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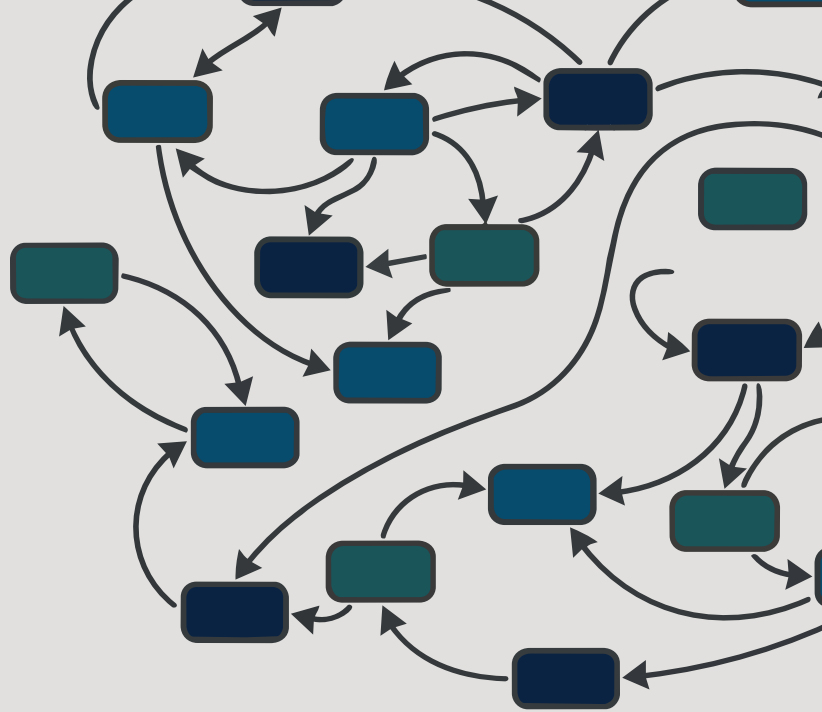
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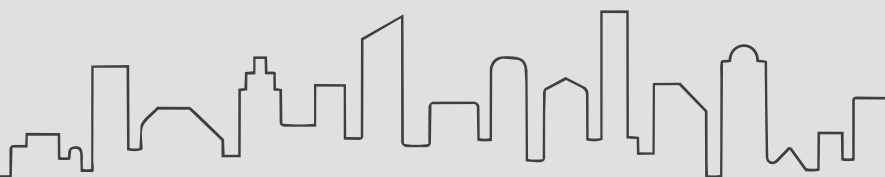
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NAVIGATING COMPLEXITY

A BEHAVIOURAL SYSTEMS APPROACH
TO POLICYMAKERS' CLIMATE
ADAPTATION DECISION-MAKING

KAI PHILIP BELLMANN



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ADAPTATION DECISION-MAKING**

Dissertation

for obtaining the degree of doctor
at Delft University of Technology
by the authority of the Rector Magnificus Prof.dr.ir. H. Bijl,
Chair of the Board for Doctorates
to be defended publicly on
Tuesday 1st September at 12:30

By

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The research presented in this dissertation was fully funded by Delft University of Technology through funds made available by the Dutch Ministry of Education, Culture and Science.

Key words: Climate adaptation, decision-making, behavioural systems, behavioural insights, boosting.

Layout: herikmedia

Printed by: Ridderprint

Cover by: herikmedia

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ISBN: 978-94-6537-771-1

An electronic version of this dissertation is available at: <http://repository.tudelft.nl>.

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‘For let us not deny it, most philologists lack that uplifting overall of the ancient world, because they are standing too close to the picture and investigate a speck of oil instead of admiring – what is more – enjoying the great, bold features of the painting as a whole’

Friedrich Nietzsche (quoted in Robertson, 2022, p. 40)

Foreword

The quote on the previous page stems from a letter Friedrich Nietzsche wrote during his tenure as professor of classical philology, a time in which he became increasingly frustrated with the narrow focus of his chosen discipline. While the title of this dissertation reveals that it is neither a philological nor a philosophical work, Nietzsche's quote captures one of its core messages: behavioural research, similar to philology in the 19th century, needs to start admiring the painting rather than isolated specks of oil. Contemporary research applying behavioural science often studies individual behaviour or micro-level interventions without aspiring to understand or change systems, limiting the discipline's societal impact. Nevertheless, this dissertation is not one written out of a feeling of frustration, but one that aims to highlight that behavioural science is equipped to widen its focus and contribute to solving today's most pressing societal challenges.

Another quote that could have been the opener for this dissertation is attributed to Plato: 'The city is what it is because the citizens are what they are'. This quote elegantly accentuates that individual behaviour underpins societal-level behaviour, another central premise of this dissertation. I aspire to comprehend societal progress in climate adaptation through a bottom-up approach, building an understanding of societal-level outcomes via the analysis of individual behaviour. While there is a plethora of criticism of behavioural research's practical impacts, which will be extensively discussed in this dissertation, I remain convinced that the discipline holds considerable potential to improve policymaking.

Whereas Nietzsche's quote cautions against a narrow perspective in academic inquiries, Plato's observation underscores that societal-level dynamics arise as a result of individual-level action. The novelty of this dissertation lies in the methodological connection of these two tenets and its application to climate adaptation policymaking. This already reveals that the dissertation has two primary contributions, one connected to its methodological approach and one to its inquiry of climate adaptation decision-making. Readers can choose which contribution they would like to prioritise by selecting one of two interpretive paths through which they can progress through the chapters.

The research presented in this dissertation builds on an extensive body of research in behavioural science, policy analysis, decision science, and systems analysis. This integration is not a result of an abstract methodological aspiration, but of the primary motivation of the underlying research project: addressing the urgency for more climate adaptation. While this dissertation contains extensive information on why climate adaptation is needed, I would like to address a common misconception associated with adaptation research(ers). Working on adaptation does not (automatically) translate to a pessimistic view of human efforts to cope with climate change and, therefore, a neglect of the importance of climate change mitigation. In contrast, this dissertation is built on the conviction that both adaptation and mitigation are equally important, with behavioural science being able to contribute to both.

Summary

The Earth's changing climate poses an unprecedented challenge to human and natural systems. Climate adaptation aims to safeguard those systems by preparing them for the expected and already occurring effects of climate change. Despite the recognition of the urgency of adaptation and the availability of cost-efficient solutions, efforts remain insufficient, resulting in an adaptation gap. This mismatch between current action and awareness has been labelled 'adaptation puzzle'.

To date, behavioural science research has primarily concentrated on citizens' behaviours in this puzzle. However, climate adaptation takes place in a multi-actor system in which a range of actors and their dynamic interactions influence societal adaptation outcomes. A key actor in this system is policymakers, whose decisions shape how society adapts via, for example, the formulation of policies, implementation of adaptation projects, and allocation of resources.

This dissertation investigates policymakers' climate adaptation decision-making and how it can be improved. In doing this, it adopts a behavioural systems approach that bridges behavioural insights and systems analysis to illuminate how the multi-actor system shapes policymakers' decisions and *vice versa*. The dissertation is guided by the overarching research question: How can policymakers' climate adaptation decision-making be understood and improved using a behavioural systems approach? This question is answered based on the findings of four central chapters, each covering a sub-element of the question.

Subsequent to an introduction to the societal challenge and theoretical foundations guiding this dissertation, Chapter 2 studies the psychological and contextual influences on policymakers' adaptation decisions. Based on data collected via interviews and a workshop, it conducts a system-focused behavioural analysis that depict behavioural dynamics and underlying determinants in a behavioural system map. The analysis shows that beliefs about consequences, the environmental context, goals, the social/professional role and identity, and social influences were the most frequently recorded behavioural determinants. It further surfaces nine themes that capture behavioural dynamics between the actors within the system. The behavioural system map further reveals three levers for change: (1) supporting precedent identification, (2) stimulating information gathering, and (3) boosting mainstreaming processes. These behavioural levers could spark system change due to their position in the system and, therefore, provide a basis for the development of interventions.

Chapter 3 builds on the findings of Chapter 2 to further understand the factors that shape adaptation policymaking and identify pathways to improving it. To do this, it takes stock of existing scholarly work on climate adaptation policymaking in a review and conducts a Delphi panel with behavioural scientists and policy experts. In the review, policymakers' context, resources, and knowledge, as well as social influences, emerged as the most frequently reported behavioural determinants. However, the review showcases that existing research on adaptation policymaking has not yet adopted a behavioural insights approach. The Delphi panel suggests a prioritised set of target behaviours and behaviour change techniques that can inform the development of interventions. The prioritised behaviours are: connect to other internal departments, broaden adaptation focus beyond water issues, engage in regional cooperation, set-up pilot projects on adaptation, communicate climate adaptation ideas to leadership, emphasise political benefits of adaptation, and involve departments in strategy development. The findings highlight the potential of behaviours directed at internal processes within administrations as intervention targets.

Following this, Chapter 4 develops and evaluates a metacognitive behavioural intervention for climate adaptation policymaking—the Climate Adaptation Reflection Navigator. This intervention adopts a

boosting approach, combining a mental contrasting task and a reflection checklist to improve decision-making performance and quality in adaptation strategy-making. An online experiment with 406 participants and two workshops with policy professionals confirm that the intervention is usable and can effectively improve both decision quality and performance. The chapter demonstrates that metacognitive boosting could be a pathway to improving policymakers' decision-making and suggests that this could spark system change.

In Chapter 5, a stepwise guide to behavioural system mapping is presented. The chapter takes stock of and compiles existing work on behavioural system maps. It suggests five steps that the development and use of the maps require. These steps are: 1) System exploration and boundary setting, (2) Data collection and behavioural analysis, (3) Construction of the map, (4) Validation and refinement of the map, (5) Analysis and interpretation of the map. The chapter also discusses how behavioural system maps extend existing behavioural analysis approaches and what future research could focus on to improve them as a methodological approach for behavioural insights research and practice.

Chapter 6 summarises the findings of the individual chapters, reflects on their implications, and discusses overarching insights. Based on the investigations presented in the dissertation, it develops a seven-step behavioural systems approach that bridges systems analysis and behavioural insights. This approach can guide the development of system-focused, context-tailored behavioural interventions. The chapter concludes with a discussion of implications for adaptation policymakers and behavioural advisors in governmental organisations.

Samenvatting

Klimaatverandering vormt een ongekende uitdaging voor menselijke en natuurlijke systemen. Klimaatadaptatie heeft tot doel deze systemen te beschermen door ze voor te bereiden op de verwachte en reeds optredende gevolgen van klimaatverandering. Ondanks het besef dat adaptatie dringend noodzakelijk is en er kostenefficiënte oplossingen beschikbaar zijn, blijven de adaptatie-inspanningen ontoereikend, wat resulteert in een adaptatiekloof. Deze discrepantie tussen de huidige maatregelen en het bewustzijn wordt aangeduid als de 'adaptatiepuzzel'.

Tot nu toe heeft gedragswetenschappelijk onderzoek zich voornamelijk gericht op het gedrag van burgers in deze puzzel. Klimaatadaptatie vindt echter plaats in een multi-actor systeem, waarin een reeks actoren en hun dynamische interacties de resultaten van maatschappelijke adaptatie beïnvloeden. Een belangrijke actor in dit systeem is de beleidsmaker, wiens beslissingen bepalend zijn voor de manier waarop de samenleving zich aanpast, bijvoorbeeld door het formuleren van beleid, het uitvoeren van adaptatieprojecten en het toewijzen van middelen.

Dit proefschrift onderzoekt de besluitvorming van beleidsmakers op het gebied van klimaatadaptatie en hoe deze kan worden verbeterd. Hierbij wordt een gedragsmatige systeembenadering gehanteerd die gedragsinzichten en systeemanalyse met elkaar verbindt om te verduidelijken hoe het systeem met meerdere actoren de beslissingen van beleidsmakers beïnvloedt en *vice versa*. Het proefschrift wordt geleid door de overkoepelende onderzoeksvraag: Hoe kan de besluitvorming van beleidsmakers op het gebied van klimaatadaptatie worden begrepen en verbeterd met behulp van een gedragsmatige systeembenadering? Deze vraag wordt beantwoord op basis van de bevindingen van vier centrale hoofdstukken, die elk een deelelement van de vraag behandelen.

Na een inleiding over de maatschappelijke uitdaging en de theoretische grondslagen van dit proefschrift, onderzoekt hoofdstuk 2 de psychologische en contextuele invloeden op de klimaatadaptatiebeslissingen van beleidsmakers. Op basis van gegevens die zijn verzameld via interviews en een workshop, wordt een systeemgerichte gedragsanalyse uitgevoerd die de gedragssysteemkaart en onderliggende determinanten in een gedragssysteemkaart samenbrengt. Uit de analyse blijkt dat overtuigingen over de gevolgen, de omgevingscontext, doelstellingen, de sociale/professionele rol en identiteit, en sociale invloeden de meest voorkomende gedragsbepalende factoren waren. Verder komen negen thema's naar voren die de gedragssysteemkaart tussen de actoren binnen het systeem weergeven. De gedragssysteemkaart bracht verder drie hefbomen voor verandering aan het licht: (1) ondersteuning van het identificeren van precedenten, (2) stimulering van het verzamelen van informatie, en (3) stimulering van stroomlijnen van processen. Deze gedragshefbomen kunnen vanwege hun positie in het systeem een systeemverandering teweegbrengen en vormen daarom een basis voor de ontwikkeling van interventies.

Hoofdstuk 3 bouwt voort op de bevindingen van hoofdstuk 2 om meer inzicht te krijgen in de factoren die bepalend zijn voor het opstellen van aanpassingsbeleid en om manieren te vinden om dit te verbeteren. Hiertoe wordt in een overzicht de balans opgemaakt van bestaand wetenschappelijk onderzoek naar het opstellen van klimaatadaptatiebeleid en wordt een Delphi-panel gehouden met gedragswetenschappers en beleidsexperts. In het overzicht kwamen de context, middelen en kennis van beleidsmakers, evenals sociale invloeden, naar voren als de meest genoemde gedragsbepalende factoren. Uit het overzicht blijkt echter dat in bestaand onderzoek naar het opstellen van aanpassingsbeleid nog geen gebruik wordt gemaakt van een gedragsgerichte benadering. Het Delphi-panel stelt een geprioriteerde reeks doelgedragingen en technieken voor gedragsverandering voor die als basis kunnen dienen voor de ontwikkeling van interventies. De geprioriteerde gedragingen zijn: contact leggen met andere interne afdelingen, de focus van aanpassing

verbreden tot buiten waterkwesties, regionale samenwerking aangaan, proefprojecten opzetten op het gebied van adaptatie, ideeën over klimaatadaptatie communiceren aan het management, de politieke voordelen van aanpassing benadrukken en afdelingen betrekken bij de ontwikkeling van strategieën. De bevindingen benadrukken het potentieel van gedragingen die gericht zijn op interne processen binnen overheidsinstanties als interventiedoelstellingen.

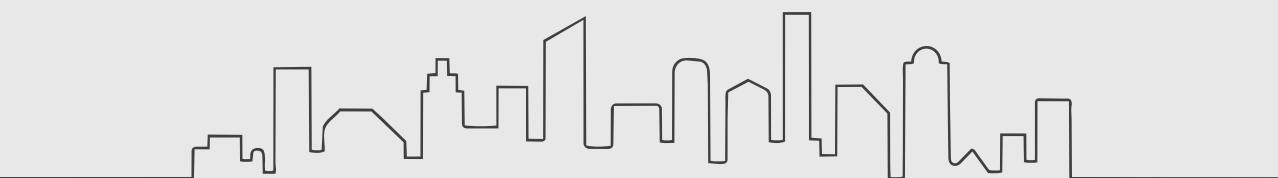
In hoofdstuk 4 wordt vervolgens een metacognitieve gedragsinterventie voor het opstellen van beleid inzake klimaatadaptatie ontwikkeld en geëvalueerd: de Climate Adaptation Reflection Navigator. Deze interventie maakt gebruik van een stimulerende aanpak, waarbij een mentale contrasttaak en een reflectiechecklist worden gecombineerd om de besluitvormingsprestaties en -kwaliteit bij het opstellen van adaptatiestrategieën te verbeteren. Een online-experiment met 406 deelnemers en twee workshops met beleidsprofessionals bevestigen dat de interventie bruikbaar is en zowel de kwaliteit van de besluitvorming als de prestaties effectief kan verbeteren. Het hoofdstuk toont aan dat metacognitieve stimulering een manier kan zijn om de besluitvorming van beleidsmakers te verbeteren en suggereert dat dit een systeemverandering teweeg kan brengen.

In hoofdstuk 5 wordt een stapsgewijze handleiding voor het in kaart brengen van gedragssystemen gepresenteerd. Het hoofdstuk maakt de balans op van en compileert bestaand werk op het gebied van gedragssysteemkaarten. Het stelt vijf stappen voor die nodig zijn voor de ontwikkeling en het gebruik van de kaarten. Deze stappen zijn: 1) Systeemverkenning en het vaststellen van grenzen, (2) Gegevensverzameling en gedragsanalyse, (3) Het opstellen van de kaart, (4) Validatie en verfijning van de kaart, (5) Analyse en interpretatie van de kaart. Het hoofdstuk bespreekt ook hoe gedragssysteemkaarten bestaande gedragsanalysebenaderingen uitbreiden en waarop toekomstig onderzoek zich zou kunnen richten om ze te verbeteren als methodologische benadering voor gedragsinzichtenonderzoek en -praktijk.

Hoofdstuk 6 vat de bevindingen van de afzonderlijke hoofdstukken samen, reflecteert op de implicaties ervan en bespreekt overkoepelende inzichten. Op basis van het onderzoek dat in het proefschrift wordt gepresenteerd, wordt een zevenstappenbenadering voor gedragssystemen ontwikkeld die een brug slaat tussen systeemanalyse en gedragsinzichten. Deze benadering kan als leidraad dienen voor de ontwikkeling van systeemgerichte, op de context afgestemde gedragsinterventies. Hoofdstuk 6 wordt afgesloten met een bespreking van de implicaties voor beleidsmakers op het gebied van aanpassing en gedragsadviseurs in overheidsorganisaties.

1

INTRODUCTION



1.1 Climate adaptation challenges

Anthropogenic climate change poses unprecedented challenges to societies and natural systems (C3S & WMO, 2025; IPCC, 2023). With the prior 10 years being the warmest on record, global temperatures in 2024 clearly exceeded the 1.5°C target that was set in the Paris Agreement for the first time (WMO, 2025). Today, climate change impacts already affect the livelihoods of millions of people worldwide and climate change projections show that global warming will likely surpass pre-industrial levels by 2°C (C3S & WMO, 2025; WMO, 2025). Global projections indicate that a warming of +3°C could result in a 10% reduction in the global gross domestic product (Waidelich et al., 2024). Temperatures in Europe increase approximately twice the speed of the global average, already affecting people across the continent. For example, estimations suggest that there were already more than 45,000 heat-related deaths on the continent in 2023. Moreover, more than 400,000 Europeans were affected by flooding and storms in 2024, with costs estimated to exceed 18 billion euros (C3S & WMO, 2025).

While climate change mitigation, referring to actions aiming to limit climate change itself, has long been at the centre of societal and academic debates on climate change (Reckien et al., 2014), there is a growing recognition that climate adaptation is equally needed (Aboagye & Sharifi, 2024; Doherty et al., 2016). Climate adaptation refers to *‘the process of adjustment to actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities’* (Calvin et al., 2023, p. 120). Climate adaptation aims to cope with the adverse effects of climate change that societies are facing, including heat, sea-level rise, wildfires, urban flooding, drought, and a surging number of extreme weather events. It entails measures such as creating rainfall management plans, urban greening, wastewater recycling, and dam construction (C40 Cities, 2020).

Adaptation measures like these are essential to safeguard climate-sensitive systems, such as the food, healthcare, waste, infrastructure, or financial systems (European Environment Agency, 2024). That is why international, national, and local governmental institutions have initiated the development of adaptation strategies and implementation programmes (C40 Cities, 2020; European Commission, 2021; United Nations Environment Programme, 2024). Amidst the growing certainty with which a global temperature rise well-beyond 1.5°C is predicted and the irreversibility of occurring impacts, the urgency for adaptation action grows rapidly (United Nations Environment Programme, 2025).

Urban environments, referring to densely populated areas, are particularly vulnerable to the effects of climate change, while, at the same time, becoming increasingly central to human livelihoods (Bazazzadeha et al., 2023; Corfee-Morlot et al., 2011; United Nations Human Settlement Program, 2024). As of today, most of the global population already lives in urban areas, with projections suggesting that this share will expand further (United Nations, 2025; United Nations Human Settlements Programme, 2022). In Europe, the proportion of the population living in urban areas is expected to increase from 71.5% in 2000 to 81.2% by 2050 (United Nations, 2025). The characteristics of urban environments, such as high proportions of impervious surfaces, limited green areas, densely built infrastructure, and high levels of congestion, amplify their sensitivity to climate change effects (United Nations Human Settlement Program, 2024). For example, climate change effects, such as urban flooding, wildfires, storms, and heat waves, will affect the livelihood of urban populations by causing water, energy, and food shortages (C40 Cities Climate Leadership Group, 2020; C3S & WMO, 2025; Noor, 2023; United Nations Human Settlement Program, 2024).

These impacts cannot be mitigated by existing urban infrastructures and local policies, which have often been developed without considering the effects of climate change (Corfee-Morlot et al., 2011; Hallegatte & Corfee-Morlot, 2011; Knierling & Klindworth, 2016; Noor, 2023). Similar to climate change mitigation, there is a risk of ‘lock-ins’ in adaptation, as decisions taken today will create long-standing infrastructures that are relevant to climate adaptation efforts in the long-term future (Lunetto et al., 2022). Accordingly,

climate adaptation measures that protect human livelihoods and natural systems need to be planned forthwith. While urban areas are often particularly vulnerable to climate change, urbanisation also leads to land use shifts that can accelerate climate change and create additional vulnerabilities. This makes them central to both mitigation of and adaptation to the earth's changing climate (Corfee-Morlot et al., 2011; Espey et al., 2024; United Nations Human Settlement Program, 2024; While & Whitehead, 2013).

Despite the increasing awareness that climate adaptation is essential and cost-efficient, in some cases offering manifold returns compared to inaction, current efforts remain insufficient, creating an aggravating adaptation gap (Bechtoldt et al., 2021; United Nations Environment Programme, 2023, 2025). For example, local adaptation plans are often underdeveloped, not fulfilling key adaptation criteria (Aboagye & Sharifi, 2024). The phenomenon that adaptation remains insufficient despite the existing awareness and cost-efficiency has been called 'adaptation puzzle' (Bechtoldt et al., 2021, p. 187). In this dissertation, I investigate this puzzle through a behavioural science perspective, aiming to better understand societal adaptation efforts and identify pathways to improving them.

1.2 Policymakers' role in the adaptation puzzle

The adaptation puzzle emerges in a multi-actor system in which actors, both public and private, collectively shape adaptation outcomes. Within this climate adaptation system, actors, such as governmental ministries, non-governmental organisations, and companies, have distinct responsibilities and objectives (Gori Nocentini, 2024; Kanarp & Westberg, 2023; Petzold et al., 2023). The interactions among these actors, combined with the heterogeneity of their roles, increase the complexity of decision-making processes in climate adaptation. For example, local government bodies are more engaged in planning adaptation measures, whereas academic institutions often strengthen the awareness for climate adaptation (Petzold et al., 2023; United Nations Environment Programme, 2024; Vargas López & Flores-García, 2023).

In the multi-actor system, governmental bodies are the central actors, as they shape how society responds to anticipated climate change impacts by developing and implementing policies (Biesbroek et al., 2018). Therefore, they are viewed as key agents for change in overcoming existing barriers in adaptation (Biesbroek et al., 2013). Especially, local government bodies are at the forefront of societal adaptation efforts, coping with the local impacts of climate change. This is exemplified by their central role in climate adaptation strategies, such as that of the European Commission (2021, p. 9), which labels them as the 'bedrock of adaptation'. While policy-focused research has acknowledged this central role by investigating barriers in adaptation policy (see Section 1.4.1), it has not yet discerned how the decision-making of policymakers shapes adaptation progress.

To date, this decision-making is frequently overlooked and, thereby, treated as a concealed 'black box' (Biesbroek et al., 2015; Siders & Pierce, 2021). For example, limited financial resources or conflicts between governmental bodies are frequently mentioned, but without tracing them back to the decision-making of policymakers, restricting the insights into how they could be ameliorated (Lee et al., 2023b; Oberlack, 2017). Policymakers are also often (implicitly) assumed to be fully rational, with their decision-making following economic rationality standards. This contradicts a large body of scientific research in behavioural science (see Section 1.3) that has demonstrated that human reasoning is not accurately reflected by utility-maximisation assumptions. Adaptation outcomes are shaped by policymakers' navigation of the multi-actor system (i.e., the black box), as they make decisions on adaptation strategies, funding distributions, and project creation (Banuri et al., 2019; Biesbroek et al., 2018; Petzold et al., 2023; Siders & Pierce, 2021).

In contrast to policy research, behavioural inquiries have yet to focus on policymaking, as they have primarily focused on household adaptation behaviours (see Section 1.4.2) to contribute to societal

adaptation efforts. Accordingly, there is a research gap at the intersection of existing behavioural and policy-focused investigations with regard to the examination of policymakers' decision-making. While both disciplines have recognised the climate adaptation gap, current work often mirrors their disciplinary traditions: policy science focuses on governance structures, while behavioural science focuses on individual behaviours of end users.

To recapitulate, policymakers are a comparatively high-power actor within the adaptation system due to their role in developing policies and making decisions that shape the behaviour of other actors. Consequently, researching their decision-making and the psychological and contextual factors that shape it could present a pathway to improving societies' climate resilience (Anguelovski & Carmin, 2011; Petzold et al., 2023; Siders & Pierce, 2021). Capturing this potential, Banuri et al. (2019, p. 311) point out that 'it is almost axiomatic that policies will be more effective when those who design and implement them' are enabled to make better decisions.

In this dissertation, I examine policymakers' climate adaptation decision-making in the Netherlands using a novel behavioural systems approach to better understand the climate adaptation puzzle and identify pathways to enhancing adaptation efforts. To do this, I bridge insights from behavioural science, policy analysis, decision science, and systems analysis, which inform the development and application of a system-focused behavioural insights approach.

In the following sections, I briefly outline the historical trajectory of behavioural insights research (Section 1.3) to illustrate the scholarly basis of this dissertation and elucidate how it expands existing work. I also introduce how existing research analysed the climate adaptation puzzle (Section 1.4), distinguishing between policy (Subsection 1.4.1) and behavioural science research (Subsection 1.4.2). Finally, I describe the research approach of this dissertation (Section 1.5) and provide guidance on how to read it (Section 1.6).

1.3 A note on behavioural insights for public policy

Despite early philosophical inquiries by thinkers such as Hume, Kant, and Nietzsche (Hume, 2007; Kant & Wood, 1998; Nietzsche, 1996), into how beliefs, values, and the characteristics of human reasoning shape social and political decisions, early psychological research was long primarily occupied with a general understanding of the human mind (Wundt, 1874), perception (Koffka, 1935), and psychoanalytic questions (Freud, 1991). Sparked by the spread of psychological findings to other social science disciplines and the promise of malleable human behaviour made by behaviourism (Skinner, 1976), the 1970s and 1980s saw the emergence of an increasing interest in drawing on psychology to solve questions in economics and public policy (Banerjee & John, 2025). Only then did more scholars concentrate on the practical application of psychological research, discovering a range of cognitive biases and heuristics shaping human decisions.

Most famously, Daniel Kahneman and Amos Tversky, following early pioneers such as Herbert Simon, investigated mental shortcuts and their implications for real-world decision-making (Kahneman & Tversky, 1979; Simon, 1976; Tversky & Kahneman, 1974). Subsequently, researchers in diverse fields, such as international politics (Jervis, 1976), economics (Thaler, 1988), and organisation studies (Neale & Bazerman, 1985), applied these insights to better understand practical questions in their domains.

While the initial mental dualisms approach by Kahneman and Tversky, which described a distinction between System 1 (fast, automatic thinking) and System 2 (slow, reflective thinking), is today often viewed as oversimplified (Bellini-Leite, 2022; Melnikoff & Bargh, 2018; Mugg, 2016; Viale, 2022), the observation that human decisions deviate from utility-based rationality assumptions is still as valid as when it was first introduced. It is, however, debated whether these rationality deviations, also known as cognitive illusions

(Pohl, 2022), are beneficial for humans (Gigerenzer, 2007; Thaler & Sunstein, 2008). While some view them as useful shortcuts to making good decisions quickly and with low effort (Gigerenzer, 2007; Todd et al., 1999), others see them as errors that require fixing¹ (Conly, 2012; Sunstein, 2015; Thaler & Sunstein, 2008).

Both groups' research has produced a long list of mental shortcuts. Among them are the well-known confirmation bias and anchoring effect² as well as less known illusions such as the Moses illusion, which describes the phenomenon that humans ignore errors in a question if the error is unrelated to the questions target (e.g., when asking about the number of animals Moses brought on the ark) (Bahnik et al., 2022; Mercier, 2022; Speckmann & Unkelbach, 2022).

The early research on cognitive illusions showed that their occurrence and impact on human behaviour can be predicted (Kahneman & Tversky, 1979; Tversky & Kahneman, 1974). This sparked the development of nudges, i.e., small adjustments of the context in which individuals make decisions (choice architecture) to influence their choices (Thaler & Sunstein, 2008; Viale, 2022). Despite the conflicting evidence for mental dualism, the approach underlies the creation of nudges, as they are designed to tap into the fast, automatic processes (System 1) of human reasoning. The idea of nudging made behavioural science practical for governments and businesses by offering the promise of minimal-invasive, cost-effective interventions that can produce behaviour change among citizens and customers (Baggio et al., 2021; Banerjee & John, 2025; Thaler & Sunstein, 2008).

While nudges started as minor interventions in choice architectures, such as changing plate sizes to reduce calorie intake (Thaler & Sunstein, 2008), they evolved into a more sophisticated approach to understanding and changing human behaviour called behavioural insights. This approach employs behavioural science theories and tools to understand human behaviour and goes beyond nudging, also drawing on other established psychological theories (Hallsworth & Kirkman, 2020). A key difference to other decision analysis approaches is the focus on actual behaviour, which is why decision scientists also use the term descriptive decision theory, differentiating it from approaches that concentrate on normative guidelines for optimal decision-making (Eisenführ et al., 2010; Peterson, 2017).

Today, many governments and businesses have dedicated units working with behavioural insights to better understand and influence behaviour (Afif et al., 2019; Baggio et al., 2021). However, with the broad adaptation of the approach also came criticisms, primarily regarding its limited impact (Hofmann et al., 2025; Mertens et al., 2022), paternalistic nature (Hertwig et al., 2025; A. T. Schmidt & Engelen, 2020; Tummers, 2023), and insufficient consideration of system dynamics (Chater & Loewenstein, 2023a; Ewert, 2020). Especially, nudging's limited effectiveness and impact have been attributed to its lack of a system view, as contextual influences and effects are often not considered. Therefore, recent research in applied behavioural science emphasises the need for behavioural insights research to adopt a system perspective, especially amidst the increasingly complex challenges societies are confronted with (Grinstein et al., 2025; Hallsworth, 2023a; Kaufman et al., 2024; R. Schmidt & Stenger, 2024). Before turning to how this dissertation addresses these calls (Section 1.5), I review how existing research in the presented behavioural insights domain and policy research approached the study of climate adaptation progress.

¹ A more comprehensive review of the debate on the usefulness of biases and heuristics is beyond the scope of this dissertation. I encourage those interested to read Kahneman and Tversky (1996) and Gigerenzer (1991) for an introduction to the arguments.

² The confirmation bias refers to the cognitive phenomenon that individuals seek out and favour information that is in line with their (existing) beliefs. In contrast, the anchoring effect describes that the perception of a stimulus serves as reference point (anchor) for subsequent cognitive processes (Bahnik et al., 2022; Mercier, 2022).

1.4 Understanding climate adaptation progress

Scholarly work has adopted different approaches to understand why the climate adaptation gap persists. One key aspect differentiating the existing studies is their perspective on the factors that affect adaptation. While some researchers concentrated on structural barriers and drivers in the governance system (Section 1.4.1), others investigated the role of individual decision-making processes (Section 1.4.2). Both present a valuable starting point for understanding policymakers' climate adaptation decision-making and offer insights into what factors a system-focused behavioural analysis needs to capture.

1.4.1 Structural governance factors affecting climate adaptation

One approach to understanding and solving the adaptation puzzle is the analysis of structural barriers. Research adopting this approach concentrates on barriers and drivers in climate adaptation, without elucidating individual-level decision-making processes (e.g., Bauer et al., 2012; Bauer & Steurer, 2015; Keskitalo, 2010; Oberlack, 2017; Phuong et al., 2018). This research field has identified an array of structural barriers that hinder adaptation. In essence, the studies operate under the assumption that a structural barrier exerts a linear influence on adaptation outcomes. Among those barriers are insufficient financial resources (Ekstrom & Moser, 2014), conflicting responsibilities (Wamsler & Lawson, 2012), a high number of involved actors (Howlett et al., 2019), insufficient information (Falaleeva et al., 2011), a lack of binding policies (Kanarp & Westberg, 2023), long-standing bureaucratic processes and structures (Biesbroek et al., 2018), and limited knowledge (Phuong et al., 2018).

While some studies considered individual-level barriers in adaptation policymaking (e.g., awareness, knowledge) (Lenzholzer et al., 2020; Phuong et al., 2018), they did not investigate decision-making processes from a behavioural lens. The focus on structural barriers has led to critiques arguing that the insufficient attention to the underpinnings of the barriers explains why the research has only generated limited insights into how to overcome them (Eisenack et al., 2014; Ishtiaque et al., 2021; Lee et al., 2023b, 2023a). Ishtiaque et al. (2021, p. 316) pinpoint these critiques by outlining that 'existing studies attempted to create an exhaustive list of barriers by focusing on "what" is occurring' but that the 'understanding of "how" or "why" barriers emerge' is limited.

To better understand the 'how' and 'why', researchers recently began to examine the barriers' origins, shifting the focus to underlying dynamics in their emergence (Ishtiaque et al., 2021; Lee et al., 2023b, 2023a). These studies connected specific barriers to factors that spark them, discovering that multiple barriers can be underpinned by the same mechanism. For example, organisational inertia underpins dynamics related to coordination difficulties, while responsibility issues can be traced to a lack of regulations on adaptation roles (Ishtiaque et al., 2021; Lee et al., 2023b, 2023a). While these studies significantly improved the understanding of climate adaptation policymaking, they still approached the assessment with a pre-determined focus on barriers or drivers (Lee et al., 2023b, 2023a; Mees et al., 2018). This might lead to a narrow view that neglects the complexity of the factors and dynamics affecting adaptation (Biesbroek et al., 2015). To date, they have also not primarily concentrated on the role of individual policymakers in the emergence and sustenance of these dynamics. This could provide insights into why barriers arise and persist and, perhaps more importantly, how they could be mitigated.

In sum, there are many studies that identify barriers that inhibit adaptation, but without researching how these barriers affect the decision-making of individual policymakers and *vice versa*. Noticing this, Siders and Pierce (2021, p. 5) underscore the need for more research on 'how decision-makers are making decisions in practice' and 'how decision-makers should choose a decision-making strategy'. In this dissertation, I adopt a bottom-up approach that aims to understand system-level climate adaptation through analysing

micro-level (behavioural) interactions between actors. This, however, shall not mean that I aim to omit what others have researched as structural influences on policy outcome. Instead, I hope to illuminate policymakers' decision-making as an intermediary between structural influence and policy outcome. For instance, dysfunctional cooperation is frequently observed as a barrier in climate adaptation policymaking (Kaufmann & Wiering, 2019; Oberlack, 2017). However, it remains unclear what micro-level behavioural interactions underpin it, which restricts the ability to develop interventions.

1.4.2 Behavioural insights research on climate adaptation

Another approach scholars adopted to understand climate adaptation progress is the focus on individual-level decision-making through a behavioural science lens. As of today, research adopting this approach has primarily focused on households and farmers, disregarding policymakers' adaptation decision-making (A. Fischer & Glenk, 2011; Houser et al., 2022; Loy & Spence, 2020; van Valkengoed & Steg, 2019a). Similar to the research focusing on barriers, the exploration of individual-level climate adaptation yielded a list of psychological barriers and drivers that affect adaptation intentions and behaviour. Among those are cognitive biases (Gifford, 2011; Grothmann & Patt, 2005), social influences (Geiger & Swim, 2016; Lo, 2013), belief in and perceptions of climate change (Blennow & Persson, 2009; van Valkengoed, Perlaviciute, et al., 2022), perceived risks (Houser et al., 2022), psychological distance (Singh et al., 2017), status quo preferences (Weber, 2015), behavioural control perceptions (Zhang et al., 2020), habits (de Coninck et al., 2018), and experiences with extreme weather (Demski et al., 2017).

Meta-analytical research points out that perceived self-efficacy and outcome efficacy, as well as the experience of negative affect and pro-adaptation descriptive norms, have the most significant effect on individual-level adaptation (van Valkengoed & Steg, 2019a). In contrast, climate change knowledge and personal experience have a relatively small impact on climate adaptation behaviours (van Valkengoed & Steg, 2019a).

While it presents another valuable starting point for this dissertation, the existing research on behavioural influences on climate adaptation does not directly concentrate on policymakers' decisions. Accordingly, less is known about the behavioural determinants of policymakers' decisions (see Box 1), which are at the core of this dissertation. As their decision context, motivation, and capabilities might significantly differ from those of households or farmers (Christensen, 2018; Petzold et al., 2023; X. Wang et al., 2025), it is imperative to examine their decisions separately to better understand adaptation outcomes. Moreover, existing psychological research does not explore how individual-level behaviour and determinants contribute to societal-level adaptation outcomes, i.e., it does not assess the societal dynamics resulting from interactions between individuals. In this dissertation, I address these research gaps on policymakers' decision-making and the micro-level behavioural dynamics underlying climate adaptation progress (see Section 1.6).

Box 1: Determinant of behaviour.

Determinant of behaviour

The psychological and contextual factors that stimulate or hinder an individual's behaviour (van Valkengoed, Abrahamse, et al., 2022).

1.5 From behavioural analysis to intervention design

As the previous sections have shown, scholarly work has identified a range of structural governance barriers and psychological factors that shape adaptation efforts. Accordingly, a behavioural investigation of

adaptation policymaking needs to adopt a holistic approach that considers psychological and contextual influences arising in the multi-actor system. To date, scholarly work has not yet carried out such an analysis of the adaptation system.

In this dissertation, I build on established behavioural insights processes, ranging from behavioural analysis to the development of an intervention. This section outlines what stages these processes incorporate (Subsection 1.5.1). I do not aim to offer a comprehensive review of behavioural insights workflows. Instead, the sections shall illustrate the key steps in applying the approach. I also describe existing work on bridging behavioural insights and systems analysis (Subsection 1.5.2), which is central to the research approach in this dissertation. Both subsections provide the basis for the studies presented in Chapters 2 to 4, which follow a system-focused process from behavioural analysis to intervention development.

1.5.1 Intervention development process

The term behavioural intervention refers to a deliberate action that aims to foster behaviour change amongst a specific target audience (Abraham & Denford, 2020; Michie & West, 2014). There is a range of step-by-step guidelines that describe the process of developing behavioural interventions (Abraham & Denford, 2020; Hankonen & Hardeman, 2020; Jungbluth et al., 2024; Michie & West, 2014). The approaches differ in their nuances but generally follow a similar logic, with some frameworks omitting certain stages, such as pilot testing or evaluating interventions.

The first step in many existing frameworks is the identification of a clear, changeable target behaviour (i.e., the behaviour an intervention will address). To do that, one needs to assess the behaviours underlying the problem one aims to address and select one that is a suitable target for an intervention (Hallsworth, 2023a; Michie & West, 2014). This process includes examining the psychological determinants that underly the target behaviour, as these will be the focus of the behavioural interventions (Hankonen & Hardeman, 2020; van Valkengoed, Abrahamse, et al., 2022). Determinants can be explored using established frameworks such as the COM-B³ or Theoretical Domains Framework, which allow their identification in qualitative data, or quantitative psychological questionnaires (Atkins et al., 2017; Michie & West, 2014).

Then, an intervention is designed based on established psychological theories of behaviour change (Hankonen & Hardeman, 2020; Michie & West, 2014). There is a broad range of theories that can serve as a basis for interventions, such as social identity theory (Reynolds et al., 2020), the stage model of self-regulated behaviour change (Bamberg, 2013), self-determination theory (Hagger et al., 2020), and the COM-B model (Michie et al., 2011). Regarding the intervention development, building behaviour change interventions on the selected theory and the identified determinants increases their effectiveness (Michie et al., 2013; Michie & West, 2014). These behaviour change techniques range from strengthening knowledge, using social influences, and giving feedback to targeting identities and associations (Michie et al., 2013).

After creating a prototype, many frameworks suggest a pilot test to ensure that it can effectively influence the target behaviour, with some scholars recently advocating for the inclusion of the target group in this stage (Hankonen & Hardeman, 2020). The pilot test results can then inform the adjustment of the intervention to ensure its impact and acceptability (Abraham & Denford, 2020; Hankonen & Hardeman, 2020). Suitable pilot test formats are the use of experimental approaches with smaller sample sizes or a group workshop in which the intervention is evaluated with the target group (Hankonen & Hardeman, 2020).

³ The COM-B model includes the domains, capability (C), opportunity (O), and motivation (M) as influences on behaviour (B) (Michie et al., 2011).

Finally, the intervention is implemented and evaluated (Abraham & Denford, 2020; Hankonen & Hardeman, 2020; Michie & West, 2014). There is a range of approaches and frameworks for the evaluation of interventions, originating from distinctive disciplines like psychology and implementation science (Matthews & Simpson, 2020). One is the APEASE framework, capturing interventions' affordability, practicability, effectiveness, acceptability, side-effects, and equity implications (Brierley et al., 2022; Michie & West, 2014). Methodologically, experimental evaluations based on large samples are often viewed as the gold standard for evaluating interventions. However, recently others have suggested that alternative evaluation methods, such as workshops or N-of-1 designs, which study behaviour change in a single individual, can provide equally valuable evaluation insights and go beyond the reductionist approach of experiments (Heino et al., 2021; Matthews & Simpson, 2020).

To take stock, existing frameworks emphasise that the development of a behavioural intervention requires an in-depth exploration of the target behaviour, the theory-based creation and testing of a prototype, and the evaluation of the intervention's effects. While many of the established workflows capture these steps, they are often not (fully) enacted in behavioural research, leading to less effective interventions (Davis et al., 2015; Hofmann et al., 2025; Szaszi et al., 2025). However, they represent the established model steps that enable the development of comparatively effective behaviour change interventions.

Still, the approaches have been critiqued for their limited consideration of the system surrounding decision-makers, which limits both the impact and success of interventions. In the following section, I will provide an overview of the calls for a system perspective in behavioural research, key concepts relevant to the integration, and early applications of system-focused behavioural insights. Taken together, Subsections 1.5.1 and 1.5.2 inform the system-focused behavioural insights approach that this study adopts.

1.5.2 Adopting a system perspective in behavioural research

The importance of adopting a system perspective in behavioural insights research has been recognised in many recent investigations, which highlight that if behavioural scientists aspire to contribute to solving today's grand challenges, such as climate change, system-focused tools and approaches are required (Chater & Loewenstein, 2023a; Hallsworth, 2023a; Hofmann et al., 2025; Kaufman et al., 2024; Varazzani & Hubble, 2025). This realisation emerged amidst the limited societal impact and effect sizes of traditional behaviour change approaches, first and foremost nudges, that have shaped the design of interventions for the past two decades (Grinstein et al., 2025; Mertens et al., 2022; Szaszi et al., 2025; Tummers, 2023). The system perspective is viewed as a potential antidote to behavioural insights' shortcomings in understanding contextual influences on decisions, accounting for non-linear behaviour change dynamics, discerning the behavioural underpinnings of wicked problems, and developing societally impactful interventions (Frame et al., 2023; Hallsworth, 2023a; Kaufman et al., 2024; Lunetto et al., 2022; Nguyen-Trung et al., 2025; R. Schmidt, 2024).

The calls for a system perspective have also been endorsed, and often championed, by practitioners who view it as a pathway to increasing the impact of behavioural science in policymaking (Del Valle et al., 2024; Dupoux et al., 2025; Puukko et al., 2024). For example, a recent report by the EU Policy Lab outlines that behavioural insights could become an integral element of all policymaking stages, especially when focused on changing systems rather than individual behaviour (Dupoux et al., 2025).

Adopting a systems perspective requires that researchers assess intra-individual processes and dynamics in the system that arise as a result of inter-individual actions, connecting different levels of analysis from the individual and group levels to the system (Caggiano et al., 2023; Davan Wetton et al., 2025; Grinstein et al., 2025; Walton & Yeager, 2023). This bottom-up approach compels the analysis of complex system features

that have only received limited attention in existing behavioural research, despite their centrality in other disciplines, such as policy analysis or complexity science (Auping et al., 2024; Byrne & Callaghan, 2022; van der Maas, 2025).

Scholarly work in systems analysis and complexity science shows that complex systems are characterised by specific properties, such as emergence, interconnections, non-linearity, and feedback (loops) (Erdi, 2008; Heino et al., 2023; Jensen, 2022; Mathews et al., 1999). Accordingly, a behavioural systems approach (see Box 2) needs to take these into account when analysing behavioural dynamics (Heino et al., 2021; Parkinson et al., 2025; van der Maas, 2025).

Box 2: Behavioural systems approach.

Behavioural systems approach
A research concept that bridges behavioural insights and systems analysis to understand system behaviour by analysing micro-level behaviour and *vice versa*.

In the following paragraphs, I briefly discuss properties of complex systems relevant to this dissertation and their connection to behavioural science research. While this dissertation does not primarily concentrate on the application of complexity science concepts to behavioural research (see Heino (2025) for pioneering research on this), these concepts’ application will repeatedly resurface in all chapters of this dissertation (see Table 1). This is necessitated by the systems approach, as it requires the analysis of dynamical interactions within the climate adaptation system.

Table 1: Complex system properties relevant to this dissertation.

Chapter	Concepts	Relevance
2	Emergence, interconnectivity, feedback loops, non-linearity	I use a thematic analysis and behavioural system mapping to understand interconnections between the behaviours of distinctive actors in the climate adaptation system. Based on this, I surface emerging dynamics that result from the multi-actor interactions. Using the map, I identify feedback loops in the system and connected levers for change.
3	Interconnectivity, feedback loops	I draw on the results from the behavioural system map to prioritise behaviours connected to the feedback loops and change levers identified in Chapter 2. The resulting set of key behaviours shall address (interconnected) ripple effects within the system.
4	Non-linearity, interconnectivity, feedback loops	Building on the results from Chapters 2 and 3, I develop a behavioural intervention that targets the identified key behaviours in the system and, thereby, feedback loops in the system. I propose that this intervention might unfold disproportionate impacts in the system due to its focus on changeable intervention targets.

5	Emergence, interconnectivity, feedback loops, non-linearity	Based on a review of existing research on behavioural system mapping, I develop a stepwise guide to their construction and use in behavioural research. The maps allow the analysis of complex system properties in systems of behaviour, such as interconnections, emerging behavioural dynamics, loops, and levers that could spark non-linear change.
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Emergence and interconnectivity. One key property of complex systems is emergence, which ‘denotes the occurrence of properties or phenomena at the aggregate level, which the individual parts do not possess’ (Jensen, 2022, p. 18). This emergence is a result of the interconnectivity between the elements within a system. In complexity science, the behaviour of bird flocks is frequently used to illustrate this phenomenon, in which system-level dynamics emerge as a result of individual behaviour in the absence of a central control. Only by observing the birds moving as a flock can one understand the interdependencies between their behaviour and the emergent patterns that are not apparent on the individual level. This is also a suitable example to illustrate the difference between existing, individual-level and system-focused behavioural insights approaches. While a traditional behavioural analysis would focus on the decisions of an isolated climate adaptation policymaker, a system perspective requires an examination of the dynamic patterns that emerge through their interconnections with other actors and *vice versa* (Jensen, 2022; Parkinson et al., 2025; Thurner et al., 2018; van der Maas, 2025).

Scholars have argued that such a system-focused approach can increase the robustness of behaviour change approaches by reducing their brittleness amidst (unconsidered) contextual influences (Parkinson et al., 2025; R. Schmidt & Stenger, 2024). Recently, behavioural scientists have suggested that more attention to between-actor interactions is needed to better understand complex societal challenges (Lunetto et al., 2022). Early methodological approaches, such as agent-based modelling (Rietkerk-van der Wijngaart et al., 2025) and behavioural system mapping (see Chapter 5, Box 3), aim to take this interconnectivity in a system into account. However, Whitmarsh et al. (2021, p. 77) note the persisting gap in scholarly work on ‘how personal action influences others, or affects the broader contexts within which people act’.

Box 3: Behavioural system mapping.

Behavioural system mapping

A method that visualises cause-effect relations between the behaviours of multiple actors to analyse behavioural dynamics in a system of interest (Hale et al., 2022; Kaufman et al., 2024).

Non-linearity. Research on complex systems highlights that dynamics within a system are not linear, meaning that inputs in the system can generate asymmetric effects (‘butterfly effect’) (Mitchell, 2009; Thurner et al., 2018). Take, for example, the reaction to a note on a national policy directive on climate adaptation (stimulus) in a presentation. Whereas it might lead to a positive reaction and uptake on one day, it might not even be noted on another (van der Maas, 2025). The reaction to the stimulus might depend on contextual differences, such as the presence of other individuals, room temperature, or the time passed since the last meal. Another well-known example of non-linearity is the intention-behaviour gap, where changes in intentions do (often) not lead to proportionate changes in behaviour (Heino et al., 2021, 2023). The concept of non-linearity is connected to tipping points, which refer to critical transition thresholds in which a non-linear, abrupt system change can occur as a result of an incremental adjustment in the system’s

conditions (Erdi, 2008; Juhola et al., 2022). Such tipping points have been observed in socio-environmental and socio-technical systems, like climate adaptation (Juhola et al., 2022), climate change mitigation (David Tàbara et al., 2018), and electric vehicle adoption (Mey et al., 2024). Both non-linearity and tipping points are connected to a key interest of systems research, leverage points. This interest is also reflected in early work on bridging behavioural science and systems analysis (Davan Wetton et al., 2025; Del Valle et al., 2024; Lunetto et al., 2022). Leverage points are spaces where an intervention could tap into existing dynamics within a system to achieve system-wide effects.

Feedback loops. The dynamics in a complex system are often shaped by feedback loops, referring to self-reinforcing mechanisms between the elements within it (Erdi, 2008; van der Maas, 2025). For example, the uptake of electric vehicles might lead to an improved charging infrastructure, which then again leads to a greater uptake of electric vehicles. In a feedback loop, an element is both effect and cause, feeding back into its input element (Byrne & Callaghan, 2022; Erdi, 2008). Feedback loops are often viewed as the core driver of a system, with methods, such as causal loop diagramming, concentrating on them in the analysis of system dynamics (Barbrook-Johnson & Penn, 2022). Behavioural research has shown that analysing such feedback loops between actors' behaviours can increase the understanding of behavioural dynamics in a system and, thereby, enable the development of interventions that make use of the self-reinforcing loops (Hale et al., 2022; Lunetto et al., 2022).

The remaining question is how the system properties presented above can be incorporated into the development of behavioural interventions. Researchers have suggested that to adopt a systems approach, behavioural scientists must change the workflows in intervention design and rethink the methodologies utilised in data collection, analysis, and intervention design (Hale et al., 2022; Kaufman et al., 2024; Lunetto et al., 2022). Some of the intervention development frameworks discussed in the previous subsection (1.5.1) encapsulate elements of a systems approach (Abraham & Denford, 2020; Hankonen & Hardeman, 2020; Kaufman et al., 2024), but it is far from being an established practice (Hallsworth, 2023a; Hofmann et al., 2025; Varazzani & Hubble, 2025).

While a typical intervention design process starts with the identification of a target behaviour based on a behavioural problem, a system approach requires analysing the system in which the behaviour takes place (Kaufman et al., 2024; Lunetto et al., 2022). This has implications for the data collection, which needs to be widened to include a broader range of perspectives. Moreover, interventions need to be context-aware and address levers for change in a system to maximise their impact, considering interconnections between behaviours and resulting chain effects (Lunetto et al., 2022; Luszczynska et al., 2020; Parkinson et al., 2025; Veltri, 2025). Accordingly, the obtained data must be analysed with a focus on leverage points and interconnections within the system instead of solely focusing on factors relevant to changing a single behaviour. This requires the adoption of new methodologies, such as behavioural systems maps, that integrate behavioural insights and systems analysis (Dupoux et al., 2025; Grinstein et al., 2025; Heino et al., 2023; Mathews et al., 1999).

Readers might have noticed that I use the term 'system' when referring to behavioural system mapping and the term 'systems' when speaking of the broader behavioural systems approach. This differentiation shall convey that, in this dissertation, behavioural system mapping is viewed as a method that captures a (behavioural) system of interest at a specific time point. In contrast, the proposed behavioural systems approach refers to a broader way of thinking about behaviour (change), which is not necessarily constrained to one system of interest.

In this dissertation, I aim to apply a behavioural systems approach that can detect emerging contextual influences and feedback loops to understand and improve policymakers' climate adaptation decision-

making. Climate adaptation, in particular, is characterised by a large number of involved actors and highly contextualised influences, necessitating a system lens to understand adaptation progress (see Section 1.4; Biesbroek et al., 2013; Brumberg et al., 2025; Petzold et al., 2023). However, as of today, there is no system-focused behavioural research on adaptation policymaking. Moreover, there is limited research on the practical translation of calls for the integration of systems thinking and behavioural science. Still, the early research on bridging complexity science and psychology (van der Maas, 2025), behavioural system mapping (Hale et al., 2022) and system-focused interventions (Jungbluth et al., 2024) provides a basis for studying climate adaptation through a behavioural systems lens.

1.6 The knowledge and methodological gaps

Climate adaptation is essential to protect natural and human systems amidst the growing challenges elicited by climate change. To take stock, the previous sections have highlighted that:

- current climate adaptation efforts are insufficient,
- policymakers' decision-making could be a pathway to enhancing adaptation,
- behavioural insights can be used to research policymakers' decision-making,
- and a behavioural systems approach is required to capture the system influencing adaptation policymaking.

While existing research primarily concentrated on structural barriers (Section 1.4.1) and household behaviours (Section 1.4.2), I aim to open the black box of policymakers' decision-making. Doing this, I focus on factors that shape their decision-making processes, considering that policymakers are part of a complex system in which societal adaptation efforts arise. Thereby, I follow scholarly work that highlighted the importance of not adopting a reductionist, pre-determined barrier focus, arguing 'the biggest "barrier" to adaptation might very well be the concept of barriers itself and how it is currently being used in studying adaptation decision-making' (Biesbroek et al., 2015, p. 494). I also address recent calls for investigations that explore the processes that lead to the emergence of barriers and drivers, as I investigate policymakers' decision-making processes (Biesbroek et al., 2015; Eisenack et al., 2014; Ishtiaque et al., 2021; Lee et al., 2023a, 2023b).

Simultaneously, I respond to numerous calls for scholarly work that uses behavioural insights in the study of climate adaptation (Domingos et al., 2018; van Valkengoed & Steg, 2019b). Thereby, the dissertation also contributes to the growing body of psychological research on climate change issues and transitions (G. de Vries et al., 2021; Whitmarsh et al., 2021).

Methodologically, behavioural scientists have emphasised that a behavioural systems approach that enables system-focused and context-sensitive research alike is required (Hallsworth, 2023a; Lunetto et al., 2022). However, practical translations of these calls are limited, which is why I explore how a behavioural systems approach can be used to research policymakers' adaptation decisions and how it can be further advanced.

The outlined research foci can contribute to a better understanding of climate adaptation efforts and advance the application of behavioural insights, addressing four interconnected research gaps:

1. *Analysis of policymakers' adaptation decision context.* There are many investigations researching barriers to climate adaptation, but policymakers' decision context and behavioural dynamics in the system have yet to be examined. Analysing the multi-actor system shaping policymakers' decision processes, including actors, dynamics, behavioural patterns, and interconnections, can increase the

understanding of climate adaptation outcomes. Doing this without a pre-determined barrier focus and, instead, with an emphasis on dynamics affecting adaptation decisions can yield novel insights into why adaptation progress is limited. Shifting the attention to policymakers can provide a basis for the development of effective behavioural interventions tailored to their decision context.

2. *Prioritising target behaviours for interventions and behaviour change techniques.* Next to exploring the system in which adaptation policymakers take their decisions, it is imperative to understand which behaviours present suitable intervention targets and what interventions can be used to improve policymakers' decision-making. Investigating the changeability and impact of policymakers' behaviours is required for creating impactful interventions. Moreover, an assessment of the behaviour change techniques that are acceptable for the target group is essential to guarantee that the intervention will be implementable.
3. *Developing and testing an intervention to improve adaptation.* There is a need for more climate adaptation. As policymakers are a key actor in adaptation, improving their decision-making could be a pathway to enhancing societal adaptation efforts. While behavioural interventions' abilities have been proven in many domains, climate adaptation-focused investigations have primarily concentrated on household adaptation. However, looking into the behaviour of households is insufficient to improve societal climate adaptation efforts. Therefore, designing and testing a behavioural intervention targeting policymakers presents an opportunity for behavioural research to contribute to climate adaptation action, while simultaneously contributing to the development of interventions for policymakers.
4. *Adopting a behavioural systems approach in researching multi-actor decision-making.* Amidst repeated calls for systems approaches in the development of behavioural interventions and behavioural research more generally, practical translations of a behavioural systems approach for both behavioural analysis and intervention design can provide a basis for future system-focused research. There is a particular need for advancing methodologies for the initial behavioural analysis of a system, as this is the basis for understanding and changing multi-actor behaviour. Connecting emerging methods, such as behavioural systems mapping, with approaches from disciplines other than behavioural science, such as systems analysis and implementation science, can strengthen them. It also contributes to the growing body of scholarly work on system-focused approaches in applied behavioural science.

1.7 Research questions and overview

In order to contribute to the knowledge and methodological gaps outlined in the previous section, the overall question guiding this research is:

How can policymakers' climate adaptation decision-making be understood and improved using a behavioural systems approach?

To answer this question, this dissertation incorporates three empirical studies investigating policy decision-making in climate adaptation and one methodological chapter formulating an analytical approach to integrating behavioural science and systems analysis. The overall aim of the research is to contribute to societal climate adaptation efforts by improving policymakers' decision-making. This requires an in-depth system analysis (Chapter 2), prioritisation of target behaviours (Chapter 3), and development of an intervention (Chapter 4). In addition, it necessitates inculcating a system perspective in behavioural research and methodological advances to achieve this (Chapter 5).

Each of the chapters is guided by a sub-research question that contributes to the overarching research objectives:

1. **Chapter 2:** Understanding slow progress in urban climate adaptation: An empirical analysis of behavioural dynamics in Dutch policymaking

Research question: What are the psychological and contextual factors influencing policymakers' urban climate adaptation decision-making processes according to Dutch policymakers?

Methodology: The study conducted semi-structured interviews and a reflection workshop to collect data on policymakers' decision-making. The data is analysed using thematic analysis, content analysis, and behavioural system mapping.

Contribution: The study uncovers actors and behavioural dynamics that shape Dutch policymakers' adaptation decisions. It also links the behavioural dynamics to underlying determinants of behaviour that interventions could target. Through the system mapping, it identifies levers of change, which signal points where behavioural interventions could evoke system change.

2. **Chapter 3:** Identifying key behavioural determinants and intervention spaces in policymakers' climate adaptation decision-making

Research question: What are the key behaviours that affect climate adaptation policymaking and what behaviour change techniques can improve them?

Methodology: The study conducted a systematic scoping review of research on policymakers' adaptation decision-making and a two-round Delphi panel with behavioural scientists and policymakers. It analyses the review articles using a behavioural analysis of determinants and behaviour change techniques and the Delphi panel data through a statistical analysis.

Contribution: The prioritisation of key behaviour in climate adaptation policymaking provides a basis for developing impactful interventions. The prioritisation of acceptable behaviour change techniques enables the development of implementable interventions. Through the systematic scoping review, the study showcases what determinants of behaviour and behavioural interventions have been analysed in adaptation policymaking research.

3. **Chapter 4:** Development and evaluation of a metacognitive behavioural intervention to improve policymakers' climate adaptation decision-making

Research question: Does an intervention combining metacognition and mental contrasting improve decision performance in climate adaptation compared to a control condition?

Methodology: The study conducted two workshops to optimise the intervention and evaluate its usability, as well as an experiment testing it.

Contribution: CARN is a practical tool policymakers can use to improve their adaptation decision-making process. It provides insights into how behavioural interventions can leverage metacognitive processes to improve decision-making.

4. **Chapter 5:** A stepwise guide to constructing behavioural system maps for behavioural public policy research

Research question: How can behavioural system maps be constructed to support system-focused behavioural analyses in policy research and practice?

Methodology: The study conducted a review of existing research on behavioural system mapping and translated the deduced insights into a stepwise guide.

Contribution: The stepwise guide enables professionals and researchers working with behavioural insights to create behavioural system maps and, therefore, adopt a system perspective in their behavioural analyses.

Taken together, the chapters provide three empirical contributions to scholarly work on climate adaptation research and one methodological contribution to existing system-focused behavioural research. They further reveal an overarching behavioural systems approach that bridges existing behavioural insights workflows (Subsection 1.5.1) and calls for a systems perspective in the application of behavioural science (Subsection 1.5.2). This dissertation thereby also makes a conceptual contribution, which I will return to in the reflection on the research findings in Chapter 6. For societal adaptation efforts, the dissertation showcases what behavioural dynamics might slow adaptation progress and suggests practical pathways addressing these dynamics.

The empirical investigations presented in Chapters 2 to 4 primarily concentrate on climate adaptation policymaking within the Netherlands. While the initial behavioural analysis is entirely constrained to Dutch policymaking (Chapter 2), Chapters 3 and 4 also collect data from individuals residing outside the Netherlands. Still, as the basis for the research presented in those chapters is the initial behavioural analysis, their findings are primarily applicable to the Dutch context. I chose the Netherlands as a study context for two primary reasons. First, it is a country particularly vulnerable to climate change and simultaneously taking policy action in order to adapt to its effects. Chapter 2 will provide further information on the climate adaptation efforts and practices in the Netherlands. Second, the proximity and availability of research participants facilitated the analysis of the Dutch adaptation system. I will discuss the applicability of the findings to other geographical contexts in each of the empirical investigations (Chapters 2 to 4) and the reflection in Chapter 6.

1.8 Outline and reading guide

This dissertation consists of six chapters. Chapters 2 to 4 follow the process from behavioural analysis to intervention design outlined in the previous sections, constituting the behavioural systems approach. I first analyse the contextual and psychological factors that shape policymakers' adaptation decisions, which provide the basis for the development of a behavioural intervention that can support decision-making (Chapter 2; Bellmann et al. (2025b)). While the second chapter primarily focuses on urban climate adaptation, the later chapters do not explicitly concentrate on urban environments. This is the result of the initial system analysis in Chapter 2, which highlighted that urban and rural adaptation are strongly interlinked in the Netherlands. This means that studying one without considering the other would detach the research from the practical realities of policymaking. In Chapter 3, I also prioritise key areas for improving the decision-making of policymakers to identify suitable target behaviours for interventions (Bellmann, de Vries, et al., n.d.-b). Subsequently, I develop and evaluate an intervention that improves decision processes in adaptation policymaking (Chapter 4; Bellmann, Scholten, et al. (n.d.)).

In Chapter 5, I then present a methodological advance at the intersection of systems analysis and behavioural science and how it can be employed to study behaviour in systems, namely, behavioural system mapping (Bellmann, 2025). Finally, I discuss the overarching implications and contributions of this dissertation to both policymaking practice and academic research in Chapter 6.

Figure 1 shows that there are two pathways to reading this dissertation. One accentuates the investigation of climate adaptation decision-making (yellow circles), whereas the other prioritises the methodological contribution to behavioural insights research (turquoise circles). Both pathways encapsulate all chapters of the dissertation. The climate adaptation pathway first takes the reader through the behavioural systems approach's application to climate adaptation policymaking, while presenting the methodological contribution taken from this approach at the end of the dissertation. In contrast, the methodological pathway presents the chapter on behavioural system mapping at the front, offering a methodological frame through which the study of climate adaptation policymaking can be viewed.

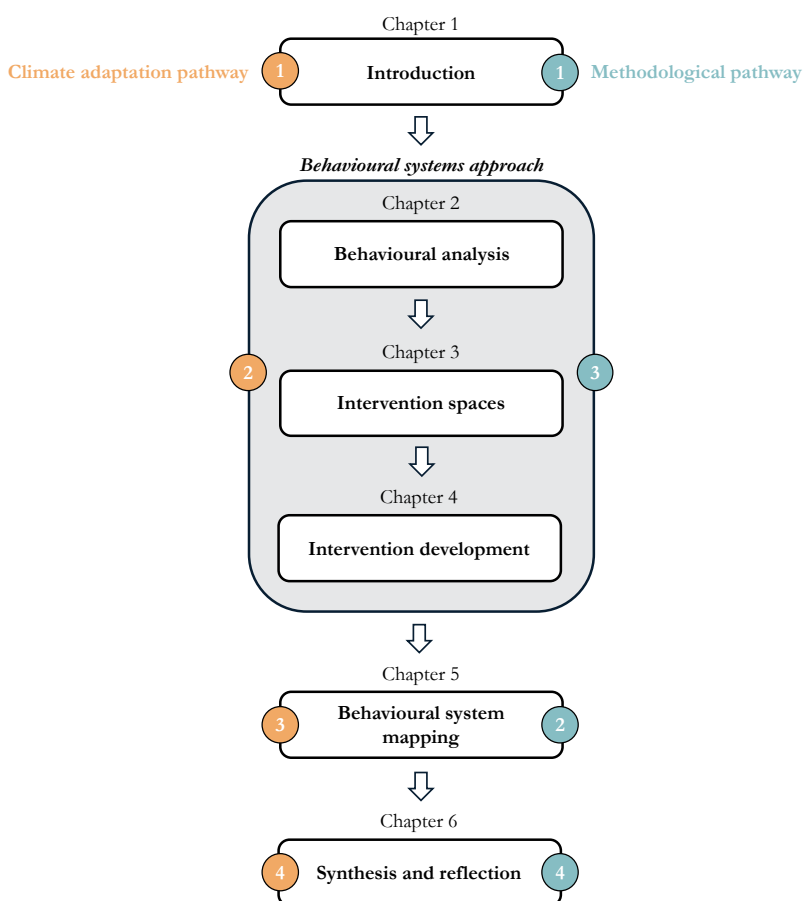
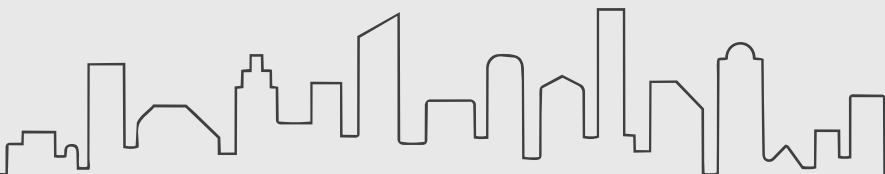


Figure 1: Reading guide.

2

UNDERSTANDING SLOW PROGRESS ON URBAN CLIMATE ADAPTATION:

AN EMPIRICAL ANALYSIS OF BEHAVIOURAL
DYNAMICS IN DUTCH POLICYMAKING



Urban areas face an increasing urgency to adapt to climate change, yet adaptation efforts remain insufficient. Addressing this adaptation gap requires an understanding of the psychological mechanisms and contextual influences shaping climate adaptation behaviour. Whereas behavioural scientists have explored citizens' climate adaptation behaviours, the decision-making of policymakers is often overlooked despite its importance in closing the adaptation gap.

To address this, we conducted a behavioural systems analysis to uncover behavioural dynamics that shape policymakers' decision-making, based on 32 semi-structured interviews and a workshop with Dutch urban climate adaptation policymakers. Combining thematic and content analysis with behavioural system mapping, our results highlight the importance of an integrated, dynamic system approach to understand psychological and contextual influences on policymakers' decision-making. We identified nine central themes reflecting key behavioural dynamics: reliance on precedents; fragmented roles and responsibilities; habitual thinking based on longstanding processes; policy stringency, clarity and process; conflicting political priorities; importance of individuals; externally-motivated action; illusion of local actor engagement; moving from awareness creation to mainstreaming. Furthermore, analysis of behavioural influences using the Theoretical Domains Framework identified policymakers' beliefs about consequences, environmental context and resources, and goals as most influential determinants of behaviour. Behavioural system mapping revealed three impactful levers for interventions, namely supporting precedent identification, stimulating information gathering, and boosting mainstreaming processes, to improve decision-making in urban climate adaptation.

By integrating behavioural insights and systems analysis, this work proposes a novel approach to analyse contextual, dynamic influences and determinants of behaviour that shape adaptation policymaking. Therefore, it aligns with recent calls from behavioural scientists highlighting the need for systemic approaches in behavioural science.

An adapted version of this chapter has been published as:

Bellmann, K. P., de Vries, G., & Scholten, L. (2025). Understanding slow progress on urban climate adaptation: An empirical analysis of behavioural dynamics in Dutch policymaking. *Journal of Environmental Psychology*, 105, 102666. <https://doi.org/10.1016/j.jenvp.2025.102666>.

2.1 Introduction

2.1.1 Policymakers' behaviour matters

Climate adaptation refers to *'the process of adjustment to actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities'* (Calvin et al., 2023, p. 120). International and local government bodies across the globe are increasing their adaptation efforts to cope with climate change impacts (MinIE, 2016; UNEP, 2022, 2023). Whereas awareness is increasing, and suitable climate adaptation instruments are often known, considered implementable, and economically cheaper than not adapting in time, present adaptation efforts are slow and remain inadequate (Biesbroek et al., 2015; Calvin et al., 2023; Carter et al., 2015; DARA & Climate Vulnerable Forum, 2012). This 'adaptation puzzle' (Bechtoldt et al., 2021, p. 187) cannot be explained by structural barriers and enablers only; a closer look at psychological factors and other behavioural influences that shape climate adaptation efforts is needed (Ishtiaque et al., 2021; Lee et al., 2023a; Siders & Pierce, 2021).

Psychological research has primarily investigated factors that influence the adaptation behaviours of citizens (e.g., Bateman & O'Connor, 2016; Singh et al., 2017). While citizen action for climate adaptation is necessary (Hegger et al., 2017), individual citizens have limited leverage over system-wide effects and are strongly influenced by adaptation policies and the choice architecture these provide (Biesbroek et al., 2018; Petzold et al., 2023; Reisinger et al., 2011). To address the adaptation gap, it is necessary to recognise that urban climate adaptation expands beyond citizen action, as it is a complex multi-actor⁴ issue, wherein efforts need to be agreed and implemented by various governmental, non-governmental, and private actors (Cunningham & Hermans, 2018; Kanarp & Westberg, 2023; Vargas López & Flores-García, 2023).

Policymakers are key actors within this system, as their decisions regarding the design and implementation of policies for climate adaptation shape the trajectory in which society adapts. Especially local policymakers are at the core of urban climate adaptation efforts as the localised nature of climate impacts, such as extreme weather events and ecosystem degradation, require local responses. Therefore, local policymakers are often the ones to decide which measures, such as green roofs and water management strategies, are allowed, facilitated, supported, or incentivised in local urban planning (European Commission, 2021; Hallegatte & Corfee-Morlot, 2011; Petzold et al., 2023; Wilbanks, 2011).

Present behavioural research, however, has paid little attention to policymakers' decision-making behaviour. A stronger focus on policymakers is needed to improve the understanding of climate adaptation efforts, as articulated in recent research (Árvai & Gregory, 2021; Siders & Pierce, 2021). Siders and Pierce (2021, p. 5) called for more research on 'how decision-makers are making decisions in practice', arguing that the wicked nature of climate adaptation challenges requires effective decision-support for policymakers. We thus seek to investigate policymakers' decision-making using a systems approach to take into account how behavioural dynamics in the complex system shape their decisions.

2.1.2 The importance of context in understanding decision-making behaviour

Behavioural insights in decision-making more broadly refer to the 'application of findings from behavioural science to analyse and address practical issues in real-world settings' (Hallsworth, 2023a, p. 311). The main interest is to identify behavioural influences that shape individual-level decision-making processes and appropriate ways to improve them (Dewies et al., 2022; Hallsworth, 2023a; Hallsworth & Kirkman, 2020; OECD, 2017).

⁴ In complex systems, individuals and organisations with the power to influence a system of interest through unilateral actions are often referred to as 'actors' (Cunningham & Hermans, 2018).

Despite the largely beneficial effects of behavioural interventions, their effect sizes are often small (Mertens et al., 2022). This has been attributed to the application of individual-level interventions to broad population groups that neither take into account the system context in which the target behaviour takes place, nor any individual-level differences, as observed in numerous policy domains, including health and environmental issues (Chater & Loewenstein, 2023a).

Therefore, behavioural scientists emphasise the need to move beyond the individual level and to take into account systemic complexity when investigating behavioural dynamics and designing interventions to address wicked problems, such as climate change (Chater & Loewenstein, 2023a; Hallsworth, 2023a; Lunetto et al., 2022). Efforts to incorporate a system approach into behavioural science studies have shown promising results in identifying social tipping points (Andreoni et al., 2021), assessing intervention impacts within systems (Hawe et al., 2009), and formulating system-focused behavioural interventions (Guariguata et al., 2020; Hale et al., 2022).

In urban areas, the context within which multiple actors develop policy and the interactions between them shape climate adaptation efforts (Lunetto et al., 2022; Petzold et al., 2023). A system perspective to illuminate contextual influences on policymakers' decision-making can improve the understanding of behavioural dynamics and the identification of ways to improve adaptation decisions through behavioural interventions.

2.1.3 Analysing the system shaping policymakers' climate adaptation decisions

One valuable starting point for investigating policymakers' decision-making is research on the structural barriers and drivers that affect climate adaptation policy and its outcomes (A. Bauer et al., 2012; A. Bauer & Steurer, 2015; Keskitalo, 2010; Phuong et al., 2018). These often result from how urban climate adaptation is governed, affecting the roles, responsibilities, and interests of actors within a specific context, the laws and regulations to consider, and also how public climate adaptation policy is financed. Consequently, the key contextual inhibitors of climate adaptation are attributable to structural influences, such as insufficient financing, a lack of guiding policy documents, and a high number of involved actors (Oberlack, 2017; Phuong et al., 2018; Shi et al., 2015). However, the reductionist focus on individual factors and whether they act as barriers or drivers in the specific circumstances leads to neglecting interaction effects and other complex, dynamic processes that lead to their emergence, wherein factors can moreover function as both barrier and driver (Biesbroek et al., 2014; Ishtiaque et al., 2021; Lee et al., 2023b). With a focus on explaining policy outcomes based on (structural) contextual differences, research on structural barriers tends to treat policymakers' decision-making processes leading to the policies and their implementation as a black box (Biesbroek et al., 2015).

Existing research on the psychological mechanisms underpinning individual-level climate adaptation behaviour provides another valuable starting point by unpacking this behavioural black box. Environmental psychologists have identified multiple behavioural barriers to individual-level climate adaptation. These range from cognitive biases (Grothmann & Patt, 2005; Weber, 2015), risk perception (Houser et al., 2022), social norms (Geiger & Swim, 2016), belief in and perceptions of climate change (Blennow & Persson, 2009), and perceived behavioural control (Zhang et al., 2020) to the ability to process information (A. Fischer & Glenk, 2011), and psychological distance (Singh et al., 2017). In their meta-analysis of adaptation behaviours, van Valkengoed and Steg (2019a) found that perceived self-efficacy, perceived outcome efficacy, the experience of negative affect, and descriptive, pro-adaptation norms exert the most significant influence. However, this research has yet to consider dynamic contextual and psychological influences on

policymakers' decision-making processes within a complex multi-actor system as encountered in urban climate adaptation.

Assessing both contextual and psychological influences requires a system-focused research approach. Causal system mapping is a suitable method for doing so. It has been widely practised in many different disciplines that endorse system thinking, policy and system analysis methods to study complex systems, at times for decades (Repenning, 2003; Wolstenholme & Coyle, 1983). Recently, applied psychologists have proposed to develop 'behavioural system maps', utilising participatory systems mapping to generate causal maps to explore cause-effect relationships explaining complex behavioural dynamics in multi-actor systems (Hale et al., 2022; Lunetto et al., 2022), thereby helping to make 'explicit the people, behaviours and influences on behaviour within a system and the nature of the relationships among these' (Hale et al., 2022, p. 4).

2.1.4 Aims and contribution of this study

In this work, we aim to advance the analysis of climate adaptation by focusing on policymakers' decisions and by moving beyond the sole analysis of barriers. Examining the contextual and psychological influences on urban policymakers' decision behaviour (rather than that of citizens), we aim to uncover the behavioural dynamics shaping urban climate adaptation decision-making. Our main research question is: *What are the psychological and contextual factors influencing policymakers' urban climate adaptation decision-making processes according to Dutch policymakers?* We combine methods from behavioural science with policy and system analysis in a novel way to address this challenge and demonstrate it for the case of urban climate adaptation decision-making in the Netherlands.

2.2 Research methodology

We adopt a qualitative research approach to investigate the decision context and gain an in-depth understanding of various actors' perceptions and experiences of urban climate adaptation decision-making. This approach consists of (i.) an analysis of the actors in Dutch urban climate adaptation governance as a basis for participant identification and selection, followed by (ii.) semi-structured interviews and a validation and reflection workshop for data collection, and then (iii.) qualitative data analysis combining thematic and content analysis of contextual and psychological influences with behavioural system mapping.

2.2.1 Study area and context

To research urban climate adaptation decision-making processes, we examine the decision-making of policymakers in (the mainland part of) the Kingdom of the Netherlands. A focus on Dutch climate adaptation policymaking is suitable, as the Netherlands are highly urbanised and face high vulnerability to climate change impacts, considering its low-lying topography. In the Netherlands, the awareness of and need for large-scale adaptation is widely accepted. This is reflected by national adaptation policies, such as the Deltaplan Spatial Adaptation and the National Adaptation Strategy developed jointly by three national ministries (MinIW et al., 2023), next to manifold adaptation strategies at local and regional levels (e.g., Rotterdam Office for Sustainability and Climate Change, 2013; Provincie Utrecht, 2020). In addition, 45 climate adaptation working regions have been established as regional cooperation platforms by the Dutch national government, provinces, water boards⁵, and municipalities to improve adaptation capacity and foster collaboration (MinIW et al., 2023).

⁵ Water boards are the governmental bodies tasked with the regional management of water levels, water quantity and quality.

The governance of climate adaptation spans across four governance levels. The national level sets overarching adaptation guidelines and goals such as being ‘climate-robust in 2050’, often without specifying what that means. Provinces and working regions translate guidelines and data to regional levels for their local partners. Finally, the municipal level is responsible for developing local adaptation strategies, planning, and implementing measures. Local planning instruments include municipal adaptation implementation programmes, sewer plans, environmental visions, and further adaptation-related plans. These planning instruments are generally updated every few years (e.g., 5 years) and guide municipal budget planning, programming, and implementation efforts. In addition to these planning instruments, municipalities have a range of adaptation actions at their disposal. These include outreach activities to create public awareness, subsidies that incentivise private adaptation, and local infrastructure projects (Hamstead et al., 2021; MinIW et al., 2023).

2.2.2 Participant sample identification and selection

We aimed to sample from a broad spectrum of policymakers in urban climate adaptation, reflecting the relevant governance actors at local, regional, and national levels and their interconnected roles. The types of actors to approach were determined through an actor analysis (Cunningham & Hermans, 2018). Based on a review of policy documents and scientific articles on climate adaptation barriers, we listed actors involved in urban climate adaptation decision-making in organisations, such as municipalities, water boards, work regions, provinces, ministries, and consultancies. Using purposive sampling, we selected participants who hold positions in urban climate adaptation planning and implementation.

Based on an initial long list of suitable participants, we sent email invitations to take part in this study, describing the research and its objectives. The long list was compiled from the contact points of the climate adaptation working regions, publicly available information on climate adaptation contacts within the identified actors, and via personal contacts of the authors and their networks. Moreover, we utilised snowball sampling, wherein initial interviewees recommended additional participants who could provide insights into the decision-making processes (Saunders et al., 2019) to broaden the scope of our search both in terms of perspectives as well as geographical distribution of respondents across the country, thereby enriching and validating the initial actor scan. Participants were continuously recruited until saturation was reached, as commonly done to determine the necessary sample size in qualitative research (Lakens, 2022). We operationalised this as reaching theoretical saturation, i.e., the point at which additional interviews do not result in the identification of new themes during axial coding (Wutich et al., 2024). Typical sample size recommendations in qualitative research aiming to develop themes from interview data suggest planning for 30 interviews (Thomson, 2010), which this study exceeded.

In total, 32 of the 133 contacted individuals were available within the foreseen timeframe and agreed to take part in an online interview. They cover a diverse range of functions and perspectives from across the country, as shown in Figure 2. Most participants held senior-level positions, often as one of the organisation’s main climate adaptation advisors or managers. Participant responsibilities included drafting adaptation strategies, supervising adaptation projects, developing outreach initiatives, and managing adaptation programmes. Following the interview series, nine participants took part in a validation and reflection workshop to consolidate the findings. In this workshop, we discussed the results of the thematic analysis and draft behavioural system maps for each theme.

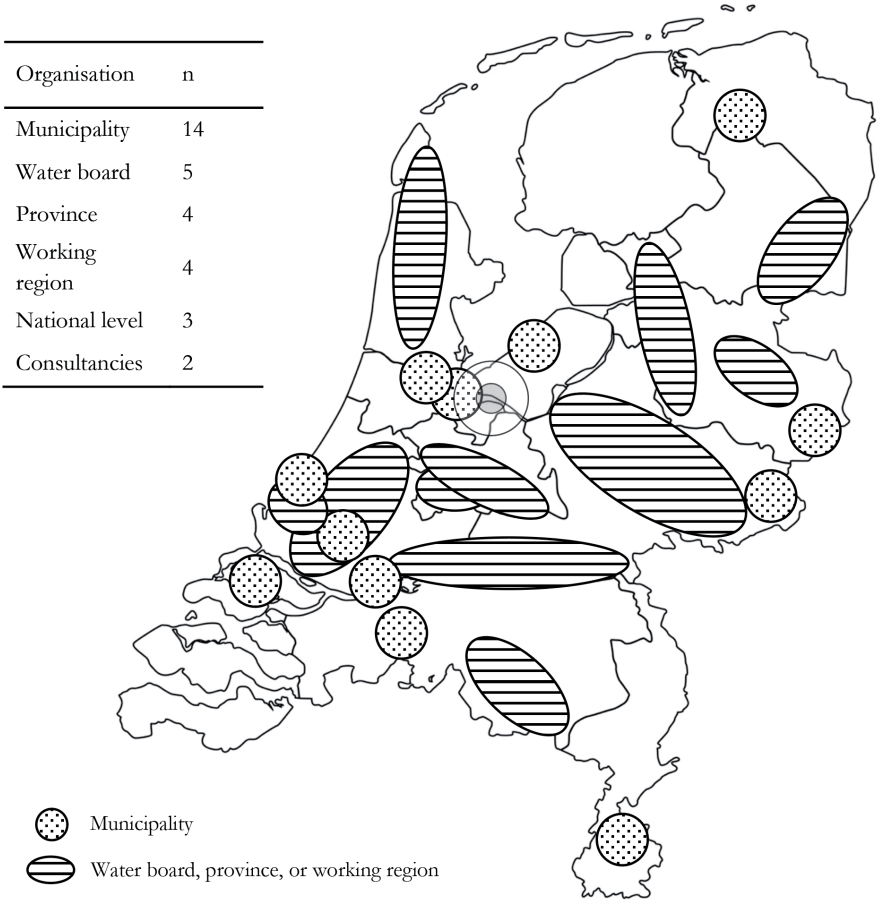


Figure 2. Sample composition. The map shows the geographical scope of responsibilities covered by the interviewees. Three held multiple climate adaptation-related positions (e.g. role in a working region and at national-level), of which only the focal role considered in the interview is displayed. Interviewees with national-level or other geographical focus (e.g., consultancies, national ministry) are not visualised for readability.

2.2.3 Data collection and consolidation

We conducted the semi-structured interviews to analyse the dynamics within urban climate adaptation, as recommended for such an in-depth investigation (Adams et al., 2014). All interviews were recorded, taking between 36.39 and 59.05 minutes ($M=47.41$ min). They were conducted as follows: Before starting the recording, we explained the purpose and scope of the research to the participant and addressed any arising questions. After confirming participant consent, we commenced the interview and the recording following the interview guidelines. The data collection approach, informed consent, and data privacy procedures for both the interviews and validation workshop were reviewed and approved by the TU Delft Human Research Ethics Committee (No 4367).

The interview covered four topical areas. First, we explored participants' role and goals in urban climate adaptation decision-making. Then, participants elaborated on the actors relevant to their decisions and the factors that shape their decision-making. We used adjusted questions from earlier research investigating barriers to climate adaptation (Lee et al., 2023a, 2023b; Mees & Surian, 2023) to assess influences on decision-making processes, however, replacing the word 'barrier' with 'factor'. This resulted in questions like, 'Which factors influence your decision-making in urban climate adaptation?'. In addition, we added questions focusing on the decision-making process to investigate when and how the identified influences affect decisions. Finally, we asked a question to identify the underlying determinants of decision-making behaviour considering participants' capabilities, opportunities, and motivation, following the COM-B model of behaviour (Michie et al., 2011). While only one question explicitly asked for decision influences, all interview questions aimed to capture factors and their dynamic interactions that shape decisions, including those that participants might not label as such (e.g., actors, process structure). The semi-structured interviews allowed for further exploration of the mentioned influences through follow-up questions. The interview guideline is provided in Appendix A in Bellmann et al. (2025b).

Six weeks after the final interview, we conducted an online two-hour workshop to validate and enrich the themes identified through the thematic analysis and reflect upon initial behavioural system maps. All authors were present and co-facilitated the workshop. First, we presented the data analysis process and the findings of the thematic analysis. Second, we formed two groups, each reflecting in breakout rooms on four or five themes, respectively. This reflection focused on three questions: 1. exploring how the dynamics influence decision-making processes, 2. what its effect is on policy decisions, and 3. how it affects policymakers' personal motivation, capabilities, and opportunities. To support the reflection, we provided behavioural system maps based on the preliminary interview findings to visualise the themes' dynamics for validation, as typically done in participatory system mapping (Barbrook-Johnson & Penn, 2022).

2.2.4 Data analysis

We analysed the interview data using a three-step qualitative data analysis process using the qualitative data analysis software Atlas.ti, version 24.2.1 (ATLAS.ti Scientific Software Development GmbH, 2024). First, we conducted a thematic analysis using open coding to surface themes that describe how key factors and dynamics shape the decision context. This approach allowed an in-depth examination of the interview data, facilitating the identification of patterns and themes (Braun & Clarke, 2006; Vaismoradi et al., 2013). Based on open codes, we identified internal and external actors that were reported to influence participants' decision-making. We then used axial coding to group the codes and develop (sub)categories (Hawker & Kerr, 2007). This allowed for a systemic understanding of how different factors are interconnected within policymakers' decision context. Finally, we used the developed categories and subcategories to identify themes that capture the dynamics within and between the categories. These themes aggregate the behavioural dynamics captured in the categories and connect multiple (sub)categories.

Second, we conducted a content analysis using deductive coding to uncover the determinants of policymakers' behaviour based on the Theoretical Domains Framework (TDF), which allows the identification of psychological and contextual determinants of behaviour (Atkins et al., 2017). The TDF provides a framework for analysing and categorising behavioural determinants across multiple behavioural domains, such as knowledge, social influences, and beliefs about consequences, that underlie actors' behaviour (Atkins et al., 2017). Building on the COM-B model (Michie et al., 2011), the TDF allows a more granular analysis of behavioural determinants in 14 domains (Atkins et al., 2017). Inter-rater agreement between two coders was calculated for a sample of four randomly chosen interviews (I7, I15, I17, I21). The average inter-rater agreement for the occurrence of the 14 TDF domains per interview was 80.36%, ranging

from 71.42% to 92.86%. All inter-rater disagreements were resolved through deliberation between the coders.

Third, we developed a behavioural system map depicting the perceived causal relationships between the mentioned contextual and psychological influences on policymakers’ decision-making. This was done by systematically extracting all mentioned observable behaviours and their interconnections from the open coding, developed themes, and workshop notes into a causal map (Kim & Andersen, 2012). We integrated the underlying determinants of behaviour from the TDF analysis into the behavioural system map. The links between the behaviours and determinants of behaviour were established based on co-occurrence in the interview data. Figure 3 illustrates the key concepts used to visualise interactions between actors in a behavioural system map.

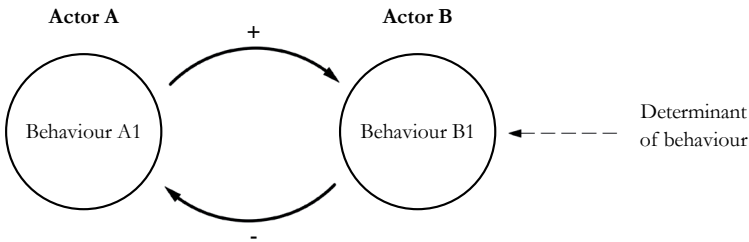


Figure 3. Schematic illustration of behavioural system mapping concepts. The arrows depict the cause-effect relations between behaviours, which can be positively (+) or negatively (-) correlated, e.g. how the behaviour of one actor A influences the behaviour of another actor B. Causal relations can be uni-directional, mutually balancing, or re-enforcing (depicted by a loop-like structure), reflecting the behavioural dynamics within the (multi-actor) system. The (positively correlated) effects of underlying determinants of behaviour on an observable behaviour in the system are represented through dotted, incoming arrows, with the cause stated at the arrowtail.

Finally, we analysed the generated map to derive insights into the behavioural dynamics within the system and to identify levers for change. This was done as follows. (1.) We analysed the maps for the key behavioural dynamics captured in the themes and as derived from the thematic analysis to analyse causal links between the behaviours. (2.) We examined the connections between the themes to identify behavioural dynamics that have a broad effect on the system. By doing this, we identified behaviours that have an impact on the behavioural dynamics of multiple themes and, therefore, behaviours that have a broad influence on the system. The dynamics underlying the levers have also been validated in the reflection workshop. (3.) We identified behaviours of municipal policymakers that could function as a lever for behaviour change due to their impact within the system, presenting a lever for interventions. Following this approach, we identified key levers for interventions that target municipal policymakers’ decision-making behaviour.

2.3 Results

2.3.1 The multi-actor system in urban climate adaptation

The interview participants named 61 external and 29 internal actors whom they perceive as distinct entities influencing their decision-making (see Appendix B in Bellmann et al. (2025b) for the list of actors). This large number and diversity highlight the complexity of the multi-actor system characterising urban climate adaptation policymaking. The behaviours of the main actors and their influence on local policymakers are displayed in Figure 4.

Of the 61 reported external actors, 29 are governmental or quasi-governmental bodies, such as national ministries, water boards, or municipal councils. While the national governmental bodies are primarily seen as influencing decisions through policy frameworks and financial incentives, regional organisations, such as the provinces, working regions, and water boards, are providing knowledge, data, and collaboration opportunities.

Private sector actors constitute a significant proportion of the multi-actor system (n=17). Especially local private actors, such as local businesses and business associations affect adaptation decisions. Moreover, consultancies are often directly involved in local adaptation, as Dutch governmental bodies contract out knowledge and strategy development. These consultancies provide data, access to climate adaptation precedents, networks, and expertise to local decision-makers.

The local community and organisations (n=8) are also relevant to urban climate adaptation decisions. While participants only perceived limited influence of interest groups, inhabitants are the main community actor perceived to be influencing decisions.

Although participants reported only seven knowledge institution actors as being relevant to their decision-making, they are perceived as a critical information source. In particular, national knowledge institutions, such as the Royal Netherlands Meteorological Institute, that translate global scientific evidence to the Dutch context shape policymakers' local decision-making. Local universities also shape decisions, as they provide more localised expertise and research collaborations.

The internal actors (n=29) reported to influence urban climate adaptation decision-making span a wide range of departments, such as spatial planning, and leadership functions. In particular, departments focusing on health, water, and environmental issues are a prevalent influence on adaptation decisions.

2.3.2 Overarching themes reflecting the decision context

Through the thematic analysis, nine themes were identified from the interviews that shape policymakers' decision context and dynamics influencing climate adaptation (CA) decision-making. The themes are listed in Table 2 and further elaborated hereunder. The theme development involved identifying patterns across the interviews and organising them into themes, synthesising responses of multiple participants (see column 'Dynamics mentioned'). The developed themes represent patterns of behavioural dynamics described by the interviewees. They capture a range of factors and dynamic, causal dependencies between them that affect decision-making processes. A table with interview quotes connected to each theme is provided in Appendix C in Bellmann et al. (2025b). All themes were validated in the workshop, in which participants reflected on the behavioural dynamics captured within each theme.

Table 2: Themes shaping policymakers' decision context in climate adaptation (CA)

Theme	Dynamics mentioned (N=32)	Characteristics
1. Reliance on precedents	26	CA examples from other municipalities are needed to convince actors and manage uncertainties.
2. Fragmented Roles and Responsibilities	31	Unclear roles and responsibilities lead to decision-making inertia, responsibility diffusion, and cooperation challenges.

3. Habitual Thinking Based on Longstanding Practices	28	Habitual thinking and longstanding practices shape CA implementation and resistance expectations.
4. Policy Stringency, Clarity, and Process	32	Policy stringency, clarity, and process spark uncertainty and limit the perceived opportunities to initiate CA.
5. Conflicting Political Priorities	28	Other political priorities affect the ability to convince actors and mobilise internal support for CA.
6. Importance of Individuals	25	Individual preferences create bottlenecks in decision-making processes and shape expectations of gatekeeping in collaboration.
7. Externally-Motivated Action	31	External motivations generate room for CA advocacy and reduce resistance.
8. Illusion of Local Actor Engagement	32	Illusions of direct contact with inhabitants shape perceived outreach needs and strategies.
9. Moving from Awareness Creation to Mainstreaming	31	Assumptions about widespread awareness shift priorities towards mainstreaming of CA.

Theme 1: Reliance on Precedents

The interviews revealed that policymakers' decisions in urban CA are marked by a reliance on precedents to assess and communicate the success prospects of a CA measure to justify the allocation of limited resources. Policymakers perceive a need for precedents as means to convince internal and external actors whose support they need for specific CA measures. Amidst a lack of own precedents, the success probability of a potential measure is often estimated based on examples from other municipalities, especially those that are geographically close. Commenting on the process of minimum rainfall retention in a municipal strategy, one participant described, 'scientifically speaking, we should do 80 millimetres [per m²]. However, we're having this like socioeconomic, political argumentation. Why we should or should not do it? So what is the easiest? We're just going to look at what other municipalities in our area are doing.'(I28).

A lack of suitable precedents can cause inertia or challenges in the development of a strategy, as policymakers aim to avoid the uncertainties connected with being a first mover. A small number of big Dutch cities emerged as role models which affect policymakers' decision-making throughout the country.

Theme 2: Fragmented Roles and Responsibilities

Overlapping responsibilities and unclear authority boundaries in CA policymaking increase the complexity for the individuals navigating them, resulting in contradictory actions and inertia. Individual policymakers perceive navigating these fragmented responsibilities as challenging. One described that 'the difference between municipalities and waterboards and provinces is just completely indigestible'(I2). In expectation of upcoming regulations or actions from other governance levels, policymakers might delay decisions and leave problems unaddressed to prevent time-consuming policy readjustments. Commenting on the fragmented responsibilities in urban CA, one participant explained: 'what happens if everyone is responsible

for it, nobody is. You tend to look at each other and think ‘ah the other one is probably picking this up’. So it’s like a blanket everybody lies under’(I12).

The interconnectedness between CA and health, urban planning, and social issues exacerbate the fragmentation of responsibilities for project managers. This also affects policymakers’ perceived ability to respond to climate change, as slow internal decision processes and extensive coordination needs reduce the speed of CA.

Theme 3: Habitual Thinking Based on Longstanding Practices

The decision context in urban CA is shaped by the geographic location in the flood-prone delta of three major European rivers, as well as longstanding institutionalised water management practices of the Dutch battling ‘water coming from all sides’ from as early as the middle-ages, preceding the establishment of the Netherlands as a nation-state in its current form. Due to this, water-related climate impacts are often prioritised in urban CA. One participant outlined that ‘we come from a water perspective so everybody’s always working on water’(I9). Traditionally, the Netherlands have controlled their aquatic environment using technological solutions. This inclination toward the technological control of the environment amidst relative environmental stability still shapes current strategies and policymakers’ decision context, including how policymakers who do not work directly on adaptation respond to mainstreaming initiatives. The interviewees stated that CA mainstreaming is perceived to interfere with these longstanding decision-making practices, shaping expectations regarding which CA efforts they can propose, as they may be incompatible with longstanding urban planning and building practices.

Theme 4: Policy Stringency, Clarity, and Process

The absence of stringent policy benefits some policymakers, enabling them to tailor CA efforts to local needs, whereas others need stringent policies to convince local actors of CA’s necessity. One participant highlighted this by saying, ‘we have to do this because of Deltaplan Ruimtelijke Adaptatie [Deltaplan Spatial Planning], we have to keep going’(I6). Accordingly, the availability of national policies shapes policymakers’ expectations of whether they can convince other actors to foster CA. Policymakers’ decision context is also shaped by the perceived clarity of climate adaptation goals. The absence of clear goals for CA and the vague ambition to be ‘climate-robust in 2050’ affect policymakers by sparking uncertainty and lacking clear guidance. For example, one participant elaborating on the 2050 goal said: ‘that’s really vague. It doesn’t really say something’(I4).

While climate change is perceived to progress at an unexpected speed, rigid policy processes reduce the ability to adjust policy in between regular strategic plan adjustments. This reduces policymakers’ perceived ability to incorporate newly attained knowledge into existing policies. One participant stated ‘we try to make sure that everything is as recent as possible. But our own policy runs, it’s a 5-year plan, so that will be 2027 when it’s going to be revised. So then there will be the new influence of whatever is there’(I21).

Theme 5: Conflicting Political Priorities

Policymakers are often confronted with conflicting political priorities, such as housing needs, climate change mitigation, flood protection, and livability considerations that affect their CA decision-making. These conflicting priorities arise from simultaneously aiming for long-term CA and short-term pressing political issues of municipalities. In particular, the protracted housing shortage and need for new construction conflict with CA efforts, which are perceived to slow down the building process while increasing building costs. One participant, describing the prioritisation of housing within municipal departments, stated, ‘they say, oh, it has to be quick. It has to be cheap’(I19). As CA measures often require physical space, which is limited in densely populated urban environments, trade-offs between housing development and CA arise in spatial planning.

Theme 6: Importance of Individuals

Individual preferences and efforts have a substantial influence on adaptation decisions, often acting as a bottleneck. Emphasising this, one participant stated, ‘So I think that’s it. It’s depending on people’(I17). This is particularly relevant in municipalities with limited CA capacities, in which CA actions depend on individual initiatives as CA ‘is still so small and therefore so person-driven’(I2). Individual preferences also shape the contact with project managers who supervise building and infrastructure developments, sometimes leading to an active search for CA-favouring individuals for support. One participant outlined that when setting up CA initiatives the CA team explores ‘can we get a project manager who is [...] more interested in climate adaptation’(I8). Participants also critically mentioned the resistance of influential individuals when implementing CA into organisational practice, which is perceived to be frustrating.

Theme 7: Externally-Motivated Action

Policymakers’ decision context in urban CA is often motivated externally, such as by environmental changes and subsidies. Especially extreme weather events, such as flooding and heatwaves, allow policymakers to showcase vulnerabilities and adaptation needs to leverage support from citizens and political leaders to initiate adaptation efforts. Participant statements included, e.g., ‘those are the examples that I use when I’m talking to people who know little about it’(I26). Similarly, policymakers often prioritise CA measures based on visible local environmental changes, especially when inhabitants approach policymakers demanding adaptation solutions. One participant explained that their focus was ‘first on extreme downpour, but we’ve had a number of heat stress events. We realised we should also focus more on that’(I16). However, ongoing climate change also creates difficulties in designing CA policies, as policymakers need to adapt their policies to observed changes before the foreseen timeframes.

Theme 8: Illusions of Local Actor Engagement

The CA governance system is built on the assumption that municipal policymakers are in regular exchange with citizens, businesses, and other local actors. Policymakers from other governance levels report that they are in indirect contact with citizens through the municipalities. However, this assumption does not align with the reality in local policymaking due to budget and personnel capacity limitations. Regardless of their designated role as contact points, municipal policymakers often struggle to engage with citizens and local actors. Their contact is mainly problem-driven, e.g., via complaints to policymakers about infrastructure functioning and existing public duties, leading to situations wherein ‘The people who don’t experience problems we don’t speak that actively’(I7), and inhabitants ‘come in action when they have big problems, damage because of the climate change’(I6). Capacity limitations thus lead to a concentration of engagement with citizens who actively complain or are directly affected by an event or redevelopment project.

Theme 9: Moving From Awareness Creation to Mainstreaming

Another important theme that shapes policymaking is the perception of being in a transition from raising awareness to implementing and mainstreaming CA. One participant described the focus of the initial CA efforts in the Netherlands by saying, ‘the first seven years it was also a lot about raising awareness’(I24). As policymakers primarily focused on creating awareness, they feel to now be in a phase of mainstreaming and perceive an urge to focus on implementing CA measures. For example, one participant accentuated that after years of awareness creation efforts, ‘now it’s on the agenda and we need to make it happen more quickly’(I26). The transition to a mainstreaming focus also shapes interactions with external actors, which are becoming less frequent and more project-oriented, as described in the previous theme.

2.3.3 Determinants of policymakers’ behaviour

The analysis of the determinants of policymakers’ decision-making behaviour revealed the following TDF domains being mentioned most frequently during the interviews (see Table 3).

Table 3: Frequency of mentioned determinants of behaviour

Domain	Description	Frequency (N=32)
1. Beliefs about consequences	Acceptance of the truth, reality, or validity about outcomes of a behaviour in a given situation	32
2. Environmental context and resources	Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence and adaptive behaviour	32
3. Goals	Mental representations of outcomes or end states that an individual wants to achieve	32
4. Social/professional role and identity	A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting	31
5. Social influences	Those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviours	31
6. Knowledge	An awareness of the existence of something	31
7. Beliefs about capabilities	Acceptance of the truth, reality or validity about an ability, talent or facility that a person can put to constructive use	28
8. Skills	An ability or proficiency acquired through practice	23
9. Memory, attention and decision processes	The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives	16
10. Emotion	A complex reaction pattern, involving experiential, behavioural, and physiological elements, by which the individual attempts to deal with a personally significant matter or event	16
11. Reinforcement	Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus	15
12. Behavioural regulation	Anything aimed at managing or changing objectively observed or measured actions	14
13. Optimism	The confidence that things will happen for the best or that desired goals will be attained	9
14. Intentions	A conscious decision to perform a behaviour or a resolve to act in a certain way	5

See Atkins et al. (2017) for a full overview of domains and subdomains.

Three behavioural domains were mentioned across all interviews (n=32), namely environmental context, goals, and beliefs about consequences, closely followed by social/professional role and identity, social influence, as well as knowledge (n = 31). In contrast, the domains of *optimism* and *intentions* were mentioned by only 7 and 5 participants, respectively. While optimism includes both optimism and pessimism, *intentions* incorporate the stability of intentions as well as intentions and stages of change. The other six domains were mentioned by somewhere between 28 and 14 respondents.

Connected to the COM-B, the analysis shows that participants' reflective motivation (beliefs about consequences, goals, social/professional role and identity, goals) is the most frequently reported component affecting participants' CA decisions. The other most frequently reported domains are connected to physical capability (environmental context and resources), psychological capability (knowledge), and social opportunity (social influences).

2.3.4 Behavioural system map of policymakers' decision-making

The behavioural system map in Figure 4 shows the dynamic cause-effect relationships (arrows) between CA behaviours (text nodes) along with the identified TDF domains that shape actors' behaviour (rounded dark blue rectangles with dotted arrows), together driving the dynamics within the system. The map depicts central loops and behaviours that shape urban climate adaptation decision-making as well as the psychological and contextual factors that underpin them. The analysis of the map surfaced three key levers for interventions to improve local policymakers' decision-making for urban climate adaptation (light blue rectangles). These levers are each connected to the behavioural dynamics in one of the identified themes that shape CA policymaking.

Lever 1: Supporting precedent identification. As shown in the lower centre of the map, policymakers' search for precedents (Theme 1) is sparked by beliefs about capabilities and beliefs about consequences, as policymakers have a low perceived capacity to carry out adaptation projects without being able to show successful precedents. As visible on the right side of the map, the identification of precedents is central to convincing other actors in the system. This identification is influenced by policymakers' knowledge and the provision of suitable precedents from consultancies and other actors. Whether policymakers attain precedents from consultancies is influenced by their social and professional role and identity, as their professional confidence and task boundaries shape their outreach to consultancies. Loop 1 shows that the identification of suitable precedents increases political support, which then increases local adaptation efforts and further searches for precedents. The dynamic presents a key lever for change, where the provision of precedent knowledge or the connection to precedent providers can lead to more local adaptation efforts.

Lever 2: Stimulating information gathering. Another central behaviour is policymakers' gathering of information, as can be seen on the top left of the map. The central determinants of this behaviour are policymakers' environmental context and resources. Extreme weather events, national policies, and other external influences (Theme 7) shape the extent to which policymakers gather information, engage with other actors, and initiate local adaptation strategies. The loops in this dynamic show that the gathering of new information results in more tailored national support (loop 2) and the updating of existing strategies (loop 3), which both again increase the gathering of information. It also increases the engagement with local knowledge providers and the incorporation of their advice. Finally, the gathering of information increases the development of new local strategies, which, in turn, leads to more information gathering. Due to these loops, the gathering of information is another central lever within the decision-making system.

Lever 3: Boosting mainstreaming processes. The third lever is connected to the mainstreaming of adaptation by local policymakers. This behaviour is underpinned by goals that prioritise mainstreaming

within the organisation. Mainstreaming sparks the adoption of new practices in other departments (Theme 3). The mainstreaming then leads to two loops. First, it increases the political support for adaptation as its internal support grows (loop 4). Second, it strengthens connections to other departments, which, in turn, increases mainstreaming attempts (loop 5). Accordingly, targeting policymakers' goals regarding mainstreaming efforts poses another key lever within the system.

Also visible by looking at the interconnections between the levers and behaviours is that the themes are deeply interconnected, collectively shaping policymakers' decision context and dynamics within it. For example, the 'reliance on precedents' is linked to 'habitual thinking based on longstanding practices' and 'policy stringency, clarity, and process'. Policymakers' dependence on established precedents can be a result of the lack of stringent guidelines and the influence of longstanding internal management processes that prioritise proven solutions. This reinforces a dynamic in which innovative measures and local experimentation are deprioritised.

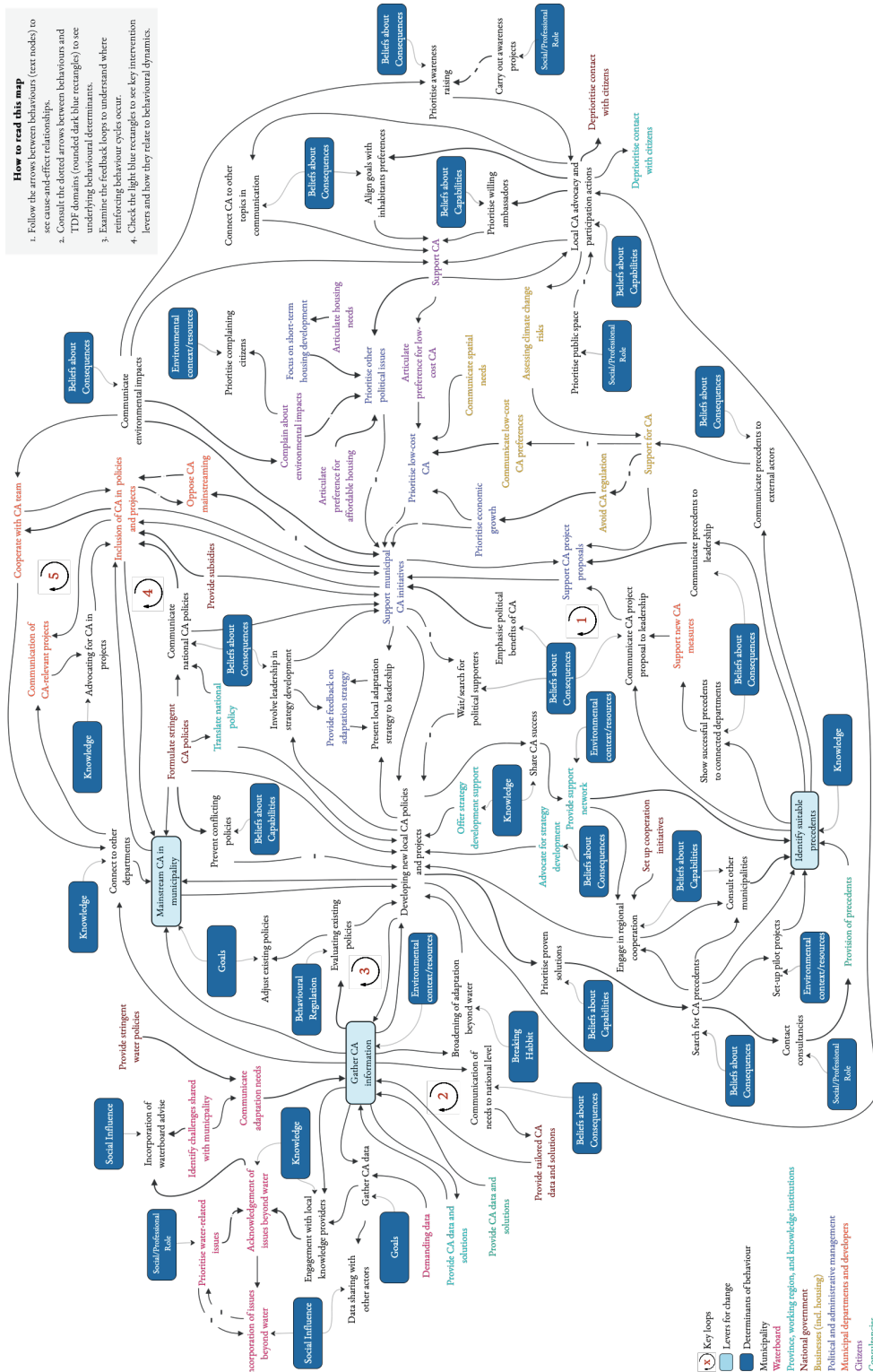


Figure 4. Behavioural system map of policymaker decision-making in urban climate adaptation in the Netherlands. Behaviours are text nodes. Arrows depict cause-effect relationships between behaviours. Colours refer to different actors. TDF domains underlying behaviours are rounded dark blue rectangles with dotted arrows. Key levers for interventions are rounded light blue rectangles. Provinces, working regions (see Section 2.1) and knowledge institutions have been clustered, as their influence overlaps.

2.3.5 Validation of the findings with policymakers

Participants in the reflection workshop confirmed that all the themes can be observed in their decision-making. The workshop yielded two primary additional insights on urban climate adaptation decision-making. First, participants emphasised the interconnections between the themes, outlining that they jointly shape their decision-making processes. For instance, they emphasised that the uncertainty sparked by a lack of stringent policy documents (Theme 4) is connected to the ‘Reliance on Precedents’ (Theme 1) and the ‘Fragmented Roles and Responsibilities’ (Theme 2). Second, participants accentuated that the themes, if navigated successfully by the individual policymaker, can positively influence adaptation decisions. For example, the ‘Habitual Thinking Based on Longstanding Practices’ can provide a supportive basis for decisions and the limited ‘Policy Stringency, Clarity and Process’ can lead to more local deliberation processes. Connectedly, participants highlighted the potential of change on the individual level to improve adaptation decision-making.

2.4 Discussion

The findings enrich existing research on climate adaptation behaviour (Bechtoldt et al., 2021; Gifford, 2011; van Valkengoed, Perlaviciute, et al., 2022; van Valkengoed & Steg, 2019b) and on structural barriers to climate adaptation by illuminating individual-level decision-making processes of policymakers and behavioural determinants that underpin them (Ishtiaque et al., 2021; Lee et al., 2023b; Oberlack, 2017; Phuong et al., 2018). The nine themes highlight that policymakers aim to follow the scientific recommendation to mainstream adaptation efforts but that behavioural dynamics in the decision context limit their mainstreaming abilities, leading to slow adaptation progress. The focus on unpacking cause-effect relationships between observable behavioural factors and underlying determinants allowed for a more comprehensive analysis of dynamics in the multi-actor system.

In particular, the results show how a ‘barrier’ in one municipality can function as a ‘driver’ of adaptation efforts in another municipality (Theme 4 in section 3.2), also showing the importance of understanding the dynamic interdependencies between behaviours and their determinants to unpack (in)action and identify relevant levers for intervention (section 3.4). This highlights the value of moving past reductionist barrier-focused thinking, as also emphasised by Biesbroek et al. (2014) and Ishtiaque et al. (2021). The findings show that certain actions aiming to remove a barrier, such as establishing national standards, will likely be ineffective as policymakers also need relevant precedents to convince local stakeholders. Shifting the focus to behavioural dynamics can help to improve within existing resource constraints, rather than expending more resources on trying to overcome them.

The overarching influence of individual initiative on adaptation outcomes leads to a situation where individuals become bottlenecks for adaptation progress. Thus, individual-level behavioural interventions tailored to the specific policymaking context may be a promising lever to change system behaviour. The insights concerning the respective determinants of behaviour establish a basis for developing such interventions as recommended by van Valkengoed, Abrahamse and Steg (2022). Similar to research on citizens’ adaptation, our results confirm self-efficacy (beliefs about capabilities) and outcome expectancy (beliefs about consequences) as relevant determinants of adaptation behaviour (van Valkengoed & Steg, 2019a). However, our results assert the importance of taking policymakers’ decision context into account, as social norms and place attachment have not been identified as primary behavioural influences prevalent in their decision-making (Bechtoldt et al., 2021; van Valkengoed & Steg, 2019a). Similarly, prior research on citizens suggests no negative correlation between climate adaptation and mitigation behaviours (Urban et al., 2021), whereas our findings suggest that mitigation action, if perceived as a political priority, reduces policymakers’ prioritisation and capability beliefs, undermining adaptation (see Theme 5).

The system perspective in this study goes beyond identifying determinants of behaviour. It also discloses how the target behaviour influences other behaviours in the system, enabling the development of individual-level interventions that affect the system through behaviours that function as levers (section 3.4). This suggests a potential route for a more active role of behavioural scientists in climate policy decision-making, as advocated by van der Linden et al. (2021). It emphasises research highlighting the importance of advancing the understanding of policymakers' decision context in climate change policymaking (Árvai & Gregory, 2021; Siders & Pierce, 2021) and proposes a methodology to analyse diverse policymaking and decision contexts.

By illuminating behavioural dynamics, our study corroborates drivers of policy diffusion processes, referring to the processes through which policies spread across multiple jurisdictions, which have been observed in research on climate adaptation. For example, organised diffusion, in which networks established from higher governance levels foster learning, are reflected in the role of working regions as providers of information and precedents (Schulze, 2024). Similarly, the study also provides evidence for an interest-driven policy diffusion mechanism, in which external influences (see Theme 7) spark local adaptation efforts (Schoenefeld et al., 2022).

Methodologically, the study contributes to recent efforts to bridge behavioural science and systems analysis (Chater & Loewenstein, 2023a; Hale et al., 2022; Hallsworth, 2023a; Kaufman et al., 2021; Lunetto et al., 2022), confirming the added value of behavioural system maps for understanding behaviour in complex systems (Lunetto et al., 2022). To the best of our knowledge, it is the first study that integrates determinants of behaviour, identified based on the Theoretical Domains Framework, in behavioural system maps. This integrated approach allows for a deeper understanding and analysis of the behavioural system as a basis for designing interventions that are sensitive to both the micro-level determinants of behaviour and the macro-level system dynamics, moving beyond solely focusing on either the individual or the system.

2.5 Conclusion and recommendations

Current behavioural science research tends to focus on the individual-level behaviour of citizens while omitting the critical importance of contextual and psychological influences on policymakers' decision-making in explaining slow progress in urban climate adaptation. This study applied a systems approach to the investigation of behavioural dynamics in urban climate adaptation processes to improve the understanding of the decision context shaping policymakers' decisions.

The thematic analysis, based on interviews with 32 policymakers and validated by a subset of nine policymakers, surfaced nine central dynamics that shape decision-making processes in urban climate adaptation: 'Reliance on precedents', 'Fragmented Roles and Responsibilities', 'Habitual Thinking Based on Longstanding Practices', 'Policy Stringency, Clarity, and Process', 'Conflicting Political Priorities', 'Importance of Individuals', 'Externally-Motivated Action', 'Illusion of Local Actor Engagement', 'Moving from Awareness Creation to Mainstreaming'. All themes, including the reliance on role models to convince actors and the dependence on individuals acting as adaptation bottlenecks which overarch the decision context, jointly shape policymakers' decision-making processes.

The content analysis revealed that policymakers' beliefs about consequences, goals, environmental context and resources, social influences, knowledge, and their social and professional role are the most influential determinants underlying their decision-making behaviour. This shows that the observed behavioural dynamics are underpinned by the interaction of determinants of behaviour with the decision context, suggesting that an inclusion of psychological determinants of behaviour in the analysis is imperative to attaining a nuanced understanding of the decision context.

Behavioural systems mapping based on thematic and content analysis allowed to identify the factors and dynamics that influence policymakers the most, exposing numerous causal interdependencies between the themes and individual behaviours. The map reveals a complex and interconnected decision context, characterised by a large number of actors and dynamics influencing policymakers' decisions. The analysis of the behavioural system map surfaced three key behavioural levers for intervention in municipal policymakers' decision-making: 'supporting precedent identification', 'stimulating information gathering', and 'boosting mainstreaming processes'. These offer the potential for impactful interventions that expand beyond individual-level behaviour change.

This study underscores how focusing on policymakers' decision-making and the determinants of their behaviour can increase the understanding of policy outcomes and the development of behavioural interventions to improve decision-making processes. The behavioural system approach facilitated this by illuminating the contextual influences on policy decisions and by disclosing levers for systemic interventions.

Several directions for future research emerge from the limitations of this study. The Theoretical Domains Framework supported the identification of determinants of behaviour of policymakers' decision-making in urban climate adaptation but lacks the capacity for in-depth examination of underlying psychological mechanisms and relations between determinants. Future research should further examine these mechanisms to strengthen understanding of the processes that behavioural interventions could target. A more comprehensive understanding of the underlying psychological determinants, their impacts and interactions, e.g. using psychological questionnaires, and clearer discrimination of determinants of behaviour could aid the purposeful design of more impactful interventions.

While this study uncovered levers that can be targeted by behavioural interventions, it did not identify specific interventions. Future research should investigate applicable interventions under consideration of the presented levers and showcase their impact on urban climate adaptation efforts. Testing different interventions through lab-field experiments could help anticipate system-wide effects of interventions, providing actionable recommendations for policymakers (List, 2007).

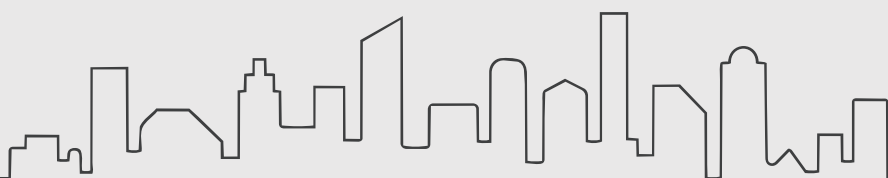
As all participants were from the Netherlands, a country with a WEIRD (Western, Educated, Industrialised, Rich, Democratic) population, the representativeness and generalisability of the findings to other populations may be limited (Henrich et al., 2010). As the governance system and cultural context have a major influence on policymakers' decision-making, the decision context in other countries will likely differ (Nutt, 2014). However, cause-effect relations between the behaviours and their determinants may well be similar. Cross-cultural comparative research is a suitable pathway to explore whether the identified levers, themes, and behaviours also apply in countries with other governance and cultural contexts.

Behavioural system maps can support the analysis of behavioural dynamics in complex systems by helping to visually analyse complex behavioural dynamics, which would otherwise be challenging to do. This supports the adoption of system-focused approaches in psychological research. However, the accessibility of the maps is affected by readability challenges that arise from the complex dynamics captured within them. Future work could seek to optimise behavioural system mapping and transfer best practices from other fields (Auping et al., 2024) to balance completeness versus tractability of the resulting maps and accessibility of findings, thereby supporting integrated systems analysis and behavioural science.

Addressing the presented limitations and future directions will contribute to a more comprehensive understanding of climate adaptation decision-making and aid analysis of complex system behaviour in other cases. Thereby, researchers can better support policymakers in designing impactful interventions.

3

IDENTIFYING KEY BEHAVIOURAL DETERMINANTS AND INTERVENTION SPACES IN POLICYMAKERS' CLIMATE ADAPTATION DECISION-MAKING



As climate change progresses, the urgency to adapt has increased, yet current climate adaptation efforts remain insufficient. While psychological research has explored behaviour change interventions for citizens, policymakers are often overlooked. Policymakers are central to advancing adaptation efforts as they decide which policy instruments to prioritise to increase societies' resilience to climate risks. Despite this, the existing basis for designing context-tailored behavioural interventions to improve their decision-making remains underdeveloped.

In this study, we integrate a systematic scoping review of 70 studies and an expert Delphi panel to identify key behavioural determinants of policymakers' adaptation decision-making and to prioritise target behaviours and behaviour change techniques (BCTs). We analysed the behavioural determinants and BCTs present in research on adaptation policymaking using the Theoretical Domains Framework and Behaviour Change Technique Taxonomy. Policymakers' context, resources, and knowledge, as well as social influences, are the most frequently reported behavioural determinants. The most commonly applied techniques to improve decisions involve setting goals, making plans, and building knowledge. The Delphi panel of behavioural science experts and Dutch climate adaptation policy professionals was conducted in two rounds ($n_1=47$, $n_2=32$) and identified seven key behaviours, which primarily occur in intermediate decision-making phases. It also prioritised BCTs, showing that making plans, setting goals, increasing knowledge, and providing social support were rated as the most implementable and acceptable intervention techniques. Contrasting our results with the peer-reviewed literature re-iterates the value of integrating behavioural, policy, and systems approaches for effective, context-tailored behavioural intervention designs.

Based on the results, we were able to identify promising intervention spaces for effective, implementable behavioural interventions targeting climate adaptation policymakers within the Dutch context. We provide recommendations for future research to develop and test such interventions as well as to generalise our findings in other contexts.

An adapted version of this chapter has been submitted as:

Bellmann, K. P., de Vries, G., & Scholten, L. (n.d.). Identifying key behavioural determinants and intervention spaces in policymakers' climate adaptation decision-making.

3.1 Introduction

3.1.1 Need for behavioural science to speed up climate adaptation

Anthropogenic climate change leads to challenges in how to adapt to extreme weather, water scarcity, biodiversity loss, and other adverse effects on societies and natural systems (C3S & WMO, 2025; IPCC, 2023). Climate adaptation refers to *'the process of adjustment to actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities'* (Calvin et al., 2023, p. 120). It encompasses measures such as developing water retention areas, restoring wetlands, adding green roofs to houses, and building dams (Azevedo de Almeida & Mostafavi, 2016; Calvin et al., 2023; Stagrum et al., 2020). Amidst already occurring or unavoidable climate change impacts, such as wildfires and flooding, that mitigation efforts cannot address, the need for climate adaptation is increasingly emphasised by international, national, and local bodies worldwide (Calvin et al., 2023; C3S & WMO, 2025; UNEP, 2022). Despite that, current adaptation efforts in Europe and elsewhere are still insufficient, resulting in an adaptation gap (IPCC, 2023; UNEP, 2024).

In researching why adaptation efforts remain insufficient, behavioural and policy scientists have advanced the understanding of citizens' adaptation decisions as well as how structural barriers hinder adaptation (C3S & WMO, 2025; Gifford, 2011; Oberlack, 2017). However, policy recommendations to mitigate barriers to adaptation and behavioural interventions addressing citizens have not alleviated the adaptation gap. Although citizens' actions are a crucial component of societies' adaptation efforts, and it is important to overcome structural barriers, scholarly work has not yet explored another pathway to enhance adaptation efforts – improving the decision-making of policymakers.

Policymakers play a key role, as their decisions shape how societies approach the adaptation to climate change impacts. For instance, they plan, facilitate, or incentivise climate adaptation measures, such as green roofs, dams, or water retention ponds. Scholarly work has demonstrated that behavioural analysis and behavioural interventions can be employed to understand and improve decision-making processes for a range of issues, such as health-related behaviours (Cesareo et al., 2022), climate change mitigation (Bergquist et al., 2023), and policymakers' decisions (World Bank, 2018). However, there is only a limited number of studies (often indirectly) assessing the factors that affect policymakers' adaptation decision-making and developing behavioural interventions to improve it (Lee et al., 2023a; Phuong et al., 2018; Uittenbroek, 2016). Noting this research gap, Lee et al. (2023a, p.2) highlight that it is 'unclear what we need to do and what needs to be addressed to overcome persisting barriers'. Similarly, other scholars have called for investigations of policymakers' decision-making processes (Biesbroek et al., 2015; Siders & Pierce, 2021) and more research at the intersection of psychology and climate change governance (Freschi et al., 2023). The present study aims to address this research gap by conducting a behavioural analysis of policymakers' decision-making, providing a basis for the development of effective behavioural interventions tailored to the context of adaptation policymaking.

3.1.2 Gaps in behavioural research on improving adaptation decision-making

The available literature discussing the success of behavioural interventions, presented below, delineates four main aspects to consider in their development: (1.) Focusing on key determinants of behaviour, (2.) Clearly linking interventions to behavioural science theory, (3.) Prioritising impactful key behaviours, (4.) Adopting a system perspective. However, scholarly work has not yet addressed these aspects in researching how to understand and improve policymakers' climate adaptation decision-making. Accordingly, current

behavioural public policy research misses an empirical basis for developing interventions that are tailored to policymakers' decision context in adaptation.

(1.) Focusing on key determinants of behaviour: Recent scholarly work highlights that interventions are most effective if they target key determinants of behaviour (van Valkengoed & Abrahamse et al., 2022). Synthesising meta-analyses of research on determinants of adaptation behaviour, Bechtoldt et al. (2021) found that a society's culture, descriptive social norms, negative affect, and outcome expectancies are the strongest predictors of adaptation behaviours. While there is psychological research on determinants of citizens' adaptation actions (Bechtoldt et al., 2021; van Valkengoed & Steg, 2019a) and interventions to increase pro-environmental behaviour (Bergquist et al., 2023), there is no research that identifies key determinants of policymakers' adaptation decision-making and connects them to potential behavioural interventions to improve it.

(2.) Clearly linking interventions to behavioural science theory: Studies frequently highlight the importance of connecting behaviour change interventions to theories of behaviour to increase effectiveness (Davis et al., 2015; Michie & Abraham, 2004; Prestwich et al., 2015). There is no shortage of psychological theories and intervention design frameworks that can be employed in researching adaptation behaviour (Dang et al., 2012; Grothmann & Patt, 2005; Truelove et al., 2015). However, existing psychological research did not apply those to policymakers' adaptation decisions.

(3.) Prioritising impactful key behaviours: Another key consideration in designing effective interventions is the focus on impactful behaviours. For instance, scholars argued that instead of focusing on pro-environmental attitudes, a narrower focus on specific behaviours (e.g., high-impact mitigation action) is more beneficial, as it allows a more nuanced analysis of psychological barriers to climate action (Asutay et al., 2023). Research has not yet conducted a prioritisation of such key behaviours for climate adaptation policymaking.

(4.) Adopting a system perspective: Recently, behavioural scientists argued that a system perspective is needed to improve the real-world impacts of research in applied psychology (Chater & Loewenstein, 2023a; Hallsworth, 2023a). Such a system perspective can increase the impact and practicality of interventions by considering the context in which behaviours occur instead of solely relying on research on universal psychological mechanisms (Chater & Loewenstein, 2023a; Grilli & Curtis, 2021; Kaufman et al., 2024; Mundt et al., 2024; Sanders et al., 2018). Scholarly work has shown that current research in environmental psychology comes short in adopting a system perspective, observing 'a scarcity of context-grounded approaches' (Freschi et al., 2023, p. 18). Recent research suggests that investigating behavioural dynamics in decision-making can increase the understanding of decision-making in urban climate adaptation policymaking (Chapter 2; Bellmann et al., 2025b). Still, it has not yet been investigated which intervention techniques are suitable to address adaptation decision-making.

3.1.3 Aims and contribution

Recognising the gaps in current research, we aim to identify behavioural determinants within policymakers' adaptation decision-making. We further aim to prioritise key behaviours and promising behaviour change techniques (BCTs) to improve decisions. Thereby, we aspire to provide a foundation for developing interventions that are tailored to climate adaptation policymaking. Our guiding research questions are:

RQ1: What are the key determinants of behaviour that affect policymakers' decisions in climate adaptation?

RQ2: What are the key behaviours that affect climate adaptation policymaking?

RQ3: Which behaviour change techniques can address the key behaviours in climate adaptation policymaking?

3.2 Methodology

We followed a multi-step research process to answer our research questions. First, we conducted a systematic scoping review of scholarly research on influences on adaptation decisions and interventions for changing the decision-making behaviour of policymakers in climate adaptation. This was followed by a Delphi panel with Dutch⁶ policy professionals and international behavioural science experts to prioritise key behaviours that shape the system of climate adaptation decision-making and promising BCTs.

3.2.1 Systematic scoping review

To inventorise and synthesise known behavioural influences on and interventions in policymakers' climate adaptation decision-making, we conducted a systematic scoping review following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols (PRISMA-P) (Moher et al., 2015). A systematic review approach allows the systematic assessment and evaluation of scholarly research on a chosen topic while reducing unwanted influences, such as selection and reporting biases, that could influence the results (Pati & Lorusso, 2018). Our review protocol following PRISMA-P is provided in Appendix 1 (see Supplementary Information 1 in Bellmann, de Vries, et al. (2026)). While we followed a systematic review approach, the heterogeneity of studies led us to adopt a more scoping review approach in synthesising the findings (Munn et al., 2018), which is why we use the term systematic scoping review.

3.2.1.1 Screening and selection

We searched the Web of Science database (January 22, 2025) for articles using keywords such as 'adaptation', 'decision making', and 'policymaker'. The research team has jointly developed the search string. A detailed overview of the search process and search string is provided in Appendix 1 (see Supplementary Information 1 in Bellmann, de Vries, et al. (2026)). Our search focused on research that investigates influences on policymakers' decision-making in climate adaptation and research on behavioural interventions that intervene in policymakers' decision-making processes. We excluded studies that did not focus on policymakers' decision-making. Our search also excluded research that is not primarily focused on adaptation decisions, such as investigations of climate change mitigation, as the decision context and processes might differ substantially due to, for example, distinct actors or policy guidelines involved. Further, we excluded studies researching tools that solely provide policymakers with resources (e.g., provision of a new prediction tool), not targeting the process through which they make decisions.

The search was restricted through a focus on peer-reviewed research articles published in English. We included empirical and conceptual studies while excluding reviews to capture original contributions. A grey literature search was conducted separately. Due to the limited insights relevant to the research questions yielded by this search, we concentrate on peer-reviewed sources while providing the process and findings of this grey literature review in Appendix 2 (see Supplementary Information 1 in Bellmann, de Vries, et al. (2026)).

⁶ We focused on Dutch policy professionals for two reasons. First, climate adaptation is an established policy field in the Netherlands with strategies at all governance levels (MinIW et al., 2023). Second, we aimed to ensure the comprehension of all behaviours, as the Delphi panel was based on data from a study conducted within the Netherlands.

The initial search returned 2681 articles after automated duplicate removal. We conducted title and abstract screening using Covidence software (Covidence, 2025). In this stage, 2565 articles were excluded, resulting in 116 articles sought for retrieval (116 articles retrieved). Following this, we assessed 116 articles for their eligibility through full-text screening. The full-text screening was conducted in a spreadsheet. Records that did not match the inclusion criteria regarding the research focus and the article type were excluded. Disagreements regarding the inclusion of articles were resolved through discussions within the research team. We included 70 studies matching our inclusion criteria in the review. The selection process is displayed in the PRISMA flowchart in Figure 5.

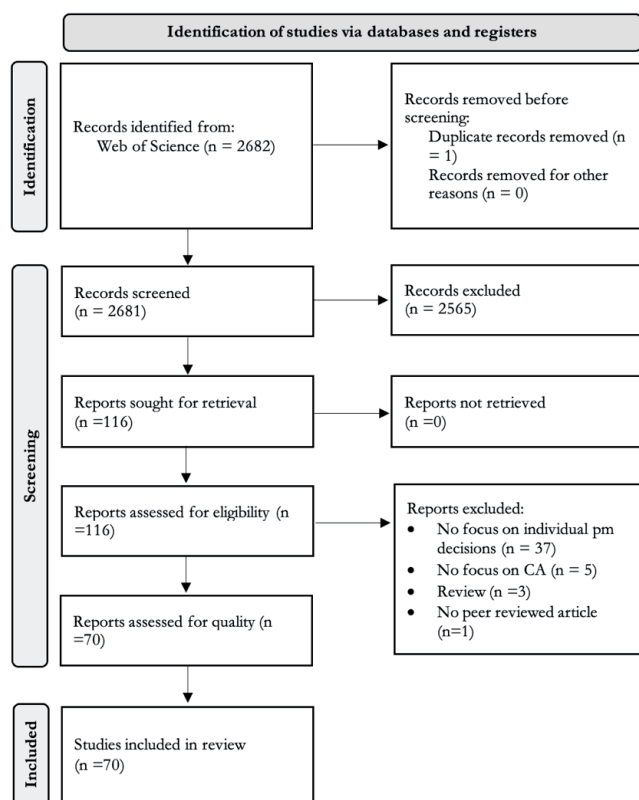


Figure 5: PRISMA flowchart (adopted by Page et al., 2021).

3.2.1.2 Quality assessment

As our review mainly includes qualitative studies, with many of them stemming from different research paradigms, we utilised the assessment tool developed for such purposes by Hawker et al. (2002) to evaluate the quality of the reviewed studies. It assesses the different parts of an article (e.g., introduction, methodology) on a scale from ‘very poor’ (1) to ‘good’ (4), guided by nine questions. We refrained from excluding studies based on the quality assessment as no article exclusively scored as ‘very poor’ or ‘poor’, and we aimed to accommodate different research approaches utilised in the reviewed literature from various research fields that lay emphasis on distinctive quality aspects. The quality assessment of the included studies can be found in Appendix 3 (see Supplementary Information 2 in Bellmann, de Vries, et al. (2026)).

3.2.1.3 Data analysis

We extracted individual-level determinants of adaptation decisions and interventions from the articles. Considering the different discipline-specific terminologies being used, we retained the original labels used in the articles in the extraction process to not narrow our initial search to a pre-defined coding framework. After extracting the data, we classified the behavioural determinants and interventions using the Theoretical Domains Framework (TDF) (Atkins et al., 2017), the COM-B (Capability, Opportunity, Motivation – Behaviour) model (Michie et al., 2011), and the Behaviour Change Technique Taxonomy (BCTT) (Michie et al., 2013). The TDF supports the identification and categorisation of 14 determinants of behaviour (‘domains’)(Atkins et al., 2017). It builds on and expands the three behavioural categories of the COM-B model, allowing for a more granular analysis of behavioural determinants (Atkins et al., 2017). Using the TDF and COM-B enabled us to capture the determinants of behaviour that earlier adaptation research has identified, as they span a broad range of influences. The BCTT classifies behaviour change interventions that are frequently applied and referred to in behavioural science research (Evans & Wheeler, 2025; Hedin et al., 2019; West et al., 2020) into 16 clusters of BCTs, which allow a ‘systematic specification of behavior change interventions’ (Michie et al., 2013, p. 93).

We classified the determinants and interventions through deductive coding following the TDF guide and definitions from Atkins et al. (2017) and BCTT cluster descriptions (Michie et al., 2013). The COM-B, TDF, and BCTT are connected, as the techniques specified in the BCTT can be mapped to the TDF domains and the COM-B. Accordingly, the classification allowed us to assess whether the applied behavioural interventions address the identified determinants of behaviour (see Figure 6). This enabled us to establish a connection between our analysis and behavioural science theory.

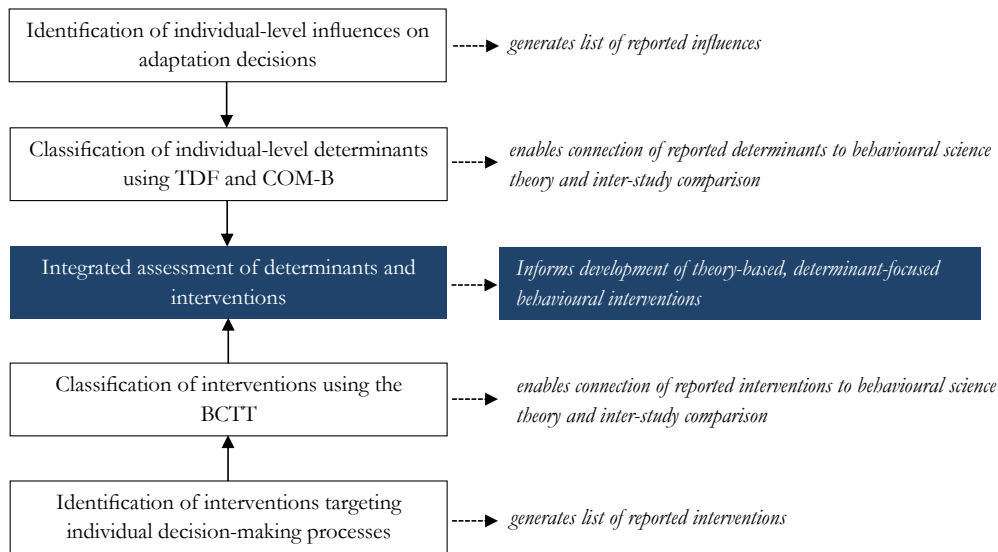


Figure 6: Classification procedure followed using TDF, COM-B, and BCTT.

In general, the structured coding approach allowed us to identify overarching patterns in the reviewed articles based on the unifying terminology provided by the TDF, COM-B, and BCTT, despite the heterogeneity of the used frameworks’ terminology and depth of elaboration on behavioural mechanisms. We accommodated the ambiguous terminology used for some influences and interventions by allowing multiple codes. We further utilised journal subject areas derived from Scimago (SCImago, n.d.), a publicly available portal ranking scholarly journals, to distinguish the included articles by disciplinary foci.

3.2.2 Delphi panel

To prioritise behavioural influences and interventions, we conducted expert consultations through a Delphi panel. The Delphi method is suitable for research situations in which a prioritisation needs to be made based on structured expert judgment amidst a lack of empirical evidence (Landeta, 2006; Okoli & Pawlowski, 2004). Research methods building on expert judgement have also been used to develop seminal behaviour change frameworks such as the Behaviour Change Wheel (Michie et al., 2011). The panel shall enable the prioritisation of behaviours that are changeable (i.e., degree of plasticity) and impactful within the system of adaptation policymaking. Here, plasticity refers to the potential for behaviour change in response to stimuli. The panel shall further identify BCTs that are acceptable for the target group and implementable in existing decision processes. This information is crucial to designing behavioural interventions (Hallsworth & Kirkman, 2020; Kaufman et al., 2024; van Valkengoed, Abrahamse, et al., 2022). The participant recruitment, informed consent, data collection, and processing procedures were reviewed and approved by TU Delft's Human Research and Ethics Committee (No 5143).

3.2.2.1 Participant recruitment

We recruited climate adaptation policy professionals and behavioural scientists working on climate adaptation via email invites using a purposive sampling approach. These groups' diverse expert knowledge of adaptation decision-making, as well as behavioural science, qualify them to prioritise behaviours and BCTs. In general, recommendations for Delphi panel sample sizes range from 10 to 80, while a number of around 30 participants is often considered to be ideal (de Villiers et al., 2005; Manyara et al., 2024; Nasa et al., 2021). Recent comparable research, conducting a Delphi panel with policymakers and researchers, has recruited 21 participants (Flood et al., 2023). However, ideal sample sizes are context-specific, depending on the number of experts in the field, the complexity of the topic, and the composition of the panel (de Villiers et al., 2005; Nasa et al., 2021). We invited 125 policy professionals and 74 behavioural scientists to take part in the investigation. In total, 70 individuals initially signed up for the panel, of which 47 completed the first round within the given timeframe. We reviewed two late submissions after the initial analysis separately, as they could not be included in the prioritisation for the second round. Their alignment with the main dataset regarding the behaviours' impact and plasticity, as well as BCT's implementability, supported the robustness of the results. Subsequently, 32 participants completed the second round within the given timeframe. Participation in the second round was only possible for individuals who completed the first round.

Of the 47 participants who completed the first round of the panel within the given timeframe, 31 are policy professionals and 16 are behavioural scientists. Example positions of participants are associate professor in the field of environmental psychology, strategic advisor for climate adaptation, and manager of a climate adaptation working region. Participants from ten different countries participated, with most respondents ($n=34$) currently working in the Netherlands. The overall average experience is 10.87 years for climate adaptation and 9.15 years in behavioural science. In total, 13 of the respondents had no experience in behavioural science and one participant had no experience in climate adaptation. In the second round, 13 policy professionals and 12 behavioural scientists participated, while seven participants' identifiers could not be matched due to errors ($n=32$).

3.2.2.2 Data collection

We conducted two rounds of the Delphi panel with a gap of about four weeks between the rounds. The questionnaires are provided in Appendix 4 (see Supplementary Information 1 in Bellmann, de Vries, et al. (2026)), and the Delphi panel process is illustrated in Figure 7. The first round focused on: (I) decision-

making behaviours' impact, (II) decision-making behaviours' plasticity, and (III) BCTs' implementability in adaptation decision-making. To assess the impact and plasticity of policymakers' behaviours, we asked participants to evaluate 20 behaviours on a 5-point Likert scale. These 20 behaviours were extracted from a study which analysed the prevalence of behaviours in climate adaptation policymaking (Chapter 2; Bellmann et al., 2025b). We randomised the order of behaviours to prevent order-induced effects. Participants were instructed to assess the influence on adaptation decisions of the respective behaviour (impact) and to evaluate how changeable the behaviour is within the existing context (plasticity). To assess the implementability of possible interventions, we utilised two items from the Feasibility of Interventions Measure (FIM), asking participants to rate how 'implementable' and how 'easy to use' BCTs taken from the BCTT are in climate adaptation decision-making (Weiner et al., 2017).

After completion of the first round, we distributed the second round and included a summary of the first round's results. This included an initial set of prioritised behaviours and BCTs. The second round explored: (I) prioritised behaviours' decision-making phase fit, (II) BCTs' acceptability, and (III) suitable BCTs to address the prioritised behaviours. To investigate the decision-making phase in which the behaviours occur, we asked participants to match them to the five decision-making phases specified by Nutt (2008): (1) intelligence gathering, (2) direction reception, (3) solutions finding, (4) evaluation, and (5) implementation. To assess the acceptability of the prioritised interventions, we utilised two items from the Acceptability of Interventions Measure (AIM), asking participants whether they 'approve' and 'welcome' the respective BCT (Weiner et al., 2017). Finally, participants had to match prioritised BCTs to the prioritised behaviours based on their suitability to address them. In both rounds, we further asked participants to describe how they evaluated the behaviours through open questions.

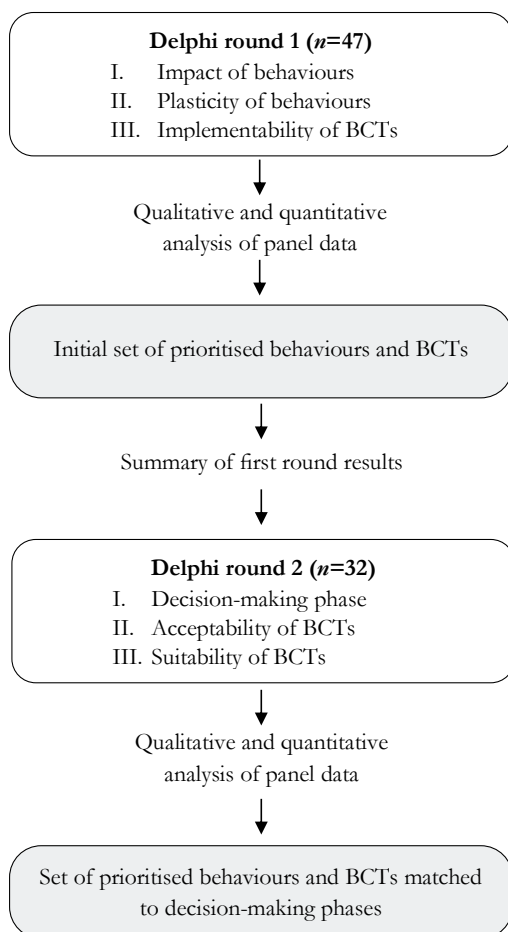


Figure 7: Delphi panel process. Text fields provide information on data analysis. White rectangles are Delphi rounds. Grey rectangles are outcomes.

3.2.2.3 Data analysis

We analysed the Delphi panel data qualitatively and quantitatively. For the quantitative analysis, we utilised Python (van Rossum & Drake, 2009). We analysed measures of central tendency, measures of dispersion, and correlations. We also employed k-means clustering, an unsupervised machine learning technique, to group behaviours and BCTs into clusters. For this, we determined the optimal number of clusters using the elbow method, which visualises the point at which additional clusters would no longer improve the model fit (elbow), assessed through the within-cluster sum of squares. To assess the robustness of the k-means clustering, we used hierarchical agglomerative clustering using the same features for behaviours and BCTs. We generated a dendrogram based on Ward's linkage method and then visually inspected the cluster structure. The resulting hierarchical clustering showed a similar group separation, supporting the validity of the k-means-derived clusters for both behaviours and BCTs. Following the clustering, we conducted Analyses of Variance (ANOVAs) to determine whether the behaviour and BCT clusters significantly differ

from each other (Bruce & Bruce, 2017; Gravetter & Wallnau, 2016). This process supported the prioritisation of impactful and changeable behaviours as well as implementable BCTs.

Before conducting the ANOVAs, we checked for normal distribution and equal variances using Shapiro-Wilk and Levene tests. In cases where group data was not normally distributed, we employed a Kruskal-Wallis test as a non-parametric ANOVA alternative. We utilised a Mann-Whitney U test adjusted by Bonferroni corrections and Tukey HSD to check whether there were significant differences between groups (Gravetter & Wallnau, 2016).

A key methodological consideration for Delphi panel research is the consensus method, referring to the criterion based on which consensus is established (Diamond et al., 2014). Similar to other Delphi studies, we used a consensus threshold of 60% to establish which behaviours and BCTs participants prioritised (von der Gracht, 2012). To do this, we assessed the share of behaviours and BCTs that more than 60% of participants scored with '4' or '5' on the 5-point Likert scales (5=highest). In contrast to a higher value, this threshold enabled us to identify a broader set of behaviours. Our prioritisation for the second round was based on both the k-means clustering and the established consensus threshold. We progressed those behaviours and BCTs that were either above the established threshold or part of the highest-ranked cluster. This integrative approach enabled us to prioritise both behaviours and BCTs with relatively high agreement for high plasticity/impact and high implementability/ease of use, while ensuring that all relatively highly-scored behaviours and BCTs are included in the second round.

To investigate the decision-making phase match and suitable BCT to address the behaviour, we analysed the frequency of matches of each behaviour. For the qualitative analysis, we conducted a thematic analysis using open coding of the textual responses to identify themes that shape participants' reasoning when reflecting on behaviours (Braun & Clarke, 2006). Following the open coding, we developed subcategories and categories that overarch the codes from the open coding stage. Finally, we identified themes that capture the categories and their connection (Hawker & Kerr, 2007).

3.3 Results

3.3.1 Systematic scoping review

3.3.1.1 Publication date, research location, and sectoral focus

All articles included in the review ($n=70$) have been published between 2007 and 2025 (see Figure 8). The studies focus on 47 different countries. Most studies have a geographical focus on climate adaptation in Europe or North America. The United States ($n=11$), the Netherlands ($n=7$), and Australia ($n=5$) are the most frequently mentioned.

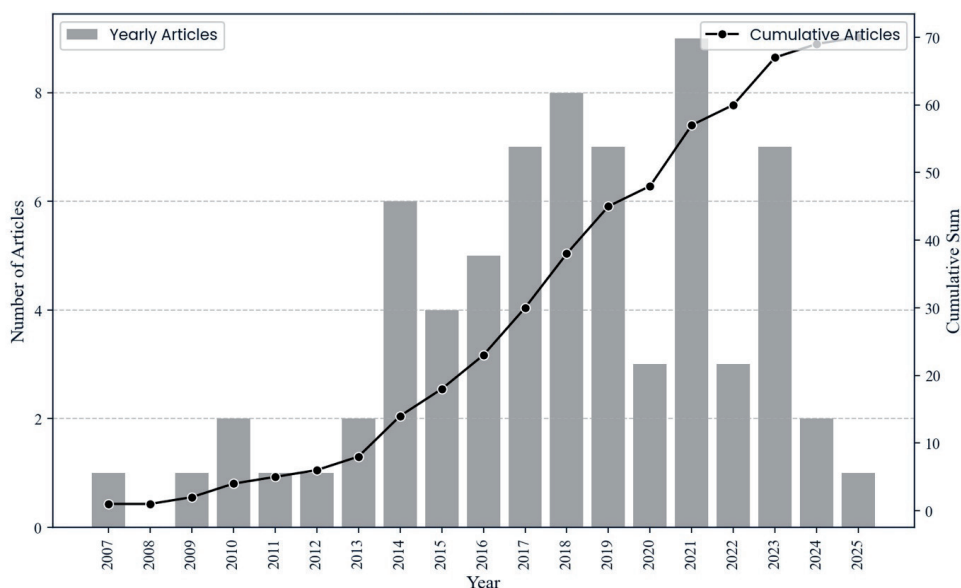


Figure 8: Publication date of included articles.

Water-focused policymaking is the most researched climate adaptation domain among the reviewed articles, with 45.7% ($n=32$) of the articles primarily focusing on water-related impacts. This includes coastal flooding, fluvial flooding (from overflowing river runoff), pluvial flooding (from surface runoff during extreme rain events), and water scarcity or drought. Despite water being the most prominent domain, many articles ($n=29$) do not have a specific sectoral focus, as they often focus on general climate adaptation goals or policy documents. Other types of adaptation domains researched in the articles include agricultural policy and bushfire adaptation.

Most of the articles ($n=38$) focus on adaptation planning and, therefore, decisions such as goal setting and measure planning in adaptation policies. Only 15.7% of the articles ($n=11$) exclusively concentrate on the implementation of adaptation projects. Less than half of the studies explicitly focused on the local (municipal) governance level ($n=30$), while the regional level (e.g., province, district) was the focus of 28.6% of the articles ($n=20$). In addition, one-fourth of the articles explored multiple governance levels ($n=18$) and only 2.9% concentrated on the national level ($n=2$). No studies addressed international or global level adaptation.

3.3.1.2 Disciplinary background, methodology, and use of theory

The most frequent journal subject areas and categories identified are specified in Table 4, reflecting the predominance of studies in natural and environmental sciences journals, followed by neighbouring social sciences disciplines. None of the articles was published in a behavioural science journal. More than one-third ($n=28$) employed a mixed-method design, while more than half of the studies ($n=45$) used interviews in their data collection. Other frequently utilised research methods were surveys ($n=21$) and document analyses ($n=18$).

Table 4: Journal subject areas and categories

Subject area	Category	Frequency (N=198)
Environmental Science	Management, Monitoring, Policy and Law	34
Environmental Science	Global and Planetary Change	26
Social Science	Geography, Planning and Development	25
Environmental Science	Ecology	11
Earth and Planetary Sciences	Atmospheric Science	10

Note. Subject areas and categories were extracted from Scimago (SCImago, n.d.). Only the top five categories are displayed.

Of the reviewed studies, four ($n=4$) utilised a psychological theory as a basis for the investigation of climate adaptation decision-making. These theories were the Theory of Planned Behaviour (Luís et al., 2018), the Protection Motivation Theory (Wolf et al., 2021), the Protective Action Decision Model (VanBuskirk et al., 2023; Wolf et al., 2021), and nudging, which the authors interpret as theory (Poch et al., 2023).

3.3.1.3 Individual-level influences on adaptation decision-making behaviour

Figure 9 displays the behavioural determinants that we have identified from the reviewed studies using TDF coding. Many of the reviewed studies report a long list of barriers and drivers connected to climate adaptation, of which only some are directly connected to the individual-level decision-making of policymakers (e.g., Lawrence et al., 2015; Robinson, 2019; Simonet & Leseur, 2019).

The primary focus is often on structural barriers and drivers, such as financial resources, without investigating their effect on individual decision-making processes or the psychological mechanisms they elicit on the individual level. Similarly, it is often not explored how individual-level decisions contribute to the recorded barriers and drivers. The primary focus is on some type of adaptation outcome (e.g., measure implementation, adaptation plan) and not on policymakers' decision-making behaviours as an intermediary between determinants and behavioural outcomes in regard to climate adaptation. In the following, the term 'influence on adaptation policymaking' is utilised to report the influences identified by the reviewed articles, while the term 'determinant of behaviour' is employed to report the TDF classification of these influences.

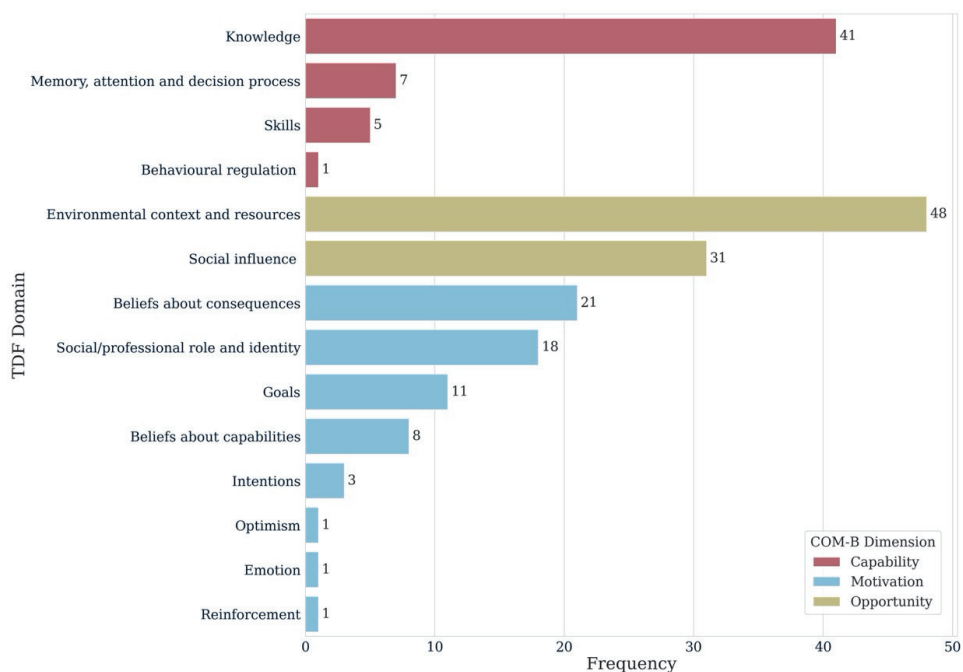


Figure 9: Influences on climate adaptation categorised by behavioural domains.

Opportunity. The majority of the recorded policymaking influences fall into the opportunity dimension ($n=79$) of the COM-B. The TDF domain ‘environmental context and resources’ ($n=48$) emerged as the most frequently occurring domain of behavioural determinants in coding the reported adaptation influences. Factors such as organisation types (Brody et al., 2010), adaptation plans (Robinson, 2019), budgetary issues (Archie, 2014), and cooperation difficulties (Lee et al., 2023b) are investigated as influences on adaptation outcomes. Another influence captured within the ‘environmental context and resources’ determinant is the experience of extreme weather events, which has been observed in multiple studies (Birchall & Kehler, 2023; Haße & Kind, 2019; Morrison et al., 2019). Other central contextual influences found in multiple studies are the governance and organisational structure (Birchall & Bonnett, 2021; Brody et al., 2010; Robinson, 2019; Storbjörk & Hjerpe, 2021) as well as resource constraints (Cañavera Herrera & MacAskill, 2021; Lee et al., 2023b; Mozumder et al., 2011). Similarly, political influences, such as political priorities and political support for climate adaptation, affect adaptation decisions (Archie, 2014; Van Oijstaeijen et al., 2022). Moreover, historically developed policies and practices (Noblet & Brisson, 2017; Uittenbroek, 2016), as well as weak connections between and within organisations, are also observed to influence adaptation policymaking (Donatti et al., 2017; Liu et al., 2016).

The third most frequently reported behavioural determinant type in the studies is ‘social influences’ ($n=31$), which also falls under the opportunity dimension within the COM-B. In particular, leadership and advocacy within organisations can shape adaptation policymaking (Archie, 2014; Birchall & Bonnett, 2021; Robinson, 2019; Simões et al., 2017). Connectedly, social conflicts and insufficient internal cohesion can also influence adaptation decisions (Azhoni et al., 2017; Cuevas, 2018; Lawrence et al., 2015). In addition, external social influences such as public pressure (Albizua & Zografos, 2014; Ibrahim et al., 2020), opposition from actors (Mozumder et al., 2011), as well as discourses and narratives on adaptation (Albizua & Zografos, 2014; Puzyreva & de Vries, 2021) have also been found as factors affecting adaptation policymaking.

Motivation. Influences on adaptation policymaking connected to the COM-B dimension motivation have been recorded 64 times ($n=64$). Most frequently in this dimension, the TDF domain ‘beliefs about consequences’ ($n=21$) has been coded as a determinant of behaviour. This primarily includes the denial of risk (Birchall & Kehler, 2023; Howlett, 2014), expectations regarding the value of climate adaptation (Van Oijstaaijen et al., 2022; Wolf et al., 2021), and climate change impact beliefs (Flugman et al., 2012; Morrison et al., 2019; Noblet & Brisson, 2017; Spiegel, 2017). In addition, policymakers’ ‘social and professional role and identity’ ($n=18$) has been frequently recorded as a determinant. For example, this includes the ownership of actions (Simonet & Leseur, 2019), self-interests (Han & Kuhlicke, 2021), values (Albizua & Zografos, 2014), and responsibility beliefs (Brillinger et al., 2021). Goals ($n=11$) have also been found as behavioural determinants, primarily as conflicting priorities (Lee et al., 2023b; Sorgho et al., 2023; Zea-Reyes et al., 2021) and adaptation priorities (Ibrahim et al., 2020; Pasquini et al., 2013). The other domains included in the motivation dimension of the TDF, beliefs about capabilities ($n=8$), intentions ($n=3$), optimism ($n=1$), emotion ($n=1$), and reinforcement ($n=1$), were less frequently observed as influences on adaptation decisions.

Capability. The capability dimension ($n=54$) of the COM-B has been recorded less often than opportunity and motivation. Despite that, ‘knowledge’ ($n=41$) is the second most frequently coded behavioural domain. The reviewed articles focus on different facets of this determinant of behaviour. While some studies focus on climate change knowledge (Pasquini et al., 2013), others also incorporate knowledge regarding adaptation measures as a behavioural influence (Brillinger et al., 2021; Donatti et al., 2017). Moreover, the reviewed articles also highlight that awareness of climate change affects adaptation policymaking (Zea-Reyes et al., 2021). However, knowledge is often not connected to behaviour and psychological mechanisms but rather knowledge levels (Gray et al., 2014) or assessed as a barrier to adaptation outcomes (Simonet & Leseur, 2019). ‘Memory, attention, and decision process’ ($n=7$) has also been found to shape adaptation decisions. For example, case-by-case decision approaches (Lawrence et al., 2015), perceptions (Cockerill et al., 2014), and signal detection (Simões et al., 2017) have been recorded by the reviewed studies. The other TDF domains connected to the capability dimension of the COM-B, ‘skills’ ($n=5$) and ‘behavioural regulation’ ($n=1$), have also been found as adaptation influences.

3.3.1.4 Behaviour change techniques and policymakers’ decision-making

Only 11.4% ($n=8$) of the reviewed studies proposed, tested, or developed a behavioural intervention, while the majority of studies focused on policy recommendations. None of the studies labelled the intervention as behavioural intervention. Instead, the focus lies on the intervention technique itself (e.g., serious game) without connecting it to behavioural intervention research. Overall, the studies employed or proposed four different types of behavioural interventions. Most frequently, decision-making guides were utilised to improve adaptation decisions (Haße & Kind, 2019; Lucertini et al., 2022; Tàbara et al., 2010). Moreover, workshops (Löschner et al., 2016; Luís et al., 2018), serious games (K. Fleming et al., 2020; Rumore et al., 2016) and nudges (Poch et al., 2023) were featured in the reviewed papers. All studies that proposed an intervention targeted local stakeholders, not exclusively policy professionals, who are involved in local adaptation decisions. The target behaviours include the development and choosing of adaptation strategies (Löschner et al., 2016; Lucertini et al., 2022), improving cooperation (K. Fleming et al., 2020; Rumore et al., 2016), and adjacent behaviours that affect adaptation outcomes. Appendix 5 in Bellmann, de Vries, et al. (2026) (Supplementary Information 1) lists the intervention types, target population, and target behaviour of the articles that include an intervention.

While two studies establish a link to psychological theories (Luís et al., 2018; Poch et al., 2023), none of the reviewed studies connects the employed or recommended intervention to behavioural determinants. Regarding the use of theory, Luís et al. (2018) used workshops to increase the adaptation intention and to

change subjective norms and knowledge, drawing on the Theory of Planned Behaviour. Building on nudging as a framework, Poch et al. (2023, p. 5) propose nudges, such as “peer pressure” platforms’, that target government officials’ decision-making without testing them.

One intervention type used in three of the reviewed studies ($n=3$) is decision process guides. These guides shall support decision-making processes by providing structure and improving the navigability of the policymaking process. For example, Haße and Kind (2019) improved an online tool that functions as a guide for decision-making processes in adaptation. Also proposing a decision process guide, Lucertini et al. (2022) developed a four-step approach that supports adaptation decisions. Another intervention type utilised in two studies is serious games. Both Rumore et al. (2016) and Fleming et al. (2020) utilised serious games as tools to foster stakeholder engagement and collaboration.

Table 5: Frequency of mentioned Behaviour Change Techniques and associated TDF and COM-B domains

Behaviour Change Technique	Frequency	TDF Domain(s)	COM-B
Shaping knowledge	7	Knowledge	Capability
Goals and planning	7	- Goals - Intentions	Motivation
Social support	4	- Emotions - Social Influence	- Motivation - Opportunity
Natural consequences	3	- Beliefs about Consequences - Emotions	- Motivation - Capability
Feedback and monitoring	2	- Knowledge - Behavioural Regulation	Capability
Reward and threat	1	- Beliefs about Consequences - Reinforcement - Social Influences	- Motivation - Opportunity
Comparison of behaviour	1	Social Influences	Opportunity

Note. The not-listed types of BCTs have not been utilised in the reviewed studies. These BCTs are: repetition and substitution, scheduled consequences, self-belief, covert learning, regulation, comparison of outcomes, associations, antecedents, identity.

Table 5 lists the types of BCTs that have been employed to intervene in policymakers' adaptation decision-making. The most frequently used BCTs are 'shaping knowledge' ($n=7$) and 'goals and planning' ($n=7$). This is due to the focus on knowledge provision and decision-process design in the described interventions. Moreover, both the workshop interventions and serious games have a 'social support' component, focusing on social learning and social support provision (K. Fleming et al., 2020; Löschner et al., 2016; Luís et al., 2018; Rumore et al., 2016). The COM-B analysis shows that the most addressed dimensions were policymakers' motivation ($n=15$) and capability ($n=12$).

3.3.2 Delphi panel

Table 6 presents the plasticity and impact scores for each behaviour, as rated by the Delphi panel, indicating how high the potential for behaviour change is and how impactful each behaviour is in adaptation policymaking. It also includes the decision-making phases in which the behaviours primarily occur and BCTs to address them. The Delphi panel data is provided in Appendix 6 (see Supplementary Information 2 in Bellmann, de Vries, et al. (2026)).

3.3.2.1 Delphi panel round 1

The first round assessed the plasticity and impact of 20 pre-selected behaviours as well as the implementability of BCTs. The data shows a strong correlation between the behaviours' impact and plasticity ($r=0.87$, $p<0.001$). The highest plasticity and impact scores were assigned to the behaviours 'broaden adaptation focus beyond water issues' ($M_{\text{plasticity}}=3.81$, $M_{\text{impact}}=3.96$), 'connect to other internal departments' ($M_{\text{plasticity}}=3.70$, $M_{\text{impact}}=3.91$), and 'emphasise political benefits of adaptation' ($M_{\text{plasticity}}=3.62$, $M_{\text{impact}}=3.83$).

Through k-means clustering, we identified three distinct clusters of behaviours regarding their impact and plasticity (see Figure 10). Cluster 1 includes high-impact, high-plasticity behaviours, which have a higher behaviour change potential and a higher impact on adaptation policymaking than the other behaviours. Cluster 2 includes medium-impact, medium-plasticity behaviours, while Cluster 3 includes low-impact, low-plasticity behaviours. ANOVAs showed significant differences between these three clusters for plasticity ($F(2, 17)=10.49$, $p<0.01$), impact ($F(2, 17)=13.99$, $p<0.001$), and a combined impact-plasticity score ($F(2, 17)=13.98$, $p<0.001$). A Shapiro-Wilk test showed that Group 2 (Cluster 2) significantly deviated from a normal distribution ($W=0.5680$, $p<0.001$). As the conducted ANOVAs assume normality, we also conducted Kruskal-Wallis tests. These tests confirmed the significant differences between the groups for plasticity ($H(2)=13.84$, $p<0.01$), impact ($H(2)=16.40$, $p<0.001$), and the combined impact-plasticity score ($H(2)=16.73$, $p<0.001$).

We further tested for significance between the groups' impact-plasticity score using a Mann-Whitney U test adjusted for multiple hypothesis testing through Bonferroni corrections. This analysis revealed significant differences between Clusters 1 and 3 (corrected $p<0.01$), Clusters 1 and 2 (corrected $p<0.01$), as well as Clusters 3 and 2 (corrected $p<0.05$).

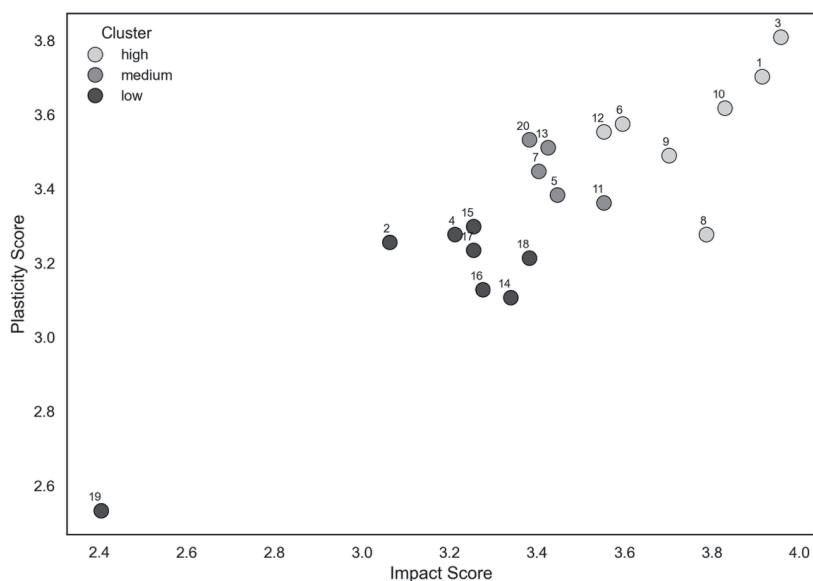


Figure 10: Behaviours as clustered by plasticity and impact scores (number of scores $n=47^7$). Numbers next to the dots correspond to behaviours in Table 6.

Regarding the impact score agreement of respondents, ‘broaden adaptation focus beyond water issues’ (76.60%), ‘emphasise political benefits of adaptation’ (72.34%), ‘connect to other internal departments’ (70.21%), and ‘set-up pilot projects on adaptation’ (65.60%) were scored ‘4’ or higher on a 5-point Likert scale (5=highest) by the highest share of participants. Regarding the plasticity score agreement, ‘connect to other internal departments’ (63.83%) and ‘broaden adaptation focus beyond water issues’ (63.83%) were scored ‘4’ or higher by more than 60% of respondents.

The thematic analysis of the stated reasoning approaches, underlying how participants evaluated the behaviours’ plasticity and impact, surfaced four themes encapsulating multiple mentions (n) for each of them. Respondents’ plasticity reasoning was shaped by ‘system constraints and capacity considerations’ ($n=21$), ‘personal experience with adaptation decision-making’ ($n=20$), ‘considering individuals as change agents’ ($n=6$), and ‘impact consequences and normative considerations’ ($n=5$). In contrast, the impact reasoning was influenced by ‘personal experiences and knowledge on adaptation decision-making’ ($n=37$), ‘existing change and system considerations’ ($n=13$), ‘focusing on key actors and processes’ ($n=10$), and ‘reflecting on the nature of impacts’ ($n=8$). Descriptions of these themes, along with added behaviours participants considered to be relevant, are provided in Appendix 7 (see Supplementary Information 1 in Bellmann, de Vries, et al. (2026)).

The analysis of the BCTs identified ‘goals and planning’ ($M=3.87$), ‘shaping knowledge’ ($M=3.79$), and ‘social support’ ($M=3.77$) as the highest-scoring BCTs. Regarding the ease of use, ‘social support’ ($M=3.30$), ‘shaping knowledge’ ($M=3.28$), and ‘comparison of behaviour’ ($M=3.26$) scored highest. K-means clustering of BCTs based on their implementability and ease of use identified three distinct clusters, as visualised in Figure 11. ANOVAs showed significant differences between these three clusters for ease of

⁷The robustness check with the two late submissions indicated a minor change in the clustering, with behaviour ‘set-up pilot projects on adaptation’ not being in the prioritised (‘high’) cluster. However, it would still have been included through the agreement threshold.

use ($F(2,13)=44.14, p<.001$), implementability ($F(2, 13)= 55.21, p<.001$), and a combined score ($F(2, 13)=80.71, p<.001$). A Shapiro-Wilk test for the implementability score comparison suggested that Group 1 (Cluster 1) significantly deviated from normal distribution assumptions. A Kruskal-Wallis test confirmed the significant differences between the groups regarding implementability ($H(2)=13.46, p<.01$).

We also tested for significance between the groups’ combined scores using a Tukey’s HSD post hoc analysis. This analysis revealed significant differences between Clusters 2 and 1 ($MD=0.49, p<.001$), Clusters 2 and 3 ($MD=-0.50, p<.001$), as well as Clusters 1 and 3 ($MD=-0.98, p<.001$) (see Appendix 8 in Supplementary Information 1 in Bellmann, de Vries, et al. (2026) for a visualisation of the group comparisons).

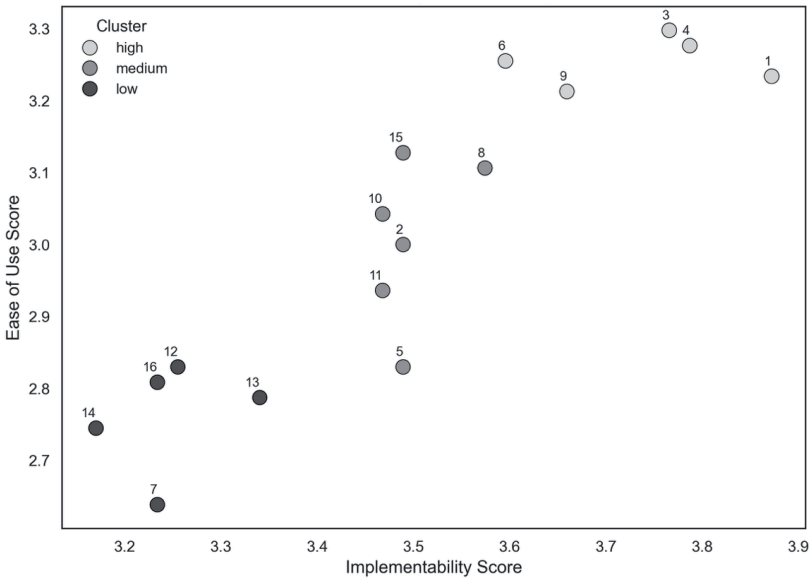


Figure 11: BCTs as clustered by implementability and ease of use scores (number of scores $n=47^8$). Numbers next to the dots correspond to BCTs in Table 7.

More than 60% of respondents scored implementability as ‘4’ or higher for ‘goals and planning’ (80.85%), ‘feedback and monitoring’ (61.70%), ‘social support’ (68.09%), ‘shaping knowledge’ (70.21%), ‘natural consequences’ (61.70%), ‘comparison of behaviour’ (61.70%), ‘repetition and substitution’ (61.70%), and ‘comparison of outcomes’ (66.00%). No BCT scored ‘4’ or higher regarding its ease of use by more than 60% of participants. Table 7 displays the BCTs’ implementability scores as well as whether they were prioritised through the panel.

⁸ The robustness check with the two late submissions confirmed the clustering and agreement threshold.

Table 6: Delphi panel prioritisation of behaviours, related decision-making phases and perceived most suitable Behaviour Change Technique

	Behaviour	Impact score		Plasticity score		Decision-making phases*	Suitable Behaviour Change Technique (BCT)*
		M	SD	M	SD		
1	Connect to other internal departments ^{ab}	3.91	1.02	3.70	0.95	Intelligence gathering	Goals and planning
2	Evaluate existing policies	3.06	0.89	3.26	0.79	-	-
3	Broaden adaptation focus beyond water issues ^{ab}	3.96	1.00	3.81	0.88	Direction definition	Shaping knowledge
4	Communicate resource needs to other organisations	3.21	0.78	3.28	0.97	-	-
5	Prioritise established climate adaptation solutions	3.45	0.75	3.38	0.80	-	-
6	Engage in regional cooperation ^b	3.60	0.80	3.57	0.74	Solutions finding	Goals and planning/ shaping knowledge
7	Search for established climate adaptation solutions	3.40	0.74	3.45	0.95	-	-
8	Set-up pilot projects on adaptation ^{ab}	3.79	0.88	3.28	0.93	Solutions finding	Shaping knowledge
9	Communicate climate adaptation ideas to leadership ^b	3.70	0.91	3.49	0.88	Direction definition	Goals and planning
10	Emphasise political benefits of climate adaptation ^{ab}	3.83	0.99	3.62	0.87	Direction definition	Comparison of behaviour

Behaviour	Impact score		Plasticity score		Decision-making phase*	Suitable BCT(s)*
	M	SD	M	SD		
11 Involve internal leadership in strategy development	3.55	0.88	3.36	0.82	-	-
12 Involve departments in strategy development ^b	3.55	0.83	3.55	0.80	Direction definition	Goals and planning
13 Communicate climate adaptation obligations	3.43	0.99	3.51	0.88	-	-
14 Gather climate adaptation data	3.34	0.81	3.10	0.89	-	-
15 Engage with knowledge institutions	3.26	0.82	3.30	0.95	-	-
16 Share data with other actors	3.28	0.85	3.13	0.77	-	-
17 Incorporate advice of knowledge institutions	3.26	0.87	3.23	0.96	-	-
18 Align goals with inhabitants' preferences	3.38	0.97	3.21	0.98	-	-
19 Prioritise complaining citizens	2.4	0.9	2.53	0.88	-	-
20 Advocate for climate adaptation initiatives	3.38	0.92	3.53	0.97	-	-

Note. ^aprioritised by consensus threshold; ^bprioritised by clustering; *only the most frequently mentioned phase is displayed. A dash (-) denotes behaviours that were not prioritised.

3.3.2.2 Delphi panel round 2

Table 6 shows the phase to which the prioritised behaviours were matched, determined based on the frequency of matches. Figure 12 visualises the frequency with which the decision-making phases have been assigned to each of the behaviours. Overall, ‘direction definition’ ($n=150$) and ‘solutions finding’ ($n=142$) were the most frequently matched phases.

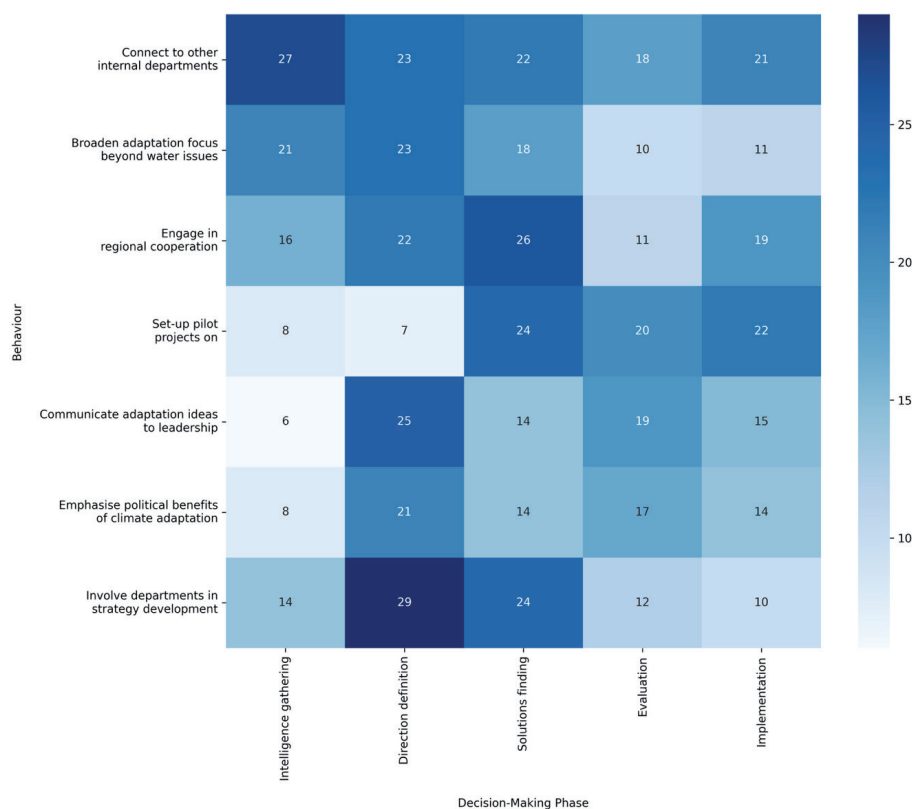


Figure 12: Frequency heatmap of decision-making phases during which the behaviours occur.

The analysis of the BCT’s acceptability shows that ‘goals and planning’ ($M_{\text{approval}}=4.31$, $M_{\text{welcome}}=4.44$), ‘social support’ ($M_{\text{approval}}=4.22$, $M_{\text{welcome}}=4.31$), and ‘shaping knowledge’ ($M_{\text{approval}}=4.16$, $M_{\text{welcome}}=4.28$), were the three highest-scoring intervention types (see Table 7). The analysis of the suitable BCTs to address the prioritised behaviours highlights that ‘goals and planning’ ($n=58$), ‘shaping knowledge’ ($n=44$), ‘comparison of outcomes’ ($n=30$), and ‘social support’ ($n=28$) were most frequently assigned. ‘Connect to other internal departments’, ‘communicate adaptation ideas to leadership’, and ‘involve departments in strategy development’ were most frequently matched to ‘goals and planning’. In contrast, ‘broaden adaptation focus beyond water issues’ and ‘set-up pilot projects on adaptation’ were most frequently assigned to ‘shaping knowledge’ while ‘emphasise

political benefits of climate adaptation’ was most frequently assigned to ‘comparison of behaviour’. ‘Engage in regional cooperation’ was assigned to both ‘goals and planning’ and ‘social support’.

Table 7: Behaviour change techniques scored implementability, ease of use, approval, and welcome scores

	Behaviour change technique	Implementable score	Ease of use score	Approval score	Welcome score
		<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>
1	Goals and planning ^{ab}	3.87 (0.71)	3.23 (0.94)	4.31 (0.64)	4.44 (0.56)
2	Feedback and monitoring ^a	3.49 (0.88)	3.00 (0.88)	4.06 (0.88)	4.25 (0.84)
3	Social support ^{ab}	3.77 (0.84)	3.3 (0.91)	4.22 (0.71)	4.31 (0.64)
4	Shaping knowledge ^{ab}	3.79 (0.88)	3.28 (0.95)	4.16 (0.81)	4.28 (0.63)
5	Natural consequences ^a	3.49 (0.83)	2.83 (0.96)	3.84 (0.72)	3.69 (0.86)
6	Comparison of behaviour ^{ab}	3.60 (0.85)	3.26 (0.87)	3.78 (0.91)	3.78 (0.83)
7	Associations	3.23 (0.89)	2.64 (0.82)	-	-
8	Repetition and substitution ^a	3.57 (0.88)	3.11 (0.84)	3.84 (0.92)	3.84 (0.95)
9	Comparison of outcomes ^{ab}	3.66 (0.98)	3.21 (0.93)	4.00 (0.72)	3.94 (0.76)
10	Reward and threat	3.47 (1.04)	3.04 (1.14)	-	-
11	Regulation	3.47 (0.95)	2.94 (1.03)	-	-
12	Antecedents	3.26 (1.03)	2.83 (0.96)	-	-
13	Identity	3.34 (0.96)	2.79 (1.00)	-	-
14	Scheduled consequences	3.17 (0.99)	2.74 (0.99)	-	-
15	Self-belief	3.49 (0.83)	3.13 (0.88)	-	-
16	Covert learning	3.23 (1.00)	2.81 (0.97)	-	-

Note. ^aprioritised by consensus threshold; ^bprioritised by clustering. A dash (–) denotes BCTs that were not prioritised.

Across rounds, the analysis reveals that ‘goals and planning’ ($M=3.96$), ‘social support’ ($M=3.90$), and ‘shaping knowledge’ ($M=3.88$) have the highest combined score across all four items measuring implementability and acceptability.

3.4 Discussion

The findings derived from the systematic scoping review and the expert Delphi panel provide a set of behavioural determinants, behaviours, and BCTs as a basis for the development of interventions tailored to climate adaptation policymaking.

3.4.1 Influences on adaptation decisions

The most frequently mentioned influences on adaptation policymaking in the reviewed scholarly literature primarily relate to policymakers' 'environmental context and resources', 'knowledge', and 'social influences', i.e., opportunity and capability components of behaviour, if categorised according to the COM-B model. With regard to the motivation component, 'beliefs about consequences' and the 'social and professional role and identity' of policymakers are most frequently recorded. Accordingly, the findings showcase that psychological influences beyond the environmental context, which is often the focus of structural barriers research (A. Bauer et al., 2012; Oberlack, 2017), affect adaptation decisions. This complements earlier research, which argues that investigating decision-making processes, rather than solely focusing on structural barriers, can produce valuable insights into adaptation policy outcomes (Biesbroek et al., 2015; Siders & Pierce, 2021).

However, prior psychological research emphasises different determinants of climate adaptation behaviour. In a synthesis of existing meta-analyses on determinants of adaptation behaviour, Bechtoldt et al. (2021) reported that, on the individual level, outcome expectancy, negative affect, self-efficacy, coping appraisal, threat appraisal, and climate change beliefs are the strongest influences on adaptation behaviour. Other researchers have found that people's climate change knowledge and personal experience have only a relatively small impact on their behaviours (van Valkengoed & Steg, 2019a). Psychological research, however, usually focuses on the general public and not on policymakers.

The differences between these results and the findings reported in the reviewed studies might be explained by two causes. First, the determinants of policymakers' behaviour likely differ from those observed in the general population due to the context in which their decision-making takes place. Second, the research foci and disciplinary embeddings of the articles reviewed in this study, as compared to the focus of psychological research or policy research, differ significantly. This likely reflects the different ontologies and worldviews in science, which result in a focus on different entities perceived to exist and matter (Brenzau et al., 2022; Sharp et al., 2023). This may also explain the limited use of psychological theories in the articles reviewed in this study, along with the absence of explicit recognition of activities, such as the use of serious games, as behavioural interventions. Furthermore, since many articles primarily focus on contextual influences, determinants directly related to external factors might be more often recorded than intra-individual psychological processes, such as emotions. Most likely, a combination of both reasons underpins the difference in found behavioural determinants.

3.4.2 Intervention spaces

In addition to the behavioural determinants obtained from the review, the Delphi panel prioritised seven behaviours based on their plasticity and impact on adaptation decisions, along with BCTs to address them. This allows the identification of promising intervention spaces to implement effective behavioural interventions.

Four of the seven prioritised behaviours relate to internal cooperation and communication within municipalities, highlighting internally directed behaviours as key targets for behavioural interventions. This aligns with recent research on behavioural dynamics in climate adaptation decision-making, which identified boosting mainstreaming efforts as a key lever in shaping adaptation decisions, likely with system-wide impacts (Chapter 2; Bellmann et al., 2025b). In particular, behaviours that ‘broaden adaptation focus beyond water issues’, ‘connect to other internal departments’, ‘emphasise political benefits of adaptation’, and ‘involve departments in strategy development’ directly relate to this dynamic. This also confirms the importance of adaptation mainstreaming within organisations, as emphasised in policy research (Braunschweiler & Pütz, 2021; Pasquini et al., 2013; Uittenbroek, 2016).

Interestingly, behaviours connected to attaining knowledge or data, which are often emphasised in previous research (Haße & Kind, 2019; Lucertini et al., 2022), were not prioritised by the expert panel. Although considered relevant for adaptation policy outcomes and actor engagement (Chapter 2; Bellmann et al., 2025b), the relatively low impact and potential for behaviour change suggest that they should not be prioritised by interventions. However, our thematic analysis revealed that participants’ reasoning was often informed by their experience, which might skew the prioritisation toward behaviours that respondents are familiar with (A. De Vries et al., 2017; Greul et al., 2023).

All prioritised behaviours occur in multiple decision-making phases, which highlights that they are not confined to a specific phase. While these phases often follow one another, they may occur in any order or run in parallel, possibly with iterations between stages. Notably, ‘direction definition’ and ‘solutions finding’ were the most frequently matched phases. This suggests that behaviours in intermediate phases, when aspirations and decisions regarding courses of action are formulated, should be primary targets for interventions (Nutt, 2008).

While our review suggests that process guides, serious games, workshops, and nudges can improve certain aspects of adaptation decision-making, the studies did not directly address specific determinants of behaviour. This complicates the understanding and evaluation of the interventions’ effectiveness (Scholten et al., 2025) and can lead to ineffective behaviour change interventions as the determinants of the target behaviour are not addressed (van Valkengoed, Abrahamse, et al., 2022). Studies of determinants of behaviour and decision-making interventions often adopt a pre-set focus on knowledge, which might lead to a self-reinforcing loop in producing scholarly work with the same focus (Donatti et al., 2017; Luís et al., 2018). Nonetheless, the interventions utilised in the reviewed publications were often tailored to the local context and hence in alignment with behavioural research that advocates for context-tailored interventions as part of a system approach (Hallsworth, 2023; Kaufman et al., 2024; see Section 1.2).

The Delphi panel prioritised BCTs based on their implementability and acceptability, with ‘goals and planning’, ‘social support’, and ‘shaping knowledge’ ranking highest. Accordingly, it prioritised BCTs that were also utilised in the reviewed research, showing that the studied BCTs are in line with the expert panel. This may stem from the studies’ focus on context and engagement with local actors, which could yield insights similar to those of the panel. Interestingly, a recent review of the effectiveness of behavioural interventions found that ‘shaping knowledge’, ‘goals and planning’, and ‘repetition and substitution’ are the most promising BCTs to induce climate-friendly behaviours of individuals and households (Masciangelo et al., 2024). This is contrary to the findings of Albarracín et al. (2024), according to which interventions focused on access, habits, and social support are most promising. Considering the conflicting evidence and different target groups, more research focused on policymakers is needed.

3.4.3 Limitations and future recommendations

Methodologically, combining the systematic scoping review and the Delphi panel enabled the identification of behavioural determinants, key behaviours, and suitable BCTs, establishing the basis for the development of context-tailored interventions. By incorporating impacts and constraints within the system as well as consulting the target group, our approach supports calls for a system approach in behavioural research (Chater & Loewenstein, 2023a; Hallsworth, 2023a). Consideration of context and complex system properties is a well-established practice in other fields, such as implementation science (Rapport, 2022), user experience research (Rouse, 2007), and increasingly also in policy design and evaluation research (Howlett, 2018; Mansoor & Williams, 2024; O'Toole & Meier, 2015).

Based on the above, we recommend that future research in behavioural public policy integrates disciplinary expertise and jargon to facilitate the analysis of dynamically interacting internal and external behavioural determinants that affect policymaking. Behavioural science frameworks, such as the TDF and COM-B (Atkins et al., 2017; Michie et al., 2011), are suitable for identifying key individual-level determinants. Policy sciences approaches help analyse the structural determinants constituting policymakers' choice architecture. Finally, systems analysis methods can map complex interactions and identify levers for behavioural interventions (Chapter 2; Bellmann et al., 2025b).

Several limitations of this study offer directions for future research. While this study established a comprehensive basis for the creation of interventions, it did not develop and test one. Accordingly, future experimental research should develop and test interventions to improve adaptation policymaking. Scholarly work should assess whether the most utilised interventions in reviewed studies, namely serious games and decision process guides, can be strengthened by connecting them to an analysis of behavioural determinants and behavioural science theories. Another limitation is that the prioritised key behaviours are still relatively broad, as they focus on types of behaviours (e.g., evaluate existing policies) rather than highly specific actions (e.g., list existing municipal measures in a spreadsheet). While beneficial for the prioritisation of an initial set of behaviours, future research needs to specify them further to develop interventions. Similarly, the consistently large standard deviations across scoring items and themes suggest high variability of experiences, highlighting the need to tailor interventions to local contexts.

Although the literature reviewed and behavioural science experts involved were international, the participating policy professionals' work focused on climate adaptation in the Netherlands. The Netherlands' unique geography and historical legacy of managing water may influence climate adaptation policymaking in ways that do not apply in other contexts. Future work should replicate the prioritisation of behaviours and BCTs with policy professionals in other country contexts to test the generalisability of the results. Addressing these limitations will strengthen the development of tailored behavioural interventions and enable the creation of effective interventions to improve adaptation policymaking.

3.5 Conclusions

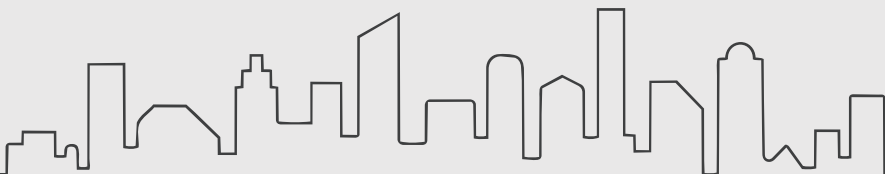
Climate adaptation requires behaviour change from citizens and policymakers. This study conducted a systematic scoping review and a Delphi panel with climate adaptation and behavioural science experts. The resulting set of behavioural determinants, behaviours, and BCTs was prioritised to establish a basis for the development of behavioural interventions that target policymakers' adaptation decision-making.

The systematic scoping review revealed that policymakers' context, resources, and knowledge, as well as social influences, are the most frequently reported determinants of adaptation decisions. Furthermore, the most frequently used BCTs include setting goals, making plans, and building knowledge to influence policymakers' adaptation decision-making. The expert Delphi panel yielded seven key behaviours with high perceived plasticity and impact on adaptation policymaking, connected to the decision-making phases in which they occur. It also prioritised BCTs based on their implementability and acceptability, showing that those including goal setting, planning, social support, and knowledge building are the most promising techniques.

By integrating insights from peer-reviewed research and the expert panel, the study offers a practical basis for intervention design, highlighting what behaviours interventions should address, what behavioural determinants shape adaptation policymaking, and which BCTs can be utilised to improve policymakers' decision-making. The resulting intervention spaces show a way forward in developing context-tailored behavioural interventions for climate adaptation policymaking. Future behavioural public policy research should test interventions developed on this basis, as current research rarely adopts a behavioural lens. For policymakers, the findings suggest which behaviours, such as mainstreaming adaptation efforts or emphasising the political benefits of measures, should be the focus of initiatives to improve adaptation efforts.

4

DEVELOPMENT AND EVALUATION OF A METACOGNITIVE BEHAVIOURAL INTERVENTION TO IMPROVE POLICYMAKERS' CLIMATE ADAPTATION DECISION-MAKING



Behavioural interventions to advance climate adaptation have focused on overcoming structural barriers and changing citizen behaviour. Despite their significant leverage to influence system-wide behaviour, policymakers are typically not targeted by interventions. In this study, we present the Climate Adaptation Reflection Navigator (CARN) and key considerations underlying its development and use. CARN integrates a reflection checklist and mental contrasting to boost policymakers' decision-making processes in climate change adaptation.

We tested its effectiveness against a control condition in a randomised online experiment with 406 participants and evaluated its usability through two workshops with 14 Dutch climate adaptation policymakers. The experimental evaluation shows that CARN can improve decision-making performance and decision quality in developing climate adaptation strategies. However, we do not find a statistically significant effect on self-efficacy beliefs and self-assessed decision-making quality. The workshop findings highlight that CARN is a highly usable intervention that can be implemented in existing policymaking processes.

CARN presents a way forward in improving policymakers' climate adaptation decision-making. By targeting policymakers, an actor group with high power, it also suggests a pathway for how behavioural interventions can spark system change. Our findings contribute to the growing research on boosting, showing how reflection-inducing boosts can be developed to enhance decision-making. We discuss implications for the development of behavioural intervention and future research directions.

An adapted version of this chapter has been submitted as:

Bellmann, K. P., Scholten, L., & de Vries, G. (n.d.). Development and evaluation of a metacognitive behavioural intervention to improve policymakers' climate adaptation decision-making.

4.1 Introduction

4.1.1 Accelerating climate adaptation through high-impact behavioural interventions

Despite the established scientific consensus on the harmful effects of anthropogenic climate change, current climate adaptation efforts do not adequately protect human and natural systems (United Nations Environment Programme, 2022, 2024). Climate adaptation refers to ‘the process of adjustment to actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities’ (Calvin et al., 2023, p. 120). It entails measures such as building dikes, increasing urban greening, using permeable pavements, and restoring forests (Bowler et al., 2010; Stavi et al., 2021). While there is a widespread awareness of the increasing adaptation needs and available measures, implementation remains slow, creating an adaptation gap (C3S & WMO, 2025; UNEP, 2024). Existing policy research has been criticised for its overemphasis on structural barriers to understand this gap and the limited attention to how barriers can be overcome (Arteaga et al., 2023; Ishtiaque et al., 2021; Lee et al., 2023b).

As climate adaptation requires behaviour change from many societal actors, a psychological perspective can uncover pathways to accelerating societal adaptation efforts (Chapter 2; Bechtoldt et al., 2021; Bellmann et al., 2025b; Whitmarsh et al., 2021). To date, scholars have primarily studied psychological determinants of and behavioural interventions for citizens’ and farmers’ adaptation behaviour (Bechtoldt et al., 2021; Purwanti et al., 2023). For example, research has shown that interventions can be used to increase flood information seeking (Terpstra & Gutteling, 2008), intentions to adopt heat protection behaviours (Bruine de Bruin et al., 2016), and socio-technical knowledge (Nguyen et al., 2024). However, these interventions were primarily focused on individual-level behaviour change without targeting dynamics in the adaptation system. Such individual-level focused interventions have recently been criticised due to their small effect sizes, limited societal impacts, insufficient consideration of contextual influences, and brittleness if applied in complex systems (Chater & Loewenstein, 2023a; Mertens et al., 2022; R. Schmidt & Stenger, 2024; Szaszi et al., 2025).

Many scholars have called for a system perspective to increase psychology’s ability to contribute to today’s grand challenges, such as climate adaptation, that uses behaviour change interventions as a lever for system change (Hallsworth, 2023a; R. Schmidt & Stenger, 2024; Varazzani & Hubble, 2025). Emerging research adopting such a perspective has shown that it can deepen the understanding of how contextual influences shape individual behaviour and, in turn, how behavioural interactions lead to dynamics on the system level (Chapter 2; Bellmann et al., 2025b; Davan Wetton et al., 2025; Lunetto et al., 2022). Moreover, shifting the focus to dynamical interactions between behaviours can support the development of interventions that tap into existing causal mechanisms, increasing their impact by eliciting domino-like effects that achieve system change (Kaufman et al., 2024; Lunetto et al., 2022; Parkinson et al., 2025).

Consequently, the development of system-focused behavioural interventions can contribute to growing demands for more research on high-impact interventions to address climate issues (Whitmarsh et al., 2021). While there are many calls for behavioural interventions targeting system change in environmental psychology and beyond, their practical translations are scarce. In this study, we present and evaluate a system-focused intervention targeting policymakers’ climate adaptation decision-making as a pathway for system change.

4.1.2 Targeting policymakers for leveraging system-wide change

In a recent article, de Ridder and Thomaes (2025) suggest four pathways for sparking system change through an individual-level behavioural insights perspective in climate change mitigation: eliciting consumer activism, altering consumers' demand and values, facilitating collective action, and enabling collective action. We propose that addressing the impactful behaviours of key actors with system leverage (i.e., high power), such as policymakers, presents a fifth pathway at the nexus of individual-level behaviour change and system change. Unlike the existing pathways, this approach does not rely on (collective) citizen action, offering an alternative avenue that may reduce the burden placed on citizen behaviour in enacting societal transitions.

As of today, behavioural research has primarily focused on citizens' adaptation actions (Bechtoldt et al., 2021; van Valkengoed & Steg, 2019a). However, research suggests that their role in climate adaptation is limited and that, instead, a focus on others with a stronger role to influence and drive adaptation efforts is (at least) equally important (Lorenz et al., 2019; Petzold et al., 2023). Policymakers have a central role in designing and implementing adaptation policies, which, in turn, shape the behaviour of citizens. Accordingly, their decision power exceeds that of other actors, such as citizens (Cunningham & Hermans, 2018; Enserink et al., 2022; Petzold et al., 2023).

In particular, local policymakers have not yet been the focus of behavioural research despite their powerful role in defining adaptation plans, coordinating regional cooperation, and overseeing the implementation of local adaptation projects (Aboagye & Sharifi, 2024; Petzold et al., 2023). As research shows that policymakers' individual-level decision-making can slow societal adaptation efforts (Chapter 2; Bellmann et al., 2025b; Oberlack, 2017), improving it presents a pathway for enhancing societies' climate adaptiveness. The term decision-making here denotes 'the deliberate process of evaluating different alternatives and choosing' between them (Morelli et al., 2022, p. 610).

To date, research into behavioural interventions for policymakers' climate adaptation decision-making is limited, despite its potential to unfold system-wide impact (Chapter 2; Bellmann et al., 2025b; Petzold et al., 2023; Siders & Pierce, 2021). While there are studies that focus on improving policymakers' decisions, these studies have not yet adopted a psychological lens. Instead, existing work primarily concentrated on solving practical challenges in cooperation and decision-making without building on behavioural science theory or targeting system change (e.g., Lucertini et al., 2022; Luís et al., 2018; Rumore et al., 2016). This missing inclusion of behavioural aspects is not exclusive to climate adaptation research and has also been observed in the broader field of transitions research, leading to calls for the integration of behavioural science in the study of societal transitions (G. de Vries et al., 2021).

Still, the potential of addressing policymakers has also been recognised by others, who have called for more research on policymakers' decision-making (Banuri et al., 2019; OECD, 2020) and decision support tools for policymakers' climate adaptation decision-making (Siders & Pierce, 2021). Commenting on this potential, Banuri et al. (2019, p. 311) argue that 'it is almost axiomatic that policies will be more effective when those who design and implement them' are enabled to make better decisions. Simultaneously, many environmental psychologists have underscored the need to focus on impactful behaviours that could significantly contribute to solving climate change challenges. This line of work has emphasised that this compels broadening the scope beyond consumers, also studying the behaviours of other actors that might hold more power (Nielsen, Clayton, et al., 2021; Nielsen, Cologna, et al., 2021; Nielsen et al., 2024; Whitmarsh et al., 2021). In this article, we present and evaluate a behavioural intervention that aims to improve policymakers' adaptation decision-making.

4.1.3 Changing policymakers' adaptation decision-making

In designing interventions that address levers for system change, the common approach is to identify and enhance those mechanisms that speed up and reduce those processes that slow down progress towards the desired system state (e.g., Dorninger et al., 2020; Meadows, 2008). Specific to changing a system of human behaviour this translates to targeting the key determinants of those behaviours that can leverage system change (Chapter 2; Bellmann et al., 2025b; Davan Wetton et al., 2025; Lunetto et al., 2022). In the present study, we consider policymakers as those who can control these levers or whose behaviour itself presents a potential pathway to system change. We hence aim to suggest a novel pathway to achieving system change by improving policymakers' individual-level decision-making.

During earlier research, we have analysed the system that shapes policymakers' climate adaptation decisions in the Netherlands using behavioural system mapping (Chapter 2; Bellmann et al., 2025b) and prioritised impactful, changeable target behaviours with policy experts and behavioural scientists (Chapter 3; Bellmann, de Vries, et al., n.d.-b). This research has uncovered behavioural dynamics, such as a reliance on precedents, which describes policymakers' beliefs that successful adaptation precedents are required to convince political leaders to support action, potentially leading to adaptation postponements (Chapter 2; Bellmann et al., 2025b). Based on expert panel data, we then prioritised intervention spaces for these behavioural dynamics (Chapter 3; Bellmann, de Vries, et al., n.d.-b). These intervention spaces include seven changeable and impactful behaviours, their determinants, and their position in the adaptation decision-making process, providing the foundation for the development of the context-tailored behavioural intervention presented in this paper (see Section 2).

Next to providing intervention spaces, the prior analyses suggested that an intervention that builds capabilities across situations is most suitable for policymakers' adaptation decision-making, particularly amidst the uncertainty, conflicting priorities, and dynamic context that characterise adaptation policymaking (Chapter 2; Bellmann et al., 2025b). Therefore, boosting is a suitable approach to improve policymakers' decision-making, as it focuses on strengthening individuals' competencies, capabilities, and self-control instead of, for example, adjusting choice architectures to elicit short-term behaviour change (Banerjee et al., 2024; Herzog & Hertwig, 2025; Paunov & Grüne-Yanoff, 2023). In contrast to such nudges, which often focus on a single time point or wear off if individuals get used to them, boosting's focus on competences can lead to sustained behaviour change across contexts (Fischhoff & Broomell, 2020; Herzog & Hertwig, 2025). Boosting is particularly preferable in situations of conflicting goals or uncertainty (such as climate adaptation policymaking), as it enables decision-makers to make better decisions themselves rather than prescribing a certain decision (Herzog & Hertwig, 2025).

4.1.4 Aims of this study

We respond to the identified research gaps by developing the Climate Adaptation Reflection Navigator (CARN), a behavioural intervention to improve climate adaptation decision-making through boosting, and experimentally testing its effectiveness compared to a control group. By this, we not only seek to respond to calls for more context-aware, high-impact interventions for individual-level behaviour change, but also to advance research targeted at policymakers' decision-making as a catalyst for system-level climate adaptation.

We label the intervention 'Climate Adaptation Reflection Navigator', as it (from the perspective of its users) is a decision support tool that allows policymakers to reflect on key behaviours in adaptation and their view of an adapted society. CARN is designed to be used whenever a strategic climate adaptation decision is made, making

it applicable across situations, such as the development of a local adaptation programme or strategic planning of an adaptation project. Here, we evaluate an online (Qualtrics) version of CARN, focusing on its effectiveness in improving decision-making processes in adaptation strategy-making and its usability for climate adaptation policymakers.

The remainder of this article is structured as follows. In Section 2, we present the development of CARN, usability reflections based on workshop data, and the final prototype. In Section 3, we describe the experimental design adopted to evaluate its effectiveness, followed by a presentation of the results in Section 4. We discuss our insights from developing and evaluating CARN in Section 5, along with providing recommendations for practical implementation in the field. Finally, our conclusions are presented in Section 6.

4.2 Introducing the Climate Adaptation Reflection Navigator (CARN)

4.2.1 Development of CARN

The development of CARN was guided by four interlacing analysis and development phases, which followed established criteria for the design of effective interventions (Abraham & Denford, 2020; Prestwich et al., 2015; van Valkengoed, Abrahamse, et al., 2022): a behavioural analysis, theory selection, intervention selection, and intervention design. The development phases are discussed below and summarised in Figure 13.

Phase 1: Behavioural analysis. As outlined in Section 1.3, we developed CARN based on a behavioural analysis and target behaviour prioritisation conducted in earlier research. This analysis resulted in seven (prioritised) target behaviours, which are presented in Table 8. It also revealed addressable key determinants of behaviour that underpin them, namely capability beliefs, beliefs about consequences, and knowledge, which are required for the development of targeted interventions (van Valkengoed, Abrahamse, et al., 2022). CARN shall address these target behaviours and their underlying determinants. Describing the behavioural analysis in detail is beyond the scope of the present article. A comprehensive report on the methodology and results can be found in Bellmann et al. (2025b) and Bellmann, de Vries, et al. (n.d.-b) (Chapters 2&3).

Phase 2: Theory selection. We then selected a suitable behaviour change theory to conceptualise the cause-effect relationships between determinants of behaviour and behaviour change. For the design of the intervention, we draw on a theoretical model that has been developed for understanding behaviour change processes, namely the stage model of self-regulated behaviour change (SSBC). Stage models emphasise the deliberate aspects of behaviour change, making them suitable for the study of self-chosen behaviour changes via boosting (Bamberg, 2013; Keller et al., 2020). The SSBC conceptualises environmental behaviour change as a transition through four stages: (1) predecisional, (2) preactional, (3) actional, and (4) postactional. As the SSBC highlights that behaviour change requires a transition to qualitatively different stages, an intervention needs to ensure that it targets all relevant stage transitions (Bamberg, 2013).

Phase 3: Intervention selection. Building on the behavioural analysis and the SSBC stages, we aimed to identify a boosting intervention that addresses policymakers' key behavioural determinants (Phase 1) and the stage transitions conceptualised in the SSBC (Phase 2). A specific behaviour change technique that adopts a boosting approach is the induction of metacognition. This technique is suitable for this study as it focuses on capability beliefs, beliefs about consequences, and knowledge (Becker et al., 2023; Prakash et al., 2019), which are the main determinants of policymakers' key behaviours in adaptation (Chapter 2; Bellmann et al., 2025b).

We here build on a functionality-focused definition of metacognition and approach it as ‘the class of mechanisms that allow us to form beliefs about other mental operations’ (S. M. Fleming, 2024, p. 243). Metacognitive abilities are crucial for decision-makers, as they allow the recognition of flaws in one’s decision processes (Batha & Carroll, 2007). Metacognition-inducing interventions, which are frequently used in developmental and health psychology, foster reflections about the decision process leading to the respective behaviour, different behavioural options, and consequences of actions (Batha & Carroll, 2007; Chew et al., 2016; Prakash et al., 2019). Therefore, it is a suitable approach to policymakers’ decision-making, eliciting reflections on whether and how the key behaviours will be carried out in the formulation of adaptation plans.

Phase 4: Intervention design: To understand how metacognition can be applied to improve adaptation decision-making, we conducted a systematic review of metacognition-based interventions that target decision-making (Chapter 3; Bellmann, de Vries, et al., n.d.-b). Based on the findings of this systematic review and the development steps above, we developed an intervention consisting of two key elements: a mental contrasting exercise and a metacognitive checklist. Their combination addresses all stage transitions in the SBCC by eliciting a goal intention through mental contrasting (goal intention formation), highlighting the advantages of adaptation behaviour (behavioural intention formation), and strengthening self-efficacy (implementation intention) (Bamberg, 2013; Batha & Carroll, 2007; H. Fischer & Fleming, 2024; A. Kappes & Oettingen, 2014). This potentially makes CARN a comprehensive approach to stimulate the progression throughout all behaviour change stages (see Section 2.2).

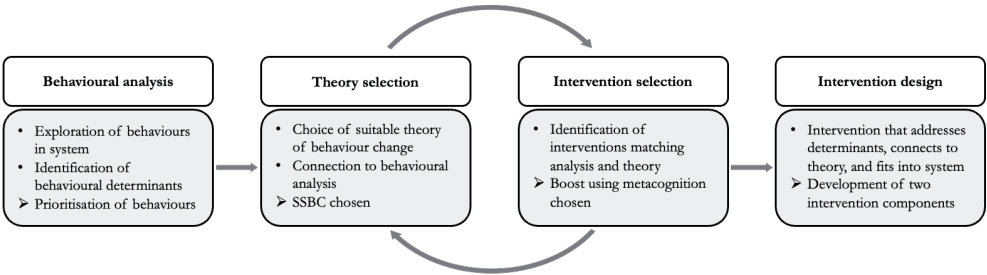


Figure 13: CARN prototype development process. Arrows illustrate workflows. Bulleted arrows in text boxes are outcomes.

4.2.2 CARN and how to use it

Based on the outcome of the behavioural analysis and intervention design process, we designed CARN with two metacognition components (see Phases 3&4), based on the SSBC (Phase 2), with the objective to address seven key behaviours in climate adaptation policymaking (Phase 1). The two metacognition components are the following:

Mental contrasting. CARN commences with a mental contrasting component. Mental contrasting is a specific metacognition-connected intervention technique that focuses on beliefs about consequences and goal pursuit (Badaan et al., 2022; Daysh et al., 2024; Oettingen, 2012; Troy et al., 2024). Mental contrasting induces reflections, leading people to imagine a desired future and then contrast it with present challenges (Oettingen, 2012; Oettingen et al., 2010). Research has proven that mental contrasting can lead to increased goal commitments, goal attainment, and striving for change (Fernando et al., 2018; H. B. Kappes & Oettingen, 2011;

Oettingen et al., 2001; G. Wang et al., 2021). Like earlier research, participants were first asked to write about their vision and then contrast it with the current situation (Fernando et al., 2018). In particular, they were asked to outline their vision of an ideally climate-adapted society and then contrast it with the current state of adaptation that they perceive. Regarding the SSBC, mental contrasting is primarily connected to the formation of the implementation and goal intentions (Bamberg, 2013). It fosters cognitive planning and goal commitment, making it a suitable intervention to support the transition from action to postaction as well as predecision to preaction.

Metacognitive checklist. The second component of CARN is a metacognitive checklist, consisting of seven behaviours and 28 reflection questions connected to these seven behaviours. A systematic review showed that metacognitive checklists and reflective questions can be utilised to improve decision-making (Bellmann, de Vries, et al., n.d.-a). For example, checklists, such as TWED (Threat, What else, Evidence, Dispositional factors), are frequently used for medical decision-making (Chew et al., 2016, 2019; Fager et al., 2025). Research shows that checklists and reflection questions can improve decision-making in clinical cases (Chew et al., 2016), job performances (Fager et al., 2025), and diagnostic reasoning (Garbayo et al., 2023). Simultaneously, they present a practical tool that can be conveyed with comparatively low implementation and supervision efforts (Chew et al., 2019). Our checklist consists of seven key behaviours (see Table 8) and respective reflection questions that were identified in earlier research on policymakers' adaptation decision-making (Chapters 2&3; Bellmann, de Vries, et al., n.d.-b; Bellmann et al., 2025b). Each of the behaviours is linked to reflection questions that need to be checked by the user of the intervention. Table 7 lists the key behaviours that CARN captures.

Table 8: Key behaviours captured by CARN's checklist.

Prioritised behaviours
1. Connect to other internal departments
2. Broaden adaptation focus beyond water issues
3. Engage in regional cooperation
4. Set-up pilot projects on adaptation
5. Communicate climate adaptation ideas to leadership
6. Emphasise political benefits of climate adaptation
7. Involve departments in strategy development

Note. Behaviours were chosen based on prior data on climate adaptation efforts in the Netherlands (Bellmann, de Vries, et al., n.d.-b).

Appendix 1 (Supplementary Material 1) in Bellmann, Scholten, et al. (2026) provides the complete intervention, including the reflection questions and the mental contrasting component. With regard to the SSBC, metacognitive interventions such as reflection checklists in general are connected to the preaction phase, in which behavioural intentions are formed, and the action phase, in which implementation intentions are formed, as they address consequence beliefs and self-efficacy (Bamberg, 2013).

4.2.3 Pilot testing and refinement of CARN

We adopted a mixed-methods research design for our prototype testing and validation process, consisting of a pilot test of the online experiment and two review workshops with policymakers. The participant recruitment, informed consent, data collection, and processing procedures were reviewed and approved by TU Delft's Human Research and Ethics Committee (No 5957).

Pilot test. CARN and the experimental protocol were pilot tested by 39 international master's students in September 2025, recruited at an introduction event for an MSc programme offered by our university. The students participated voluntarily without any reward. After testing the experiment, students were debriefed on the purpose and background of the study and requested to provide feedback. The pilot testing confirmed the functionality of the intervention and experimental design. It also provided exploratory results on effectiveness measures. As the pilot test responses only included limited insights into participants' reasoning, we included an additional prompt asking participants to explain their choices in the experiment (see Appendix 2 (Supplementary Material 1) in Bellmann, Scholten, et al. (2026) for the adjustment).

Review workshop. To evaluate and adjust CARN to practical usability considerations in the field, we held two online review workshops in September and October 2025 with 14 Dutch climate adaptation policymakers. The participants were recruited via personal email invitations. In total, we invited 114 individuals based on a list of individuals involved in climate adaptation policymaking in the Netherlands. During the 2-hour workshops, participants reviewed the usability of CARN in a group discussion facilitated by the authors and guided by the APEASE (acceptability, practicability, effectiveness, affordability, side-effects, equity) criteria of Michie and West (2014) to assess behavioural interventions. More details on the pilot testing and validation procedures are provided in Appendix 3 (Supplementary Material 1) in Bellmann, Scholten, et al. (2026). Based on the review workshops, we added six reflection questions to the checklist and adjusted two existing questions (see Appendix 1 in Bellmann, Scholten, et al. (2026)).

The review workshops were not only used for the development of the final version of CARN but also to review its usability. To do this, we conducted a thematic analysis of the notes from both reflection workshops. This analysis surfaced four themes spanning the insights on participants' evaluation of CARN. We here concentrate on the essence of this thematic analysis with regard to CARN's usability and provide the full thematic analysis in Appendix 3 (Supplementary Material 1) in Bellmann, Scholten, et al. (2026). The participants generally viewed CARN as an effective and usable tool. However, they suggested some adjustments that could increase its practicability for policymakers. These included connecting it to existing policy guidelines, allowing users to pick relevant reflection modules, and highlighting the benefits of adopting the respective key behaviour.

4.3 Experimental evaluation

We used an online experiment to examine whether CARN can improve decision-making performance in climate adaptation. The recruitment and experimental procedures were approved by TU Delft's Human Research and Ethics Committee (No 5957). Experimental evaluations are suitable to test a behavioural intervention's effectiveness, allowing the analysis of causal effects of an independent variable, such as CARN, on dependent variables of interest (Kirk, 2013). We adopted a between-subject design with two groups, with the treatment group receiving CARN and the other group an active control condition. We preregistered our experimental evaluation prior to the data collection, including the aspired sample size, hypotheses, and statistical

tests (Bellmann et al., 2025a). Our primary hypothesis was that *individuals using CARN will exhibit higher adaptation decision performance than those in the control group (H1)*. Our secondary hypotheses postulated that CARN simultaneously increases *decision-making quality in developing an adaptation plan (H2)*, *decision-making quality (H3)*, and *self-efficacy beliefs (H4)*.

4.3.1 Sample

We used G*Power to compute our required sample size (Faul et al., 2009). Our goal was to obtain .8 power to detect a medium effect size of .3 at the standard .05 alpha error probability, resulting in a required sample of at least 352 individuals. We assumed an allocation ratio $N2/N1$ of 1 (see Bellmann et al. (2025a)). We recruited 440 participants via Prolific Academic, an international platform for recruiting research participants (Prolific, n.d.).

Our inclusion criteria were that participants had to reside in an English-speaking country, be fluent in English, and have at least completed an undergraduate degree. We required participants to be fluent in English, so that they could understand all study materials (e.g., CARN, manipulation check), which were exclusively developed in English. The degree requirement was added to reflect the education level of the intervention's target group (i.e., adaptation policymakers). We implemented a number insertion task as an attention check and a manipulation check for the treatment group, asking participants to correctly select what information CARN includes. We excluded 34 participants, as 24 failed the manipulation check, two Prolific IDs mismatched our dataset so the submissions could not be verified, and eight participants did not comply with our degree requirements. None of the participants failed the attention check. This resulted in a total sample of 406 ($N=406$) for the statistical analysis, with 193 participants in the treatment group and 213 in the control group.

In this sample, participants' age ranged from 21 to 83 years ($M=41.66$). More than half of the participants were male ($n=215$, i.e., 52.96%), while 46.55% were female ($n=189$) and 0.49% were non-binary or preferred not to say ($n=2$). Participants were residents of the United Kingdom ($n=199$), the United States ($n=159$), Canada ($n=42$), Australia ($n=4$), and New Zealand ($n=2$).

4.3.2 Design of experiment and data collection

The experiment was conducted online using the survey software Qualtrics. Participants were randomly allocated to the control or treatment groups using Qualtrics' randomisation algorithm. The treatment group received the CARN intervention, which consists of the mental contrasting activity, followed by the metacognitive checklist (see Section 2.2). The control group completed a comparable but unsupported activity, wherein participants first had to describe in writing what climate adaptation entails for them (as a mental contrasting equivalent) and received a climate change fact list (checklist equivalent). The experimental dataset is provided in Supplementary Material 2 in Bellmann, Scholten, et al. (2026).

Then, participants had to complete the development of a climate adaptation plan for a fictional municipality. Participants were asked to explain how they are approaching the development of the adaptation strategy and what key considerations they would include. In the survey environment, we prevented participants from pasting text in the response field to ensure that their texts were self-written.

4.3.3 Effectiveness measures

In this study, we combine four outcome measures to evaluate CARN's effectiveness in improving decision-making: decision-making performance, decision-making quality, self-assessed decision quality, and self-efficacy beliefs. Each outcome measure captures a dimension relevant to assessing whether decision-making has improved, accommodating distinct operationalisations of decision-making effectiveness and the assessment of metacognitive interventions in applied psychology research (Fischhoff & Broomell, 2020; Greengrass et al., 2024; Oettingen et al., 2010; Redmond & Deveau, 2021; Spiliotopoulos et al., 2020; Yun & Kang, 2024). The full questionnaire, including all items, is provided in Appendix 2 (Supplementary Material 1) in Bellmann, Scholten, et al. (2026).

Our primary dependent variable was participants' *decision-making performance*. We qualitatively analysed participants' responses to a decision-making case that required them to develop an adaptation strategy for a fictional municipality. This performance measurement rests on the assumption that effective decision-making can be operationalised as the presence of empirically grounded key behaviours. These behaviours reflect impactful and changeable behaviours that, if adopted, can significantly improve adaptation policymaking. We coded the responses using a codebook (see Appendix 4 (Supplementary Material 1) in Bellmann, Scholten, et al. (2026)) that is based on the key behaviours in adaptation policymaking identified using an expert panel of policymakers and behavioural scientists in earlier research (Chapter 3; Bellmann, de Vries, et al., n.d.-b). The coder was blinded to the group of the participants. Based on the coding, we created a frequency score reflecting the extent to which participants included the seven key adaptation behaviours in their plan (8-point scale).

Our secondary (exploratory) dependent variables were participants' decision quality in the strategy task response, overall decision quality, and self-efficacy. We qualitatively analysed participants' responses using the decision quality requirements by Spetzler et al. (2016) to examine their *decision quality in the case response*. These criteria allow an assessment of whether the adaptation plan decision process includes (1) an appropriate frame, (2) reliable data sources, (3) the creation of alternatives, (4) clear values and trade-offs, (5) sound reasoning, and (6) a commitment to action. The decision quality measure is based on the notion that effective decisions arise as a result of a decision-making process that adheres to this set of criteria. Based on the qualitative codes, we created a frequency score of how many of the six criteria were reflected in the responses (7-point scale).

Additionally, we measured participants' *decision-making quality* using the Decision Making Quality Scale (DMQS) developed by Hollen (1994). The DMQS reflects that decision effectiveness can also be evaluated based on a subjective evaluation of the decision-maker. It uses seven items with a four-point scale ranging from 0 (not at all true) to 3 (very true) (Hollen, 1994; Rhee et al., 2007). We adjusted the introductory question ("Thinking about the development of the climate adaptation plan, how true are these statements about your decision-making?") and the items to tailor it to our climate adaptation case, for example, in the item 'I have confidence in my ability to develop climate adaptation plans'.

Finally, we measured participants' *self-efficacy beliefs* using the Personal Efficacy Beliefs Scale (Riggs et al., 1994). Similar to the self-assessed decision quality, self-efficacy measures are frequently used to assess the effectiveness of metacognitive interventions, concentrating on a subjective capacity evaluation following a decision (Cheang, 2009; Yun & Kang, 2024). The Personal Efficacy Beliefs Scale includes ten items measuring individual self-efficacy regarding their jobs on a seven-point Likert scale.

4.3.4 Data analysis

We analysed the data obtained from the experiment with Python (van Rossum & Drake, 2009) and Atlas.ti (ATLAS.ti Scientific Software Development GmbH, 2024). In Python, we used Pandas (McKinney, 2010), Pingouin (Vallat, 2018), Numpy (Harris et al., 2020), and Scipy (Virtanen et al., 2020). Figures were generated using Seaborn (Waskom, 2021) and Matplotlib (Hunter, 2007). To develop the score for participants' decision-making performance and decision quality in the case response, we coded the climate adaptation strategies they developed using pre-defined codebooks (see Appendix 4 (Supplementary Material 1) in Bellmann, Scholten, et al. (2026)). For the Personal Efficacy Beliefs Scale, we reversed the negatively worded items' scoring before the analysis.

We employed t-tests to assess statistical differences between the group's scores. In situations in which a Levene test indicated heterogeneity of variances and/or a Shapiro-Wilk test suggested normality violations, we used Welch's t-tests to correct for unequal variances and non-parametric Mann-Whitney U tests to account for normality deviations. In addition, we computed Hedge's g and, if Mann-Whitney U tests were used, the rank-biserial r to assess the effect sizes (Howitt & Cramer, 2024).

4.4 Effectiveness of CARN

In this section, we present the results from our statistical analysis of the experimental data. Table 9 summarises the results of the statistical analyses for all four measures.

The results confirm our first hypothesis, which postulated that the treatment group using CARN will exhibit higher adaptation *decision-making performance* than the control group. The Welch's t-test ($t(233.6)=-18.03, p<.001$) showed that scores of the treatment group ($M=3.10, SD=1.96$) were significantly higher than the scores of the control group ($M=0.41, SD=0.68$), with a large effect size (Hedges' $g=-1.86$). Figure 14 shows the data distributions for both groups.

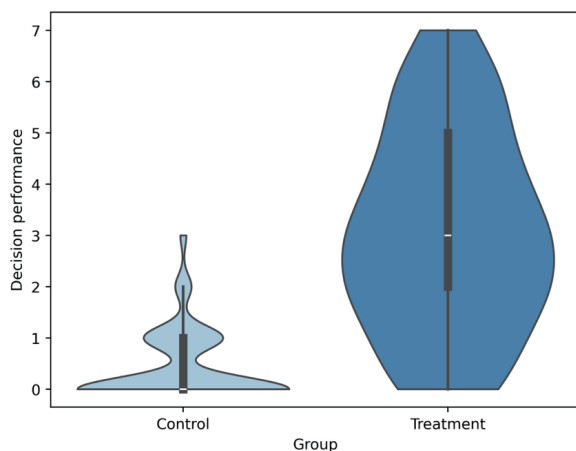


Figure 14: Decision performance per group. Violin plot shows the kernel density estimate of the data's distribution per group.

This result was confirmed by a Mann-Whitney U test ($U=4185, p<.001$), also showing a large effect size (*rank-biserial* $r = -.80$). Figure 15 presents the proportion with which each of the key adaptation behaviours was included by the groups. It shows that the proportion of inclusion for all key behaviours was higher in the treatment group. The most frequently included behaviours in the treatment group were ‘engage in regional cooperation’ (.58) and ‘connect to other internal departments’ (.55). Participants in the control group most frequently mentioned ‘broaden adaptation focus beyond water’ (.26) and ‘engage in regional cooperation’ (.11).

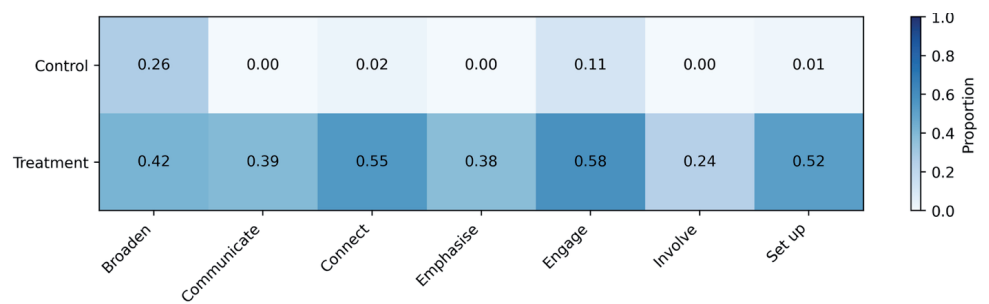


Figure 15: Key behaviour proportion per group. From left to right, the behaviours are: 1. Broaden adaptation focus beyond water issues; 2. Communicate climate adaptation ideas to leadership; 3. Connect to other internal departments; 4. Emphasise political benefits of climate adaptation; 5. Engage in regional cooperation; 6. Involve departments in strategy development; 7. Set-up pilot projects on adaptation.

The data also support our second hypothesis, which postulated that the treatment group would exhibit higher *decision quality in the case responses*. A Welch’s t-test ($t(367.80)=-15.15, p<.001$) highlighted that the treatment group’s scores ($M=3.34, SD=1.47$) were significantly higher than the ones of the control group ($M=1.32, SD=1.18$), which was confirmed by a Whitney U test ($U=6413, p<.001$). The computation of Hedges’ g ($Hedges’ g=-1.52$) and *rank-biserial* r (*rank-biserial* $r = -.69$) shows a large effect size. Figure 16 presents the value distributions for the control and treatment groups.

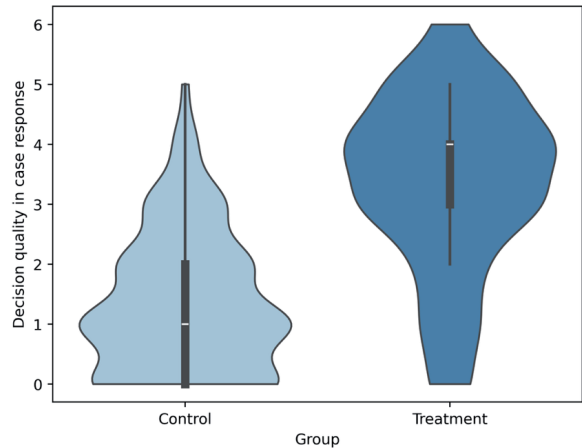


Figure 16: Decision quality in case response per group. Violin plot shows the kernel density estimate of the data's distribution per group.

We did not find a statistically significant effect that supports our third hypothesis, which assumed that CARN recipients would exhibit higher self-assessed decision quality than the control group. A Welch's t-test ($t(402.38)=-1.19$, $p=.20$) showed that the control group's decision-making quality scores ($M=3.35$, $SD=0.53$) were not significantly different from the scores of the treatment group ($M=3.41$, $SD=0.45$) with a very small effect size ($Hedges' g=-0.12$). This result was confirmed by a Mann-Whitney U test ($U=19646$, $p=.43$), also showing a very small effect size ($rank\text{-}biserial r=-.04$).

Similar to the third hypothesis, we did not find a significant effect of CARN on the self-efficacy beliefs of the treatment group. We examined the group differences in *self-efficacy beliefs* using a t-test. The t-test ($t(404)=-0.52$, $p=.61$) showed that the control group's self-efficacy scores ($M=3.77$, $SD=1.12$) were not significantly different from the scores of the treatment group ($M=3.83$, $SD=1.22$) with a very small effect size ($Hedges' g=-0.05$). We also conducted our statistical tests without excluding any participants from our dataset. These tests confirmed the robustness of our results, leaving them substantially unchanged.

Table 9: Group difference tests

	Treatment group	Control group	<i>df</i>	<i>t</i>	<i>p</i>	<i>Hedges' g</i>
	<i>M (SD)</i>	<i>M (SD)</i>				
Decision-making performance ^a	3.10 (1.96)	0.41 (0.68)	233.6	-18.03	>.001	-1.86
Decision-making quality in case ^a	3.34 (1.47)	1.32 (1.18)	367.8	-15.15	>.001	-1.52
Decision-making quality ^a	3.41 (0.45)	3.35 (0.53)	402.38	-1.19	.20	-0.12
Self-efficacy beliefs ^b	3.83 (1.22)	3.77 (1.22)	404	-0.52	.61	-0.05

^aWelch's t-test ^bt-test

4.5 Discussion

4.5.1 Effects of CARN on decision performance and process

Our results show that the metacognitive behavioural intervention we developed, called Climate Adaptation Reflection Navigator (CARN), can improve decision-making performance in climate adaptation. Experiment participants using CARN covered significantly more key adaptation behaviours in the developed adaptation plan, compared to a control group. This finding suggests that CARN can lead individuals to direct attention to key decision-making behaviours, thereby supporting reflective decision processes. Combining mental contrasting and reflective questions counteracts the tendency to omit these behaviours and increases their

cognitive availability, while simultaneously heightening goal pursuit (Batha & Carroll, 2007; H. Fischer & Fleming, 2024; A. Kappes & Oettingen, 2014; Oettingen, 2012; Rivas et al., 2022).

While the effect size we found for decision-making performance is substantive, especially when compared to those typical for behavioural interventions (Hofmann et al., 2025; Mertens et al., 2022; Nisa et al., 2019), it must be kept in mind that CARN captures the behaviours that were used to evaluate the decision-making performance. This likely affected the magnitude of the observed effects, although it is inconsequential for its practical use in policymaking, where purely the inclusion of the key behaviours matters. However, instead of presenting a methodological artefact, this reflects the applied focus of this study to increase the uptake of key behaviours in climate adaptation strategy-making (Nielsen, Cologna, et al., 2021). It still warrants further tests of CARN's effect, especially of real-world decision-making in field studies. Instead of existing research on climate-related interventions, which primarily concentrate on household decision-making and behavioural intentions (Howe et al., 2018; Kievik & Gutteling, 2011; Nisa et al., 2019; Sinclair et al., 2025), CARN targets policy planning decisions, attenuating the comparability.

Despite the significant overall decision-making performance improvement among CARN users, the inclusion rate of some key behaviours remained comparatively low (e.g., involving departments in strategy development). Accordingly, more research is needed to discern why CARN users include some key behaviours more than others. Several explanations for the different effectiveness of the reflection checklist are plausible. Some behaviours' contributions to improving an adaptation plan may be less palpable, leading participants to disregard them altogether. Alternatively, participants might believe that some behaviours are redundant, such as connecting to departments and involving departments in the strategy development. Finally, some reflection questions might be less equipped to elicit the reflections required to adopt the key behaviours in the adaptation plan.

In the experimental evaluation, the participants using CARN showed higher levels of inclusion in the plan for all of the key behaviours, with the highest proportion for 'engaging in regional cooperation' and 'connecting to other internal departments'. In contrast, the control group participants' highest inclusion proportions were observed for the behaviours 'broadening adaptation beyond water issues' and 'engaging in regional cooperation'. Notably, participants in the control group did (almost) not at all capture internal procedural considerations in their adaptation planning (e.g., emphasising political benefits of adaptation). This provides evidence that CARN can foster the consideration of a set of behavioural options in adaptation planning that is otherwise omitted.

Our findings also show that CARN users, as hypothesised, exhibited higher decision quality in the case response than the control group. This highlights that CARN not only shaped the behaviours included in the strategy-making, but also the procedural decision-making consideration underlying it. While high decision quality does not guarantee a favourable decision outcome, CARN may present a tool that is able to facilitate better decisions in uncertain situations by improving those procedural aspects that a decision-maker can control (Spetzler et al., 2016). This finding is particularly relevant amidst the uncertainties and conflicting priorities that characterise adaptation policymaking (Orlove et al., 2020).

Our findings also suggest that CARN can improve these procedural aspects in the development of a climate adaptation plan. As with decision performance, the effect size for decision quality should be interpreted in light of its conceptual closeness to the measures. The decision quality codes (e.g., appropriate frame) were only

assigned to response parts which focused on climate change adaptation. Second, some of the key behaviours in CARN (e.g., the creation of pilot projects) are directly connected to decision quality criteria (e.g., commitment to action).

Contrary to our hypotheses, we did not find a statistically significant effect of CARN on self-efficacy beliefs and self-assessed decision-making quality. This somewhat contradicts earlier work on metacognitive interventions (Açıl & Keçeci, 2024; Church et al., 2021; Pedram et al., 2024; Spiliotopoulos et al., 2020), although the trend in the data suggests that a larger sample might detect statistically significant effects. A potential explanation for the null effect of CARN on self-efficacy beliefs and self-assessed decision-making quality could be that they would only change in the long-term after the positive effects of CARN on decision-making performance are experienced (Gueroni et al., 2024). Alternatively, the characteristics of the measures used to assess both variables could underpin the results. As they both rely on self-evaluations of one's decision-making, they require participants to detect quality differences in their decision-making. However, as participants were no experts in climate adaptation, they may be unable to judge their decisions due to the absence of (cognitively) available evaluation criteria. In contrast, the analysis of their decision performance and quality in the case response was based on expert insights that provide clear criteria for the evaluation of decision-making processes. This difference in the nature of the measures might underlie the observed difference in the effect sizes.

4.5.2 Scientific and societal implications

Our findings contribute to scholarly work and policy practice by (1) introducing a metacognitive intervention tailored for climate adaptation policymakers, (2) demonstrating its ability to improve decision performance and quality, (3) providing a practical decision support tool for adaptation policymaking.

The findings on CARN's effectiveness and usability test contribute to the growing field of psychological research on climate adaptation (Bechtoldt et al., 2021; van Valkengoed & Steg, 2019a). To the best of our knowledge, CARN is the first behavioural intervention that targets policymakers' adaptation decisions. Thereby, this study expands earlier work on interventions that aim to shape household adaptation behaviours (Bruine de Bruin et al., 2016; Nguyen et al., 2024) and calls for widening the range of behaviours researched in environmental psychology (Nielsen et al., 2024).

Our results provide evidence for the ability of boosting to improve decision-making, strengthening evidence that it presents a viable alternative to nudging, which has dominated much of contemporary behaviour change research (Hertwig et al., 2025; Herzog & Hertwig, 2025; Hofmann et al., 2025). Specifically, CARN addresses recent critiques of nudging's paternalistic nature, neglect of contextual influences, and focus on short-term behaviour change by focusing on capability building and reflection (Ewert, 2020; A. T. Schmidt & Engelen, 2020; R. Schmidt & Stenger, 2024; Tummers, 2023). It expands existing research in the boosting programme by providing insights into how metacognition could be present a novel approach to boost policymaking (Hertwig et al., 2025). Therefore, we also supplement studies that have proven the ability of metacognitive interventions and future thinking to influence behaviour and intentions (Chew et al., 2019; Fernando et al., 2018; Heidbrink & Weinrich, 2021; Sinclair et al., 2025).

While CARN is focused on climate adaptation, our results indicate that metacognitive interventions could also improve decision-making in other areas by enhancing the target audience's decision-making. To date, most

decision support approaches for (environmental) policymaking concentrate on modelling, criteria-based evaluations, simulations, or predictions of decision outcomes (Cristal et al., 2019; Kwakkel et al., 2015; Orlove et al., 2020; Scholten et al., 2017). Although these techniques provide valuable information for decision-makers, comparatively little attention has been dedicated to how this information is used in the decision processes. By addressing this research gap, psychological research could further contribute to solving the challenges posed by climate change (Nielsen, Cologna, et al., 2021; Whitmarsh et al., 2021).

A substantial body of research in psychology and decision science shows that uncertainty perception increases maladaptive cognitive strategies such as avoidance and denial, as well as beliefs in pseudoscience and anti-establishment sentiments (Anderson, 2003; Krekó, 2023; Swim et al., 2009; van Prooijen, 2023). In parallel, habits, low capability beliefs, or a preference for the status quo might lead to policy inertia (Chapter 2; Bellmann et al., 2025b; Samuelson & Zeckhauser, 1988; Steg, 2023). Although we did not directly test it in this study, metacognitive interventions such as CARN may reduce inaction and other maladaptive psychological responses by counteracting habitual patterns, promoting reflective processing, encouraging belief updating, and increasing the availability of behavioural options. Recently, scholars argued that these properties of metacognition might make it a pathway to evidence-based belief updating in politically contested domains (H. Fischer & Fleming, 2024).

As these key adaptation behaviours present impactful levers for accelerating societal climate adaptation and the targeted policymakers are high-power actors (Bellmann et al., 2025b; Petzold et al., 2023), our findings suggest the potential of CARN to improve adaptation policymaking. To reiterate, we argue that targeting high-power actors within a system presents another pathway through which behavioural research may contribute to systems change, especially when behavioural dynamics and ripple effects in the system are considered. Therefore, this study also contributes to the growing research on behavioural interventions that target system change (de Ridder & Thomaes, 2025; Dupoux et al., 2025; Kaufman et al., 2024). At the same time, our evaluation concentrated on immediate decision-making outcomes without testing whether these effects translate into the aspired societal-level change. Research on complex systems emphasises their non-linear dynamics, which makes it inherently difficult to predict the effect of an intervention in a deterministic way (Grinstein et al., 2025; Heino et al., 2021; Jensen, 2022). Accordingly, it is within the realm of possibility that improving policymakers' decision-making results in both intended and unintended downstream effects on system outcomes.

Methodologically, combining insights from workshops and an experiment allowed an in-depth assessment of the developed intervention. The workshops also enabled the inclusion of the target group in the design of interventions, which prior research has highlighted as an imperative step to ensure an intervention's usability (Abraham & Denford, 2020; Jungbluth et al., 2024). Similarly, research has shown that the impact of interventions is often negatively affected by the insufficient attention paid to their implementation process. This means that factors (i.e., the context) affecting the implementation success as well as the process itself must be considered in the research design (M. S. Bauer et al., 2015; Luszczynska et al., 2020). By including policymakers in the design process, the present study tailored CARN to their decision-making, advancing psychological research on context-aware interventions (R. Schmidt & Stenger, 2024).

For climate adaptation policymakers, CARN illustrates how psychologically-grounded decision support could strengthen climate adaptation decision processes. Especially the limited inclusion of the particularly impactful internal procedural considerations by the control group suggests that an intervention, such as CARN, is needed to advance adaptation (Braunschweiger & Pütz, 2021). Beyond the experimental evaluation, the workshop

findings suggest that CARN presents a more flexible and scalable approach than other interventions that have been developed to improve climate adaptation policymaking, such as trainings, workshops, or role play simulations (Löschner et al., 2016; Luís et al., 2018; Rumore et al., 2016). CARN does not compel the intervention designers to be present during its delivery, it can be used without instructions, and it can be employed during the actual decision-making process. This makes CARN an intervention that is readily scalable, which strengthens its ability to unfold practical impacts (Hsieh et al., 2024; Koorts et al., 2025). While directly comparable studies are not available, findings on training interventions, which might be an alternative to CARN, indicate that CARN may be more effective in affecting decisions (Hatfield et al., 2020).

4.5.3 Emerging future directions

Several questions and future directions for scholarly work in applied psychology emerge from our findings.

First, while the experimental evaluation and the workshops have shown that CARN can be a pathway to improving societal adaptation efforts, we have not yet assessed its long-term effects in the field. Especially as the Prolific sample did not consist of Dutch adaptation policymakers, it could be tested to what extent the obtained results are transferable to the real-world decision-making of policymakers. Accordingly, future research could gather longitudinal field data to examine whether a metacognition-inducing intervention, such as CARN, can improve adaptation policymaking. Suitable data points could, for example, be whether the key behaviours are included in adaptation strategies, the adoption rate of CARN, self-assessments of the decision performance, and observational data on whether the behaviours are performed in practice. This could also enable the analysis of whether the effect of the boost persists, a key question for the comparison of boosts and nudges. As large samples of policymakers are relatively difficult to obtain, such a longitudinal investigation could also use workshops, N-of-1 studies with a single participant, field experiments, or pre-post designs (List, 2007; Matthews & Simpson, 2020).

Second, evaluating different modes of delivery for CARN and its transferability to other domains would strengthen the basis for developing metacognitive interventions. In this study, our scope was limited to an online version of CARN that targets an individual decision-making scenario. Future research could further analyse its functionality if delivered offline or in a group setting. For example, field experiments could be employed to compare a paper-pencil version of CARN with an online version or a chatbot trained to facilitate the reflection on key behaviours in adaptation. We also recommend future research to investigate whether a metacognitive boost like CARN can improve decisions in other policy domains, especially those characterised by a high degree of uncertainty. The workshop participants outlined that they would like to use reflection tools like CARN across domains, as it prevents policymakers from overlooking relevant considerations in the development of a policy. As of today, scholarly work on metacognitive interventions has not yet explored their potential for policymaking. Especially amidst the uncertainty and complexity involved in many of today's most pressing challenges, we believe that they present a promising approach to enhancing policymakers' decision-making.

Third, as the participants in both experiment and workshops were residents of a Western, educated, industrialised, rich, democratic (WEIRD) country, we recommend that future research also examines whether the findings can be generalised to non-WEIRD populations (Henrich et al., 2010). Moreover, the presented version of CARN has been primarily developed based on data obtained in the Netherlands, and the usability test has been exclusively conducted with Dutch policymakers. This is, for instance, reflected in its emphasis on

moving beyond water issues, which have historically been at the centre of Dutch flood prevention and climate adaptation efforts. Accordingly, future research could further test whether CARN's content (i.e., the checklist behaviours) is also applicable in other geographical contexts. While we believe CARN's format would function similarly, a different surrounding adaptation system (i.e., contextual influences on decisions) would warrant an assessment of whether the key behaviours are equally relevant. One suitable pathway for achieving that, as suggested by the workshop participants, is the development of a modular version of CARN in which users can choose reflection topics relevant to their task or context.

Finally, we recommend future research to focus on discerning the effects of the mental contrasting element and the metacognitive checklist in CARN, which were not examined in the present study. To do this, future research could adopt a factorial design and evaluate each element separately. This would enable an understanding of whether the effects on decision-making can be observed only when both elements are delivered jointly or whether using either alone would evoke the same changes. However, as we drew on the SSBC in this study, we would expect that only the combination of both elements elicits the recorded effect sizes. Simultaneously, it could be further investigated to what extent the improved decision performance can be attributed to heightened metacognition. To do this, researchers could test alternative explanations, such as increased availability or reduced cognitive load, and pair those with an analysis of CARN's effect on metacognition, which was out of scope for the present study.

Overall, this study has shown that CARN can significantly improve decision performance in climate adaptation. Thereby, it provides the basis for further validation of the effects, testing in distinct contexts, comparisons with alternative decision support tools, and modification for other policy domains.

4.6 Conclusion

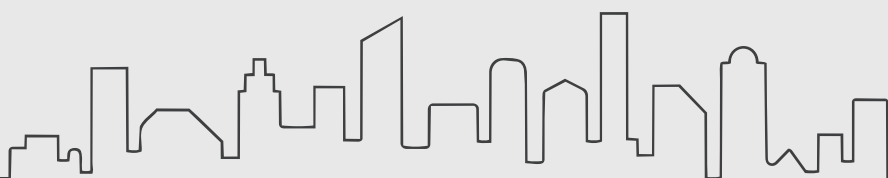
Existing behaviour change research rarely focuses on policymakers. In this study, we have developed and evaluated a behavioural intervention, called CARN, that targets policymakers' climate adaptation decision-making. Our findings of an online experiment with an adult sample show that CARN can improve decision-making performance and quality in the development of adaptation strategies. In addition, two reflection workshops with climate adaptation policy professionals affirmed the usability of CARN.

Its adoption could be a pathway to achieving system change via individual-level behaviour change, as it targets policymakers, whose decisions shape societal adaptation efforts. Our findings further highlight that metacognitive boosting, such as combining a reflection checklist and mental contrasting, bears potential for developing effective, scalable behaviour change strategies that go beyond nudging. We also demonstrate how a context-tailored intervention for policymaking can be developed in four stages, namely behavioural analysis, theory selection, intervention selection, and intervention design.

For policymakers, CARN can serve as a decision support tool that enables reflection in climate adaptation decision-making. Future research could conduct field validations of CARN, as well as optimise its scalability and dissemination for the adoption in adaptation policymaking.

5

A GUIDE ON DEVELOPING BEHAVIOURAL SYSTEM MAPS FOR BEHAVIOURAL PUBLIC POLICY RESEARCH



While the early 21st century saw the emergence of nudging as an approach to influence individual behaviour, complex environmental, technological, and social challenges require the development of a systems perspective in behavioural science. One methodological approach to achieving this is the creation of behavioural system maps, which bridge behavioural science and systems analysis. These maps allow the analysis of cause-effect relations between the behaviours of multiple actors.

Drawing on behavioural research and scholarly work on system mapping, this guide on the development of behavioural system maps includes five key steps: (1) System exploration and boundary setting, (2) Data collection and behavioural analysis, (3) Construction of the map, (4) Validation and refinement of the map, (5) Analysis and interpretation of the map. The article highlights how existing research using behavioural system maps has approached these steps and connects them to other system mapping methods, such as causal loop diagrams. It also provides a case example, showing how behavioural system mapping has been utilised to understand climate adaptation efforts. The article concludes by discussing pathways for advancing the approach and its integration in behavioural research.

An adapted version of this chapter has been published as:

Bellmann, K. P. (2025). A Stepwise Guide to Behavioural System Mapping.
<https://dx.doi.org/10.2139/ssrn.5444814>.

5.1 Introduction

5.1.1 The need for a behavioural systems approach

While the last two decades saw the emergence and broad adoption of nudging to influence individual behaviour, complex environmental, technological, and social challenges require behavioural scientists to rethink their methodological approaches. Amidst the observation of behavioural interventions' limited societal impacts, scholars have repeatedly emphasised that an integration of systems thinking and behavioural science is required, as today's grand societal challenges require system change rather than solely focusing on individual-level behaviour change (de Ridder & Thomaes, 2025; G. de Vries et al., 2021; Hallsworth, 2023a; Varazzani & Hubble, 2025).

In addition to the limited societal impact, part of the rethinking of existing behavioural intervention approaches also stems from their small effect sizes and contextual brittleness (Hofmann et al., 2025; Mertens et al., 2022; R. Schmidt & Stenger, 2024). This has been attributed to the application of individual-level interventions without considering the context in which the target behaviour takes place (de Ridder & Thomaes, 2025; Hallsworth, 2023a; R. Schmidt, 2024). These shortcomings have led to calls for system-focused approaches in behavioural research that move beyond the individual level and take into account behavioural dynamics in a system when designing interventions (de Ridder & Thomaes, 2025; Hallsworth, 2023a; Kaufman et al., 2024; Lunetto et al., 2022).

Early applications of a behavioural systems approach have shown promising results in identifying social tipping points (Andreoni et al., 2021), understanding slow policy progress (Bellmann et al., 2025b), formulating system-focused behavioural interventions (Hale et al., 2022), and linking structural and individual-level interventions (Doolaard et al., 2025). These investigations show that adopting such a system perspective holds several advantages. It can increase the impact of interventions on systems by addressing leverage points and behavioural dynamics shaping the system. Moreover, it can also help identify entrenched behavioural patterns, spillover effects, and influential determinants of behaviour, facilitating a bottom-up understanding of a system (Bellmann et al., 2025b; Hallsworth, 2023b; Kaufman et al., 2024; Lunetto et al., 2022).

Recently, the first approaches to developing methodologies enabling this systems perspective led to the introduction of behavioural system maps (BSMs) (Hale et al., 2022; Lunetto et al., 2022). These maps explore cause-effect relationships between behaviours of multiple actors and underlying influences to explain complex behavioural dynamics in multi-actor systems (Bellmann et al., 2025b; Hale et al., 2022). In contrast to other existing mapping approaches, BSMs focus on human behaviour and are grounded in a behavioural analysis (Hale et al., 2022; Kaufman et al., 2024). They present a pathway to further advancing behavioural public policy beyond nudging by taking account of a diversity of actors, widening the scope of the problems of interest, and drawing on the broader field of social science research, as suggested by researchers (Dupoux et al., 2025; Ewert, 2020; Hallsworth, 2023a; Varazzani & Hubble, 2025).

While behavioural system mapping has seen its first applications (Allison et al., 2024; Hale et al., 2022), there is no comprehensive guideline that captures the diverse set of approaches to their development. This article reviews current behavioural system mapping approaches and develops a stepwise guide to their application.

5.1.2 Why behavioural system mapping?

The term system refers to a ‘set of elements or parts that is coherently organized and interconnected in a pattern or structure that produces a characteristic set of behaviors’ (Meadows, 2008, p. 188). The behaviour of a system is the result of the structure of the elements within it and their dynamic interactions. Accordingly, one needs to understand these elements and their interactions to understand current system behaviour as a whole (Meadows, 2008). However, existing methodological approaches in behavioural science are not equipped to capture the high interconnectivity between factors and non-linear interactions between them that characterise complex systems (Enserink et al., 2022; Heino et al., 2021; Parkinson et al., 2025).

One approach to understanding the elements within a system and their interactions is system mapping, in which they are visually linked in cause-effect maps (Barbrook-Johnson & Penn, 2022). Such a causal map depicts a ‘network of causal assertions (cause/link/effect) that can be expressed in a matrix or diagram form’ (Armstrong, 2005, p. 27). Causal system mapping has been widely practised in many scientific disciplines that study complex systems, with many researchers applying it to the study of complex societal challenges (Axelrod, 1976; Coletta et al., 2021; Groundstroem & Juhola, 2021; Repenning, 2003). Generally, a causal map can increase the understanding of the dynamics within a system by enabling ‘a qualitative form of “what if?” analysis’ and create a theory of a system’s inner workings (Enserink et al., 2022, p. 70).

The desire of behavioural researchers to analyse complex systems through a psychological lens has led to the development of BSMs (Hale et al., 2022; Heino et al., 2021; Kaufman et al., 2024; Parkinson et al., 2025). These maps are one methodological pathway with the potential to integrate systems thinking into behavioural research. Systems thinking is a multi-faceted concept that combines a holistic view of interconnected elements and attention to underlying dynamics shaping the elements’ interactions with practical instruments to investigate them (e.g., system mapping) (Gannon & Monat, 2015). Behavioural system mapping is a systems thinking method specifically tailored for the analysis of the behaviour of multiple actors and for the identification of pathways for behaviour change (Davan Wetton et al., 2025; Hale et al., 2022). This is also what differentiates it from other causal mapping approaches that do not focus (primarily) on behavioural dynamics (Barbrook-Johnson & Penn, 2022).

BSMs can add two main contributions to existing behavioural public policy research and practice. First, they improve the analysis of the decision context an individual navigates and, therefore, facilitate a more nuanced assessment of the factors that shape decisions (Bellmann et al., 2025b). By connecting psychological and contextual factors they address calls for the consideration of contextual influences in behavioural insights research (R. Schmidt, 2024; R. Schmidt & Stenger, 2024). Second, BSMs can increase the understanding of a system’s behaviour and enable the identification of change levers, strengthening behavioural research’s ability to contribute to solving complex societal challenges (Lunetto et al., 2022). The identification of levers can generate hypotheses for the study of behaviour change interventions, i.e., for exploring whether a specific lever can spark system change. Simultaneously, it can increase the knowledge on potential target behaviours for interventions related to a challenge of interest, which a focus on a pre-defined behavioural problem might not uncover (Kaufman et al., 2024; Lunetto et al., 2022).

Especially the practical application of behavioural science outside secluded lab environments is often marked by complexity, which is why practitioners need system-focused methodologies (Dupoux et al., 2025; Varazzani & Hubble, 2025). Challenges in policymaking include a range of actors, from civil society organisations to consultancies (de Bruijn & Heuvelhof, 2012; Enserink et al., 2022). To understand these complex policy

decisions, it is therefore imperative to understand the involved actors' influence and, if system change is aspired, also what shapes their decisions. As BSMs can support this analysis, they can be a particularly promising tool for policy professionals aiming to navigate today's environmental, technological, and social challenges.

5.2 A stepwise approach to developing behavioural system maps

There is a range of different mapping approaches, including causal loop diagramming, fuzzy cognitive mapping, system dynamics models, and Bayesian belief networks (Barbrook-Johnson & Penn, 2022). Behavioural system mapping builds on these approaches but primarily focuses on capturing connections between the behaviours of multiple actors (Chapter 2; Bellmann et al., 2025b; Hale et al., 2022). As of today, a limited number of academic publications have utilised BSMs, and there is no established guideline for their creation (Allison et al., 2024; Bellmann et al., 2025b; Davan Wetton et al., 2025; Hale et al., 2022). Based on the existing approaches, five key steps in the development of BSMs can be identified that can serve as a guide for future applications (see Figure 17). Chapter 2 provides a practical example of the application of behavioural system mapping, spanning all the steps presented in Figure 17.

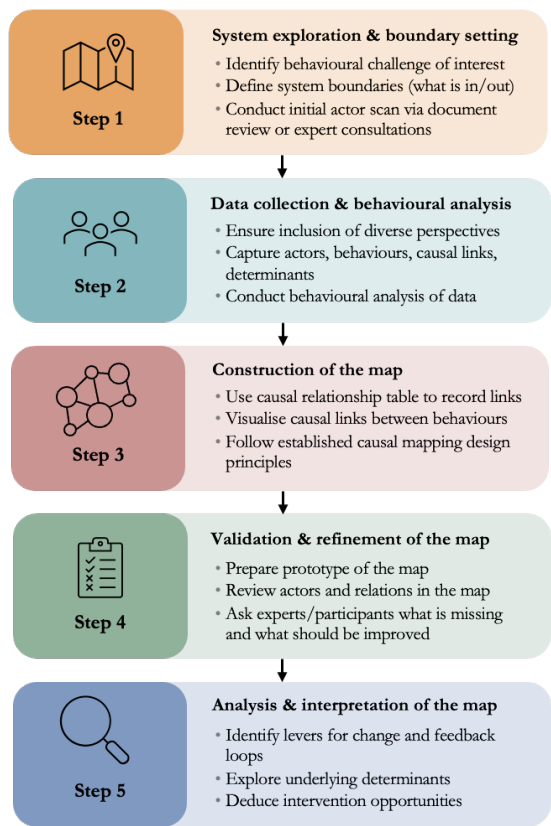


Figure 17: A stepwise approach to developing behavioural system maps.

Step 1: System exploration and boundary setting

Following the identification of a behavioural challenge of interest, the first step in developing a BSM is to understand the human behavioural system one intends to explore. This refers to the actors and behaviours surrounding the behavioural problem that is the focus of the analysis. This initial exploration is also the first step in developing other causal maps like causal loop diagrams (Barbrook-Johnson & Penn, 2022). In this step, one must obtain an overview of the system boundaries that demarcate the scope of the analysis. This includes the identification of actors that are part of the system through an actor scan. Policy scientists have developed different approaches to doing this. For example, actors can be determined through an instrumental approach that focuses on those actors formally involved in the problem one is researching or a normative view prioritising actors affected by a problem (see Cunningham & Hermans, 2018).

An initial overview of actors can be generated through a review of policy documents or expert consultations like key informant interviews (Chapter 2; Bellmann et al., 2025b; Enserink et al., 2022; Varvasovszky & Brugha, 2000). This initial actor scan is imperative as it informs the data collection process, highlighting which actors should be considered. Current approaches to behavioural system mapping all opted for including diverse actors, emphasising the importance of getting insights from multiple perspectives (Allison et al., 2024; Bellmann et al., 2025b; Davan Wetton et al., 2025; Hale et al., 2022).

Step 2: Data collection and behavioural analysis

So far, BSMs have been constructed based on participatory mapping workshops (Hale et al., 2022), focus groups (Davan Wetton et al., 2025), interviews (Chapter 2; Bellmann et al., 2025b; Davan Wetton et al., 2025), and scholarly literature (Allison et al., 2024). Key aspects the data collection needs to capture are the actors and their roles in the system, the behaviours of the involved actors, and causal links between behaviours. For both interviews and workshops⁹ the developed guiding questions should be able to capture these aspects. It is imperative to make sure that the data collection focuses on behaviours rather than structural factors, as these are the central building blocks of the map (Hale et al., 2022). Ideally, this would be assessed using an iterative approach, in which pilot testing is utilised to ensure that the questions capture behaviours and their links (Chapter 2; Bellmann et al., 2025b). The initial analysis of the system also generates a list of behaviours interventions could target that investigations that start with a pre-defined target behaviour might not consider.

In addition to behaviours, actors, and connections, BSMs can be enriched by including underlying determinants of behaviour. Data on these can be collected by developing questions based on the COM-B model dimensions (capability, opportunity, motivation - behaviour) or the Theoretical Domains Framework's (TDF) determinants (Atkins et al., 2017; Bellmann et al., 2025b; Davan Wetton et al., 2025). The focus on human behaviour and its underlying behavioural determinants is the key characteristic differentiating BSMs from other system mapping approach (Chapter 2; Barbrook-Johnson & Penn, 2022b; Bellmann et al., 2025b; Davan Wetton et al., 2025).

The prioritisation of what data to include in the BSM can be made with the participants (Hale et al., 2022), based on the frequency of the occurrence of codes in the qualitative analysis of textual data (Davan Wetton et al., 2025), or based on themes identified through a thematic analysis of textual data (Chapter 2; Bellmann et al., 2025b). A grounded theory approach using thematic analysis is commonly used in the development of causal maps. In this approach, the qualitative data is coded using an open coding approach to develop categories and subcategories (axial coding), which then inform the development of themes (Chapter 2; Bellmann et al., 2025b;

⁹ See Barbrook-Johnson & Penn (2022) for a guideline on participatory system mapping.

Kim & Andersen, 2012; Newberry & Carhart, 2024). Furthermore, a content analysis based on a behavioural science framework, such as the COM-B and TDF, can be used to identify determinants underlying the behaviours included in the map (Chapter 2; Bellmann et al., 2025b; Davan Wetton et al., 2025). Only after attaining an initial understanding of the collected data can one start constructing the BSM. For participatory mapping, Steps 2 and 3 occur simultaneously and with iterations between them (Hale et al., 2022).

Step 3: Construction of the map

In general, a BSM includes actors, behaviours, causal links between behaviours, and feedback loops. These feedback loops capture self-reinforcing mechanisms within the maps that exert influence on the system as a whole (Salmon et al., 2022). To construct a map, one must identify causal statements in the obtained data, which disclose links between the factors (i.e., behaviours) within the system (Armstrong, 2005). After deriving themes or coded behaviours from the qualitative data source (see Step 2), relationships between the behaviours must be recorded. This can be done through an iterative process in constructing the map or in a table format (coding chart), as it is commonly done in causal mapping (Kim & Andersen, 2012; Newberry & Carhart, 2024; Yearworth & White, 2013). Table 10 presents an example of such a table format, adapted for behavioural system mapping. The captured relations must then be transformed into behaviours and arrows for the system map (see Figure 18).

Table 10: Causal relationship table (adapted from Kim & Andersen, 2012)

Behaviour 1	Determinant of 1	Directionality	Behaviour 2	Determinant of 2
Behaviour A	Determinant of A	+	Behaviour B	Determinant of B
Behaviour B	Determinant of B	+	Behaviour A	Determinant of A
Behaviour B	Determinant of B	-	Behaviour C	Determinant of C

Figure 2 illustrates how BSMs visualise relations between actors’ behaviours and underlying determinants. The arrows show the cause-effect relations between behaviours. These can either be positive (+) or negative (-). Based on the directionality of the behaviours, causal relations between two behaviours can either be unidirectional, mutually balancing, or reinforcing. The determinants underlying the behaviours can be inserted using dotted arrows to highlight the primary determinant relevant to the respective behaviour. In Figure 2, the behaviours of Actor A and Actor B mutually reinforce each other, signified by the circle-shaped black arrow.

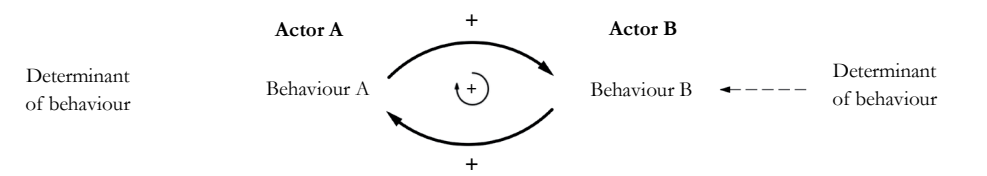


Figure 18: Components of BSMs (adapted from Bellmann et al., 2025b).

In developing BSMs, it is important to consider certain rules that apply to all types of causal maps. First, each behaviour in the map needs to be connected to at least one other behaviour, with arrows depicting the causal

relations between behaviours. Second, the directionality of the causal relation should be made clear using plus and minus signs. Finally, arrow lines should not cross to maintain readability (Enserink et al., 2022).

A common challenge in the construction of system maps is their readability, as the depicted complexity of a system often results in a map with many factors. Researchers have made several suggestions on how to deal with this, including limiting the number of depicted factors (Enserink et al., 2022; Hale et al., 2022), focusing only on prioritised behaviours (Chapter 2; Bellmann et al., 2025b; Davan Wetton et al., 2025), and tailoring maps to the visual literacy of the audience (Barbrook-Johnson & Penn, 2022). Moreover, colour coding can be used to categorise behaviours according to the included actors (Chapter 2; Bellmann et al., 2025b; Hale et al., 2022) and determinants according to COM-B dimensions (Davan Wetton et al., 2025). Table 11 summarises the current approaches to the development of BSMs.

Step 4: Validation and refinement of the map

It is a common practice in causal mapping to validate and refine the map with actors involved in the system (Chapter 2; Bates et al., 2022; Bellmann et al., 2025b; Davan Wetton et al., 2025; Enserink et al., 2022). This shall ensure that the map accurately captures the system of interest. The refinement of the map has also been an important step in the current work on behavioural system mapping, with a validation of the map through the research participants (Chapter 2; Bellmann et al., 2025b; Davan Wetton et al., 2025; Hale et al., 2022). Some have postulated that the refinement stage ‘is arguably the most important, but the most underestimated’ (Barbrook-Johnson & Penn, 2022, p. 53). In the validation, it should be explored whether the participants agree with the included behaviours and dynamics the map depicts, whether they think anything is missing, and whether they would exclude any elements (Barbrook-Johnson & Penn, 2022; Davan Wetton et al., 2025; Happach et al., 2012).

One approach to the validation and refinement is conducting a workshop with individuals involved in or with expertise of the system. In such a workshop, participants get introduced to the map and presented with reflection tasks. Ideally, this takes place in subgroups before presenting reflections and adjustments to all participants (Barbrook-Johnson & Penn, 2022; Happach et al., 2012). After gathering data on participants’ views of the map, it should be adjusted to accurately reflect the system’s behaviour. In general, including participants directly in the construction of the map can not only improve the map itself but also strengthen its perceived legitimacy, participants’ ownership, and the trust of participants in each other and the mapping process (Barbrook-Johnson & Penn, 2021; van den Akker et al., 2023).

Step 5: Analysis and interpretation of the map

BSMs can be analysed for key actors, determinants, feedback loops, and leverage points (Davan Wetton et al., 2025; Hale et al., 2022). The analysis of actors and their behaviours can increase the understanding of the system by outlining who to consider in decision-making processes, exposing conflicts between actors, collaboration potentials, power dynamics, and change agents (Cunningham & Hermans, 2018; de Bruijn & Heuvelhof, 2012; Enserink et al., 2022; Weick & Quinn, 1999). This analysis can be done by exploring the connections between the actors recorded in the map. If determinants were included in the map, one should also analyse them to assess the drivers underlying the actors’ behaviour. To do this, one can either assess the overall relevance of a specific determinant (e.g., social influences) across a map or examine the determinants per actor (Chapter 2; Bellmann et al., 2025b; Davan Wetton et al., 2025; van Valkengoed, Abrahamse, et al., 2022).

In analysing feedback loops, it is imperative to assess whether the loop is negative, positive, or balancing to understand the reinforcement dynamics in the map. Feedback loops are closed causal links between two or more factors (Barbrook-Johnson & Penn, 2022; Meadows, 2008). While a positive feedback loop suggests that behaviours increase each other over time, a negative loop implies that they will decrease (Enserink et al., 2022). After identifying feedback loops, the behaviours and underlying influences amplifying them should be identified. It also needs to be checked which actors are involved to gain a deeper understanding of the system. A map can also be analysed for relevant sub-systems and their interconnections to better understand system behaviour (Davan Wetton et al., 2025).

BSMs can also be analysed for change levers, referring to ‘places in the system where a small change could lead to a large shift in behavior’ (Meadows, 2008, p. 145). So far, research working with BSMs has primarily identified levers through a qualitative assessment of the map and the underlying data (Chapter 2; Bellmann et al., 2025b; Hale et al., 2022). Others solely concentrated on the identification of feedback loops or intervention opportunities (Allison et al., 2024; Davan Wetton et al., 2025).

Other measures commonly considered in network analysis and causal mapping include different types of centralities that can show the involvement of a certain factor within the map (Armstrong, 2005; Cunningham & Hermans, 2018; Engome Tchupo & Macht, 2022). These could also be utilised in the analysis of BSMs. For example, degree centrality can be used to assess the total number of connections (incoming and/or outgoing) a behaviour has in a map. Alternatively, betweenness centrality can help identify behaviours that bridge sub-systems of behaviour, as it can show which behaviour most frequently lies on the path between other behaviours (Cunningham & Hermans, 2018).

Table 11: Approaches to behavioural system mapping in published journal articles.

Construction step	Hale et al. (2022)	Allison et al. (2024)	Davan Wetton et al. (2025)	Bellmann et al. (2025b)*
1. System exploration and boundary setting	Defined scope based on case and developed initial actor map	Started with target behaviour and defined focus through literature review	Defined scope based on case	Initial actor network scan and snowball sampling approach
2. Data collection and behavioural analysis	Series of participatory mapping workshops	Qualitative analysis of literature review data	Qualitative coding using a pre-developed codebook of data from focus groups, interviews, and workshops	Thematic analysis and content analysis using TDF of interview transcripts
3. Construction of the map	Integration of group maps from participatory workshop	Visualisation of actors, behaviours, and connections based on literature	Visualisation of actors, behaviours, influences, and connections based on qualitative coding	Visualisation of behavioural dynamics identified in thematic analysis and connection of behaviours to TDF domains
4. Validation and refinement of the map	Second workshop with participants with adjustments	Stakeholder consultation without adjustments	Two expert review rounds with adjustments	Validation workshop with sample of participants with adjustments
5. Interpretation of the map	Workshop-based identification of intervention potentials	Focus on identification of relevant actors and behaviours as starting point for intervention development	Focus on feedback loops, leverage points, and sub-system interactions	Focus on feedback loops, leverage points, and underlying behavioural dynamics

Note. The four articles included in the table are the result of a search in the Web of Science database using the keywords 'behavioural system map' and 'behavioural system mapping'. *Chapter 2

5.3 The present and future of behavioural system mapping

While the emergence of nudging has already strengthened behavioural scientists' ability to influence real-world behaviour, many scholars and practitioners have called for a system-focused approach in behavioural research to increase the discipline's impact (Hallsworth, 2023a; Kaufman et al., 2024; Varazzani & Hubble, 2025; Viale, 2022). Behavioural system mapping can help researchers and practitioners to harness behavioural science for system change by enabling a bottom-up understanding of complex systems and identifying levers for change. It is a step toward the integration of behavioural science and systems thinking that many scholars view as essential to improve behavioural research (Kaufman et al., 2024; Lunetto et al., 2022; Parkinson et al., 2025).

Following the five steps outlined in this guide can enable researchers and practitioners to adopt such a system perspective by creating BSMs. Despite being in the early phase of its adoption, the approach has already yielded valuable insights into behavioural dynamics and decision-making in systems (Chapter 2; Bellmann et al., 2025b; Davan Wetton et al., 2025; Hale et al., 2022; Lunetto et al., 2022). In particular, it can illuminate the decision context of an actor of interest, capturing both psychological and contextual influences on decision-making processes (Chapter 2; Bellmann et al., 2025b). Moreover, BSMs can increase the understanding of dynamics within the system and generate hypotheses for behaviour change research by suggesting pathways through which individual-level behaviour could spark changes in systemic dynamics.

However, to date, BSMs solely offer a snapshot of a system of interest that is depended on the initial data collection for the mapping (Step 2). They are a device that can allow researchers and practitioners to better understand a system, but they do not provide an encompassing view of all factors within the system. Still, BSMs can increase the understanding of dynamics in the systems as they are perceived by the actors that are part of it.

Future work should explore some key limitations to further improve behavioural system mapping. First, research should define how to determine what constitutes a lever for behavioural interventions and explore the best way to identify one in a BSM. Promising approaches are the use of backward induction, expert judgement, or the focus on core behavioural dynamics (Chapter 2; Bellmann et al., 2025b; Davan Wetton et al., 2025; Meadows, 2008).

Connectedly, analysing whether interventions based on BSMs can successfully influence system behaviour could help evaluating their value for the design of interventions. To do this, the integration of BSMs into existing intervention development workflows could be further examined (e.g., Abraham and Denford, 2020; Hallsworth and Kirkman, 2020; Michie and West, 2014). Future research could also seek to understand how the maps can be further integrated with behavioural science theory to fully exhaust the discipline's potential to improve the analysis of systems. A promising approach is the inclusion of determinants of behaviour within the map (Chapter 2; Bellmann et al., 2025b; Davan Wetton et al., 2025). While the TDF and COM-B can be utilised for this, a system-focused analysis may benefit from a determinant analysis framework that has been developed to capture systemic influences on behaviour. The recently introduced socio-ecological COM-B (SeCOM-B) could facilitate such an analysis (Nguyen-Trung et al., 2025), which is why future research could employ it for the development of BSMs.

To make BSMs more relevant for policy practice, it could be explored how BSMs can be utilised in situations that require real-time assessments of systems and the analysis of system changes over time. Such maps could support operations managers by disclosing real-time blockages and allow policymaker evaluate the long-term impact of a policy. This would either require a map that includes a temp

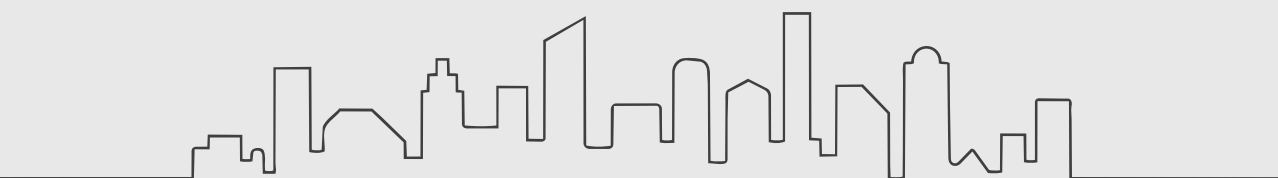
component or an approach that compares maps over time. For both these endeavours, longitudinal data collections are needed. For comparing the resulting maps, researchers can draw on comparative cognitive mapping research (Cunningham & Hermans, 2018; Engome Tchupo & Macht, 2022; Yoon & Jetter, 2016) and other system mapping methodologies that include a comparative component (Barbrook-Johnson & Penn, 2022). The maps could also function as a basis for quantitative models with behavioural components (e.g., agent-based models and system dynamics models), which can be utilised to simulate and understand system behaviour (Auping et al., 2024; Lane, 2017; Rietkerk-van der Wijngaart et al., 2025).

Another aspect requiring further attention to enhance BSMs for policy research and practice is the exploration of the most suitable level of granularity for BSMs. Future research could assess how much granularity is needed to develop effective interventions and how granularity and practicability can be balanced. While listing all individuals in one organisation as one actor in the map (macro approach) might be better for the depiction of the system, a focus on teams or individuals within an organisation (micro approach) might increase researchers' ability to target interventions (Heino et al., 2021).

Addressing these limitations and avenues for future research will strengthen BSMs as a tool to analyse complex systems from a behavioural science perspective. BSMs are a particularly suitable tool for policymakers, who create policies to intervene in complex systems. The maps can support the anticipation of an intervention's effects by making the factors influencing its success explicit. They can also be utilised to communicate intervention needs to other actors, as they provide a visual snapshot of a system. In sum, BSMs offer great potential in advancing both research and practice in behavioural public policy by enabling researchers to analyse behaviour in a system.

6

REFLECTIONS, SYNTHESIS, AND OUTLOOK



6.1 Discussion and synthesis of findings

Climate adaptation is essential to protecting human and natural systems. Policymakers play a key role in climate adaptation, as they decide on policies and projects that shape societal adaptation efforts. In this dissertation, I adopted a behavioural science lens to research policymakers' decision-making in the climate adaptation system. The investigations presented in the previous chapters were guided by the following overarching research question:

*How can policymakers' climate adaptation decision-making be **understood** and **improved** using a **behavioural systems approach**?*

To respond to this question, I conducted three empirical studies in which I examined policymakers' decision context, intervention spaces in the system, and a metacognitive behavioural intervention for adaptation policymaking. These three studies were each focused on a separate sub-question, which covers a part of the overarching question (see parentheses):

RQ1: What are the psychological and contextual factors influencing policymakers' urban climate adaptation decision-making processes according to Dutch policymakers? (*understood*)

RQ2: What are the key behaviours that affect climate adaptation policymaking and what behaviour change techniques can improve them? (*understood & improved*)

RQ3: Does an intervention combining metacognition and mental contrasting improve decision performance in climate adaptation compared to a control condition? (*improved*)

The findings pertaining to these sub-questions make three interconnected empirical contributions to behavioural research on climate adaptation, which will be detailed in this chapter. First, they deepen the understanding of policymakers' decision-making and the factors that influence it. Second, they provide impactful intervention spaces in climate adaptation policymaking. Third, they demonstrate that a metacognitive intervention can improve adaptation decision-making. Beyond that, the overarching approach taken to answer them provides a conceptual contribution by demonstrating how a behavioural systems approach can be employed to analyse complex societal challenges.

I also compiled how behavioural system maps can be created and used to enhance the study of complex challenges through a behavioural perspective. The resulting guide can enable practitioners and researchers to map behavioural dynamics in the analysis of societal challenges, providing a replicable methodological process for their development. This methodology-focused chapter aimed to respond to the question:

RQ4: How can behavioural system maps be constructed to support behavioural analyses in policy research and practice? (*understood & behavioural systems approach*)

In this chapter, I revisit the findings on the sub-questions and outline each chapter's primary scientific contributions (Subsections 6.1.1 to 6.1.4). I then synthesise the findings from all chapters to illustrate the *behavioural systems approach* that overarched the investigation of policymakers' climate adaptation decision-making (Subsection 6.1.5). I also reflect on the generalisability of the findings (Subsection 6.1.6) and discuss future research directions, concentrating on those pertaining to the overarching approach of this dissertation (Section 6.2). Finally, I propose how the findings can be applied in adaptation policymaking (Section 6.3).

6.1.1 What are the psychological and contextual factors influencing policymakers' urban climate adaptation decision-making processes according to Dutch policymakers?

Based on 32 semi-structured interviews with Dutch policy professionals and a reflection workshop with nine participants, Chapter 2 presented an analysis of the contextual and psychological factors that shape adaptation policymakers' decision-making. To answer the research question, I conducted a threefold analysis of the interview transcripts, connecting content analysis, thematic analysis, and a behavioural system map to understand policymakers' decision context. This threefold analysis facilitated the identification of psychological and contextual influences on policymakers' decisions by generating nine behavioural dynamics that shape policymaking, a set of psychological influences on policymakers' decisions, and a behavioural system map that bridges contextual and psychological influences.

The nine emerging themes I identified based on the thematic analysis are: reliance on precedents; fragmented roles and responsibilities; habitual thinking based on longstanding processes; policy stringency, clarity and process; conflicting political priorities; importance of individuals; externally-motivated action; illusion of local actor engagement; moving from awareness creation to mainstreaming. These themes describe the dynamic interactions between actors in the multi-actor system and how they shape policymakers' decision context (see Chapter 2).

The analysis of the determinants of behaviour led to the identification of the determinants underpinning the themes' dynamics, visualised in the behavioural system map. Simultaneously, it showed that beliefs about consequences, the environmental context, goals, the social/professional role and identity, and social influences were the most frequently recorded factors shaping decisions. The behavioural system map then revealed behavioural levers at the intersection of specific determinants and the behavioural dynamics in the system. This resulted in three levers for change, signifying points where individual-level behaviour change could unfold system-wide impact. The three levers were: supporting precedent identification, stimulating information gathering, and boosting mainstreaming processes.

Overall, the findings reveal a complex interplay of contextual and psychological factors that shape climate adaptation policymaking. The surfaced behavioural dynamics can act as both an inhibitor and an accelerator for adaptation efforts. As they are driven by individual behaviours, they can be addressed through behavioural interventions. With regard to societal climate adaptation efforts, the chapter provides practical insights into how policymakers can understand the adaptation puzzle and improve climate adaptation efforts. It showcases levers that can be addressed through interventions, suggesting a pathway to reducing the adaptation gap. In addition, it highlights how multi-actor interactions, with policymakers at their centre, can slow societal adaptation efforts. By answering the guiding research question, Chapter 2 makes three primary contributions to scholarly work on climate adaptation:

- **Barrier dynamics:** The study expands recent work on the dynamic mechanisms underpinning barriers to climate adaptation (Ishtiaque et al., 2021; Lee et al., 2023b, 2023a). It takes a novel approach by illuminating the individual-level behavioural interactions that shape those dynamics that others have labelled as drivers or barriers. Thereby, it also responds to calls for more actionable insights on how barriers could be alleviated (Biesbroek et al., 2013, 2015). Notably, the findings demonstrate the shortcomings that a reductionist barrier-focused approach might entail, as the climate adaptation outcomes of a factor's influence often depend on underpinning behavioural dynamics. For example, one policymaker might welcome a lack of stringent national policy as autonomy-inducing, whereas another might feel restrained without it. The chapter also establishes the basis for the development of behavioural interventions by developing a bottom-up

understanding of the system that shapes climate adaptation in the Netherlands. It provides three actionable levers for system change and connected determinants of behaviour, which are required to design effective interventions (van Valkengoed & Steg, 2019b).

- **Policymakers' decision context:** The findings also illuminate what shapes policymakers' decision-making. They show how behavioural dynamics, which have not been observed in citizen-centred research (e.g., conflicting political priorities), shape adaptation policymaking. This expands earlier research on household climate adaptation behaviour (Bechtoldt et al., 2021; van Valkengoed & Steg, 2019a) that has not yet focused on the unique interplay of contextual and psychological influences affecting policymakers. Thereby, it also answers calls for investigations on the real-world decision-making of policymakers (Siders & Pierce, 2021).
- **Behavioural systems:** The development and analysis of the behavioural system map contribute to recent studies at the intersection of behavioural science and systems analysis (Del Valle et al., 2024; Grinstein et al., 2025; Kaufman et al., 2024; Parkinson et al., 2025), especially those on using system mapping to understand behavioural interactions connected to a policy challenge (Davan Wetton et al., 2025; Hale et al., 2022; Lunetto et al., 2022). The study's analytical approach presents a novel pathway to behavioural system mapping that builds on both a thematic and content analysis of interview data.

6.1.2 What are the key behaviours that affect climate adaptation policymaking and what behaviour change techniques can improve them?

To understand key behaviours in adaptation and suitable intervention techniques, I used a systematic scoping review of 70 studies and an expert Delphi panel. The two-round expert panel asked both policy and behavioural science experts to prioritise target behaviours and behaviour change techniques.

This panel prioritised seven key behaviours in climate adaptation policymaking based on their impact and changeability. These key behaviours are: connect to other internal departments, broaden adaptation focus beyond water issues, engage in regional cooperation, set-up pilot projects on adaptation, communicate climate adaptation ideas to leadership, emphasise political benefits of adaptation, and involve departments in strategy development. The panel further prioritised eight behaviour change techniques based on their implementability in adaptation policymaking and their acceptability: goals and planning, feedback and monitoring, social support, shaping knowledge, natural consequences, comparison of behaviour, repetition and substitution, comparison of outcomes.

While the review aimed to surface existing interventions that could inform the development of a context-tailored intervention in this study, it primarily highlighted the scarcity of existing research on interventions or decision support targeting adaptation policymakers' decision-making processes. It also showed that existing interventions do not build on behavioural science theory and stem from alternative disciplinary backgrounds. In the review, policymakers' context, resources, and knowledge, as well as social influences, were the most frequently reported behavioural determinants.

Overall, the findings expand the initial analysis of behavioural dynamics in climate adaptation (Chapter 2) by highlighting target behaviours for behavioural interventions and deepening the understanding of policymakers' behavioural determinants. For societal adaptation efforts, the chapter reveals a set of behaviours of policymakers that could accelerate adaptation progress. Scientifically, the study expands scholarly work on:

- **Climate adaptation policymaking research:** The findings of the review elucidate gaps in scholarly work, especially those pertaining to interventions targeting policymakers and research on the psychological determinants of their behaviours. They provide further evidence for two observations on the nature of current climate adaptation research. First, they show that there is limited attention to how policymakers' decision-making underpins the adaptation barriers (Ishtiaque et al., 2021; Lee et al., 2023b). Second, they confirm that there is limited research on how policymakers make their decisions in practice (Siders & Pierce, 2021). The results of the review further stress that research on interventions in policymaking has not yet built interventions based on an analysis of behavioural determinants (Haße & Kind, 2019; Lucertini et al., 2022), which might decrease their effectiveness (Abraham & Denford, 2020; Scholten et al., 2025; van Valkengoed, Abrahamse, et al., 2022).
- **Mainstreaming behaviours in adaptation:** The prioritisation of internally-focused behaviours by the expert panel confirms earlier work that positioned mainstreaming as a key strategy to advance adaptation efforts (Braunschweiler & Pütz, 2021; Schulze, 2024). However, the findings of the study and those in Chapter 2 go beyond the existing body of knowledge on mainstreaming by showcasing what individual-level behaviours could accelerate mainstreaming efforts. Put differently, existing research has shown that mainstreaming increases adaptation progress, while this dissertation illuminates what individual behaviours increase mainstreaming, i.e., involving departments in the development of strategies. At the same time, it somewhat contradicts the behavioural emphasis in earlier research. Whereas existing work on adaptation policymaking interventions often focused on external cooperation and knowledge accumulation (K. Fleming et al., 2020; Rumore et al., 2016), the expert panel primarily prioritised behaviours connected to internal processes within administrations.
- **Intervention space prioritisation:** The findings of this study provide a set of addressable behaviours and applicable behaviour change techniques. This set provides the basis for research on context-tailored interventions for climate adaptation policymaking and, therefore, contributes to the broader psychological research agenda on climate change behaviours (Whitmarsh et al., 2021). Methodologically, the combination of a review of existing research and the expert panel facilitated the identification of suitable target behaviours for interventions within the adaptation system, rendering the basis for context-aware interventions (R. Schmidt, 2024; R. Schmidt & Stenger, 2024; Veltri, 2025). It also provides the foundation for moving from the behavioural system map developed in Chapter 2 to the development of a system-focused, context-tailored intervention, a key challenge in behavioural research. Thereby, it contributes to emerging research on system change through behavioural interventions (Davan Wetton et al., 2025; Kellner et al., 2024) and provides the basis for moving beyond one-size-fits-all nudges.

6.1.3 Does an intervention combining metacognition and mental contrasting improve decision performance in climate adaptation compared to a control condition?

Based on the findings of Chapters 2 and 3, I developed a metacognitive behavioural intervention called Climate Adaptation Reflection Navigator (CARN). CARN connects a climate adaptation mental contrasting task and a reflection checklist with key adaptation behaviours to improve decision-making in climate adaptation. To evaluate CARN's ability to improve decision performance, I used a multi-method approach, consisting of an online experiment with 406 participants and two workshops with 14 Dutch policymakers.

In the online experiment, CARN users demonstrated significantly higher levels of decision performance and decision quality. The experiment tested group differences between CARN users and an active control group based on responses to a simulated task in which participants had to develop a climate adaptation plan. While decision performance measured the extent to which they considered the impactful key behaviours identified in Chapter 3, decision quality assessed procedural quality aspects evident in the developed plans. However, I did not find significant group differences for participants' self-efficacy beliefs and self-reported decision-making quality. In addition, the workshop highlighted that CARN is usable for the target group, making it a practical intervention for adaptation policymaking.

Taken together, the findings of the experiment and the workshops provide a decision support tool that addresses the behavioural dynamics in climate adaptation and key behaviours that could spark system change. This decision support tool (CARN) could advance societal adaptation efforts if it is adopted by policymakers. The chapter contributes to research on:

- **Decision support in climate adaptation:** CARN presents a behaviourally-informed decision support tool for adaptation policymaking, making it, to the best of my knowledge, the first boost that targets behavioural dynamics in climate adaptation. Specifically, CARN increases the inclusion of impactful actions in adaptation plans, which could exert system-wide impacts if adopted, as surfaced in Chapter 2. CARN contributes to existing adaptation intervention research that has primarily concentrated on citizens (van Valkengoed & Steg, 2019b). By targeting a high-power actor (policymakers), CARN also responds to numerous calls for research on behavioural interventions that consider and address systemic dynamics (de Ridder & Thomaes, 2025; Hallsworth, 2023a; R. Schmidt & Stenger, 2024; Varazzani & Hubble, 2025; Whitmarsh et al., 2021). Beyond applied psychology, Chapter 4 complements research on decision support for adaptation decision-makers that, due to its distinctive objectives, has primarily concentrated on data provision and prediction (Cristal et al., 2019; Kwakkel et al., 2015).
- **Metacognitive boosting:** The findings also contribute to the growing research on boosting as a behaviour change approach (Hertwig et al., 2025; Herzog & Hertwig, 2025), expanding the field by exploring reflective decision support for policymakers. They show how a metacognitive checklist and a mental contrasting exercise can improve decision performance and quality in adaptation planning. As these techniques have primarily been adopted in fields other than behavioural public policy (Chen & McDunn, 2022; H. Fischer & Fleming, 2024; Heidbrink & Weinrich, 2021), this study also provides evidence that metacognitive boosts can improve policy-related decision performance and quality.

6.1.4 How can behavioural system maps be constructed to support behavioural analyses in policy research and practice?

In Chapter 5, I developed a stepwise guide to the construction of behavioural system maps. The basis for researching behavioural systems is the understanding of behavioural interconnections within a system and underlying determinants. One recently introduced approach that can facilitate this is behavioural system mapping. The approach builds on existing techniques in system mapping and systems analysis. The guide includes five steps: 1. System exploration & boundary setting, 2. Data collection & behavioural analysis, 3. Construction of the map, 4. Validation & refinement of the map, 5. Analysis & interpretation of the map. It shows that behavioural system maps can support behavioural insights research by uncovering interconnections and dynamics within a system as well as underlying behavioural determinants. By doing this, they present a way forward in understanding emergence, feedback loops, and other properties of

complex systems. This can then provide the basis for the design of system-focused interventions that target specific dynamics or high-power actors within the system of interest. For practitioners, the approach presents a structured workflow that can enable the analysis of societal challenges through a behavioural lens. It could also facilitate the shift from primarily studying end-user behaviour, which can lead to an overburdening of citizens, to exploring a more diverse set of actors.

By surfacing and enriching the steps involved in the development of a behavioural system map, the guide goes beyond the mapping description in Chapter 2, contributing to studies on:

- **Mapping behavioural interactions:** The chapter contributes to existing research on behavioural system maps by synthesising how they can be constructed (Davan Wetton et al., 2025; Hale et al., 2022; Lunetto et al., 2022). By taking stock of existing approaches, it produces a replicable process for future behavioural research with system maps. Thereby, it indicates how agency and system structure can be viewed as an interplay rather than distinctive areas of investigation (Nielsen, Clayton, et al., 2021). Hence, it addresses calls for studies on how interactions between individuals shape their decision context and *vice versa* (Hallsworth, 2023b; Whitmarsh et al., 2021). It also demonstrates that existing approaches in behavioural insights might miss crucial influences on behaviour beyond the intra-individual dimension that only become apparent within the map, as demonstrated in Chapter 2.
- **System-focused behavioural insights:** The guide addresses a crucial gap in behavioural insights workflows by providing a replicable methodological approach to conduct system-focused behavioural analysis (Hallsworth, 2023a; Varazzani & Hubble, 2025). It showcases that behavioural system maps can support the analysis of levers for change, increasing the understanding of the system and pathways for changing it. It also strengthens researchers' ability to illuminate what others have called choice infrastructure, i.e., the ecosystem constituting an individual's decision context (R. Schmidt, 2024). More generally, it presents a methodological pathway for integrating a complexity science lens in behavioural research, contributing to the broader body of work at the intersection of social science and complexity science (Byrne & Callaghan, 2022; van der Maas, 2025).

Summary of key contributions

The chapters have contributed to existing climate adaptation research by...

- illuminating behavioural dynamics affecting adaptation progress (Chapter 2),
- identifying suitable target behaviours for behavioural interventions (Chapter 3), and
- developing a context-tailored decision support tool for policymakers (Chapter 4).

Moreover, they advanced applications of behavioural science by...

- developing behavioural system maps based on interview data (Chapter 2),
- showing how target behaviours for interventions can be prioritised via an expert panel (Chapter 3),
- creating a metacognition-based intervention for policymakers (Chapter 4), and
- providing a guide that takes stock of existing behavioural system mapping approaches (Chapter 5).

6.1.5 A behavioural systems approach to understand and boost climate adaptation policymaking

Beyond the individual contributions of the chapters (see Box 4), the process overarching Chapters 2 to 4 demonstrates how a behavioural systems approach could be adopted in researching climate adaptation. The process across the chapters encapsulates seven key steps. This seven-step process represents a bottom-up approach to understanding how micro-level behavioural interactions and determinants shape system-level outcomes (see Figure 19). I here concentrate on the replicable methodological steps that future research can follow without repeating all the insights on climate adaptation they yielded (see previous sections).

1. **Problem identification.** First, a problem of interest is identified. In contrast to traditional behavioural insights approaches, the problem here does not denote a particular behaviour. Instead, the focus is on a broader challenge of interest, with a specification of a target behaviour later in the process. In this dissertation, climate adaptation was the underlying challenge of interest. While a system-focused behavioural analysis can be employed for all types of problems, this dissertation has demonstrated that it could be particularly valuable for dissecting so-called wicked challenges, as it is better equipped to capture behavioural interactions. Whereas existing approaches often highlight that the problem must be clearly formulated in behavioural terms (Hallsworth & Kirkman, 2020), the system approach does not require this *a priori*.
2. **Actor analysis.** An integral part of the behavioural systems approach is the assessment of actors involved in the challenge of interest. The actor analysis generates an overview of those actors, establishing the basis for the analysis of their behaviours. Whereas traditional behavioural insights approaches tend to focus on one pre-defined actor, a behavioural systems approach first captures

all actors relevant to the challenge. In this dissertation, the initial actor scan has been enriched iteratively via the interviews to ensure that the multi-actor system surrounding climate adaptation is captured adequately. The actor scan is not only vital to the analysis of the system itself, but also as a basis for developing the data collection approach. It informs both the sampling of actors in the data collection and the study material development. In addition, the actor analysis yields data on the actors involved in a societal challenge, which, for many wicked challenges (e.g., climate adaptation), already constitutes a relevant scientific contribution itself.

3. **System-focused behavioural data collection.** The system-focused behavioural analysis needs to capture behaviours, behavioural determinants, and interconnections between actor behaviours. Therefore, the chosen data collection method needs to address both individual-level and contextual determinants of the actors' behaviours. It further needs to obtain data on how behaviours are connected within the system. Traditional individual-level focused approaches are ill-equipped to achieve this, as they centre around a pre-chosen target behaviour. In this dissertation, I used both interviews and a workshop to collect data on behavioural dynamics in the system (Chapter 2). In applying these methods, it is essential to concentrate on processes rather than one specific behaviour. For example, instead of asking policymakers what shapes the creation of a climate adaptation plan, I explored the process through which an adaptation plan is developed. This subtle difference is crucial, as it enables a nuanced assessment of the determinants of multiple sub-behaviours. Moreover, the behavioural analysis of multiple actors in the system produces an extensive list of potential target behaviours (Chapter 2), which behavioural intervention research would typically miss, as existing approaches start with a pre-defined target behaviour—often the one with the most apparent connection to the problem of interest. Accordingly, the system-focused analysis extends the basis for the prioritisation of target behaviours (Chapter 3). Only through the generation of this list, specifically suitable target behaviours, i.e., those that are changeable and impactful, can be addressed.
4. **Behavioural dynamics analysis.** After collecting the data, I conducted a system-focused behavioural analysis to identify feedback loops, emergent dynamics, and levers for change (Chapter 2). To do this, I connected the findings of the thematic analysis and a content analysis based on the Theoretical Domains Framework in a behavioural system map (Chapters 2&5). This map offers a visual snapshot of the system that shapes individual-level decisions while simultaneously showcasing how the individual behaviour shapes the system. Chapter 2 has shown that behavioural dynamics emerging within the climate adaptation system only become apparent when connecting multiple data analysis methods and adopting a system perspective. In contrast, the review of existing studies on policymakers' adaptation decisions did not yield insights into behavioural interactions between actors, showing the limitations of contemporary frameworks (Chapter 3). Based on the behavioural dynamics analysis, I identified levers for change in policymakers' decision-making, presenting points at which individual-level behaviours could spark system-wide changes. These levers can provide the basis for prioritising target behaviours for interventions. This separates the behavioural systems approach from traditional behavioural insights workflows, in which the target behaviour often is the starting point for the inquiry (see Step 1).
5. **Intervention space identification.** I then prioritised target behaviours in the climate adaptation system that would be suitable for behavioural interventions using an expert panel survey (Chapter 3). The initial set of behaviours that were evaluated was chosen based on the behavioural dynamics and themes surfaced in the system-focused behavioural analysis and mapping (Chapters 2&5). In this dissertation, I based the prioritisation of the target behaviours on two key domains for which experts rated them, i.e., changeability and impact. Similar to traditional behavioural insights

approaches, the objective was to select those behaviours that generate the most impact with regard to the challenge of interest, while simultaneously ensuring that they can be changed within the existing decision context. However, the primary difference is that the behaviours were only selected subsequent to the behavioural analysis.

6. **Behaviour change technique selection.** Before developing the intervention prototype, I selected the underlying behaviour change technique suitable for addressing the selected target behaviours. To do this, I considered both the contextual and psychological factors that shape the chosen key behaviours (Chapters 2&3) as well as the insights on preferred behaviour change techniques by the expert panel (Chapter 3). In particular, the expert panel suggested acceptable techniques that are implementable in the existing processes (Chapter 3). These included 'goals and planning', 'feedback and monitoring', 'social support', 'shaping knowledge', 'natural consequences', 'comparison of behaviour', 'repetition and substitution', and 'comparison of outcomes'. I then selected an intervention approach that can address multiple target behaviours (Chapter 3), fits within the existing decision context (Chapter 2), and uses one or multiple of the prioritised BCTs (Chapter 3). At the same time, the intervention technique needed to be able to address the determinants specified in the SSBC and the initial behavioural analysis, namely capability beliefs, beliefs about consequences, and knowledge (Chapters 3&4). These steps ensure that the intervention fits the context of the target behaviours, while simultaneously addressing their behavioural determinants. Through this, a metacognitive boost emerged as a suitable intervention technique, as it addresses the determinants, allows a focus on decision-making processes, enables targeting multiple behaviours, and fits within the decision context (Chapters 2, 3&4).
7. **Intervention development and evaluation.** Finally, I developed and evaluated an intervention prototype that addressed the target behaviours identified in Step 4. This intervention development drew on existing research on suitable behaviour change techniques, in particular metacognitive interventions. The development and evaluation process was not split up to signal the importance of iteratively adjusting the intervention based on the obtained results (see Figure 19). In the development, I also built on existing behavioural insights research, especially in the domains of boosting and environmental behaviour change. To evaluate the usability of the intervention, I conducted two review workshops following the APEASE criteria (Michie & West, 2014). This usability evaluation is often not part of traditional behavioural insights, although it is a crucial step to assessing the contextual fit of the intervention.

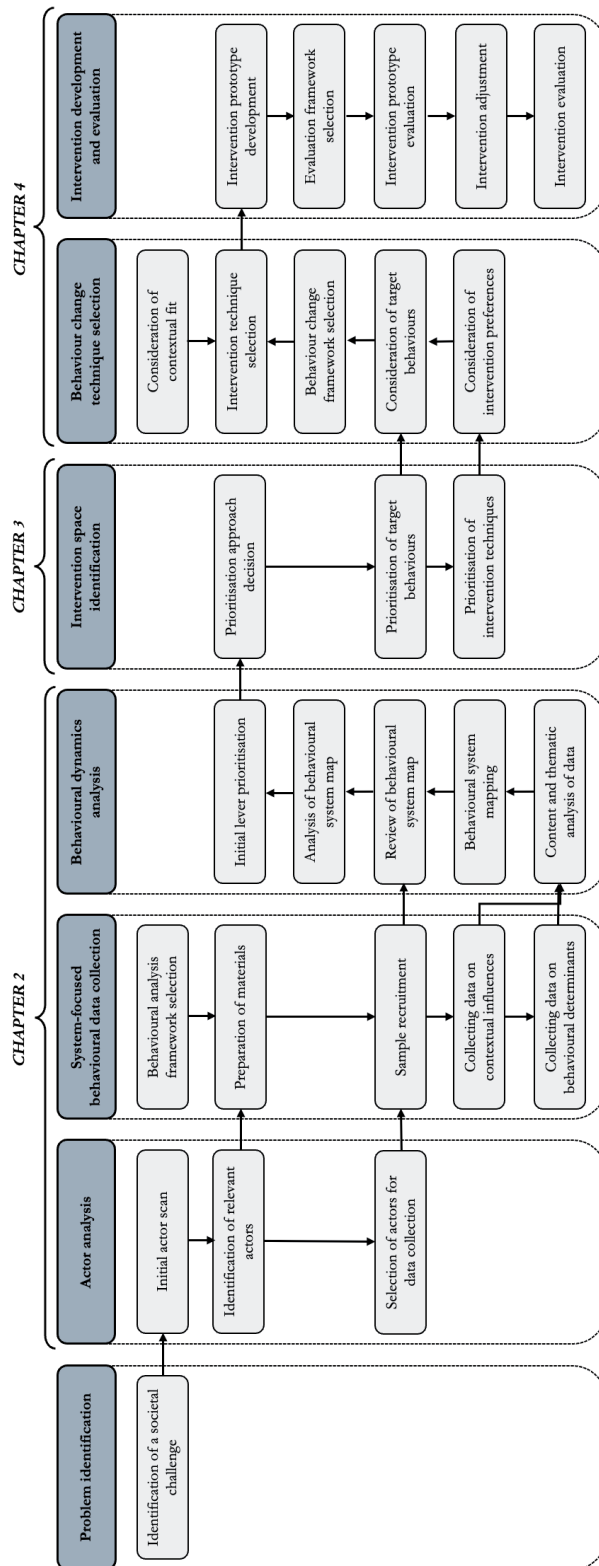


Figure 19. Flowchart illustrating the behavioural systems approach.

The behavioural systems approach suggests a pathway for studying the properties of complex systems highlighted in Section 1.5.2 (emergence, interconnectivity, non-linearity, feedback loops) in the development of behavioural interventions. While it emerged through the presented investigations of climate adaptation, it provides a replicable methodological process for future system-focused research in applied behavioural science beyond adaptation, thereby addressing calls for bridging behavioural science and systems analysis (Grinstein et al., 2025; Hallsworth, 2023a; Heino et al., 2023; Varazzani & Hubble, 2025). It contributes to recent research on the potential of individual-level change as a pathway to system change (de Ridder & Thomas, 2025; Hallsworth, 2023b; Lunetto et al., 2022). The seven-step process extends existing intervention development frameworks by adding systems analysis components (Hallsworth & Kirkman, 2020; Michie & West, 2014). The primary difference is that an initial analysis of the system is carried out before proceeding with the intervention development steps commonly adopted in behavioural research (see Section 1.5). The steps are in line with pioneering work on introducing a system focus in behavioural intervention workflows, which also introduced an initial system scan at the start of the process (Kellner et al., 2024).

The approach accounts for two shortcomings scholars have noted with regard to existing research. First, it addresses the criticism that behavioural research is too individualistic and consumer-centric, not taking context, actor diversity, and systemic dynamics into account (Lunetto et al., 2022; Nielsen, Cologna, et al., 2021; Whitmarsh et al., 2021). Second, it demonstrates how to differentiate between potential target behaviours using expert judgement, suggesting an approach for prioritising behaviours based on their changeability and impact (Whitmarsh et al., 2021). Therefore, it responds to calls for a fundamental shift in psychology, in which individuals are studied as part of a system rather than in isolation (Grinstein et al., 2025).

While it agrees with the diagnosis that system dynamics are insufficiently considered, the behavioural systems approach rejects the strict distinction between i-frame and s-frame put forward by Chater and Loewenstein (2023a). Comprehensive critiques of this separation can be found elsewhere (Caggiano et al., 2023; Sunstein, 2023; Thaler, 2023; Walton & Yeager, 2023). Here, I primarily concentrate on the contrived differentiation of ‘i’ and ‘s’ levels (Grinstein et al., 2025; Hallsworth, 2023b). The climate adaptation research presented in this dissertation demonstrates that what has been described as s-frame, such as subsidies and bans (Chater & Loewenstein, 2023a), results from individual-level interactions of policymakers, politicians, and other actors (see Chapter 2). By viewing these as s-frame solutions, researchers equate the i-frame with citizens (Chater & Loewenstein, 2023a). In a response to their critics, Chater & Loewenstein (2023b, p. 78) attempt to clarify the distinction between the frames, outlining that ‘S-frame interventions involve changing the rules of the game; i-frame interventions attempt to modify the actions of the players, within the existing rules’. This perspective fails to account for the fact that the ‘rules of the game’ are themselves a result of the interactions of the ‘players’, as shown in this dissertation. The behavioural systems approach views the individual level and system level as inherently connected, and system-level dynamics as a result of individual-level interactions (and *vice versa*). This corroborates studies that aim to jointly examine these levels (Davan Wetton et al., 2025; Grinstein et al., 2025; Hallsworth, 2023b).

This behavioural systems approach is particularly applicable for inquiries into complex societal challenges, in which system change is aspired, including climate change adaptation and mitigation (G. de Vries et al., 2021; Petzold et al., 2023; Whitmarsh et al., 2021). In contrast, it might not be needed if the objective is to change a pre-defined target behaviour, such as the simple purchase of a book in a store. Steps 1 to 4 might still be beneficial as they enable an analysis of contextual constraints on decisions that a traditional analysis might not reveal. However, as the target behaviour does not need to be prioritised, Step 5 can be omitted. And if evidence

on suitable interventions is readily available or the intervention technique is chosen *a priori*, Steps 6 and 7 can be merged. However, its value for the analysis of topics other than adaptation needs to be explored further.

An overarching difference to existing behavioural insights also lies in the research methodologies, especially regarding the inclusion of the studied target group (i.e., policy professionals) in the behavioural analysis and intervention development. For example, the workshop in Chapter 2 allowed a verification of the observed behavioural dynamics as well as an assessment of their influence on decision-making processes. Similarly, the workshops in Chapter 4 allowed the adjustment of CARN to the existing decision-making processes. While participatory approaches are frequently used in other disciplines (Barbrook-Johnson & Penn, 2021; Guariguata et al., 2020), behavioural research has yet to harness their potential for designing interventions. Therefore, this dissertation is connected to scholarly work that aims to bridge implementation science and behavioural science to enhance the contextual fit and effectiveness of interventions. Existing research on behavioural interventions frequently views the context as a passive background rather than an active environment that restrains or facilitates the success of interventions. Instead, an implementation science perspective suggests that engagement with the target group and the assessment of contextual influences are vital to the success of an intervention (Veltri, 2025). Connectedly, this dissertation confirms the advantages of the mixed-method research approach imbued in the behavioural systems approach (Creswell, 2022; Plano Clark & Ivankova, 2016). The mixed-methods approach delivered rich insights into policymakers' climate adaptation decision-making that go beyond what individual qualitative or quantitative research could generate. Qualitative research can enable an in-depth analysis of a system, whereas a quantitative analysis can support the identification of leverage points and the testing of interventions. The overarching approach that guided the chapters shows that the development and evaluation of a context-tailored intervention likely require such a mixed-method approach.

The behavioural systems approach also requires a distinctive use of behavioural science theory in the workflow from behavioural analysis to intervention development. As it does not specify a target behaviour from the start, the initial behavioural analysis requires a framework that captures a range of determinants of behaviour, such as the TDF or the COM-B. Only after deciding on the target behaviour(s) the intervention shall address, a suitable behaviour change theory can be chosen. For example, if the adoption of a specific technology by policymakers emerges as a system change path, the Technology Acceptance Model might be suitable (Venkatesh & Bala, 2008). In contrast, if a protective health behaviour is to be changed, Protection Motivation Theory might be more suitable (Rogers, 1975). Accordingly, adopting a behavioural systems approach likely requires a multi-framework approach, with one framework for the initial analysis and one to inform the design of the behavioural intervention.

For governance and policy analysis scholars, the behavioural systems approach can function as a bridge between the analysis of structural change and the underlying micro-level behavioural interactions. To date, research in these disciplines often disregards the agency of actors, studying policy outcomes as a result of structural forces. The behavioural systems approach suggests a conceptual shift toward a bottom-up approach in how policymaking processes and governance systems can be understood. Rather than treating institutions, governance arrangements, and behaviour as disconnected analysis units, it conceptualises policy outcomes as the result of behavioural interactions in a system. Thereby, it indicates how frequently observed phenomena, such as horizontal governance systems, path dependencies, institutionalisation, and administrative traditions (Barnett et al., 2015; A. Bauer et al., 2012; Corfee-Morlot et al., 2011; Phuong et al., 2018), can be traced back to the behaviour of individual actors. This then can inform the design of novel intervention types, such as the reflection tool (CARN) presented in Chapter 4.

A reflection on libertarian paternalism and the behavioural systems approach

Since their first introduction, nudges have been criticised for manipulating people (Rebonato, 2012; A. T. Schmidt & Engelen, 2020). These criticisms have sparked a scholarly debate on the ethicality of nudging and the underlying concept of libertarian paternalism, which refers to the idea of influencing people's decisions while maintaining their freedom of choice. Proponents of the approach argue that it is broadly beneficial for humans and less coercive than other approaches (Conly, 2012; Sunstein, 2014, 2015). In contrast, opponents claim that they are unethical due to their manipulation of decisions (Grüne-Yanoff, 2012; Rebonato, 2014, 2012). The debate between these two groups has led to numerous publications on the ethics of nudging (A. T. Schmidt & Engelen, 2020), as well as calls for a more nuanced consideration of their characteristics when judging their ethicality (Viale, 2022).

The discussion of what makes some nudges more ethical than others has surfaced some key criteria to consider, including their alignment with overall preferences, conservation of autonomy and control, degree of transparency, reversibility, and whether they focus on outcomes or processes (Bovens, 2009; Kuyper & Gordijn, 2023; Lades & Delaney, 2022; Rebonato, 2014; A. T. Schmidt & Engelen, 2020; Viale, 2022). Among the critics of nudging, interventions encouraging deliberation, reflection, and the development of capabilities are viewed as more ethical (Hertwig & Grüne-Yanoff, 2017; Rebonato, 2014; Viale, 2022). Instead, nudges focused on automatic cognitive processes are less transparent, affecting the initial consideration of choices, reducing autonomy, less reversible, and outcome-focused (Kniess, 2022; Rebonato, 2014; Viale, 2019, 2022). While many of the discussions of nudging's ethicality concentrate on the intervention delivery, other frameworks used to evaluate interventions also encapsulate equality aspects (Abraham & Denford, 2020; Matthews & Simpson, 2020; Michie & West, 2014).

The behavioural system approach applied in this dissertation complies with the criteria outlined above. First, it aligns with policymakers' own preferences by being based on needs they articulated in the in-depth analysis in Study 1 (Chapter 2) and by not prescribing a certain decision outcome. It also conserves their autonomy and control by giving them a transparent reflection tool that can be integrated into existing decision processes (Chapters 3&4). It is also fully transparent, and its use is reversible. Furthermore, it is based on a comprehensive analysis of the actors and dynamics shaping adaptation, ensuring a consideration of diverse perspectives in the intervention design. Similar to endeavours comparing nudging and boosting, future research could contrast the ethicality of the behavioural systems approach in this dissertation with traditional behavioural insights approaches (Bovens, 2009; Hertwig & Grüne-Yanoff, 2017).

6.1.6 Reflections on the generalisability and scope of the findings

When interpreting the findings synthesised in the previous subsections, specific limitations to their generalisability beyond the studied scope should be considered. The empirical studies (Chapters 2-4) centred on climate adaptation in the Netherlands. This is reflected in both the recruited study participants and the geographical focus of the collected data. Accordingly, the findings on behavioural dynamics, prioritised intervention spaces, and CARN are primarily applicable to Dutch adaptation efforts. As outlined in the empirical studies, Dutch climate adaptation efforts and policymaking are rooted in a long-standing tradition of environmental management, with a particular focus on water due to its low-lying topography (see Chapter 2). This influences the generalisability of the findings, such as the prioritised target behaviours (Chapter 3), which might not be as changeable and impactful in other regions.

Next to the data collection scope, the chosen methodologies also affect the generalisability of the findings. While the interviews (Chapter 2) provided an in-depth assessment of the behavioural system, they did not capture longitudinal data that would allow for tracking long-term temporal dynamics. Similarly, the workshops (Chapters 2&4) primarily provided expert reflections and face validity but did not enable an independent assessment of the real-world applicability of the dynamics or the uptake of CARN. The Delphi panel allowed a plausible prioritisation of target behaviours and BCTs, but the reported score differences were small, suggesting a need for further validation in future research. In addition, the online sample for the experimental evaluation of CARN did not consist of policymakers (Chapter 4). Although policy professionals partaking in the workshop evaluated CARN positively, generalisations to real-world policymaking warrant further inquiries. The experiment did not assess real-world behaviour over time, but it provided early confirmatory evidence for the hypothesised effect on decision performance. As it was based on a single online experiment, this presents promising evidence for CARN's impact that needs to be validated in future replications.

Finally, the investigations focused exclusively on climate adaptation, and they are not directly transferable to other policy challenges, such as climate change mitigation. While specific behavioural dynamics, such as conflicting political priorities (Chapter 2), target behaviours (Chapter 3), interventions preferences (Chapter 3), or CARN effects (Chapter 4) might also apply to other policy domains, this was not examined in this dissertation.

Taken together, the scope of this research leads to the findings primarily being context-specific to Dutch adaptation efforts. They provide a basis for the generation of hypotheses for future scholarly work, which is detailed in the following section.

6.2 Future research directions

In addition to the scientific contributions and findings, all chapters identified future research directions. These directions relate to the core objectives of this dissertation, namely understanding climate adaptation policymaking, improving adaptation decision-making, and bridging behavioural insights and systems analysis.

6.2.1 Understanding climate adaptation policymaking

Existing policy analysis research on structural adaptation barriers has not yet focused on individual-level behaviour, disregarding its potential to enhance adaptation efforts (see Chapter 3). This dissertation shows that

the individual behaviour of policymakers can be both an inhibitor and an accelerator of adaptation progress, indicating three distinctive directions for future research on climate adaptation policymaking.

(1) First, scholars could further explore policymakers' adaptation decision-making in other geographical contexts, as the behavioural interactions and key behaviours might differ substantially due to distinctive actors involved in climate adaptation. For example, in a country with a decentralised governance system, regional actors might play a different role, working with dissimilar resources, responsibilities, and behavioural options. These might in turn lead to distinctive behavioural outcomes, as these factors shape behavioural determinants, such as their capability beliefs. Studying behavioural dynamics in other contexts could establish the basis for comparing decision contexts and behavioural dynamics across countries. Suitable formats could be the development of a behavioural system map, a thematic analysis of interview data, or an expert panel (see Chapters 2&3).

(2) Second, psychological research could continue shifting the focus from citizens to other actors, as others have suggested in the domain of climate change mitigation (Nielsen, Clayton, et al., 2021; Nielsen, Cologna, et al., 2021; Whitmarsh et al., 2021). While researchers often acknowledge that citizens' decisions cannot be accurately described by utility maximisation assumptions, other actors, such as policymakers or business leaders, are often (implicitly) assumed to adhere to economic rationality standards. This dissertation has shown that this assumption might lead to omitting rationality deviations, supplementing recent research on decision-making in public administrations (Banuri et al., 2019; Bolton, 2023; Siders & Pierce, 2021). Accordingly, future inquiries could, for example, replicate the behavioural analysis presented in Chapter 2 with a focus on business leaders or politicians.

(3) Third, research could further examine the behavioural dynamics underpinning climate adaptation progress throughout time, as this dissertation only captured a snapshot of current adaptation efforts. This could be done by comparing multiple behavioural system maps that are updated after a given period or the occurrence of external stressors (e.g., extreme weather events). Such a longitudinal approach would also allow an assessment of the external validity of the behavioural system map.

6.2.2 Improving climate adaptation decision-making

This dissertation has shown that policymakers' individual decision-making can have a significant impact on adaptation policy progress (Chapter 2). It further suggested that the developed metacognitive intervention, CARN, could improve decision-making processes in climate adaptation policymaking by addressing key adaptation behaviours (Chapter 4). Based on the experiment and workshops that were used to evaluate CARN, two primary future research directions emerge.

(1) As of now, CARN's effects have only been tested in a simulated task with an online sample. Future studies could conduct longitudinal field tests of CARN by, for instance, observing a group of adaptation policymakers using it. Alternatively, a panel format with repeated questionnaires could monitor its perceived effectiveness over time. Recent research has highlighted the benefits of studying the long-term effects of boosting, especially to contrast the durability of its effects with nudging (Paunov & Grüne-Yanoff, 2023). Accordingly, a longitudinal study on CARN could increase the understanding of the persistence of its effects.

(2) Scholarly work could also extend and optimise CARN for its uptake in policymaking, which constitutes a behaviour change mechanism in itself. For example, a modular version of CARN, in which reflection modules

can be chosen by the users, would allow the use of a self-tailored version of CARN. Similarly, connecting it to existing policy frameworks in the respective context could also strengthen its integration in existing workflows (Chapter 4). This connection could be facilitated by collecting data in expert interviews or workshops.

6.2.3 Bridging behavioural insights and systems analysis

The integration of behavioural insights and systems analysis in this dissertation suggests a novel approach to studying multi-actor challenges through a behavioural lens. This novel approach presents three directions for future work.

(1) One direction for future research is to compare behavioural dynamics between policy challenges. Complexity scientists have shown that complex systems often share properties (Jensen, 2022; van der Maas, 2025). This leads to the question of whether the dynamics observed in this dissertation also occur in other policy challenges, such as climate change mitigation. Future research could compare behavioural dynamics across policy challenges and explore whether there are intervention types that could be suitable across domains. This would also allow the differentiation between policy challenges based on their behavioural dynamics' properties. In doing this, future work should further test the value of the presented behavioural systems approach for other societal challenges and discern what factors should inform the selection of this comprehensive workflow (e.g., when multiple actors are directly involved).

(2) Scholarly work could also explore what alternative systems analysis methods could, similar to system maps, advance the application of behavioural insights. For example, agent-based modelling could be an equally valuable approach to prioritising intervention spaces (Rietkerk-van der Wijngaart et al., 2025). Future research could therefore assess different methodological approaches within the steps presented in the behavioural systems approach (e.g., Step 4).

(3) As the system-focused behavioural analysis is an essential step of the behavioural systems approach, future work could further advance and evaluate frameworks that can guide it. To date, behavioural insights frameworks often concentrate on intra-individual processes. For example, the TDF only includes one determinant explicitly focused on the environmental context (Atkins et al., 2017). Recent efforts, such as the SeCOM-B (Nguyen-Trung et al., 2025), which bridges the COM-B with socio-ecological models to grasp and differentiate systemic influences on behaviour, provide a promising starting point for the connection of multiple levels of analysis. The SeCOM-B fundamentally aligns with the behavioural systems approach, as it also rejects the dichotomy of individual and systems, approaching them as part of a set of nested layers. Using the SeCOM-B within the behavioural systems approach could facilitate the behavioural analysis, but this warrants further research. Similarly, the Behaviour Change Ball (BCB) could support a system-focused behavioural analysis of policymaking by linking organisational-level behaviours to individual-level determinants (Hendriks et al., 2013). Combining the SeCOM-B and the BCB might allow the connection of a diverse set of behavioural determinants with both individual and organisational behaviours.

6.3 Implications for climate adaptation policymaking

While the chapters in this dissertation have already outlined individual policy implications, the question of what their integration indicates for societal adaptation efforts has yet to be discussed. Taken together, the findings offer several insights for policymakers working on climate adaptation:

1. **Integrated view on climate adaptation.** One aspect that emerged from the interviews, workshops, review of literature, expert prioritisation, and intervention evaluation is that considering climate adaptation's connection and synergies with other policy domains can accelerate adaptation efforts (Chapters 2-4). This means that adaptation should not be approached as an isolated domain but rather as a mainstreamed element in relevant fields such as health, climate change mitigation, infrastructure development, and economic affairs. Practically, this translates to developing adaptation strategies that consider the outlined domains from the start by, for example, consulting other departments early in the process and involving them in the strategy development. This can also strengthen the local support for adaptation measures, especially when the belief that adaptation slows progress in other domains is addressed. While the importance of adaptation mainstreaming has also been noted by others (Braunschweiler & Pütz, 2021), this study shows that analysing the behavioural mechanisms underpinning it can shed light on the success or failure of mainstreaming efforts. Behavioural system maps are a suitable method to support the mainstreaming process, as they offer insights into the involved actors' behaviours and underlying determinants. Accordingly, climate adaptation organisations could build mapping expertise via behavioural advisors or the attendance of existing trainings by international organisations to attain actionable insights on how to foster mainstreaming that go beyond the broader focus of this dissertation. Simultaneously, CARN can be used during adaptation strategy-making to increase the adoption of mainstreaming behaviours.
2. **Consideration of individuals.** The findings presented in Chapters 2, 3, and 4 also emphasise that adaptation policymakers should consider whether local internal and external actors, such as project managers, can become bottlenecks that slow adaptation progress. A behaviourally informed policy would then not only assess the behaviour of citizens in its implementation, but also the behaviour of other actors, especially policymakers. Thereby, policies could be designed in a way that makes them less sensitive to the resistance of relatively few individuals. For example, the key behaviours identified in Chapter 3, such as connecting to other departments, are often carried out by one individual due to resource constraints. This could be prevented by creating policies that mandate this individual to perform certain actions or measures that ensure multi-individual ownership. However, as the research also shows that policymakers are often driving local adaptation, identifying and enabling these individuals might be another strategy worth exploring. In sum, those who formulate policies should explicitly consider the individuals who implement or oversee them to anticipate potential bottleneck effects.
3. **Building local cooperation.** While increasing cooperation is often a recommendation in climate adaptation research and policy research more broadly, Chapters 2, 3, and 4 surfaced insights into how this can be achieved in practice. In particular, the chapters show that for the cooperation with both internal and external actors on the local level, such as businesses, a convincing narrative is essential, adaptation concerns need to be addressed, strategies need to be developed jointly, and synergies need to be made salient. A convincing narrative is one that highlights the advantages of climate adaptation while simultaneously outlining the consequences of not adapting. It is connected to the active engagement with adaptation concerns that collaboration partners might have. For example, Chapter 2 shows that adaptation can be perceived to slow down building processes, result in high costs, or produce unclear benefits. To facilitate cooperation, Chapters 3 and 4 highlight that it is also vital to create ownership and develop strategies jointly. Connected to the findings of Chapter 2, this suggests

that jointly developing strategies can not only improve local cooperation but also political support, as the involvement of other departments can be a decisive cue for pro-adaptation decisions by political leaders. Similar to mainstreaming, CARN, or a similar decision support tool, can be employed to increase the consideration of cooperation in strategic decisions.

4. **Integration of a behavioural perspective.** Participants in Chapters 2 and 4 repeatedly highlighted the value of understanding behaviour in their daily decision-making, articulating a desire to get more practical guidance on how to convince local actors. While there are specific communication guidelines and behavioural insights guidance available for Dutch policymakers, future efforts from national behavioural insights teams and organisations at the science-policy interface could further target their dissemination and adoption in local policymaking. In particular, guidance on how to create a coherent narrative for climate adaptation and convey it locally could strengthen policymakers' ability to communicate effectively. It might also reduce their reliance on consultants as precedent or cooperation brokers by enabling them to establish cooperation themselves.

Moreover, the implications also bear significance for policymakers working with behavioural insights.

1. **Target policymakers' decision-making.** As evident in the rise of governmental behavioural insights units, behavioural perspectives are already applied in policymaking. However, they almost exclusively focus on citizens. Widening this perspective to policymakers, who are subject to the same psychological mechanisms, can provide insights into contextual and psychological influences on their practical decision-making. This can then inform the identification of leverage points and the development of tailored decision support. The findings presented in Chapters 3 and 4 also suggest that it is crucial to consider whether an intervention, such as CARN, a workshop, or a training, is acceptable for policymakers and whether it is implementable in existing decision-making processes. This can affect the scalability and adoption of behavioural interventions. In targeting policymakers, those working with behavioural insights can follow the seven-step behavioural systems approach outlined in this dissertation (see Section 6.1.5). This process enables the development of system-focused interventions in policymakers' decision-making.
2. **View policymaking processes as behavioural systems.** Decision-making processes in policymaking are often conceptualised as linear steps. Adopting a behavioural systems view on these policymaking processes themselves can illuminate when and where which actors influence decision-making processes. Today, stakeholder analyses are already frequently used in policymaking. However, they only capture which actors are involved without specifying their roles or behaviours. Therefore, adding a system-focused behavioural analysis to the more traditional policy analysis approaches can increase the understanding of behaviour in the system. In essence, this means following the first four steps of the presented behavioural systems approach, i.e., problem identification, actor analysis, system-focused behavioural data collection, and behavioural dynamics analysis. By adopting this process, one can attain an understanding of the actors and dynamics that might influence the success of a planned policy (process).
3. **Strengthen competencies, for example, using metacognition.** While Chapters 2 and 3 highlighted the complexity of climate adaptation decision-making and suggested that some behaviours are more impactful than others with regard to societal adaptation outcomes, Chapter 4 showed that inducing

metacognition can help navigate this complexity. This suggests that increasing policymakers' reflective abilities can aid them in navigating wicked problems. Accordingly, metacognition-focused training or tools could be a pathway to improve decision-making in public administrations. Checklists can be a practical means for translating insights gained through a system analysis, such as the ones presented in Chapter 2, into a practical decision aid. For climate adaptation decision-making, CARN can be used and further improved. In other policy domains, metacognitive interventions are scarce or not available at all. Accordingly, policymakers could either develop them internally or outsource their creation to behavioural science experts, for example, by funding research projects.

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Acknowledgements

This dissertation shall allow those interested to understand my PhD journey: the whole painting in Nietzsche's words. For that, one final piece is still missing: the people who enabled me to complete it.

I would like to start by thanking my supervisors, Lisa and Gerdien, for their support, trust, and encouragement. Thank you for being supervisors that every PhD would wish for and for giving me the autonomy that made this PhD feel like my project. (And thank you for tirelessly reading draft after draft of all my ideas - I know it has been a lot.) Lisa, your decision competence, endless knowledge, grit, and kindness make you one of the most inspiring people I have ever met. Thank you for helping me to see what could be truly novel (and what not), for always encouraging me to think about the policy impact of our work, and for giving me advice that will certainly shape my career. Gerdien, your work ethic, communication skills, and empathy have taught me what it takes to succeed in this academic world, and I will try to live up to your example. Thank you for always making the time for me, for your ability to make me see new things with a single question, and for your reassuring pragmatism.

As every behavioural scientist knows, (usually) one of the greatest struggles of behavioural research is finding participants. However, in our project, we encountered a great willingness to contribute to our behavioural inquiry on climate adaptation on all governance levels. I would like to express my gratitude to all participants for accommodating my limited Dutch skills (which are improving), welcoming non-technical perspectives from a TU Delft researcher, and enabling us to complete this project. I am also thankful to those collaborators, especially Gert-Jan and the BIN-NL, who have allowed me to better understand the practice of behavioural insights.

Thank you to all members of my committee for the time they invested in engaging with my thesis. Neelke and Hans, thank you for following my research project from the Go-NoGo Meeting to the dissertation. Stefan, thank you for all our insightful conversations, which I hope will continue in the future. Jan Willem and Lars, thank you for developing inspiring research that encourages PhDs like me to pursue a career in behavioural science.

My colleagues at TPM, I would like to thank you all for creating such a supportive and enjoyable environment. Martijn, thank you for mentoring me throughout this PhD. Your knowledge of the academic world has been invaluable. A special thank you to Nely and Pouria, the best paranymphs I could have wished for. Nely, thank you for all the snacks along the way, which served as the fuel for my PhD. You were and are the most wonderful office mate and have become a dear friend. Pouria, I have enjoyed every single burrito and conversation with you (and the elegance of your 'not too bad'). I hope that this tradition will continue in the future. To my colleagues, Ignasi (the best PhD buddy), Thorid, Aashna, Adrien, Joos, Astha, Paula, Palok, Liz, Kailas, Lukas, Lynn, Mariëlle, Fabiën, Jorine, Tineke, Leon, Pieter, and many more, thank you for all the great conversations and support. Karoline, Willem, Jen, and Janniina, thank you for being such great office mates. I would also like to thank the students that I have engaged with as part of my PhD, especially Suzanne, Simone, and Ralph, for their curiosity and dedication.

Throughout my PhD, I have enjoyed many conversations with researchers whom I wish to acknowledge as a source of inspiration. In particular, my research visit to Monash University provided an opportunity for many stimulating conversations. A special thank you to Filia and Stefan, who made this visit so memorable. Annette,

Liam, Martijn, and Michelle, thank you for opening doors for me and for all the great conversations. And also thank you to the PhD community at Monash, which has welcomed me so warmly. I am grateful to the KNAW for funding this visit.

I would also like to thank those who have led me to understand that a PhD is an immensely exciting endeavour (which I still think it is): Tereza, Nick, Natascha, Ulrich, and Arnaud. Our conversations have led me down the (for me) right path.

Vielen Dank an meine Eltern, die mich bei all meinen Vorhaben unterstützt haben. Mama, ohne deine Unterstützung wäre dieser PhD, und alles was davor kam und noch kommen wird, niemals möglich gewesen. Papa, die von dir gelernte Disziplin hat es mir ermöglicht, diesen Weg zu gehen.

Finally, Jule, I will forever be grateful for your support and love. You bring so much happiness and warmth in my life, and I feel incredibly lucky to have you by my side.

About the author

Kai Philip Bellmann (b.2000, Berlin, Germany) completed his Bachelor of Science in Business Psychology at Hochschule Fresenius in Berlin. Due to his increasing interest in political decision-making, he decided to pursue a Master of Science in Political Psychology of International Relations at the University of Birmingham. In his thesis, he researched how inter-country economic inequality shapes emotions, political preferences, trust, and solidarity. Seeking a deeper understanding of how human behaviour intersects with policymaking and governance challenges, he then completed a second master's programme jointly delivered by LUISS School of Government in Rome and the Centre International de Formation Européenne in Berlin and Nice. The programme, called Global Economic Governance and Public Affairs, also allowed him to obtain the certification as Policy Officer in European and International Organisations. His thesis investigated the mitigation of system justification tendencies in the acceptance of transformative policy proposals. Drawn to the interdisciplinarity at the Faculty of Technology, Policy and Management at Delft University of Technology, he started his PhD research as a member of the Policy Analysis Section. His research focuses on connecting behavioural science and systems analysis to study policymakers' climate adaptation decision-making.

List of publications

Bellmann, K. P., de Vries, G., & Scholten, L. (2025). Understanding slow progress on urban climate adaptation: An empirical analysis of behavioural dynamics in Dutch policymaking. *Journal of Environmental Psychology*, 105, 102666. <https://doi.org/10.1016/j.jenvp.2025.102666>.

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Bellmann, K. P., Scholten, L., & de Vries, G. (under review). Development and evaluation of a metacognitive intervention to improve policymakers' climate adaptation decision-making. *Manuscript under Review*.

Bellmann, K. P. (2026). Did I consider that? How metacognition can improve (your) decision-making. *Center for Behavioural Decisions*.

Bellmann, K. P., de Vries, G., & Scholten, L. (in preparation). Did I consider that? Boosting decision-making through metacognitive interventions. *Manuscript in preparation*.

Presentations

Bellmann, K. P., de Vries, G., & Scholten, L. (2024). Decoding Multi-Actor Decision-Making in Urban Climate Adaptation Using Behavioural Insights. Urban Transitions 2024. Sitges, Spain.

Bellmann, K. P., de Vries, G., & Scholten, L. (2024). Investigating policymakers' climate adaptation decision-making. Social Innovation in the Energy Transition Platform. Virtual presentation.

Bellmann, K. P., de Vries, G., & Scholten, L. (2025). The Psychology of Urban Climate Adaptation: Identifying Behavioural Influences and Dynamics in Policy Decision-Making. International Conference of Environmental Psychology. Vilnius, Lithuania.

Bellmann, K. P., de Vries, G., & Scholten, L. (2025). The Psychology of Urban Climate Adaptation: Identifying Behavioural Influences and Dynamics in Policy Decision-Making. UCL Behaviour Change Conference. Lisbon, Portugal.

Bellmann, K. P., de Vries, G., & Scholten, L. (2025). Understanding slow progress on urban climate adaptation: An empirical analysis of behavioural dynamics in Dutch policymaking. Rijkswaterstaat. Behavioral Operation Research Brown Bag Seminar Series. Virtual presentation.

Bellmann, K. P., de Vries, G., & Scholten, L. (2025). The Psychology of Urban Climate Adaptation: Identifying Behavioural Influences and Dynamics in Policy Decision-Making. Symposium: Research and Policy for the Climate: Insights from behavioral, psychological, and political sciences. Brussels, Belgium.

Bellmann, K. P., de Vries, G., & Scholten, L. (2025). Understanding slow progress on urban climate adaptation: An empirical analysis of behavioural dynamics in Dutch policymaking. Behavioural Insights Team Directurenoverleg, Ministry of Infrastructure and Water Management. The Hague. The Netherlands.

Bellmann, K. P., de Vries, G., & Scholten, L. (2025). Understanding slow progress on urban climate adaptation: An empirical analysis of behavioural dynamics in Dutch policymaking. Behavioural Insights Team Bühne. Virtual presentation.

Bellmann, K. P., de Vries, G., & Scholten, L. (2025). Understanding slow progress on urban climate adaptation: An empirical analysis of behavioural dynamics in Dutch policymaking. Rijkswaterstaat. Virtual presentation.

Bellmann, K. P. (2026). Behavioural Systems Mapping in Practice. BESEY Behavioural Systems Group. Virtual Presentation.

Bellmann, K. P., Scholten, L. & de Vries, G. (2026). Development and evaluation of a metacognitive behavioural intervention to improve policymakers' climate adaptation decision-making. UCL Behaviour Change Conference. Lisbon, Portugal.

