WHEN IS FLOOD RISK TOLERABLE?

Innovative flood risk assessment and tolerability mapping to inform planning in levee-protected areas

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While there are many ways to define and assess flood risk, the available guidelines agree that this should not be exclusively determined by the probability and intensity of flooding. Flood risk frameworks should integrate hazard, exposure of life and/or property, vulnerability and resilience as key risk components (UNIDSR, 2015). Yet, there seems to be a lack of standardised procedures and tools to measure and aggregate these key risk components with the outcomes of hydraulic modelling.

One of the main reasons for this is that vulnerability and resilience are inherently difficult to quantify, which calls for the use of non-dimensional indices. However, these indices are not practical because they present the challenge of having to arbitrarily establish thresholds for when risk is acceptable, tolerable or intolerable. As a result, flood mitigation measures and planning responses are often driven by flood behaviour, rather than flood risk.

This study developed an innovative flood risk assessment approach to address these constraints for application to the levee-protected areas of Launceston, Tasmania. Here, the typical challenges of risk tolerability mapping are further complicated by the "levee paradox", whereby residents may develop flood risk complacency because of the protection from the levee, often thought to be failsafe.

A key aspect of a risk assessment exercise is to produce results that can readily inform planning responses. That is, is the risk model capable of consistently identifying thresholds between intolerable, tolerable and acceptable risk? Are these thresholds consistent with industry standards or with the expectation of the community, beyond any risk awareness bias?

Benchmarking an index-based risk assessment to tolerability thresholds based on industry standards and community feedback is one of the most innovative aspects of the proposed tool.

The tool is based on a model proposed by Queensland Reconstruction Authority (QRA, 2011). This is an index-based risk model that uses a typical probability-consequence matrix to obtain a risk score. A consequence score is obtained through an additive formula involving indicators of exposure, vulnerability and tolerability.

While additive risk models are relatively easy to apply, the degree of simplification that they introduce means that the inherent multiplicative nature of the risk components remains uncaptured. For instance, there should be no consequences without exposure, or these should double if exposure or vulnerability double.

The proposed model from the Launceston project uses a multiplicative formula to calculate consequences. Additionally, the indicators to assess exposure, vulnerability and resilience were modified to include a wider range of socio-economic aspects, as well as additional or alternative indicators to better reflect the data available for Launceston. Finally, the adopted multiplicative model includes expedients to reflect the levee-protection that applies to the study area.

Six design flood events (5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and 0.05% AEP) were considered under present and two future climate scenarios: year 2050 and year 2090. An additional scenario in year 2050 was included to investigate the potential effects of a levee breach caused by the 1% AEP event. This was selected because the 1% AEP event in 2050 would reach the crest of the embankment and a breach in that scenario would be more likely and would cause the greatest incremental impacts beyond the levee. The levee breach model outcomes for this scenario were obtained from a previous modelling exercise (BMT, 2018), which provided a flood envelope of 23 different breaches occurring at arbitrarily-selected locations along the levee.

Additionally, for scenarios in 2050 and 2090, an estimate of the development potential of each precinct in the study area was used to infer the possible future number of lots.

Importantly, the model's risk tolerability thresholds were benchmarked against industry standards and community expectations. While industry standards are relatively well defined, at least when it comes to cornerstones such as avoiding flood risk to property up to the 1 in 100 AEP event and risk to life up to the PMF, every community, in fact every individual, has a different flood risk tolerability threshold.

In Launceston, we attempted to capture this variability via a community survey, which was designed by Molino Stewart and distributed by Council to all residential and commercial addresses in the study area (Dufty et al., in press). In addition to exploring local tolerability thresholds, the survey assessed community resilience as a combination of factors such as risk awareness and perception, preparedness, emergency response and social capital. A total of 476 completed surveys were received from residential and commercial properties.

The community survey informed the "calibration" of the risk model. The model assumptions were adjusted iteratively until it produced risk tolerability scores that were consistent with floodplain management best practices and the self-assessed tolerability thresholds of the Launceston community, at least to an extent commensurate to the estimated risk awareness bias.

The results of the study suggest that, under current climate conditions, no properties in the study area have intolerable flood risk, while 30% have tolerable risk and 70% have acceptable risk. However, under future climate conditions and with increased development, 8% of properties may have intolerable flood risk by 2050, which increases to 38% by 2090.

When the levee breach scenario in a 1% AEP event in the year 2050 is considered, the risk model produces significantly higher flood risk levels, although this is largely due to the assumptions of the BMT (2018) breach model, including an envelope of flood extents and depths of 23 different breaches. In a real event, a single breach would be most likely to occur, and the actual flood impact would be significantly less.

The model was designed to be sensitive to variations in vulnerability and resilience, consistent with the relevant literature (Cardona et al., 2012). This assumption meant that measures to manage vulnerability and resilience may result in a significant reduction of the number of lots with intolerable risk in year 2050. However, in year 2090, risk will be mostly driven by the increased frequency of flooding due to climate change, and more stringent and transformational planning responses, or measures to change flood behaviour may be necessary.

Finally, the study outcomes were used to inform medium to long term planning strategies for flood risk management in Launceston, and specifically:

- To define and map Flood Risk Precincts (FRP) for the purpose of structuring planning conrols; and
- To select suitable planning controls in each FRP. In particular, it was proposed that, in some instances, developers should demonstrate that flood risk will be tolerable (as a minimum) using the study's risk assessment tool and assumptions.

References:

Australian Bureau of Statistics (ABS), 2016. Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia, 2016.

BMT, 2018. North and South Esk Rivers Flood Modelling and Mapping Update Levee Breach Assessment.

Cardona, O. D., Van Aalst, M. K., Birkmann, J., Fordham, M., Mc Gregor, G., Rosa, P., Pulwarty, R.S., Schipper, E.L.F., Sinh, B.T., Decamps, H. and Keim, M. (2012). Determinants of risk: exposure and vulnerability. In *Managing the risks of extreme events and disasters to advance climate change adaptation: special report of the intergovernmental panel on climate change* (pp. 65-108). Cambridge University Press.

Dufty, N., Garrett, R., Dall'Osso, F. and Sanborn, K. (in press). Living behind the Launceston levee: Insights from a community survey. *Australian Journal of Emergency Management*.

Queensland Reconstruction Authority, 2011. Planning for Stronger, More Resilient Floodplains.

United Nations Office for Disaster Risk Reduction (UNISDR), 2009. 2009 UNISDR Terminology on Disaster Risk Reduction.