We acknowledge the tradition of custodianship and law of the Country on which the University of Sydney campuses stand. We pay our respects to those who have cared and continue to care for Country.

THE UNIVERSITY OF SYDNEY

Community Risk Assessment

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Significance

Practical significance

Need to change

- Agencies are at different stages of a moderate to significant revision of community risk assessment practices:
  - Incubation
  - Development
  - Implementation

Theoretical significance

Need to reflect complexities

- Multi-hazard scenarios
- Multi-stakeholder scenarios
- Dynamic scenarios
- Consideration of vulnerability and resilience

Systematic literature review

Key literature to establish the concepts

- “community risk assessment”
  - 47 manuscripts
- “disaster risk assessment”
  - 298 manuscripts

Quality check

- 45 manuscripts
- Analysis and synthesis of literature

Analysis and synthesis of the concepts

- Community risk assessment approach/methodology table
- [illegible]
  - Exposure data
  - Hazard data
  - Vulnerability data
  - Data for identified risk elements

Empirical study: interviews with 29 individuals from a range of agencies and organisations across the country

Main Outputs

→ **Guideline for development of community risk assessment**

- What are the range of potential approaches and their capabilities?
- How can we innovate and do it differently?

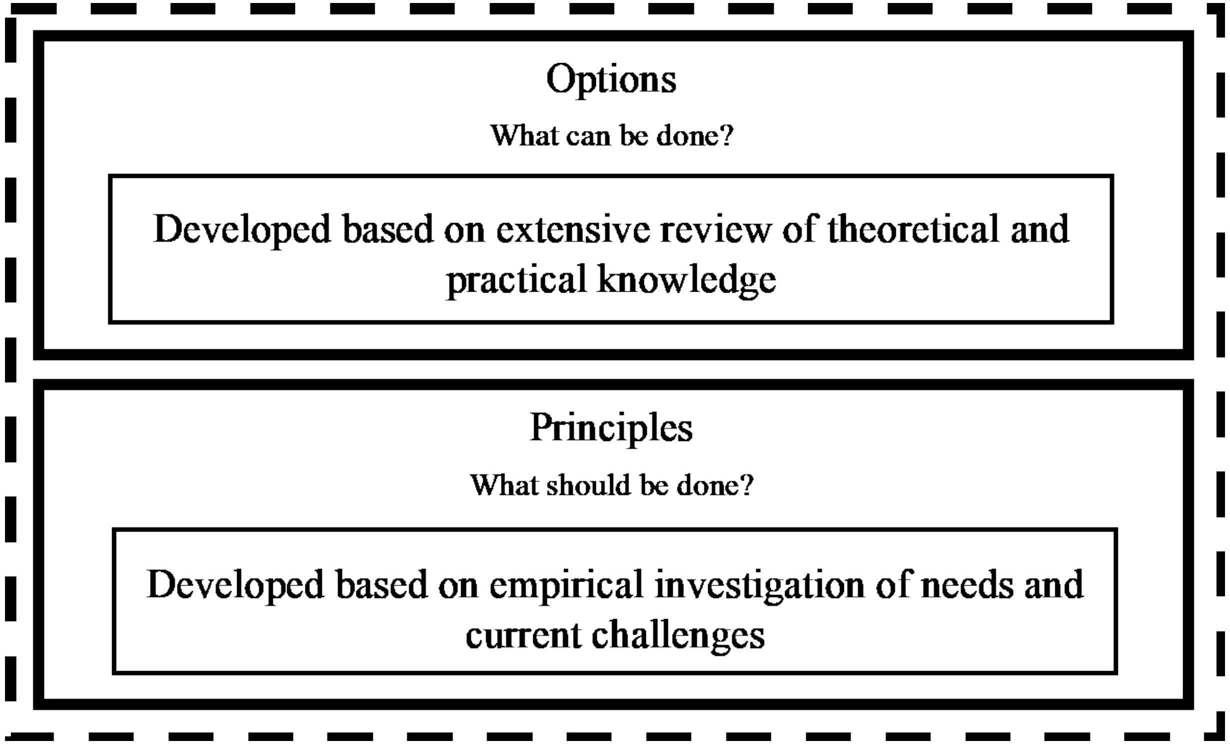


Table 1 Quantitative and semi-quantitative risk assessment methods

Ref	Disaster risk(s)	Definition of risk	Risk element assessment method and (output)					Risk assessment approach
			Hazard (H)	Exposure (E)	Vulnerability (V)	Other	Risk	
(Brink and Davidson, 2015)	Earthquake	$R = f(H, V, RE)$	Monte Carlo simulation with importance sampling (probabilistic ground motion maps)	-	Fragility analysis (fragility curves for building types)	Resilience (RE): Weighted sum (household socioeconomic resilience index)	Joint probability distribution (damage exceedance probability curves)	Hybrid: Statistical/index-based
(Cai et al., 2019)	Flood	$R = f(H, V, E)$	Hydrodynamic simulation (inundation depth, inundation area, and inundation duration)	GIS analysis (ground elevation, ground slope and impermeability)	GIS analysis (building density and point of interest density maps)	-	Fuzzy comprehensive evaluation (risk level map)	Hybrid: Index-based/simulation-based
(Guo et al., 2014)	Flood	$R = f(H, \mathrm{E}, V, RES)$	Variable fuzzy set (VFS) theory set pair theory/GIS spatial analysis (Hazard level map)	Variable fuzzy set (VFS) theory/set pair theory/GIS spatial analysis (Exposure level map)	Variable fuzzy set (VFS) theory/set pair theory/GIS spatial analysis (Vulnerability level map)	Restorability: Variable fuzzy set (VFS) theory/set pair theory/GIS spatial analysis (Restorability level map)	Multiplication of exponentiated indicators (Risk level map)	Index-based
(Hizbaron et al., 2018)	Volcano	-	Pre-existing (volcano hazard maps)		Statistical and spatial analysis (Physical, social, economic, and total vulnerability maps)			Index-based
(Jin et al., 2022)	Lightning	$R = f(H, \mathrm{S}, \mathrm{F})$	GIS spatial analysis (lightning hazard level map)	GIS spatial analysis (frangibility level map)	See note	Sensitivity of the hazard-bearing environment GIS spatial analysis (Sensitivity level map)	Weighted sum of indicators (risk level map)	Index-based

Table 2 Example Hazard indicators used in the selected studies and corresponding sources of data

Disaster	Factors/indicators	Study: Data source
Flood	Annual precipitation	(Sun et al., 2022): National Meteorological Administration [China] (Guo et al., 2014): China Meteorological Data Sharing Service Network during 1960–2009 (Luo et al., 2020): Henan Water Resource Bulletin [China]
	Frequency of rainstorm	(Sun et al., 2022): National Meteorological Administration [China]
	Inundation depth	(Cai et al., 2019): Not specified; Internal to DigitalWater Simulation hydrodynamic model
	Inundation area	(Cai et al., 2019): Not specified; Internal to DigitalWater Simulation hydrodynamic model
	Inundation duration	(Cai et al., 2019): Not specified; Internal to DigitalWater Simulation hydrodynamic model
	Extreme precipitation event frequency	(Guo et al., 2014): China Meteorological Data Sharing Service Network during 1960–2009
	Drainage density	(Wu et al., 2015, Wu et al., 2017): Geospatial Data Cloud
	Slope	(Dwivedi et al., 2022): Remote sensing; Previous work
	Distance to river stream	(Dwivedi et al., 2022): Remote sensing; Previous work
	Landslide susceptibility	(Dwivedi et al., 2022): Remote sensing; Previous work
	Elevation	(Dwivedi et al., 2022): Remote sensing; Previous work
Earthquake	Earthquake ground motion intensity	(Brink and Davidson, 2015): Monte Carlo simulation with importance sampling on results of previous works
	Occurrence probability	(Brink and Davidson, 2015): Monte Carlo simulation with importance sampling on results of previous works (Sarica et al., 2020): U.S. Geological Survey Database
	Magnitude of Earthquake	(Pan et al., 2020): Santai County Statistical Yearbook; Santai County Statistical Bulletin; Random sampling to assess the local earthquake losses (Sherrill et al., 2022): Deterministic counterfactual scenario
	Peak ground acceleration	(Xia et al., 2022): China Earthquake Parameter Zoning Map (Sarica et al., 2020): U.S. Geological Survey Database (Zhang et al., 2021): Earthquake Catalog; Tectonics and Geology data

Table 3 Exposure indicators used in the selected studies and corresponding sources of data

Disaster	Factors/indicators	Study: Data source
Flood	Urbanization rate	(Sun et al., 2022): Statistical Yearbook (China National Bureau of Statistics)
	Population density	(Sun et al., 2022): Statistical Yearbook (China National Bureau of Statistics)
		(Guo et al., 2014): Statistical Yearbook of Liaoning Province; Chinese macro data mining analysis system website
	Building density	(Sun et al., 2022): Statistical Yearbook (China National Bureau of Statistics)
	Economic density	(Sun et al., 2022): Statistical Yearbook (China National Bureau of Statistics)
	Ground elevation	(Cai et al., 2019): Not specified; Internal to DigitalWater Simulation hydrodynamic model
	Ground slope	(Cai et al., 2019): Not specified; Internal to DigitalWater Simulation hydrodynamic model
	Impermeability	(Cai et al., 2019): Not specified; Internal to DigitalWater Simulation hydrodynamic model
	Assets density	(Guo et al., 2014): Statistical Yearbook of Liaoning Province; Chinese macro data mining analysis system website
	Economy density	(Guo et al., 2014): Statistical Yearbook of Liaoning Province; Chinese macro data mining analysis system website
	Number/value of exposed properties	(Ming et al., 2022): National property database; Digimap service
Earthquake	Built-up area	(Sarica et al., 2020): Landsat TM images; digital elevation models (DEM); OpenStreetMap (OSM) data; land-use maps; local historical road network maps
	Population	(Xia et al., 2022): World pop project
		(Sherrill et al., 2022): Census data, employment data, proprietary insurance data, expert opinion, and tax records (Internal to Hazus model)
	Building inventory	(Zhang et al., 2021): Census data; statistical reports; field investigation
		(Sherrill et al., 2022): Census data, employment data, proprietary insurance data, expert opinion, and tax records (Internal to Hazus model)

Table 4 Vulnerability indicators used in the selected studies and corresponding sources of data

Disaster	Factors/indicators	Study: Data source
Flood	Old and young population per unit area	(Sun et al., 2022): China Statistical Yearbook (China National Bureau of Statistics)
	Proportion of crop − sown area	(Sun et al., 2022): China Statistical Yearbook (China National Bureau of Statistics)
	Building density	(Cai et al., 2019): Not specified; Internal to DigitalWater Simulation hydrodynamic model
	Points of interest density	(Cai et al., 2019): Baidu map
	Proportion of male and female	(Guo et al., 2014): Statistical Yearbook of Liaoning Province [China] ; Chinese macro data mining analysis system website
	Education level	(Guo et al., 2014): Statistical Yearbook of Liaoning Province [China] ; Chinese macro data mining analysis system website
	Proportion of industrial electricity	(Guo et al., 2014): Statistical Yearbook of Liaoning Province [China] ; Chinese macro data mining analysis system website
	Waterlogged farmland	(Guo et al., 2014): Statistical Yearbook of Liaoning Province [China] ; Chinese macro data mining analysis system website
	Population	(Wu et al., 2015, Wu et al., 2017): Department of Comprehensive Statistics (National Bureau of Statistics [China])
	GDP	(Wu et al., 2015, Wu et al., 2017): Department of Comprehensive Statistics (National Bureau of Statistics [China])
	Sown area of farm crops	(Wu et al., 2015, Wu et al., 2017): Department of Comprehensive Statistics (National Bureau of Statistics [China])
Earthquake	Building fragility	(Brink and Davidson, 2015): Institut Teknologi Bandung; Geoscience Australia; Previous work (Sherrill et al., 2022): Internal to Hazus model
	Mortality rate	(Xia et al., 2022): Previous work

Table 5 Indicators of other risk elements used in the selected studies and corresponding sources of data

Risk element	Disaster	Factors/indicators	Study: Data source
Emergency and recovery capabilities	Flood	Number of health technicians (per 10,000 people)	(Sun et al., 2022): Statistical Yearbook (China National Bureau of Statistics)
		Number of beds in medical institutions (per 10,000 people)	(Sun et al., 2022): Statistical Yearbook (China National Bureau of Statistics)
		Number of medical and health institutions	(Sun et al., 2022): Statistical Yearbook (China National Bureau of Statistics)
		GDP per capita	(Sun et al., 2022): Statistical Yearbook (China National Bureau of Statistics)
		Unemployment rate	(Sun et al., 2022): Statistical Yearbook (China National Bureau of Statistics)
Restorability	Flood	Density of road network	(Guo et al., 2014): Cold and Arid Regions Science Data Centre at Lanzhou; Database of Global Change Parameters (Chinese Academy of Sciences)
		The per capita medical person	(Guo et al., 2014): Statistical Yearbook of Liaoning Province; Chinese macro data mining analysis system website
		Per capita GDP	(Guo et al., 2014): Statistical Yearbook of Liaoning Province; Chinese macro data mining analysis system website
Household resilience	Earthquake	Income	(Brink and Davidson, 2015): Indonesian government statistics bureau household survey; damage survey data collected after the 2009 Padang earthquake
		Wealth	(Brink and Davidson, 2015): Indonesian government statistics bureau household survey; damage survey data collected after the 2009 Padang earthquake
		Individual fragility	(Brink and Davidson, 2015): Indonesian government statistics bureau household survey; damage survey data collected after the 2009 Padang earthquake
		Education	(Brink and Davidson, 2015): Indonesian government statistics bureau household survey; damage survey data collected after the 2009 Padang earthquake
		Household size	(Brink and Davidson, 2015): Indonesian government statistics bureau household survey; damage survey data collected after the 2009 Padang earthquake

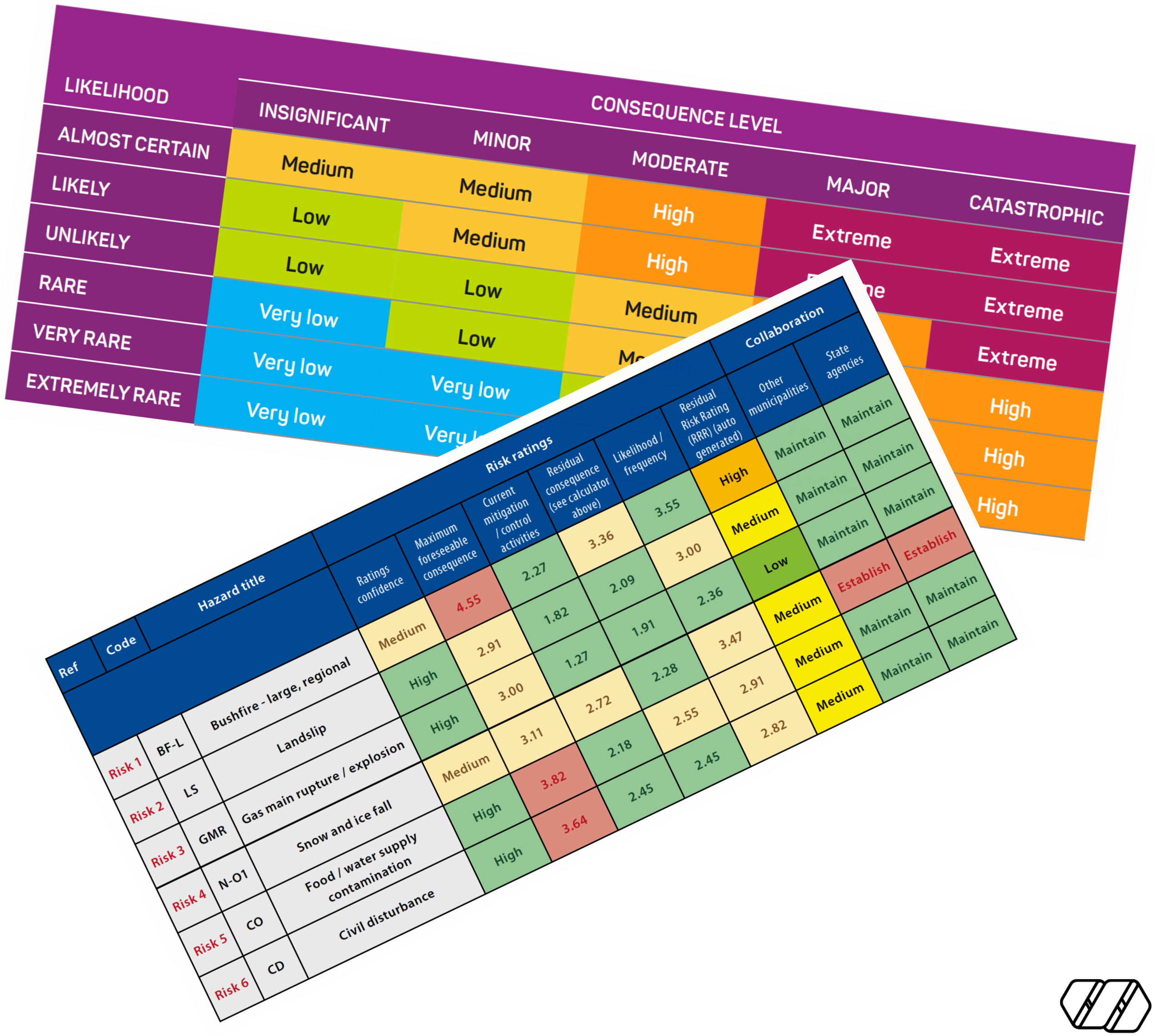
Alternative approaches

→ **Top-down**

- Statistical
- Simulation based
- Index based

→ **Bottom-up**

- Focus groups and informant interviews
- Hazard mapping
- Seasonal calendar analysis
- Transect walks



LIKELIHOOD	CONSEQUENCE LEVEL				
	INSIGNIFICANT	MINOR	MODERATE	MAJOR	CATASTROPHIC
ALMOST CERTAIN	Medium	Medium	High	Extreme	Extreme
LIKELY	Low	Medium	High	[illegible]	Extreme
UNLIKELY	Low	Low	Medium	[illegible]	Extreme
RARE	Very low	Low	[illegible]	[illegible]	High
VERY RARE	Very low	Very low	[illegible]	[illegible]	High
EXTREMELY RARE	Very low	[illegible]	[illegible]	[illegible]	High

Ref	Code	Hazard title	Risk ratings: Ratings confidence	Maximum foreseeable consequence	Current mitigation / control activities	Residual consequence (see calculator above)	Likelihood / frequency	Residual Risk Rating (RRR) (auto generated)	Collaboration: Other municipalities	State agencies
Risk 1	BF-L	Bushfire - large, regional	Medium	4.55	2.27	3.36	3.55	High	Maintain	Maintain
Risk 2	LS	Landslip	High	2.91	1.82	2.09	3.00	Medium	Maintain	Maintain
Risk 3	GMR	Gas main rupture / explosion	High	3.00	1.27	1.91	2.36	Low	Maintain	Maintain
Risk 4	N-01	Snow and ice fall	Medium	3.11	2.72	2.28	3.47	Medium	Establish	Establish
Risk 5	CO	Food / water supply contamination	High	3.82	2.18	2.55	2.91	Medium	Maintain	Maintain
Risk 6	CD	Civil disturbance	High	3.64	2.45	2.45	2.82	Medium	Maintain	Maintain

Integrated Approach

→ **Bottom-up approach**

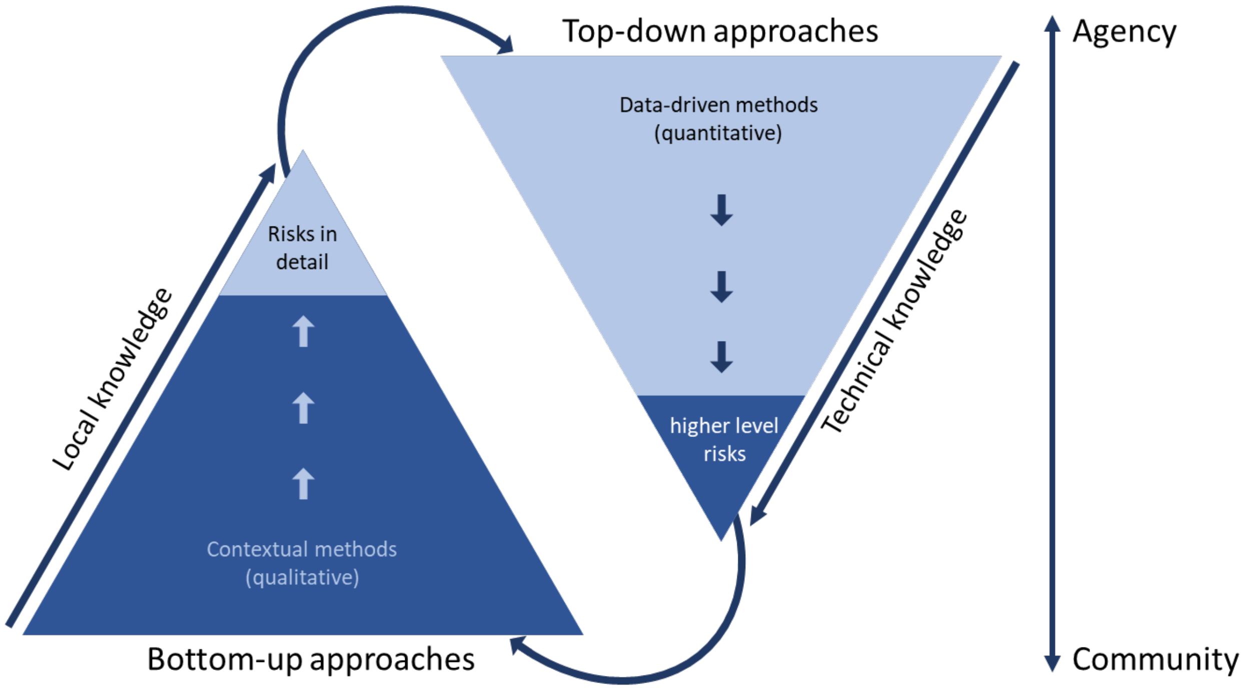
- Based on input and engagement of local and Indigenous community including rich contextual understanding

→ **Top-down approach**

- Based on technical and scientific input and analysis

→ **Integrating bottom-up and top-down community risk assessment**

- Complimenting data – filling data gaps
- Tailoring community responses
- Validation and verification using community input



Challenges

Risk assessment data

- Availability, accessibility, and interoperability of data
- Data granularity
- Data privacy

Risk assessment models

- Modeling assumptions
- Quantification challenges
- Model limitations
- Multi-hazard scenarios
- Complexity of models
- Communication of the results of the models

Challenges

Risk assessment scale	• Aggregating small-scale analysis • Discrepancies across the scales
Organisational governance	• Organisational structure, responsibilities, and ownership • Centralisation versus flexibility • Disjointed and uncoordinated risk assessment efforts • Social, political, and financial influences on decision-making

Challenges

Community

- Values and priorities
- Perceptions
- Dynamic nature of communities
- Heterogeneity of communities
- Low uptake of community engagement campaigns

Resources

- Human resources
- Physical resources

Principles

- Considerations of risk assessment scale
- Coordination of risk assessment actions
- Consistent practices within the sector
- Focus on impact and consequences of scenarios
- Support diversity
- Develop shared understanding
- Systematic community knowledge acquisition
- Developing bi-directional feedback mechanism with communities

Path forward

Resourcing integration of bottom-up and top-down risk assessment

Bi-directional integration: systems approach

Appropriate level of integration based on context

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