Planned Adaptive Regulation: Learnings from the Delta Programme

By Dr Richard Judge, Prof Arthur Petersen

Executive summary: Planned adaptive regulatory methods (PAR) offer considerable potential as a way of tackling significant uncertainties – such as those arising from rapidly advancing innovations or from multi-decade time horizons. The Dutch Delta Programme, grounded in adaptive management approaches, shows what can be achieved. It provides valuable transferable experience of both the benefits and the implementation challenges for PAR.

Tags: regulatory systems, governance, adaptive methods, risk management, flood protection, freshwater supply resilience, spatial planning, climate change, innovation, The Netherlands

Section 1: Background and introduction

Many people will know the tale of the Dutch boy who noticed the sea trickling in through a small hole in a dyke and averted disaster by plugging the hole with his finger[1]. The real-life equivalent took place during the 1953 North Sea Flood. Arie Evegroen used his grain barge to plug a large hole in the dyke along the river IJssel and reportedly saved the town of Nieuwerkerk from flooding.[2]

Others were less fortunate. On 31 January 1953, an extreme combination of a high spring tide, heavy rainfall and a severe windstorm over the North Sea caused an area of more than 1500 km^2 to flood. Coupled with a combination of human errors and technical failures (see **Box 1**), this storm cost many lives[3,4] – 1,836 people died in the Netherlands, 72,000 people lost their homes, 30,000 livestock were lost, with a 0.7 bn Euros cost to the Dutch economy (about 10% of GDP).

Box 1: The 1953 *Watersnoodramp (flood disaster)*

Human errors & technical failures combined to cost lives:

- Weak spots from inadequate maintenance led to over 65 breaches of protective dykes in SW Holland.
- As coastal dykes collapsed, flood waters then hit and broke through inland dykes.
- This domino effect meant that communities faced water levels rising up to 3m within hours.
- The scale and unexpected nature of the disaster meant that warning systems were ineffective.
- Local alarms sounded by church bells failed because use was not sufficiently ingrained in daily lives.
- Rescue efforts took several days to develop fully.

The 1953 *watersnoodramp* (flood disaster) led to a major rethink of coastal defences, weather prediction and flood warning systems in the Netherlands. This resulted in the creation of the Delta Works (**Figure 1**), an enormous and innovative series of flood defences built over several decades at a cost close to 5 bn Euros.

However physical infrastructure forms only part of the picture. Actions to develop equally critical but intangible infrastructures have been an important part of the response. These actions include extensive investment in research and capability to build and apply knowledge, evolution of the institutional frameworks to strengthen governance and sustained stakeholder engagement.

This case study outlines how the Netherlands shifted from protecting themselves from immediate threats of flooding to a more forward-looking system able to adapt to future challenges (such as climate change). The case focuses on the Delta Programme's adaptive management approaches, which are designed to cope with the significant uncertainties that multi-decade timelines bring. The experience is transferable to the governance of other complex projects and innovations, in particular to the development and application of 'Planned Adaptive Regulation'.

Section 2: Analysis and insights

The Delta Programme

The primary purpose of the Delta Programme is to ensure that the

Figure 1: The Delta Works, a €5 billion, 30-year programme of flood defences consisting of levees, dikes, dams, sluices and storm surge barriers. Many new structures were built, together with reinforcement / upgrade of existing defences. a) map of Delta Works. b) 1958 – storm surge barrier in the river Hollandse Ijssel. c) 1986 – storm surge barrier in Eastern Schelde. (Source: Rijkswaterstaat via [5])

Netherlands is protected from flooding and freshwater shortages — now and for the foreseeable future.

While this core purpose has remained constant, the detail has changed in many ways since its inception in the 1950s. The Delta Programme's priorities are captured in the Delta Decisions[6] published in 2014 (refreshed 2021). These set out the overarching policy framework for flood risk management, freshwater supply and spatial planning that is climate-proof and water-resilient.

The governance system

The approach to governance has been informed by two Delta Commissions: the first set up shortly after the 1953 floods; the second in 2007. Key developments are identified in **Figure 2**.

With almost a third of its land below sea level, Dutch communities have a long history of strengthening natural sea and river protection by creating and maintaining artificial barriers, controlling inland waterways and caring for reclaimed land (the polders). Current approaches to governance build on institutional frameworks and collaborative models that have long been instrumental in protecting the Netherlands. This includes an on-going role for district water-boards that have been at the heart of Dutch water management activities since the 13th century.

Figure 3 provides an overview of the many organisations involved in the governance system and the responsibilities of key actors (central government, district water-boards, Rijkswaterstaat and the Delta Commissioner). The boundaries of this system align to the Delta Programme's water management responsibilities (with its inter-dependent tasks of flood protection, freshwater supply and spatial planning). In practice, interconnections are also needed with other infrastructures, activities and communities that interact with the Programme (such as inland shipping or fisheries).

System complexities

The 1953 disaster brought to life the complex interplay between interconnected physical, natural and social systems. It showed failures rapidly cascading and escalating, as breaches in primary coastal defences led to failures in secondary dyke systems. Although many of the risks had been foreseen, it was this disaster that brought the political consensus and funding needed for action.

Flooding in the 1990s highlighted the need for sustained vigilance and for anticipating future issues in sufficient time to prepare. The multi-decade timeframes involved bring significant uncertainties:

- Emerging engineering knowledge (such as dyke failure mechanisms) and technologies;
- Impacts of climate change (such as sea levels rising and land mass falling);
- Socio-economic changes (such as population growth and urban development);

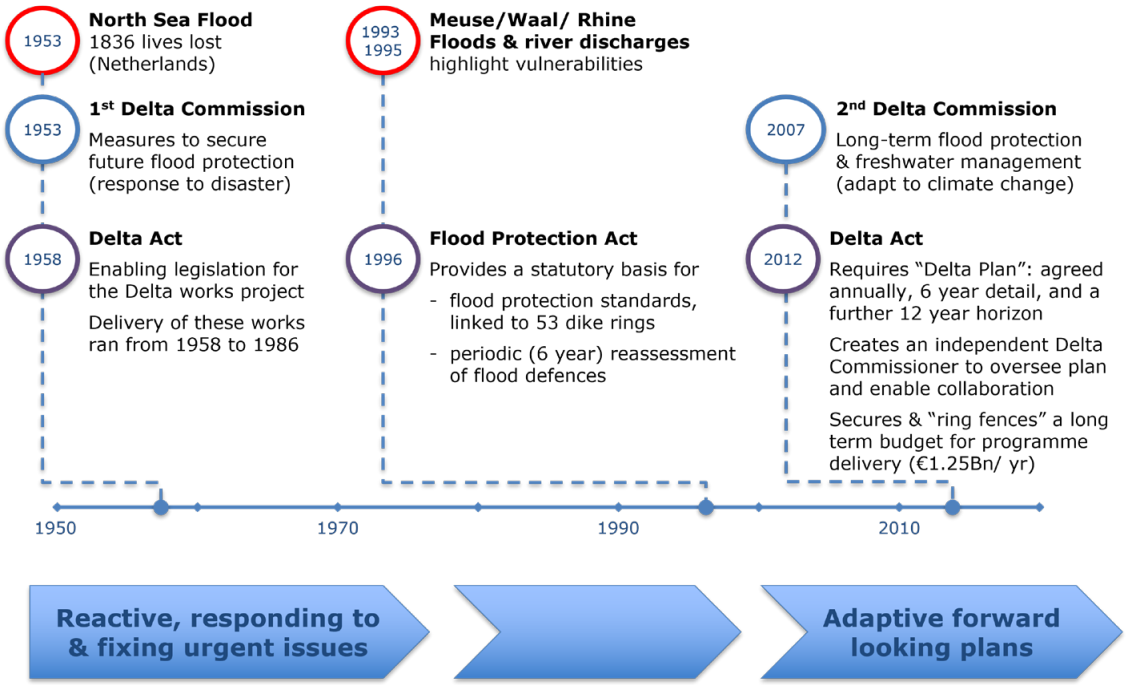

Figure 2: Evolution of approaches

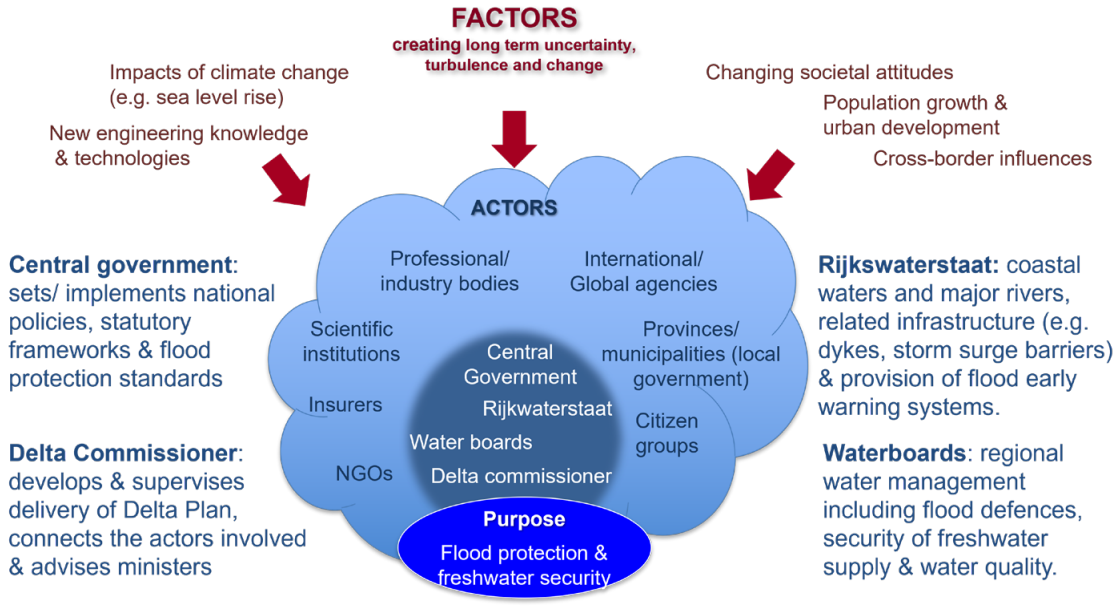

Figure 3: The governance system and its context. (Adapted from [7])

- Cross-border influences (such as the impacts of decisions taken upstream by other nations);
- Changing societal attitudes (adding unpredictability to political choices and trade-offs).

Adaptive Delta Management

The importance of adaptive policymaking was emphasised by the second Delta Commission and in the ensuing Delta Programme. The concept of Adaptive Delta Management was introduced as a way of dealing with the uncertainties of multi-decade timeframes. This shifted the emphasis from reaction to anticipation and adaptation: from reacting to issues flagged by periodic reassessments to anticipating possible futures and putting in place mechanisms that enable flexible responses.

Accompanying timeframes reflect the long-term horizon: six-year review cycles for strategic decisions; allowing until 2050 to implement infrastructure improvements; research to inform major choices beyond 2050 (for example on sea level rise).

Associated governance practices draw on five strongly inter-related elements: institutional mechanisms; flood standards; anticipatory mechanisms; systematic monitoring and feedback; and stakeholder engagement. Each is described below.

Institutional mechanisms

The typically short-term nature of political decision-making can present a particular challenge when addressing long-term issues. The 2012 Delta Act included three 'policy commitment devices' to sustain long-term focus. These:

- Required the development, periodic review and annual presentation to Parliament of a Delta Programme that addresses future risks to floods and freshwater supplies.
- Secured long-term funding for development and delivery of the Delta Plan, and associated research activities, through the Delta Fund (averaging €1.25 bn / year until 2032).
- Formalised the role of an independent Delta Commissioner[8] to oversee and connect the multiple governmental layers and stakeholders involved. The Commissioner informs and supervises delivery of the Delta Programme, taking a systems perspective that ensures cohesion between its component parts and connects short-term decisions to long-term goals. The Commissioner does not have formal decision-making authorities, but instead relies on influence through their powers: to convene, facilitate and catalyse stakeholder actions; to report directly to parliament; and to draft the yearly investment programme.

The independence of the Delta Commissioner, together with funding to support knowledge development, reinforces the separation between those advising on what is needed and those elsewhere in government formally responsible for decision-making and implementation.

Flood defence standards

Safety standards for coastal flood protection were established in the 1950s (by the first Delta Commission) and for rivers in the 1970s. Protection levels for each of the 53 uninterrupted rings of water defences (dyke rings) were formalised by statute in the 1995 Flood Protection Act.

Fundamental changes to flood protection standards were introduced in 2017, building on more than a decade of underlying research and studies. These shifted focus from the probability of a flood exceeding the height of the dyke to the probability of an individual losing their life due to flooding. Making the standards more outcome focussed brings a number of advantages[9]:

- It shifts the focus from 'hazard' to 'vulnerability', which also helps provide a stronger rationale for adaptive methods;
- It takes account of the many advances in probabilistic tools over recent decades, such as methods to include uncertainties in design assessments and extensive relevant data;
- It allows for different dyke failure modes (beyond water levels exceeding dyke heights), including those indirect modes that may be linked to maintenance or inspection issues;
- It enables greater granularity than dyke rings. The standards ensure consistency across different areas (with a minimum protection level for individual fatalities at 1:100,000 per annum) and the option of enhancing protection in specific areas (such as critical infrastructure);
- It opens the option of a multi-layered flood strategy, including prevention, flood resilient spatial planning and crisis management. For example, the standards can be achieved by avoiding the risk (building on higher ground) or by effective response (reliable and robust evacuation strategies).

In introducing these standards, a specific challenge has been to develop the software and other assessment tools that make sophisticated assessments more readily usable by non-experts.

Anticipatory mechanisms (adaptation pathways)

Adaptation pathways use a combination of systems analysis, storylines and scenarios to describe and plan for future developments. They step forward in time from current conditions to describe the evolving impacts of changing physical, natural or socio-economic conditions, as well as showing how responses to these impacts can themselves affect the changing conditions (**Figure 4**). Examples of adaptation pathways developed for the Delta Programme is detail in their 2014 report[10].

These methods provided insight into policy options, the sequencing of actions over time, potential lock-ins and path dependencies. Importantly, they also highlighted 'tipping points' – those future points in time when actions are needed to avoid system failure. A total of 14 pathways, with a planning horizon until 2100, provide the basis for regional strategies, actionable plans and a committed budget allocation averaging €1.25 bn / year until 2032.

Explicitly acknowledging uncertainty and knowledge gaps brought wider benefits. The adaptation pathway diagrams helped to raise awareness about the issues faced, allowed people to visualise multiple alternatives and provided political support for keeping long-term options open. They were seen as a useful way of communicating concepts and attracting stakeholder support. The added transparency also motivated policymakers, politicians and other decision-makers to

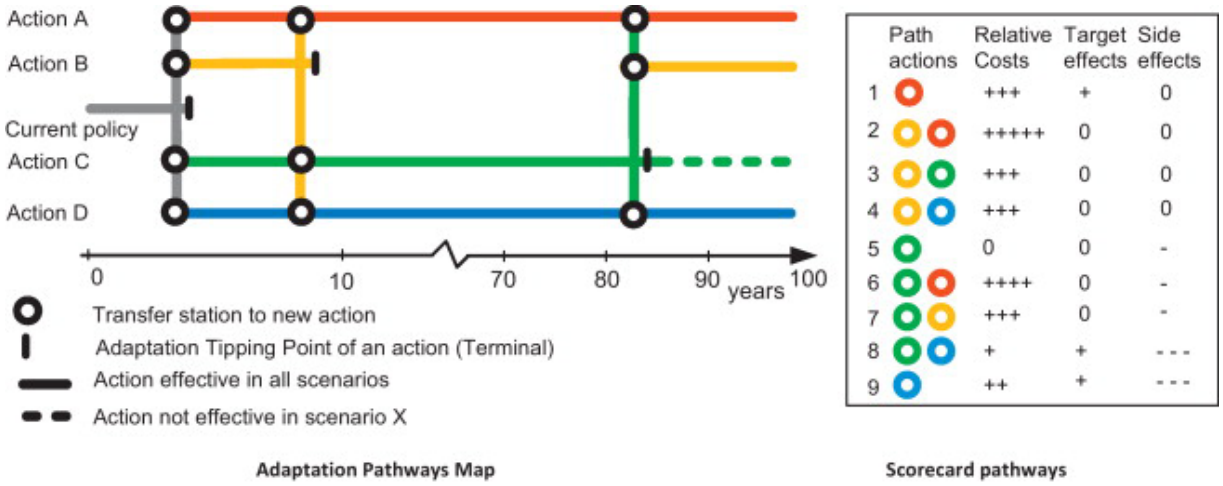

Figure 4: Generic map of adaptation pathways. Starting from today, targets begin to be missed after 4 years. There are four options: Actions A and D achieve the targets for the next 100 years in all scenarios; Action B reaches a tipping point at about 9 years. A shift to one of the other actions will be needed; Action C achieves the targets for the next 100 years for most scenarios (but not Scenario X); However, under Scenario X, Action C requires a shift to one of the other actions at about 82 years. The scorecard shows implications. Colours relate to actions A (red), B (orange), C (green), and D (blue). (Source [11])

incorporate uncertainty about future conditions into their plans.[12]

However, developing adaptation pathways is not straightforward. The many practical challenges include the determination of tipping points (when conditions require an alternative strategy) and quantifying the added value of flexibility (detailed options analysis was considered too complex in a lot of cases). There was also the need to connect with the investment agendas of other organisations and to unravel the interdependence of measures in different policy fields and areas.

And the pathways may themselves need to flex and adapt to new knowledge or conditions. Timelines can be a particular issue due to the trade-offs between long lead times (certainty) around infrastructure developments and the nimbleness (flexibility) needed if the pace of climate change or other societal developments create issues sooner than originally anticipated.

Systematic monitoring and feedback

The Delta Programme has structured feedback mechanisms (monitoring, analysing, acting). These assess progress on the implementation of infrastructure projects, the performance of existing defences (through physical monitoring and review), and external developments that may require adjustment of choices, strategies and plans (such as responding to cyber risks). Collecting and integrating that feedback into decision-making is a central principle of Adaptive Delta Management.

As part of its feedback processes, the Delta Programme created a multi-disciplinary Signal Group that brings together authoritative knowledge institutes in the field of water, spatial planning and climate. Inputs are themed around 'knowledge and innovation', 'climatic and socio-economic developments' and 'changes in societal preferences'. The resulting advice targets action at the appropriate level, including when to trigger decisions set out in adaptation pathways[12]. The inputs are also used to inform the six yearly review that revisits the Delta decisions and plans.

Stakeholder engagement

The Dutch 'polder model' (consensus-based decision-making) is said to have its origins in the need for communities to collaborate and cooperate on water management. Without agreement on shared responsibility for maintenance of the dykes and pumping stations, everyone could suffer.

Sustaining this collaborative ethos is a key part of the Delta Commissioner's remit. Government (at national and local levels), the business community, knowledge institutes and NGOs are involved through varied mechanisms. These include gathering independent advice from the Dutch Government's Physical Environment Consultative Council (*Overlegorgaan Fysieke Leefomgeving*)[13], and hosting an annual Delta Congress to connect stakeholders and stimulate knowledge sharing. One important outcome from these activities is to secure on-going confidence in the governance system and political commitment as the Delta Programme evolves.

Efforts are also made to involve citizens, including through local engagement on projects affecting them directly. There is variable take-up or impact. While public

confidence in the effectiveness of flood prevention measures is a strong positive, it can undermine emergency preparedness. This 'levee paradox' (in which individuals have such high trust in the systems protecting them that they leave themselves unprepared) presents an on-going challenge for the Delta Programme.

Delta Programme: looking to the future

The recent six yearly review of the Delta Programme[14] reaffirmed its overall direction, with some fine tuning of programmes to reflect changing contexts. It highlighted the continuing importance of collaborative approaches, of making best use of available knowledge and of adaptive strategies.

The review also recommended:

- Additional focus on implementation (in order to achieve 2050 goals) and on raising awareness of the increasing risks from sea level rises beyond 2050. Recent severe droughts in the Netherlands have raised questions about pace: are the 30-year timelines envisaged for infrastructure works too relaxed given the increasing visibility of climate change impacts?
- Taking stock of experience to date with the adaptive planning tools and associated monitoring, analysis and action frameworks. While evolutionary infrastructure investments to date have been effective in securing progress and outputs are clear to see, measuring outcomes is a challenge: given the extent of climate change uncertainties, how do you assess the capacity of the system as a whole to adjust to climate impacts and, hence, whether pace is sufficient?
- Improving interconnections between the three core tasks of flood protection, freshwater supply and spatial planning, as well as reinforcing links to other societal / national initiatives: how might decisions in other related infrastructure systems (such as inland shipping) help mitigate risks or enable even more transformative options for tackling water related issues?

Section 3: Discussion and transferable learnings

Adaptive models are used in both regulatory and governance systems as a way of dealing with the deep uncertainties of complex systems or innovations. This case study focuses on how experience from Adaptive Delta Management might inform the design and application of such systems.

Adaptive regulation

Adaptive regulation takes many different forms[15]. In essence, it is defined as a regulatory framework that is explicitly designed to allow for changes in regulatory policies or rules over time as new evidence and knowledge emerges. The precise way in which this is achieved varies.

Planned Adaptive Regulation (PAR)[16] is characterised by the use of pre-defined mechanisms for adapting regulatory policies or designs towards an agreed end goal as knowledge is gained and/ or regulatory contexts evolve. As well as being forward looking (anticipating possible or desired futures), PAR requires a conscious plan and systematic effort to collect and review relevant performance indicators from the outset.

Box 2 provides examples of PAR. These span different sectors, nations and cultures to demonstrate that adaptive methods can be successfully applied in many different contexts. The examples include 'Agile Regulation' — an emerging concept that is broadly comparable[17].

Box 2: Examples of planned adaptive regulation

Retrospective reviews some time after implementation, which may be one-off or periodic, for example as seen in the periodic re-assessment of EU and US particulate matter standards (air quality) supported by investment in the accompanying science to advance knowledge.[16]

Goal based regulations that specify overall regulatory outcome but allow for evolution, informed by practical experience, in how to achieve this. In Rwanda, such approaches enabled novel uses for drones (delivery of medical products, agriculture and infrastructure inspection).[18]

Regulatory sandbox in which existing regulations are relaxed within a controlled and monitored environment to trial innovations. In Singapore, temporary relaxation of environmental regulations enabled pilot tests on a novel on-site compact waste gasification plant.[19]

Phased, conditional approvals for medicines by the European Medicine Agency, with clinical trials supported by real life data, being piloted to allow for early and progressive patient access to a medicine in areas of high medical need.[20]

Adaptation within governance systems (beyond state led regulation), such as the transnational regime managing Internet protocol (IP) address delegation.[21]

Adaptive methods work well in some environments but may be unsuitable for others, making it important to understand their strengths and limitations. For example, the benefits of a stable regulatory system may outweigh the value of adaptive models.

The following sections outline conditions that can support or hinder adaptive regulatory methods and relate this to the Delta Programme experience (which has many parallels). Detail on the regulatory aspects is provided in the International Risk Governance Council's conference report on PAR (2016)[22] and a foresight review on the future of regulatory systems (2021)[23].

Success factors

Adaptive regulatory designs benefit from the following:

- The end goal needs clear definition ('adapt to what, exactly'?), consensus on the use of adaptive approaches and firm commitment to the practical implications (such as secured funding to support the underpinning research and systematic data collection). This can be challenging given the power dynamics often involved in regulatory developments.

  The national imperative to address flood risk and secure freshwater supplies, underpinned by a strong political consensus, has helped the Delta Programme. While the long history of collaboration on water management in the Netherlands (the so-called 'polder culture') is a helpful enabler, the governance mechanisms supporting adaptive methods go much wider.

- Systems thinking brings helpful discipline and structure to understanding the dynamic issues at play. A whole-of-system view is particularly important given the interconnections between different parts of government, organisations and people involved and the external factors that disrupt (or become disrupted by) how the overall system behaves. In regulatory contexts, taking a systems approach also opens different options for achieving the overall outcomes.

  Although the Delta Programme took a systems view from the outset, the latest review[12] highlights that even more is needed to deal with the interdependencies between flood protection, freshwater supply and spatial planning as well as wider government initiatives.

- Trust is fundamental: there needs to be stakeholder confidence (i) that there is genuine long- term commitment (ii) that decisions will not get retrospectively reversed too easily downstream and (iii) that people anticipating future revisions will not undermine compliance. Trust can be supported by 'policy commitment devices'[24] (such as new institutions, legislation, secured budgets for knowledge or capability development, or financial incentives).

  The Delta Act addresses this aspect with its creation of an independent Commissioner, secured long term funding and emphasis on collaboration and cooperation.

- Adaptive leadership: in which there is an explicit acknowledgement of uncertainty and anticipation of how issues might develop (through tools such as scenarios or horizon scanning). It makes use of structured mechanisms to identify and systematically track key indicators (early warning systems). The resulting feedback is integrated into decision processes and enables adaptive regulatory responses. 'Adaptation pathways'[25] offer one way of mapping out policy options and visualising options.

  The adaptation pathways used by the Delta Programme proved effective in raising awareness of uncertainties and communicating how futures may play out. But there are still challenges in turning what might be seen as hypothetical options into timely action when change is needed.

- Diversity: the ability to draw on diverse perspectives is of critical importance when tackling complex systemic issues. This diversity can be further enhanced (and trust built) by engaging interested individuals from outside established institutions, such as the intended beneficiaries of the regulatory policies, who may not have what is seen as the 'usual' professional or academic background. Getting full value from these inputs often needs specific tools (deliberative mechanisms) that can help ensure common language and shared understanding, and hence support effective dialogue and debate.

  The Delta Programme goes part way towards this through the independent inputs of the Physical Environment Consultative Council and its Delta Congress, although these are largely targeted at a professional community who share a common language and interests.

Potential limitations

Regulatory designs are highly context specific. Adaptive approaches will not always be appropriate. Potential limitations to their application include:

- It may be a step too far. Adaptive regulation does not sit well with the 'regulate and forget' mind-sets seen in many jurisdictions and the cultural shifts involved may be demanding. Similarly, recognised regulatory vulnerabilities such as trans-boundary issues, knowledge asymmetries or power imbalances can all feature even more strongly in disruptive environments. They could act as barriers to new, more adaptive, methods. (**Figure 5**).

- Implementation costs (both financial and time) may prove to be prohibitive given the potential

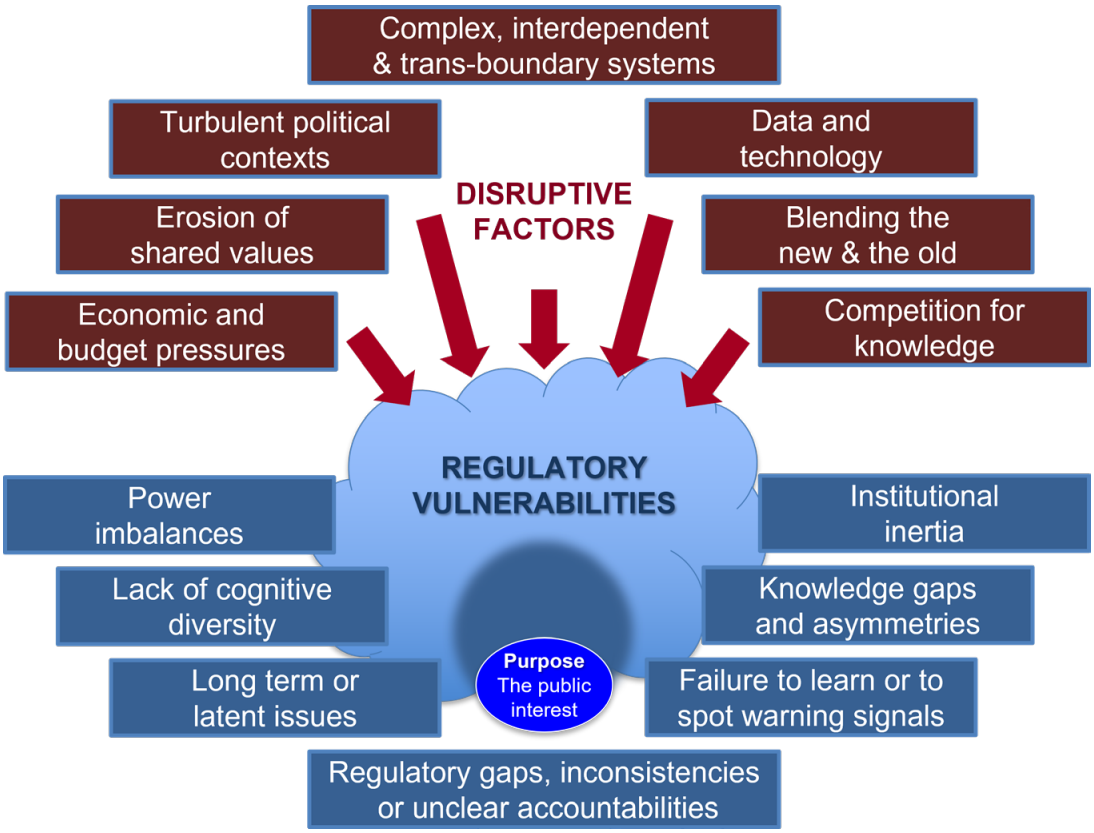

Figure 5: Vulnerabilities of regulatory systems (Source [23])

demands of both data collection and analytical capabilities. While the fundamental importance of water management to the Netherlands warrants high levels of investment in knowledge development and critical infrastructures, the timelines and amounts involved have been significant. In other domains and applications, the question about how much complexity is warranted and identifying what is 'fit for purpose' may feature even more strongly.

- Citizen attitudes. Although engagement can help sustain public trust and create the conditions needed for adaptive methods[26], there are limits: under what conditions and for what purposes will society accept experimentation and adaptation? Participation might also be less effective than imagined: a review of Dutch public consultation on water framework directives highlighted: relatively low citizen interest until they are personally affected; a sense that opinions shared had limited influence in shaping policy outcomes; and the questionable value of an open public participation process for highly technological policies. Care is needed about how citizen participation is used and tuned to the different stages of policy development.
- Practical issues, such as how to ensure timely detection of those tipping points that trigger a switch in strategies within situations that have large natural variability; and responses that may have significant lead times. There are also basic trade-offs to resolve within adaptive designs. Examples include: frequency of review (more rapid updating of policies vs. greater instability for those affected); scope of impact assessments (light touch vs. more comprehensive, but at greater cost); and the nature of decision mechanisms (rapid, reliable, automatic vs. slower, deliberative, discretionary).

Conclusion

There are compelling arguments for using planned adaptive regulatory methods — particularly for rapidly advancing technologies and for responding to an increasingly disruptive world. However, experience has shown that moving from a compelling concept to practical reality brings many implementation challenges, not least of which is tackling entrenched mind-sets and culture.

The continuing evolution of the Delta Programme shows what can be achieved. Progress to date highlights the value of its whole-of-system perspectives; its collaborative methods that draw in diverse stakeholders and enable knowledge sharing; and of the strong political commitments (with secured funding) that underpin its adaptive approaches and long-term focus.

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Acknowledgements

We greatly valued the inputs from many colleagues, co-researchers and international experts who kindly contributed a wealth of constructive ideas and suggestions over the course of our research. This work was supported by a grant from the Safer Complex Systems programme of Engineering X, an international collaboration founded by the Royal Academy of Engineering (the Academy) and Lloyd's Register Foundation (LRF). The opinions expressed in this publication are those of the author(s) and do not necessarily reflect the views of the Academy or LRF.

Affiliations

Dr Richard Judge, Director, Bartlett Judge Associates

Prof Arthur Petersen, Professor of Science, Technology and Public Policy, Dept of Science, Technology, Engineering and Public Policy, University College London, UK