A REVIEW OF AUSTRALIAN MODELS TO PREDICT DIRECT TANGIBLE FLOOD DAMAGES: DO WE NEED BETTER TOOLS?

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Damage assessment is a key component of floodplain management; it quantifies flood risk to property and guides the adoption of mitigation measures.

This paper reviews current Australian flood damage assessment methods for direct tangible damages, in an attempt to highlight their pros and cons and provide insights on their level of accuracy. The scope of the review is restricted to relatively recent (i.e post 2004) and well referenced publications.

A building damage curve is a mathematical model which associates a flood "demand" parameter to the predicted damage level, for a given building type. The first component is the flood "demand" parameter. A "demand" parameter is a quantitative measure of the "demand" that a given flood poses on a building's structural and content integrity (eg. peak flood depth, peak flow velocity). The second component curve is a damage indicator. In most instances, damages are measured in absolute terms using the "cost to repair" as the damage indicator, although alternative indicators for assessing damage are available.

Most riverine flood studies have historically used building damage curves in which the flood demand parameter was the peak flood depth and the damage indicator was the cost to repair the building. This particular subtype of building damage curves is referred to as "stage-damage curves", where the word "stage" refers to the use of flood depth as the demand parameter. Stage-damage curves are the industry standard globally and in Australia.

Stage-damage curves for residential and non-residential properties have been developed empirically or analytically. Some quantify damage in absolute terms, some use a-dimensional indexes. Some curves assess damage to building fabric only, some others have attempted to include contents and exteriors. Some recent models have considered post-disaster inflation, and have attempted to consider human behaviour, in terms of preparatory measures to protect building contents and how this might be driven by the owner's insurance status.

Importantly, most Australian approaches have focused on residential damages, while the literature is much thinner when it comes to damages to non-residential properties. Methods such as ANUFLOOD (Greenaway and Smith, 1983) have been shown to severely underestimate damage. Yet, ANUFLOOD is still used for non residential damages assessments as no alternative options have been developed in Australia.

The Dale et al. (2004) synthetic stage-velocity damage curve uses both flood depth and flow velocity as demand parameters and shows the combinations of depth and velocity that would cause structural failure typical Perth in single-storey residential buildings, although it does not provide the predicted damage to the building when this is not moved off it foundations.

After it was proved that ANUFLOOD would severely underestimate flood damages, the NSW Government (NSW Government, 2007) developed a set of stage-damage curves for residential buildings based on work undertaken by Risk Frontiers (Blong & McAneney, 2003). The Risk Frontiers report was based largely on an analysis of flood damage from flooding in Katherine in 1984 and drew further on 1974 Brisbane flood data

(Blong & McAneney, 2003). This data was based on insurance claims. The report's analyses of building damages considered changes in average home sizes with time and the inflated cost of reconstruction in the period following a flooding event, resulting from greater demand for building materials and labour. Since their release in 2007, the flood damage guidelines developed by the NSW Government have become the standard method to assess flood damages to residential properties in NSW, and ANUFLOOD stage-damage curves have been used more rarely and only for non-residential properties.

Geoscience Australia has been leading Australia's Federal Government work on stage-damage curves since the 2011 Brisbane floods, with a number of curves generated in the last decade including analytical stage-damage curves for riverine damage in NSW (Maqsood, 2013) and QLD (Geoscience Australia, 2012a), the latter of which was validated with empirical data (Wehner et al., 2017) showing moderate to significant variability for insured and uninsured homes respectively.

The Mason et al. (2012) curves adjusted the Geoscience Australia (2012a) curves with empirical data obtained from insurance claims, and accounted for post disaster inflation and underinsurance. The work developed four semi-empirical total loss (i.e. building and contents) vulnerability curves for typical Brisbane residential building.

Nafari et al. (2016) developed and validated an alternative predictive model for direct tangible flood damages to residential and non-residential buildings. While the resulting stage-damage curves calculate only building fabric damage, the model was fully validated showing good results.

The review of the above listed work concluded that, in Australia:

- Publicly available approaches are rather fragmented: there is no "one size fits all" option;
- There are no probabilistic damage models;
- There are insufficient or outdated options for non-residential buildings;
- Only three residential models were validated, with variable results;
- There is a limited capability to consider building contents (important where velocity is low), flow velocity or duration (where these are high);
- The low specificity of the resulting models means that the curves, being deterministic, are associated with a relatively high variability. This may be ok when the curves are used on very large building samples, however small to medium scale applications that are typically undertaken to assess the benefits of flood modification measures may be affected by significant error.

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