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Review of Climate Resilience Framing and Measurement

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Table of Contents

1. Executive Summary

The idea of resilience has been applied to disaster risk management for many years. The broader application to climate change adaptation has been a more recent development. It has emerged from the need to recognise that the investments we make today are of benefit to society in the future. The idea of resilience epitomises the need for flexibility on the one hand, and sturdiness on the other, as a formula for managing during and after natural hazards and permanent changes in climate.

This paper has been prepared through interviews with leading researchers and practitioners, literature review and examination of best practice approaches. The purpose of these activities was to identify theoretical frameworks for resilience MER and practical examples of where these had been applied at scale. This report has focused on examples where:

- The research or practical example had lessons that were applicable to a western cultural context, a government program or a program of similar scale.
- The main context of the research or practical application was resilience, rather than general monitoring and evaluation.
- The practical examples had sufficient detail to understand the context, drivers and issues with implementation.

All of the resilience specific examples examined in this report share a common vision, albeit nuanced depending on the specific context. This is: *the ability to withstand shocks and stressors, and be prosperous into the future*. It is a function of the socio-ecological systems' response to a shock or a stress. Resilience MER requires an understanding of the socio-ecological system and how the investment program will intervene to move the system to a more desired state. This implies that the MER approach must have a vision or statement of a desired state of the system, and the MER framework monitors progress towards that desired state.

MER for resilience may need to look more broadly than direct investment goals of the program because it must also measure changes in the socio-ecological system that will build resilience. This must be underpinned by an understanding of the socio-ecological system, the desirable characteristics of the system that need to be enhanced, and the undesirable ones that need to be weakened.

Different frameworks have begun to emerge to identify how best to frame resilience interventions. A review of the literature shows that these approaches generally converge on two lenses:

Lens 1: Changes in system wide **capacities**:

- Improve **predictive** capacity to be aware of climate risks
- Improve capacity to **absorb** shocks and weather impacts, quickly recover and move on
- Improve capacity to **adapt, reshape or transform** institutions, governance and communities to better cope with a future climate.

Lens 2: Improvement in the inherent **characteristics** of a resilient socio-ecological system. The building blocks of the system itself lead to its resilience. This can include factors such as high levels of diversity, community connectedness, and general financial capacity.

Application of general **principles** are also important to guide MER given the long time frames associated with resilience and the unpredictable nature of both the climate change and other factors associated with resilience (e.g. macroeconomic forces). It is difficult and in some cases impossible to predict when resilience will truly be "tested" through, for example, a natural disaster or extended drought. These shifts, which would allow for resilience "testing" are unpredictable and hopefully avoidable altogether, and they could happen years or decades in the future. In this context, principles matter.

Examination of the practical examples highlights many lessons that can be applied to a resilience MER framework, and these are considered in chapter 5. All the resilience specific examples above share a common vision, albeit nuanced depending on the specific context. This is: *the capacity to withstand shocks and stressors, and be prosperous into the future.*

All practical examples were delivered in the context of their own socio-ecological systems and the MER approaches reflected this. Only one, the BRACED MER Framework, defined and tested a comprehensive theory of change. The remaining examples included extensive stakeholder engagement, which is assumed was sufficient to capture the nuances of their local situation and ensure that the MER approaches were targeted towards the areas of most concern or influence.

The application of Lens 1: Capacities was most commonly used to define MER Frameworks. Where Lens 2: Characteristics was used, it was for a MER Framework for a small community's resilience plan.

Many the MER Frameworks include processes and principles to ensure the ongoing evolution of the MER process. It has been recognised that understanding resilience can be a complex undertaking, and so it is necessary to ensure that the assumptions in the MER framework are tested and evolve as it is implemented.

2. Purpose of the review

This review has been prepared to inform those who are considering implementing resilience based Monitoring, Evaluating and Reporting (MER) approaches. Resilience provides a suitable theoretical framework to consider the long term, because it is premised on the need to build capacities that are embedded in the target sectors, and will improve the capacity of the sectors to respond to future challenges.

The objectives of this report are to undertake a review of global, international and national climate change resilience MER frameworks to identify best practice monitoring and evaluation of climate change resilience (strategic and operational),

3. Methodology

This paper has been prepared through interviews with leading researchers and practitioners, literature review and examination of best practice approaches. The purpose of these activities was to identify theoretical frameworks for resilience MER and practical examples where these had been applied at scale.

3.1. Interviews

The first stage of the process was to interview key personnel who had been involved in the development of resilience MER, or large scale reviews of MER programs more generally. These were conducted in person, via Skype or email. The key focus of the discussions was to identify both relevant theoretical frameworks and examples of practical application.

- Patrick Pringle – Director of the UK Climate Impacts Program (UKCIP), and has been a lead author for several European-wide reports on MER.
    - Listed relevant UKCIP reports that touched on resilience concepts in MER.
- Andrea Jol – Director EU Adapt within the European Union and co-author to several European-wide reviews of MER.
    - Provided references to European Union-wide studies of MER that included insights into the application of resilience approaches.
- Pamela Kertland – Program Manager for the Canadian Adaptation Program overseeing development of the national adaptation MER approach.
    - Was not aware of resilience approaches being used in Canada, particularly at the provincial scale.
- Andrew Mason – Government of Queensland undertaking a detailed review of MER frameworks for the Queensland Climate Adaptation Strategy.
    - Provided a host of resources and research on general MER.
- Dr Lara Hansen and Eric Mielbrecht - Directors of ECOAdapt, a USA-based adaptation consultancy who coordinate the US National Adaption Forum. Also, Board members for the American Society of Adaptation Professionals.
    - Apart from the Rockefeller Resilience Cities program, were not aware of resilience MER being used in any of the jursidictions in USA.
- Ragne Lowe – ClimateXChange Scotland, coordinating the Scottish National Risk Assessment.

    - Provided advice on the indicators used in the Scottish National Risk Assessment.
- Willem Ligtvoet, PBL Netherlands Environmental Assessment Agency, Coordinator of the Delta Programme.
    - Provided information on how the MER program he coordinates uses committee structures to understand external drivers of change.
- Victoria Sword-Daniels, Consultant with Itad Ltd, overseeing the Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) MER Framework.
    - Provided information and access to reference material on how resilience is being used for the BRACED MER Framework.
- Rüth van Petra – Climate Impacts and Adaptation, Federal Environment Agency, Germany.
    - Provided information on the German Climate Change Adaptation Strategy and the MER approach. This provided a library of indicators that has been used to measure adaptation outcomes.

The majority of interviewees were not aware of resilience MER frameworks being used at scale, and provided references to relevant reports and resources where they were available. Starting from these initial resources, citation lists within these reports were also reviewed to identify additional resources, which were accessed where relevant.

3.2. Internet Search

Web searches were undertaken using combinations of search words from the list below. The first 3 pages of results were reviewed to identify additional source material. The focus was to identify sources that relate directly to resilience monitoring. Research on more generic monitoring and evaluation approaches was not included, unless it provided specific lessons for resilience outcomes.

List of key Google Search words

Assessment	Reduction
Climate	Resilience
Change	Resilient
Disaster	Reporting
DRR	Rockefeller
Evaluation	Risk
Integrated	Vulnerability
Monitoring	

3.3. Resilience Measurement Community of Practice

Finally, an invitation was given to join the Resilience Measurement - Monitoring Evaluation and Learning (MEL) Community of Practice[1]. This is a network of global resilience practitioners and thought leaders. A request was made through the network blog for additional resources and practical examples. At the time of writing, members of the

[1] http://resiliencemeasurementcop.groupsite.com/main/summary

network had not suggested any additional material beyond that which had already been identified.

3.4. Assessment criteria

These processes identified a significant number of resources, and it was necessary to apply selection criteria that were useful for potential target audiences in western governments. This report has therefore focused on examples where:

- The research or practical example had lessons that were applicable to a western cultural context, a government program or a program of similar scale.
- The main context was resilience, rather than general monitoring and evaluation.
- The practical examples had sufficient detail to understand the context, drivers and issues with implementation.

When comparing the quality and applicability of practical applications (section 5), it was useful to assess each in terms of the following criteria to identify what would be most useful. These are listed in Table 1.

Table 1: Criteria to compare examples of resilience MER approaches

Resilience focus	Is the MER approach underpinned by a resilience theoretical framework or at least, resilience concepts?
Statement of desired future	Is there a clear articulation of the components of the desired socio-ecological system that will ensure greater resilience?
Theory of change	Is there an articulated theory of change for how the interventions will achieve the desired future? This has links to the theories of resilience MER discussed in Section 4.
Coverage of indicators	Are there sufficient indicators to cover off the key areas of the theory of change?
Alignment of indicators	Do the indicators align with the theory of change in scope, scale, time-frame and data availability?
Types of indicators	Are the indicators qualitative or quantitative, subjective or objective?
Other elements	What are the other elements of best practice MER that are inherent in the resilience framework (e.g. governance, stakeholder engagement)?

This research phase identified that there are a number of theoretical frameworks for MER for resilience that have been proposed, and a smaller number of practical applications.

4. Theory of MER for Resilience

The various theoretical frameworks of MER for resilience are discussed in this section, followed by a summary of lessons learned. The detail about the theoretical frameworks is contained in Appendices 1 & 2.

4.1. Resilience concepts and application to climate change

The idea of resilience has been applied to disaster risk management for many years. The

broader application to climate change adaptation has been a more recent development. It has emerged from the need to recognise that the investments we make today are of benefit to society in the future. The idea of resilience epitomises the need for flexibility on the one hand, and sturdiness on the other, as a formula for managing during and after natural hazards and permanent changes in climate (Lisa, Shipper, & Langston, 2015).

Conceptualisations of resilience suggest socio-ecological systems that have several different properties that allow them to function 'well' – in the sense of providing stability, predictable rules, security and other benefits to their members. Their ability to deal with shocks and stresses is derived from various capacities that collective and individual actions can enhance. A socio-ecological system with these capacities is less likely to be undermined by shocks and stresses, so wellbeing can be ensured and development can continue to progress in locations exposed to climate extremes and disasters (Aditya, et al., 2015).

The Rockefeller Resilient Cities Framework uses the notion of chronic stresses or sudden shocks threatening widespread disruption or the collapse of physical or social systems. It accepts the possibility that a wide range of disruptive events – both stresses and shocks – may occur but are not necessarily predictable. Resilience focuses on enhancing the performance of a system in the face of multiple hazards, rather than preventing or mitigating the loss of assets due to specific events (Arup, 2015).

Socio-ecological systems are populated with individuals and institutions and their subjective values, agendas, points of view and priorities. Resilience-building initiatives must therefore reflect on normative questions such as 'resilience of what, to what and for whom?'. These questions arise because of the desire to make resilience operational and to develop frameworks to measure it (Bahadur, Wilkinson, & Tanner, 2015).

Resilience interventions are about strengthening the ability of households, governments, institutions etc. to choose – from a whole 'portfolio' of options – what they perceive at that time as the "right" response(s), rather than be forced by circumstance to choose the only option they have at their disposal at that moment, which might be detrimental overall (e.g. selling assets) (Béné, Frankenberger, & Nelson, 2015).

A resilience system is one that has the resources, capability and options to respond to shocks and stressors. This raises questions about who benefits the most from resilience interventions, and how trade-offs are managed. Consider, for example, where one large community constructs flood levies to protect their assets, but which more quickly transfers the flood water into the neighbouring smaller community, thereby significantly increasing their risk of flooding. Such maladaptive actions may act to improve overall resilience by protecting the largest percentage of the population, but are clearly not dealing with the ethical or social impacts of the resilience process.

Managing such trade-offs is inherent in the development of a resilience system or approach. This 'point of view' is a critical factor in the resilience-building processes, as the concept of resilience is framed or interpreted differently by different people in a system. This includes trade-offs in scale, where building resilience at one scale may have negative repercussions for resilience at other scales; and trade-offs between groups where resilience for one group

within a system may come at the cost of resilience for another group (Bahadur, Wilkinson, & Tanner, 2015).

Therefore, resilience MER requires a comprehensive understanding of the socio-ecological system and how that system will change to become more resilient. MER for climate change adaptation is inherently complex, multifaceted, and long-term in scope (Bours, McGinn, & Pringle, 2014).

It can mean that the MER approach must consider factors outside the direct investment goals. Adopting a resilience lens means recognising the importance of uncertainty, risks, shocks and changes. It also means recognising that shocks, stressors and trends affect not only individuals and households but also communities, institutions, infrastructure and higher-level systems (e.g., agro-ecological systems, market systems, governance systems) (Béné, Frankenberger, & Nelson, 2015).

Williams (2016) described that the source of this complexity stems from the fact that climate resilience is a complex issue, and is what some term a 'wicked problem' — a problem that is extremely challenging to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognise. These kinds of complex, evolving problems require adaptive and creative solutions across sectors, are context-specific, and may be ever-changing as both problems and solutions shift over time. This has implications for climate and disaster resilience MER, including:

- what works well in one context may not work anywhere else. Therefore, the transferability, replicability, and scalability of solutions cannot be assumed;
- in general, neither the problems nor the solutions are formulaic (or agreed upon by the multitude of stakeholders), therefore MER models that assume linear cause-and-effect relationships between interventions and outcomes/impact may not apply, at least not in most instances; and
- the realities strongly suggest that MER frameworks and approaches should be innovative and iterative, adapting over time, based on experience and a deeper understanding of what works both in each case, and based on insights gained from broader experience.

To achieve this, the author establishes a set of MER principles that seek to ensure that learning and dynamism is inherent in the MER framework. The headline principles are summarised below, and are explained more fully in Appendix 3.

1. Accountability and learning are both priorities for climate and disaster resilience MER; however, the natural tensions and trade-offs between these are recognised and should be considered
2. User-focused and participatory
3. Consider existing systems and requirements
4. Consider—and invest in—local capacity, balancing building capacity with realistic expectations
5. Encourage innovation
6. Factor in the inherently multidimensional and complex nature of resilience
7. Flexibility and improvement over time are expected.

Principles are important to guide MER, given the long time-frames associated with resilience and the unpredictable nature of both the climate change and other factors associated with resilience (e.g. macroeconomic forces). It is difficult, and in some cases impossible, to predict when resilience will truly be "tested" through, for example, a natural disaster or extended drought. These shifts, which would allow for resilience "testing" are unpredictable and hopefully avoidable altogether, and they could happen years or decades in the future. (Williams, 2016). In this context, principles matter.

4.2. Theoretical frameworks for resilience MER

Most authors highlighted that context matters when developing the MER framework and for the selection of indicators (Lisa, Shipper, & Langston, 2015) (Brown, Shaker, & Das, 2016) (Garcia & Zazueta, 2015) (Béné, Frankenberger, & Nelson, 2015) (Williams, 2016). Attempts have been made to establish frameworks to classify resilient MER approaches within the context of a socio-ecological system. Different frameworks have begun to emerge and a review of the literature shows that these approaches generally converge on two lenses:

1. changes in system-wide capacities, and
2. improvement in the inherent characteristics of a resilient socio-ecological system.

Lens 1: Changes in system-wide capacities

The first lens captures the broad system-wide capacities that are enhanced to improve resilience. It is based on the notion that if interventions strengthen these capacities to respond, the socio-ecological system will react in a way that achieves greater resilience. MER assesses the extent to which these capacities are being enhanced.

The key themes that these approaches define capture the activities and investments that are made to:

- improve predictive capacity to be aware of climate risks,
- improve capacity to absorb shocks and weather impacts, quickly recover and move on, and
- improve capacity to adapt, reshape or transform institutions, governance and communities to better cope with a future climate.

Although differentiating the three capacities is useful for analytical purposes, they fall along a continuum and jointly facilitate different types of responses that range from a low to a high degree of structural change (Béné, Frankenberger, & Nelson, 2015). For instance, improving enabling environments (e.g., service delivery, governance, infrastructure, policies, access to social protection) can also have a positive synergistic effect on the absorptive and adaptive capacities of households, communities, and higher-level systems.

Three examples were identified that use capacities: UN, BRACED and GIZ. Each of these frameworks is detailed in Appendix 1 and is summarised through this discussion. These theoretical frameworks were developed for slightly different purposes. United Nations (UN) Climate Resilience Initiative was developed as a framework to assess comparative resilience across 114 countries. The Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) Framework was used to assess the contribution to resilience of 15 field-based resilience building projects across 13 countries. The German agency Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) approach provides a broad theoretical approach that has been proposed for application for GIZ projects. Figure 1 illustrates these capacities.

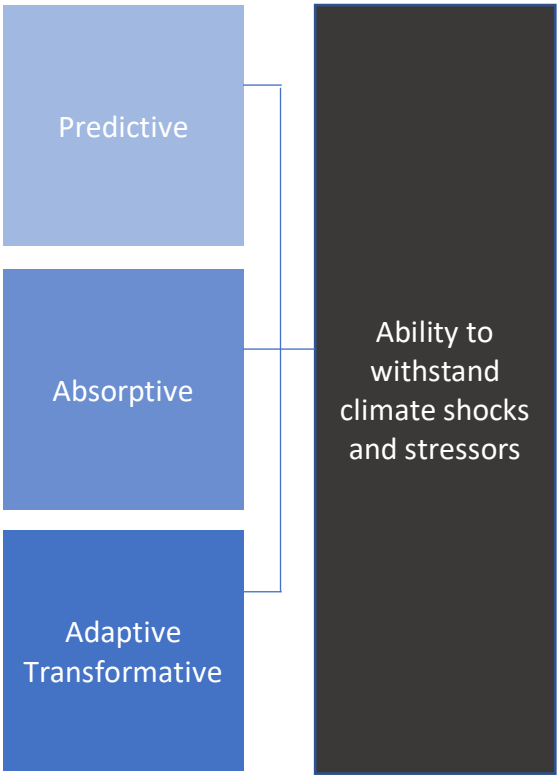


Figure 1: Capacities in the Climate Resilience Framework.

Improving Predictive Capacity

Within the example frameworks it is also referred to as Anticipatory capacity. This is broadly defined as the ability of systems to anticipate and reduce the impact of climate variability and extremes through preparedness and planning. This capacity is seen in proactive action before a foreseen event to avoid upheaval, either by avoiding or reducing exposure or by minimising vulnerability to specific hazards (Kellett & Peters, 2014). Predictive capacity is displayed when actors can forecast particular shocks, for example through the use of drought and cyclone early warning systems or geospatial information. An additional component of predictive capacity is the ability of communities to undertake vital planning and preparedness activities to manage disaster risk.

Monitoring and evaluation of this capacity examines the extent to which predictive information is available, integrated into decision-making processes and subsequently used.

Improve Capacity to Absorb Shocks

This represents the ability of a system to absorb, mitigate or recover from the impacts of negative events using predetermined coping responses to preserve and restore essential basic structures and functions (e.g. human life, housing, productive assets). In conceptual terms, it is concerned principally with 'functional persistence' – that is, the ability of a system to buffer, bear and endure the impacts of climate extremes in the short term and to avoid collapse. A distinction from predictive capacity is that it captures longer term measures that are built in to absorb the shocks, as well as the available resources and capacity to recover after the event.

Monitoring and evaluation focuses on areas such as the level of investment in risk reduction activities (e.g. infrastructure hardening), financial capacity of individuals (e.g. mortgage stress, insurance) or assessments of how the early warning systems and response mechanisms actually performed.

Adaptive and Transformative Capacity

This covers the broad spectrum of activity that ranges from making minor changes in systems and institutions in response to learnings from previous disasters or events, through to fundamentally changing an industry or institutional framework in response to projected impacts that are yet to occur. It is the capacity to take deliberate and planned decisions to achieve a desired state, even when conditions have changed or are about to change. Adaptive capacity is usually made apparent and strengthened during non-emergency periods, for example in accessing and using a mix of historical data and downscaled climate projections to understand changing rainfall patterns to inform the design of drainage systems.

Monitoring focuses on areas such as changes in industry practices, response mechanisms, planning regimes etc. that occur in anticipation of future changes or as a result of impacts from previous events.

Transformation has been a source of discussion in the literature. Some authors have argued for including "transformative capacity" in any schema of resilience capacities (Béné et al., 2012). While transformation can be an unintended change, it generally refers to deliberate attempts to engineer changes required to achieve a desired goal or outcome. Transformations can be influenced by policy shifts that fundamentally change the institutional "rules of the game". To demonstrate the potential for transformation, any initiative must embody three essential characteristics: be catalytic, have impact at scale and produce sustainable outcomes.

Catalytic effects imply the ability to leverage wider change, including the replication and financing of similar approaches by others. Catalytic interventions may produce shifts in policy, regulations and behaviour. 'At scale' reflects one of the most common interpretations of transformation, whereby interventions become transformational when they are used at a greater scale or in integrated combinations with much greater effects than before. The scale of impacts may be measured in terms of the outcomes achieved in relation to the magnitude of resource inputs. Transformational scale may also refer to the potential of the approach to be up-scaled through replication. Finally, transformational actions are expected to have sustainable outcomes, so lead to a process of resilience-building that can withstand changes in the wider environmental, socio-political, economic and cultural context (Villanueva & Gould, 2016).

In contrast, the BRACED Framework argues that transformation is not a specific capacity, but is instead the outcome from good investment in the other capacities (Bahadur, Wilkinson, & Tanner, 2015). In their view, understanding whether an action today is truly transformative in the future is too hard to assess directly. To that end, the BRACED MER approach seeks only qualitative statements from its projects on the potential for transformation arising from the actions.

Dimensions

The GIZ framework provides a mechanism to further inform MER by defining five dimensions under predictive, absorptive and adaptive/transformative capacities that roughly align with the Five Capitals Model (GIZ, 2014). In each of the capacities it is useful to consider the sub-elements that drive the changes in capacities as shown in Figure 2.

The **social dimension** primarily refers to characteristics such as health, education, skills and demographics. It also encompasses the prevalence of social networks as well as similar system-wide aspects that create cohesion, information transfer and resource sharing.

The **ecological dimension** addresses the diversity and state of the natural environment. These factors (e.g. biodiversity, deforestation rate) determine not only the ecosystem's own ability to adapt to a changing climate, but also the functioning of certain ecosystem services on which human beings critically depend (e.g. drinking water, fresh air).

The **economic dimension** comprises the economic activities as well as the availability and distribution of financial assets and other endowments, which may fulfil a variety of purposes. Savings can, for instance, be used to repair productive goods damaged by a climatic hazard (restore basic functions) or to finance adjustments in planting behaviour (incremental structural change).

The **physical dimension** mainly focuses on physical infrastructure such as housing, transport infrastructure, communication networks or health facilities. Their operability, particularly during and after the occurrence of extreme events (e.g. main roads being passable after a storm surge) but also in the face of slow onset hazards (e.g. houses on stilts being habitable despite sea level rise) has a great influence on the overall climate resilience.

Finally, the **institutional dimension** which includes effective governance and institutions as well as participation on various levels. They largely determine how the process of building climate resilience is managed and how different perceptions and objectives are harmonised.

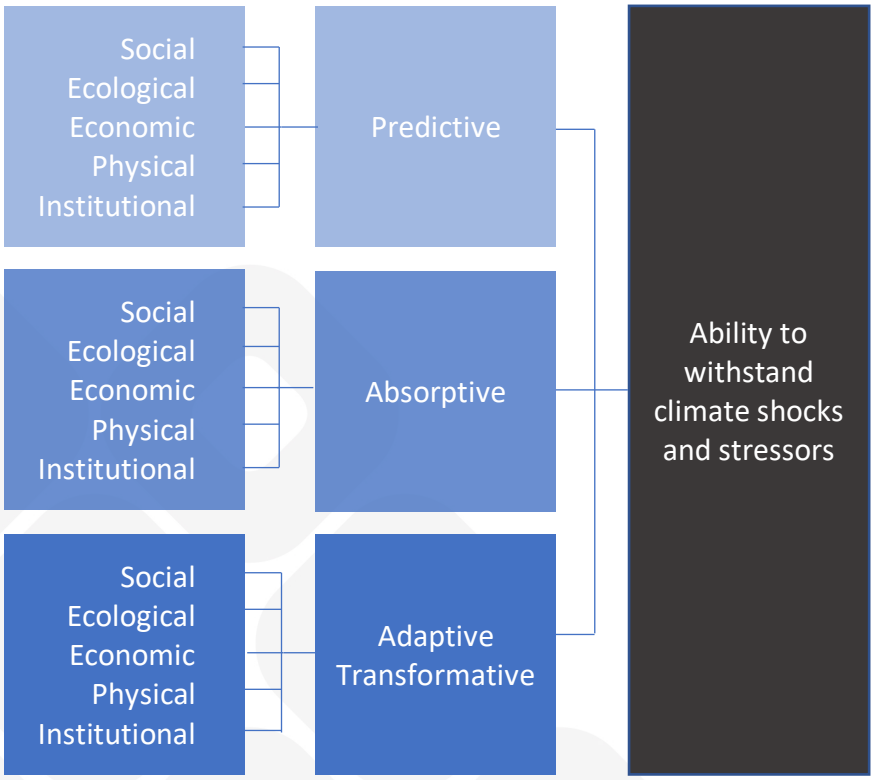


Figure 2: Climate Resilience Framework incorporating the five dimensions (adapted from GIZ, 2014)

Lens 2: Underpinning characteristics

Since 2013, there has been an emergence of an additional layer of complexity for resilience MER. In addition to the approaches and capabilities that can be shown to be improving, resilient systems can be defined to be comprised of inherent characteristics. The building blocks of the system itself lead to its resilience. The inclusion of this conceptual framework is to enhance the understanding of the socio-ecological system by focusing more on the core elements of the system function. It provides another way to confirm if the investment being made is more likely to result in an improvement in resilience.

Appendix 2 contains detailed examples of different approaches, which are discussed below.

The approach proposed by GIZ is shown in Figure 3. It illustrates that if these factors are enhanced, then the desired outcome will be achieved.

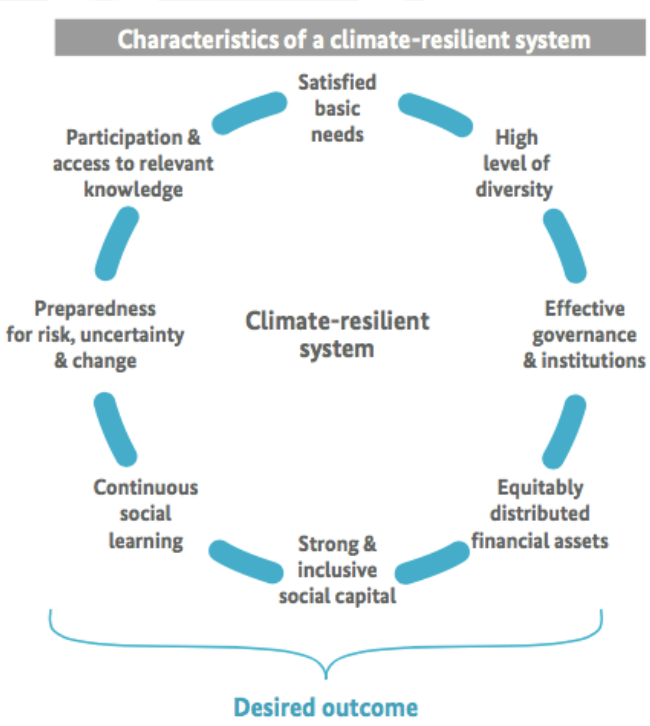


Figure 3: Characteristics of a climate resilient system proposed by GIZ (GIZ, 2014)

The authors proposed that these characteristics should not be measured directly (GIZ, 2014). Instead, their purpose is to guide the development and definition of capacities described in the previous section. Their reasoning was that it is difficult to characterise whether one is more important than another, and they do not specifically focus on climate risks. They represent the desired outcome of efforts towards building climate resilience. The relative contribution of each characteristic will depend on the specific context in which it is being applied.

The Rockefeller City Resilience Framework provides an illustration of how the context informs the application of characteristics. These are described as the seven 'qualities' of resilient cities: (Arup, 2015)

- has alternative strategies ('Flexible')
- has backup capacity ('Redundant')
- limit spread of failure ('Robust')
- can easily repurpose resources ('Resourceful')
- ability to learn ('Reflective')
- includes broad consultation and communication ('Inclusive')
- has systems working together ('Integrated').

Figure 4 illustrates how these qualities are reflected in the MER framework. Each quality is represented by a sequence of indicators across all of the dimensions (represented by grey bars). It provides an example of how the qualities are linked directly to the broad strategies, and therefore can be directly monitored for impact.

Figure 4: 100 Resilient Cities Framework

The Framework describes that these qualities distinguish a resilient city from one that is simply liveable, sustainable or prosperous (Arup, 2015). So, while the twelve strategies (in yellow above) outline systems, infrastructure and services that need to be robust, the qualities are the inherent characteristics that will ensure they are also resilient. These qualities are important in preventing breakdown or failure; or enabling appropriate and timely action to be taken. For example, health services that are flexible can reallocate staff to deal with an outbreak of disease. Protective infrastructure that is robust will not fail catastrophically when design thresholds are exceeded. Energy systems with redundancy will accommodate surges in demand or disruption to supply networks.

When reviewing the various published resilient cities reports, no cities sought to directly monitor the achievement of these characteristics. This lends weight to the view expressed by GIZ that characteristics inform capacities.

The same thinking underpins the approach proposed by The Stockholm Resilience Centre (www.stockholmresilience.org). To be able to address the impacts of the changes, a resilient socio-ecological system has the capacity to deal with change and continue to develop, be it an individual, a forest, a city or an economy (Stockholm Resilience Center, 2017).

They identify seven key characteristics (called principles). This informs how management actions should be targeted to build these specific characteristics, and therefore what MER should be undertaken. The specific characteristics are:

1. Diversity and redundancy
2. Connectivity
3. Slow variables and feedbacks
4. Complex adaptive systems thinking
5. Learning and innovation
6. Broad participation
7. Polycentric governance.

4.3. Lessons for practical application of a Resilience MER Framework

This short review of the current literature and practices has identified several lessons that are useful for practical application.

Definition of resilience
Resilience is usually defined as an ability to withstand shocks or stressors now and into the future. It is a function of the socio-ecological system's response to a shock or a stress. Resilience MER requires an understanding of the socio-ecological system and how the investment program will intervene to move the system to a more desired state. This implies that the MER approach must have a vision or statement of a desired state of the system, and the MER framework monitors progress towards that desired state.

Scope of MER
MER for resilience may need to look much more broadly than direct investment goals of the program, because it must also measure changes in the socio-ecological system that will build resilience. This must be underpinned by an understanding of the socio-ecological system, the desirable characteristics of the system that need to be enhanced, and the undesirable ones that need to be weakened. The theory of change for the program should therefore capture how the desired state is being achieved as a result of the investment program.

Capacities, dimensions and characteristics
The desired changes can be characterised as underlying changes in capacities (Predictive, Absorptive, Adaptive/Transformational). This can be further defined by the dimensions

(social, ecological, economic, physical and institutional). Characteristics can be used to inform the actions and strategies.

Principles

MER for resilience and climate change must account for the complexity of the socio-ecological system and the potentially long time-frames between cause and effect. Therefore, MER frameworks and approaches should be innovative and iterative, adapting over time, based on experience and a deeper understanding of what works both in each case and based on insights gained from broader experience. The application of principles can help to direct the MER framework to be more responsive and to focus on learning outcomes.

5. Lessons from practical applications

As discussed in the methodology section, practical examples were selected where:

- The practical example had lessons that were applicable to a western cultural context, a government program or a program of similar scale.
- The main context of the practical example was resilience, rather than general monitoring and evaluation.
- The practical examples had sufficient detail to understand the context, drivers and issues with implementation.

The discussion that follows explores these examples in more detail. The assessment criteria arise from some of the lessons that arose from the previous section. The criteria are listed below in table 2. Table 3 provides a summary of the assessment

Resilience focus	Is the MER approach underpinned by a resilience theoretical framework, or at least resilience concepts?
Statement of desired future	Is there is a clear articulation of the components of the desired socio-ecological system that will ensure greater resilience?
Theory of change	Is there an articulated theory of change or strategic objectives for how the interventions will achieve the desired future? This has links to the theories of resilience MER discussed in Section 4.
Coverage of indicators	Are there sufficient indicators to cover off the key areas of the theory of change or strategic objectives?
Alignment of indicators	Do the indicators align with the theory of change in scope, scale, time-frame and data availability?
Types of indicators	Are the indicators qualitative or quantitative, subjective or objective?
Other elements	What are the other elements of best practice MER that are inherent in the resilience framework (e.g. governance, stakeholder engagement)?

Table 2: Criteria used to compare different practical approaches to resilience MER.

Criteria	Rockefeller	TSRA	BRACED	UNEA	UK CCC	Dutch Delta	Germany
Resilience focus	Yes	Yes	Yes	Yes	No (risk reduction)	No	No
Desired future stated	Yes	Yes	Yes	Partial	Partial	Yes	No
Theory of change	No	Partial	Yes	No	No	No	No
Coverage of indicators	Unclear	Yes	Yes	Partial	Yes	Yes	Yes
Alignment of indicators	Unclear	Yes	Yes	Yes	Yes	Yes	Yes
Types of indicators	Quantitative Objective	Quantitative Objective	Qualitative Quantitative Subjective	Qualitative Subjective	Quantitative Objective	Yes	Quantitative Objective
Other elements	Yes	Yes	Yes	Unknown	Yes	Yes	Yes

Table 3: Summary of assessment for each practical example

5.1. Rockefeller Resilient Cities

In Australia, both Sydney and Melbourne are part of the Rockefeller Resilient Cities network. Both cities have completed preliminary resilience assessments and taken steps towards developing action plans, with Melbourne being the most advanced.

There is no clearly articulated theory of change in either of these reports. Instead, the plans described the features of a resilient future and then set about defining actions that would bring that future about. The actions were developed through consultative processes.

For both Sydney and Melbourne, the first stage of monitoring and evaluation has focused only on baseline establishment. Both cities have information on their key drivers, risks and advantages that they must overcome or leverage to become more resilient. There is no further consideration of monitoring and evaluation beyond the establishment of the baseline. The selection of baseline indicators focuses on key elements of resilience as defined by the Stockholm Resilience Centre - connectedness, social equity, relative disadvantage, health and wellbeing, economy.

In reviewing other plans from cities in Europe, USA and Canada, only the Glasgow plan had a section on monitoring evaluation in the long term (City of Glasglow, 2017). The plan makes a commitment to develop a MER Framework and provide an annual resilience report card based on six indicators.

- Strength of social networks
- Employment networks
- Business survival rate
- Male and female life expectancy
- Access to public spaces
- Child care access

Resilience focus	Yes – Resilience is the key objective.
Statement of desired future	Yes – Describe a future where the community is safer and able to absorb shocks.
Theory of change	No – Improvement is assumed to arise from improvement in underlying social, economic and environmental outcomes.
Coverage of indicators	Too early to assess.
Alignment of indicators	Too early to assess.
Types of indicators	Where indicators have been used to identify a baseline, these are quantitative and objective.
Other elements	Has broad participation across communities, and involvement in key decision-making processes.

5.2. TSRA

The Torres Strait Climate Change Adaptation and Resilience Plan (TSRA, 2016) represents a genuine attempt by a community to develop an end-to-end resilience planning, implementation and MER process. In this plan, resilience is defined as the ability of a community or a system to respond to change or impacts in such a way that negative impacts are minimised and the community continues to function well under stress. Resilient communities and systems tend to recover quickly from shocks and can often turn challenges into opportunities. They are more self-reliant but still keep strong connections with other local and distant communities.

The plan includes a statement of a desired future, titled the Core Proposition, which is further elaborated into six resilience focus areas that capture the broad suite of actions, and forms the basis of the MRE approach (TSRA, 2016). The Resilience Outcomes were developed through consultation with the community, and tested with expert opinion and research.

Resilience Outcome 1: The governance arrangements for the Torres Strait Region and for each community enable development of responsive, resilient and sustainable communities with climate change and resilience fully integrated into development planning and policy development.

Resilience Outcome 2: Health risks are managed and reduced through holistic health and well-being strategies and interventions.

Resilience Outcome 3: The community is strong, confident and capable and has increased its capacity to respond positively to change and impacts.

Resilience Outcome 4: The infrastructure and services in the Torres Strait are fit for purpose, systems have built-in redundancy, have low operation and maintenance costs and meet the needs of the local and regional community.

Resilience Outcome 5: The land and sea are healthy and can adjust to the changing climate without losing diversity or productivity.

Resilience Outcome 6: Enterprise in the region and in each community aligns with community values and is meeting the majority of the communities' local needs.

There is no clearly articulated theory of change for this plan. Instead, the assumption is that by focusing on the outcomes listed above, resilience will be enhanced. Progress towards achieving resilience is measured as improvement beyond a baseline in each of the key indicator areas. The full detail and indicators have been attached to this report.

The plan also outlines the governance and reporting processes that will be implemented to drive the community towards greater resilience.

Resilience focus	Yes
Statement of desired future	Yes – The Core Proposition and Resilience Outcomes clearly articulate the desired future.
Theory of change	Partial – Improvement is assumed to arise from improvement in underlying social, economic and environmental outcomes.
Coverage of indicators	Broad coverage of indicators across all sectors.
Alignment of indicators	The indicators provide a detailed understanding of the drivers and outcomes in each sector.
Types of indicators	Indicators are mostly quantitative and objective.
Other elements	There are planned governance, stakeholder engagement and reporting approaches to achieve changes to the socio-ecological system.

5.3. BRACED

The Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) program is a comprehensive attempt of a resilience MER approach at a program scale (Villanueva & Gould, 2016). BRACED funds a series of 15 projects across 13 countries in East Africa, the Sahel and Southeast Asia. The focus of the projects is on disaster resilience.

The purpose of the BRACED MER framework is to provide a programme-level vision of change. It ensures a common language and alignment of MER efforts across BRACED, while acknowledging and accommodating project-specific MER approaches and plans in different contexts. Each of the 15 projects has its own theory of change and MER framework. The challenge was to develop a coherent program-level framework across the interventions that accounted for the overall contribution to resilience. The framework needed to be flexible enough to be relevant across several different socio-political, geographical and climatic contexts, while retaining robustness and coherence.

Figure 5 outlines the assessment framework that has been established to assess the overall contribution to resilience across the funded activities.

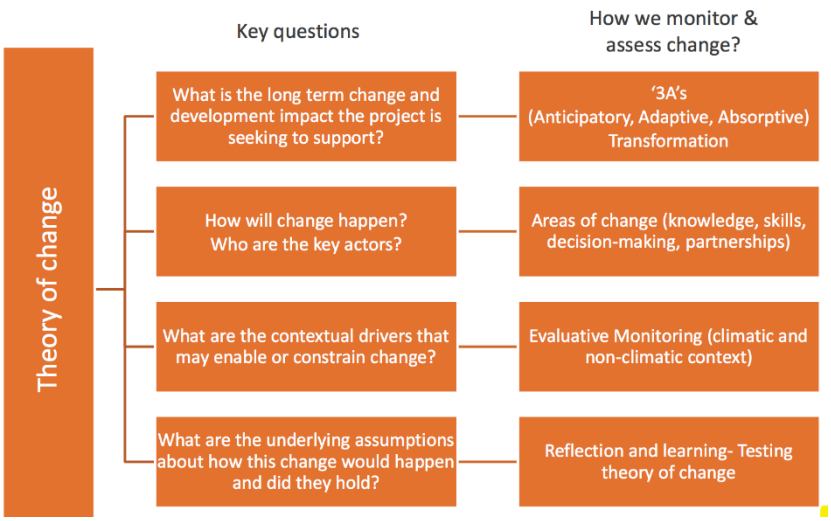


Figure 5: BRACED MER approach

BRACED has developed a comprehensive theory of change and has developed the MER format to test it (refer Appendix 4). Each component of the MER framework uses a different assessment method.

3As and Transformation – Comprises a self-assessment from each project of the level of impact. It includes one-on-one interviews with the project managers. This approach was used because of the difficulty in understanding each project's context. Instead, they relied on the views of the project manager to define the impact based on these areas:

- Sustainability
- Catalytic effect
- Scale
- Innovation.

Areas of Change – Each project is required to report implementation of activities. This section is summarised from those reports and the contribution to the theory of change assessed.

Evaluative Monitoring – To understand the context, a literature review of research and country-relevant reports is being undertaken.

Reflection and Learning – Internal discussions based on the results from the previous three processes, and whether the MER approach is effective or could be improved.

Together these are used to develop a comprehensive picture of how the diversity of projects in the different socio-ecological contexts are contributing to overall resilience. The BRACED program is currently undertaking the first round of detailed assessment consistent with this framework, and will report later in the year.

Resilience focus	Yes
Statement of desired future	Yes – disaster risk reduction focus.
Theory of change	Yes – very detailed theory of change that outlines the key areas of the socio-ecological system, the drivers and desired outcomes.
Coverage of indicators	Broad coverage of MER processes across the areas of the theory of change.
Alignment of indicators	The indicators provide a detailed understanding of the drivers and outcomes in each component of the theory of change.
Types of indicators	Used a combination of quantitative and qualitative information based on a pragmatic assessment of data availability, complexity and reporting burden. Use both quantitative and qualitative information.
Other elements	MER process has strong engagement with the project managers.

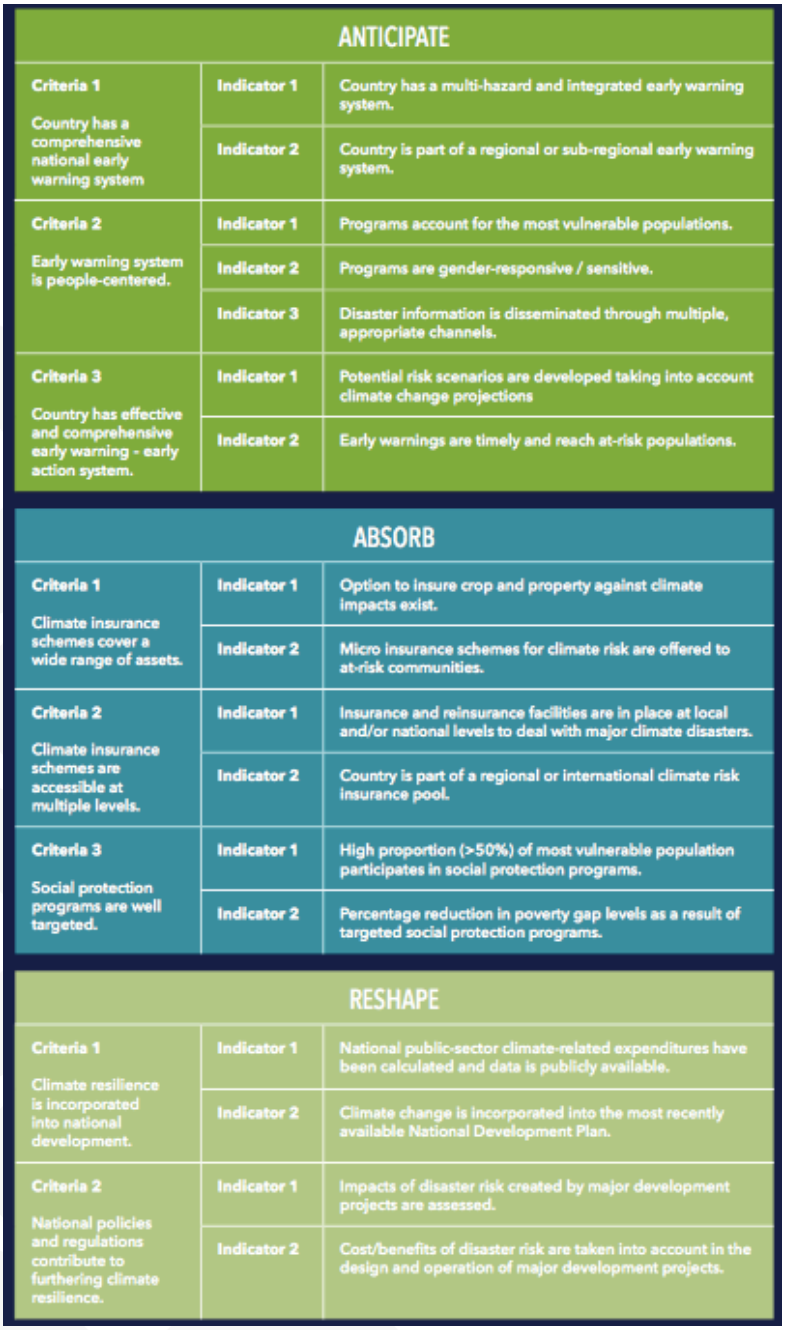
5.4. UN Environment Agency

The United Nations (UN) Environment Agency established a framework to assess the resilience of 114 countries most vulnerable to climate change from the least developed countries, small islands nations and African countries. They used the Anticipate, Absorb, Reshape (A2R) framework to classify resilience across the diverse group of nations. The survey consisted of a self-assessment process using 17 indicators across all three areas (figure 6). These are very high-level indicators whose purpose is to provide an initial indication across the diversity of countries. The report highlights several issues when attempting to capture resilience data at this scale (Väänänen, Dale, & Dickson, 2017).

- Some of the key terms in the indicators are difficult to define across contexts. For example, while 'early warning systems' are clearly defined, the term 'early action' can be complex, spanning a range of activities and approaches at different timescales.
- Accessing data for each of the indicators in each country highlighted the differing data collection methods and priorities, limiting the comparability of the indicators.
- Self reporting and non-responsiveness is a limiting factor in gaining a comprehensive understanding.
- A lack of gender and age disaggregation of the data, so that it was not possible to assess the differential impact/benefit on women and youth.
- Countries were unwilling or unable to provide information on how much they or their businesses spend on areas that are likely to have the highest impact. This limits the ability to use reporting framework to understand the effectiveness and impact of the interventions.

As a result, this report highlighted that while these broad definitions are useful for creating a thematic understanding of action across a diversity of countries, they lack sufficient detail to inform policy interventions on a case-by-case basis. There are also limitations with the comparability of data, and the self-reporting mechanism of data collection. There are not yet any independent mechanisms for qualitative assessment of the information received from the reporting countries.

While there are limitations, the authors highlight that this process is establishing a baseline that will be useful in future assessment processes. Figure 8 summarises the indicators.



ANTICIPATE		
Criteria 1 Country has a comprehensive national early warning system	**Indicator 1**	Country has a multi-hazard and integrated early warning system.
	Indicator 2	Country is part of a regional or sub-regional early warning system.
Criteria 2 Early warning system is people-centered.	**Indicator 1**	Programs account for the most vulnerable populations.
	Indicator 2	Programs are gender-responsive / sensitive.
	Indicator 3	Disaster information is disseminated through multiple, appropriate channels.
Criteria 3 Country has effective and comprehensive early warning - early action system.	**Indicator 1**	Potential risk scenarios are developed taking into account climate change projections
	Indicator 2	Early warnings are timely and reach at-risk populations.

ABSORB		
Criteria 1 Climate insurance schemes cover a wide range of assets.	**Indicator 1**	Option to insure crop and property against climate impacts exist.
	Indicator 2	Micro insurance schemes for climate risk are offered to at-risk communities.
Criteria 2 Climate insurance schemes are accessible at multiple levels.	**Indicator 1**	Insurance and reinsurance facilities are in place at local and/or national levels to deal with major climate disasters.
	Indicator 2	Country is part of a regional or international climate risk insurance pool.
Criteria 3 Social protection programs are well targeted.	**Indicator 1**	High proportion (>50%) of most vulnerable population participates in social protection programs.
	Indicator 2	Percentage reduction in poverty gap levels as a result of targeted social protection programs.

RESHAPE		
Criteria 1 Climate resilience is incorporated into national development.	**Indicator 1**	National public-sector climate-related expenditures have been calculated and data is publicly available.
	Indicator 2	Climate change is incorporated into the most recently available National Development Plan.
Criteria 2 National policies and regulations contribute to furthering climate resilience.	**Indicator 1**	Impacts of disaster risk created by major development projects are assessed.
	Indicator 2	Cost/benefits of disaster risk are taken into account in the design and operation of major development projects.

Figure 6: UN Climate Resilience Initiative Indicators

Resilience focus	Yes
Statement of desired future	Yes – disaster risk reduction focus.
Theory of change	No – assumed, based on Sustainable Development Goals and the Sendai Framework for Disaster Risk Reduction.
Coverage of indicators	Broad coverage of indicators across the key thematic areas.
Alignment of indicators	Unclear

Types of indicators	Used a combination of quantitative and qualitative information based on a pragmatic assessment of data availability, complexity and reporting burden. Information is largely objective.
Other elements	Not available

5.5. UK CCC

The Adaptation Sub-Committee of the UK Climate Change Committee (CCC) oversees the most comprehensive and systemic climate change adaptation and mitigation monitoring program of any country. This adaptation MER approach is focused on risk reduction, and is not fully applicable to a resilience assessment. However, given their efforts to come to terms with issues of MER (Thompson, 2016).

To ensure that they had a comprehensive set of indicators, the secretariat undertook a series of deep dives of key sectors. This was useful to identify the types of mechanisms that were driving the required changes, and the indicators they would need to understand whether the desired activities needed to be achieved. The deep dives were undertaken prior to the investment in adaptation actions and the selection of indicators, and the methodological approach was similar to an impact analysis.

A key lesson is that the CCC sought to understand the socio-ecological system and define the specific indicators that will be most useful to assess the desired outcome. A copy of the indicators has been provided with this report. It includes the CCC's assessment of the quality, usability and availability of the data for each indicator.

The UK approach also contains many lessons about how to implement MER governance, stakeholder engagement and reporting to drive changes to the socio-ecological system. For example, the reporting processes are independent of government but timed to be delivered at the optimal point to influence government decision making. Furthermore, indicators were reported in a way that informs future decision making. An example is below in figure 7.

This figure models how much impact the planned flood prevention strategies are having on reducing the risk to flooding for UK households. It demonstrates that while a great deal is being achieved to reduce flood risk in some areas, it is still not sufficient to reduce the number of homes who are in the highest risk categories.

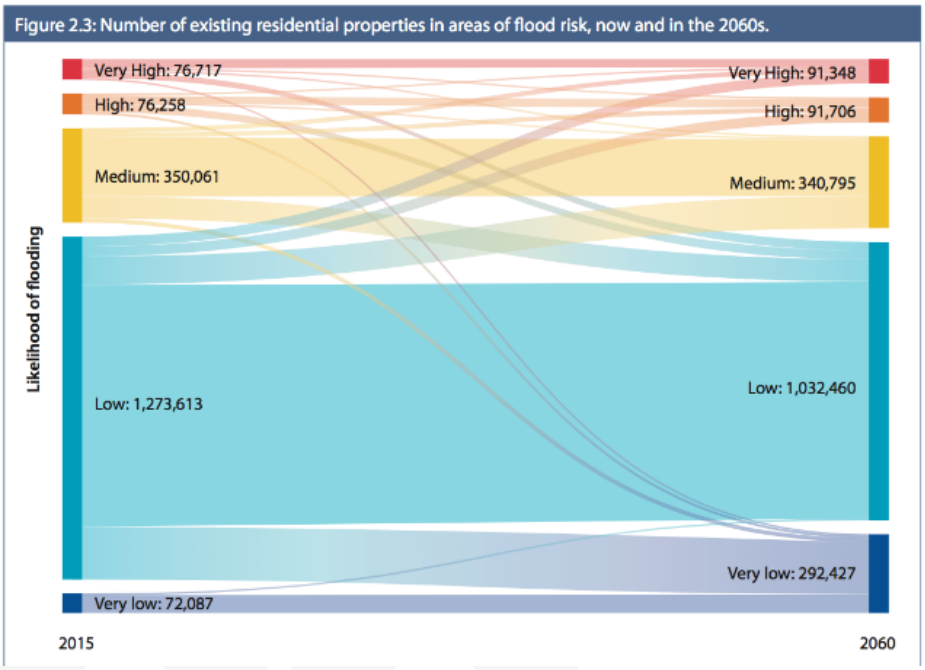


Figure 7: UK Assessment of the overall benefit of planned flood interventions

Resilience focus	No
Statement of desired future	Partial – describe a future that is less risky than today. This is a future that is less likely to be significantly affected by adverse events.
Theory of change	Partial – emerges from the deep dives in the sectors of interest.
Coverage of indicators	Broad coverage of indicators across all sectors.
Alignment of indicators	The indicators provide a detailed understanding of the drivers and outcomes in each sector. Well-articulated understanding of data requirements and timeframes, and how this affects the MER framework.
Types of indicators	Indicators are quantitative and objective.
Other elements	Has very strong governance, stakeholder engagement and reporting approaches to drive changes to the socio-ecological system.

5.6. Delta River Programme

The Dutch Delta River Program provides an illustration of a government that has undertaken a learning-based MER approach (Ligtvoet, 2017). It recognises that resilient systems are those that evolve and respond to changes - learning is critical. While it is not specifically focused on resilience outcomes, it is included in this report because it provides practical application of adaptive MER – learning, rapid decision making, accountability and trust.

The Delta Programme is in place to protect the Netherlands from flooding and to ensure a sufficient supply of fresh water. The main themes of the Delta Programme are flood risk management, fresh water supply and spatial adaptation. In the implementation stage, the Delta Programme aims at adaptive management — given the uncertainties that lie ahead —

and seeks to ensure the participation of numerous parties and the adoption of a broad and integral approach which can coalesce the ambitions and efforts of a range of stakeholders. The Delta Programme is a nation-wide initiative with a complex network structure involving many parties, such as provincial councils, municipalities, district water boards, social organisations and private stakeholders. The MER approach has been created to:

- increase the Delta Programme's capacity for systemic learning,
- integrate adaptive management,
- create a basis for shared accountability, and
- create a basis for trust and transparency.

The learning and evolution process needs to address three types of learning. Unless all three learning approaches are achieved, the resilience process will not be effective.

- Technical Learning - indicators and information that tells what is happening and whether project delivery is occurring as projected.
- Social Learning – improving networks, information sharing and community interactions.
- System Learning – the policy-making process learns the ability to respond to what is being determined.

One important process used in the program is the mechanisms to ensure that the underlying assumptions and drivers are correct, or whether they need to be amended. This is monitored through two key groups.

Signal Group to assess External Dynamics – Key external and environmental factors that are a big influence on the program. Consists of a team of external experts who can inform the discussion on the external dynamics – (report every 2.5 and 5 years).

Core Group to assess Internal Dynamics – Key policy process and programs that the program can directly influence. Consists of senior policy officers from across government – (report every year).

Together these groups can challenge the fundamental assumptions that underpin the successful delivery of the program.

5.7.Germany

The German Federal Cabinet adopted the German Strategy for Adaptation to Climate Change in 2008. This included an extensive MER approach with 102 indicators. After the completion of the first assessment, a review was undertaken and a comprehensive report produced (Schönthaler & Andrian-Weburg, 2015).

The Adaptation Strategy is comprehensive and covers 13 sectors. Consequently, the MER process involved all government agencies and many experts and research institutions. The indicators examined either climate impacts or processes of implementation. Unlike for a resilience approach, the MER did not focus on outcomes and benefits. It has been included in this report because of the scale and number of indicators that are used, and which can inform an MER Framework. A copy of the indicators is attached to this report.

5.8. Lessons for practical application

The examples discussed above all begin with a conceptualisation of resilience - what resilience is in the socio-ecological system, and how that resilience will be achieved.

Statement of Resilience

All of the resilience-specific examples above share a common vision, albeit nuanced depending on the specific context. This is: *the ability to withstand shocks and stressors, and be prosperous into the future*.

Understanding the underlying socio-ecological system

This has been approached in several different ways in the practical examples. The approach taken by the TSRA outlines an example where the focus is on a single community. Hence, the statements of resilient outcomes focus on the specific areas in that community where resilience will be improved.

The other examples are delivered at a much broader scale, and therefore defining the socio-ecological system is more difficult. The BRACED program has overcome this by having each specific project define its own local context, and the ways in which the project contributes to improving that context. In contrast, the UN highlights that its own broad scope limits the applicability of the indicators to all but indicative comparisons.

Within the Rockefeller Resilient Cities, none of the existing plans provide a discussion of the socio-ecological system or a theory of change. One would assume that stakeholder consultation is presumed to automatically capture the key issues and drivers for the society.

Theory of Change

Most practical examples listed above do not include a well-articulated theory of change, such as appears in the BRACED program. Instead, they include a statement of desired outcomes or vision statements, followed by consultative processes to develop the action plans (e.g. Rockefeller Resilient Cities). The basis of the assessment processes for these programs is to articulate a baseline condition, and presumably measure improvement from the baseline as a result of the planned actions.

Focus on capacities

Section 4 describes how capacities are used to define MER frameworks. The UN and BRACED programs both use capacities in their MER frameworks.

Focus on characteristics

Section 4 also discusses characteristics of resilient systems. The TSRA program focuses its resilience effort on improving inherent characteristics in the system. There is an implication here that the application of characteristics works best when focused on a more narrowly defined scale (e.g. a city or small community). This could be confirmed if there were further practical examples and frameworks for use.

Learning and evolution of MER

Despite the best efforts to have a society become more resilient, the efforts in the programs may not lead to better outcomes. This could be attributed to other factors outside the investment program that undermined the outcomes. Both the BRACED and the Dutch Delta programs include specific mechanisms to identify these externalities. Within BRACED they include a reflection and learning process to test the Theory of Change. The Dutch Delta Programme uses the Signal Group, consisting of external experts in diverse fields.

The UK CCC program relies on baselines to identify genuine improvements. For example, their reporting on houses exposed to flooding, models the benefit of policy and investment outcomes into the future, and looks at the total number of houses at risk of flooding resulting from those investments.

The Rockefeller and TSRA MER frameworks also include baseline measurements. These are most effective when there are governance processes that ensure that the investment program can rapidly respond to trends as they emerge. As an example, the UK CCC process includes extensive mechanisms to ensure that the reporting is aligned to decision making and political processes. Their MER framework is specifically designed to improve engagement and drive outcomes.

The discussion in section 4 highlights that the application of principles creates another mechanism to improve the learning and evolution of the MER framework.

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Appendix 1: Examples of Changes in System-Wide Capacities

This section outlines different approaches to defining resilience as changes in system-wide capacities.

The UN Climate Resilience Initiative:

The UN Environment Agency established a framework to assess the resilience of 114 countries most vulnerable to climate change from the least developed countries, small island nations and African countries. They used the Anticipate, Absorb, Reshape (A2R) framework as a means to classify resilience across the diverse group of nations (Väänänen, Dale, & Dickson, 2017). It consists of the following components:

> **Anticipate** centres on accelerating action towards the establishment and strengthening of early warning action systems for addressing climate risk. Early warning systems refer to methods designed to provide alerts about impending hazardous events. Early action systems encompass a broad range of actions designed to reduce vulnerability through risk reduction before a hazard occurs.
>
> **Absorb** centres on the capacity to absorb shocks by increasing access to climate risk insurance and social protection systems. This is measured in the ability to both access insurance, and gain access to financial mechanisms to fund recovery, such as grant schemes and micro loans.
>
> **Reshape** centres on the capacity to reshape development pathways by transforming economies to reduce risks and root causes of vulnerabilities, and to support the sound management of physical infrastructure and ecosystems. Understood to be a process, the creation of a climate-resilient pathway often includes reforming institutions to better manage change within complex socio-economic and environmental systems. These changes may be incremental or transformational, and should align with broader efforts to integrate sustainable development into national priorities. This is recognised as a major long-term effort requiring a sustained focus and investment.

The BRACED Framework

This defines three areas of focus for monitoring and evaluation; Adaptive, Anticipative and Absorptive Capacities (Aditya, et al., 2015). The Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) program is funded by UK Aid. It comprises 15 field-based resilience building projects across 13 countries in the Sahel, East Africa and South-East Asia. The focus areas for monitoring are:

> **Adaptive Capacity** - Adaptive capacity is the ability of social systems to adapt to multiple, long-term and future climate change risks, and also to learn and adjust after a disaster. It is the capacity to take deliberate and planned decisions to achieve a desired state, even when conditions have changed or are about to change. Adaptive capacity is usually made apparent and strengthened during non-emergency periods, for example in accessing and using a mix of historical data and downscaled climate projections to understand changing rainfall patterns to inform the design of drainage systems.

Adaptive capacity is enhanced by learning from disturbances (including by looking at historical patterns). Communities with such capacity are able to recover in ways that reduce their vulnerability to the same shocks should they occur again, as well as to new and emerging risks.

> Example indicators included seasonal income stability, total annual income, overall increase or decrease. Other indicators have been used to look at the underlying drivers of income, such as agricultural production systems and market access.

Anticipatory Capacity: Anticipatory capacity is the ability of social systems to anticipate and reduce the impact of climate variability and extremes through preparedness and planning. Anticipatory capacity is seen in proactive action before a foreseen event to avoid upheaval, either by avoiding or reducing exposure or by minimising vulnerability to specific hazards (Kellett & Peters, 2014). Anticipatory capacity is displayed when communities are able to forecast particular shocks, for example through the use of drought and cyclone early warning systems or geospatial information. An additional component of anticipatory capacity is the ability of communities to undertake vital planning and preparedness activities to manage disaster risk.

> Example indicators include the extent of disaster planning, risk mapping, strengthening coordination networks, government agency involvement and enhancing communication with vulnerable communities.

Absorptive Capacity: The ability of social systems to absorb and cope with the impacts of climate variability and extremes is known as 'absorptive capacity'. In conceptual terms, it is concerned principally with 'functional persistence' – that is, the ability of a system to buffer, bear and endure the impacts of climate extremes in the short term and to avoid collapse (death, debilitation and destruction of livelihoods). In practical terms, this is most visible in the form of coping with the impacts of a disaster. Experience has shown the importance of accessing financial resources in the immediate aftermath of a disaster, as communities and states attempt to rebuild and maintain essential functions. This can include substituting and drawing on diverse assets and resources, and can happen at a variety of scales: from individuals accessing finance via personal connections and remittances, through to a government protecting its budgets through sovereign risk insurance.

> Example indicators include the level of savings, wealth and exchangeable assets to which communities have access. This can include the amount of readily available government funding and insurance that is available.

GIZ

The final approach, used by German agency Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, outlines that a future socio-ecological system will be resilient if it can build capacity to respond to climate shocks and stressors in three areas, as shown in

Figure 1 (GIZ, 2014). GIZ are a German international development agency, with a particular focus on developing countries. They are a public benefit federal enterprise with a commitment to ensuring their funded activities meet strict ethical guidelines and effective outcomes. MER is important for accountability.

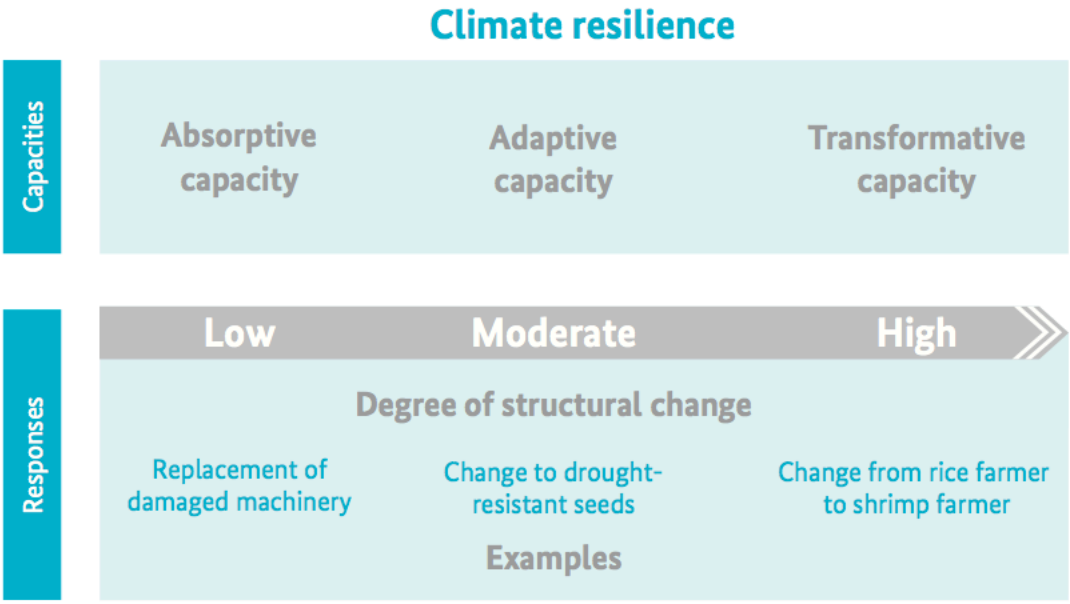


Figure 1: GIZ Climate Resilience Framework

Absorptive capacity: Ability of a system to prepare for, mitigate or recover from the impacts of negative events using predetermined coping responses to preserve and restore essential basic structures and functions (e.g. human life, housing, productive assets).

> Examples: Early warning systems, savings, weather insurance schemes, trained disaster risk reduction teams, dyke systems in flood-prone areas (climate hazard-specific).

Adaptive capacity: Ability of a system to adjust, modify or change its characteristics and actions to better respond to existing and anticipated future climatic shocks and stresses and to take advantage of opportunities.

> Examples: Adjusted planting behaviour, climate change-related information and education events, improved natural resource management, diversification of early warning systems to reach a broader network of actors.

Transformative capacity: Ability of a system to fundamentally change its characteristics and actions when the existing conditions become untenable in the face of climatic shocks and stresses.

> Examples: Livelihood transformation (e.g. from rice farmer to shrimp farmer), migration from rural to urban areas, change from fossil energy system to renewable energies.

APPENDIX 2: EXAMPLES OF CHARACTERISTICS OF RESILIENT SYSTEM

GIZ

The approach proposed by German agency Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, outlines that a future socio-ecological system will be resilient if it can enhance these characteristics, as shown in Figure 1 (GIZ, 2014). The articulation of underpinning capabilities has emerged in 2013[2]. These are listed below and shown in Figure 3:

Satisfied basic needs: The population's basic needs such as shelter, sanitation, food, clean water or health care are satisfied.
High level of diversity: Different and partly inter-related forms of diversity exist within the socio-ecological system such as biological and ecosystem diversity, livelihood diversity and a diverse natural resource base.
Effective governance and institutions: Decentralised, flexible and inclusive organisational structures and policies are in place, which take into account the needs of the whole population, including all minority groups.
Equitably distributed financial assets: Financial assets as prerequisites for several strategies to deal with adverse shocks and stresses are available and equitably distributed within the SES.
Strong and inclusive social capital: A high amount of social capital based on mutual trust, norms and social networks exists, which facilitates strong cohesion and cooperation, emergency-support and consensus-building among all actors in the SES.
Continuous social learning: Both individuals and organisations adopt a forward-looking perspective and engage in a continuous process of social learning to be able to anticipate future challenges and act accordingly.
Preparedness for risk, uncertainty and change: The population accepts risk, uncertainty and change as regular elements of their daily lives, acknowledges the need for flexibility in this context, and actively plans for them instead of trying to return to a 'normal' situation.
Participation and access to relevant knowledge: The actions within the SES to deal with shocks and stresses exhibit a high degree of participation and ownership and are based on both traditional and scientific knowledge, which is made widely available to the public.

[2] In by Bahadur et al (2013) titled Characterising Resilience: Unpacking the Concept for Tackling Climate Change and Development and were adapted to fit into the GIZ framework (reported in (GIZ, 2014))

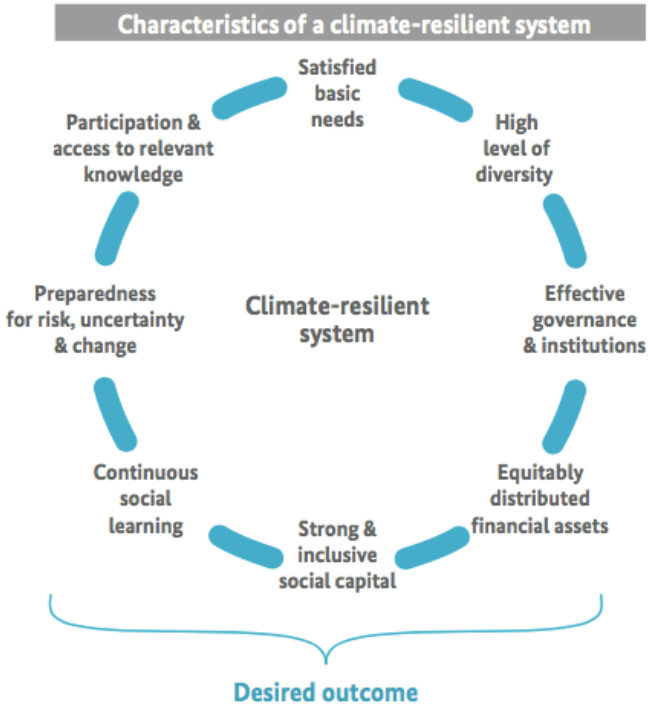


Figure 3: Characteristics of a climate-resilient system proposed by GIZ

Rockefeller City Resilience Framework

Other frameworks have used a similar approach. The Rockefeller City Resilience Framework is based on four dimensions of resilience (health and well-being, economy and society, leadership and strategy, infrastructure and environment), which are then sub-divided into 12 'drivers' of resilience (3 per dimension). These include, for example, the need for leadership promotion and effective management within a city, and assurance of public health services, among others. The Rockefeller Foundation also presents seven 'qualities' of resilient cities: (Arup, 2015)

- ability to learn ('Reflective')
- limit spread of failure ('Robust')
- can easily repurpose resources ('Resourceful')
- has alternative strategies ('Flexible')
- has backup capacity ('Redundant')
- includes broad consultation and communication ('Inclusive')
- has systems working together ('Integrated').

Figure 4 illustrates how these qualities are reflected in the MER process. Each quality is represented by a sequence of indicators across all of the dimensions (represented by grey bars). It provides an example of how the qualities are linked directly to the indicators.

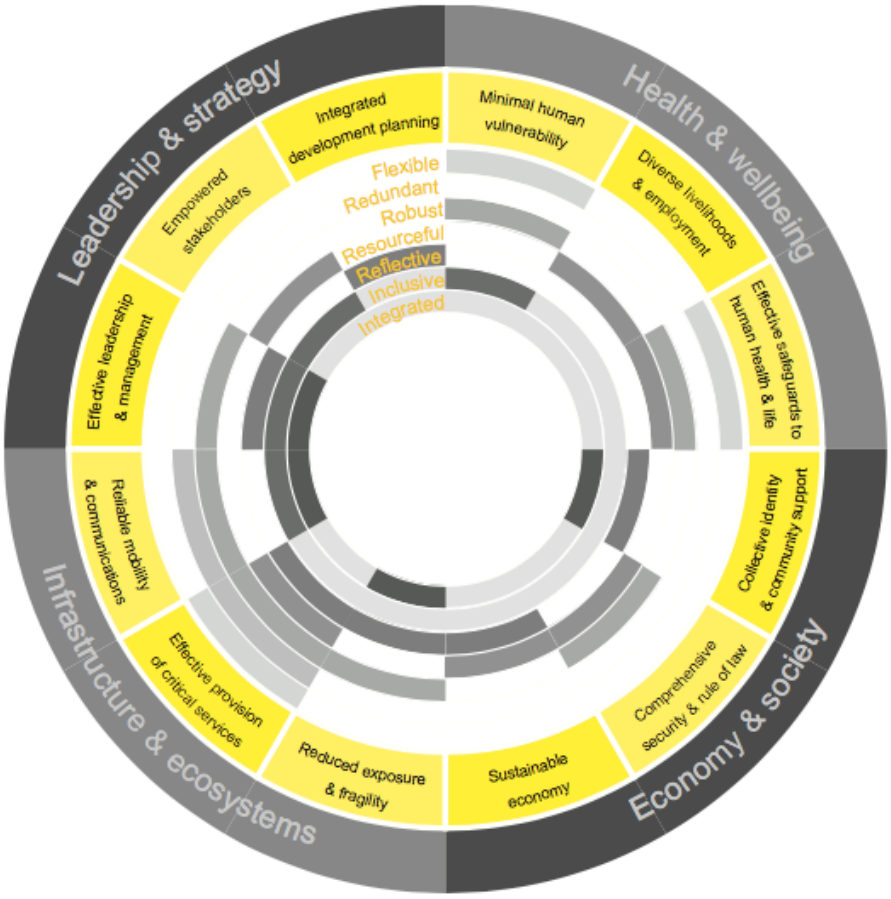


Figure 4: 100 Resilient Cities Framework

The Cities Resilient Framework defines these inherent characteristics as:

Reflective
Reflective systems are accepting of the inherent and ever-increasing uncertainty and change in today's world. They have mechanisms to continuously evolve, and will modify standards or norms based on emerging evidence, rather than seeking permanent solutions based on the status quo. As a result, people and institutions examine and systematically learn from their past experiences, and leverage this learning to inform future decision-making.

Robust
Robust systems include well-conceived, constructed and managed physical assets, so that they can withstand the impacts of hazard events without significant damage or loss of function. Robust design anticipates potential failures in systems, making provision to ensure failure is predictable, safe, and not disproportionate to the cause. Over-reliance on a single asset, cascading failure and design thresholds that might lead to catastrophic collapse if exceeded, are actively avoided.

Redundant
Redundancy refers to spare capacity purposely created within systems so that they can accommodate disruption, extreme pressures or surges in demand. It includes diversity: the presence of multiple ways to achieve a given need or fulfil a particular function. Examples include distributed infrastructure networks and resource reserves. Redundancies should be

intentional, cost-effective and prioritised at a city-wide scale, and should not be an externality of inefficient design.

Flexible
Flexibility implies that systems can change, evolve and adapt in response to changing circumstances. This may favour decentralised and modular approaches to infrastructure or ecosystem management. Flexibility can be achieved through the introduction of new knowledge and technologies, as needed. It also means considering and incorporating indigenous or traditional knowledge and practices in new ways.

Resourceful
Resourcefulness implies that people and institutions are able to rapidly find different ways to achieve their goals or meet their needs during a shock or when under stress. This may include investing in capacity to anticipate future conditions, set priorities, and respond, for example, by mobilising and coordinating wider human, financial and physical resources.

Resourcefulness
This is instrumental to a city's ability to restore functionality of critical systems, potentially under severely constrained conditions.

Inclusive
Inclusion emphasises the need for broad consultation and engagement of communities, including the most vulnerable groups. Addressing the shocks or stresses faced by one sector, location, or community in isolation of others is an anathema to the notion of resilience. An inclusive approach contributes to a sense of shared ownership or a joint vision to build city resilience.

Integrated
Integration and alignment between city systems promotes consistency in decision-making, and ensures that all investments are mutually supportive to a common outcome. Integration is evident within and between resilient systems, and across different scales of their operation. Exchange of information between systems enables them to function collectively and to respond rapidly through shorter feedback loops throughout the city.

Stockholm Resilience Centre

The Stockholm Resilience Centre (www.stockholmresilience.org) has identified five key principles.

1. **Diversity and redundancy**
   Systems with many different parts (e.g. many species, diverse sources of knowledge and skills, diverse economies) tend to be more resilient than simple systems. Redundancy (having spare capacity, e.g. having a back-up generator in the power supply system), provides insurance against a loss of function if part of the system fails. Redundancy is even more valuable if the parts providing this capacity react differently to change and shocks, so they are not subject to the same stressors that caused the initial failure.

2. **Connectivity**

   Well-connected systems can overcome and recover from disturbances more quickly. For example, if a community has good connections with the communities around it, skills and resources can more easily be brought in if needed. However, high levels of connectivity can also increase risks. For example, infectious diseases can spread more rapidly in highly connected communities. These risks can be managed if recognised. For example, monitoring a network of disease transition helps limit spread through the system.

3. **Complex adaptive systems thinking**

   The reality of the world is that it is built up of a web of complex interactions operating over different time-frames and spatial scales. Having some understanding of how the different parts of our communities and environments interact, where their limits might lie, what things enable action and what things inhibit action, is an important step towards developing effective responses to complex challenges. Because the world is complex and dynamic and undergoing increasing rates of change, we need to be adaptive in how we respond to challenges to ensure new information is considered, and to be able to change our approach or direction if needed.

4. **Learning and innovation**

   Adaptive management and adaptive governance all have learning as a core focus. Learning involves not just collecting new information, but also being prepared to try new things and to learn from the failures and successes (learning by doing). Different types and sources of knowledge need to be valued and considered when developing solutions.

5. **Broad participation**

   Broad and well-functioning participation can build trust, create shared understanding and uncover perspectives that may not be gained through conventional processes. Having a diverse range of people engaged in an issue helps to build legitimacy and increase the depth and diversity of knowledge.

APPENDIX 3: OVERARCHING PRINCIPLES FOR MER

Adapted from (Williams, 2016).

A set of overarching climate and disaster MER guiding principles, to inform and shape the approach to MER including frameworks, indicators, and evaluation approaches. Overarching guiding principles help to shape MER strategy, decision-making, learning, reporting, and unintended consequences.

Principle 1. Accountability and learning are both priorities for climate and disaster resilience MER; however, the natural tensions and trade-offs between these are recognised and should be considered

MER systems historically have leaned toward supporting accountability—to identify results, to report to funders, and to communicate to core stakeholders. Whether programs and projects have met their targets and achieved their results, whether money has been efficiently spent, and whether there were any unintended consequences (positive or negative) are the types of accountability often supported by MER. With an accountability focus, MER is often viewed as an audit function, particularly when funding is contingent upon demonstrating results and value for money.

MER for learning purposes can also support accountability, but truly embracing learning involves recognising the learning-by-doing and experimental nature of complex interventions (including, by default, essentially all resilience interventions). To embrace ongoing learning requires support for program adaptation, including, for example, adapting implementation strategies early and often, testing promising innovations which may have a high chance of failing, and experimenting with high-risk, high-return strategies.

Among other things, a learning approach will thus involve permission to fail—or more specifically to plan for "intelligent failures" which promote organisational learning.

In the context of resilience, a more flexible approach to learning-by-doing—including trial and error and expecting failure along the way—may very well support long-term success more effectively than a traditional accountability approach. In this way, accountability to learning is perhaps a useful construct; however, achieving this means letting go of certain expectations that have traditionally accompanied MER, such as adhering to plans or taking low-risk strategies with a guaranteed "return".

A learning approach will also lead to more real-time approaches to MER than have historically been undertaken by the international development community. The traditional mid-term reviews and ex-post/terminal evaluations have often missed valuable opportunities for learning and continuous improvement—in the time-frames that would be most useful for program/project improvement success. Therefore, alternative approaches including developmental and formative evaluation, and other approaches to continuous improvement that may not be considered "evaluation" (such as rapid-stakeholder feedback techniques), are not automatically built into project implementation.

A learning approach may also involve adjusting program design, including the results framework and indicators, more often than is common for institutions that prefer to monitor progress toward specific goals over the course of a few years or more.

These are the kinds of tensions and trade-offs inherent in designing for both accountability and learning.

Principle 2. User-focused and participatory
Given that resilience is particularly unique to each intervention and stakeholder population, it is particularly important for the MER of resilience to be designed for specific users, whether these be funders, implementing entities, beneficiaries, or other stakeholders. Participation of MER users should be built into the MER process to make use of local and national knowledge, and ensure a design suited to each user's needs and intended uses (e.g., to guide funding decisions, to understand whether an innovative investment is working as expected, or to know understand the sustainability of an intervention from the perspective of beneficiaries or implementing entities). Open data / data sharing and feedback loops with key users and stakeholders will improve participation and the utility of MER findings.

Principle 3. Consider existing systems and requirements
Climate and disaster resilience MER systems should consider alignment with existing MER frameworks and systems to keep the data collection burden to a minimum and enable macro-level analysis, while also acknowledging and planning for unique contexts. At the same time, existing MER systems may have room for improvement—and as such should not necessarily be automatically adopted simply because they are in use elsewhere.

Principle 4. Consider and invest in local capacity, balancing building capacity with realistic expectations
Climate and disaster resilience MER should consider data availability, local technical capacity, and resources available for data collection, reporting, and analysis. Building local capacity through, for example, offering training, utilising local experts, providing funding for data collection, and encouraging stakeholder participation, will likely help, though may require a significant investment. Therefore, thought should be put into balancing a more "light touch" approach that is less burdensome and considers common capacity constraints versus investing in more ambitious and resource-intensive systems. Without considering these trade-offs, the cost-to-value ratio may not be compelling.

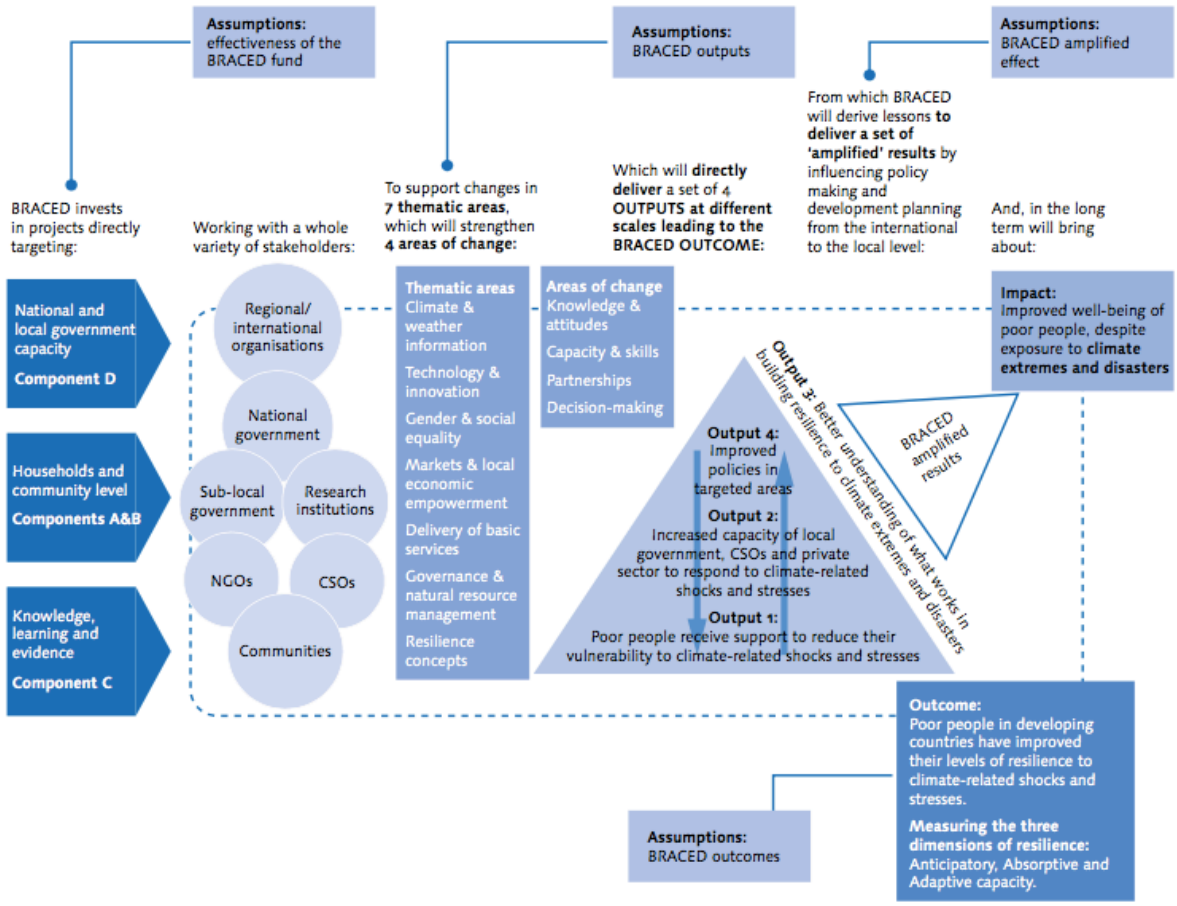
Principle 5. Encourage innovation
Given the unprecedented nature of climate and disaster resilience, and the corresponding need for creative, iterative MER approaches that support ongoing learning, climate and disaster resilience, MER systems should be intentionally focused on innovation, creativity, and experimentation beyond traditional methods. These could involve pilot testing new qualitative and/or quantitative approaches, experimenting with scalability and transferability, and considering creative options suited for systems-level analysis.

Principle 6. Factor in the inherently multi-dimensional and complex nature of resilience
MER of climate and disaster resilience should consider up front the complexity and multiple dimensions of resilience, including:

- Climate and non-climate stressors;
- Multiple climate and disaster hazards;
- Vertical dimensions (e.g., different layers of society in a system and where resilience sits at the local, regional, and national levels, including governance aspects);
- Horizontal dimensions (e.g., multi-dimensional stakeholder and sectoral linkages);
- Time scales, given that resilience-related problems can take a long time to manifest (as can the solutions to these), and thus resilience-building (and related planning and MER systems) needs to have short, medium, and long-term components; and
- Uncertainty: Approaches that are robust to a variety of uncertain future scenarios.

Principle 7. Flexibility and improvement over time are expected
Climate and disaster resilience MER is largely a learning-by-doing endeavour. Experience over time will inform what works and does not work well, and periodic updates to all major components of the MER system should be expected. This could occur, for instance, through an annual or semi-annual review followed by a decision on whether to make formal updates.

APPENDIX 4: BRACED THEORY OF CHANGE



From: (Villanueva & Gould, 2016)