Show Me the Money! – Economic Analysis in Floodplain Management

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Abstract

Within the NSW Floodplain Risk Management (FRM) Process, economic analysis is used as a tool to assist decision making through establishing an understanding of the level of economic impact associated with a particular flood event, as well as translating this across a range of events to an annualised average damage, and facilitating prioritisation between identified floodplain management options.

To date, economic cost benefit analysis has largely focused on the quantification (in dollar terms) of property related flood damages and in some cases factors for intangible damages. Other impacts of flooding, such as environmental impacts or social impacts, are typically considered qualitatively or assessed through a multi-criteria assessment.

The resulting outcome is that cost benefit analysis results for flood mitigation options are typically weak in providing economic justification as they only compare one potential benefit stream against the total cost of the mitigation. This can lead to a disparity when comparing flood mitigation works with other infrastructure where a more holistic economic analysis may have been undertaken.

This paper undertakes a review of some of the economic analysis approaches and guidelines adopted outside of floodplain management, including the Roads and Maritime Services, NSW Coastal Management (through the NSW Coastal Management Manual) and the Asian Development Bank. The review looks at ways in which some of these approaches might be suitable for floodplain management.

Based on the outcomes of this review, initial recommendations and suggestions are made on the economic analysis approach to provide more holistic economic results for floodplain management option assessment. These recommendations consider the balance between the overall cost of the infrastructure versus the cost of undertaking the more detailed assessment.

Acknowledgement

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Introduction

Economic assessment for floods may be used in studies undertaken for a range of purposes to inform different types of decisions: These may include:

- by councils to understand and make decisions on their flood risk often through the NSW floodplain risk management (FRM) process outlined in the NSW Floodplain Development Manual 2005. Management may involve management actions to:
  - reduce flood damages to existing private and public buildings (primarily residential, commercial and public buildings and their contents) and infrastructure (both private and public). These may include mitigation works such as levees, detention basins or flow conveyance improvements.
  - reduce exposure of people in the community to flood risk and therefore improve public safety. These may include flood warning systems, upgrade of evacuation routes.
- by developers to examine the most cost effective way to meet development conditions
- by transport managers to examine the ability to improve serviceability of their networks.

This allows decisions to proceed for projects or prioritisation of similar projects to be made based upon the benefits in relation to the specific issue they are intended to address, which may relate to the funding source. For example, the NSW Floodplain Management Program provides councils with funding to understand and manage their flood risk.

Within the NSW Floodplain Risk Management Process (refer Figure 1), the prioritisation and selection of mitigation options is undertaken within the Floodplain Risk Management Study and Plan phases. This is typically undertaken through a combination of economic analysis and multi-criteria assessment.

Once the preferred options are selected and a plan is prepared, the next stage is the Plan Implementation. At this point, most NSW councils will be required to prepare funding applications to the NSW government for funding, as well as to apply internally for any funds to come from the council itself (or the local community). Such applications effectively function as business cases for the project, outlining the proposed risk management plan and governance structures for implementation as well as demonstrating the economic outcomes of the options.

**Economic Analysis**

Economic analysis in studies, in line with the NSW Floodplain Development Manual, typically incorporate:

- Direct damages, primarily related to the inundation of residential, commercial, residential and agricultural properties. These damages are estimated through "damage curves", which relate the level of inundation to a corresponding damage or cost. For example, the DECC (now OEH) Residential Damage Curves (DECC, 2007) includes direct damage but also allow for indirect damages as outlined below;
• Indirect Damages – this relates to costs associated with social and community disruption, as a result of the evacuation, clean-up and recovery activities. Some damage curves, such as FLDamage (Water Studies, 1992), include some allowance for this (for example, lost income from commercial properties during the recovery phase, alternative accommodation costs etc).

• Intangible Damages – these include social impacts such as increased levels of ill health, depression etc following the flood event. These damages are typically poorly understood or quantified in studies. In some floodplain management studies, a blanket factor is applied to the direct and indirect damages, but this is very much an approximation with limited research in this area.

A key focus of the economic assessment above is on property related damages and the reduction of these damages by floodplain management options. The direct, indirect and intangible damages identified above are all directly related to property damages. Other benefits of options that may arise but are generally not assessed include:

• Potential reductions to loss of life and injury;
• Reductions in loss of transport connectivity (i.e. improvements to flood immunity of a road or rail line, emergency access);
• Down time of public infrastructure (for example, a recreational park that cannot be used after a flood or a wastewater treatment plan that is not operational for a period after a flood);
• Public recreation (the damage to public parks etc has a value associated with it that is not typically accounted for); and,
• Environmental values.

Such benefit streams are typically broadly considered through the use of multi-criteria assessment or direct qualitative considerations and professional judgement to consider how significant these factors may be.

The resulting outcome is that cost benefit analysis for flood mitigation options are typically low (Benefit Cost Ratio (BCR) below 1) as they only compare one potential part of the overall benefit of an option. While highly conservative in approach, this can lead to a disparity when comparing flood mitigation works with other infrastructure where a more holistic economic analysis might have been undertaken. This may be problematic when prioritising the investment of public funds.

A review of other industry economic guidelines is provided below along with some initial thoughts on a potential approach to a more holistic economic analysis for floodplain management.
Economic Analysis in Other Industries

Transport for NSW

Economic analysis forms part of the investment decision process for transport infrastructure in NSW. This is principally guided by the *Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives* (Transport for NSW, 2016). Similar guidance exists for other states and at a Federal level.

While the guidelines provide an overview on a range of benefits that may be incorporated within an economic analysis, the primary focus of economic assessment for transport infrastructure projects tends to be on road user benefits, which typically include:

- Travel time savings;
- Vehicle Operating Costs (VOC);
- Accident Reductions;
- Reliability and resilience of the infrastructure;
- Flood immunity of the road;
- Wider Economic Benefits (for projects in excess of $1B); and,
- Environmental externalities.

In general, Transport for NSW (and NSW Road and Maritime Services) do not consider infrastructure projects with BCRs of less than 1. This is in stark contrast to many of the floodplain management options implemented, where BCRs (based upon a narrow calculation) are commonly less than 1.

Asian Development Bank

The Asian Development Bank (ADB) oversees and funds numerous projects throughout the Asia-Pacific Region. In 2020, the ADB is expected to spend roughly $14 billion on infrastructure, across a whole range of sectors (power, transport, water etc) (ADB, 2017).

As part of project due diligence, ADB projects require an economic analysis, which is undertaken in accordance with the *Guidelines for the Economic Analysis of Projects* (ADB, 2017). Given the large variety of projects, the guidance is more on the economic...
methodology rather than providing specific advice on valuation of economic benefits. However, there are some key components of the guidelines and economic analysis for ADB projects that are useful for comparison:

- There is a distinct focus on achieving a minimum economic internal rate of return (EIRR – i.e. the discount rate required for the present value of the benefits to equal the costs) of 9% for most projects. In the previous guidelines from the ADB this was 12%. It would be extremely rare for an ADB project with an EIRR of less than 9% (i.e. BCR less than 1) to gain funding.
- There is a focus on quantifying as many of the benefits as possible within the analysis. For example, Thomson et al (2012) for a 24 bridge upgrade study in the Solomon Islands, incorporated improvements benefits such as travel times as well as the impact of reduced closure times on economic production of agriculture in the region. Consideration of producer surplus models and economic multipliers is occasionally utilised.
- Distributional Analysis and Poverty Impact Assessment – ADB projects require an estimate not just on the total benefits of the project, but on how these benefits are distributed amongst the community. This is useful to understand how wide or narrow the benefits are to the community. In particular, consideration of vulnerable communities through poverty impact assessments is often used.

Suggestions for Potential Approach for Future Floodplain Management Projects

The current economic assessment that is adopted for floodplain management in NSW provides a relatively simple way with which to determine the likely impacts on existing properties. The method focuses on property damage, with other potentially quantifiable benefits of options being qualitatively assessed through Multi-Criteria Assessment or similar approaches. This can result in conservatively low BCRs.

The economic assessments that are undertaken in other industries, such as the NSW Roads and Maritime Services (RMS) or the Asian Development Bank (ADB), generally require significantly more effort than adopted for floodplain management. However, it is also recognized that the infrastructure in question is often significantly more expensive than works proposed within a floodplain risk management plan.

The key for floodplain risk management studies is achieving a balance between the effort to undertake the assessment versus the cost to implement the actual measure. Where a floodplain management option is relatively cheap to implement, then additional assessment or detail may not be warranted.

A potential approach to the economic assessment could be to base the level of detail required based on the capital investment (and/or ongoing maintenance requirement costs) in the floodplain risk management measure:

- Level 1 Assessment, similar to the existing approach with some improvements;
- Level 2 Assessment.
**Level 1 Assessment – Strategic Level Assessment**

This level of assessment is similar to the existing approach, where the economic cost benefit analysis is undertaken through a damage assessment related to properties, and the remaining benefits are qualitatively incorporated through a multi-criteria assessment. This effectively represents the level of detail that is currently undertaken through a floodplain risk management plan.

This level of assessment could be undertaken below a capital investment threshold – for example, $2 million. This would ensure that the level of effort is representative of the level of investment.

An option to further improve this level 1 assessment would be to incorporate other benefits using rapid assessment techniques or scaling techniques. For example valuation of risk to life improvements where an option attempts to address this (e.g. flood warning system).

**Level 2 Assessment**

A Level 2 Assessment would be undertaken on higher capital value floodplain risk management measures that are identified in the plan. This could be undertaken as part of a stage after the adoption of the plan. These higher cost options are likely to warrant further investigation and concept design, and a more detailed economic assessment could be undertaken concurrently with this stage of the project. This could aid decisions in relation to access to funding for detailed design and construction.

The incorporation of broader benefits into analyses is discussed further below. This incorporation needs to be carefully undertaken to ensure that the source and objective of the funding is understood. This is discussed further in subsequent sections.

**Incorporating Benefits**

A number of benefits were identified above that are not typically incorporated in economic assessment within flood management optioneering. Based on the focus of most floodplain risk management measures, some additional benefits for consideration that may materially alter cost benefit analysis would include:

- Transport connectivity
- Risk to Life
- Future Development
- Externalities and Intangible damages

The following provides an overview of these benefits, and some ways in which they might be incorporated within an economic assessment

**Risk to Life**

Many floodplain risk management measures have a focus on risk to life as well as risk to property. TfNSW (2016) provides guidance on the value that people are prepared to pay to avoid serious injury or death, and there are numerous other sources providing an estimated value of statistical life that may be able to be adopted for flood assessments.
An approximate value of around $6.9M is often used as representative of the cost of a fatal casualty as part of the transport economic assessments.

The Grantham 2011 flood in the Lockyer Valley is one of the most significant in recent history in terms of loss of life. A total of 12 deaths were estimated to have occurred in this event (WRL, 2016). The event had an AEP estimate of 0.25%. Using this information, a preliminary estimation of the economic impact of this flood was undertaken, and provided in Table 1. This assumes that there would be no loss of life for events more frequent than a 0.25% AEP event.

Table 1. Grantham 2011 Flood - Economic Impact - Loss of Life ($2018)

<table>
<thead>
<tr>
<th>Cost of Event</th>
<th>$82 million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Average equivalent</td>
<td>$206,000</td>
</tr>
<tr>
<td>Present Value</td>
<td>$2.8 million¹</td>
</tr>
</tbody>
</table>

Figure 1 provides an estimate of the present value of a single loss of life in different events, to provide an indication of the magnitude of the economic impact. For example, if there was one loss of life in a 1% AEP event² (and none for events more frequent than this), the present value of the economic impact would be $950,000.

Figure 2. Loss of Life Estimate ($2018)

The key challenge with any estimation of this benefit is the quantification of the risk to life and how this may change between the base case and the project case. WRL (2016) undertook a review of various loss of life estimation models, but most of these showed significant variance in results and did not match real world outcomes (using the Grantham 2011 flood). If these models can be developed further, then the economic assessment of risk to life may add significant value.

**Intangible Damages**

Externalities capture indirect costs (typically received by third parties) generated as a result of an event or action. In the road transport space, externalities may include noise

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¹ Calculated based on a discount rate of 7% over a 50 year period.
² And assuming no more than one loss of life for events larger than the 1% AEP
and air pollution as a result of vehicle emissions. An externality of flooding may be the amenity reduction and debris following the event or negative odours.

Intangible damages, as defined in the flooding discipline\(^3\), include social impacts such as increased levels of ill health, depression etc following the flood event. Some previous studies have adopted a factor (such as 50%) of the tangible damages to estimate this value. However, there has been little research into this and any such allowance would potentially be questionable. Further research would be needed to derive appropriate factors or indicators. It is noted that other industries do not typically incorporate these types of factors.

Further, industries such as TfNSW (2016), which include value for loss of life, do not typically attempt to incorporate these extra factors into the economic analysis, other than to discuss them qualitatively. However, ADB (2017) frequently considers health benefits (e.g. water quality improvements, post-disaster aid, cost of medicine) as part of its analyses.

It is possible that under certain project circumstance, attempts to quantify typically both externalities and intangible benefits may be appropriate.

**Transport Connectivity**

Major transport routes within a study area may be impacted by flooding, resulting in delays or the need for traffic to take alternative routes. TfNSW (2016) provides guidance on the estimation of costs associated with travel time and vehicle operating costs. In a complex transport network these can be difficult to estimate without traffic modelling or analysis.

However, there may be applications where a simplified approach of looking at potential delays on traffic is sufficient, based on the value of travel time. For example, a detention basin upstream that reduces the overtopping time of roads and therefore the waiting time for traffic.

An indication of some potential benefits is provided in Figure 2. In this figure, based on a typical rural traffic composition, the cost for a 1 hour, 2 hour and 3 hour delay are shown on the left versus the estimate traffic volume for that road (in vehicles per day). On the right, the present value of this impact is shown if this were to occur on average once per year.

As an example, a proposed flood risk management measure, in addition to improving flooding on properties, reduces flooding on two key roads, with traffic volumes of approximately 5000 vehicles per day. The measure will result in a reduction in overtopping time of around 3 hours every year, reducing delays for traffic of the same time. This is equivalent to a savings of around $350,000 in present value terms.

These graphs provide some indication on the likely merit of considering incorporating this benefit within an analysis. For example, at low traffic volumes, the overall benefit is unlikely to be large unless there is a very long delay. Consideration, would also need to

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\(^3\) It is noted that this can have a different meaning in the economic discipline.
be given to detour routes than vehicles may prefer to take, rather than just wait for waters to subside (noting that this has a cost associated with it as well).

Further work could be undertaken to develop a simplified method to assess traffic related benefits similar to this.

**Figure 3. Economic Impacts of Traffic Delays ($2018) – annual delay cost on left, present value equivalent on right**

**Future Development**

Increases in development can result in a non-stationary risk within a floodplain. McLuckie et al (2016) provided some guidance on dealing with this non-stationarity in regard to flood risk. Whereas climate change affects the likelihood of the flood event, development affects the consequences of the event when it happens.

For an economic assessment, the key change is the assessment over time of the economic damages. In a similar way to climate change, there is a need to reassess the economic impact at different slices in time, to ensure that the changes in development are incorporated within the analysis. This type of approach would be appropriate for a Level 1 assessment as well as a Level 2 assessment.

The key issue associated with this approach is the potential to encourage floodplain management measures that allow or unlock development potential in areas that are intertwined with the existing community (infill development) and the work proposed to protect these, rather than using management measures to protect only existing property.

Consideration also is needed for the source of the funding. For example flood mitigation works under the NSW Floodplain Management Program focus on protection of existing properties within communities.

Where there is the potential for a mitigation work to benefit both existing property and new infill development in an area consideration could be given to examining how the benefits to the community are distributed. The key way to address this is through a distributional analysis (refer below), that can divide the benefits between the existing properties, and any new infill development within the floodplain that would benefit from the mitigation.

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4 Assessed with a discount rate of 7% over a 50 year period
works. This may also be useful to inform levies on or contributions from any new development based on the benefit that they attain from the floodplain management measure. This can also be done qualitatively outside of the analysis, recognising where a mitigation option is primarily focused on existing development or future development.

A further consideration is for flood risk and economic impacts on greenfield developments. Generally, the focus on these should be development controls (such as minimum fill and floor levels). While a development control has relatively low cost for the authority involved, it can result in additional costs for the developer. If needed, an economic assessment of the cost of the policy for the developers relative to the benefit to the community can be determined to assist in justification of the policy.

**NSW Floodplain Management Program**

The focus of the NSW Floodplain Management Program is to reduce risk to life and property. Prioritisation of mitigation projects under the program, both within and between management plans, needs to consider the relative costs and benefits of works to address these risks. This needs to be undertaken on a consistent and equitable basis.

These factors should be considered in the estimation of damages and effort expended. For example, the funding program would generally not consider funding for works that are primarily aimed at, or whose primary benefit is, to improve transport connectivity or that would be primarily aimed at the protection of future development (as discussed above).

Therefore, if the economic analysis is to be undertaken under this program for mitigation projects which may seek funding under the program consideration of program objectives and consistency in assessment between projects is essential. Two alternatives could be considered:

- Only assess those benefits related to the Program, recognising that this is likely to underestimate the benefits and lower the BCR in some situations;
- Estimate both the readily quantifiable benefits, including non-Program benefit as well as the BCR relating to the benefits only under the Program. This would have the advantage of facilitating the equitable comparison with other flood mitigation projects against the program objectives whilst not underestimating the broader BCR, and ensuring that floodplain projects do not appear to be poor value for money relative to other infrastructure. It would also be useful for other decision makers (for example, councillors) to understand the wider benefits of an option. An example of the benefits that might be included within the Program are provided in Table 2.

**Table 2. Benefits related to NSW Flood Program**

<table>
<thead>
<tr>
<th>Type of Benefit</th>
<th>NSW Floodplain Management Program</th>
<th>Other Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property Related Damages</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Risk to Life</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Intangible Damages</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Transport Connectivity</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Environmental</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Future Development</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
Distributional Analysis

While an economic assessment and cost benefit analysis can reveal whether a proposed project represents a net social gain (i.e. BCR > 1) or costs (BCR < 1) to society, it does not allow for discernment of equity and appropriateness within this. For example, two floodplain measures may have the same BCR, but one option may protect only a single large commercial property while the other protects a large number of residences.

These type of considerations are examined through the distributional analysis of a project. A distribution analysis provides an indication of the relative costs and benefits to different groups within a community. For example, this might include local community, government and business. Decision making authorities may need to make valued judgements in accordance with their jurisdictions and objectives as to the appropriate allocation of resources where there is unequal distribution of benefits amongst stakeholders. Further, the source of funding should also be considered when undertaking distribution analysis.

The ADB (2017) go further with distributional analysis to undertake a poverty assessment, to understand the proportion of the community below the poverty line that may benefit from a particular investment project. While the approach adopted by the ADB may not be specifically appropriate for Australia, incorporating an assessment of benefits for lower socio-economic communities in a floodplain may be worthwhile in some circumstances. For example, retirement villages or permanent living caravan parks may bear undue costs of flooding or benefits associated with flood mitigation. These communities generally have less capacity to recover from a flood event and a likely to be more severely affected following an event.

Conclusions

This paper has undertaken an initial review of the economic analysis of floodplain management, and some ways in which the assessment could be expanded further to better highlight the benefits of flood mitigation projects. It is particularly important to ensure that the level of effort required for the economic assessment matches the level of capital expenditure.

In addition to property damages, there are a number of additional benefits that floodplain management measures may bring to a community. Incorporation of these benefits, where appropriate, may result in a more holistic approach to the economic analysis. An initial overview on how some of these might be incorporated has been provided.

References


