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Title: Sea-level rise a game changer for public policy

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Abstract

Sea-level rise is uncertain for long timeframes. Decisions taken today have long life-times, necessitating decision-making approaches that can enable adjustments to policy without entrenching current or creating future exposures to risk. We discuss the policy context that creates decision-making challenges for sea-level rise impacts; how Dynamic Adaptive Policy Pathways (DAPP) planning has been used in national level guidance on coastal hazard decision-making in New Zealand; how community values can be acknowledged; and change monitored adaptively using decision triggers ahead of costly damages, thus adopting game-changing policy practice. Suggestions for the applicability of this approach to other decision domains are made.

Key words: sea-level rise; climate change adaptation; dynamic adaptive policy pathways; public policy.

1. Introduction

Sea-level rise (SLR) poses a particularly challenging problem for public policy. It is a chronic ongoing change that will be existential for some communities in low-lying coastal situations, and its rate and magnitude are deeply uncertain towards the latter part of this century and beyond. Sea-level rise compounds coastal hazard impacts through an increasing frequency of extreme inundation events, the increased exposure of people and assets that are increasing in value, and from the legacy of past decisions (Bell et al., 2015). Many low-lying areas will be rendered uninhabitable, necessitating eventual withdrawal in anticipation of the harm, or abandonment with all the associated social and economic disruption.

Governments at national and local levels have varying mandates to 'do no harm' and some have embedded consideration of climate change effects into their regulatory frameworks. New Zealand is one of those. Nevertheless, sea-level rise challenges our institutional frameworks and currently practiced public policy tools. This is because they are primarily designed to create certainty for people and communities, and by using spatially and temporarily static instruments within the statutory frameworks (Lawrence et al., 2013). While they are reviewed periodically (every 10 years or so), they fix current risk understanding in space and time. For example, land uses are either in or out of coastal hazard zones, and properties at the landward edge will only be affected toward the end of the planning period. Such zones also give no information about timing or frequency of inundation with sea-level rise. This information is required for decision making because inundation could occur more frequently at lower SLR levels, necessitating decisions earlier. If review periods are at intervals of around 10 years this can also enable further development to take place and increase the difficulty of changing course as climate change risk profiles change. Decision-making approaches are therefore needed that 'fit' the changing environment and risk exposure arising from the widening uncertainty in the rate of sea-level rise into the future. Policy approaches must therefore, enable adaptation choices that can be adjusted at just the right time ahead of damage occurring, without entrenching current exposure to risk, nor incurring large adjustment costs in the future.

The consequence of these challenges is two-fold. Any adaptation strategy must unlock path dependency, be cognisant of future levels of risk (some of which like SLR will go on for centuries because of GHG emissions already in the atmosphere), or transition communities away from areas at risk. This suggests that public policy tools need to be

able to deal with widening uncertainty bounds to accommodate ongoing change into the future, compounded by deep uncertainty in upper-range SLR if the polar ice sheets become unstable. Furthermore, considerable engagement will be required with communities and stakeholders that are immediately affected, and with those that inevitably will pay for the adaptation actions—local ratepayers and national tax payers. Decision makers and communities are familiar with paying for the 'victims' of climatic disasters and systems are in place to do that after the 'fact'. There is less familiarity with anticipatory planning that is dynamic in nature and can operate where deep uncertainty exists.

The precautionary principle is one policy concept that anticipates uncertainty by alerting decision makers to situations where the consequences could be serious or irreversible. This suggests cautious anticipation ahead of climate events and not using lack of certainty as a reason to postpone responses. However, the concept can be misused in practice and is the subject of much criticism for being imprecise, lacking coherence and used to justify arbitrariness (Fisher et al., 2006). On the other hand if the principle is embedded within statutory instruments and there is guidance as to its use as intended, it can provide a framework within which adaptive tools can be situated. This has happened in New Zealand. This paper shows how draft national guidance has been crafted that can enable adaptive actions to be designed and implemented in situations of deep uncertainty and dynamic change, ahead of the harm and damage.

2. Background

New Zealand is an island nation with a long coastline (15K km) and with many of its major cities and smaller communities located in low-lying coastal areas or near harbours. Some areas have experienced periodic coastal erosion, or have been subjected to coastal storm inundation on several occasions (Stephens, 2015) increasing on the back of the historic rise in mean sea level of 1.8 mm/year (Ministry for the Environment, 2017). Risk exposure (replacement value of buildings only) at the coast has been estimated at $3 billion within 50 cm and $20 billion within 150 cm of the spring high tide mark measured vertically (Bell et al., 2015).

However, these signals have been insufficient for policy settings to shift from a focus on disaster response, to an anticipatory focus that can address uncertainties and changing risk profiles as sea levels continue to rise and potentially accelerate. The response to more frequent climate events in a greater range of geographical settings around New Zealand, (on the back of the challenges of reconstruction from the impacts of several major earthquakes since 2010), has begun to put the spotlight on the implications of current policy settings for addressing the challenge of rising seas (Parliamentary Commissioner for the Environment, 2015), and the effects of climate change more generally (Gluckman, 2013; Royal Society of New Zealand, 2016). The Government's policy response has been to set up a Climate Change Technical Working Group to advise the Minister of Climate Change Issues on actions to date and nation-wide options to address the impacts of climate change.

Within this context, and following the last Intergovernmental Panel on Climate Change (IPCC) review (Reisinger et al., 2014), the Ministry for the Environment decided to revise

its 2008 coastal guidance for local government and for those providing services and infrastructure to coastal areas. Four areas for particular attention were:

- changes to the roles and responsibilities of local government in managing coastal hazard risks, for example the revised New Zealand Coastal Policy Statement (Minister of Conservation, 2010);
- the growing understanding of sea-level rise impacts, including coastal inundation and impacts further inland like salinization and rising ground water levels;
- new adaptive tools that can enable uncertainty to be addressed in policy development and decision making;
- new public engagement approaches that are inclusive of those affected by sea-level rise in developing transition pathways for adaptation.

Such non-statutory guidance sits within a suite of available instruments which are decreasingly directive in character. At the statutory level, the Resource Management Act (RMA) 1991, the primary statute for integrated resource management, including land-use planning, makes provision for: a) "consideration of the effects of climate change" (RMA section 7(i))— where effects include cumulative effects, high-probability and low-probability effects with high potential impact; b) provision for the management of significant risk from natural hazards as a matter of national importance recently added (RMA section 6(g)); c) provision for avoidance and mitigation of natural hazards (RMA section 30(1)(iv) and section 31(1)(b)(i) and power to decline subdivision for development if the land or its access is hazard-prone (RMA section 106)). While these provisions on the face of it address uncertainty, in practice the instruments have been unable to motivate responses that address the uncertainty around the rate and magnitude of sea-level rise for decisions that have long lifetimes. This is especially the case for

existing developments, and in some cases, for new developments. A number of factors are at play here—the contested nature of the climate change as a policy problem, development pressures in coastal areas, short-term political cycles, inadequate use of statutory instruments and analytical tools for managing uncertainty over long timeframes, and un-coordinated governance across scale and domains of interest (Lawrence, 2015; McIntosh et al., 2013)

The RMA is designed to be exercised through a hierarchy of mandatory and optional statutory instruments at all levels of government (Hansard., 1989): primary statutory requirements and principles (mandatory); promulgation of National Policy Statements (NPS) and National Environmental Standards (NES) (optional, except for the New Zealand Coastal Policy Statement which is mandatory); adherence to any NPS or NES that is issued (mandatory); regional policy statements (mandatory), regional plans and rules (optional); regional coastal plans (mandatory at the regional level); and district plans and rules (mandatory at the district and city levels). The New Zealand Coastal Policy Statement (NZCPS) 2010, promulgated under the RMA (includes direction for climate change adaptation at the coast for sea-level rise, storm surge and associated wave height), is the only specific *statutory* directive for decision makers that is relevant for considering climate change effects on coastal environments. Non-statutory national guidance is the next level at which the revisions to the national coastal hazards guidance were undertaken.

The locally mandated climate change adaptation function is also supported by an emergency management regime which operates at national and local levels under the Civil Defence and Emergency Management Act 2002 and the National Civil Defence and Emergency Management Strategy 2008 (currently under revision by 2018 to align with the 2015 Sendai Framework and with more focus on resilience). Emergency management

generally focuses on readiness, response and recovery to disaster risk, while the RMA regime addresses the reduction of risk, through avoidance and mitigation of hazard risk. This is carried out through the statutory land use planning regime (RMA) which is effects-based and exercised by district/city councils without the power to address existing uses located on the coast, unless there are regional rules. Regional rules have been limited as regional councils are naturally reluctant to start discussions with district/city councils on extinguishing existing use rights and withdrawal from the coastal margin. Where they have done so, they have received opprobrium, but if they delay, the risk will escalate as further investment at the coast takes place. The planning and emergency management activities are not well integrated and it has been only in recent years that councils are beginning to start processes that encompass anticipatory adaptive planning in coastal areas (e.g. Tasman District, Mapua and Ruby Bay Plan Change 22[4], Hawkes Bay Tangoio-Clifton Coastal Strategy 2120[5]).

If the planning system is unable to reduce ongoing risk exposure to sea-level rise, coastal erosion and inundation, then the growing burden is shifted to the emergency management system to deal with increasing frequency of events and other ongoing impacts of rising seas (e.g., rising groundwater tables and drainage). The burden also increases for the homeowners affected and to the State as an insurer of last resort through the EQC Fund[6] or as it continues to make ad hoc 'event' based payments for disaster relief, as private

[4] http://www.tasman.govt.nz/policy/plans/tasman-resource-management-plan/plan-change-projects/operative-changes-and-variations/change-22-mapua-and-ruby-bay-development

[5] http://www.hbcoast.co.nz/strategy-development/

[6] Earthquake Commission (EQC) manages a fund under the Earthquake Commission Act 1993 which provides insurance funding for residential property damage from natural disasters which is funded through a levy on private property insurance, for underwriting damages up to $100,000 per claim (proposed to be revised up to 200,000).

insurers withdraw or increase prices beyond the ability of people to pay, and to future generations.

3. National Guidance

National guidance on coastal hazards including sea-level rise thus provides nationally consistent processes and benchmarks for local councils for managing uncertainty and changing risk profiles when exercising their statutory functions. The following discussion sets out the critical elements of the draft guidance that address uncertainty and change over long timeframes and gives some examples of how these elements have been used in practice.

3.1 Who is the guidance for?

The guidance was developed to assist local government to assess, plan and manage the rising hazard risks facing coastal communities. The guidance is targeted at multiple functions and services provided by local government for coastal and estuarine areas, which will be subject to increasing risk as seas rise or the emergence of new coastal hazard risks in areas or environments previously unaffected e.g., lowland rivers, rising groundwater. Consideration by all the relevant functions and services and their interaction in the policy, and strategy decision process (e.g., planning, policy, asset management, transport planning, civil defence, building control, river/coastal engineering and legal) will better ensure the development of a coherent and coordinated coastal adaptation strategy. Familiarity with the guidance material and how it addresses the adaptation challenge will also be essential for those providing multi-disciplinary support services to local government, communities, iwi and hapū (e.g., consultants, scientists, infrastructure providers, surveyors, lawyers, planners, and community-engagement facilitators). A

summary document is designed for a wider audience, including coastal residents, iwi and hapū, property owners (present and purchasers), the general public, educators, insurers, executives, elected regional and district councillors and government officials. The guidance revolves around an iterative 10–step decision cycle (Figure 1) detailing the steps for developing a robust coastal adaptation strategy.

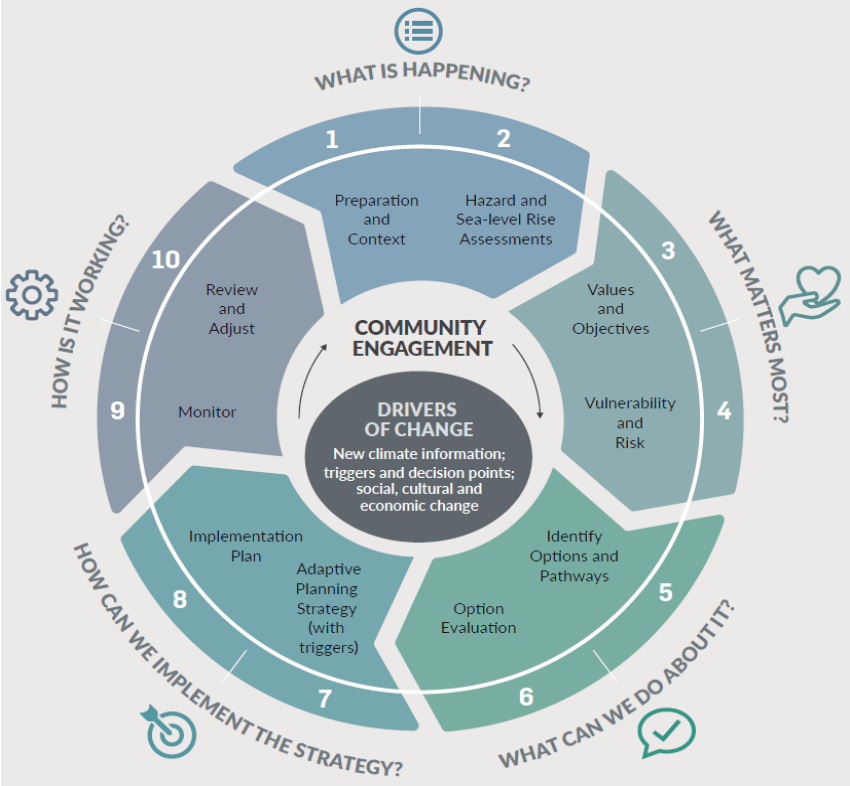

Figure 1 The 10-step iterative decision cycle in the revised 2017 NZ coastal guidance, grouped around five questions that frame each stage in the process (Source: (Ministry for the Environment., 2017). Adapted by the Ministry for the Environment from (UN-Habitat, 2014).

3.2 The elements of the guidance that address uncertainty

Analysing, characterising and dealing with uncertainty is fundamental to decision making about climate change adaptation (Jones et al., 2014). There are four elements of the new guidance that support the development and implementation of strategies to deal with uncertainty over long time frames. These incorporate;

- different types of uncertainty and scenarios
- community engagement
- dynamic adaptive pathways planning (DAPP)
- monitoring regime that enables flexibility while reducing path dependency

The 10-step cycle is intended to be iterative and re-visited in the light of new climate-change information, social and economic change, changes in adaptation capacity of the community or service, or from monitoring and review of the how the strategy is working (step 10), which may require revisiting some or all of the steps. The 10-step decision cycle can also apply more broadly to planning under changing and uncertain conditions.

There has been considerable advance internationally in understanding some of barriers and enablers to implementing strategies or plans in the face of considerable uncertainty around the future rate of sea-level rise, and how to transition communities to a more sustainable future. In particular, more dynamic or agile forms of adaptive planning or policy approaches that specifically address various types or levels of uncertainty have come to the fore (Haasnoot et al., 2012; Kwakkel et al., 2016; Walker et al., 2003; Walker

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et al., 2013). These dynamic adaptive approaches to adaptation have been developed in a variety of community/catchment contexts e.g., Lakes Entrance – Gippsland Lakes (Barnett et al., 2014), Thames Estuary Flood Strategy 2100 for London (Ranger et al., 2013), Rhine-Meuse delta (Haasnoot et al., 2013) and for future river-flood response options in Lower Hutt (Wellington region) (Lawrence and Haasnoot, 2016).

3.2.1 Uncertainty and use of scenarios

When considering the effects of climate change, treatment of uncertainty is unavoidable. For coastal areas, it is "*virtually certain*" (in the calibrated language of IPCC) that SLR will continue beyond 2100 for many centuries (Church et al., 2013) – but what is deeply uncertain is the rate of rise in sea level. This in turn results in a wide future window when response options could be needed, particularly towards and beyond the end of this century. There is more certainty in the near-term e.g., global SLR by 2040–60 is projected to be in a relatively narrow range of 0.2–0.4 m for a range of emission scenarios, compared to 2100 and beyond. Near-term decisions, however, still need to build in flexibility to enable changes to actions or pathways that can accommodate higher sea levels over longer timeframes, and not lock in potential maladaptation or path dependency. This is critical for decisions with long lifetimes such as new subdivisions and infrastructure.

SLR scenarios versus single planning values

The range of plausible SLR projections widen around 2050–60 and increasingly out to and beyond 2100, across the four Representative Concentration Pathways (RCP) (as adopted by IPCC for the 5th Assessment Report). More recent monitoring and projections of polar ice sheet responses, mean that it is difficult to pre-determine what coastal futures might eventuate for any community, even over planning timeframes of the next 100 years

(Ministry for the Environment, 2017). Further, defining an overall probability distribution of SLR for various timeframes has not been possible even for global averages – only probabilistic distributions of possible SLR for a *given* RCP (Church et al., 2013; Ministry for the Environment, 2017). It is therefore more appropriate and inherently flexible to use a range of SLR scenarios to test the performance of adaptive response options or actions, than attempting to provide either a worst-case or "most-likely" estimate, to characterise the deep uncertainties around carbon emissions, ice sheets and associated rates of SLR.

The 2008 New Zealand coastal guidance (Ministry for the Environment, 2008) provides two SLR tie points (starting with a minimum 0.5 m, and to consider *at least 0.8 m* by the 2090s) for input to a risk assessment (and whether future adaptation options are limited), using a range of higher SLR values for the 2090s planning timeframe. Beyond 2100, a 10 mm/year heuristic is recommended. In practice, users either simply adopt the minimum value (even for regional planning in some cases) or use the second value without running through both a vulnerability assessment (e.g. coping capacity, ability to adapt, sensitivity to climate change) and associated risk assessments. The draft revisions to that guidance addresses this decision behaviour using tools that can specifically address uncertainty.

The revised guidance adopts a suite of four scenarios for SLR projections to 2150 (Ministry for the Environment, 2017), based on three of the four RCPs (Figure 2).

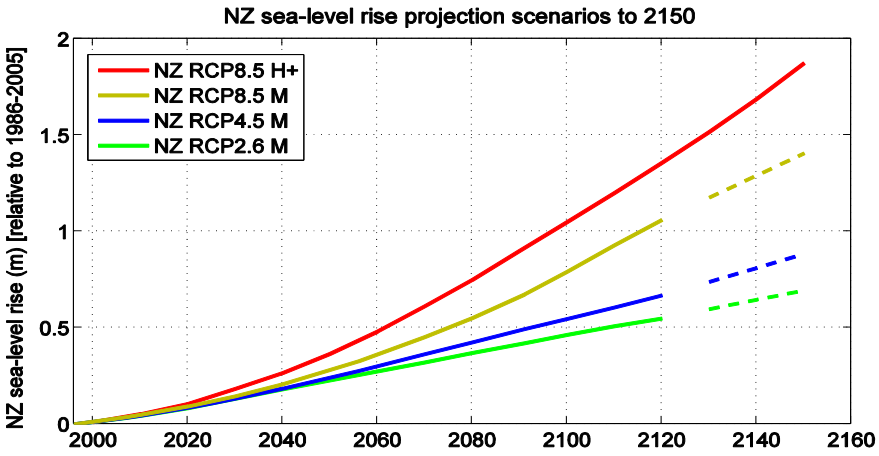

Figure 2 Four scenarios of New Zealand-wide regional sea-level rise projections for use with the revised guidance, based on median (M) IPCC projections for the three lower curves (Church et al., 2013), with extensions to 2150 and a higher H^+ scenario based on (Kopp et al., 2014). Note: these scenarios include an additional regional-sea contribution of up to 0.05 m by 2100.

These four scenarios primarily support: i) initial hazard and risk screening assessments over a range of plausible scenarios to determine potentially-affected areas and when risks first emerge; and ii) stress testing various adaptive pathways or response actions/policies, to determine their robustness, their "shelf life" and flexibility for switching to alternate pathways. Switching would need to occur when community objectives or council objectives (e.g., level of service for assets or infrastructure) are no longer being met for that pathway, which could be linked to a trigger for a specific local SLR, number of flood events (which may also be influenced by climate variability), tolerability levels, or exhausting economic sources of beach nourishment material for eroding coasts. Rather than pre-determining the future by selecting a "best estimate" SLR, a scenario-options approach provides a wider window in which alternative pathway combinations can be formulated engaging with affected communities and stakeholders, and decisions activated once pre-agreed signals and triggers are reached at some point in the future. The SLR

scenario approach for adaptation planning is used in the UK and USA – for example the recent suite of scenarios for the USA (Sweet, 2017).

To enable decision makers to transition to this new planning approach, the draft revisions to the New Zealand guidance provides transitional SLR allowances (values or scenarios) that can be used in the interim, until dynamic adaptive pathways planning (DAPP) (see below) is undertaken through the 10-step decision cycle. To assist implementation, the transitional SLR allowances have been linked to a development or activity category. The allowances recommended are;

- For managing existing exposed development, a specific SLR value that is largely consistent with values currently being used for adaptation planning by most councils: 1 m by 2115 (at least a 100-year timeframe as required by the NZCPS).
- For non-habitable, short-lived buildings or assets (e.g., surf club buildings), a lower value of 0.65 m
- For coastal greenfield developments or major new infrastructure a higher range of values from the H^+ SLR scenario (Figure 2).
- For justification of proposals for intensification of existing development a full DAPP process using all four SLR scenarios (Figure 2).

The DAPP process is new for New Zealand decision makers and their advisors. It is expected that it will take time to fully mainstream the approach, but in the meantime decisions are being made and transitional allowances are necessary to avoid further exposure to hazard risk which could make future adjustments more difficult and costly.

Matching uncertainty type to hazard/risk assessments

When using hazard/risk assessments in decision making, four levels of uncertainty exist (Table 1) (Walker et al., 2003; Walker et al., 2013) that lead to different types of

assessment approach or treatment of coastal hazard components (including SLR) and scale of development, and on through to decisions and policies (Ministry for the Environment, 2017).

Table 1 The four levels of uncertainty and possible policy responses.
Adapted from (Walker et al., 2003; Walker et al., 2013).

Future coastal hazards	**Response**
1. …are knowable (*little uncertainty*)	→ predict and act policies and/or actions
2. …will behave in much the same way as the past (*statistical uncertainty*)	→ "trend-based" policies and/or actions
3. …are well described by a few overarching scenarios (*scenario uncertainty*)	→ "static robust" policies and/or actions
4. …are unknown or disagreed upon by experts and/or stakeholders with no consensus on what the future might bring (*deep uncertainty*)	→ adaptive and iterative policies and/or actions

The type of coastal adaptation decision being made and the type of uncertainty that needs addressing will guide the choice of hazard assessment. Guidance is provided on the range of hazard modelling scenarios to undertake (e.g., number, hazard probabilities and SLR scenarios or increments of SLR) and the associated modelling complexity and cost that match the appropriate level of uncertainty that should be considered for that decision (Ministry for the Environment, 2017). Similarly, guidance is provided on a tiered approach to vulnerability and risk assessment starting with risk screening assessments across a region or district, moving to more detailed assessments using the recommended SLR scenarios to support the development, option evaluation and implementation of dynamic adaptive pathways planning.

3.2.2 Community engagement

An appropriate level of community and stakeholder engagement is central to acceptance of the need for the tough choices about an uncertain future, and the development of a long-term coastal adaptation plan, in the face of ongoing rising seas. Delivering the required foreseeable needs and services for future generations, alongside an ongoing changing environment, is challenging for local government which represents both present and future communities. The revised guidance therefore provides guiding principles for inclusive engagement, suggested types and levels of engagement at different stages in the 10-step decision cycle.

Varying impacts and coping capacities in each local situation, along with different values, expectations and worldviews may result in difficulties reaching consensus. This means that a transparent and considered community engagement process is essential – but recognising that guidance cannot prescribe particular methods. Rather, the focus is on establishing guiding principles and providing answers to common questions that crop up (e.g., who should participate? How should participation proceed at each stage of the decision cycle?). For the latter, the guidance adopts the International Association of Public Participation (IAP^2) spectrum of public participation (Ministry for the Environment, 2017) starting from *inform*, through increasing levels of engagement – *consult*, *involve*, *collaborate* and *empower*. Guidance is provided on the level of engagement at various steps in the adaptation planning (Ministry for the Environment, 2017).

The revised guidance also takes a values-based approach, where community and stakeholder values are canvassed, as a basis for reflecting community objectives. For example, in response to retention of various recreational values, the objective could be to

"maintain safe, aesthetically pleasing, public greenspaces (including picnic and playground facilities) close to the foreshore and distributed throughout the community" (Ministry for the Environment, 2017). Local councils will also need to develop objectives for the provision of services and assets. These objectives can then fed into the development of adaptive pathways, and tested for their ability into the future to meet those specific objectives.

3.2.3 Dynamic adaptive pathways planning (DAPP)

The guidance adopts an adaptive planning approach to addressing the deep uncertainty about the future rate and magnitude of SLR, to avoid locking in path dependency, which may occur if a "best-estimate" scenario is assumed. The particular adaptive approach used is called dynamic adaptive pathways planning (DAPP) (Haasnoot et al., 2013; Lawrence and Haasnoot, 2016). As its name suggests, the approach identifies alternative ways forward (*pathways*) that could, singly or in combination, meet agreed objectives despite uncertainty, while remaining responsive to changes when this might be needed (*dynamic*).

DAPP involves engaging with communities and stakeholders to develop a range of adaptation responses, actions or policies, which are then tested against several possible future scenarios (e.g., the four SLR and other coastal hazard scenarios). Inter-connecting alternative or staged pathways can then be mapped ahead of time and evaluated (e.g., costs, environmental impacts, shelf-life) that will best manage, reduce or avoid the increasing coastal hazard risk. A plan is then developed, with short-term actions and long-term options with pre-defined decision points (*triggers*) where the decision to switch pathways can be revisited (Figure 3).

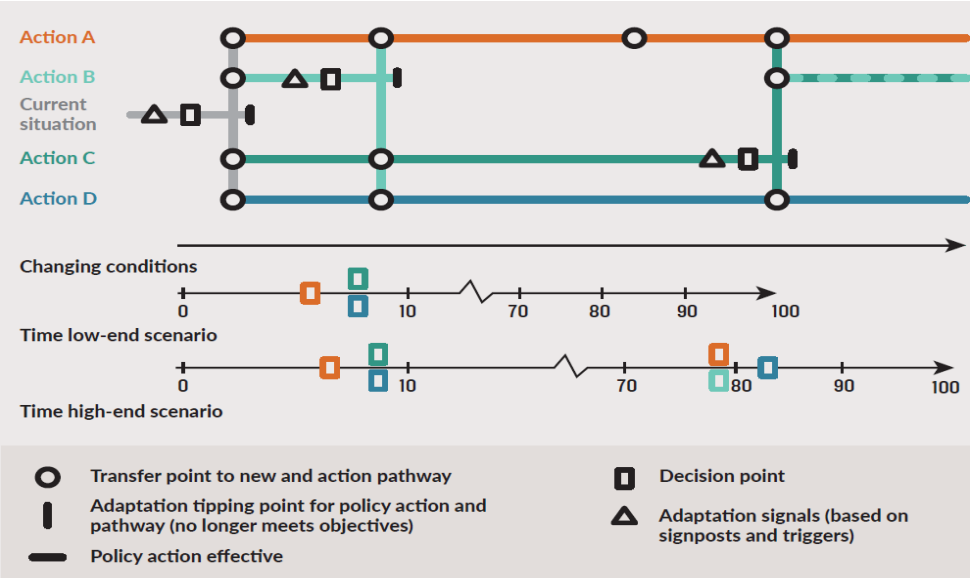

Figure 3 An example of an adaptation pathways map using the DAPP approach. (Adapted from a graphic supplied by M. Haasnoot, Deltares and TU Delft).

This flexibility allows the pre-agreed course of action to change with new or improved climate, emissions or social and economic information. Also as part of DAPP, early warnings (*signals*) should be determined for ongoing monitoring, which provide sufficient lead time to the trigger to cover consenting, community engagement, policy development and implementation, well before the threshold of damage and loss is reached. Triggers for a locality could be couched in terms of societal pressures such as occurrence of a certain number of coastal inundation events, a coastal erosion set-back distance to houses, or a decrease below a level of service, where assessments show risk or performance starts to become intolerable for sections of the community or a council service. Such triggers need to be designed to avoid catastrophic events, after which it is too late to be anticipatory and reactive modes kick in following significant harm.

By accommodating a range of future coastal changes at the outset, which can cover surprises either way (e.g., from polar ice sheet instabilities or achievement of severe curbs

on global carbon emissions), this adaptive approach helps avoid locking in investments that could make future adjustments difficult and costly. Some options for a particular location (e.g., a seawall) may only have a short "shelf-life" if SLR accelerates more than anticipated or repeated storm damage becomes a maintenance burden. Such an adaptive approach assists with both longer-term sustainability (and the needs of future generations) and community resilience. It also enables councils and communities to "map out" the future, commencing with an agreed initial pathway, rather than waiting until uncertainties are reduced (e.g., when clear evidence of SLR acceleration emerges), before making decisions.

A key component of DAPP is the commitment to regular monitoring (e.g., progress towards signals and triggers, that can gauge how the current pathway is working, by documenting damaging or nuisance events and social tolerability) and the ability to re-visit or adjust the plan in the light of new information (Steps 9–10, Figure 1). This dependence has implications for implementation of the decisions and for governance of decision making under conditions of uncertainty over the long term (Lawrence, 2015).

3.2.4 Linking present statutory framework to coastal adaptation

The statutory framework operating in the coastal environment in New Zealand currently provides for assessments of the actual and potential effects of climate change (s7 (i), RMA), controlling the use of land for the purpose of avoidance or mitigation of natural hazard risks (s30, 31 RMA) and a relatively prescriptive set of objectives and policies in the NZCPS to give effect to. For example, development of an adaptation strategy for significant existing development that could include moving inland (Policy 27). Adaptation projects (including funding contributions) could also be considered in council long-term (10-year) plans under the Local Government Act 2002, engaging with coastal

communities, and through 30-year council asset management plans. These statutory instruments enable a range of measures to be considered, along with other non-statutory or physical response options, in the DAPP process. Some councils have been able to implement more restrictive land-use plan changes to cap any further development in low-lying coastal areas (Tasman District case study (Ministry for the Environment, 2017)), where the council implemented a plan change which includes closed residential zones at the coast, but providing for development on adjacent higher ground.

However, the short to medium term windows for most council planning processes is challenging, when matched with long-term coastal adaptation to ongoing SLR, and ensuring the shorter-term planning decisions do not lock in eventual maladaptation and incur significant additional costs. While the NZCPS requires consideration of managed retreat for existing development when planning adaptation, there are practical issues as yet unresolved for implementing pathways planning. These include property-owner acceptance of the need to eventually transition inland, equity for some groups in society; who pays, when (anticipatory or reactive), and how and where communities might retreat to. A Coastal Hazards Strategy 2120 on the Hawkes Bay coast from Tangoio-Clifton is a good example where these issues are currently being addressed, using a similar process to that set out in the draft guidance, with the communities affected and those that will inevitably be affected by the decisions taken to reduce and avoid risk. Further research is underway on the elements necessary for how anticipatory managed retreat could be accomplished in the New Zealand coastal and statutory context. Under the rubric of two National Science Challenges (Deep South and Resilience to Nature's Challenges) this includes research on the signals and triggers that can be used in the monitoring of dynamic adaptive pathways, funding models, the relationship between funding and insurance

(Storey et al., 2017) and the engagement, planning and legal aspects of managed retreat. This research will inform further ongoing revisions to the national coastal guidance.

4.00 Relevance to other public policy domains

The approach set out in this paper is designed to address the various levels of uncertainty (Walker et al., 2003; Walker et al., 2013) that are present in this particular policy problem. All public policy problems will be affected to a greater or lesser extent by different types or locations of the uncertainty. This means that the different types of uncertainty germane to the particular problem will need to be transparent to decision makers and addressed as to their criticality for the decision in an appropriate way for that uncertainty. For the case presented here, we have translated the different types of uncertainty into different decision types (accept, adapt, or avoid the hazard) and tools to use (values and scenarios) to simplify the consideration of uncertainty for decision makers in Figure 4.

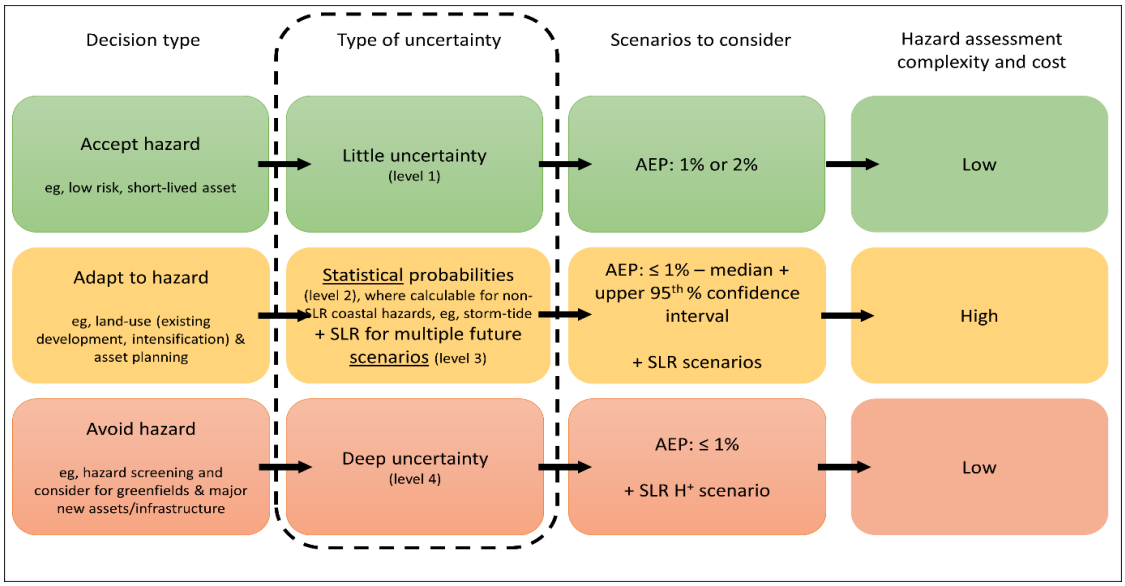

Figure 4: Relationship between decision type, related uncertainty, scenario to consider and model complexity

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This can also be done for whatever the decision problem is that has different types of uncertainty.

Furthermore, our case shows how one particular planning approach (DAPP) that is relevant to the coastal hazard risk management as it evolves with climate changes over time and with increasing uncertain bands, can facilitate decision making in the present time while maintaining flexibility to adjust when triggers emerge.

The relevance of these two parts of the policy assessment and planning process and the central role that community engagement plays to other policy domains is to provide a way of navigating uncertainty without locking in decisions and creating path dependency. In practice it is social and economic change over time that determines the effectiveness of policy outcomes. In this context the approach set out in the draft national guidance provides for both the technical aspects of uncertainty and the value preferences that will change over time. For an issue like climate change and many others like provision of pensions for example will require long term political and community commitment. Using flexible and adaptive policy approaches and assessment methods, of which there are many (Watkiss and Hunt, 2013) has conceptual attraction and practical value for any policy problem that has elements of deep uncertainty and the potential for surprise e.g. defence strategy, management of the oceans, corporate business management, environmental management, to name a few.

5.00 Conclusions

The draft revised New Zealand coastal hazards and climate change guidance addresses uncertainty in the policy and decision process using four critical elements; treatment of uncertainty and changing risk profile; through different types and levels of community engagement; through dynamic adaptive pathways planning, and through a monitoring

regime that enables flexibility while reducing path dependency. However this leaves the enablers for implementation under-developed and the role governance can play in supporting monitoring/reviews and retaining policy commitment over long timeframes largely unexplored.

Sea-level rise is a game changer for how we undertake the policy process because of uncertainty and on-going changing conditions, which current policy frameworks and practice largely ignore or struggle to cope with. It forces us to address uncertainty and to discontinue hiding behind the 'safety' barrier thinking we are safe into the future and have done our analysis thoroughly using the static tools of trade. It challenges the decision makers to think beyond the electoral cycle when making investment and planning decisions, by changing the mode of governance by undertaking constructive dialogue with communities and stakeholders that can change the pathway to the future and build trust through formalised commitments. Current decision makers will not bear the 'cost' of their decisions, but current and future generations will. The temptation to delay consideration of uncertainty and changing risk profiles, if taken, will increase the exposure to risk and transfer it to future generations.

There are tools that can be used to help decision making under uncertain conditions across many domains where uncertainty is a critical decision matter for effective outcomes. The challenge is whether the governance can adapt to changing states, based on collaborative processes using dynamic and adaptive tools and thus enable policy commitment politically and at a societal level, to endure. The draft revised New Zealand coastal hazard guidance provides an adaptive framework and processes that can catalyse a change to our decision-making traditions that in large measure assume a static systems, when we now live in a dynamic rapidly-changing physical environment that is close to 'home'.

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