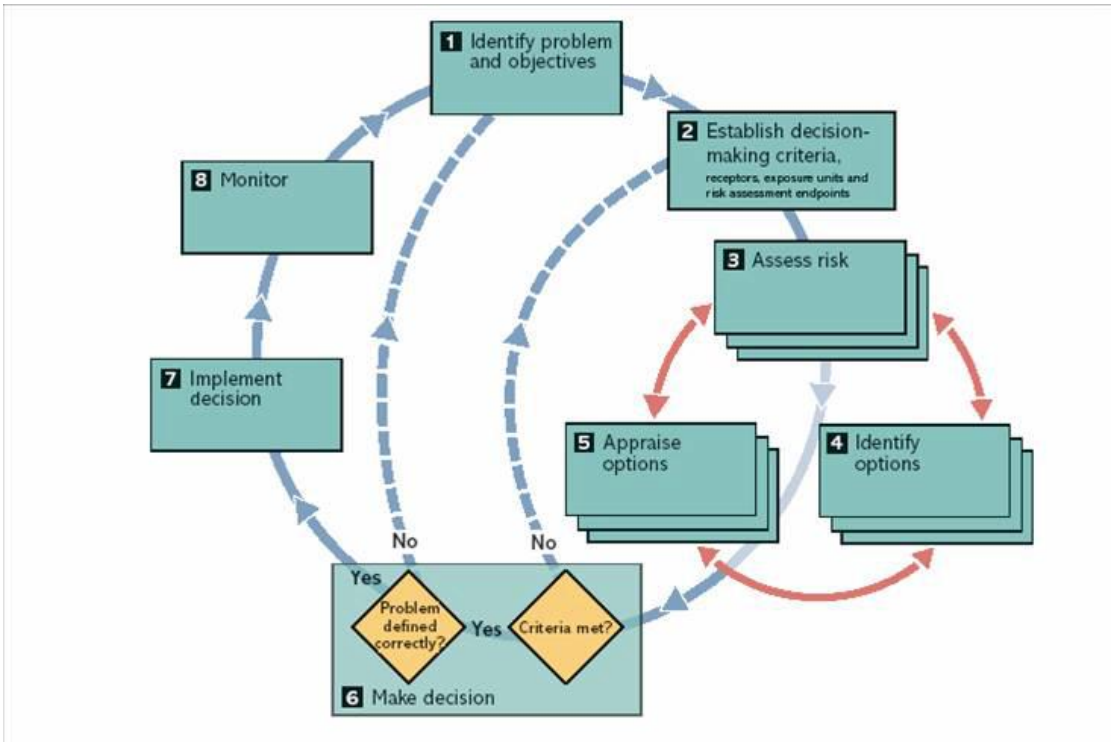

Figure 3 UKCIP framework for supporting decision-making in the face of climate risk (UKCIP, 2003)

Very clear actions are laid out within the strategy, with implication that this is being put into practice. The 2010 revision document (CLC, 2010) refers to the 2007 version having been 'adopted' by the Corporation, with various actions (at national, Greater London Authority and City levels) detailed as already having been put in place in response. The document is very clear in setting out future planned actions **however there is little reference to how a flexible adaptation pathway approach will be used**.

Case study: New York State

The **New York State Climate Action Council** was created in 2009 with the purpose of assisting the state in identifying the best opportunities to mitigate and adapt to climate change and reduce costs associated with climate change activities. The Council and supporting panels performed a systematic review of vulnerabilities to the effects of climate change and approved draft adaptation policy recommendations across eight sectors.

As the authors of the main State reports (NYSCAC, 2010; NYSERDA, 2011) are largely those of the New York City reports, **there is therefore much overlap/duplication of theory and methodology between the two. However, they fundamentally differ in terms of the scale and scope of the strategies**.

This is an 'interim' report and therefore there are few examples of how, when and in response to what triggers the pathways will alter. However, development of these seems to be a clear intention with the following referred to in connection with many of the recommendations: 'decisions-making tools ... to provide various adaptation strategy options'; 'a coordinated, multi-disciplinary and multi-institutional applied research program focused on …. adaptation strategies'; 'emphasizing the flexibility associated with adaptive management practices so that adjustments in … management could be made as more research becomes available or as … objectives change' (New York State Adaptation Technical Work Group, 2010).

At present, however, unlike New York City which has committed to the full development of the interim report into adaptation strategy, no such undertaking has occurred at state level. Following the change of Governor at the start of 2011, the Climate Action Council has not been reconvened, and therefore the further analysis and implementation of policy options laid out in the interim report have not been put into action. Thus, no specific thresholds have been defined that would trigger changes in strategies or policies that relate to climate hazards, and currently there are no planned changes to any existing relevant strategies or policies being considered. Whilst there are ongoing efforts to improve climate resilience in some sectors, they are not part of an overall adaptation strategy and do not share a common planning framework such as flexible adaptation pathways (Lowery, 2012).

Case study: Queensland, Australia

In Queensland, and separate to the Coastal Adaptation Decision Pathways Project, Coastal Hazard Adaptation Strategies are required for urban areas projected to be at high risk coastal hazard areas. Queensland's **'Guideline for Preparing Coastal Hazard Adaptation Strategies'** (Department of Environment and Resource Management, 2012) sets out one of the guiding principles of adaptation strategies to be 'flexibility, recognising that climate change benchmarks may change over time'.

The guidance emphasises that 'adaptation options selected **need to include optimal timing for investment, trigger points and review processes for decisions taking into account risks and uncertainties'**...'Trigger points or indicators based on the CBA findings should be set to identify the level of acceptable change before adaptation options must be implemented' and that a **'A triggered approach allows for actions to be implemented as the threat arises, while also allowing time to improve coastal hazard data and obtain necessary funding, resources and capacity'**. The guidance also highlights the need to identify funding and resources required for 'monitoring and evaluation to determine whether new risks have arisen, the likelihood or consequence of risks have changed, and to identify when trigger points have been reached'.

A series of **generic potential adaptation strategies** e.g. 'defend', 'accommodate', 'change use', 'retreat', and abandon' are set out in the guidance, along with a trajectory for sea level rise in relation to existing assets and adaptation options and trigger points to inform when and what adaptation measures should be undertaken. Threshold ranges include: no impact, impact tolerable, impact significant (adaptation cost less than asset value), impact intolerable (adaptation cost greater than asset value). It also refers to the concept of a 'vulnerability envelope' explaining that 'assets assessed as high vulnerability will reach impact thresholds earlier in time than those assets assessed as low vulnerability'.

The approach described is being piloted through the Townsville Pilot Project which will complete at the end of 2012. We have requested further information about the project.

Case study: New Zealand

In New Zealand, the national government has produced guidance for local authorities on **'Coastal Adaptation to Climate Change – Pathways to Change'** (NIWA, 2011). Its focus is on advocating a flexible approach to adaptation set within a risk management approach and adaptive management process. The guidance explains that the adaptive management process and use of monitoring and evaluation allows the implementation of pre-planned actions of adaptation stages to 'be advanced or delayed well ahead of time depending on how changes in sea level and other coastal hazards are tracking – faster or slower than expected'.

It explains how in taking a risk management approach it is possible to define the acceptable level of risk for a property, or community, or coastal area and says the acceptable level of risk is 'the level of risk individuals and communities are prepared to live with, along with the amount they are prepared to pay for activities that would help them to adapt to climate change effects'. The guidance also refers to people and councils being faced with a range of pathways and barriers through time which makes suggestions to help councils make decisions in the face of uncertainty; this includes aiming for 'robust rather than optimal adaptation'. It explains that 'adaptation involves managing changing levels of risk, including minimising or reducing risk where possible, and managing any residual risk. It also involves a process for achieving change over time to enable people and communities to adjust to changing conditions and to minimise or reduce risk.'

Two possible approaches to identify and manage risk are suggested:

- **A classical top-down** approach which starts with selecting the most appropriate climate change scenario before deciding on adaptation stages which will be implemented over time.

- **An adaptation tipping point or scenario neutral analysis** which considers how much climate change existing communities or infrastructure can cope with. The timing of the implementation of adaptation measures is addressed separately through an adaptive management process coupled with regular monitoring and reviews. The Thames Estuary, London is provided as an example of this 'adaptive management approach'.

The use of tipping points coupled with a flexible and risk management approach, coupled with the reference to the Thames Estuary, suggests this might otherwise be referred to as a relatively loose interpretation of a 'flexible adaptation pathway approach'. It was not possible however to obtain any further information on situations where such an approach has been applied in New Zealand or of any subsequent recommendations.

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