

Appendix 1: the revised PPRR framework used in this study

Framework 'categories' are in caps (e.g., ANTICIPATE) and 'activities' are in sentence case (e.g., Vulnerability mapping). Activities comprise measures linked to disaster resilience by case study sources and include concepts such as 'shared responsibility'.

1. ANTICIPATE

Vulnerability mapping and assessment;
vulnerability or resilience indicators
Hazard information (e.g., flood studies, modelling, mapping, disaster loss data); consistent methodologies; accessibility
Hazard monitoring, forecasting and warning systems
Climate change adaptation strategies (may specify qualities such as: long-term view; iterative; flexible; no regrets; robust)
Risk assessment; risk management assessment and plans
Decision support systems for avoiding / mitigating (including access to information, trade-off and synergy evaluation)
Investigate / understand underlying disaster causes[†] (e.g., inequity; population growth; climate change; land degradation; human intervention; terms of trade; urbanisation)
Foster an adaptive learning culture (e.g., Research, innovation; post-disaster review; reassess strategies, values, institutions; lesson learning)

2. AVOID

Land use planning and management, land use zoning and enforcement
Land use change (as part of urban renewal or transition)
Climate change mitigation to avoid increased disaster risk (emissions reduction / sequestration)

3. EXPOSURE REDUCTION

[subset: ENGINEERING STRUCTURES]
Flood barriers (e.g., levees, flood gates)
Diversion (e.g., channels)
Artificial flood storage (e.g., flood storage dams)
Rapid drainage (e.g., deeper, wider, concreted, straightened drains; backflow prevention; vegetation removal)
Channel / foreshore stabilization (e.g., concrete lining, groynes)

Energy dissipation structures (e.g., bulkheads, breakwaters, artificial reefs)

4. EXPOSURE REDUCTION

[subset: INCREMENTAL IMPROVEMENT]
[of engineered structures] Improved design; heightening; whole system planning; administration; maintenance; financing; operation; education; legislation; enforcement

5. ACCOMMODATE

[subset: BUILT ENVIRONMENT]
Resistant construction standards; enforcement (e.g., water or wind velocity; fire; quake; flood-proofing)
Accommodating construction standards; enforcement (e.g., raised above; water flow below; moveable; temporary)
Urban design (e.g., SUDS evacuation routes; zoning and standards for flood compatibility, including critical infrastructure, hazardous substances)

6. ACCOMMODATE

[subset: ECOSYSTEM BASED]
Reduced reliance on structural approaches; an appropriate balance
'Living with Floods': mindset of working with ecological processes (rather than fighting them)
Room for rivers to flood; expand area for temporary flooding; dyke removal or relocation; reconnect floodways
Protecting / enhancing natural flow paths and flood buffers: wetlands, riparian and coastal ecosystems
IWRM, co-benefits, multiple use and supporting governance arrangements
Regional / catchment-based data and planning
Basin land management (e.g., erosion control; permeability; agricultural practices)
Public education / understanding of hydrology, ecosystems, catchment / human interactions

7. ACCOMMODATE

[subset: PREPARE]

Awareness of risks and knowledge of what to do before and during an emergency

Foster adaptive capacity through allowing exposure to hazard or disturbance

Capacity building (e.g., fostering networks; partnerships; volunteering; stakeholder participation; empowerment; sharing knowledge, skills, information, resources, technology)

Shared responsibility (individuals, businesses, communities, governments); self-reliance; safety behavioral / cultural change

Reducing vulnerability of disadvantaged groups (e.g., social equity; health; education; inclusion; land tenure; sustainable development; food security)

Institutional arrangements (e.g., agencies, leadership, roles, responsibilities, coordination; accountabilities; policy integration; laws; incentives; funding; investment policies; before, during, after disasters)

Business continuity planning; capacity of critical infrastructure and services to function in disasters; redundancy; substitutability

Multi-hazard disaster management planning (e.g., by households, business, public sector and emergency management agencies)

Evacuation planning, infrastructure and supplies

Planning for/preventing disaster-related epidemics

Recovery planning

Anticipatory transformational recovery planning; windows of opportunity

8. RESPOND

Information and communication systems, strategies

Response capacity, capability and flexibility

(local and scaled-up; staff; equipment; emergency supplies; skills; shelters; operation centres; interoperability and redundancy)

Drills and scenario simulations, training

Decision support systems for response management

Volunteer recruitment, training and support

9. RECOVER

[subset: ASSESSMENT AND FUNDING]

Financing recovery (e.g., insurance; maintaining insurance affordability / availability; charity; public relief and recovery funding; 'risk sharing' compensation; loans; subsidies; local labour; mitigation incentives)

Post-disaster needs assessment; local participation

10. RECOVER

[subset: BOUNCE BACK TO PRE-EXISTING STANDARDS]

Rapid rebuild to prior standards

Non-financial recovery support (e.g., long term health; rebuilding communities)

Recovery of existing industries

Ecosystem recovery

11. RECOVER

[subset: INCREMENTAL IMPROVEMENT]

Improved rebuild or post-disaster upgrade

Adjustment of existing industries; diversification[‡]

12. RECOVER

[subset: TRANSFORMATIONAL CHANGE]

Relocation; land use change (as part of recovery)[‡]

New, flood compatible industries; alternative livelihoods[‡]

Recovery targeting long term improvements for the most vulnerable

[†] Transformational approaches often address underlying causes. For inclusion in this activity, the document had to either recommend this be done or the document itself provide an examination of one or more underlying cause. Documents that merely listed underlying causes in a preamble or rationale were not included (else this activity would be meaningless as most policy documents include a brief rationale).

[‡] These are 'build back better' activities that have greatest chance of uptake following a disaster. However, they may also be pre-emptive strategies initiated outside the recovery phase. *Voluntary relocation*, in particular, tends to be a measure implemented over many decades. *Alternative livelihoods* is a form of land use change aimed at both avoiding flood damage (abandoning the previous flood-susceptible land use) and accommodating floods (through the new flood-tolerant land use). *Diversification* could be pursued as a continuity strategy (accommodate: prepare) undertaken on an individual business or broader economic scale. The recovery phase is sometimes used as a 'window of opportunity' to implement these changes (this generally requires pre-planning and supportive institutional arrangements as the opportunity is brief).