

A local coastal adaptation pathway

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Local governments are not adapting to sea-level rise because it is difficult to build consensus on the need for change and the best way to implement it. In theory, adaptation pathways can resolve this impasse. Adaptation pathways are a sequence of linked strategies that are triggered by a change in environmental conditions, and in which initial decisions can have low regrets and preserve options for future generations. We report on a project that sought to empirically test the relevance and feasibility of a local pathway for adapting to sea-level rise. We find that triggers of change that have social impacts are salient to local people, and developing a local adaptation pathway helps build consensus among diverse constituencies. Our results show that adaptation pathways are feasible at the local scale, offering a low-risk, low-cost way to begin the long process of adaptation to sea-level rise.

Adaptation is a process of adjusting to changes, which has to be sustained over very long periods of time^{1,2}. Adaptation decisions are not easily calibrated with the distant futures described by climate science: for whereas climate models resolve outcomes in multi-decadal timescales (for example, in the years 2050 and 2100), adaptation decisions must respond to unfolding processes of changes in the interim. This impedes decision-making about adaptation, particularly at local scales, where the public remain divided in their convictions about the need for adaptation and how it should be implemented^{3–5}.

Flexible and responsive institutions that can steer adaptation as changes unfold are possible, at least in theory. Building adaptive capacity and resilience, adaptive management, structured decision strategies, real options and safety margins are all approaches that enable initial actions that are robust to uncertainty, although there are few examples of these being implemented with respect to adaptation^{6–13}. Central to these approaches is the principle that adaptation cannot be solved through a single action, but is rather a process to be managed over time. Extending and consolidating this thinking, the idea of adaptation pathways has recently emerged as a way to guide adaptation decisions into the future.

An adaptation pathway is a decision strategy that entails a vision for the entity exposed to climate risks, to be met through a sequence of manageable steps over time, each of which is triggered by a change in environmental (or, as we argue social) conditions^{7,14–18}. These triggers may be thought of as ‘adaptation tipping points’—the points in time when adaptation actions cease to be effective and new actions are required^{15–18}. In this approach, adaptation is as much about actions in time as in space.

There are two well-described examples of adaptation pathways: these address the risks of flooding and sea-level rise in the Thames Estuary and the Rhine–Meuse delta^{14,17}, respectively. In both cases, sets of options for future action are anticipated, creating an ‘adaptation map’ with choice sets arising at future points in time. In both examples, the scale of the social-ecological system is very large, technical capacity is high, there is a strong higher-order government institution in charge, and the goals are clear and predetermined (avoiding flood damages). Both have been developed through intensive processes of scenario generation, and both have proposed engineering-focused solutions.

These applied examples are exciting and have advanced the adaptation science-policy frontier. However, although such approaches may be appropriate for cities with significant capacity and assets to protect, they are unlikely to be useful or applicable to smaller towns for three main reasons. First, smaller local communities and governments rarely have the technical skills and financial resources necessary to implement big projects such as those on the Thames or the Rhine–Meuse^{19–21}. Second, whereas these big projects seek to manage catastrophic risks with a strong imprimatur from central governments, at local levels the risks are not of national significance, and local decision-makers do not have such a clear mandate for action^{5,22,23}. Third, decisions about adaptation at local scales typically rely far more on consensus within local constituencies^{2,4,5}.

Local consensus on adaptation decisions is difficult, because within communities there are differences among people with respect to their awareness of the risks of climate change, preferences for the distribution of benefits and costs of action and inaction, associations and attachments to places, and hopes for the future. The local politics of climate change is further complicated by degrees of resistance to outside and expert framings of risks, typically inadequate inclusion of local knowledge and values, failure to agree on the goals of adaptation, and processes that do not allow for the slow working through of psychological, spiritual and emotional responses^{5,22–25}.

These challenges help explain observations of very slow progress on adaptation at local levels^{4,5,26,27}. The concept of adaptation pathways holds great promise as a pragmatic way for local communities and governments to begin adapting to sea-level rise. In this paper we report on a project that sought to test if the principles of an adaptation pathway can be applied locally, in this case in the township of Lakes Entrance in South-Eastern Australia.

The study area

In Lakes Entrance the prevailing approach to adaptation has involved restrictions on development imposed by extra-local institutions (Box 1). These restrictions have been widely opposed by local residents, who feel it transfers many of the costs of adaptation onto present generations in the form of devalued assets and constraints to local economic development (Box 1)^{2,28}.

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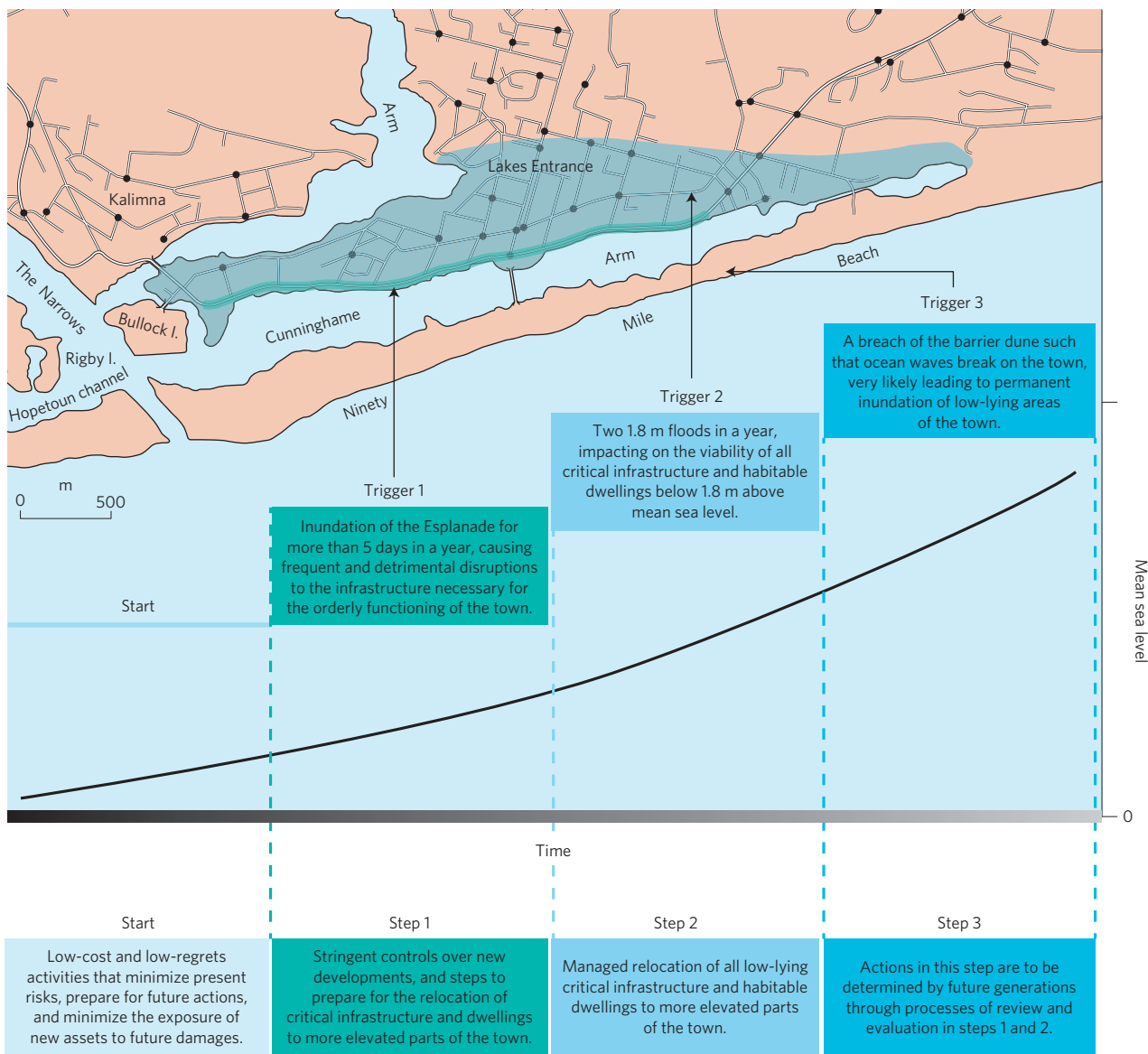


Figure 1 | Key features of the proposed local adaptation pathway for Lakes Entrance, showing the sequence of triggers, the areas they are likely to effect, and the policy steps they activate.

This experience has prompted new kinds of thinking about adaptation in Lakes Entrance, with decision-makers suggesting that adaptation needs to slow down and be more locally-driven and strategic, giving rise our proposed local adaptation pathway, which we refined through a workshop with local decision-makers and focus group interviews with local residents.

Results

Figure 1 summarizes the key features of the proposed adaptation pathway that was developed in this project, including the trigger points and actions in each step that they activate. It shows the three triggers that were found to mark a departure from normal experience such that a step-change in adaptation policy is warranted. These are events that have discernible (social) impacts: on local businesses, employment, access to goods and services, disadvantaged groups (in particular the elderly), and costs of living.

Respondents in the focus groups discussed the logic of these triggers (Table 1). Flooding on the main road more than five days a year was identified as the first trigger because of the impact this would have on access to schools, health services, banks and

supermarkets, and because past floods of this magnitude have caused damage to local businesses. There was also considerable concern that this new flooding regime would increase the costs of insurance and decrease the value of coastal properties. The event of two 1.8 m floods in a year was seen as as the second trigger because this was a level of change that would be ‘diabolical’ for its impact on businesses, tourist arrivals, employment, elderly people, and the ability of people to access the more specialized and emergency medical services in the closest rural city of Bairnsdale. The third trigger—a permanent breach of the barrier dune—was seen as signalling the end of the town in its current built form.

Figure 1 also describes the nature and intentions of policies and measures that were considered by participants to be appropriate at each step. There was agreement that initial actions should take the form of low-cost and low-regrets activities that minimize present risks, prepare for future actions, and minimize the exposure of new assets to future damages. Many of the suggestions from focus group respondents focussed on establishing appropriate institutional structures, including clear lines of responsibility and communication. There was also agreement about maintaining

Box 1 | The study area.

Lakes Entrance sits behind a barrier dune at the eastern end of the Gippsland Lakes, which are a large coastal lagoon system fed by six rivers. The town is located at the one permanent opening between the lakes and the sea. Lakes Entrance floods when there is a combination of high tides, low-pressure systems and strong rainfall^{34,35}.

The main conclusions of various studies of potential climate impacts on Lakes Entrance are that climate change will cause: an increase of the 1:100 yr flood level at Lakes Entrance by between 2 and 20 cm in 2030 relative to baseline flood levels (set in 1952; ref. 36), and by between 4 and 59 cm by 2070; and increased sediment transport from west to east along the Gippsland coast,

but not such that there is a significant risk of a permanent breach in the barrier dune until later this century^{34,35}.

Partly informed by these and other studies, in 2010, after a complicated planning dispute about preparing for sea-level rise, the Victorian Civil and Administrative Appeals Tribunal (VCAT) imposed a series of unprecedented interim controls on building developments in the town. These were unpopular with local people, caused conflict, and have been described in the literature as maladaptive and unsustainable^{2,28}. The controls stimulated a more strategic discussion about how to better adapt to sea-level rise, one product of which was our research project and the local adaptation pathway that has been developed.

Table 1 | The logic of pathway triggers and policies as proposed in the focus groups.

Stage	Triggers and rationales	Policies and measures
Now	Triggers negotiated and defined through consultation	<p>Improved communication "Be open in saying these are the options we've got. Let people know. Having this round discussion we are having now, have it with the whole town and keep people informed" (Focus group 1)</p> <p>Maintain existing flood defences "I think keeping the entrance clear, the valves on the drainage pipes. If all those things are tried and exhausted and we're still getting floods, then it's major" (Focus group 1)</p>
Step 1	<p>Inundation of the Esplanade for more than five days in a year "I suppose if it (low-level flooding) happened four or five time years a year, you'd be saying, well, that's enough, we'll have to do something else" (Focus group 1) "Even if the flood never got back past the main street, the effect would get out through the whole town because without that main street - because all our shops are in that one bit of road" (Focus group 3) "If you've got to replace carpets ten times a year, the insurance company's going to go hey, come on, put tiles down, we're not going to do this" (Focus group 3)</p>	<p>Defence of critical infrastructure, preparation for relocation, further strategic planning "If the further we go on that evidence becomes more solid, then obviously I think that planning has to start to move the town up the hill a bit." (Focus group 1) "If it was only happening here (and not other parts of the coast), then certainly technical solutions-practical solutions would be the order of the day." (Focus group 3)</p>
Step 2	<p>Two 1.8 m floods in a year "It would take a lot longer to recede, so you'd be looking at months and months and businesses, for them to do their businesses back up and dry everything out, they might be out of action for 12 months." (Focus group 1) "A major regional hospital is in Bairnsdale, so if anything needs to get up there-emergency services or whatever—that's going to create a little bit more of a problem." (Focus group 2)</p>	<p>Initiation of previous strategic plans "You'd probably draw up a new township and have stages or ballots or who can afford to go up there first goes" (Focus group 1) "There's a further focus on repositioning to enable the normal life of the town to continue" (Focus group 3)</p>
Step 3	<p>A breach of the barrier dune such that ocean waves break on the town "If it (the sea level) rises and you get the storms and that that we do, it's going to break holes right through the sand dunes all the way along... Then you're not going to have any beach either and that's why I live here. If there's no beach, there wouldn't be much point." (Focus group 1)</p>	<p>Actions in this step are to be determined by future generations through processes of review and evaluation in steps 1 and 2</p>

existing flood defences, including dredging the entrance from the Gippsland Lakes to the ocean, and fitting return valves on stormwater drains (Table 1).

Suggestions for the first step, activated after the first trigger, aimed to regulate new developments so that they are not exposed to flooding. Because Trigger 1 signals a change in the flooding regime, the discussion of actions in Step 1 recognized that more enduring solutions need to be investigated, such as moving up the hill. Thus actions in Step 1 are aimed at planning for this shift, through government investments in land, the development of innovative financial instruments, and planning for new sites for commercial and housing developments. For local people this step is critical to

enabling effective and orderly action at Step 2, in which all low-lying critical infrastructure and dwellings in the flood zone are to be relocated to more elevated areas.

There are some actions to be sustained throughout each step in the pathway. Data on social and environmental conditions, particularly those that pertain to the social determinants of each trigger, are to be regularly collected. Regular reviews of adaptation goals, triggers and subsequent steps are to be conducted based on periodic assessments of data, available technologies, and evidence from adaptation elsewhere. At the beginning of each new step the detailed policies to be implemented at subsequent steps are also to be determined.

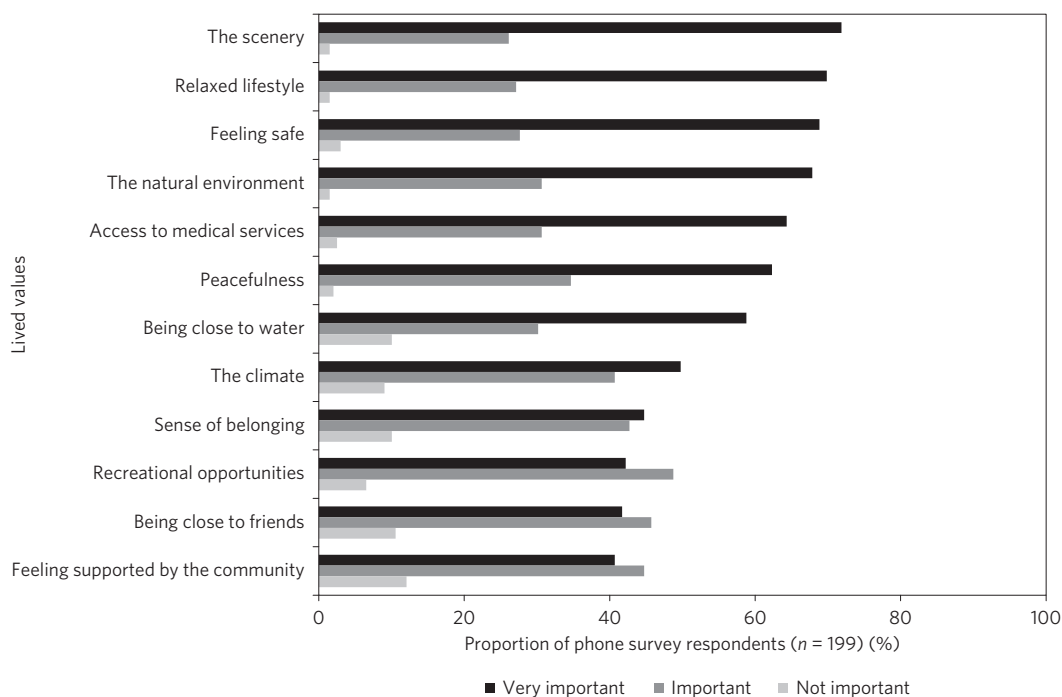


Figure 2 | The attributes of Lakes Entrance that are most important to the local community, and which they wish to preserve through adaptation, as revealed through a phone survey of 199 residents.

The process by which this adaptation pathway was, and continues to be, determined is as important as its outcomes—for although the triggers and actions can be changed subject to periodic review, it is the means by which they are negotiated that has to endure. Indeed, the value of our method as a template for policy development was noted in the focus groups (Table 1). The method was also conducive to thinking about adaptation as a process to be managed over a series of steps.

Social thresholds and consensus

There are two key ways in which our approach advances knowledge about adaptation pathways. First, in our approach the thresholds of change are social impacts that are salient to local people rather than those related purely to changes in environmental conditions. The level of flooding that matters in this case is that which residents consider to have unacceptable impacts on their lived values, and for which there is some local analogy: a once in 20 years flood event (1:20 yr flood) leads to flooding of the main road through the town, the 1:100 yr flood maximum is 1.8 m, and locals know of past (if ephemeral) breaches of the barrier dunes. The grounding of triggers in socially-salient local experiences makes them meaningful windows of opportunity in which new policies can be most easily implemented^{29,30}. They are effectively expressions of the collective tolerable level of risk in Lakes Entrance³¹.

Triggers determined in this way are also robust to uncertainty about the timing of environmental changes, and are consistent with the various proposals to develop flexible and responsive institutions discussed at the beginning of this paper. It also addresses the concerns expressed by policy actors interviewed about the uncertainty, timing and fairness of existing adaptation approaches (Box 2). A shift to the next step happens when adverse social consequences occur, and not necessarily when the environmental perturbation that we anticipate today occurs. For example, many coastal adaptation policies in Australia refer to a rise in sea level of 80 cm by 2100, which is a benchmark of change that is uncertain, will not be uniform across all coastal places, and which may or may not be a problem depending on local geomorphology.

The second key way our approach advances knowledge about adaptation pathways is that it builds consensus among a broad range of local people. In the focus groups and semi-structured interviews we found that people disagree about climate change and about present and future changes in environmental conditions, thus making shared beliefs in the impacts of climate change a poor basis for building consensus on adaptation policies. In contrast, we have found that people are eager to share and concur in their understanding of the social characteristics of their local places, including its identity, its amenity, its economy, and its desired future. This offers a basis by which adaptation can be discussed and consensus developed—not as a discrete policy activity, but as a means to managing long-term risks to the important features of local places.

Our understanding of the bases by which consensus can be built among people in Lakes Entrance emerged from our research on the ‘lived values’ that people in the town hold dear³²(Fig. 2). We therefore began our focus groups by asking people what they collectively valued about the town³³. They identified its environmental amenity, the lifestyle it enables, the proximity to loved ones, the friendly people, and its community feel. These values are time- and place-specific attributes of the town that people wish to preserve, that were also rated highly in the earlier survey and interviews, and they correspond well with the local government’s vision for the future of the region, which is to achieve “a sustainable future through liveable and productive communities supported by a healthy environment”. In the pathway, adaptation is therefore framed in terms of managing risks to this larger social goal. This provides a solid basis of agreement about what is important about the town and aspirations for the future, and establishes a meaningful context in which to determine socially-relevant triggers and actions at each step of the pathway.

The initial consensus that emerged through this process was sustained by the stepped approach to policy. In the focus groups, even the self-confessed ‘climate sceptics’ agreed that the proposed initial low-regrets actions to manage the risks of sea-level rise were reasonable precautions, and that the environmental changes associated with each socially-relevant trigger point would

Box 2 | Policy actors' concerns about current adaptation institutions and policies.

“the thing that... is important, is peoples' security in decision-making” (Local-level policy actor)

“I don't think there's a very good, well thought through, strategically guided decision making process in place at all. I think there's more 'ad hocery' still than there is strategy.” (Local-level policy actor)

“If we just move through a solid, genuinely good process, and look at what our options are, then it might not be as scary as people think. It might actually feel logical to the community and if you

have something that feels logical that they understand.” (State-level policy actor)

“I don't think it matters what comes out... as long as there's certainty or some clarity for everyone and at the moment there's not.” (State-level policy actor)

“I think the difficulty is the local government, in East Gippsland Shire in particular, lack of clarity... how do they adapt (and) still allow or facilitate development or town structures and things?” (Regional policy actor)

demonstrate to them that the environment was changing, and that something needed to be done. Thus linking actions to observed changes helps establish a social licence for actions in the present and the future.

Conclusions

Our research demonstrates that a locally focused and socially-relevant adaptation pathway is feasible. Such an approach can facilitate a level of consensus sufficient to enable adaptation to begin, coupled with a framework that leaves future generations better prepared.

The approach we developed was readily understood by, and appealed to, local residents and decision-makers for the following reasons: it is simple (at least relative to other pathways that entail complex sets of options for future action); it creates the time and space for building collective action; it is flexible in the light of new information, technologies, and social and environmental conditions; it accommodates diverse lived values; and it distributes responsibility for decision-making and the costs and benefits of decisions across generations.

The adaptation pathway we have tested in this research would better prepare the Lakes Entrance community to make timely decisions and investments at socially-relevant moments of change, giving residents and businesses confidence in the future of their town and their descendants' place in it. Of course, not all investment decisions can be phased over time in this way: some decisions about long-lived investments (such as airports or dams) need to be made now. In these circumstances, adaptation pathways may be less suitable, and more conventional risk management approaches are needed⁹.

Local adaptation pathways such as we have described create a socially-acceptable framework that guides adaptation into the future. Using this approach creates a palatable narrative about adaptation that is time-sensitive, community-sensitive, and owned by local people. Further research to test this and provide more detail of the reality of implementation within existing institutions would be beneficial.

Methods

The justification and logic of the adaptation pathway proposed here emerged through three years of research on social justice in adaptation to sea-level rise in Lakes Entrance, a project conducted in partnership with the East Gippsland Shire Council and three state government organizations.

In these first two years we collected a range of secondary data about the town: information about the population and economy, its geomorphology and ecology, anticipated climate impacts, and its history of resource management and adaptation (Fig. 1). We collected primary information through: 30 interviews with policy actors, operating at federal (5), State (13) and local (12) tiers about existing adaptation institutions; and 18 interviews with residents and a phone survey of 199 local residents and second-home owners to ascertain their lived values. The interviews with residents also sought to understand local perceptions of existing coastal flooding and environmental change. Furthermore, we participated in various local events and meetings³³.

Both sets of interviews revealed the nature of policy actors' and residents' concerns about existing sea-level rise adaptation policies and provided a range of perspectives on how these limitations could be addressed. Our analysis revealed that residents and policy actors alike believed equitable adaptation must take time to lay out information, allow local ownership of the adaptation process, and then allow people time to adapt³³. The interviews with, and phone survey of, residents revealed the things that people value about Lakes Entrance, and as such the things of value that are most at risk of sea-level rise and the associated adaptation actions. The analyses of these three data sets pointed to the need for an adaptation pathway for Lakes Entrance and provided the foundation for scoping what such a pathway might look like.

In the final year of this project we sought to empirically test the relevance and feasibility of an adaptation pathway in Lakes Entrance. The primary data used to test our approach came from two sources. First, we conducted a six-hour workshop with four key local decision-makers with responsibility for coastal, community and emergency planning and management. In this workshop the concept of a pathway was explained, and the goals, triggers and actions at each step of the pathway were proposed and extensively discussed. Our approach was further refined and detailed on the basis of the outcomes of this workshop. We then conducted three focus groups with residents of Lakes Entrance. There were on average five people at each of these, and they represented the broad spectrum of values and life stages in the town: the length of time participants had lived in the area spanned from 4 to 53 yr; there were approximately equal numbers of men and women; and equal numbers of retirees and workers, which is reflective of the broader population. Young people (under 30 years old) and indigenous people were not well represented in the focus group sample.

The focus groups lasted approximately two hours each. These began by discussing what participants valued about living in Lakes Entrance and establishing desired goals for the future of the town. Participants were then asked to discuss the most recent flood they could remember and highlight on a map of the town where they had previously observed flooding. They were then presented with two hypothetical future flooding scenarios that had been developed during the workshop: 25 days of low-level (1:10 yr) floods in a year; and two 1:100 yr floods in a year. These scenarios prompted a discussion of what kinds of triggers were meaningful to participants. The aim of this exercise was to determine the frequency and extent of flooding that they would consider disrupts the orderly functioning of the town, and what level of flooding would signal to them a level of social and environmental change that departed from the present. Participants were then asked to suggest the kinds of responses they would expect in the event of such a change.

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References

- Stafford-Smith, M. *et al.* Rethinking adaptation for a 4 °C world'. *Phil. Trans. R. Soc. A* **369**, 196–216 (2011).
- Hurlimann, A. *et al.* Urban planning and sustainable adaptation to sea-level rise. *Landscape Urban Plan.* **126**, 84–93 (2014).
- O'Riordan, T., Nicholson-Cole, S. & Milligan, J. Designing sustainable coastal futures. *Twenty-first Century Soc.* **3**, 145–157 (2008).
- Moser, S. C., Williams, S. J. & Boesch, D. F. Wicked challenges at Land's End: Managing coastal vulnerability under climate change. *Annu. Rev. Environ. Res.* **37**, 51–78 (2012).
- Berke, P. & Lyles, W. Public risks and the challenges of climate change adaptation: A proposed framework for planning in the age of uncertainty. *Cityscape* **15**, 181–208 (2013).
- Cheong, S.-M. *et al.* Coastal adaptation with ecological engineering. *Nature Clim. Change* **3**, 787–791 (2013).

7. Parson, E. A. & Karwat, D. Sequential climate change policy. *WIREs Clim. Change* **2**, 744–756 (2011).
8. Abunnasr, Y., Hamin, E. & Brabec, E. Windows of opportunity: Addressing climate uncertainty through adaptation plan implementation. *J. Environ. Plan. Manage.* <http://dx.doi.org/10.1080/09640568.2013.849233> (2013).
9. Hallegatte, S. Strategies to adapt to an uncertain climate. *Glob. Environ. Change* **19**, 240–247 (2009).
10. Levin, K. *et al.* Overcoming the tragedy of super wicked problems: Constraining our future selves to ameliorate global climate change. *Policy Sci.* **45**, 123–152 (2012).
11. Wilby, R. & Dessai, S. Robust adaptation to climate change. *Weather* **56**, 180–185 (2010).
12. Wilson, C. & McDaniels, T. Structured decision-making to link climate change and sustainable development. *Clim. Policy* **7**, 353–370 (2007).
13. Downing, T. Views from the frontiers in climate adaptation economics. *WIREs Clim. Change* **3**, 161–170 (2012).
14. Haasnoot, M. *et al.* Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. *Glob. Environ. Change* **23**, 485–498 (2013).
15. Kwadijk, J. C. J. *et al.* Using adaptation tipping points to prepare for climate change and sea level rise: A case study in the Netherlands. *WIREs Clim. Change* **1**, 729–740 (2010).
16. Wise, R. *et al.* Reconceptualising adaptation to climate change as part of pathways of change and responses. *Glob. Environ. Change* <http://dx.doi.org/10.1016/j.gloenvcha.2013.12.002> (in the press).
17. Ranger, N., Reeder, T. & Lowe, J. Addressing 'deep' uncertainty over long-term climate in major infrastructure projects: Four innovations of the Thames Estuary 2100 Project. *EURO J. Decis. Process.* **1**, 233–262 (2013).
18. Walker, W. E., Haasnoot, M. & Kwakkel, J. H. Adapt or perish: A review of planning approaches for adaptation under deep uncertainty. *Sustainability* **5**, 955–979 (2013).
19. Waters, E., Barnett, J. & Puleston, A. Contrasting perspectives on barriers to adaptation in Australian climate change policy. *Climatic Change* **124**, 691–702 (2014).
20. Measham, T. G. *et al.* Adapting to climate change through local municipal planning: Barriers and challenges. *Mitig. Adapt. Strateg. Glob. Change* **16**, 889–909 (2011).
21. Flugman, E., Mozumder, P. & Randhir, T. Facilitating adaptation to global climate change: Perspectives from experts and decision makers serving the Florida Keys. *Climatic Change* **112**, 1015–1035 (2011).
22. Moser, S. C. in *Successful Adaptation to Climate Change: Linking Science and Policy in a Rapidly Changing World* (eds Moser, S. C. & Boykoff, M. T.) 289–305 (Routledge, 2013).
23. Burch, S. *et al.* in *Successful Adaptation to Climate Change: Linking Science and Policy in a Rapidly Changing World* (eds Moser, S. C. & Boykoff, M. T.) 270–286 (Routledge, 2013).
24. Fincher, R. *et al.* Time stories: Making sense of futures in anticipation of sea-level rise. *Geoforum* **56**, 201–210 (2014).
25. Brace, C. & Geoghegan, H. Human geographies of climate change: Landscape, temporality, and lay knowledges. *Prog. Hum. Geogr.* **35**, 284–302 (2011).
26. Baker, I. *et al.* Local government response to the impacts of climate change: An evaluation of local climate adaptation plans. *Landscape Urban Plan.* **107**, 127–136 (2012).
27. Bedsworth, L. & Hanak, E. Adaptation to climate change: A review of challenges and tradeoffs in six areas. *J. Am. Plan. Assoc.* **76**, 477–495 (2010).
28. Macintosh, A. Coastal climate hazards and urban planning: How planning responses can lead to maladaptation. *Mitig. Adapt. Strateg. Glob. Change* **18**, 1035–1055 (2012).
29. McSweeney, K. & Coomes, O. Climate-related disaster opens a window of opportunity for rural poor in northeastern Honduras. *Proc. Natl Acad. Sci. USA* **108**, 5203–5208 (2011).
30. Spence, A. *et al.* Perceptions of climate change and willingness to act sustainably influenced by flood experiences. *Nature Clim. Change* **1**, 46–49 (2011).
31. Hall, J. *et al.* Proportionate adaptation. *Nature Clim. Change* **2**, 833–834 (2012).
32. Graham, S. *et al.* Local values for fairer adaptation to sea-level rise: A typology of residents and their lived values in Lakes Entrance, Australia. *Glob. Environ. Change* **29**, 41–52 (2014).
33. Barnett, J. *et al.* *Equitable Local Outcomes in Adaptation to Sea-Level Rise*. (Univ. Melbourne, 2014); <http://msd.unimelb.edu.au/equitable-outcomes-adaptation-sea-level-rise>
34. McInnes, K., Macadam, I. & Hubbert, G. *Climate change in Eastern Victoria – Stage 3 Report: The effect of climate change on extreme sea levels in Corner Inlet and the Gippsland Lakes* (CSIRO, 2006).
35. Sjerp, E. & Charteris, A. *Discussion Paper – Sea Level Change and Coastal Subsidence: Implications for Geomorphological Aspects and Associated Physical and Natural Assets of the Gippsland Coast* (Gippsland Coastal Board, 2007).
36. Grayson, R. *et al.* *Gippsland Lakes Flood Level Monitoring Project: Final Report* (Centre for Environmental Applied Hydrology, Univ. Melbourne, 2004).

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Author contributions

All authors participated in the design of the study and in writing the paper. J.B., S.G., C.M. and E.W. conducted the workshop with local decision-makers. J.B., R.F., S.G. and C.M. conducted the focus groups, and analysed the data.

Additional information

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Competing financial interests

The authors declare no competing financial interests.