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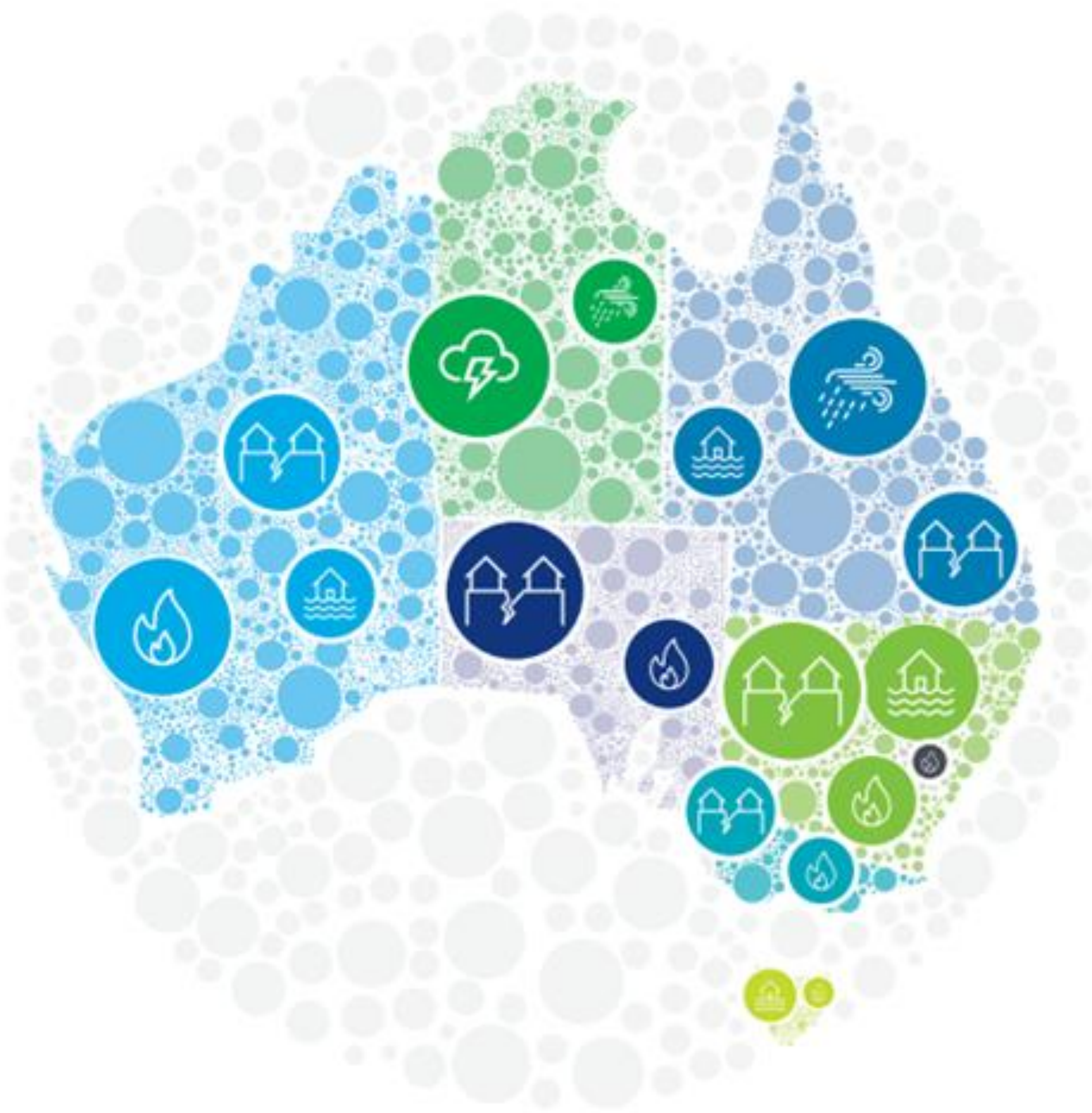

Update to the economic costs of natural disasters in Australia: Methodology paper

Australian Business Roundtable

for Disaster Resilience and Safer Communities

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Deloitte Access Economics

Contents

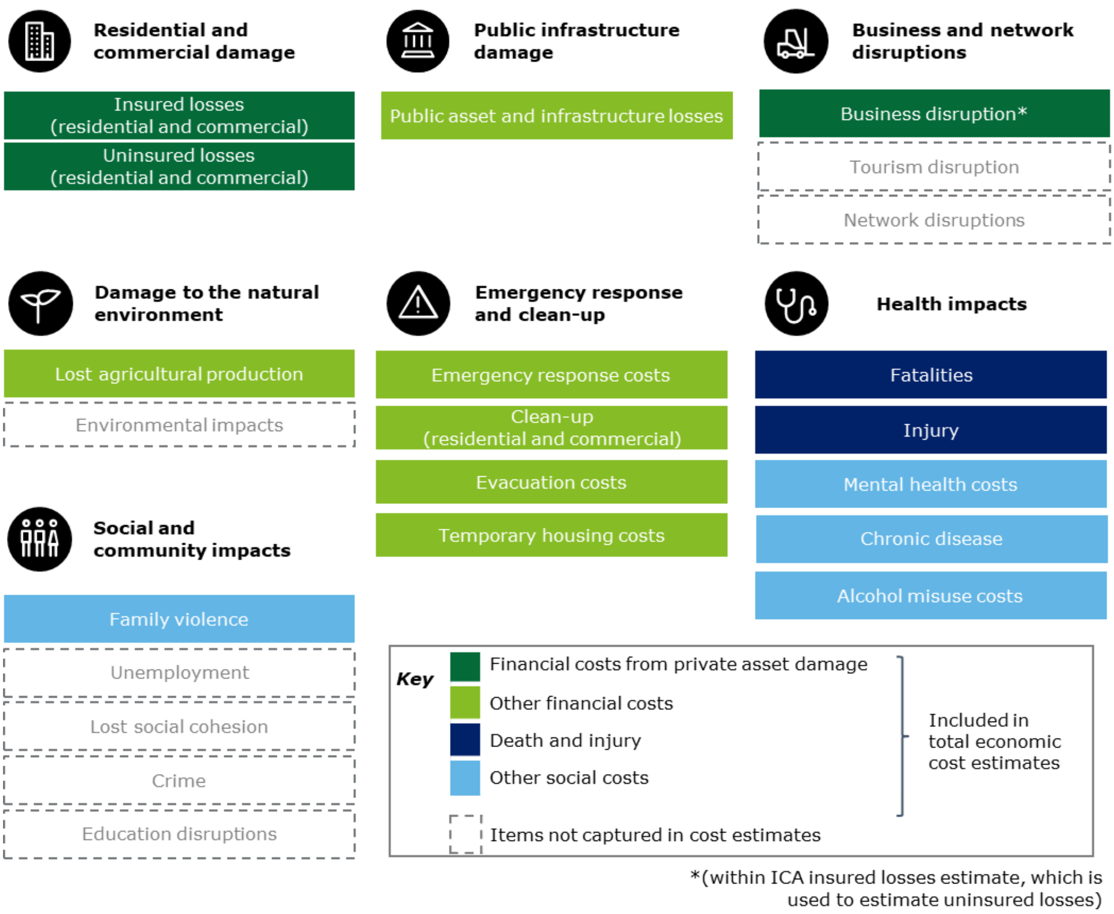
1 Modelling methodology

This paper outlines the methodology used to estimate the total economic cost of natural disasters in *Special report: Update to the economic costs of natural disasters in Australia*.

This methodology is based on that used by Deloitte Access Economics in previous ABR reports, which has been estimated over time.

Figure 1.1 identifies the four different cost components – financial costs from private asset damage, other financial costs, death and injury and other social costs - captured using this methodology. The cost categories under these four components are the same as the cost categories used in the 2017 modelling. Figure 1.1 also shows that some costs of disasters are not quantified in the modelling, which are explained in the modelling notes (Section 2.1)

Figure 1.1: Costs included in total economic costs estimate[1]



Source: Deloitte Access Economics 2021

[1] Different community groups and business sectors affected by a disaster may experience several of the cost types identified in Figure 1.1. For example, an agricultural primary producer might experience insured and/or uninsured asset losses; business disruption costs, lost agricultural production and associated with social impacts such as mental illness.

1.1 Methodology overview

Figure 1.2 summarises the approach for estimating the total economic costs of natural disasters.

Figure 1.2: Methodology for estimating total economic costs of natural disasters

	Stage 1: Asset losses		**Stage 2:** Calculate multipliers to estimate flow-on impacts		**Stage 3:** Apply multipliers to estimate total cost
	Annual Average Damage (residential only) under each RCP	Annual Average Damage (commercial & residential) under each RCP	Additional financial costs	Costs of social impacts	Total economic costs of disasters
Outputs	Financial costs			Social costs	Total economic costs
Costs included	• Residential damage (insured and uninsured) • Contents losses • Business disruptions	• Commercial damage (insured and uninsured)	• Public asset damage • Residential clean-up costs • Commercial clean-up costs • Lost agricultural production • Evacuation costs • Temporary housing costs • Emergency response costs	• Fatalities • Injuries • Mental health impacts • High-risk alcohol consumption • Exacerbated chronic disease • Family violence	Sum of financial and social costs
	Chapter 3 provides estimates of the components of cost identified above and explains why some other costs have not been captured.				
Approach	• Expected value of asset losses due to natural disasters. • Losses vary under different scenarios (RCPs) • AAD varies based on population growth and housing values	• Total AAD is estimated using the ratio of commercial and industrial loss to residential loss.	• Additional financial costs were estimated by Joy (1991) using a set of ratios. • These ratios are adjusted based on bottom up estimates of the 3 reference events • Ratios vary by disaster type	• The ratios are again adjusted, to include additional social costs of disasters. • These social cost ratios are estimated from the same 3 reference events. • The incidence of social impacts are applied to the proportion of AAD that can be explained by large events captured by the ICA database • Ratios vary by disaster type	• Apply multipliers to Annual Average Damage (commercial & residential) under each RCP, as calculated in stage 1
Data inputs	• AAD under different warming scenarios (IAG) • Property values (Westpac) • Housing value forecasts (Deloitte Access Economics) • Population forecasts (ABS, state governments, Deloitte Access Economics)	• Ratios of commercial to residential exposure asset exposure (Munich Re)	• Tangible cost ratios, estimated using Joy (1991) multipliers, ICA data, NDRRA claims and economic literature (Deloitte Access Economics)	• Intangible cost ratio, estimated using reference events (Deloitte Access Economics) • ICA dabatabase	• Asset losses under each RCP (stage 1 output) • Multiplier to scale up for social costs (stage 2 output)

Source: Deloitte Access Economics 2021

The **first stage** of the approach is to estimate disaster-related **asset losses** under different future climate scenarios. The approach uses IAG estimates of AAD for residential buildings and contents at different temperatures rises, which were aligned with the IPCC climate forecasts as a base for estimating costs over time.[2] From this base, estimates of commercial and industrial losses are derived using ratios of commercial (and industrial) to residential risk exposure (data provided by Munich Re). This process is detailed in stage 1.

The **second stage** is to estimate a set of multipliers, which are applied in stage 3 to scale up total asset damage values, to account for additional financial costs, and to include social costs. Additional financial costs include clean-up and evacuation costs, while social costs include the economic costs attributable to deaths, injuries, other health effects and family violence associated with disasters. The multiplier used to estimate these additional costs is based on a set of ratios developed in the academic literature, which have been adjusted by Deloitte Access Economics following analysis of the actual costs associated with three historical Australian natural disaster reference events.

The **third stage** is estimate total economic costs, by applying the multipliers estimated in stage two to the asset damage values estimated in stage one. This results in total economic costs which account for both the financial and social impact of natural disasters. The total cost of disasters will vary under different RCPs, based on the value of asset damages.

1.2 Data sources

The modelling presented in this paper uses data provided by member organisations of the ABR and Deloitte Access Economics forecasts. The following data sets from ABR members were used as inputs to the modelling:

- **IAG:** Average Annual Damages (AAD) (in 2019 dollars) for each type of natural disaster at the SA3 level under baseline, +2C and +3C warming scenarios. This includes insured and uninsured losses (including contents) for all residential properties (both IAG and non-IAG properties).
- **Munich Re:** Estimates of commercial to residential asset exposure, as well as overall and insured losses by type of natural disaster.
- **Westpac:** Current (2019) median value of housing stock and number of dwellings by postcode.

The following public data inputs were also used:

- **IPCC:** global estimates of future warming under four RCPs, obtained using the mean estimate of climate models included in the IPCC's fifth Assessment Report (AR5).
- **State government agencies:** Population projections, by SA3 or LGA depending on availability.
- **ABS:** Population projections by state.

The other key modelling inputs were developed by Deloitte Access Economics. This includes forecasts of growth in the structural value of the housing stock, which are based on macroeconomic projections of new dwelling investment.

To estimate the flow-on financial and social costs of disasters based on the damage cost, a multiplier method was used. These multipliers were developed by Deloitte Access Economics, which drew on academic literature and analysis of the costs of actual disaster 'reference events'. The reference events selected were:

- The South East Queensland Floods (Queensland, 2010–11)
- The Black Saturday bushfires (Victoria, 2009)
- The 'Pasha Bulker Storm', an East Coast Low event (New South Wales, 2007)

[2] AAD can be understood as the replacement value of asset losses – that is, the value of both insured and uninsured assets.

2 Notes on modelling

This section discusses key elements of the modelling methodology to assist with interpretation of the modelling results.

2.1 Total economic cost estimates are the expected value of future costs

Total economic costs represent the expected value of future costs, rather than a forecast of what actual (realised) costs will be in any given year. This is a result of economic costs forecasts being based on Average Annual Damages (AAD) which represent average damage per year that may occur in an area for any given year (with the period analysed).

The result of this modelling approach means that, in some years, the total economic costs of natural disasters will likely be much higher (or much lower) than the cost estimates from the modelling. What the modelling predicts is that costs will, on average, increase in line with global temperatures presented in the three trajectories. Put differently, the economic costs of natural disasters are expected to increase on average, with variation in the actual (realised) cost of natural disasters from year to year. This yearly variation has not been modelled in this work.

An associated limitation of the expected value approach to estimating costs is that transitory, distributional, and context-specific costs such as supply chain disruptions are not captured. The total economic cost estimates consider the fact that, in some instances, costs may be incurred in one area (or time period), but an offsetting benefit (in terms of spending or demand) will be received in another area (or time period). In such cases, the economic cost of a disaster will be smaller than the costs incurred by those impacted, after considering the offsetting benefits to other regions or persons. Ignoring these effects would result in 'double counting', which can overestimate the economic costs of disasters.

Some examples of the types of costs that have not been captured in the modelling include:

- **Tourism impacts.** Natural disasters often impact the number of visitors to a region, which may reduce spending on tourism related industries. Yet, this can be offset by visitors going to another part of the country or increasing their spending on other goods. For example, if tourism in the Blue Mountains is temporarily reduced as a result of recent bushfires, it will create a significant cost for the local community. But tourism operators and communities elsewhere in Australia may see an increase in business as tourists visit other parts of Australia instead or spend money on other goods and services. Given the difficultly to quantify the extent of economic activity that is transferred to another region the total economic cost modelling excludes tourism costs to avoid any potential overestimation of economic costs.

- **Long term supply chain effects.** The reference events are used to create a ratio of total economic costs relative to damage costs, which can then be generalisable to all locations where a particular peril is applicable. Given this intent, specific event characteristics, which are highly context and location dependent, are excluded to ensure that the selected reference events are representative (of other events of the same nature).

  For example, the costs associated with extensive network disruptions and the removal of the Pasha Bulker following the NSW East Coast Low (2007) have not been included, as these are considered beyond the scope of a 'typical' storm event. This aligns with the principle that the aggregate cost is an expected average value – recognising that, within a given type of natural disaster, events will have different levels of severity.

  As per the tourism example, the impact of natural disasters may cause distributional effects, which may be offset. For instance, a decline in agricultural produce may be offset in increased demand for produce from other agricultural sectors. Expected values at the SA3 level do not include the transfer of this cost between local communities as these are likely to offset each other and will be smoothed out across other SA3s and over time. Ignoring this offsetting principle would overestimate costs.

For example, the New South Wales East Coast Low (2007) resulted in the Pasha Bulker coal ship being run aground. If costing the Pasha Bulker storm as an individual event, it would be important to assign costs to the network disruptions and supply chain impacts. For instance, an estimated 300,000 people were without mains electricity for four days (some for up to a month), the coal export chain was suspended for two weeks and communications were interrupted for days.[i] Similarly, the loss of electricity services caused by the 2007 Victoria cost the national economy $234 million.[ii] While these are large costs, it would be inappropriate to include these costs as an 'expected' cost of the average storm event, because such multipliers may be overstated.

- **Environmental impacts.** Another highly contextual cost that has not been explicitly included in the modelling is environmental damage. This is because environmental damage is at times partially captured in other costs (infrastructure rebuilding costs etc). However, not all environmental costs would be captured through this methodology, and the environmental damage caused by natural disasters is highly location specific (for instance, compare the damage of a tropical cyclone impacting the Great Barrier Reef with the impact on remote bushland). As a result, environmental costs have been excluded from the cost estimates. In other studies, these environmental costs are often estimated based on in-depth case studies of natural disasters. This explored further in the breakout box below.

2.2 Total economic costs grow in line with AAD, as warming occurs

The modelling approach using multipliers means that the relationship between disasters of different sizes and their associated costs remains constant over time. This assumption is necessary given the lack of reliable information regarding how both total economic costs and AAD change as the frequency and intensity of natural disasters vary. Without such information it is not prudent to consider whether total economic costs should increase relative to AAD as global warming occurs, or vice versa. This is a potential area for future research.

The implication of this assumption is that the total economic cost multipliers remain constant over time and does not capture the potential 'interaction' effect of natural disasters – which may occur if intensity and frequency vary. This potentially results in underestimating of costs of natural disasters if total economic costs grow more rapidly than AAD as climate change worsens. For example, if two different significant natural disasters impact one region in a short time there could be mental health impacts for the resident population greater than the sum of the individual natural disasters.

2.3 Historical reference events (for each type of natural disaster) drive the relationship between tangible and intangible costs into the future

The modelling uses historical reference events to estimate the relationship between tangible and intangible costs for each type of natural disaster.

This relationship was applied to the estimated proportion of AAD that could be accounted for large scale disasters. For the estimated proportion of smaller scale events (compared to the ICA database), social costs were not included. This is not to imply that small scale events do not incur social costs, but to reflect that social costs could be reasonably expected to reflect a smaller share of total costs than in the reference events. The relationships – for both large- and small- scale disasters – remain constant over time, even as changes in other variables, such as temperature, occur.

The limitation of this assumption is that the ratio of tangible to intangible costs for each type of natural disaster is constant geographically and over time for large scale events. Applying the multiplier across different geographies means that a natural disaster will have a similar ratio of total costs to AADs in a metropolitan city and a regional city. However, given the spatial differences in AAD, the modelling does fully reflect regional differences in total economic costs.

Smaller natural disasters are likely to incur social costs. In the methodology, these social costs are assumed to be equal to the reference event or set to zero. Further information around the social costs could lead to more accurate estimates of costs for events of this magnitude.

Similarly, applying this relationship constantly over time means that the event will have the same ratio each year into the future. Extensive data on how these relationships change across geographies and over time would be required to improve on this modelling assumption.

2.4 Commercial AAD is based on commercial exposure relative to residential exposure for each location

Residential AAD values were used to estimate commercial and industrial property losses. To model the relationship between residential to commercial and industrial damages, data from Munich Re on the ratio of commercial (and industrial) exposure to residential exposure was used. This data was used as a proxy for the ratio of commercial (and industrial) AAD to residential AAD, by postcode. The implication of this assumption is that estimates of commercial (and industrial) AAD rely on the ratio in Munich Re data, which varies by location, but stays fixed over time.

This approach should also be recognised as an approximation for estimating commercial losses. If commercial assets had high levels of resilience to natural disasters this approach could overestimate the losses. However, there is no significant evidence base to determine any bias in the above approach.

For public assets, the costs associated with replacing or repairing are included in the tangible cost ratio, estimated based on the Category B NDRRA expenditure (which covers restoration of essential public assets, and assistance to small businesses, primary producers, not-for-profit organisations through concessional loans, subsidies or grants).[iii]

2.5 Building resilience is assumed to increase at a constant rate

Increasing levels of mitigation and resilience over time have been captured through a fixed annualised percentage (0.8%) reduction in AAD caused by natural disasters. This assumption is based on research suggesting that enhanced building codes can reduce damage by 55-65%.[iv] This range was reduced to reflect the likelihood of some dwellings not upgrading or where upgrades are not as effective as the parameter above. In addition, changes to building codes, which apply only to new residential buildings, will only affect about 1.3% of housing stock per annum. Deloitte Access Economics calculations estimate that changes to building codes take about 44 years to flow through to entire stock of dwellings (given the age of current stock).[v]

The limitation of this assumption is that the research is based on one type of natural disaster – tropical cyclones – and does not account for the variation in resilience based on different disasters. There are also alternative mechanisms for improving resilience – such as improving critical infrastructure resilience standards or improved planning to reduce exposure to natural disasters, which are not explicitly captured.

This was a necessary assumption due to insufficient data and uncertainty around the likely path of resilience investments and their effectiveness in the future prevents detailed estimates of resilience by peril. The approach taken in this study is conservative and is based on historical data of improved building resilience, which has been annualised in the modelling.

2.6 The cost of heatwaves and droughts are not included

Natural disasters are shocks caused by a natural process or phenomenon that may cause loss of life, injury, damage and disruption.[vi] The cost estimates are limited to the types of natural disasters measured within the AAD dataset provided by IAG. The types of natural disasters measured are storm, tropical cyclone, flood, earthquake (does not vary by RCP) and bushfire.

A limitation of this analysis is that it only captures the costs associated with disaster events for which residential building insurance is available. This precludes costs associated with drought and heatwaves, two disasters types which are likely to see a significant increase in costs as a result of climate change.

However, this approach is in line with the commonly accepted definition of a natural disaster as 'rapid onset' and the well-established approach to modelling disaster costs based on insurance records. For instance, the quantified types of natural disasters broadly align with those included in the original BTE study, which does not include the costs of drought or heatwaves as their analysis is aligned to the disasters covered at the time by the Natural Disaster Relief Arrangements.[vii]

Similarly, the ICA Catastrophe database does not include records for drought of heatwave.[viii] Notably, the costs of these events are more difficult to identify and quantify, given the slow onset or gradual nature of damage, relative to a clearly defined event which causes immediate disruption.[ix] This is distinct from the Productivity Commission definition of natural disasters as 'rapid onset events'.

2.7 Total economic costs are only estimated up to the point where +3C warming occurs

The total economic cost estimates in this paper are based on IAG estimates of damages under current (baseline) temperatures, +2C and +3C warming, relative to pre-industrial levels. After warming of more than +3C occurs, the effect of natural disasters on asset damages becomes less certain and IAG have not provided AAD estimates to guide the economic analysis beyond +3C warming. To avoid extrapolating beyond IAG's estimates, the economic cost modelling is limited to the period before global temperatures reach greater than 3C warming. The implication of this assumption is that the modelling period is limited to the period up until 2060, after which global temperatures rise above 3C warming under RCP 8.5.

2.8 AAD estimates reflect all insured and uninsured losses for all residential properties.

Total cost estimates rely on the accuracy of the IAG AAD estimates in capturing underinsurance and do not consider any potential under insurance not already captured in the IAG modelling. Systematic underinsurance in a locality would introduce bias into the total economic costs estimated. Deloitte Access Economics has not assessed the validity of the AAD estimates.

2.9 The number of households and dwellings increase proportionately to population growth.

Population growth and corresponding increases in the number of dwellings are measured using state government population projections. Household formation remains constant over the time period, consistent with ABS forecasts. Incorporating population and housing growth requires an assumption that AADs and total economic costs increase proportionally to the number of dwellings. This implies that future developments will occur in currently developed locations, and that current exposure levels will persist into the future.

2.10 Total economic costs increase with forecast real growth in the structural value of housing.

This assumption is necessary given a lack of information regarding how AAD varies as the number and density of dwellings increases in a region. As a result, total economic costs are forecast to increase in line with state and territory government population forecasts.

Endnotes

[i] Verdon-Kidd, D, Kiem, A, Willgoose, G, Haines, P (2010) *East Coast Lows and the Newcastle/Central Coast Pasha Bulker storm*, National Climate Change Adaptation Research Facility, Gold Coast, 61 pp <https://knowledge.aidr.org.au/media/1925/verdon-kidd_2010_east_coast_lows_pasha_bluker _storm.pdf>

[ii] Deloitte Access Economics (2013) *The Economic Cost of the Social Impact of Natural Disasters* (report for the Australian Business Roundtable for Disaster Resilience and Safer Communities) <http://australianbusinessroundtable.com.au/assets/documents/Report%20%20Social%20costs/Report %20-%20The %20economic%%20of%20the%20social%20impact%20of%20natural%20disasters.pdf>

[iii] Australian Government Department of Home Affairs*, Natural Disaster Relief and Recovery Arrangements* (factsheet) <https://www.disasterassist.gov.au/Documents/Fact-sheets/NDRRA-Factsheet.pdf>.

[iv] Risk Frontiers, n.d. Senate Standing Committee on Environment and Communications: Inquiry into recent trends in preparedness for extreme weather events.

[v] Deloitte Access Economics (2017) *Building Australia's resilience to natural disasters* (report for the Australian Business Roundtable for Disaster Resilience and Safer Communities) <http://australianbusinessroundtable.com.au/assets/documents/ABR_building-resilience-in-our-states-and-territories.pdf>.

[vi] Department of Home Affairs (2018) National Disaster Risk Reduction Framework, https://www.homeaffairs.gov.au/emergency/files/national-disaster-risk-reduction-framework.pdf.

[vii] Bureau of Transport Economics (BTE), *Economic Cost of Natural Disasters in Australia*, Report 103 (2001) <https://www.bitre.gov.au/sites/default/files/report_103.pdf>.

[viii] Insurance Council of Australia *ICA DataGlobe: search for ICA data records* <https://www.icadataglobe.com/metadata-search>.

[ix] SGS Economics and Planning *At what cost? Mapping where natural perils impact on economic growth and communities* (report for Insurance Australia Group, 2016) <https://www.iag.com.au/sites/default/files/Documents/Reports/At%20what%20cost%20-%20mapping%20where%20natural%20perils%20impact%20economic%20growth%20and%20communities.pdf>.

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