Understanding and Quantifying Flood Risk in Australia

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Introduction: Importance of Flood

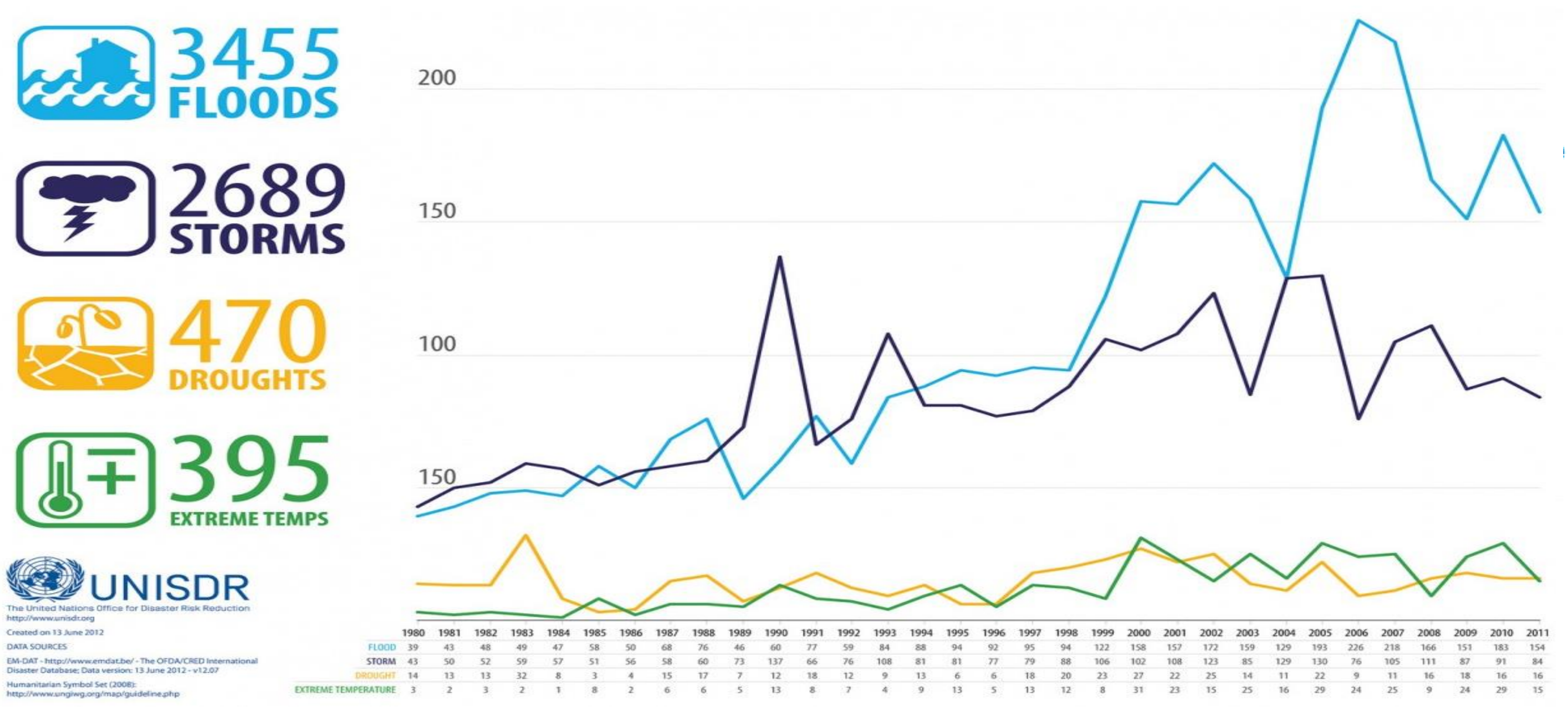


Figure 3: Number of Natural Disasters Around the World (1980-2011) [3]

[1] Emergency Events Database (EM-DAT) Website
[2] Bureau of Transport Economics
[3] United Nation Office for Disaster Risk Reduction

Introduction: Flood risk management

1971 “Preparedness Programme in Bangladesh”- Based on lessons learnt from 1970 Pakistan cyclone that includes: **early warning system, shelter, evacuation, volunteers, etc.**

1990 International Decade of Natural Disaster Reduction (IDNDR)

2000 International Strategy for Disaster Reduction (ISDR)

2015 Sendai framework for Disaster Risk Reduction (DRR)

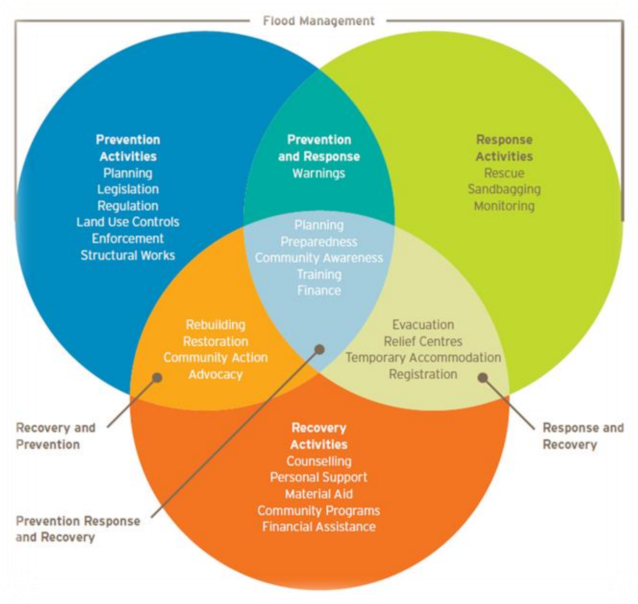
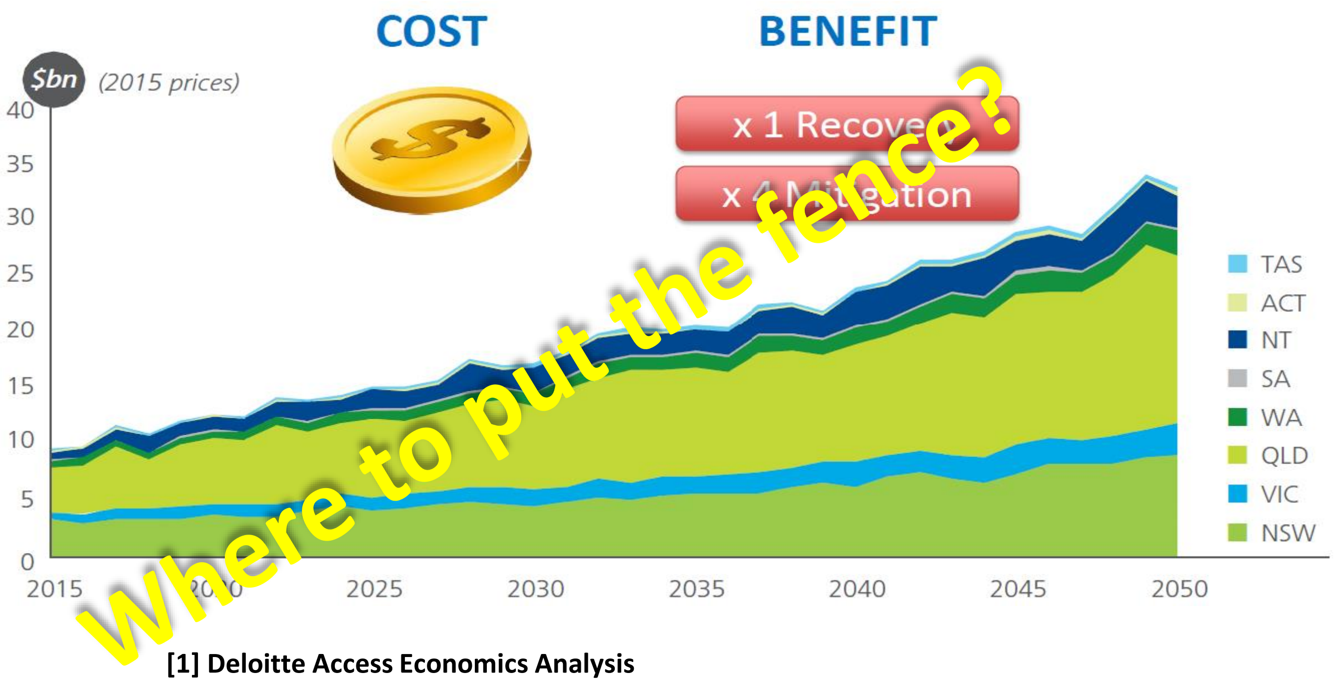


Figure 4: Flood Risk Management Activities

A new global movement from “Disaster Management” to “Disaster Reduction”.

Introduction: Prevention or Cure?



[1] Deloitte Access Economics Analysis

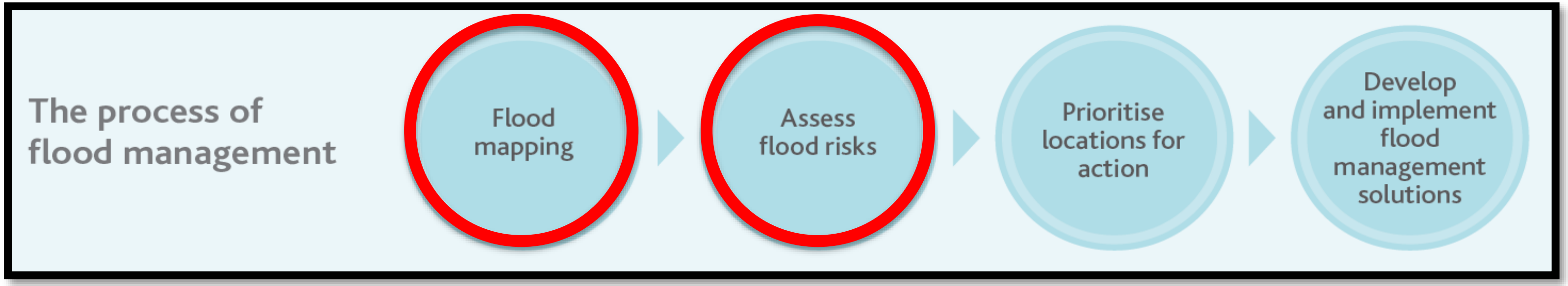
"Better to build a fence at the top of a cliff, than park an ambulance at the bottom"

Helen Clark, 2015 Sendai

Understanding Flood Risk

Understanding Flood Risk is the First Priority of Risk Management Frameworks, because it is essential for:

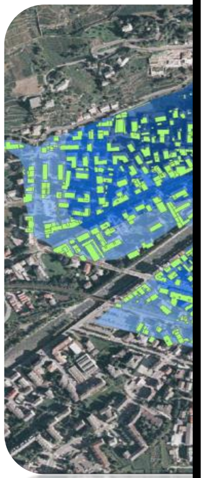
- Prioritisation of locations
- Cost benefit analysis and calculating AAD
- Checking the feasibility of risk mitigation options
- Selecting best practices in risk reduction



Flood Risk Assessment is NOT Flood Mapping

"Risk is the probability and the magnitude of expected Damages."

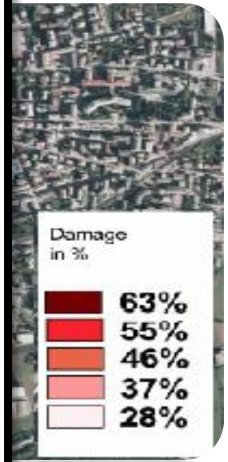
Risk= Probability (Hazard) X Damages



Likelihood of Consequence	AEP Range %	LEVEL OF CONSEQUENCE: Insignificant	Minor	Moderate	Major	Catastrophic
Likely	>10	People Community PROPERTY	~~Property~~			
Unlikely	1 to 10		PEOPLE COMMUNITY PROPERTY	Community	~~People~~ ~~Property~~	
Rare to very rare	0.01 to 1			Community PROPERTY	People ~~Property~~	
Extremely Rare	<0.01			Community	People Property	

Legend: Consequences before treatment or where risk is unchanged, CONSEQUENCES AFTER TREATMENT WHERE CHANGED

Risk Scale	Very Low	Low	Medium	High	Extreme

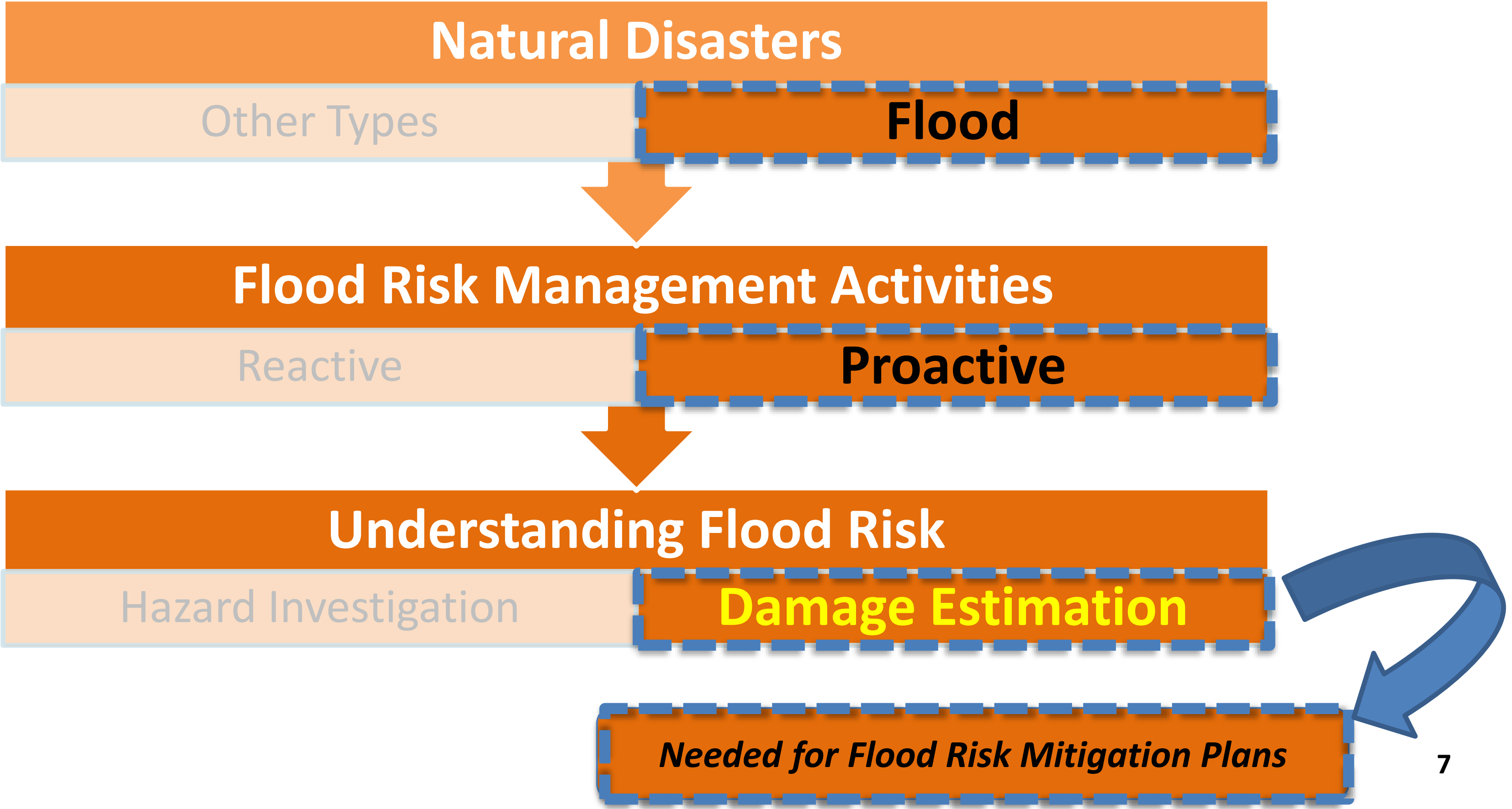


Flood Risk: ... imation

models are ...

[1] Kreibich and Thieken, 2008; Merz et al., 2004; Meyer et al., 2013

Research Direction



Different Types of Damages

DIRECT

INDIRECT

Common Damage Estimation Methods

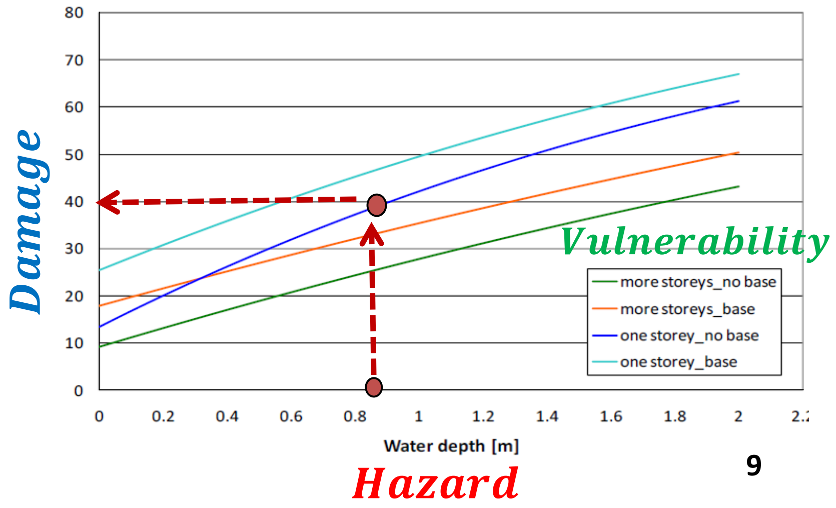
Averaging Methods:

Considers some mean values of damage for all flooded buildings, including those inundated above and below floor level.

Value of contents	Mean potential damages per m² (includes external, internal contents and structural damages)
Low (e.g. offices, sporting pavilions, churches)	$45
Medium (e.g. libraries, clothing businesses, caravan parks)	$80
High (e.g. electronic, printing)	$200

Stage-damage Functions:

They make a causal relationship among the magnitude of the hazard, resistance of flooded objects, and extent of losses for each stage of water. They are categorised into **absolute & relative** types.

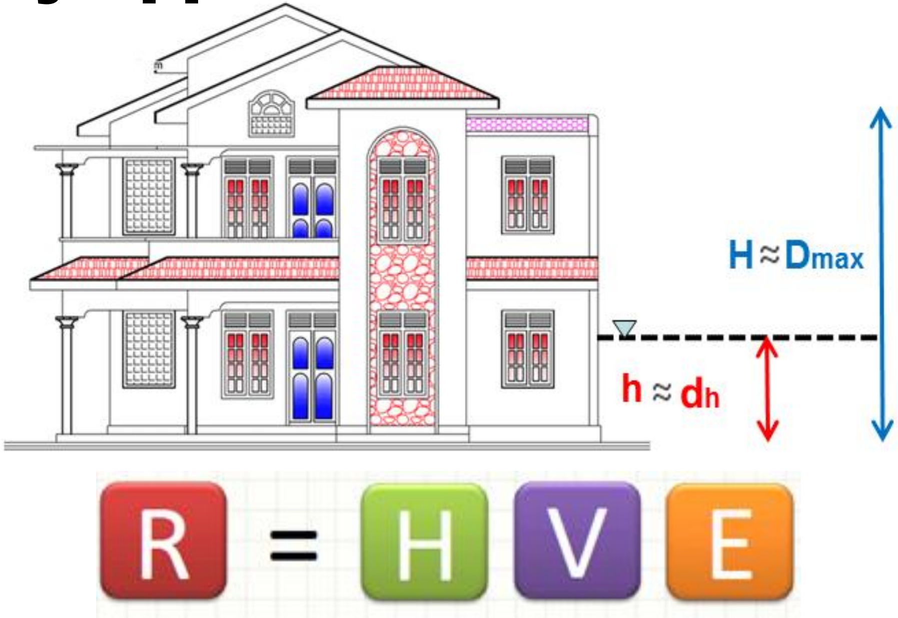


Limitations

- Most damage models are synthetic, they are NOT calibrated with empirical data, and few studies have been conducted on the validation of results;
- Most approaches are absolute which is more rigid and does not easily transfer across time and space;
- All approaches are the traditional type which relies only on a deterministic relationship between type or use of properties at risk and depth of water: the interaction of the most damage-influencing parameters and the uncertainty of data is neglected.

General idea: Sub-assembly approach

- **Foundation and below first floor**
- **Structure framing**
- **Roof covering and roof framing**
- **Exterior walls:** includes wall coverings, windows, exterior doors and insulation; and
- **Interiors:** includes interior walls and floor framing, drywall, paint, interior trims, floor coverings, cabinets, and mechanical and electrical facilities.



V: The vulnerabilities of structural components are different. Damage of each category begins at different water depths (after a specific level of total damage).

E: The exposed value of each category relative to the total value of the structure is different.

GHD

General idea: Sub-assembly approach

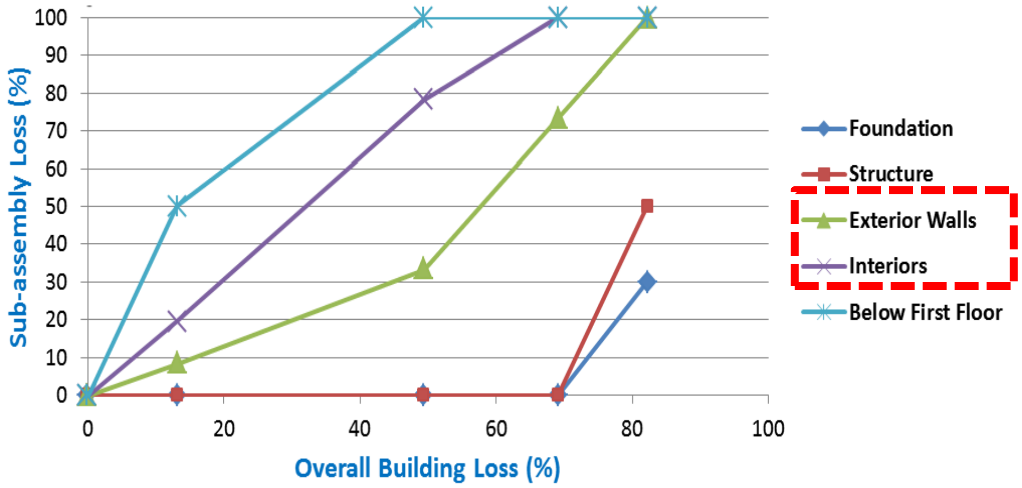
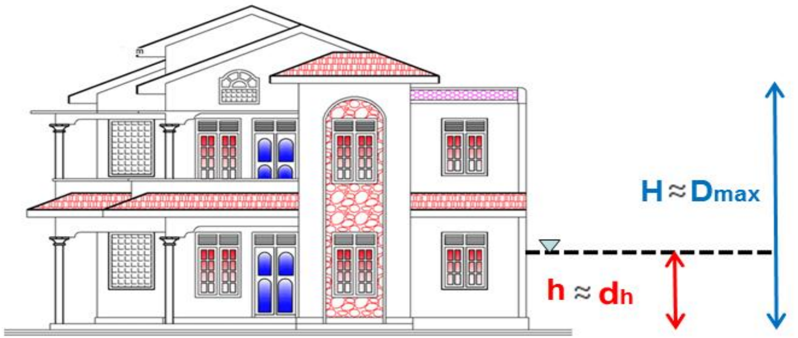


Figure 5. Illustration of sub-assembly loss vs overall building loss for one-storey buildings with timber walls.

Assembly Components	Relative Value
Foundation and below first floor	12%
Structure framing	9%
Roof covering and roof framing	7%
Exterior walls	22%
Interiors	50%
Total	100%

Figure 6. Sub-Assembly replacement values for the common types of residential buildings.

$$d_h = \left(\frac{h}{H}\right)^{\frac{1}{r}} \times D_{\max}$$



FLFA: Model Development

A. Defining the most common building types and the representative building category for the selected area of study in Australia [1]

"4" classes for residential buildings and "1" generic class for commercial buildings.

B. Model Calibration (2013 Bundaberg flood event):

For the newly derived model in this work, the extent of damage (dh) in each level of water (h) is a function of two parameters:

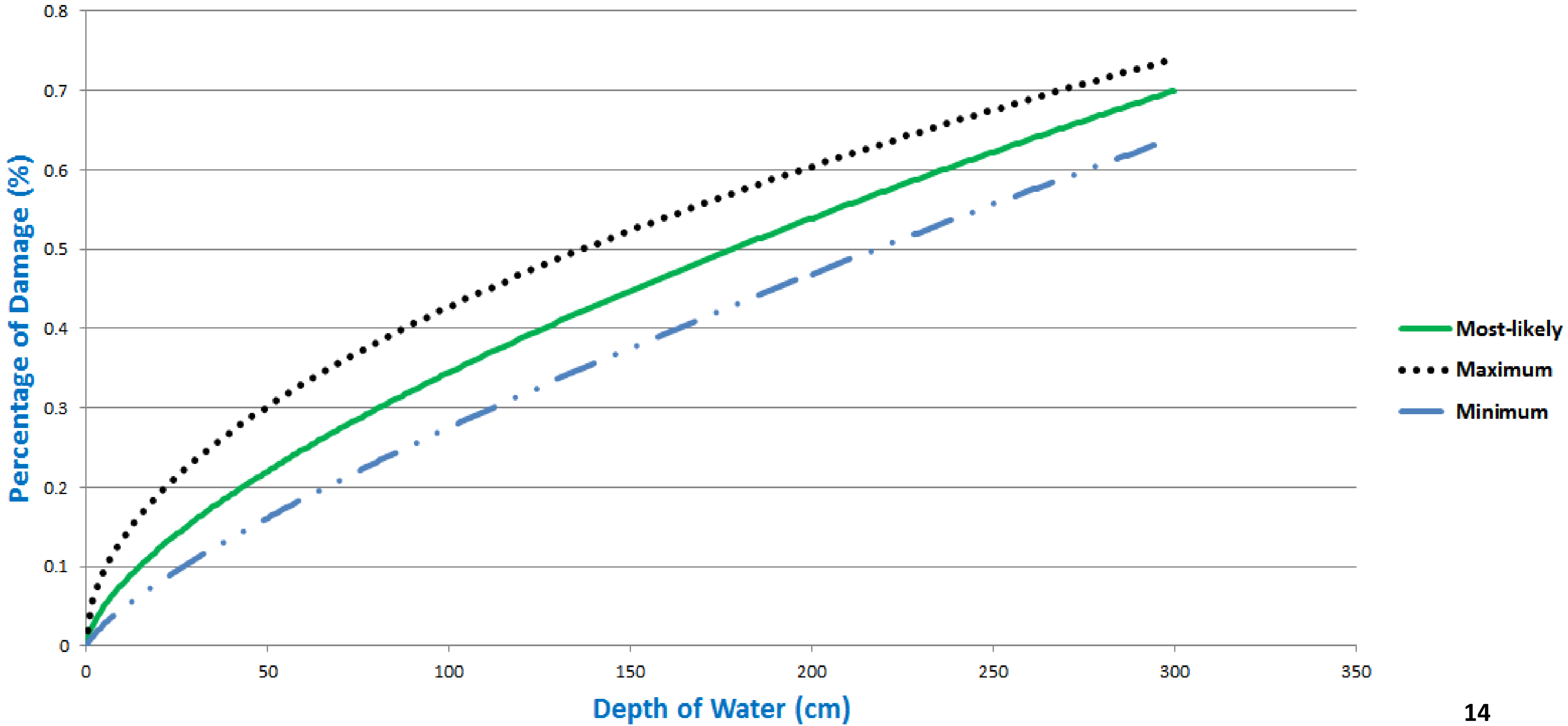
- **Maximum percentage of damage "Dmax "; and**
- **Rate control of function "r "**

$$d_h = \left(\frac{h}{H}\right)^{\frac{1}{r}} \times D_{\max}$$

These two parameters, with reference to the empirical data, should be stabilised to the most appropriate values.

[1] National exposure information system of Australia (Dunford et al., 2014)

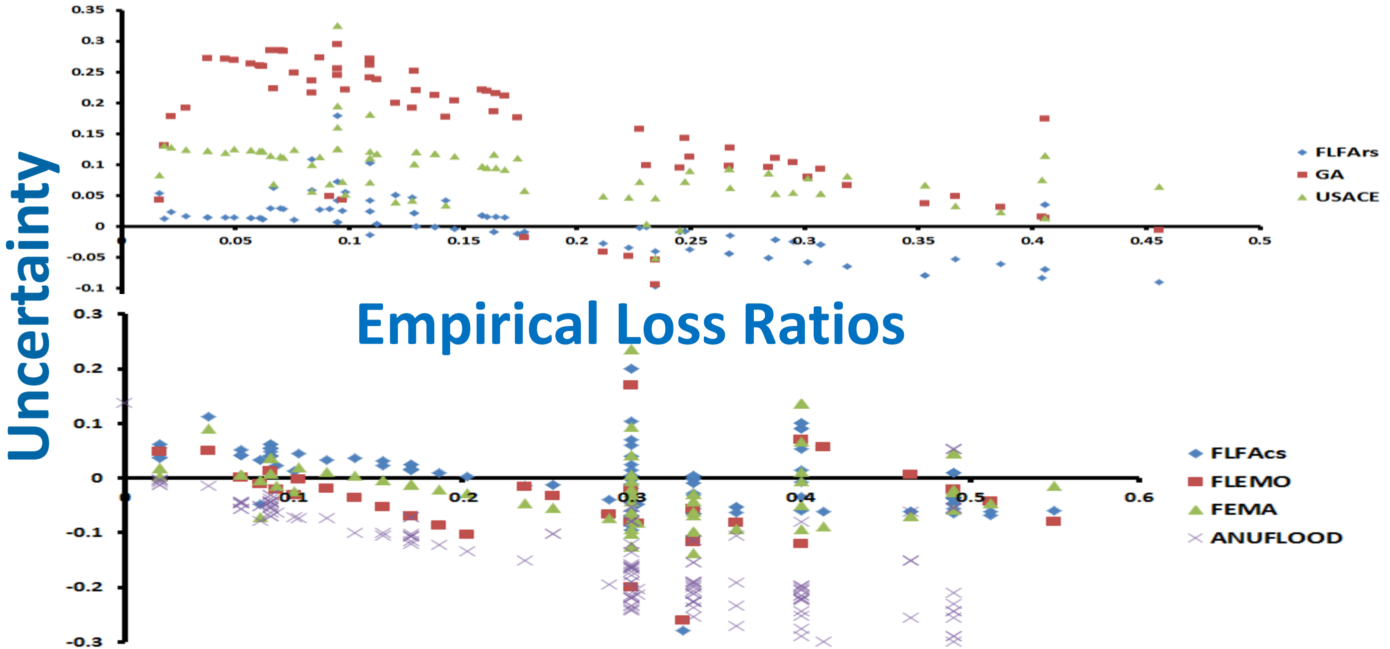
FLFA: Model Calibration



FLFA: Results Comparison

Figure 7. Residual plot, residential buildings

Figure 8. Residual plot, commercial buildings



Advantages:

- More accurate compared to the existing methods
- Calibration and validation with empirical data
- A better level of transferability in time and space
- Consideration of the epistemic uncertainty of data.

FLFA: Publications

E3S Web of Conferences 7, 05002 (2016) DOI: 10.1051/e3sconf/20160705002

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Nat. Hazards Earth Syst. Sci., 16, 15–27, 2016
www.nat-hazards-earth-syst-sci.net/16/15/2016/
doi:10.5194/nhess-16-15-2016
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International Journal of Disaster Risk Reduction

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Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2017-92, 2017
Manuscript under review for journal Nat. Hazards Earth Syst. Sci.
Discussion started: 6 March 2017

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Flood loss modelling with FLF-IT: A new Flood Loss Function for Italian residential structures

Roozbeh Hasanzadeh Nafari[1,2], Mattia Amadio[3,4], Tuan Ngo[5] and Jaroslav Mysiak[3,4]

GHD

Tree-based Model

Flood damage is a complicated process, and it might be dependent on a variety of factors which are not taken into account

We have explored the interaction, importance, and influence of *water depth, flow velocity, water contamination, precautionary measures, emergency measures, flood experience, floor area, building value, building quality, and socioeconomic status*

Tree-based Model

A. Data mining for more than 1000 real-world samples (which includes information on structural damages, impact parameters, and resistance variables)

Categories	Predictors		Type	Range
Flood impact	WD	Water depth	C	between 0 cm and 700 cm above ground
	Vel.	Flow velocity	O	1 = calm to 3 = high
	Con.	Water Contamination	O	0 = no contamination to 2 = heavy contamination
Emergency	EM	Emergency Measures	O	0 = no measure undertaken to 3 = many measures undertaken
Precaution, experience	PM	Precaution Measures	O	1 = no measure undertaken to 4 = many measures undertaken
	Exp.	Flood experience	O	1 = few flood experience to 3 = recent flood experience
Building characteristic	BQ	Building quality	O	1 = very bad to 6 = very good
	BV	Building value	C	1756 to 3594000 AUD
	FS	Floor space per person	C	13 to 870 m^2
Socioeconomic status	SA	Special attention resident	N	0 = No, 1 = Yes
	Own.	Ownership status	N	0 = rent, 1 = own
	Inc.	Monthly income	O	1 = \$1–\$599, 2 = \$600–\$1999, 3 = greater than \$2000
	LE	Low education residents	N	0 = No, 1 = Yes

Figure 9. Description of the 13 candidate predictors.

Tree-based Model

B. Model Development: Using **regression tree** & **bagging decision tree (*including 200 trees*)** techniques with the Weka machine-learning software algorithms.

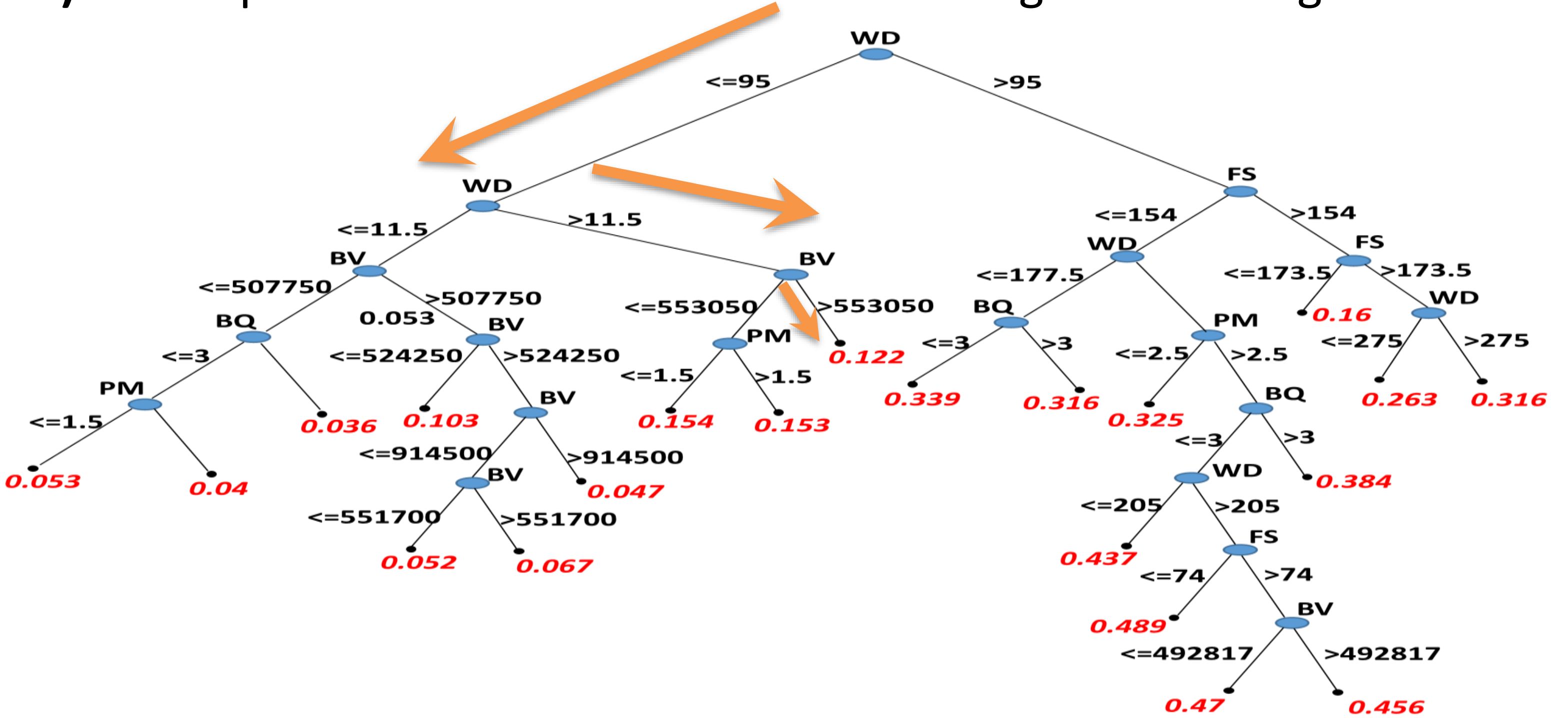


Figure 10. Regression tree with 21 leaves for estimating the structural loss ratios. (WD: water depth, FS: floor space, PM: precaution measures, BV: building value, BQ: building quality)

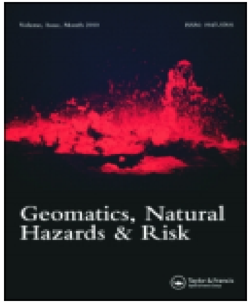
Tree-based Model

D. Model Interpretation:

water

MDPI

Article



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Geomatics, Natural Hazards and Risk

Predictive applications of Australian flood loss models after a temporal and spatial transfer

ISSN: 1947-5705 (Print) 1947-5713 (Online) Journal homepage: https://www.tandfonline.com/loi/tgnh20

Adv

- ... he
- C
- Future Development: Developing for other types of buildings and non-typical structures (e.g. roads and bridges).

Results lead to improvement in understanding flood risk: Needed for Flood Risk Mitigation Plans

- Calibration with empirical data,
- A better level of transferability in time and space,
- Consideration of the epistemic uncertainty of data.

Tree-based models were developed for exploring the interaction, importance, and influence of different damage-influencing parameters on the extent of losses.

Acknowledgements

US Army Corps of Engineers

THE UNIVERSITY OF MELBOURNE

bushfire&natural HAZARDS CRC

Queensland Government
Queensland Reconstruction Authority

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