



Adaptation pathways in planning for uncertain climate change: Applications in Portugal, the Czech Republic and the Netherlands



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ABSTRACT

Adaptation pathways are developed to design adaptive policies to handle climate change uncertainty. Use of this tool varies across planning practices and adaptation challenges and adjusting the tool to particular practices can foster its adequate use. To gain insight into the use of adaptation pathways, we compared four initiatives (one each in Portugal and the Czech Republic and two in the Netherlands) with regard to design choices made. We found six design choices which need to be considered when adjusting adaptation pathways. Design choices about the geographic scale, inclusion of sectors, the generation and delineation of adaptation options, specification of possible pathways, the related performance metrics and the type of assessment are interdependent, but they are also influenced by contextual aspects. Analysis of the institutional diversity, planning culture and framing shows that the use of adaptation pathways is flexible enough to be adjusted for diverging planning practices. However, the tool is best suited to deliver local adaptation solutions, and adequate use depends on consensus about the adaptation problem, setting objective thresholds and determining uncertainty about future change. We conclude that understanding the customised use of tools for local planning practices is essential for adaptive policy design.

1. Introduction

Climate change is full of uncertainty, therefore adaptation should entail a portfolio of response options (Pielke, 1998; Henstra, 2016). To prepare climate adaptation policy, adaptive planning tools address these uncertainties by assessing different proposed responses. The adaptation pathways approach (Haasnoot et al., 2012, 2013) is a promising adaptive planning tool. In addition to traditional scenario analysis tools, in which the impact of different climate scenarios and possible responses are assessed (Van Vliet and Kok, 2015), adaptation pathways start analysis with the possible extension over time of feasible options under climate change. Additionally, the tool aids in studying if and how current portfolios of responses can be diversified through adaptation measures. Adaptation pathways claim to support policy-making by offering five contributions: (1) using objective-based thresholds; (2) handling uncertainty in principal drivers; (3) structuring

a wealth of adaptation options; (4) pointing out possible lock-ins; and (5) incorporating multiple stakeholder preferences (Haasnoot et al., 2012).

In planning processes, planners and policymakers need to make choices about issues, such as the demarcation of the system, the geographic scale at which adaptation responses are assessed, specification of adaptation measures and the necessity and possibility of quantifying the effects of interventions. These choices will influence the contributions and outcomes of using the adaptation pathway tool. A clearer understanding of how these design choices are made and their consequences will enable planners to better operationalize them for their particular planning practices. Better choices and operationalization of tools can improve the quality and effectiveness of adaptive policies. Moreover, planners may want to know the possible pitfalls of any tool. Such knowledge can increase the quality of the process and enhance usefulness and legitimacy of the developed adaptation responses.

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We start from the premise that design choices about the use of adaptation pathways determine the process after a specific direction is chosen. These can be conceptualized as boundary choices which structure how a planning process will unfold (Karstens, 2009; Van Broekhoven et al., 2015). When choosing the design of an adaptation pathway, planners are confronted with dilemmas concerning the benefits and downsides of particular choices. Analysis of the use of one specific tool in different planning practices can contribute to studies comparing various policy tools or adaptation policies across multiple contexts (e.g., Bubeck et al., 2015; Eikelboom and Janssen, 2017). Studying applications of adaptation pathways in different situations offers the opportunity to learn how the tool was used and which choices were made to adjust it to diverging circumstances. Moreover, such analysis can offer insight in the adequacy of the tool to deliver the five claimed contributions in different adaptation planning practices.

Our main objective is to study the use of the tool in different planning practices to gain an understanding of the design choices available to planners. Additionally, we want to gain insight into their consequences and the relation of choices to specific adaptation practices. We answer two related questions: ‘Which choices structure the use of adaptation pathways in different adaptation planning practices?’ and ‘To what extent is the customised use of adaptation pathways in different planning practices adequate?’ To this end we studied four applications of adaptation pathways (one each in Portugal and the Czech Republic and two in the Netherlands) and compared the processes of how users (e.g. planners, facilitators, policy-makers) of the tool chose a particular design of pathway and how the tools were used during specific planning processes. In the next section, we outline our research approach. Following this, we describe which design choices determined the use of the adaptation pathways in the four cases and outline why planners made particular choices. In the fourth section, we reflect on the design choices and contextual aspects which influenced which choice was made. Lastly, we discuss our findings in light of the use of adaptive planning tools for climate adaptation and present our conclusions.

2. Research approach

Key ingredients of the adaptation pathways are to identify adaptation tipping points (Kwadijk et al., 2010), to explore possible pathways and to monitor critical developments that start from the premise that policy responses have an expiration date. An adaptation tipping point is reached when the magnitude of external change is such that a policy response no longer meets its objectives. The ineffectiveness of a policy response will depend on how the future develops and can be assessed through scenario studies. Tipping points can be assessed to gain insight into the opportunity to appropriately adapt, postpone or antedate a response when new information about changing conditions is gained (Van der Vlist et al., 2015).

The aim of adaptation pathways is to select a set of policy responses by timing and sequencing different response options in light of one or more drivers of future change (Haasnoot et al., 2013). Planners generally do this in several steps, which results in a sequence of policy responses over time to achieve a set of pre-specified objectives under uncertain changing conditions (Haasnoot et al., 2012). For the purpose of communication, pathways can be depicted as a map showing different interconnected paths (Fig. 1). Planners can assess paths regarding different time horizons and scenarios using multi-criteria scorecards or cost-benefit analysis techniques (Haasnoot et al., 2013).

Planners need to take four steps to create an adaptation pathways map. These are related to four of the contributions mentioned in the introduction:

1. Set the objectives, performance metrics and related threshold values. This contributes to using objective based thresholds.
2. Assess adaptation tipping points for the current policy or

management situation, based on thresholds under different scenarios. This contributes to the handling of uncertainty in drivers of change.

3. Explore and select policy responses and assess their adaptation tipping points. This supports the structuring of a wealth of options.
4. Combine the different responses into combinations of alternative pathways which can be assessed on costs and benefits and multiple criteria to enable the selection of a preferred path. This helps highlight possible lock-ins.

The fifth contribution, incorporating multiple stakeholder preferences, is not embedded in a specific step but relevant for each of the four steps.

When an adaptation pathways map is created, planners need a monitoring system to collect information for early warning signals (triggers) to alter, or adjust (i.e. advance or postpone) policy responses. In each of the steps, design choices have to be made which are of profound importance for the use of adaptation pathways, but those choices are not set by the tool itself. Instead, users assess their specific situations, which determines to a large extent the effectiveness of the tool and the quality of its outcomes. The contribution of each step depends on the design choices of planners regarding the operationalization of each step in their particular situation.

We approached the use of adaptation pathways through the aforementioned steps and explored these steps for possible design choices and contextual variables that determined the outcome of these choices in the four cases. We carried out a comparative case study of applications of the pathways in four planning processes to develop policies to adapt to climate change (Farthing, 2016). Our cases differ regarding their planning objective, scope, amount of participation and planning culture. The cases were part of the European research project Bottom-up climate Adaptation Strategies towards a sustainable Europe (BASE) (BASE, 2016). In this project, 22 case studies across Europe were conducted to gather insight into sector-specific adaptation activities and to examine interactions across multiple policy levels. For this, planners used multiple adaptation analysis methods in which they received training through workshops.

We used four of these case studies for our comparison: the Ílhavo and Vagos Coast in Portugal, Prague in the Czech Republic and IJsselmeer and Rotterdam in the Netherlands. In each of these cases, planners used adaptation pathways to assess climate adaptation responses, but for different types of climate impacts. Moreover, we chose these cases because they have distinctly different planning objectives and scopes (both spatially and in adaptation responses) and a different emphasis on participation within BASE. Lastly, in the design of the study, the planners in the cases went through each of the four steps described above.

We took a comparative approach in which the planners in each of the cases were trained to use the adaptation pathways and apply them in their specific case studies. Subsequently, during the planning process, the experimental application of pathways was observed and reflected upon as the cases progressed through the different steps of the adaptation pathways. Each of the cases has a distinct methodology, data collection and analysis. The Ílhavo and Vagos Coast case was based on participatory action research, spatial modelling and interviews; the Prague case on spatial analysis, and additional interviews and a workshop; the IJsselmeer case on focus groups and interviews; and Rotterdam on action research, interviews and spatial and economic assessments. The results of these studies were separately documented for each case (BASE, 2016). These case documents were analysed to identify a list of questions for a comparative analysis. Based on these questions and written data, the first author conducted reflective interviews with the case study planners about their use of the tool and choices during the process. We used these reflections to create case narratives, describing the use of pathways, the justification of different methodical steps in the cases, the aspects that may influence why a

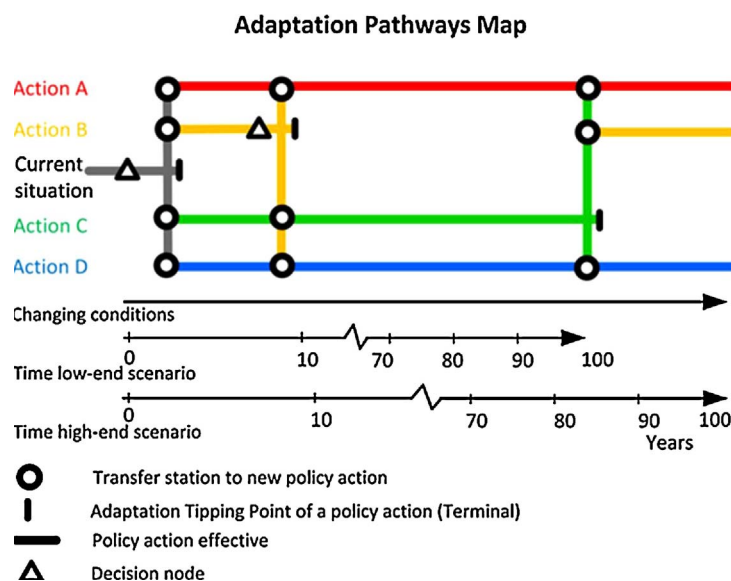


Fig. 1. Adaptation pathways depicted in their original conceptualisation with four different actions and adaptation tipping points and scenarios on the x-axis (Haasnoot et al., 2013).

choice was made and which consequences this may have for the outcomes. These case narratives were crosschecked with the BASE case documents and the case study planners and, lastly, compared to derive insights into the main commonalities and differences in how choices were made during the application of the adaptation pathways.

3. Adaptation pathways in four cases

In this section we first give a general description of the location, context and identified adaptation problem for each case. Then, we describe the application of adaptation pathways, the different steps taken and the design choices made in the four cases.

3.1. Water resource management in the IJsselmeer

The IJsselmeer is an estuary that was dammed and separated from the Wadden Sea in the 1930s and comprises 1100 km² of water. The IJsselmeer is managed for flood safety and to supply of fresh water. Adaptation was deemed pivotal due to altered discharge from the IJssel river (a tributary of the Rhine river), sea levels rising, and an increasing prevalence of drought. The Delta Programme IJsselmeer was run from 2010 to 2014 to study the possible policy actions for climate change adaptation in the water system (DP, 2014). This programme was a multi-level and cross-governmental programme to develop a nationwide strategy and six regional strategies for long-term flood risk and water resources management. Policy-makers developed long-term water resource management strategies for the IJsselmeer's water level and water usage in the regions along the lake.

Adaptation pathways were used to address the cost-effectiveness of preliminary policy options, to assess possible options and to communicate these with (non-governmental) partners. The objectives were to sustain long-term flood safety and the regional water supply. Planners set the performance metrics for the drivers of change, which were sea level rise and altered discharge of the IJssel river, both related to minimum and maximum water levels of the lake. For flooding, the threshold is a maximum water level, while for water supply a minimum water level determines the additional buffer size of the lake. The national Delta Programme centrally determined the stressors and surrounding uncertainty in four scenarios.

The planners determined options based on the primary choices of adjusting the water level, affecting the area along the lake, or maintaining current water levels, both affecting the discharge regime into the Wadden Sea. They based adaptation tipping points on alterations of

the water level under projections for low and high sea level rises in 2100 and were also informed by studies executed for the different regions around the lake. The simplicity of the performance metrics and thresholds, both related to specific water level alterations, allowed for quantitative assessment of current and alternative strategies under increasing sea level rise and assumptions about water inflow.

By means of the pathways, planners evaluated possible options and stakeholder preferences. In doing so, they considered packages of technical and governance measures. According to the planners, the preliminary conceptualisation of paths was less useful, because the large number of options rendered them unhelpful for communicating and progressing to the final policy decisions. Moreover, stakeholders had difficulty understanding the pathway maps. They perceived a large number of options as irrelevant due to the physical characteristics of the management problem. The final path consists of more flexible yearly water level management in the short term and building pumping capacity to drain the lake on the longer term (after 2050) (DP, 2014). According to the planners, this reflects a preference for flexibility, since the other main strategy (increasing water levels) would need major investments in dyke reinforcements and alterations of regional drainage capacity (BASE, 2016).

3.2. Coastal management in Ílhavo and Vagos, Portugal

On the west coast of Portugal, the highly vulnerable stretch of low-lying dune barrier (~20 km) belonging to the municipalities of Ílhavo and Vagos is particularly exposed to coastal erosion, storm surges and flood risks (Alves et al., 2011; Dias et al., 2014). Aware of the role and conflicts of different actors in the co-construction and implementation of coastal adaptation policy, planners integrated the use of the adaptation pathways in a broader participatory approach based on the Scenario Workshop method (Schmidt-Thomé and Klein 2013; Campos et al., 2016a). This method included three stages (i.e. critique, vision and action-plan) over two full-day workshops (held one month apart) and was complemented by risk assessment studies, a multi-criteria analysis, and a cost-benefit analysis. The objective for the case was to find consensus on a set of policy options and develop an adaptation action-plan for the future.

The facilitating team structured the adaptation measures, conducted a multi-criteria study based on the adaptation options chosen during the first workshop and designed a set of possible adaptation pathways. There were no predefined explicit objectives, although in the first workshop two objectives were defined: retaining flood safety and

supporting the local economy by retaining a sandy beach. These objectives were not predetermined, but participants recognised the flood safety objective as enabling a healthy coastline, a precondition for other economic objectives. The planners asked participants to choose their preferred adaptation pathways or design their own pathways by combining predefined pathways based on their tacit knowledge of the area. The planners informed participants with printed versions of potential adaptation pathways and results of a multi-criteria analysis. Five sub-groups worked out the specific issues for five sub-stretches of the coastal area with distinct geographical characteristics. This resulted in five pathway maps, one for each sub-stretch of the coastline, hand-designed by participants and based on the potential for adaptation. In consultation with the participants of the workshop, these pathways were aggregated into one set of final pathways applicable to the whole coastal zone of Ílhavo and Vagos. This was possible due to the similarity of the measures and the adaptation tipping-points across the five interdependent sub-regions (BASE, 2016).

The main stressors were coastal erosion and overtopping, potentially accelerated by sea level rise. Uncertainty in this stressor did not play a large role, since the tipping points were defined for the worst case scenario (RCP 8.5 and 100 year flood). Adaptation tipping points were determined based on spatially modelling coastal erosion and overtopping, fitted to the regional circumstances and climate scenarios. The derived measurable objective is restoring and maintaining a safe coast for which erosion needs to be mitigated. Although multiple paths were brought to the attention of stakeholders, the workshop participants (e.g., farmers, inhabitants, fishermen and the mayors of the municipalities) placed emphasis on technical options (e.g., sand nourishment or groynes) and discarded legal or spatial options (e.g. expropriation of farmers for flood protection); because these solutions may be expensive and only able to postpone tipping points for the local situation.

3.3. Managing the urban heat island effect in Prague, Czech Republic

In Prague, adaptation pathways were used to explore solutions for the urban heat island (UHI) effect in the city district Prague 6. In this district, several developments are taking place, including construction of administrative buildings and planned renovation of the neighbourhood near the Czech Technical University's campus. The planned developments include building on current green space and replacing parks with office buildings. The effects of the proposed redevelopment and the possibilities to lower the UHI effect were the main impetus for the study (BASE, 2016).

Climate projections for the coming 30 years in the Czech Republic show increases in the number of tropical days and nights compared to the period between 1961 and 2012. A similar trend for the number of heatwaves is predicted (Štěpánek et al., 2016). The UHI potential for the climate projections and the effects of ameliorating measures were assessed with an urban heat mapping tool, based on climatic factors with the UHI potential based on current and future land use. The performance metric was the UHI potential of interventions. The urban heat mapping tool was used by planners to quantify UHI potential of different land uses on a 10-point scale and they determined that a UHI value of 6 would be so severe that it was chosen as an adaptation tipping point for changes in land surface. Then, planners distinguished adaptation tipping points based on percentages of ameliorating land uses by UHI. By including changes in urban land use, the pathways show the relative effect of different measures on the UHI and the impact of urban plans on future UHI effects. Policy makers indicated that while the types of measures were deemed less applicable for direct adaptation policy interventions, the intention and conceptualisation of the pathways were interesting and useful to adapt urban development plans. During a participatory seminar in Prague, stakeholders prioritized UHI and risk of heatwaves as the main climate related impacts. The use of the UHI tool in combination with pathways and mapping of stakeholder

preferences was, however, difficult because more information was needed concerning different land uses, specific measures (the effect of green roofs versus a pond versus a park, etc.) and their ameliorating effect on UHI.

3.4. Flood risk management in Rotterdam

Rotterdam is located in the Rhine-Meuse delta and is flood-prone due to peak river discharges and storm surges, which will increase due to climate change (Jeuken et al., 2015). Planners used adaptation pathways in the context of the Delta Programme Rijnmond-Drechtsteden, with the objective to provide region-wide strategies for long-term flood risk management. Planners conceptualized adaptation pathways as 'development paths' indicating the timely order of decisions and envisioned them as a tool to assess costs and benefits of different adaptation strategies and to inform the participatory process. The objective to reduce flood risk was considerably elaborated based on exactly determined water levels. In addition to these objectives, planners added the analysis of economic effects on assets, inhabitants of the area and the harbour-based economy to understand the wider impacts of flood risk reduction measures. The planners used intermediate pathways for sub-areas and economically informed pathways during strategy formulation. According to an interviewee, these pathways showed clear optimal policy approaches and timing of when adaptation tipping points may occur. This was also due to a few quantifiable tipping points that included one dominant threshold for determining options and which coincided with the expected technical lifetime of the Maeslant storm surge barrier (BASE, 2016).

Though they assess policy options and their timely effects in the face of drivers of change, the final pathways proposed by the Delta Programme are very general and lack details about tipping points and transfer options (DP, 2014). According to an interviewee, this was due to the shift in objective and performance metrics from height and associated water levels to the strength of the dykes, which depends more on the duration of high water levels instead of the most extreme levels (BASE, 2016). This changed the set of options and the valuation of possible solutions, because an additional performance metric was included. The underlying discussion is that for height, options include building higher dykes, lowering the water level through altering the river bed or closing the delta on the seaward side.

Due to the regional scale and the long time horizon of the Delta Programme, intensive discussions about the objectives and desirable strategies took place, involving stakeholders groups and all levels of government. At the start, the process reflected different perspectives (i.e. a nature-friendly open estuary versus a closed system with barriers). In the end, one path was chosen, as the decision-makers discarded alternative paths that remain options for the long term. This choice came about due to the geographical diversity of the area, with the problem shifting from the west side were the height of the dykes is an issue, to the east, were strength of the dykes is an issue. Moreover, the complexity of the institutional setting led to deferments on fore-closing options such as river bed alterations or dyke reinforcements.

4. Comparison

When reflecting on the cases and comparing them, two aspects are pertinent. The design choices which are chosen and the external factors that influence these choices. Each of the four cases has taken the steps which make up the adaptation pathways tool. As evidenced in the four descriptions above, there are large differences between the cases as to how the planners undertook each of the four steps (Table 1).

From the cases, we found that planners can design adaptation pathways in different ways. The geographic scale on which pathways are formulated ranges from a small coastal stretch (Ílhavo and Vagos) to a large delta area with different land uses and drivers of change (Rotterdam). Planners also deliberately chose the number of sectors to

Table 1
The choices made in each case for the four steps of the adaptation pathways.

| Steps | Set objectives, performance metrics, threshold values | Assess tipping points under different scenarios | Select policy responses and assess tipping points | Combine responses in alternative pathways & assess impacts |
|----------------------------------|--|---|---|--|
| IJsselmeer, Netherlands | Sustaining long-term water supply and flood risk safety | Lake's water levels, specified in cm | Participation of experts and policymakers | 2D hydraulic model |
| Ílhavo and Vagos Coast, Portugal | Sustaining the ability to protect coastal areas under influence of sea level rise, increasing erosion and flood risk | General effects on coast, unspecified threshold values | Participation of experts and stakeholders | Scenario Workshop/Multi-criteria analysis |
| Prague, Czech Republic | Sustainability of measures to decrease urban heat | Urban heat, specified threshold values in% urban heat potential | Expert-based | GIS mapping, urban heat tool |
| Rotterdam, Netherlands | Supporting on-going flood risk management | Water levels, costs or damage; End of lifetime of storm surge barrier | Participation of experts and policymakers | 2D hydraulic model, cost-effectiveness analysis |

be involved in the planning process, leading to more or less integrated sets of pathways (IJsselmeer and Prague, respectively). Planners in each of the four cases chose how much participation to allow or deliberately organise in order to generate and delineate options. In the Prague case, participation was almost absent while – on the other end of the spectrum – participation was deliberately organised in the Portuguese case. This influences two other design choices: the specification of pathways and the related performance metrics and threshold values. Planners can choose generic paths without clear thresholds or specification of detailed paths and objective thresholds. For example, planners reduced the IJsselmeer pathways to the most decisive paths but made specific and contained detailed thresholds, while planners in the Rotterdam case only chose several generic paths without clear thresholds or performance metrics (DP, 2014). The sixth choice we found to be decisive for the design of pathways and their implementation is the way of assessing them. In the cases studied, these ranged from GIS mapping (Prague) to hydraulic models (IJsselmeer) to cost-effectiveness (Rotterdam) to participative assessment (Ílhavo and Vagos).

We found these six design choices to be decisive when using and embedding the pathways within the particular adaptation planning processes. But this raises a second important issue, namely to what extent the choices made in each of the cases were adequate to achieve the advantages claimed by the adaptation pathways tool. This depended strongly on how choices were made. We found that, in no case, were the involved design choices made independently. Each choice influenced other choices. For example, the geographic scale determines which sectors and stakeholders might be included in the process, which further determines the generation of options. Another example is the determination of specific pathways and indicators. These are influenced by the choice of how options are generated and delineated. In addition to such interdependencies between choices, we found that each of the individual design choices and the involved aspects were also structured by the context of the particular planning practice. When comparing the four cases, we found that three distinct but tightly interlinked aspects influenced how planners chose to design the adaptation pathways and their implementation. These aspects are the institutional diversity affecting a planning problem, the particular planning culture and the framing of objectives and uncertainty. We turn to these three influential aspects to assess whether the adaptation pathways delivered on their claimed contributions.

4.1. Institutional diversity

In the IJsselmeer case, the wealth of options generated during the process provoked much debate. This was partly due to the diversity of actors involved. Actors did not always accept the extreme climatic scenarios and the package of options initially proposed for the area. Some actors were suspected of actively thwarting the planning process, making the use of the adaptation pathways difficult. According to the planners in this case, the hybrid top-down national and bottom-up regional planning process explains part of this difficulty. While main objectives and scenarios with related uncertainty were established in a top-down manner, helping national consistency, this approach lacked a shared problem-perception, leading actors to oppose them. According to the planners, the straightforward participative use of the pathways in the Ílhavo and Vagos case enabled the inclusion of a diverse set of visions on the coastal zone. The speed with which the workshop participants resorted to only physical options during the construction of pathways might explain the easy inclusion of diverse visions on the coast. Other aspects that led to easy inclusion were the use of scenario workshop methodology, which made clear what the question at hand, the easy visualisation of the proposed adaptation pathways and skilled facilitation (Campos et al., 2016b). In the Prague case, the options were not discussed with different actors, so nothing meaningful can be said about the effects of institutional diversity in this case. In Rotterdam, institutional diversity led to a significant emphasis on the contribution

of each of the options to local areas, while the pathways for the regional scale lacked choices between paths (DP, 2014). Moreover, according to an interviewee, the vested interests and the power of the shipping industry made the harbour activities partly decisive for the strategies. According to the planner and reflected in the final pathways (DP, 2014), the mismatch between geographic and institutional scales led to fuzzy thresholds, a large array of options and unclear institutional responsibilities for specific paths.

4.2. Planning culture

In the IJsselmeer case, discussing an unfavourable option (a strong increase of the water level) led to a heated debate. The decision makers discarded this option due to the strong preferences of stakeholders and the involved financial costs. This, as we discussed in a focus group, can be partly attributed to a planning culture which heavily relies on a perception of the manageability of the water level (Faludi, 2005). In Portugal's coastal planning culture, technical options and civil engineering are highly dominant (Schmidt et al., 2014). The pathways seem to sustain such a technical perception. According to the planners, other options (e.g., restrictive land use policies, legal prohibitions for coastal settlements or insurance options) were not extensively considered. In this sense, chosen pathways can reinforce a dominant lock-in or challenge the dominant culture, if unfavourable options are considered. Prague's planning culture might be regarded as a major obstruction for public adaptation efforts, as was shown by Maier (2000). When the developer took over the area's developments, the power of the municipality to alter its course was rendered obsolete, because local government has a weak position in urban development (Spilková and Perfin, 2010). This made the use of the tool redundant, because it was not introduced in the initial phases of the planning process. The acceptance of the information delivered by the pathways was, according to the local planners, low. Determining the exact effects of the functioning of the adaptation pathways in this context is difficult, because decision makers might react negatively for other reasons not queried in our case. In Rotterdam, an interviewee indicated that opting for specific geographic boundaries builds on the economic importance of the area but further exploration of this comment did not fit in the structure of our research. Past planning choices led to starting with these specific boundaries, which included an area with a large geographic diversity. This hindered the creation of a specific strategy for the whole area and negatively influenced the use of the pathways throughout the process, leading to unrefined pathways without clear thresholds.

4.3. Framing objectives and uncertainty

The Dutch parliament formulated the objectives for the IJsselmeer and Rotterdam cases, and they adjusted them for the IJsselmeer case during the process. This negated the possibility of several options, especially those pertaining to spatial measures. In Rotterdam, the objective to cope with water levels (associated with rare extremes) led to options which were later deemed redundant. Executed assessments showed a low relevance of this objective for the more important issue of dyke strength. Moreover, several options were already integrated in the objectives and problem statement. We observed that the continuous and prolonged debate led to constant reframing of objectives and thresholds for some of the regional scale options. This diminishes the prevention of lock-ins, although we observed that the pathways helped to think through the consequences of choices. This indicates that pathways work best with upfront agreement on what the objectives and solutions are.

In the Portuguese case, the framing of objectives influenced the considered options. When reflecting on the process we observed that the objectives (to protect populations and the beach and to prevent further erosion of the dune system and the connection between the sea and the lagoon) which could be translated into measures, already had a seaward focus and a spatial-technical connotation. In Prague,

communication and framing of both the objectives and options were not a shared endeavour, rendering the advice to increase either green or blue space in the redevelopment project difficult. That Prague's policymakers judged the options as unrealistic might be due to the specific presentation of the options as percentages of land uses. This could be overcome by translating the availability of space into more specific measures (e.g. green roofs and parks). Another solution in the design of the pathways might be a collaborative framing of the objectives with decision makers to increase the acceptance of the resulting pathways, as was done in the Portuguese case.

Concerning uncertainty, all of the pathways show a small bandwidth of uncertainty in the scenarios. In the IJsselmeer case, uncertainty in sea level rise was framed as being clear and small (BASE, 2016). The strategy could thus be reduced to two options, with the timing of the options being quite certain. Reflecting on the final set of pathways, they seemed to fall short of expectations of what the tool could offer regarding uncertainty: structuring a wealth of options and highlighting lock-ins. In the Ílhavo and Vagos case, some uncertainty remained about the effectiveness of options. After the scenario workshops, technical and cost-benefit analyses of the options in the final pathways clarified at least some uncertainty. The scenarios did not show much uncertainty, because erosion is an actual problem, and sea level rise was perceived as a certain, steady process. The adaptation pathways in Prague remained uncertain as to the effectiveness of the options, requiring further specification in terms of particular green and blue measures and their cooling effect. In Rotterdam, all options were left open until 2100 (DP, 2014). This presupposes that the planners do not see uncertainty as affecting the adequateness of the interventions on the mid or long term (cf. Zandvoort et al., 2017).

4.4. The contributions of adaptation pathways

The institutional diversity, planning culture and framing of objectives and uncertainty influenced the six design choices in each of the four cases. This influenced whether the adaptation pathways tool could deliver on its five claims and how planners could go about the design choices when using pathways in their local situation (Table 2). In general, the institutional diversity affected three contributions – i.e. the determination of objective thresholds, the generation and subsequent structuring of options and accounting for preferences during the process. The use of adaptation pathways was hindered on a regional planning scale by the diversity of involved actors. In general, a higher institutional diversity was more problematic for delivering these three contributions. To cope with actor diversity and avoid unclear pathways, planners should make sure that actor preferences are represented in objectives before venturing into next steps. Thus, the tool can best be used from the start of the planning process onwards.

Planning cultures mainly affect the contribution of pathways to identify possible lock-ins and the generation and structuring of a wealth of options. Deeply engrained visions in planning cultures create a lock-in that should be accounted for when adaptive planning is brought forward. In order to establish objective thresholds and identify lock-ins, scales matter. The cases show that planning cultures can be challenged or sustained by pathways and that choices are strongly informed by default thinking of how things ought to be done in particular situations. None of the cases shows a strongly diverging trajectory or a transition towards different interventions (BASE, 2016). The use of pathways in each of the four cases depended on how geographic boundaries were set. We found that adequate use of pathways is more feasible on a local planning scale and with options broadly addressing the physical or natural environment than options on a regional scale with distributed institutional networks and non-physical or non-natural environmental. To cope diverse spatial characteristics and stakeholder preferences, sensible categorisation of different interventions and packages of similar projects and interventions, such as river widening or urban greening, may help develop strategies for larger geographical scales. To

Table 2
The contributions of adaptation pathways in each of the four cases.

| Contributions Cases | Use objective based thresholds | Handle uncertainty in principle drivers | Structure a wealth of options | Identify possible lock-in | Incorporate multiple stakeholder preferences |
|---------------------|--|--|--|---|--|
| Usselmeier | Hybrid scales rendered objective thresholds difficult | Scenarios were not accepted by all actors | Debate due to a diversity of actors. Preferences and financial implications led to rejection of multiple options | An unfavourable option led to heated debate partly due to a perception of the manageability of the water level | Lack of a shared problem perception |
| Ílhavo and Vagos | Predetermined objectives led to (coarse) thresholds about which consensus existed | Succeeded due to scenario workshop methodology | A technical perception was dominant due to existing preferences within this set, structuring of options was effective | Pathways were used to uphold a lock-in/ dominant culture but were fairly effective in showing the lock-ins | Straightforward inclusion led to open debate and consensus |
| Prague | A late introduction of the tool and weak role of local government made the tool redundant | The expert-based approach led to a fairly straightforward handling of uncertainty | Framing the objectives led to coarse options for the area and a lack of structuring effects between options | Information about lock-ins was not effective for redevelopment because it was not assessed by stakeholders | Incorporation was not considered. Acceptance of information from the tool was low |
| Rotterdam | Mismatch between scales led to fuzzy thresholds and debate about objectives during the process | Unclear which uncertainty to handle led to reiteration of the pathways during the process, reducing their effectiveness | There were no clear thresholds set due to diverging scales embedded in the historic approach to the region | Past planning choices hindered informing about lock-in, due to negative effects | Economic stakes dominated. Institutional diversity and mismatch between scales led participation to be partly redundant |
| General | The different framing of objectives, partly due to the high diversity and a mismatch in scaling, rendered this contribution difficult. | Use of scenarios and the attention to uncertainty can render this a strong point, but stakeholder preferences can affect adequate handling of uncertainty. | Planning cultures determine the acceptability of options to a large extent, both before and during the structuring of a wealth of options. | Embedded preferences and institutional diversity can obstruct transitions between pathways. In all four cases this contribution was determined by the local planning culture. | Incorporation of stakeholder preferences is neither necessary nor done everywhere. Success depends on adequate incorporation through tools other than AP themselves. |

cope with a technical bias in planning culture, planners can include a high diversity of actors and set clear objectives allowing for non-technical interventions. This at least enables that the consequences of different choices are addressed.

Lastly, framing influenced all the claimed contributions of adaptive pathways, due to the perception of objective thresholds and uncertainty in drivers of change on which the tool builds. When combined with scenario workshop methods, planners can explicitly define the objectives and have an additional tool to align frames (Campos et al., 2016b). Here, the general insight we found is that sufficient consensus is needed about the problem, the objective thresholds and uncertainty. Planners might consider paying attention and making time for the framing of objectives and the support of decision-makers. As for uncertainty, planners need to evaluate uncertainty and the flexibility or robustness for the pathways.

5. Discussion

Adaptation pathways reflect a way of considering uncertainty in long-term planning, characterized by integrating adaptiveness in a decision-making process. Pathways are also useful in structuring a portfolio of adaptation options in a visually attractive way. Our aim was to study the choices involved in using adaptation pathways in different planning practices. We studied the choices that determined the use of the tool in four cases from different adaptation planning practices in Portugal, the Czech Republic and the Netherlands. We compared how users (e.g. planners, facilitators and policymakers) chose a particular pathway design and how they used the tool during their planning processes.

We found six design choices which need to be considered when the adaptation pathways are adjusted to develop a portfolio of options for a specific adaptation problem. In each case different design choices were made, demonstrating a large methodological diversity in the use of the tool. Although such diversity is not problematic *per se*, we saw that diverse methods might influence the claimed contributions of the pathways. These contributions are objective-based thresholds, handling uncertainty, structuring a wealth of adaptation options, identifying possible lock-ins, and incorporating multiple stakeholder preferences. We showed that opting for a particular design in a way that deviates from the original conception of the pathways may indeed reduce the adequacy of the tool to deliver on these contributions.

None of the cases fully succeeded in delivering on the claimed contributions, although the Portuguese case was most successful in this respect. The contribution least achieved was the claim to identify lock-ins. The current study found that planning cultures and the institutional contexts lead to pathways that support lock-in on the already chosen development path, instead of highlighting them to adjust and respond to options accordingly. This finding is in agreement with Hetz and Bruns (2014) in their single case study of Johannesburg. We add to their found constraints from a process-judicative perspective by indicating constraints from other origins, embedded in particular planning cultures or institutional settings.

We found that a misfit between the tool and its use in local planning practices also affected the handling of uncertainty. Although somewhat successful, planners did not consider uncertainty systematically, although they did tailor a portfolio of options to particular drivers of change. However, our cases imply that the specific adaptation problem and uncertainty regarding drivers of change need to guide the specific use and adjustments of the adaptation pathways tool. This seems straightforward, but all four cases indicate this is a challenging endeavour due to the three contextual variables: the institutional diversity and related scale choices, the local planning culture and the framing of objectives and uncertainty. These findings implicate that the conclusion of Lawrence and Haasnoot (2017: 55) that ‘contextual matters [...] provided a backdrop that helped enable the adoption of [adaptation pathways] for planning’ is less straightforward. While contextual

variables enable adoption of the tool, we found that they are also the most important hurdles to overcome in the adequate adjustment of the tool. Additionally to the study by Lawrence and Haasnoot (2017), we specified three contextual variables and showed how the institutional diversity, planning culture and framing influenced adjustment of the tool.

Our findings are consistent with Henstra (2016), who outlines that there are trade-offs in tool selection. We showed that even after selecting planning tools, design choices keep influencing the adequate use of tools. Additionally, policy transfer studies indicate that – in addition to the instrumental transfer of tools – planners can also benefit from adopting ‘soft’ ideas such as using the conceptualisation of pathways to handle uncertainty (Benson and Jordan, 2011). We indeed found that in all four cases the application of adaptation pathways promoted a trans-disciplinary learning process, important for enhancing adaptive capacity and a higher degree of institutional flexibility.

The case studies show that how adaptation pathways are designed and used is determined by how they are adjusted for local planning practices. To be adequate and to simplify their use, planners who want to use pathways need to define adaptation objectives clearly and decide who is ultimately responsible for enacting the resulting adaptive planning policies (Lawrence and Haasnoot, 2017). As this study indicates, this might be problematic for adaptation pathways and similar tools, due to ambiguous institutional responsibilities for policy delivery in networked governance structures (Bannink and Ossenwaarde, 2012; Hajer, 2003). The shift to networked governance might very well hamper adequate use of tools. Actors can use tools to their advantage, for example in rallying support for adaptation solutions. However, this may too quickly focus on details instead of considering large scale, systemic transformation options. While more research is necessary into the effects of an unclear division of responsibilities for adaptation and commitments related to the use and outcomes of tools such as adaptation pathways (cf. Barton, 2013; Mees et al., 2015), their combined use with the scenario workshop method appears to be a possible solution for this integration.

6. Conclusions

We have compared the use of adaptation pathways in four planning practices to find common design choices and conclude that purposefully deciding on six choices is imperative to ensure adequate use of the tool. Adaptation pathways as tool is flexible enough to be adjusted for diverging planning contexts. When adjusting tools, however, planners should match them to their particular situation and embed tool design in their local planning context to successfully harvest promised contributions. In our case studies, this was not an easy endeavour.

While this study focused on existing practices of adaptation pathways use, a promising avenue for future research would be to deliberately design and experiment with different adjustments of tools to test their adequacy in delivering adaptive planning policy for a range of adaptation problems and contexts. This may account for the six design choices and give further guidance for the uptake of adaptation pathways and other adaptive planning tools. Another avenue for future application is to deliberately make tools more flexible to quickly adjust for different situated practices (e.g., easy incorporation of add-ons such as scenario workshop methodology and cost-benefit analysis). A last suggestion is to study the functioning of tools in their planning-institutional environment. Consistently embedding the use of policy design tools for climate change adaptation in relevant planning contexts is necessary, but issues of power, knowledge uptake and adequate transfer need to be accounted for.

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