This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

LIQUEFACT

Assessment and mitigation of liquefaction potential across Europe: a holistic approach to protect structures/infrastructure for improved resilience to earthquake-induced liquefaction disasters.

H2020-DRA-2015

GA no. 700748

DELIVERABLE 5.2

Data Collection Toolkit for Community Resilience Case Studies (for WP6/7)

Author(s):	Keith Jones
Responsible Partner:	Anglia Ruskin University (ARU)
Version:	1.0
Date:	19/05/2017
Distribution Level (CO, PU)	PU

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

DOCUMENT REVISION HISTORY

Date	Version	Editor	Comments	Status
10/05/2017	01	Keith Jones		First draft
19/05/2017	01-1	Esther Norton		Submitted

LIST OF PARTNERS

Participant	Name	Country
ARU (Coordinator)	Anglia Ruskin University Higher Education Corporation	United Kingdom
UNIPV	Universita degli Studi di Pavia	Italy
UPORTO	Universidade do Porto	Portugal
UNINA	Universita degli Studi di Napoli Federico II.	Italy
TREVI	Trevi Societa per Azioni	Italy
NORSAR	Stiftelsen Norsar	Norway
ULJ	Univerza v Ljubljani	Slovenia
UNICAS	Universita degli Studi di Cassino e del Lazio Meridionale	Italy
SLP	SLP Specializirano Podjetje za Temeljenje Objektov, D.O.O, Ljubljana	Slovenia
ISMGEO	Istituto Sperimentale Modelli Geotecnici	Italy
Istan-Uni	Istanbul Universitesi	Turkey

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

GLOSSARY

Acronym	Description
EILD	Earthquake Induced Liquefaction Disaster
RAIF	Resilience Assessment and Improvement Framework
FCM	Fuzzy Cognitive Map
CI	Critical Infrastructure
UNISDR	United Nations Strategy for Disaster Risk Reduction
AHP	Analytic Hierarchy Process
ANP	Analytic Network Process

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

CONTENTS

Document Revision History..... 2

List of Partners..... 2

Glossary..... 3

List of Figures..... 5

List of Tables..... 5

Executive Summary..... 6

Introduction, Goal and Purpose of this doocument..... 6

Scope of this document..... 7

Target Audience..... 7

DATA COLLECTION TOOLKIT FOR COMMUNITY RESILIENCE CASE STUDIES (FOR WP6/7)

1. Introduction..... 9

2. Background and Brief Review of Liquefact Deliverable D5.1..... 10
- 2.1 The Resilience Assessment and Improvement Framework..... 10
- 2.2 The UNISDR Disaster Resilience Scorecard for Cities..... 14
- 2.3 Measuring the Resilience of Critical Infrastructure..... 19

3. Research Methodology and Data Collection Tools..... 21
- 3.1 Develop and Validate the Most Severe and Most Probable EILD Scenarios..... 21
- 3.2 Community Resilience Toolkit..... 23
- 3.3 Critical Infrastructure Resilience Toolkit..... 52

4. Summary and Next Steps..... 70

5. **References**..... 72

Appendix A: UNISDR Disaster Resilience Scorecard for Cities..... 73

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

LIST OF FIGURES

Figure 1: The Resilience Assessment and Improvement Framework (RAIF)

Figure 2: Cutter's DROP Model mapped to the RAIF

Figure 3: Research Plan for developing and validating resilience tools for the RAIF

Figure 4: Indicative Data Collection tool for Community Resilience. Refer to UNISDR Disaster Scorecard for Cities in Appendix A for further information of any items. (Source: Derived from the UNISDR Disaster Scorecard for Cities, 2015)

Figure 5: Critical Infrastructure Resilience Framework

Figure 6: Hypothetical example of a typical indicator

Figure 7: Indicative data collection tool for assessing CI resilience to an EILD event.

LIST OF TABLES

Table 1: Summary of the subject/issues addressed in the UNISDR Disaster Resilience Scorecard for Cities (Source: UNISDR, 2015)

Table2: Factors and sub-factors affecting CI Resilience

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

EXECUTIVE SUMMARY

Recent events have demonstrated that Earthquake Induced Liquefaction Disasters (EILDs) are responsible for significant structural damage and human casualties with, in some cases, EILDs accounting for half of the economic loss caused by earthquakes. With the causes of liquefaction being largely acknowledged, it is important to recognise the factors that contribute to its occurrence; to estimate the impacts of EILD hazards; and to identify and implement the most appropriate mitigation strategies that improve both building/critical infrastructure and community resilience to an EILD event. The LIQUEFACT project adopts a holistic approach to address the mitigation of risks to EILD events. The LIQUEFACT project sets out to:

- achieve a more comprehensive understanding of the impacts that EILD events have on the resilience of communities and buildings/critical infrastructure on which they rely;
- achieve a more comprehensive understanding of the range of mitigation techniques (technical, operational, managerial and organizational) that can be implemented to improve the resilience of communities and building/critical infrastructure to EILD events;
- develop more appropriate mitigation techniques (technical, operational, organizational and managerial), for both European and worldwide situations; and
- develop a Resilience Assessment and Improvement Framework (RAIF) to allow community and building/critical infrastructure stakeholders to make the business case for mitigation interventions.

This report outlines the research methodology and initial data collection tools that will be used to assess the resilience of a community and critical infrastructure system to EILD events. The full data collection tools will be developed later in LIQUEFACT Work Package 5 and Work Package 7.

INTRODUCTION, GOAL AND PURPOSE OF THIS DOCUMENT

This report presents the research methodology that will be used to assess the resilience to earthquake induced liquefaction disaster (EILD) events of the Emilia Romagna Region of Italy. The report briefly reviews the theoretical background to the Resilience Assessment and Improvement Framework (RAIF) being developed in LIQUEFACT Work Package 5; the UNISDR Disaster Resilience Scorecard for Cities; and the critical infrastructure (CI) resilience toolkits being developed by other EU funded projects and explains how these have informed the research approach that LIQUEFACT will use to develop its EILD Resilience Toolkits. The toolkits will be tested and refined during LIQUEFACT Work Package 7 (Case Study of Emilia Romagna Region, Italy) with the final versions being integrated into the SELENA-LRG software package in LIQUEFACT Work Package 6. The report builds on previous resilience literature reviewed in LIQUEFACT Deliverable D1.1; the disaster risk reduction frameworks reviewed in LIQUEFACT Deliverable D1.3; the RAIF outlined in LIQUEFACT Deliverable D1.4; and the report on individual stakeholder and urban community performance metrics presented in LIQUEFACT Deliverable D5.1. The report presents the first iteration of the data collection tools for assessing community and CI resilience that will be used in LIQUEFACT Work Package 7 along with the detailed

research plan for reviewing and refining the tools through successive iterations with local stakeholders during the case study period. As such this report should be considered a work in progress which will be reviewed and modified throughout the duration of the LIQUEFACT project to reflect emerging issues identified in the case study by the research team, project partners, external stakeholders and advisors. This report should be read in conjunction with LIQUEFACT Deliverable D5.1.

Goal: The primary aim of this report is to provide the LIQUEFACT project partners and researchers with the research plan that will be used to develop the community and critical infrastructure resilience tools that will be developed in Work Package 7 and integrated into the SELENA-LRG software (Work Package 6). The report also provides the first iteration of the data collection schedule that will support the tools.

SCOPE OF THIS DOCUMENT

The contents of this report should be considered a work in progress which will be amended and modified throughout the duration of the LIQUEFACT project, to reflect emerging issues identified by project partners; location specific characteristics of the case study sites; issues identified by the external stakeholders; and advice received from the expert advisory groups.

TARGET AUDIENCE

Although the report is publically available it is principally an internal working document intended for the LIQUEFACT project partners and researchers.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Data Collection Toolkit for Community Resilience Case Studies (for WP6/7)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

1 INTRODUCTION

1.1 This report presents the research methodology that will be used to assess the resilience to earthquake induced liquefaction disaster (EILD) events of the Emilia Romagna Region of Italy. The report briefly reviews the theoretical background to the Resilience Assessment and Improvement Framework (RAIF) being developed in LIQUEFACT Work Package 5; the UNISDR Disaster Resilience Scorecard for Cities; and the critical infrastructure (CI) resilience toolkits being developed by other EU funded projects and explains how these have informed the research approach that LIQUEFACT will use to develop its EILD Resilience Toolkits. The toolkits will be tested and refined during LIQUEFACT Work Package 7 (Case Study of Emilia Romagna Region, Italy) with the final versions being integrated into the SELENA-LRG software package in LIQUEFACT Work Package 6. The report builds on previous resilience literature reviewed in LIQUEFACT Deliverable D1.1; the disaster risk reduction frameworks reviewed in LIQUEFACT Deliverable D1.3; the RAIF outlined in LIQUEFACT Deliverable D1.4; and the report on individual stakeholder and urban community performance metrics presented in LIQUEFACT Deliverable D5.1. The report presents the first iteration of the data collection tools for assessing community and CI resilience that will be used in LIQUEFACT Work Package 7 along with the detailed research plan for reviewing and refining the tools through successive iterations with local stakeholders during the case study period. As such this report should be considered a work in progress which will be reviewed and modified throughout the duration of the LIQUEFACT project to reflect emerging issues identified in the case study by the research team, project partners, external stakeholders and advisors. This report should be read in conjunction with LIQUEFACT Deliverable D5.1.

1.2 The primary aim of this report is to provide the LIQUEFACT project partners and researchers with the research plan that will be used to develop the community and CI tools that will be developed in LIQUEFACT Work Package 7 and integrated into the SELENA-LRG software in LIQUEFACT Work Package 6.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

2.0 BACKGROUND AND BRIEF REVIEW OF LIQUEFACT DELIVERABLE D5.1

This section provides a brief overview of the RAIF; the UNISDR Disaster Resilience Scorecard for Cities (UNISDR, 2015); and the principles underpinning some of the CI resilience toolkits being developed by other EU funded projects. Further details of the above can be found in LIQUEFACT Deliverable D5.1.

2.1 The Resilience Assessment and Improvement Framework

2.1.1 The RAIF (Figure 1) is a decision support tool that can be used by built assets owners and/or managers to assess the antecedent vulnerability, resilience and adaptive capacity of their built assets (buildings and Infrastructure) to disaster events; particularly EILD events. The RAIF can also be used to identify and evaluate alternative mitigation interventions to reduce vulnerability and/or improve resilience at the built asset and community level. The RAIF is an enhancement of the risk/resilience framework developed by Jones et al (CREW, 2012) to extreme weather events. In particular the risk/resilience framework has been enhanced and refined to reflect the latest disaster risk reduction guidance provided through the Sendai Framework for Disaster Risk Reduction (UN General Assembly, 2015) and best practice extracted from other disaster risk reduction frameworks (LIQUEFACT Deliverable D5.1). By extension the framework can also be used by EU, national, regional and local decision makers to assess vulnerability, resilience and adaptive capacity of urban communities to EILD events.

2.1.2 The underlying theory underpinning the RAIF is based on Cutter's (Cutter et al, 2008) Disaster Resilience of Place (DROP) model in which antecedent conditions, including coping response and absorptive capacity, are assumed to directly affect speed of recovery and system resilience. The LIQUEFACT project has integrated Cutter's DROP model with the performance based built asset management model (Sharp and Jones, 2007) to produce a six stage toolkit that can assess antecedent conditions and evaluate the potential of mitigation options to improve building/CI and community resilience to a range of disaster scenarios (Figure 2). The six stages in the RAIF are:

1. Assess the level of risk of a building/CI asset to an EILD event.
2. Identify the potential impact that an EILD event would have on the ability of the building/CI asset to deliver its core service (i.e. at different service performance levels).
3. Assess the impact that an individual building/CI asset would have on the service performance level of the overall system and assess whether any loss of performance is acceptable from a community resilience perspective. If the loss of performance is acceptable then no more action is taken.
4. If the loss of performance is unacceptable then investigate a range of mitigation interventions that can either lower vulnerability, improve resilience, or both.
5. Assess the cost/benefit of each mitigation intervention and undertake an options appraisal to select and prioritise the most appropriate mitigation interventions.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

6. Develop a built asset management plan to programme mitigation works into the built asset life cycle.

Full details of the RAIF can be found in LIQUEFACT Deliverables D 1.3, D1.4 and D5.1.

2.1.3 In order to support the RAIF, a number of tools are being developed in the LIQUEFACT project (susceptibility models, risk models, vulnerability models and resilience models). Figure 2 shows these tools mapped against Cutter's DROP model (ibid). Of particular relevance to this report are the community and CI resilience tools that are being developed to assess the potential of a range of mitigation interventions to improve resilience to EILD events. The community resilience tool seeks to assess the antecedent (baseline) and post-mitigation community resilience to an EILD event. The CI tool seeks to assess the resilience of CI system(s) to the EILD event. The background to the tools is presented in LIQUEFACT Deliverable D5.1 and briefly summarised in the next two sections of this report.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

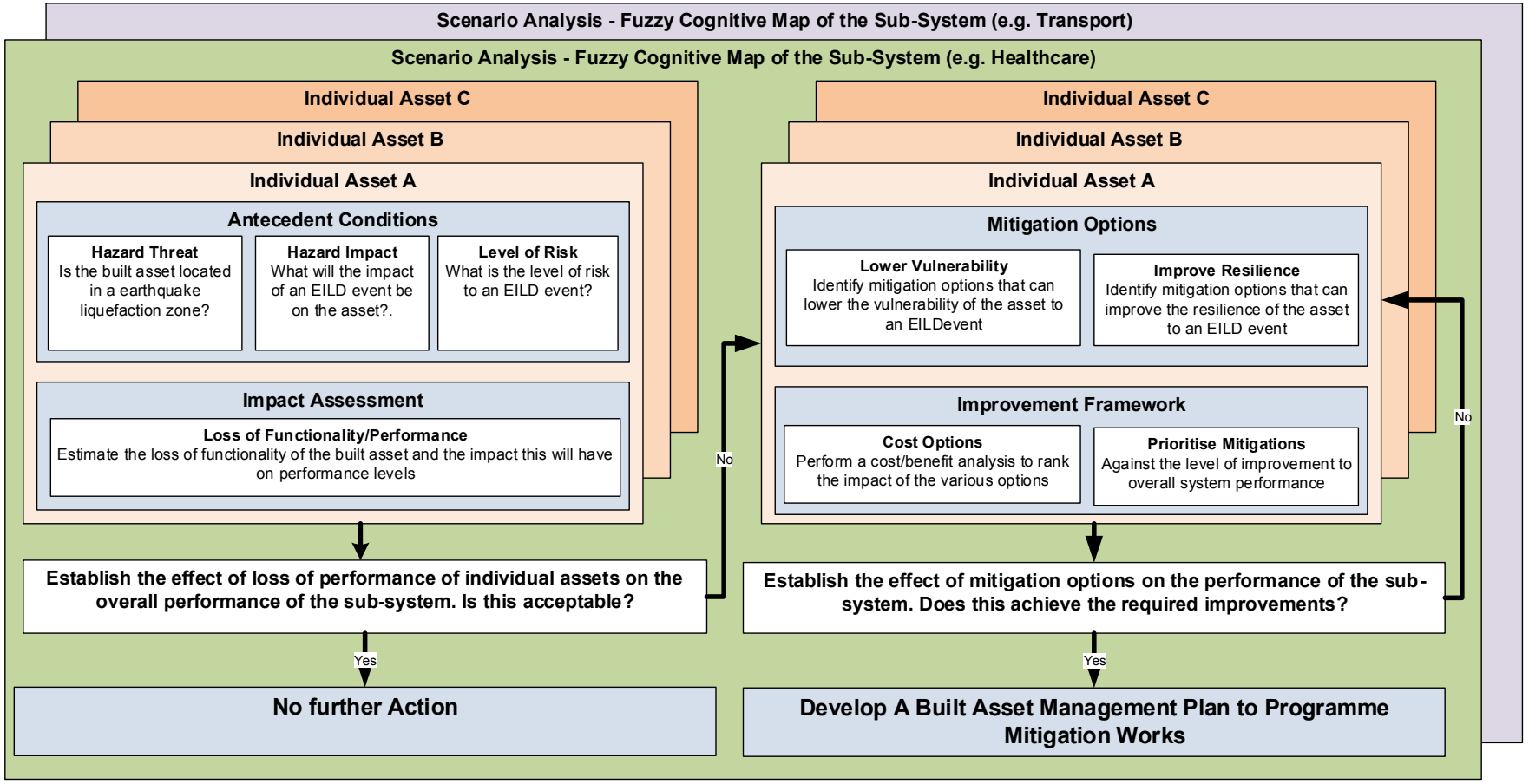


Figure 1: The Resilience Assessment and Improvement Framework (RAIF)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

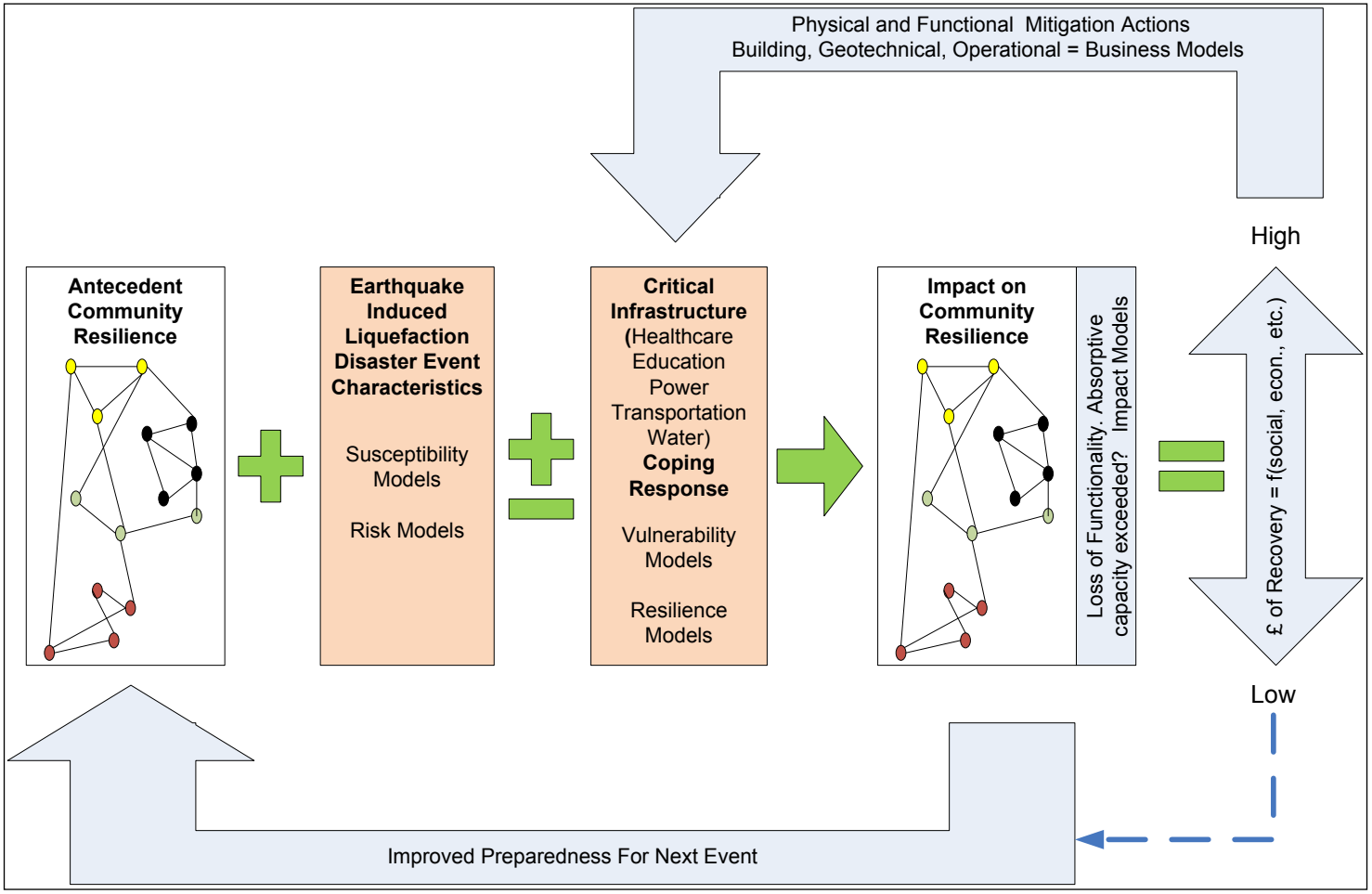


Figure 2: Cutter's DROP Model mapped to the RAIF

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

2.2 The UNISDR Disaster Resilience Scorecard for Cities

2.2.1 The latest international guidance on improving community resilience to disaster events is contained in the Sendai Framework for Disaster Risk Reduction 2015-2030[1] (UN General Assembly, 2015). The Sendai Framework is a 15-year non-binding agreement that was adopted at the Third United Nations World Conference on Disaster Risk Reduction, held from 14 to 18 March 2015 in Sendai, Miyagi, Japan. The stated intention of the Sendai Framework is to support a *''… substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries.''.* To this end the Sendai Framework encourages countries to adopt a concise, focused, forward-looking and action-oriented approach to disaster risk reduction that considers a wide spectrum of small to large scale, frequent and infrequent, sudden and slow onset disasters caused by natural and man-made hazards. The Sendai Framework is based on (but not limited to) the following guiding principles:

- Disaster risk reduction is a shared responsibility between government, authorities, sectors and stakeholders. It requires all-of-society engagement;
- When managing disaster risk, consideration should be given to protecting people, their health, property and livelihoods, as well as productive, cultural and environmental assets;
- Disaster risk reduction depends on coordination mechanisms within and across sectors and with relevant stakeholders, and requires empowerment of local communities;
- Disaster risk reduction requires multi-hazard and risk–informed decision making based on scientific information complemented with local knowledge that contextualises the information to local circumstances;
- Disaster risk reduction is more cost-effective than post disaster response and recovery and a "build-back-better" philosophy reinforces future risk reduction.

2.2.2 When developing implementation plans the Sendai Framework (ibid) suggests that national states should focus on four priority areas for action.

- **PRIORITY 1: Understand the disaster risk**

  A holistic understanding of disaster risk in all its dimensions is essential to support effective risk management. Using relevant and reliable data (nationally and locally) will provide base-line information on vulnerability, adaptive capacity, exposure and hazard characterisation which will allow primary and secondary impact scenarios to be modelled and the effectiveness of coping strategies to be evaluated. The scenarios can also provide a mechanism to communicate the disaster risks to central planners and the wider community.

- **PRIORITY 2: Strengthen disaster governance to manage risk**

[1] See http://www.unisdr.org/we/coordinate/Sendai-framework for full details.

Develop clear vision, plans, guidance, command, control, and coordination activities within and across sectors that engage all the stakeholders in disaster risk management. In developing the systems, consideration should be given to publicly and privately owned CI as well as to households, communities and businesses. Whilst systems can be designed centrally they should be enabled locally with local authorities empowered to act at the local level.

- **PRIORITY 3: Invest in disaster risk reduction to improve resilience**

  Public and private investment in disaster risk reduction is essential to enhance economic, social, health and cultural resilience of people, communities, countries and their assets. Effective mechanisms should exist to promote disaster risk transfer (e.g. insurance, risk sharing and retention, financial protection etc.) for both public and private assets and in particular CI assets including appropriate design standards; building materials; and maintenance and refurbishment strategies. With regards to business resilience, effective understanding of the integration of disaster risk management into business models, including the supply chain, is critical if livelihoods are to be protected.

- **PRIORITY 4: Enhance disaster preparedness and build-back-better**

  Pre-planning is essential for an effective recovery, rehabilitation and reconstruction following a disaster event. This phase also offers an ideal opportunity to build-back-better by integrating disaster risk reduction into development and reconstruction projects. To prepare for disaster events requires contingency plans and programmes to be developed and tested routinely across the community. These plans need to consider forecasting and early warning systems as well as communication systems and channels. Policies to improve the resilience of existing CI should be developed and implemented as part of routine refurbishment. Logistics required immediately after a disaster event should be stockpiled and a distribution system established for their release immediately following a disaster event.

2.2.3 To support the implementation of the Sendai Framework the UNISDR commissioned the development of a Disaster Resilience Scorecard for Cities (UNISDR, 2015). The Scorecard seeks to provide a better understanding of: the disaster risks a city might face; how to mitigate the risks; and how to respond to disasters in a way that seeks to minimise loss of life, livelihoods, property, infrastructure, economic activity, and the environment. The Scorecard is based on assessing the impact that a disaster event would have on 'Ten Essentials' for making cities resilient. The 'Essentials' are grouped into three sections addressing governance and financial issues; planning and disaster preparation; and disaster response and post-disaster recovery. In all there are 95 disaster resilience evaluation criteria (Table 1) grouped by subject/issue; details of the item being measured; a qualitative or quantitative statement of an indicative measurement; an indicative measurement scale (from 0 to 5, where 5 is best practice); and comments to help those applying the item being measured. Each item is assessed against two risk scenarios; a "most probable" scenario and a "most severe" scenario. These scenarios are defined by each city in response to its assumed hazard threat level.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Where possible individual assessments are based on objective measures but where these do not exist subjective assessments can be made. Irrespective of which type of assessment is used, full justification for the scores given should be recorded; this will not only allow for external validation but will also act as a start point for assessing future revisions. Where items are not under the direct control of a single stakeholder, scoring should be done following consultation with all relevant stakeholders. Finally, not all items listed in the Scorecard will apply to all situations and as such the Scorecard should be contextualised to reflect city specific circumstances and disaster type.

Table 1: Summary of the subject/issues addressed in the UNISDR Disaster Resilience Scorecard for Cities (Source: UNISDR, 2015)

Essential Element	Subject/Issue	Number of Items Measured
Organise for Disaster Resilience	Organization and Coordination	5
	Integration of disaster resilience with other initiatives	1
	Capturer, publication and sharing of data	2
Identify, Understand and Use Current and Future Risk Scenarios	Risk Assessment	4
	Update process	1
Strengthen Financial Capacity for Resilience	Financial plan and budget	3
	Contingency funds	1
	Incentives and financing for business, community organizations and citizens	5
	Financing of resilience expenditures	1
Pursue Resilient Urban Development	Land use - effectiveness of zoning to prevent exposure build–up	3
	Building codes	3
	New developments	2
Safeguard Natural Buffers to Enhance Protective	Ecosystem services	3

Functions Offered by Natural Ecosystems		
Strengthen Institutional capacity	Skills and experience	1
	Public education and awareness	2
	Training delivery	1
	Languages	1
	Learning from others	1
Increase Societal and Cultural Resilience	Grass roots organizations	4
	Private sector / employees	2
	Systems of engagement	1
Increase Infrastructure Resilience	Protective infrastructure	2
	Communications	3
	Electricity	3
	Water and sanitation	3
	Gas	4
	Transportation	6
	Law and order, First responders	2
	Education	3
	Healthcare	3
	Administrative operations	1
	Computer systems and data	2
Ensure Effective Disaster Response	Early warning	1
	Event management plans	1
	Staffing / responder needs	2
	Equipment and relief supplies	1

	Food, shelter, staple goods, and fuel supply	4
	Interoperability and inter-agency compatibility	2
	Drills	2
Expedite Recovery and Build Back Better	Post event recovery planning	3

2.2.4 Experience from those cities that have completed the Scorecard suggest that they have done so at three different levels (UNISDR, 2015). Some cities have adopted a high level survey approach where a one to two day workshop supplemented with a pre-event questionnaire has been used to provide a simple (average or consensus) score for each 'Essential' and, if required, an aggregated score across all 'Essentials'. Other cities have adopted a more focussed approach, concentrating on specific aspects of resilience (e.g. a selection of the 'Essentials') to provide an in depth assessment of that specific aspect of resilience (in the case of LIQUEFACT this could be 'Essential 8', CI systems). In contrast, other cities have taken the opposite approach and performed an in depth assessment of all of a city's resilience 'Essentials' but it was noted that such an approach can be very time consuming. LIQUEFACT proposes to adopt a high level survey approach to identify generic community resilience to an EILD event supplemented with a detailed assessment of CI system resilience to identify the potential benefits of alternative mitigation interventions.

2.2.5 The final decision that those using the Scorecard need to make is their approach to aggregating the scores given to the items measured in each 'Essential' and between 'Essentials'. Whilst a simple arithmetic summation or average will provide an overview of a city's resilience, it does assume that all the items within an 'Essential' are of equal importance to its resilience and that all the 'Essentials' are of equal importance to the city's overall resilience. Such an approach, whilst providing a reasonable basis for general discussions on a city's resilience, is probably a little simplistic if the Scorecard is to be used to assess the effectiveness of a range of mitigation actions to improve resilience (as required in the LIQUEFACT project). The Scorecard does provide for an alternative approach to aggregating resilience scores using weightings derived from expert opinion and applied through either a simple balanced scorecard approach or a more sophisticated multi-criteria approach. Such an approach is consistent with resilience literature and theory, and with the other EU funded projects that are seeking to develop CI and community resilience toolkits. It is also consistent with the RAIF model developed by the LIQUEFACT project. As such the LIQUEFACT project will develop a more sophisticated approach to aggregating resilience scores.

2.2.6 Given the current status of the Disaster Resilience Scorecard for Cities and its compatibility with the objectives of the LIQUEFACT project and RAIF, a modified version of the Scorecard will be used as the basis for measuring a city's resilience to EILD events. The issues, items, indicators and metrics contained in the Scorecard will be reviewed by the LIQUEFACT project partners and Expert Advisory Panel to identify a refined set of items that are potentially affected by an EILD event. This refined set of items will then be weighted to identify their relative importance on community resilience to an EILD event. The refined set of issues, items, indicators and metrics will be tested against extreme and probable EILD scenarios, applied to the Emilia Romagna Region of Italy, where an assessment of the community's level of resilience to EILD events will be made. The resilience of each item will be scored using a 0 to 5 scale and normalised to provide a consistent assessment of each issue. The normalised scores for each issue will then be combined using the expert derived weightings to provide an assessment of the resilience of each 'Essential'. These will be used to inform discussion on the potential mitigation interventions required to improve the resilience of each 'Essential' to an EILD event. An assessment of the overall community resilience to EILD events will be modelled using a Fuzzy Cognitive Map (FCM), developed by an expert panel, that weights the relative importance of each 'Essential' to provide the basis by which EILD mitigation interventions can be modelled and their cost/benefit assessed. The modified Scorecard and modelling approach will be validated by a range of Emilia Romagna stakeholders as part of LIQUEFACT Work Package 7.

2.3 Measuring the Resilience of Critical Infrastructure

2.3.1 There have been many attempts to produce guidance and toolkits to measure and reduce disaster risks and improve the resilience of CI systems. Whilst the details of each toolkit are specific to the risk scenario being considered and the CI system being investigated, the majority are based on identifying a range of components and factors that affect the system's resilience and then developing a range of qualitative and quantitative indicators/metrics to measure the resilience of the components/factors. These components/factors are then combined to obtain an overall assessment of the CI system resilience. The individual component/factor resilience and the overall CI resilience is typically calculated using a simple or weighted summation approach to obtain resilience scores. Whilst this can provide a high level assessment of the impact that the various components/factors have on resilience, the modelling approach doesn't reflect the inter-dependencies and interactions that are known to exist between components/factors and indicators/metrics. As such these generic approaches do not provide the level of detail that will be needed by the RAIF as it attempts to quantify the specific benefits (and costs) associated with alternate EILD event mitigation interventions on CI systems. As such LIQUEFACT will develop a more detailed and specific resilience scoring tool to measure CI system resilience.

2.3.2 The LIQUEFACT project has reviewed (see Deliverable D5.1 for more details) six current EU funded projects that are exploring issues pertinent to improving the resilience of CI systems to natural and manmade disaster event (RESILENS, IMPROVER, SmartResilience, DARWIN, RESIN, and EU-CIRCLE). The review considered the theoretical approach that each toolkit used to model the CI system and the indicators and metrics they intend to use to assess the resilience of each system. Whilst the details of each toolkit differ to reflect their specific circumstances, their generic approach is broadly consistent with that used by the UNISRD Disaster Resilience Scorecard for Cities. Each toolkit seeks to identify the range of issues that affect the resilience of the CI system and then express each issue through a number of items that can be measured using a quantitative or qualitative scale. Where the toolkits differ is in the way they define the issues, which will vary depending on the type of CI system being considered (e.g. healthcare, transportation, power etc.), and the relationships they assume exist (or not) between issues (e.g. relationship between technical systems and performance of service delivery). As such no single toolkit currently under development will provide the level of detail to allow the mitigation options appraisal required in the RAIF. Thus LIQUEFACT will develop its own CI tool that will seek to build on those currently under development in other EU funded projects.

2.3.4 The LIQUEFACT project will develop a bespoke tool to assess the resilience of CI systems to an EILD event and provide the basis against which alternative mitigation interventions can be evaluated. The LIQUEFACT CI resilience tool is based on the generic approaches currently being adopted by other EU funded CI resilience projects and is consistent with the approach used in the UNISDR Disaster Resilience Scorecard for Cities. For consistency, the LIQUEFACT CI resilience tool will use a scoring framework (i.e. 0-5 supported by qualitative statements) compatible with the UNISDR Disaster Resilience Scorecard. As such the scores from the LIQUEFACT CI resilience tool will be compatible with, and feed directly into, the refined UNISDR Scorecard being used to assess community resilience to an EILD event. Where the LIQUEFACT CI tool differs from many of the existing tools is in the way it seeks to address the impact that a disaster event has on service delivery. The LIQUEFACT CI tool will enhance the measurement of CI resilience by explicitly extending the range of factors beyond those associated with the direct impacts of a disaster event on physical assets and organizational preparedness to include factors that assess the indirect impacts of a disaster event on the ability of the CI provider to deliver their essential services. This will include a detailed assessment of the resilience of both service design and service delivery models and the use of multi-criteria modelling that acknowledges inter-dependencies and feedback between factors. Ultimately it is the performance of service delivery that is critical to the post-disaster recovery of communities to a disaster event and by addressing this level of detail the LIQUEFACT CI resilience tool will be able to support the evaluation of mitigation options which directly address service level performance. This is an essential requirement of the RAIF.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

3 RESEARCH METHODOLOGY AND DATA COLLECTION TOOLS

The research plan to design and test the community and CI resilience tool is shown in Figure 3. The research plan consists of four phases. In phase 1 the UNISDR and CI resilience tool will be developed and contextualised to reflect EILD events and the two EILD risk scenarios (most probable and most severe) will be defined. The tools and scenarios will be applied to the Emilia Romagna Region of Italy (phase 2) and the antecedent resilience of the region and selected CI systems will be calculated. In phase 3 a range of mitigation intervention options (technical, operational, organizational and managerial) will be identified at both the community and CI system level, and the impact that these have on the resilience of the community and CI system resilience will be modelled. The relative improvement (assumed) in resilience resulting from individual and combined mitigation interventions will be input into the RAIF where a cost/benefit analysis will be used to develop business models against which each mitigation (or combined mitigations) can be evaluated and prioritised. The initial resilience tools and EILD scenarios will be developed in Work Package 5 and will be tested and refined in Work Package 7.

3.1 Develop and Validate the Most Severe and Most Probable EILD Scenarios

3.1.1 The most severe and most probable EILD event scenarios that could affect the Emilia Romagna Region of Italy will be developed jointly by all the LIQUEFACT partners and representatives from the Emilia Romagna region. A detailed literature review (in conjunction with LIQUEFACT Work Package 2) of the impact and consequences of past EILD events on the Region will be undertaken (with reference to public documents, previous academic studies and existing Emilia Romagna risk assessment reports) and two hypothetical risk scenarios (most severe and most probable) will be developed. These scenarios will be presented for validation to the LIQUEFACT Expert Advisory Panel and wider academic community. The revised scenarios (following feedback from the validation process) will form the basis for discussion at a stakeholder workshop by stakeholder representatives drawn from across the Emilia Romagna Region. The final versions of the most severe and most probable EILD risk scenarios will be developed following the stakeholder workshop and will form the basis for the evaluation of the resilience of the Emilia Romagna Region and its CI systems to an EILD event. As this process will largely be a desk based activity no specific data collection tools will be developed beyond the most severe and most probable scenarios.

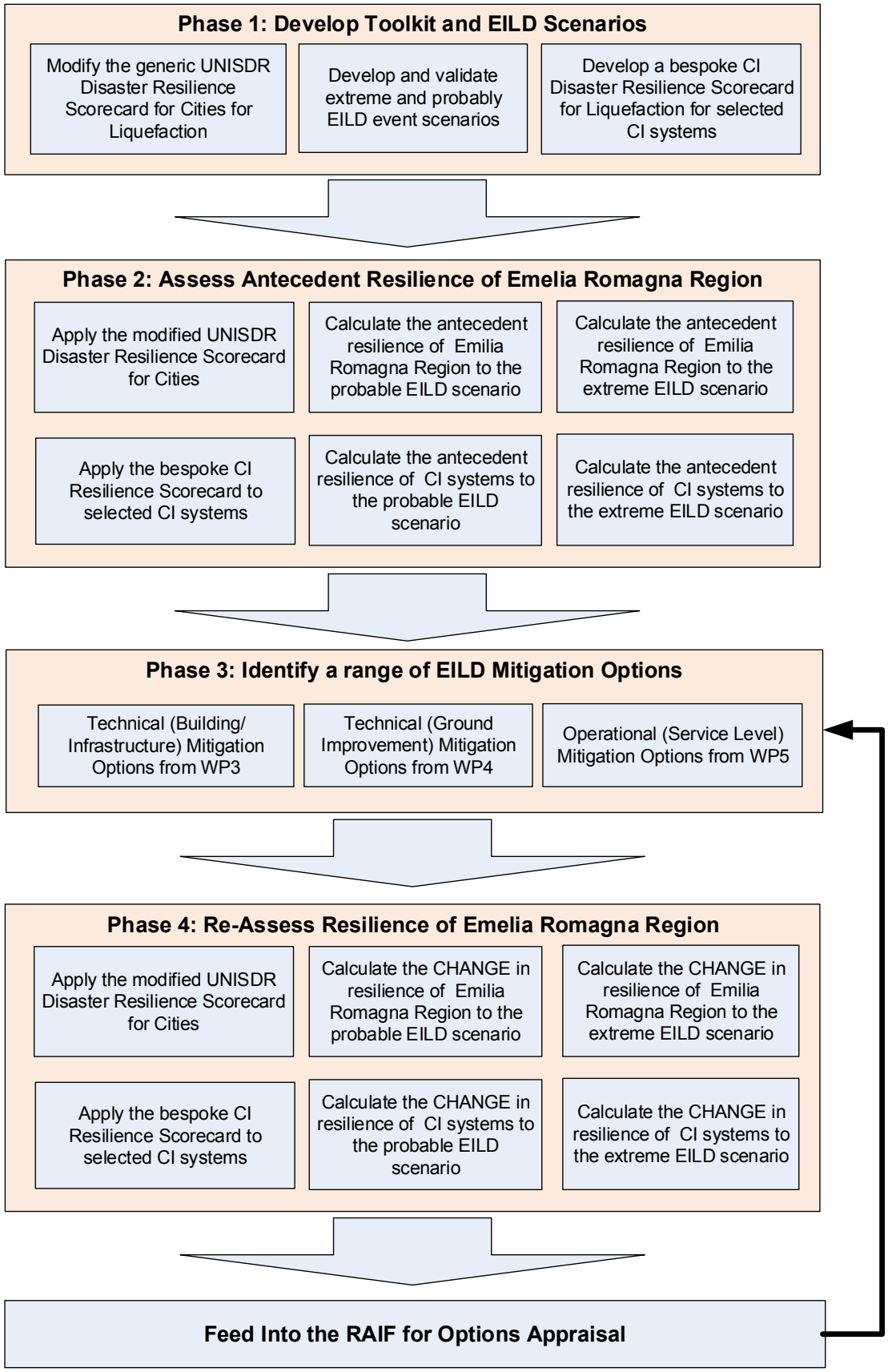


Figure 3: Research Plan for developing and validating resilience tools for the RAIF

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

3.2 Community Resilience Toolkit

3.2.1 The community resilience toolkit to measure Emilia Romagna's resilience to EILD events will be a contextualised version of the UNISRD Disaster Resilience Scorecard for Cities. The 95 items that comprise the scorecard (Table 1) will be reviewed by the LIQUEFACT partners to identify those items that are likely to be affected by an EILD event. This assessment will take the form of a critical review of each item to identify: the relevance of the item in the context of an EILD event (may be generic to any disaster event or specific to an EILD event), the importance of the item in the context of a EILD event (1-5 Likert scale), the type of impact that an EILD event would have on the item (organizational/managerial, technical/physical, operational/service delivery) and an open text field to record the reasons why each respondent gave the responses they did. The 95 items will be presented to respondents as a self-administered questionnaire. The indicative data collection tool that will be used with the LIQUEFACT partners is shown in Figure 4.

3.2.2 The results obtained from the questionnaire survey of LIQUEFACT partners will be used to develop a bespoke EILD Resilience Scorecard and provide a set of initial weightings for the relative importance of each item to each 'Essential' and of each 'Essential' in the overall resilience score for the Region. These weightings will be used to construct the initial FCM from which the overall community resilience of the Emilia Romagna Region to EILD events will be modelled.

3.2.3 The bespoke EILD Resilience Scorecard and the FCM will be reviewed by the Expert Advisory Panel. Following feedback from the Expert Advisory Panel, a final draft of the EILD Scorecard for Cities and its associated FCM model will be produced and this will be used in LIQUEFACT Work Package 7 to model the pre and post mitigation resilience of Emilia Romagna to a 'most severe' and 'most probable' EILD event. The specific data collection tool to be used in LIQUEFACT Work Package 7 will be developed following detailed discussions with representatives from the Emilia Romagna Region to ensure that it accurately reflects local conditions and circumstances. This said, it is very likely that the final version of the EILD Scorecard will be a subset of the indicative data collection tool shown in Figure 4.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
1.1 Organization and coordination	1.1.1 Co-ordination of all relevant pre-event planning and preparation activities exists for the city's area, with clarity of roles and accountability across all relevant organizations.	Presence of organizational chart documenting structure and role definitions at each relevant agency to achieve a single overall point of co-ordination. Structure agreed and preferably signed off by all participants via MOU or similar.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	1.1.2 Co-ordination of all relevant event response activities in the city's area, with clarity of roles and accountability across all relevant organizations.	Presence of organizational chart documenting structure and role definitions at each relevant Agency to achieve a single overall point of co-ordination. Structure agreed and preferably signed off by all participants via MOU or similar.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	1.1.3 Participation and coordination of all relevant organizations in the structure(s) defined.	Level of participation and coordination achieved (see right)	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	1.1.4 Co-option of physical contributions by both public and private sectors.	Identification of physical contributions for each major organization.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	**Item Measured**	**Indicative Measurement**	**Relevance in the context of an EILD event**	**Importance in the context of an EILD event**	**Impact that an EILD event would have on the item** (Tick all that apply).	**Reasons for choices**
	1.1.5 Coordination for all post event activities in the city's area, with clarity of roles and accountability across all relevant organizations.	Presence of organizational chart documenting structure and role definitions at each relevant agency to achieve a single overall point of co-ordination. Structure agreed and preferably signed off by all participants via MOU or similar.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
1.2 Integration of disaster resilience with other initiatives	1.2.1 Extent to which any proposal in government is also evaluated for disaster resilience benefits or impairments.	Explicit stage in policy and budget approval process where disaster resilience side benefits, or impairments, of any city government initiative are identified and counted towards the Return on Investment (ROI) for that proposal.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
1.3 Capture, publication and	1.3.1 Extent to which data on the city's resilience position is shared with other organisations involved with the city's resilience.	Availability of a single "version of the truth" – a single integrated set of resilience data for practitioners.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
sharing of data	1.3.2 Extent to which data on the city's resilience position is shared with the community organizations and public.	Availability of a single "version of the truth" – a single integrated Set of resilience data for citizens and community organizations containing at least the items shown at right.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
2.1 Risk assessment	2.1.1 Knowledge of hazards (also called perils) that the city faces, and their likelihood.	Existence of recent, expert reviewed estimates of probability of known hazards or perils and their extent.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	2.1.2 Knowledge of exposure and vulnerability	Existence of scenarios setting out city-wide exposure and vulnerability from each hazard level.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	2.1.3 Understanding of critical assets and the linkages between these.	All critical assets are identified (see Essential 8) and relationships between them are identified in the form of potential "failure chains". This is used to frame disaster plans and triage (see Essential 9) and also retrofits and upgrades to improve the capability of the infrastructure to withstand disasters.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	**Item Measured**	**Indicative Measurement**	**Relevance in the context of an EILD event**	**Importance in the context of an EILD event**	**Impact that an EILD event would have on the item** (Tick all that apply).	**Reasons for choices**
	2.1.4 Hazard maps	Presence of hazard maps	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
2.2 Update process	2.2.1 Process ensuring frequent and complete updates of scenarios.	Existence of a process agreed between all relevant agencies to: - Update hazard estimates every 3 years or less; Update exposure and vulnerability assessments and asset inventory every 18 months or less.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
3.1 Financial plan and budget	3.1.1 Adequacy of financial planning for all actions necessary for disaster resilience.	Presence of financial (capital and operating) plan(s) with a reasoned set of priorities, based on disaster resilience impact achieved, and keyed to "most probable" and "most severe" scenarios in Essential 2. Priorities for disaster resilience investment, costs are clear and defensible, based on a view of most beneficial impact. Priorities are assembled into five year plan that integrates spending by all key organizations and will meet scenarios in Essential 2.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	3.1.2 Capital funding for long running engineering and other works that address scenarios and critical asset identification in Essential 2 and Essential 8.	Funding for capital elements of plan(s) relative to estimated cost. Degree of protection ("ring-fencing") from cuts or from being taken away to be used for other purposes.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
	3.1.3 Operating funding to meet all operating costs of disaster resilience activities.	Funding for operating expenses relative to estimated costs: presence of separately delineated budget line item(s). Degree of protection ("ring-fencing") from cuts or from being taken away to be used for other purposes.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
3.2 Contingency funds	3.2.1 Contingency fund for post disaster recovery (may be referred to as a "rainy-day fund").	Existence of fund(s) capable of dealing with estimated impacts from "most severe" scenario (See Essential 2). Degree of protection ("ring-fencing") of contingency fund(s) from being taken away to be used for other purposes	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
3.3 Incentives and financing for businesses, community organizations and citizens.	3.3.1 Affordability of, and help with achieving safe housing.	Existence of incentives and affordable financing to help owners and tenants of all substandard buildings bring them to a standard to deal with the "most severe" scenario (Essential 2).	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
	3.3.2 Domestic insurance coverage	Extent of coverage of domestic housing. (Personal or life coverage is not assessed).	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	3.3.3 Incentives to business organizations to improve disaster resilience – disaster plans, premises etc.	Existence of incentives to help business owners take steps to improve disaster resilience to a standard to deal with the "most severe" scenario (Essential 2).	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	3.3.4 Incentives to non-profit organizations to improve disaster resilience – disaster plans, premises etc.	Existence of incentives to help non-profits take steps to improve disaster resilience to a standard to deal with the "most severe" scenario (Essential 2).	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	3.3.5 Non-domestic insurance coverage	Extent of insurance coverage of non-domestic property, infrastructure and assets.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	**Item Measured**	**Indicative Measurement**	**Relevance in the context of an EILD event**	**Importance in the context of an EILD event**	**Impact that an EILD event would have on the item** (Tick all that apply).	**Reasons for choices**
3.4 Financing of resilience expenditures.	3.4.1 Pursuit of all possible methods of financing and funding, as required.	Where a city has outstanding resilience expenditure needs (revenue or capital) – the extent to which it has pursued all possible financing strategies and funding sources.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
4.1 Land use – effectiveness of land use zoning in preventing exposure build-up.	4.1.1 Agricultural land at risk.	% of agricultural land at risk	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	4.1.2 Economic activity at risk.	% of employment at risk	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
		% of business output at risk	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	4.1.3 Potential population displacement.	% of population at risk of displacement	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
4.2 Building codes	4.2.1 Existence of building codes designed to address risks identified in Essential 2.	Existence of applicable codes to all physical assets.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	4.2.2 Application of building codes.	Implementation of building codes on relevant structures.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	4.2.3 Updates to building codes.	Conformity of statutory codes with latest standards in building practice and with perils faced.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
4.3. New development	4.3.1 Urban design solutions that increase resilience.	Use of urban design solutions to improve resilience, often by maximizing the extent and benefit of ecosystem services within the city (see also Essential 5).	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	4.3.2 Sustainable building design standards.	Use of sustainable building design standards such as LEED, Green Star and BREEAM to improve resilience.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
5.1 Ecosystem services	5.1.1 Awareness of the role that ecosystem services may play in the city's disaster resilience.	Ecosystem services are specifically identified, and managed as critical assets.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	5.1.2 Ecosystem health	Change in health, extent or benefit of each ecosystem service in last 5 years.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	5.1.3 Impact of land use and other policies on ecosystem services	Absence of policies or land uses liable to weaken ecosystem services.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
6.1 Skills and experience	6.1.1 Availability of skills and experience in disaster resilience – risk identification, mitigation, planning, response and post event response.	Known (i.e. inventoried in last 1 year) availability of key skills, experience and knowledge.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
6.2 Public education and awareness	6.2.1 Exposure of public to education and awareness materials/messaging.	Coordinated public relations and education campaign exists, with structured messaging, channels, and delivery.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
		Exposures per member of the public, per month to messaging	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
	6.2.2 Validation of effectiveness of education.	Knowledge of "most probable" risk scenario and knowledge of key response and preparation steps is widespread throughout city. Tested by sample survey.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
6.3 Training Delivery	6.3.1 Availability, take-up of training.	Training offered and available to all population (from city government, voluntary or other sources)	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
		% of population trained in last year.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
		Frequency of repeat training	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
6.4 Languages	6.4.1 Accessibility of education and training to all linguistic groups in the city.	Availability of all education and training in all languages spoken in the city.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
6.5 Learning from others	6.5.1 Effort taken to learn from what other cities, states and countries (and companies) do to increase resilience	Learning activities executed with other cities and other practitioners.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
7.1 Grass roots organizations	7.1.1 Coverage of grass roots organization(s) throughout the city.	Presence of at least one nongovernment body for pre and post event response for each neighbourhood in the city.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	7.1.2 Effectiveness of grass roots network	Grass roots organization meeting frequency and attendance.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
		Clear identification and coordination of pre and post event roles for grass-roots bodies, supported by training. Roles agreed and signed off, preferably via MOU or similar.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	7.1.3 Social connectedness and neighbourhood cohesion.	Likelihood that residents will be contacted immediately after an event, and regularly thereafter to confirm safety, issues, needs etc.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
	7.1.4 Engagement of vulnerable segments of the population.	Evidence of disaster resilience planning with or for the relevant groups covering the span of the vulnerable population. Confirmation from those groups of effective engagement.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
7.2 Private sector / employers	7.2.1 Extent to which employers act as a channel with employees.	Proportion of employers that pass resilience communications to employers, and allow limited time off for resilience volunteer activities.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	7.2.2 Business continuity planning	Proportion of business with a solid business continuity plan	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
7.3 "Systems of Engagement"	7.3.1 Use of mobile and e-mail "systems of engagement" to enable citizens to receive and give updates before and after a disaster	Use of mobile and social computing-enabled systems of engagement (supported by email).	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	**Item Measured**	**Indicative Measurement**	**Relevance in the context of an EILD event**	**Importance in the context of an EILD event**	**Impact that an EILD event would have on the item** (Tick all that apply).	**Reasons for choices**
8.1 Protective Infrastructure	8.1.1 Adequacy of protective infrastructure (Ecosystem services offering protection or mitigation – see Essential 5)	Protective infrastructure exists or is in the process of construction – capabilities known to match hazards envisioned in "most probable" and "most severe" scenarios in Essential 2.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	8.1.2 Effectiveness of maintenance	Processes exist to maintain protective infrastructure and ensure integrity and operability of critical assets.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
8.2 Communications	8.2.1 Service days at risk of loss	"Communications loss factor". If: a = estimated # of days to restore regular service area-wide; and b = % of user accounts affected then the communications loss factor = a x b.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	**Item Measured**	**Indicative Measurement**	**Relevance in the context of an EILD event**	**Importance in the context of an EILD event**	**Impact that an EILD event would have on the item** (Tick all that apply).	**Reasons for choices**
	8.2.2 Designated critical asset service days at risk of loss from communications failure.	"Communications critical asset (CCA) loss factor". If: a = estimated # of days to restore regular service area-wide; and b = % of critical assets affected then the CCA loss factor = a x b.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	8.2.3 Cost of restoration.	Likely cost of loss of service and restoration of communications system(s) as % of annual billed Revenue.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
8.3 Electricity	8.3.1 Customer service days at risk of loss.	"Electrical energy loss factor". If: a = estimated # of days to restore regular service area-wide; and b = % of user accounts affected then the electrical energy loss factor = a x b.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
	8.3.2 Designated critical asset service days at risk of loss from energy failure.	"Electricity critical asset (ECA) loss factor". If: a = estimated # of days to restore regular service area-wide; and b = % of critical assets affected then the ECA loss factor = a x b.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	8.3.3 Cost of restoration	Likely cost of lost service and restoration as % of annual billed revenue.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
8.4 Water, sanitation	8.4.1 Customer service days at risk of loss.	"Water/sanitation loss factor". If: a = estimated # of days to restore regular service area-wide; and b = % of user accounts affected then the water / sanitation loss factor = a x b.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
	8.4.2 Designated critical asset service days (for example, service to hospitals or other critical assets) at risk of loss from water or sanitation failure.	"Water/sanitation critical asset (WCA) loss factor". If: a = estimated # of days to restore regular service area-wide; and b = % of critical assets affected then the WCA loss factor = a x b.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	8.4.3 Cost of restoration of service	Likely cost of lost service and restoration as % of annual billed revenue	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
8.5 Gas	8.5.1 Safety and integrity of gas system	Use of fracture resistant gas pipes in seismic or flood zones, and installation of automated shut-off capabilities.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	8.5.2 Customer service days at risk of loss.	"Gas loss factor". If: a = estimated # of days to restore regular service area-wide; and b = % of user accounts affected then the gas loss factor = a x b.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
	8.5.3 Designated critical asset service days at risk of Loss from gas supply failure.	"Gas critical asset (GCA) loss factor". If: a = estimated # of days to restore regular service area-wide; and b = % of critical assets affected then the GCA loss factor = a x b.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	8.5.4 Cost of restoration of service	Likely cost of lost service and restoration as % of annual billed revenue.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
8.6 Transportation	8.6.1 Road – service from road system at risk of loss	Road loss factor If: a = miles of major road network for city and surrounding area at risk of becoming impassable to any type of vehicle after event; b = likely number of days estimated before reopening; and c = total of major roads in the city and surrounding area lost for one day then the road loss factor = (a/c) x b as a %.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	**Item Measured**	**Indicative Measurement**	**Relevance in the context of an EILD event**	**Importance in the context of an EILD event**	**Impact that an EILD event would have on the item** (Tick all that apply).	**Reasons for choices**
	8.6.2 Road – survival of critical access and evacuation routes	Road critical asset (RCA) loss factor. If: a = carrying capacity (vehicles per hour) of evacuation / emergency supply routes to and from the city at risk of becoming impassable after event; b = # of days estimated before reopening; and c = carrying capacity (vehicles per hour) of all designated critical evacuation/emergency supply routes then the RCA loss factor = (a/c) x b as a %.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
	8.6.3 Rail/metro (if applicable) – service from rail system at risk of loss	Rail loss factor (for rail, use tons; for metro, use passengers). If: a = carrying capacity (tons or passengers per day) of affected rail lines to the city; b = # of days estimated before reopening; and c = carrying capacity (tons per day per hour) of all rail links to the city then the RCA loss factor = (a/c) x b as a %.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	8.6.4 Air	Airport loss factor. If: a = estimated # of flights in and out per day possible after the disaster b = max # of flights per day in normal operations; and c = # of days estimated before restoration of full capacity, then the Airport loss factor = (a/b) x c as a %.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
	8.6.5 River/Sea	River/seaport loss factor. If: a = estimated # of dockings per day possible after the disaster; b = max # of dockings per day in normal operations; and c = # of days estimated before restoration of full capacity, then the river/seaport loss factor = (a/b) x c as a %.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	8.6.6 Other public transport	(Buses and taxis effectively captured in road measures above).	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
8.7 Law and Order, First responders	8.7.1 Protection of critical law and order/responder assets.	"Law & Order critical asset (LOCA) loss factor". If: a = estimated # of designated critical law and order assets rendered inoperable by the event; and b = total # of designated critical law and order assets then LOCA loss factor = a/b expressed as %.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
	8.7.2 Disaster resilience of prison system	Ability of prison system to survive "most probable" and "most severe", scenarios, without releasing or harming inmates.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
8.8 Education facilities	8.8.1 Structural safety of education facilities	% of education structures at risk of damage from "most probable" and "most severe" scenarios	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	8.8.2 Loss of teaching time	Number of teaching days lost as % of total in academic year.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	8.8.3 Education data	% of critical education data and associated applications imaged at remote site.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
8.9 Healthcare	8.9.1 Structural safety and disaster resilience of health care and emergency facilities.	"Bed days lost" – estimated # of beds at risk x number of days' loss under "most probable" and "most severe" scenarios.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
		"Critical bed days lost" - estimated # of bed days for designated critical services (e.g. ER, dialysis, intensive care – TBD) at risk under "most probable" and "most severe" scenarios.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	8.9.2 Health records and data	% of patient and health system data and associated apps stored and process able at location unlikely to be affected by the event.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	8.9.3 Availability of emergency healthcare including facilities and urgent medical supplies for acute needs.	Sufficient acute healthcare capabilities exist to deal with expected major injuries.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
8.10 Administrative operations	8.10.1 Assurance of continuity of all critical administration functions.	Estimated # of days disruption to critical administration services under "most probable" and "most severe" scenarios, given availability of redundant facilities, support staff etc.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
8.11 Computer systems and data	8.11.1 Assurance of continuity of computer systems and data critical to government continuity.	% of critical applications and associated data (to include social services and other personal records) imaged at, and accessible from, remote site.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	8.11.2 Assurance of continuity of computer systems and data critical to any of the above infrastructure.	% of critical applications and associated images at, and accessible from, remote site.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
9.1 Early warning	9.1.1 Existence and effectiveness of early warning systems.	Length and reliability of warning – enabling practical action to be taken.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
		Reach of warning – will 100% of population receive it?	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
9.2 Event management plans	9.2.1 Existence of emergency response plans that integrate professional responders and grass roots organizations.	Existence of plans formulated to address "most likely" and "most severe" scenarios, shared and signed off by all relevant actors (including citizen organizations).	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
9.3 Staffing/responder needs	9.3.1 "Surge" capacity of police also to support first responder duties.	Sufficient back-up or paraprofessional capacity to maintain law and order in "most severe" and "most probable" scenarios, in addition to supporting burden of first responder duties.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	9.3.2 Definition of other first responder and other staffing needs, availability – including fire, ambulance, healthcare, neighbourhood support etc.	Staffing needs are defined for "most probable" and "most severe" scenarios.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
		Estimated shortfall in staff/responders per defined needs – potentially from multiple sources. MOUs Exist for non-city sources, especially from private sector.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
9.4 Equipment and relief supply needs	9.4.1 Definition of equipment and supply needs, and availability of equipment.	Equipment and supply needs are defined for "most probable" and "most severe" scenarios in Essential 2	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
		Estimated shortfall in available equipment per defined needs – potentially from multiple sources. MOUs exist for non-city sources, especially from private sector.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
9.5 Food, shelter, staple goods and fuel supply.	9.5.1 Likely ability to continue to feed population	"Food gap" - # of days that city can feed all segments of its population likely to be affected minus # of days' disruption estimated under those scenarios.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	9.5.2 Likely ability to meet needs for shelter/safe places	"Shelter gap" – numbers of displaced persons minus shelter places available within 24 hours.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
		"Shelter gap" – ability of shelters to withstand disaster events and remain safe and usable.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	Item Measured	Indicative Measurement	Relevance in the context of an EILD event	Importance in the context of an EILD event	Impact that an EILD event would have on the item (Tick all that apply).	Reasons for choices
	9.5.3 Ability to meet likely needs for staple goods.	"Staples gap" - % shortfall in supply within 24 hours relative to demand.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	9.5.4 Likely availability of fuel.	"Fuel gap" - # of days that city can meet fuel requirements, minus # of day's disruption to regular supply.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
9.6 Interoperability and inter-agency compatibility	9.6.1 Interoperability with neighbouring cities/states and other levels of government of critical systems and procedures.	Ability to cooperate at all levels with neighbouring cities and other levels of government.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	9.6.2 Emergency operations centre	Existence of emergency operations centre with participation from all agencies, automating standard operating procedures specifically designed to deal with "most likely" and "most severe" scenarios.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Item	**Item Measured**	**Indicative Measurement**	**Relevance in the context of an EILD event**	**Importance in the context of an EILD event**	**Impact that an EILD event would have on the item** (Tick all that apply).	**Reasons for choices**
9.7 Drills	9.7.1 Practices and rehearsals – involving both the public and professionals.	Testing of plans annually, by reference to simulated emergency and actual nonemergency events.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	9.7.2 Effectiveness of drills and training	Level of effectiveness of drills.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
10.1 Post event recovery planning – pre event!	10.1.1 Planning for post event recovery and economic reboot.	Existence of comprehensive post event recovery and economic reboot plans.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	10.1.2 Shadow financial arrangements for processing incoming aid and disbursing funds.	Post event arrangements exist for dealing with incoming financial aid and disbursements.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	
	10.1.3 Learning loops	Existence of a process and format for "post-mortems" on what went well and less well in the event response and post-event phases.	[ ] Yes [ ] No [ ] Don't Know	[ ] High [ ] Medium High [ ] Medium [ ] Medium Low [ ] Low	[ ] Organizational/Managerial [ ] Technical/Physical [ ] Operational/Service delivery	

Figure 4: Indicative Data Collection tool for Community Resilience. Refer to UNISDR Disaster Scorecard for Cities in Appendix A for further information of any items. (Source: Derived from the UNISDR Disaster Scorecard for Cities, 2015).

3.3 Critical Infrastructure Resilience Toolkit

3.3.1 Although the UNISDR Disaster Resilience Scorecard for Cities contains a section on the impact that CI has on community resilience (Essential 8), it isn't detailed enough to allow the effectiveness of alternative mitigation interventions on improving resilience to an EILD event at the CI system level to be evaluated. As such, LIQUEFACT will develop its own CI resilience tool that provides the level of detail to allow mitigation options appraisals to be performed and provides input directly into the community resilience tool. In this way the CI resilience tool can be used to both assess the resilience of a CI system and to assess how changes in the resilience of the CI system post mitigation will affect overall community resilience to an EILD event. However, as each CI system is unique, in terms of both the impact that an EILD event will have on the system and the service design and delivery models adopted by the CI system, the CI resilience toolkit must be flexible enough to reflect the uniqueness of each CI system whilst allowing robust comparisons to be made between systems. As such, LIQUEFACT will not develop a single generic CI resilience tool, but we will develop a generic CI resilience framework from which bespoke tools can be developed that reflect the specific circumstances encountered by each CI system.

3.3.2 The generic CI resilience framework will be developed following detailed discussions with CI system stakeholders. Figure 5 shows an initial set of indicators that have been derived from a review of other projects (see LIQUEFACT Deliverable D5.1) and reflect the range of indicators that the LIQUEFACT researchers believe are relevant to assessing resilience to EILD events. The resilience indicators are grouped into three factors and seven sub-factors that reflect the range of activities that influence the resilience of the CI system and that could be influenced by specific technical, operational, organizational and management mitigation interventions (Table 2). Whilst some of the indicators should be applicable to all CI providers (e.g. having a specific budget identified to fund resilience measures) others will be specific to the particular CI circumstances (e.g. service design resilience in the health sector will be different to service design resilience in the transportation sector). As such, the list of indicators shown in Figure 5 will form the basis of detailed discussions with CI stakeholders (at various levels within each organization) to develop specific metrics that reflect each CI systems particular circumstances.

3.3.3 The format for each CI resilience tool will be similar to that used in the UNISDR Disaster Resilience Scorecard for Cities (Appendix A) in which the sub-factor equates to the subject/issue; the indicator describes the item to be measured; and the metric specifies the indicative measurement which is scored against a six point scale (0 – 5). A commentary box will provide further guidance and give examples of the indicator being assessed. A hypothetical example of a typical indicator is shown in Figure 6.

3.3.4 Once the final set of indicators, metrics, measurement scales, and examples have been developed for a particular CI system they will be scored by stakeholders drawn from that CI system to provide an assessment of the resilience of the CI system to an EILD event. The scores for the indicators associated with each sub-factor will be combined and normalised to provide a single score for that sub-factor to an EILD event. It is currently assumed that the Analytic Hierarchy Process (AHP) (Saaty, 1980) will be used as the basis of this assessment but if the number of indicators becomes too large then a more simplistic weighting regime will be used to obtain the normalised score. It should be noted that the pairwise comparison used in the AHP approach becomes very time consuming for participants as the number of indicators increases and as such the inconsistency between weightings can become too great.

Table2: Factors and sub-factors affecting CI Resilience

Factor	Sub-factor
Organization and Management	Finance
	Coordination
	Business Planning
Technical Systems	Physical Assets
	Asset Infrastructure
Operational Systems	Service Design
	Service Delivery

3.3.5 Once a score for each sub-factor has been calculated they will be combined using the AHP to provide a single assessment of the resilience of each of the factors to an EILD event. However, whilst it has been assumed that a set of individual indicators and sub-factors can be defined that are largely independent of each other, it is acknowledged that this is unlikely to be the case for the factors. Whilst each of the factors represents specific resilience issues, they are in reality all inter-related and therefore the impact of an EILD event on one factor will influence the other factors. As such, when combining the resilience scores from each factor to obtain an overall assessment of the CI resilience to EILD events, consideration will need to be given to inter-dependencies and feedback and so it is proposed to combine the resilience scores using the Analytic Network Process (ANP) which was specifically developed to address such complexities (Saaty, 1996). The AHP and ANP models described above, and the assumptions underpinning them, will be developed and tested in LIQUEFACT Work Package 7. The indicative data collection tool that will be used to develop each CI system toolkit is shown in Figure 7.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

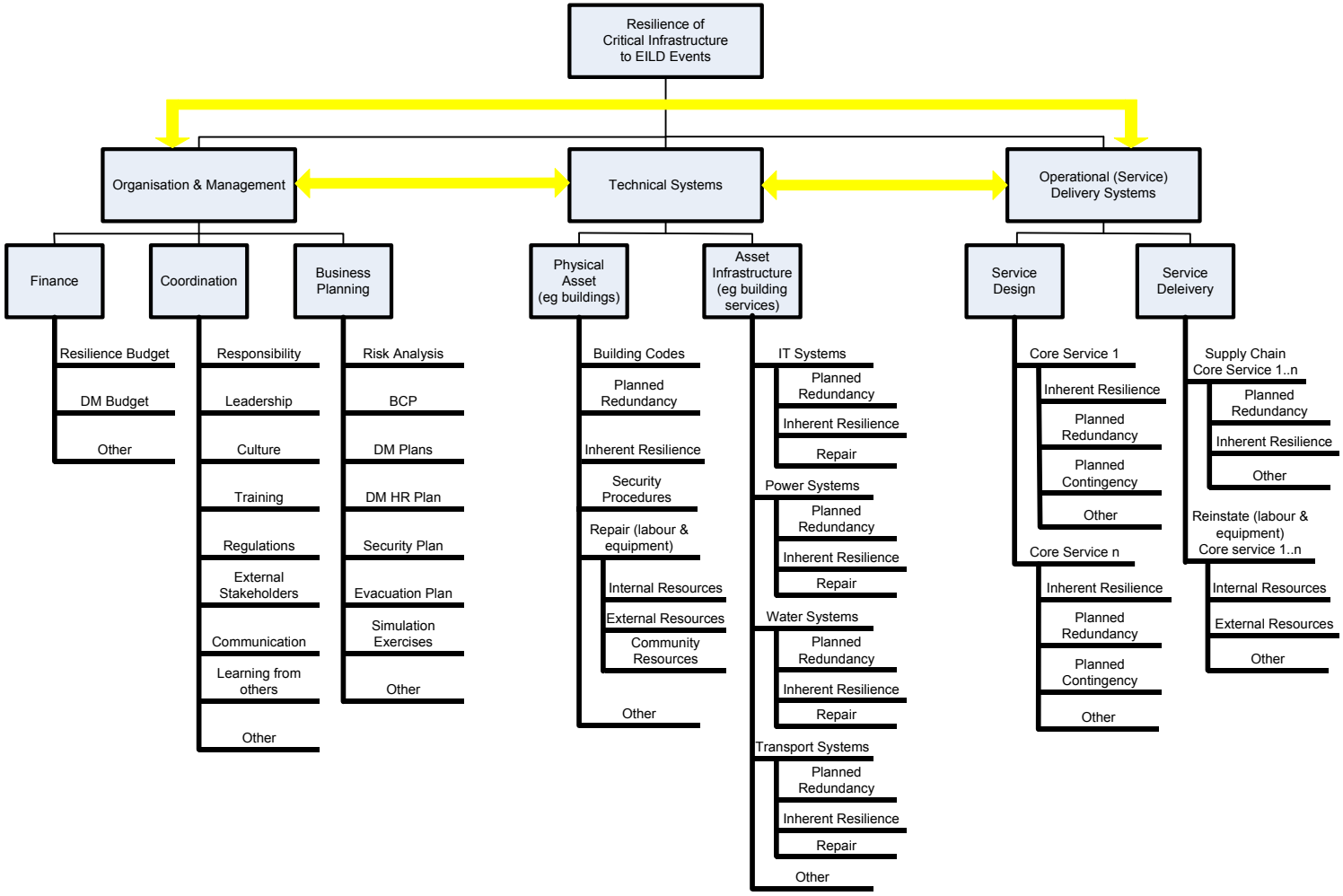


Figure 5: Critical Infrastructure Resilience Framework

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Sub-Factor	Indicator	Metric (Indicative measurement)	Indicative measurement scale	Comments
Service design	Resilient practices	Resilience of supply chain	5 – Resilience of all suppliers has been assessed and alternative suppliers have been identified and contracts confirmed. 4 – Resilience of all suppliers has been assessed and some alternative suppliers have been identified but not for all suppliers and/or formal contracts have not been confirmed. 3 – Resilience of all suppliers has been assessed but alternative suppliers have not been identified. 2 – Resilience of all suppliers has not been assessed although the resilience of key suppliers has been assessed. 1 – Resilience of all suppliers has not been assessed although key suppliers in the supply chain have been identified. 0 – No consideration has been given to the resilience of the supply chain.	Even if you are not directly affected by an EILD event the suppliers that you rely on as part of your service design model might be. If your suppliers are not able to provide you with the service you expect then you will not be able to provide the community with your service. You need to assess the resilience of your supply chain by assessing the resilience of each part of your supply chain. These assessments might take the form of a detailed analysis of each of your suppliers EILD disaster resilience plans including identifying minimum required service performance levels and alternative service providers and negotiating contracts for the provision of the service in a time of disaster and the identification of key

Figure 6: Hypothetical example of a typical indicator

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Sub-Factor	Indicator	Metric (Indicative measurement)	Indicative measurement scale	Comments
Finance	**Specific budget for resilience measure**	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Specific budget for disaster management	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Other indicators	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
Coordination	**Single point of responsibility**	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Sub-Factor	Indicator	Metric (Indicative measurement)	Indicative measurement scale	Comments
	Clear leadership	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Resilience culture	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Training and Education	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Compliance with regulations	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Relationships with external stakeholders	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Sub-Factor	Indicator	Metric (Indicative measurement)	Indicative measurement scale	Comments
	Internal and external communication	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Corporate learning	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Other indicators	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
Business Planning	**Detailed risk analysis**	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Compressive business continuity plan	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Sub-Factor	Indicator	Metric (Indicative measurement)	Indicative measurement scale	Comments
	Detailed disaster management plan	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Disaster management human resources plan	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Security plan	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Evacuation plan	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Regular simulations	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Sub-Factor	Indicator	Metric (Indicative measurement)	Indicative measurement scale	Comments
	Other indicators	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
Physical Assets (e.g. Building Structure)	**Compliance with latest building codes**	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Degree of planned redundancy	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Antecedent resilience of buildings / infrastructure	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Security systems	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Sub-Factor	Indicator	Metric (Indicative measurement)	Indicative measurement scale	Comments
	Maintenance and Repair (labour)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Maintenance and Repair (equipment)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Maintenance and Repair (external resources)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Maintenance and Repair (community resources)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Other indicators	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Sub-Factor	Indicator	Metric (Indicative measurement)	Indicative measurement scale	Comments
Asset Infrastructure (e.g. Building Services)	**IT systems (planned redundancy)**	*To be developed in consultation with the specific CI system stakeholders*	*5 – 4 – 3 – 2 – 1 – 0 –*	*To be developed in consultation with the specific CI system stakeholders*
	IT systems (inherent resilience)	*To be developed in consultation with the specific CI system stakeholders*	*5 – 4 – 3 – 2 – 1 – 0 –*	*To be developed in consultation with the specific CI system stakeholders*
	IT systems (Repair – labour and resources)	*To be developed in consultation with the specific CI system stakeholders*	*5 – 4 – 3 – 2 – 1 – 0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Power systems (planned redundancy)	*To be developed in consultation with the specific CI system stakeholders*	*5 – 4 – 3 – 2 – 1 – 0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Power systems (inherent resilience)	*To be developed in consultation with the specific CI system stakeholders*	*5 – 4 – 3 – 2 – 1 – 0 –*	*To be developed in consultation with the specific CI system stakeholders*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Sub-Factor	Indicator	Metric (Indicative measurement)	Indicative measurement scale	Comments
	Power systems (Repair – labour and resources)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Water/Sanitary systems (planned redundancy)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Water/Sanitary systems (inherent resilience)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Water/Sanitary systems (Repair – labour and resources)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Transportation systems (planned redundancy)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Sub-Factor	Indicator	Metric (Indicative measurement)	Indicative measurement scale	Comments
	Transportation systems (inherent resilience)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Transportation systems (Repair – labour and resources)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Other indicators	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
Service Design	**Core service 1 (inherent resilience)**	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Core service 1 (planned redundancy)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Sub-Factor	Indicator	Metric (Indicative measurement)	Indicative measurement scale	Comments
	Core service 1 (planned contingency)	*To be developed in consultation with the specific CI system stakeholders*	*5 – 4 – 3 – 2 – 1 – 0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Core service 1 (other indicators)	*To be developed in consultation with the specific CI system stakeholders*	*5 – 4 – 3 – 2 – 1 – 0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Core service n (inherent resilience)	*To be developed in consultation with the specific CI system stakeholders*	*5 – 4 – 3 – 2 – 1 – 0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Core service n (planned redundancy)	*To be developed in consultation with the specific CI system stakeholders*	*5 – 4 – 3 – 2 – 1 – 0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Core service n (planned contingency)	*To be developed in consultation with the specific CI system stakeholders*	*5 – 4 – 3 – 2 – 1 – 0 –*	*To be developed in consultation with the specific CI system stakeholders*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Sub-Factor	Indicator	Metric (Indicative measurement)	Indicative measurement scale	Comments
	Core service n (other indicators)	*To be developed in consultation with the specific CI system stakeholders*	*5 – 4 – 3 – 2 – 1 – 0 –*	*To be developed in consultation with the specific CI system stakeholders*
Service Delivery	**Reinstate internal service delivery logistics: core service 1 (labour)**	*To be developed in consultation with the specific CI system stakeholders*	*5 – 4 – 3 – 2 – 1 – 0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Reinstate internal service delivery logistics: core service 1 (equipment)	*To be developed in consultation with the specific CI system stakeholders*	*5 – 4 – 3 – 2 – 1 – 0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Reinstate internal service delivery logistics: core service 1 (other indicators)	*To be developed in consultation with the specific CI system stakeholders*	*5 – 4 – 3 – 2 – 1 – 0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Reinstate internal service delivery logistics: core service n (labour)	*To be developed in consultation with the specific CI system stakeholders*	*5 – 4 – 3 – 2 – 1 – 0 –*	*To be developed in consultation with the specific CI system stakeholders*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Sub-Factor	Indicator	Metric (Indicative measurement)	Indicative measurement scale	Comments
	Reinstate internal service delivery logistics: core service n (equipment)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Reinstate internal service delivery logistics: core service n (other indicators)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Supply chain: core service 1 (inherent resilience)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Supply chain: core service 1 (planned redundancy)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Supply chain: core service 1 (other indicators)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Sub-Factor	Indicator	Metric (Indicative measurement)	Indicative measurement scale	Comments
	Supply chain: core service n (inherent resilience)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Supply chain: core service n (planned redundancy)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*
	Supply chain: core service n (other indicators)	*To be developed in consultation with the specific CI system stakeholders*	*5 –* *4 –* *3 –* *2 –* *1 –* *0 –*	*To be developed in consultation with the specific CI system stakeholders*

Figure 7: Indicative data collection tool for assessing CI resilience to an EILD event.

4 SUMMARY AND NEXT STEPS

4.1 The LIQUEFACT project aims to develop a more comprehensive and holistic understanding of the earthquake soil liquefaction phenomenon and the effectiveness of mitigation techniques to protect structural and non-structural systems and components from its effects. To this end the LIQUEFACT project will develop a RAIF to assess the vulnerability, resilience, and the adaptive capacity of communities and CI to EILD events. The RAIF will also provide business models to assess the potential of mitigation interventions to improve community and CI resilience and the cost/benefit models to allow option appraisals and prioritisation of mitigation interventions into built asset management plans. This report presents two resilience assessment tools; one which focuses on the resilience of CI systems to an EILD event; the other that focuses on community resilience to an EILD event. Both these tools form a fundamental part of the RAIF.

4.2 The theoretical background to the RAIF is based on Cutter's DROP model (Cutter et al, 2008) and Jones's risk/resilience model developed as part of the CREW project (CREW, 2012). The RAIF integrates these models into a six stage built asset management framework that those responsible for managing CI systems can use to identify, evaluate and plan mitigation actions (technical, operational, organizational and managerial) to reduce their vulnerability or improve community and CI resilience to EILD events. To support the RAIF a series of resilience tools need to be developed that model both community and CI resilience to EILD events. These tools are the primary output from this report.

4.3 A modified version of the UNISDR Disaster Resilience Scorecard for Cities will be used to assess community resilience to EILD events. The Scorecard will be reviewed and contextualised to reflect the impact that a 'most severe' and 'most probable' EILD scenario event will have on the resilience of the Emilia Romagna Region of Italy. The initial data collection tool that will be used as the basis for the review is shown in Figure 4. This tool will be refined in LIQUEFACT Work Package 5 and tested in LIQUEFACT Work Package 7. The final version of the contextualised tool will be included as part of the SELENA-LRG software to be developed in LIQUEFACT Work Package 6.

4.4 A series of bespoke tools will be developed to assess the resilience of CI systems to an EILD event. The bespoke tools will be reviewed and contextualised to reflect the impact that a 'most severe' and 'most probable' EILD scenario event will have on the resilience of each of the CI systems being examined. The bespoke tools will be derived from the generic CI resilience framework shown in Figure 7. The bespoke tools will be developed in LIQUEFACT Work Package 5 and tested in LIQUEFACT Work Package 7. The final versions of the bespoke

tools will be included as part of the SELENA-LRG software to be developed in LIQUEFACT Work Package 6.

4.5 The next steps will be the full development of the tools by all the LIQUEFACT partners and stakeholders drawn from the Emilia Romagna Region and their validation by the LIQUEFACT Expert Advisory Panel and wider academic and practitioner communities. This activity forms part of LIQUEFACT Work Package 5.

5 REFERENCES

CREW (2012) 'Community Resilience to Extreme Weather – CREW Project: Final Report.', Available online at http://www.extreme-weather-impacts.net. Accessed on April 2017.

Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). 'A place-based model for understanding community resilience to natural disasters', *Global Environmental Change*, *18*(4), 598–606. http://doi.org/10.1016/j.gloenvcha.2008.07.013

Jones, K. & Sharp, M. (2007) 'A new performance-based process model for built asset maintenance', Facilities, Vol 25, No 13/14, 2007, pp 525-535.

Saaty, T., L. (1980) 'The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation', McGraw-Hill**,** ISBN 0-07-054371-2,

Saaty, T., L. (1996) 'Decision Making with Dependence and Feedback: The Analytic Network Process', RWS, ISBN 0-9620317-9-8.

UN General Assembly. (2015) 'The Sendai Framework for Disaster Risk Reduction 2015–2030'. Available online at www.unisdr.org/we/inform/publications/43291 Accessed on April 2017.

UNISDR (2015) 'Disaster Resilience Scorecards for Cities', Available online at: www.unisdr.org/2014/campaign-cities/Resilience%20Scorecard%20V1.5.pdf Accessed on April 2017.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700748

Appendix A: UNISDR Disaster Resilience Scorecards for Cities

Disaster Resilience Scorecard for Cities

Using the Draft Revised "Ten Essentials" based on the Sendai Framework for Disaster Risk Reduction 2015-2030

Compiled for the United Nations International Strategy for Disaster Risk Reduction (UNISDR)

by IBM and AECOM

Current status as at April 30th 2015: this is a working document, and may continue change, possibly significantly, as further experience is gained with using it and as the HFA2 framework continues to be developed. Comments and suggestions are welcomed.

The Disaster Resilience Scorecard is provided "as is" and no warranty is made as to completeness and accuracy. Users should satisfy themselves that it is suitable and complete for their purposes.

Disaster Resilience Scorecard for Cities, based on UNISDR's "Ten Essentials"

This scorecard provides a set of assessments that will allow cities to understand how resilient they are to natural disasters. It is based on the UNISDR's draft revised "Ten Essentials"[1] of disaster management. It has been compiled by IBM and AECOM, who are members of UNISDR's Private Sector Advisory Group (PSAG).

The term "resilience" is often taken to include responses to a spectrum of factors, ranging from "chronic" stresses such as environmental pollution, ground water depletion or deforestation, to "acute" stresses such as floods, droughts, earthquakes, hurricanes or wild-fires[2]. "Disaster resilience" as defined here is at the "acute" end of this spectrum: it covers the ability of a city to understand the disaster risks it may face; to mitigate those risks; and to respond to disasters that may occur, in such a way as to minimize loss of or damage to life, livelihoods, property, infrastructure, economic activity and the environment. Clearly, disaster resilience will be affected by the chronic stresses that the city may also face, for example where deforestation increases the propensity for flash flooding, or where water pollution exacerbates the impact of a drought.

As Figure 1, below, shows the Ten Essentials offer a relatively complete coverage of the many issues cities need to address to become more disaster-resilient:

- Essentials 1-3 cover governance and financial issues;
- Essentials 4-8 cover the many dimensions of planning and disaster preparation;
- Essentials 9-10 cover the disaster response itself and post-event recovery.

While Essentials 1-3 should be complete first, the remaining essentials are not intended to be completed in any particular order.

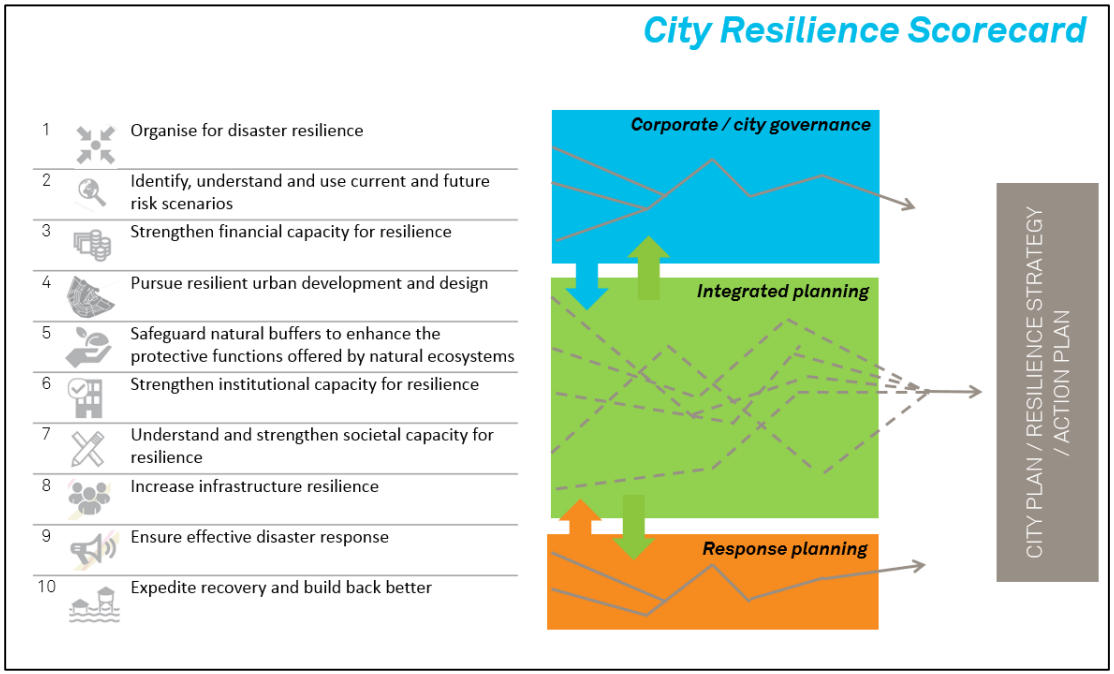
Using the Essentials, the Disaster Resilience Scorecard (hereafter, "the scorecard") is intended to enable cities to establish a baseline measurement of their current level of disaster resilience under each Essential, to identify priorities for investment and action, and to track their progress in improving their disaster resilience over time. It consists of some 90 disaster resilience evaluation criteria, with each evaluation criterion being broken down to set out the aspect of disaster resilience being measured, an indicative measurement and the measurement scale (from 0 to 5, where 5 is best practice).

---

[1] The original pre-Sendai Ten Essentials are available from: http://www.unisdr.org/campaign/resilientcities/toolkit/essentials. The draft of the Revised Ten Essentials is incorporated in this document in the introduction to each section.

[2] These terms have been defined in numerous works by Prof. Joseph Fiksel, Ohio State University.

Figure 1



The scorecard provides an aspirational definition of disaster resilience – it is very unlikely that any city would currently score maximum points, and most will not score more than 50%. Its intention is to guide cities towards optimal disaster resilience, and to challenge complacency. This demanding standard reminds cities that there is *always* more that could be done, and to establish investment goals (including time and effort) for achievement over a period of years.

Disaster resilience for a city is a big subject, requiring cross-functional effort and input. As you complete the scorecard, keep in mind that:

- You will need a clear understanding of the risk of each possible disaster and its impacts on your city. The scorecard assumes that your city has two risk scenarios defined – a "most probable" and a "most severe" (ie a "worst case"). However, even if you do not have these defined as such, it may still be possible to draw on existing risk assessment work.

- While the scorecard aims to be systematic, individual scores may unavoidably be subjective – use your judgment to decide which scores apply most closely to your level of disaster resilience. Recording your justification for each evaluation score will enable validation, as well as future revisions and tracking progress.

- Some aspects of disaster resilience may not be under the control of your organization (for example, the city's electricity supply or phone system may be operated by a separate utility, or there may be a provincial or neighboring government that also needs to be involved). Ideally, the scorecard should be completed in consultation with these other organizations. The consultation process will also help to engage and build understanding, ownership and alignment with these other organizations.

- Consulting your citizens as you complete the scorecard will improve the validity of your results.

- Not all measures in the scorecard will apply to all cities or all disaster events (for example, there is a measure related to ports and your city may not have one).

- Being as accurate and realistic as possible will help accurately identify areas of vulnerability, enabling their prioritization for attention and funding. Wishful thinking or denial will eventually be ruthlessly exposed by nature, when a disaster happens!

- **The scorecard may not address all the disaster resilience issues facing your city. Equally, some scoring criteria may not be directly applicable to your city. If in doubt take advice from an expert in risk management or other relevant discipline.**

Cities that have completed the Scorecard have found that it can be approached at several levels:

- As a high level survey, often via a 1 or 2 day workshop – this may or may not be supported by questionnaires based on the scorecard which participants fill out in advance. Sometimes an average or consensus score is applied at the level of each Essential, rather than for each individual assessment.

- As a limited exercise focusing on some individual essentials, to create an in depth review of some specific aspects of resilience – perhaps community-level preparedness, or some such.

- As a detailed review of the city's entire resilience posture, taking some weeks or even months to complete.

Before proceeding to complete the scorecard please read the companion document, Scorecard FAQs. This contains guidance on process and issues that may be encountered. If you wish you can apply weightings to the essentials to allow some to have more impact in the assessment than others. A suggested set of weightings is available if required.

If you have any questions (or if you wish to suggest any improvements), please contact the authors: Peter Williams, at peter.r.williams@us.ibm.com; Michael Nolan, at michael.nolan@aecom.com; or Abhilash Panda, at pandaa@un.org. A glossary of terms used is included at the end of the document.

The scorecard is made freely available by the UNISDR, to be used by cities or local government agencies; companies providing derivative products or services based on the scorecard may also use it without charge.

We wish you success in completing the scorecard. Finally, we would like to thank those in a number of organizations and individuals whose comments and experience in using it have already allowed us to improve it.

30th April 2015.

The Disaster Resilience Scorecard for Cities

Essential 1: Organize for Resilience

Put in place an organizational structure and identify the necessary processes to understand and act on reducing exposure, its impact and vulnerability to natural disasters. Recognizing that the exact format/structure will vary within and between countries, this will include but is not limited to:

- Establishing a single point of coordination in the city, accepted by all stakeholders.
- Exercising strong leadership and commitment at the highest elected level within the city authority, such as the Mayor.
- Ensuring that all departments understand the importance of disaster risk reduction for achieving objectives of their policies and programs; and that they have a framework within which to collaborate as required.
- Ensuring that all city government discussions routinely capture resilience implications; that the resilience implications of policies, and standards in use are also assessed; and that action is taken upon these as needed.
- Engaging and building alliances with all relevant stakeholder groups including government at all levels (e.g national, state, city, parish or other subdivision, neighbouring cities or countries as applicable), civil society and community organizations, the private sector.
- Engaging and learning from other city networks and initiatives (e.g. city to city learning programmes, climate change, resilience initiatives etc.)
- Establish necessary strategies, acts, laws, codes or integrate resilience qualities into existing policies aimed at preventing the creation of risk and reduction of existing risk.
- Create policies to gather and manage data for sharing amongst all stakeholders and citizens.
- Putting in place reporting mechanisms for all citizens that capture key information about resilience and promote transparency, accountability and improved data capture over time (e.g. consider use of UNISDR tools LGSAT and City Resilience Scorecard) and enable information sharing with other organizations and with the public..

Data you will need to answer this section of the scorecard will include*: organization charts; lists of organizations by area, subject and so on; as applicable, MOUs and other role descriptions for each organization concerned; names of key individuals involved; meeting minutes and actions from the organizations concerned; a list of information and data available to reach stakeholder*.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
1.1 Organization and coordination	1.1.1 Co-ordination of all relevant **pre-event** planning and preparation activities exists for the city's area, with clarity of roles and accountability across all relevant organizations.	Presence of organizational chart documenting structure and role definitions at each relevant agency to achieve a single overall point of co-ordination. Structure agreed and preferably signed off by all participants via MOU or similar.	5 – Single point of coordination exists with agreed roles and responsibilities. 4 – Single point exists but with some minor exceptions. 3 – Single point exists in principle, but with some major omissions, or lack of agreement on some major areas. 2 – Initial steps taken to create a single point of coordination. 1 – No single point but plans exist to create one. 0 – No single point and no plans to create one.	The single point of co-ordination may be a person, or a group or committee (with sub-groups or committees as appropriate). It will coordinate the relevant (see below) activities of: - The city government and, if separate, highways, police, armed forces/civil defense, water, energy, or any other relevant city organizations); - Other tiers of government (eg state, ward-level) or neighboring municipalities); - Private sectors organizations with relevant roles – for example, utilities, phone companies, healthcare, logistics companies, fuel depots, property companies, and so on. Some cities may have different organizational arrangements for different types of disaster. However, these need at least to work through the same coordination point (person or committee) to ensure consistency in response arrangements; and also to enable management of simultaneous disasters as applicable. The test of relevance is whether the organization or activity must contribute in any way to preparing for the event scenarios covered below in Essential 2.
	1.1.2 Coordination of all relevant **event response** activities in the city's area, with clarity of roles and	Presence of organizational chart documenting structure and role definitions at each relevant	5 – Single point of coordination exists with agreed roles and responsibilities.	As above – the single point may be a person or a group.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
	accountability across all relevant organizations.	agency to achieve a single overall point of co-ordination. Structure agreed and preferably signed off by all participants via MOU or similar.	4 – Single point exists but with some minor exceptions. 3 – Single point exists in principle, but with some major omissions, or lack of agreement on some major areas. 2 – Initial steps taken to create a single point of coordination. 1– No single point but plans exist to create one. 0 – No single point and no plans to create one.	Event response coordination arrangements should be regularly tested, if not by real events, at least in simulation exercises – see Essential 9.
	1.1.3 Participation and coordination of all relevant organizations in the structure(s) defined.	Level of participation and coordination achieved (see right)	5 – Effective participation of all relevant agencies, private and public, in pre-event and event response activities. 4 – Effective participation but with some minor exceptions 3 – Participation but with significant gaps in participation, or failing to resolve some overlap, duplication etc. 2 – Some participation, perhaps between pairs of agencies – but not universal. Subject is receiving significant attention, however.	Effectiveness of participation and coordination can be measured by: - Attendance at meetings as required with staff of the right level for the decisions being made; - Timely and complete provision of agreed physical contributions (see below) - Absence of disagreement on roles, strategy, methods etc; - Achievement of planned timelines and milestones; - Extent to which proven either in practice or by simulation exercises (see essential 9). - Documented agreements to collaborate.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			1 – Intent exists to improve coordination but so far no impact. 0 – Collaboration is poor and no intent to improve it.	
	1.1.4 Co-option of physical contributions by both public and private sectors.	Identification of physical contributions for each major organization.	5 – All key contributions fully defined for pre and post-event, underwritten by MOUs. 4 – Most key contributions defined – some minor gaps in coverage. MOUs may not exist. 3 – Some contributions formally defined but full leverage of private sector yet to be achieved. 2 – One or two contributions defined for specific areas – perhaps via informal agreements. 1 – Plans being developed to seek contributions. 0 – No private sector contribution defined.	Physical contributions refer to plant and equipment, people, premises and accommodation, supplies, data, computer systems, and so on. These will supplement those provided by the city and may come from other agencies or from private sector organizations such as those defined above. The key is to have a clear view of what will be needed to supplement the city's own resources (defined in essential 9); and then to enter into explicit MOUs with the organizations that will supply those items.
	1.1.5 Coordination for all **post-event** activities in the city's area, with clarity of roles and accountability across all relevant organizations. .	Presence of organizational chart documenting structure and role definitions at each relevant agency to achieve a single overall point of co-ordination.	5 – Single point of coordination exists with agreed roles and responsibilities. 4 – Single point exists but with some minor exceptions. 3 – Single point in principle, but with some major omissions, or	As above – the single point may be a person or a group. Key activities will be: - Day to day government (especially if provided by a stand-in entity such as the armed forces, a neighboring state etc).

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
		Structure agreed and preferably signed off by all participants via MOU or similar.	lack of agreement on some areas. 2 – Initial steps taken to create a single point of coordination. 1– No single point but plans exist to create one. 0 – No single point and no plans to create one.	- Longer term management of rebuilding process – an organizational arrangement is needed for including all stakeholders including citizen groups. One major issue will be the speed with which this organization can be assembled and begin operation. The post event organization should in effect be mobilized at the same time as the event response organization, and will have a high degree of continuity with it.
1.2 Integration of disaster resilience with other initiatives	1.2.1 Extent to which *any* proposal in government is also evaluated for disaster resilience benefits or impairments.	Explicit stage in policy and budget approval process where disaster resilience side benefits, or impairments, of any city government initiative are identified and counted towards the Return on Investment (ROI) for that proposal. .	5 – Explicit decision step, applied to all policy and budget proposals in all relevant functional areas. 4 – Explicit or semi-explicit decision step, applied in most cases and in most functional areas. 3 –No formal process, but disaster resilience benefits are generally understood to be "helpful" to a proposal, in most functional areas. 2 – Decision step sometimes applied, but very likely to be overlooked in most functional areas if a proposal would impair disaster resilience. 1 – Applied ad hoc or occasionally. 0 – Not applied.	For example: - Traffic management systems may also help with evacuation, so increasing disaster resilience; - A development approval may locate people in harm's way; - A land use change may reduce benefit of wetlands in preventing floods. Includes, but not restricted to, the functional areas of: land use and zoning; development; water, energy; public safety; transportation; food supply; healthcare.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
1.3 Capture, publication and sharing of data	1.3.1 Extent to which data on the city's resilience position is shared with other organizations involved with the city's resilience.	Availability of a single "version of the truth" – a single integrated set of resilience data for practitioners.	5 – Full availability of the information listed at right on readiness and risk; fully shared with other organizations.. 4 – Some minor gaps, or the information is in more than one place – but it is shared and it is at least linked to enable navigation. 3 – Some more significant gaps, for example on readiness; other organizations may have to "hunt around" to create a complete picture for themselves. 2 – Some significant information on readiness and risk is withheld from other organizations or is missing and/or badly fragmented across multiple websites. 1 – Information provision to other organizations on readiness and risk is rudimentary at best. Not possible to for those organizations to derive specific conclusions for themselves. 0 – No information.	Information to consider making open for public access might include: - A summary of readiness – perhaps the LG SAT. - The outcomes of this scorecard; - An explanation of the hazards and perils that the city is thought to face, and probabilities; - A hazard-map based summary (see Essential 2) of at-risk areas; - A description of what building codes will protect against, and where these have been applied; - A full set of disaster response plans and known issues; - Key roles and accountabilities; - Planned investments that will affect the city's resilience position. - Further resources and contact details.
	1.3.2 Extent to which data on the city's resilience position is shared with the community organizations and public.	Availability of a single "version of the truth" – a single integrated set of resilience data for citizens and community organizations containing at least the items shown at right.	5 – Full availability of the information listed at right on readiness and risk; fully shared with other community organizations and available to	Information to consider making open for public access might include: - A summary of readiness – perhaps the LG SAT or a summary of the outcomes of this scorecard;

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			the public via website, mobile device etc. 4 – Some minor gaps, or the information is in more than one place – but it is shared and it is at least linked to enable navigation. 3 – Some more significant gaps, for example on readiness; other organizations or citizens may have to "hunt around" to create a complete picture for themselves. 2 – Some significant information on readiness and risk is withheld from other organizations or is missing and/or badly fragmented across multiple websites. . 1 – Information provision to other community organizations and to citizens on readiness and risk is rudimentary at best. Not possible to for those organizations or citizens to derive specific conclusions for themselves or their neighbourhoods. 0 – No information.	- An explanation of the hazards and perils that the city is thought to face, and probabilities; - A hazard-map based summary (see Essential 2) of at-risk areas; - A description of what building codes will protect against, and where these have been applied; - A full set of disaster response plans and known issues; - Key roles and accountabilities; - Planned investments that will affect the city's – or a neighbourhood's - resilience position. - Further resources and contact details.

Essential 2: Identify, Understand and Use Current and Future Risk Scenarios

City Governments should identify and understand their risk scenarios, and ensure that all stakeholders both contribute to, and recognize, these. Risk scenarios should identify hazards, exposures and vulnerabilities in at least the "most probable" and "most severe" ("worst-case") scenarios, paying particular attention to the following:

- How hazards might change over time, given the impact of factors such as urbanization and climate change;
- How multiple hazards might combine, and how repeated small scale disaster events (if there is a relevant risk of these) might accumulate in their impact over time;
- Geographic areas exposed and territorial impact;
- Population segments, communities and housing exposed;
- Economic assets and activities exposed;
- Critical infrastructure assets exposed, the consequent risk of cascading failures from one asset system to another (for example where loss of power prevents water being pumped or weakens the hospital system);
- Timescales over which risks, vulnerabilities and impacts occur and responses are required.
- Creation and publication of risk and exposure maps detailing the above.

Scenarios should be:

- The means for current and future investment decisions;
- Based on participatory processes that seek input from the full range of stakeholders (including ethnic and social groupings);
- Regularly updated;
- Widely communicated and used for decision-making purposes, and for updating of response and recovery plans.

Note that actions to address the hazards in each scenario are covered in other sections of the scorecard.

Data you will need to complete this section of the scorecard will include: *documentation of hazards, exposures and vulnerabilities; identification of critical assets and dependencies between these*.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
	2.1.1 Knowledge of hazards (also called perils) that the	Existence of recent, expert-reviewed estimates of	5 – Comprehensive estimates exist, were updated in last 3 years and	Cities need to have a view of the hazards or perils that they face – what specific hazards

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
2.1 Risk assessment	city faces, and their likelihood.	probability of known hazards or perils and their extents.	reviewed by a 3rd party. "Most severe" and "most probable" hazards are generally accepted as such. 4 – Estimates exist but have minor shortcomings in terms of when updated, level of review, or level of acceptance. 3 – Estimates exist but with more significant shortcomings in terms of when updated, level of review or acceptance. 2 - Some estimates exist but are not comprehensive; or are comprehensive but more than 3 years old; or are not reviewed by a 3rd party. 1 – Only a generalized notion of hazards, with no attempt systematically to identify probability. 0 – No estimates.	(tsunami, hurricane, earthquake, flood, fire etc) exist and how severe might they be? For each hazard there needs to be identified, as a minimum: - a "most probable" incident; - a "most severe" incident. Hazards may be identified from probability distributions, specifically conducted for the purpose of assessing disaster resilience: "most probable" would be at the midpoint of the range of hazards that need to be addressed and "most severe" would be from the top 10% of the probability range. Alternatively, they may be approximated from such sources as: - General hazard assessments for the region - Assumptions created as an input to land zoning, planning discussions or permitting; - Insurance industry risk assessments; - Expert opinion as to "typical" hazards; - Prior experience or historical records of disasters in the region. However, if these levels of knowledge are not available, cities should still try to assemble a picture from prior experiences and/or estimation of the general level of hazard that they face. Sophisticated cities may also attempt to estimate the impact of multiple consecutive

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
				smaller hazards, or combinations of hazards (a hurricane and accompanying storm surge, for example). It is important to note that hazards may change over time as a consequence of urbanization and land use (for example where deforestation increases propensity for flash flooding), climate change (for example, changing rainfall or storm patterns), or better knowledge (for example, understanding of seismic threats or likely storm tracks). Thus, hazard estimates need to be updated regularly.
	2.1.2 Knowledge of exposure and vulnerability	Existence of scenarios setting out city-wide exposure and vulnerability from each hazard level (see above).	5 – Comprehensive scenarios exist city-wide, for the "most probable" and "most severe" incidence of each hazard, updated in last 18 months and reviewed by a 3rd party. 4 – Scenarios have minor shortcomings in terms of coverage, when updated, level or thoroughness of review. 3 – Scenarios have more significant shortcomings in terms of coverage, when updated, level of review, thoroughness. 2 – Partial scenarios exist but are not comprehensive or complete; and/or are more than 18 months old; and/or are not reviewed by a 3rd party. 1 – Only a generalized notion of exposure and vulnerability, with no attempt systematically to identify impacts.	Exposure may be thought of as who or what (people, land, ecosystems, crops, assets, infrastructure, economic activity) is potentially in harm's way as a result of a hazard. Vulnerability may be thought of as the potential consequences of that exposure (loss of life, property or service; physical damage; health impact, economic impact; environmental impact and so on). Different exposures and/or vulnerabilities may combine, for example where the tsunami generated by the Tohoku earthquake in Japan in 2011 badly damaged the Fukushima nuclear power plant – generating a whole additional set of exposures and vulnerabilities. Exposures and vulnerabilities may be assessed from sources such as regional flood maps or earthquake hazard maps, or from expert estimation. Hazards, exposures and vulnerabilities need to be assembled into "scenarios". Scenarios are comprehensive pictures of the total impact of

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			0 – No risk assessment.	the hazard (if any) across all neighborhoods and all aspects of the city, and will include: - Exposure and vulnerability of neighborhoods and economic zones; - Exposure and vulnerability of critical infrastructure items, with and without alternatives (see below); - Benefit from, and status of ecosystem services, where applicable; - Estimates of recovery time, given estimated benefit of mitigation measures, if any. Scenarios will ideally have been for reviewed for thoroughness and plausibility by a 3rd party and updated in last 18 months. This is more frequently than the reviews of hazards, above, as land use and development that may affect exposure and vulnerability happens on a faster time-scale.
	2.1.3 Understanding of critical assets and the linkages between these.	All critical assets are identified (see Essential 8) and relationships between them are identified in the form of potential "failure chains". This is used to frame disaster plans and triage (se essential 9) and also retrofits and upgrades to improve the capability of the infrastructure to withstand disasters.	5 – Critical assets are identified city-wide and systematically linked into failure chains as applicable. The city has a retrofit and triage strategy that allows it to prioritize upgrades and repairs. 4 – Critical assets and failure chains are generally identified with some minor gaps and omissions. A retrofit and triage strategy exists but it may also have gaps.	As identified above, critical assets are equipment, facilities, infrastructure or computer systems/data that are critical to the functioning of the city, maintenance of public safety or disaster response. While many cities will identify these, at least to some degree it is much rarer to identify how they are linked and the "failure chains" that may exist. A failure chain is a set of linked failures spanning critical assets in multiple infrastructure systems in the city. As an example – loss of an electricity substation may stop a water treatment plant from

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			3 = Critical assets and failure chains identified to some degree but some significant known omissions; or 3 = Critical assets are identified but failure chains are not. No triage or strategy is therefore possible and retrofits are prioritized, if they happen at all, by individual city departments. 1 – Identification of critical assets is patchy at best – significant gaps exist by area, or by infrastructure system. No triage strategy. 0 – No identification of critical assets.	functioning; this may stop a hospital from functioning; and this in turn may mean that much of the city's kidney dialysis capability (say) is lost. This is a failure chain that spans energy, water and healthcare systems.
	2.1.4 Hazard maps	Presence of hazard maps	5 – Fully comprehensive, detailed and up to date hazard maps exist for the entire city, covering perils, assets and populations at risk, and are known to be accurate. 4 –Hazard maps exist for the entire city but with some minor omissions of content or detail, perhaps because an update is due. 3 – Hazard maps exist but with more significant omissions or known inaccuracies. 2 – Hazard maps are partial in coverage and fragmented: – exposure and vulnerability data for key assets or areas in particular may be entirely lacking.	(Publication of maps to other organizations and to the public – see Essential 1)

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			1 – Hazard maps are old, incomplete and known to be unsound as a basis for decision making. 0 – No maps.	
2.2 Update process	2.2.1 Process ensuring frequent and complete updates of scenarios.	Existence of a process agreed between all relevant agencies to: - Update hazard estimates every 3 years or less; - Update exposure and vulnerability assessments and asset inventory every 18 months or less.	5 – Update processes exist, are proven to work at required frequency and thoroughness, and are accepted by all relevant agencies; 4 – Processes exist with some minor flaws in coverage, date slippage or less important agencies being bought in. 3 – Processes exist, but with at least 1 major omission in terms of frequency, thoroughness or agency buy-in. Risk identification may be compromised in some areas, accordingly. 2 – Processes have some major flaws to the point where overall value is impaired and original risk assessments are becoming significantly obsolete. 1 – Processes are rudimentary at best. A complete risk assessment – even if elderly – has yet to be achieved. 0 – No processes.	Updates are essential because hazards may change over time (especially if weather or sea-level related); and because land use, population and economic activity patterns may also change as cities grow. Updates need to address: - Hazard patterns - Dwellings - Businesses - City infrastructure and facilities (see essential 8), including critical assets and failure chains. - Critical computer systems and data (see essential 8) - Schools and healthcare facilities (see essential 8) - Ecosystem services (see essential 5) The focus here is on the process itself and its ability to ensure continued and complete updating of scenarios. Updates may be by means of a regular updating exercise that captures all changes for the preceding period, or by means of an

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
				incremental update process that reliably captures changes as they occur.

Essential 3: Strengthen Financial Capacity for Resilience

Understand the economic impact of disasters and the need for investment in resilience. Identify and develop financial mechanisms that can support resilience activities. Key actions might include:

- Understand and assess the significant direct and indirect costs of disasters (informed by past experience, taking into account future risk); and the relative impact of investment in prevention rather than incurring more significant costs during recovery.
- Assigning a ring-fenced capital budget for any major works found to be necessary to improve resilience.
- Including risk management allocations in operating budget as required to maintain the required state of resilience over time.
- Assessing disaster risk levels and implications from all planning, permitting and capital spending decisions, and adjusting those decisions as needed.
- Creating incentives for homeowners, low-income families, communities, businesses and public sector to invest in reducing the risks they face (e.g. business continuity planning, redundancy, building upgrades).
- Applying (if necessary, generating) insurance coverage for lives, livelihoods, city and private assets.
- Exploring as needed innovative financing mechanisms such as specialised bonds, specialised insurance, tax efficient finance, development impact bonds etc.

Data you will need to complete this section of the scorecard will include*: budget and capital plan documentation; documentation of any incentives or financing schemes (for example, loans for seismic upgrades) with a disaster resilience impact, together with take-up statistics for each area of the city; insurance coverage statistics*.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
3.1 Financial plan and Budget	3.1.1 Adequacy of financial planning for all actions necessary for disaster resilience.	Presence of financial (capital and operating) plan(s) with a reasoned set of priorities, based on disaster resilience impact achieved, and keyed to "most probable" and "most severe" scenarios in Essential 2. Priorities for disaster resilience investment $$ are clear and defensible, based	5 – A coherent city-wide set of priorities exists that covers all identified needs, is argued coherently and assembled into a coherent set of 5 year plans (there may be multiple responsible agencies). Plans are protected from political change. 4 – Single 5 year set of priorities and plans exist but with some minor omissions and inconsistencies. Political continuity may be an issue.	If (as is likely) funding comes from several sources, the combined funding needs to be adequate for the city's disaster resilience needs, and also coherently deployed "as if" there was a single source and a single plan. Thus, if there are separate subsidiary plans (for example, transportation or sustainability plans), these need also to be coordinated, complete and mutually consistent.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
		on a view of most beneficial impact. Priorities are assembled into 5 year plan that integrates spending by all key organizations and will meet scenarios in Essential 2.	3 – Plans exist but longer than 5 years and may have some gaps and inconsistencies. Political continuity is a known issue, 2 – Multiple plans from different agencies – these have never been coordinated and it is unclear whether they are consistent or not or will together deliver the required level of disaster resilience. 1 – Plans exist but with substantial gaps. 0 – No prioritization – spending, if any, is haphazard. No plan	Plans also need to persist, even if changed or updated, through changes in the political leadership of the city.
	3.1.2 **Capital** funding for long run engineering and other works that address scenarios and critical asset identification in Essential 2 and Essential 8.	Funding for capital elements of plan(s) relative to estimated cost. Degree of protection ("ring-fencing") from cuts or from being taken away to be used for other purposes.	5 – Plans are 100% funded and protected. 4 – Plans are 75-100% funded and protected. 3 – Plans are 50-75% funded, and may be liable to funds being diverted for other purposes. 2 – Plans are 25-50% funded, and liable to funds being diverted for other purposes. 1 – Plans are 0-25% funded, and routinely diverted for other purposes. 0 – No plan.	If capital funds are spread across separate sources and/or organizations, the deployment of the combined funding needs to be coordinated and mutually consistent in line with the plan above.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
	3.1.3 O**perating** funding to meet all operating costs of disaster resilience activities.	Funding for operating expenses relative to estimated costs: presence of separately delineated budget line item(s). Degree of protection ("ring-fencing") from cuts or from being taken away to be used for other purposes.	5 – Budget exists, is 100% adequate and is protected. 4 – Budget exists, is 75-100% adequate, and is protected. 3 – Budget exists, is 50-75% adequate but is liable to diversion for other purposes. 2 – Budget exists, is 25-50% adequate but is liable to diversion for other purposes. 1 – Budget exists, but is only 0-25% adequate and is routinely diverted for other purposes. 0 – No budget.	If operating funds are spread across separate sources and/or organizations, or separate budget line-items, the deployment of the combined funding needs to be coordinated and mutually consistent in line with the plan above.
3.2 Contingency funds	3.2.1 Contingency fund for post disaster recovery (may be referred to as a "rainy-day fund"). .	Existence of fund(s) capable of dealing with estimated impacts from "most severe" scenario (See Essential 2). Degree of protection ("ring-fencing") of contingency fund(s) from being taken away to be used for other purposes	5 – Contingency fund (and insurance as applicable) exists to rectify impacts from "most probable" scenario, is 100% adequate and protected. 4 – Fund exists, is 75-100% adequate and protected. 3 – Fund exists, is 50-75% adequate but may be liable to funds being diverted for other purposes. 2 – Fund exists, is 25-50% adequate, and liable to funds being diverted for other purposes.	Include impact of insurance coverage where applicable (see below). Include money also available form other agencies, different levels of government etc.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			1 – Fund exists is only 0-25% adequate, and routinely diverted for other purposes. 0 – No fund.	
3.3 Incentives and financing for businesses, community organizations and citizens.	3.3.1 Affordability of, and help with achieving safe housing.	Existence of incentives and affordable financing to help owners and tenants of all sub-standard buildings bring them to a standard to deal with the "most severe" scenario (Essential 2).	5 – Incentives/financing exist, to address all known issues, for all segments of the city's population. 4 – Incentives/financing exist for most of the population with minor gaps in coverage of issues. 3 = Incentives/financing exist for most neighborhoods but gaps in issue coverage exist. 3 = Incentives exist for some issues but neighborhood coverage gaps exist. 1 – Significant weakness in coverage of the city, coverage of issues or in level of adequacy. 0 – No incentives.	Incentives and financing may come from multiple sources.
	3.3.2 Domestic insurance coverage	Extent of coverage of domestic housing. (Personal or life coverage is not assessed).	5 – 75 - 100% of likely housing losses from "most severe" scenario are covered city-wide by insurance. 4 – 75-100% of likely losses from "most probable" scenario are covered city-wide. 3 – 50-75% of likely losses from "most probable" scenario are covered city-wide.	This assessment covers insurance on domestic dwellings. Personal or life coverage is excluded. Governmental, industrial and commercial insurance is covered below. Insurance may come from multiple public or private providers.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			2 – 25-50% of likely losses from "most probable" scenario are covered city-wide. 1 – 0-25% of likely losses from "most probable" scenario are covered city-wide. 0 – No cover.	
	3.3.3 Incentives to businesses organizations to improve disaster resilience – disaster plans, premises etc.	Existence of incentives to help business owners take steps to improve disaster resilience to a standard to deal with the "most severe" scenario (Essential 2).	5 – Incentives are visibly achieving (or have achieved) required results evenly with businesses across the city. 4 – Incentives are generally effective but with some minor shortcomings perhaps in some areas. 3 = Incentives have larger gaps in coverage of the economic base. 3 = Incentives have larger gaps in coverage of the required issues. 1 – Incentives have major weaknesses and have so far failed to achieve their purpose 0 – No incentives.	Incentives and financing may come from multiple sources.
	3.3.4 Incentives to non-profit organizations to improve disaster resilience – disaster plans, premises etc.	Existence of incentives to help non-profits take steps to improve disaster resilience to a standard to deal with the "most severe" scenario (Essential 2).	5 – Incentives are visibly achieving (or have achieved) required results evenly with non profits across the city. 4 – Incentives are generally effective but with some minor shortcomings perhaps in some areas.	Incentives and financing may come from multiple sources. Non profits may be directly concerned with disaster resilience issues (for example, emergency response groups, neighborhood watch, food kitchens); or indirectly (for

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			3 = Incentives have larger gaps in coverage of the non-profit base. 3 = Incentives have larger gaps in coverage of the required issues. 1 – Incentives have major weaknesses and have so far failed to achieve their purpose 0 – No incentives.	example, churches, environmental watch or similar).
	3.3.5 Non-domestic insurance coverage	Extent of insurance coverage of non-domestic property, infrastructure and assets.	5 – 75 - 100% of likely losses from most severe scenario are covered city-wide by insurance. 4 – 75-100% of likely losses from "most probable" scenario are covered city-wide. 3 – 50-75% of likely losses from "most probable" scenario are covered city-wide. 2 – 25-50% of likely losses from "most probable" scenario are covered city-wide. 1 – 0-25% of likely losses from "most probable" scenario are covered city-wide. 0 – No cover.	This question covers insurance to commercial, industrial property and assets, as well as to NGO-, government- or city-owned buildings, assets and infrastructure. Domestic insurance is covered above. Insurance may come from multiple providers. Some governments and agencies and some businesses may self-insure. It will be necessary to confirm that funds exist to meet the likely needs.
3.4 Financing of resilience expenditures.	3.4.1 Pursuit of all possible methods of financing and funding, as required.	Where a city has outstanding resilience expenditure needs (revenue or capital) – the extent to which it has pursued all possible financing	5 – The city has a systematic inventory of financing methods and all potential sources of funds for different resilience expenditures, and a strategy	(If no additional financing needs apply, omit this assessment).

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
		strategies and funding sources.	for using them in ways that complements its own resources. 4 – The city knows of many funding methods and uses them, but not necessarily systematically or as part of an overall strategy. 3 – The city has a good range of funding sources and financing methods but uses them in an ad hoc way – some opportunities may be missed or sometimes external funds duplicate internal activity. 2 – The city knows of some funding sources and alternative financing strategies, and uses these from time to time, but some needed expenditures are not made when in fact funds might have been available. 1 – The city has only just begun to explore alternative financing methods and funding sources – it may have used them once. 0 – No exploration of financing methods and funding sources.	Alternative financing methods and sources may include, but are not restricted to: - Leasing; - Government grants, including matching grants; - Social impact or resilience bonds (payment for results achieved); - Development banks and aid organizations; - Foundations that may have a direct interest in some aspect of resilience – for example where a conservation NGO might support restoration of ecosystem services, or an education NGO might support awareness and training; - Other government agencies that may have a direct interest in some aspect of resilience – for example where a transportation agency finances a new bridge that may also improve evacuation capacity; - Crowd-funding; - Development fees; - Public-private partnerships; - Taxes and surcharges.

Essential 4: Pursue Resilient Urban Development

The built environment needs to be assessed and made resilient as applicable. Building on the scenarios and risk maps from Essential 2, this will include:

- Land zoning and management of urban growth to avoid or exacerbating resilience issues – identification of suitable land for future development taking into consideration of how low-income groups can access suitable land;
- Risk-aware planning, design and implementation of new buildings, neighbourhoods and infrastructure, using innovative or existing/traditional techniques as applicable;
- Addressing needs of informal settlements including basic infrastructure deficits such as water, drainage and sanitation
- Development and implementation of appropriate building codes, and using these to assess existing structures for resiliency to potential hazards, incorporating appropriate retro-fitting of prevention measures;
- Maximizing use of urban design solutions such as impermeable surfaces, green areas, shadowing, water retention areas, ventilation corridors etc) that can cope with risks and also reduce the dependency on technical infrastructure like sewage systems, dikes etc.
- Engaging affected stakeholders in appropriate and proportional participatory decision-making processes when making urban development decisions
- Incorporating exemplary sustainable design principles into new development. Link to other existing standards where appropriate (BREEAM, LEED, Greenstar, etc).
- Updating building regulations and standards regularly (or periodically) to take account of changing data and evidence on risks.

In addition, it will be necessary to assess infrastructure for resiliency to potential hazards: this is covered in Essential 8.

***Data you will need to complete this section of the scorecard will include**: land use, population, income levels and economic activity by segment of the city; and also relevant building codes and their application on a property-by-property basis*.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
4.1 Land use – effectiveness of land use zoning in preventing exposure build-up (See also essential 5 on ecosystem services)	4.1.1 Agricultural land at risk.	% of agricultural land at risk	5 – No loss of agricultural land from "most severe" scenario. 4 – No loss of agricultural land from "most probable" scenario. 3 – <2.5% of agricultural land at risk from "most probable" scenario.	This assessment is intended to focus on agricultural land required to feed the city, excluding imported food from other regions or countries. Loss is for 6 months or longer. Effectiveness of zoning should ideally be independently validated (see also Essential 2).

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			2 – 2.5-5% of agricultural land at risk from "most probable" scenario. 1 – 5-7.5% of agricultural land at risk from "most probable" scenario. 0 - >7.5% of agricultural land at risk from "most probable" scenario.	
	4.1.2 Economic activity at risk.	% of employment at risk	5 – No loss of employment from "most severe" scenario. 4 – No loss of employment from "most probable" scenario 3 – <2.5% of employment at risk from "most probable" scenario 2 – 2.5-5% of employment at risk from "most probable" scenario 1 – 5-7.5% of employment risk from "most probable" scenario 0 - >7.5% of employment at risk from "most probable" scenario	Employment is at risk from damage to farmland, factories, offices, and so on. Loss is for 3 months or longer. Effectiveness of zoning should ideally be independently validated (see also Essential 2).
		% of business output at risk	5 – No loss of business output from "most severe" scenario. 4 – No loss of business output from "most probable" scenario. 3 – <2.5% of business output at risk from "most probable" scenario. 2 – 2.5-5% of business output at risk from "most probable" scenario.	Business output measured in financial terms. This assessment also includes loss through business being forced to relocate elsewhere, even if only temporarily, due to loss of premises or facilities, loss of markets, loss of services from the city or loss of workforce through inability to reach their place of work. Loss is for 3 months or longer.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			1 – 5-7.5% of business output risk from "most probable" scenario. 0 - >7.5% of business output at risk from "most probable" scenario.	Effectiveness of zoning should ideally be independently validated (see also Essential 2).
	4.1.3 Potential population displacement.	% of population at risk of displacement	5 – No population displacement from "most severe" scenario. 4 – No population displacement from "most probable" scenario. 3 – <2.5% population displacement from "most probable" scenario. 2 – 2.5-5% population displacement from "most probable" scenario. 1 – 5-7.5% population displacement from "most probable" scenario. 0 - >7.5% population displacement from "most probable" scenario.	Displacement for 3 months or longer as a consequence of housing being destroyed or rendered uninhabitable, or the area in which it is located being rendered uninhabitable. This assessment also needs to cover informal and unplanned settlements. Effectiveness of zoning should ideally be independently validated (see also Essential 2).
4.2 Building codes	4.2.1 Existence of building codes designed to address risks identified in Essential 2.	Existence of applicable codes to all physical assets.	Codes exist that will ensure: 1– Zero damage (to the point safety risk) from "most severe" scenario. 4 – Zero damage (to the point of safety risk) from "most probable" scenario. 3 – Damage to <5% of all physical structures and assets to the point safety risk in the "most probable" scenario. 2 – Damage to 5-10% of all physical structures and assets to the point of	Building codes should be specifically evaluated for ability to deal with "most probable" and "most severe" scenarios in Essential 2. It may make sense to subdivide the city by region or neighborhood. Effectiveness of codes should ideally be independently validated (see also Essential 2).

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			safety risk in the "most probable" scenario. 1 - Damage to 10-20% of all physical structures and assets to the point of safety risk in the "most probable" scenario. 0 - Damage >20% of all physical structures and assets to the point of safety risk in the "most probable" scenario.	
	4.2.2 Application of building codes.	Implementation of building codes on relevant structures.	5 – Codes are 100% implemented on applicable structures 4 - Codes are 90-100% implemented on applicable structures 3 – Codes are 80-90% implemented on applicable structures. 2 – Codes are 70-80% implemented on applicable structures. 1 – Codes are 70-80 % implemented on applicable structures. 0 – Codes are <70% implemented on applicable structures	Effectiveness of codes should ideally be independently validated (see also Essential 2). Application of codes will be a particular issue in unplanned settlements.
	4.2.3 Updates to building codes.	Conformity of statutory codes with latest standards in building practice and with perils faced.	5 – Codes are or will be reviewed for suitability for "most severe" scenario and updated every 5 years or more frequently. They embody the latest standards in building practice. 4 – Codes are or will be reviewed for suitability for the "most probable"	Codes may be updated as building practice evolves or as new needs (for example an increased storm risk) dictate.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			scenario every 10 years. They may not embody the very latest standards in building practice. 3 – Codes are or will be reviewed for suitability for the "most probable" scenario every 10 years. They probably do not embody the very latest standards in building practice. 2 – Codes are or will be reviewed for suitability for the "most probable" every 15 years or longer. They are known to be obsolete in significant respects. 1 – Codes exist, but are not reviewed at all, and no there are no plans for this. They are wholly obsolete. 0 – No codes.	
4.3. New development	4.3.1 Urban design solutions that increase resilience.	Use of urban design solutions to improve resilience, often by maximizing the extent and benefit of ecosystem services within the city (see also Essential 5).	5 – Systematic use of design solutions to improve resilience throughout the city, enforced by codes. Assumed to be "the norm". 4 – Widespread use of urban design features but some missed opportunities. Proposals to use urban design solutions are likely to be favourably received but not mandated.. 3 – Some use of urban design features – perhaps in some areas, or perhaps concentrating on one or two solutions. Their use is not assured but the	Urban design solutions that can improve resilience will include, but are not limited to: - soakaways and porous pavement used to deal with urban storm-water run-off and replenish ground water; - underground parking garages used as holding tanks for storm water, and parks that function as flood zones; - green roofs to help cool buildings and reduce storm run-off; - trees and greenery to reduce heat-island effects, or stabilize hillsides;

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			argument for using them can be made depending on each case. 2 – Scattered use of urban design solutions, but interest in expanding this. 1 – Little use and little interest. 0 – No use and no interest.	- neighbourhood micro-grids or roof-top generation as back-up to the main energy supply.
	4.3.2 Sustainable building design standards	Use of sustainable building design standards such as LEED, GreenStar and BREEAM to improve resilience.	5 – Systematic specification of meaningful green building standards for all new-build or retrofit, enforced by codes. Assumed to be "the norm". 4 – Widespread use of green building standards, but some missed opportunities. Proposals to use such standards are likely to be favourably received but not mandated. 3 – Some use of green building standards – perhaps in the downtown area. Their use is not assured but the argument for using them can be made depending on each case. 2 – Scattered use of green building standards developing on the developer's interest, but interest in expanding this. 1 – Little use and little interest. 0 – No use and no interest.	Sustainable building designs can improve resilience by: - reducing demand for energy and water; - dealing better with heat events; - incorporating features such as green roofing that also helps to control storm water runoff;

Essential 5: Safeguard Natural Buffers to Enhance the Protective Functions Offered by Natural Ecosystems

Essential 5 addresses the identification, monitoring and protection of critical ecosystem services that confer a disaster resilience benefit. Relevant ecosystem services may include, but are not limited to: water retention or water infiltration; afforestation; urban vegetation; floodplains; sand dunes; mangrove and other coastal vegetation; and pollination. Many ecosystem services that are relevant to the city's resilience may be provided well outside its geographical area.

The essential includes:

- Recognising value and benefits from ecosystem services for disaster risk prevention, protecting and /or enhancing them as part of risk reduction strategies for cities.
- Considering also natural buffers in the rural hinterland of the city and wider region, and cooperation with municipalities there to establish a regional approach of land use planning to protect the buffers.
- Anticipating changes from climate trends and urbanization and planning to enable ecosystem services to withstand these.

Integration of ecosystem services for more urban resilience into urban land use management, urban design and into relevant investment projects, is covered in Essential 4.

Note that ecosystem services that benefit a city may be located many miles away (for example, where upstream forests may manage floodwater run-off to the benefit of cities on downstream floodplains). Ecosystem services may not be recognized or even suspected, and you may require external expertise to identify them. But if there really are no ecosystem services that affect your city's disaster resilience, omit this section. Ecosystem services that offer a generalized, planetary benefit (for example, polar icecaps) are excluded.

Data you will need to complete this section of the scorecard will include: *land use and zoning documentation, plus data on the extent and health of relevant ecosystems as measured by applicable indicators.*

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
5.1 Ecosystem services	5.1.1 Awareness of the role that ecosystem services may play in the city's disaster resilience.	Ecosystem services are specifically identified, and managed as critical assets.	5 - Critical ecosystem services identified and monitored annually on a defined set of key health/performance indicators. 4 – Critical ecosystem services identified and monitored annually, but less systematic use of metrics. 3 – Critical ecosystem services identified but have ad hoc monitoring – no real attempt to track health over time. 2 – Some key ecosystem services omitted from monitoring altogether. 1 – Identification and monitoring of ecosystem services is formative at best, or is seriously deficient. 0 - No monitoring.	Ecosystem services may include: - Sand dunes, coastal wetlands, mangroves or reefs that protect against storm surges and tsunamis; - Forestation that protects against flash flooding, landslides; - Natural overflow channels, sandy soil soak-zones, and marshes that can protect against river flooding and storm water run-off; - Lakes, rivers and aquifers that supply water; - Water-tables that, if lowered, may cause low-lying or reclaimed land to shrink to below sea level; - Trees and greenery that reduce urban heat-island effects or enable urban soak-way zones for flood management. The location of the ecosystem service may be many miles from the city, but still relevant to its disaster resilience: for example, mountain forestation can reduce flood crests that affect cities on floodplains hundreds of miles away. Many ecosystem services also relieve chronic stresses – for example, wetlands help to remediate water pollution; forests help to remediate air pollution, and so on. Where those chronic stresses degrade the city's disaster resilience (for example, where pollution reduces water available in a drought or where lack of pollinating insects reduces

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
				food supply) then the ecosystem services concerned should also be monitored.
	5.1.2 Ecosystem health	Change in health, extent or benefit of each ecosystem service in last 5 years.	5 - Improved health and performance across the board for critical eco-system services' 4 – At least neutral status across the board, with some improvements in some cases. 3 – Neutral status on average – some improvements offset by some declines. 2 – Generalized decline in ecosystem service status. 1 – Generalized severe degradation in status known or suspected. 0 – Potentially fatal damage to some or many key eco-system services.	Measures will include extent, health (perhaps captured as species diversity) and buffering capacity. Measures will be specific to each ecosystem and may need to be derived by scientists or technical experts practicing in the relevant areas.
	5.1.3 Impact of land use and other policies on ecosystem services	Absence of policies or land uses liable to weaken ecosystem services.	5 - Land use policies are strongly supportive of critical ecosystem services and are fully enforced.	This assessment complements the assessment of land use zoning in Essential 4.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			4 - Land use policies are strongly supportive of critical ecosystem services and are generally enforced. 3 - Land use policies are broadly supportive but are not fully enforced. 2 – Land use policies (or lack thereof) may lead or have led to damage to one or more critical ecosystem services. 1 – Land use policies (or lack thereof) inflict generalized degradation on ecosystem services. 0 – Land use policies (or lack thereof) may lead or have led to complete destruction of critical ecosystem services.	

Essential 6: Strengthen Institutional Capacity for Resilience

It is important ensure that all institutions relevant to a city's resilience have the capabilities they need to discharge their roles. "Institutions" include, as applicable, central, state and local government organizations; private sector organizations providing public services; (depending on locale, this may include phone, water, energy, healthcare, road operations, waste collection companies and others as well as those volunteering capacity or equipment in the event of a disaster); industrial facility owners and operators; building owners (individual or corporate); NGOs; professional, employers' and labor organizations; and cultural and civil society organizations (see Essential 7).

Capacity should be developed across the five key DRR areas of understanding, prevention, mitigation, response and recovery planning. Factors affecting capacity will include:

- Skills, including but not limited to: hazard/risk assessment, risk-sensitive planning (spatial and socio-economic), integrating disaster and climate risk considerations in project evaluation/design (including engineering design) , co-ordination, communication, data and technology management, and disaster management, response, recovery, assessment of structures post disaster; business and services continuity planning).
- Training, based ideally on case studies of how DRR can be implemented and what business continuity requires.
- Creating and implementing information and data frameworks for resilience and disaster risk reduction that build consistency in data capture and storage and enable data access, use and re-use by multiple stakeholder groups for regular development processes.

Shared understanding of roles and responsibilities, and a framework of shared and open information on resilience in the city are also important to capacity – these are covered in Essential 1.

Data you will need to complete this assessment include*: training curricula; training records for those trained, courses run; school and university curricula; survey and market research data on effectiveness*.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
6.1 Skills and experience	6.1.1 Availability of skills and experience in disaster resilience – risk identification, mitigation, planning, response and post event response.	Known (ie inventoried in last 1 year) availability of key skills, experience and knowledge.	5 – Skills inventory carried out in last year and all key skills and experience are available in required quantities for all organizations relevant to city disaster resilience. 4 – Inventory carried out - shows with minor gaps in	Skills will include: land planning, energy, environmental, water and structural engineering, logistics, debris disposal, healthcare, law and order, project planning and management **[others tbd].** Knowledge refers to operating knowledge of city government and city infrastructure(s): the

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			quantity or skill type in some organizations. 3 – Inventory carried out but each organization has at least one skill or experience type in short supply. 2 – Inventory may not have complete coverage, but known widespread lack of multiple skill or experience types in many organizations. 1 – Rudimentary and partial inventory. Suspicion of complete or almost complete lack of skills available across the city. 0 – No inventory.	energy, water, sanitation, traffic and other critical city systems at risk.(see Essential 8) Experience refers to experience of the types of perils the city faces (see Essential 2) (Some skills, knowledge or experience may be purchased from specialist consultancies, or supplied on a one-time basis by aid agencies). (First responders – see essential 9)
6.2 Public education and awareness	6.2.1 Exposure of public to education and awareness materials/messaging.	Coordinated public relations and education campaign exists, with structured messaging, channels, and delivery.	5 - Systematic, structured campaign exists using at least 6 of the media at right, via neighborhood mobilization (see essential 7), and schools outreach. 4 – Campaign uses at least 5 of the media/channels above, including 1 of neighborhood mobilization and schools outreach. 3 - Campaign uses at least 4 of the media/channels above; also	Likely to be based on information made public – see Essential 1. Media may include: - Print – books, newspapers, leaflets, fliers; - School and college teaching material; - TV – advertisements. Documentaries, news features; - Radio – as for TV; - Web – websites, advertisements, content on city web-sites;

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			weighted to least informative such as radio and poster ads. 2 – Campaign uses 3 of the media/channels above; also weighted to least informative such as radio and poster ads. 1 – Ad hoc – no structured education and awareness campaign as such. 0 - No education work.	- Mobile – as for web but also social media – Twitter, Facebook, Weebo etc; Possibly also create specialist app for city's disaster resilience information; - Posters – on buildings, busses, trains, city offices. Material may come from multiple agencies and sources, but should have coordinated messages. Schools and colleges may be an especially important channel; also churches, neighborhood groups, libraries.
		Exposures per member of the public, per month to messaging	5 - Average 1 or more exposures per person per week, city-wide. 4 - Average 1 exposure per person per two weeks, city-wide. 3 - Average 1 exposure per person per month, city-wide. 2 - Average 1 exposure per person per quarter, city-wide. 1 - Average 1 exposure per person per six months, city-wide. 0 - Average 1 exposure per person per year or worse.	Exposures established, for example, via traffic counts (web sites, mobile), audience figures (TV, radio), road traffic counts (ie, road traffic past posters), and so on. If funds permit exposures could also be validated via survey.
	6.2.2 Validation of effectiveness of education.	Knowledge of "most probable" risk scenario and knowledge of key response and preparation	5 – "Most probable" scenario, and applicable response and preparation, appears to be generally known by >90% of	Survey can be delivered to different samples via phone; surveys in school classes; mail-

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
		steps is widespread throughout city. Tested by sample survey.	respondents as verified by opinion poll. 4 – 75–90% known. 3 – 50-75% known. 2 – 25-50% known. 1 – 10-25% known. 0 – <10% known, or no poll.	shot; as an add-on to city meetings; as a fill-in portion for leaflets and print-media; and so on.
6.3 Training Delivery	6.3.1 Availability, take-up of training.	Training offered and available to all population (from city government, voluntary or other sources)	5 – Full training curriculum is available for all, derived from known or anticipated needs. 4 – Full training curriculum is available but not fully known about. 3 – Training curriculum available but has some gaps and may not be fully deployed across the city. 2 - Ad hoc training classes address some issues for some area of the city. 1 – Material is known to be dated or inaccurate and not in process of being updated. 0 - No training.	Important to build training into school and college curricula. (See also drills – Essential 9)
		% of population trained in last year.	5 - 5% or better in all neighborhoods	Effectiveness of training validated via drills – see Essential 9

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			4 – 2.5-5% in all neighborhoods 3 – 1-2.5% in all neighborhoods 2 – 0.5-1% in all neighborhoods 1 – <0.5% in all neighborhoods 0 - No training.	
		Frequency of repeat training	5 – 6 monthly refreshers and emergency drills city-wide for all trained participants. 4 – Annual refreshers and emergency drills city-wide for all trained participants. 3 – Annual refreshers and emergency drill cycle but may not be city-wide or reach all participants. 2 – Two-yearly refreshers and emergency drill cycle but may not be city-wide or reach all participants. 1 – Ad hoc refreshers and emergency drills – timing, attendance and content depends on enthusiasm of local organization. 0 - No refreshers or emergency drills.	See also Essential 9.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
6.4 Languages	6.4.1 Accessibility of education and training to all linguistic groups in the city.	Availability of all education and training in all languages spoken in the city.	5 – Available for 100% of linguistic groups and 100% of the population. 4 – Available for 95% of the population irrespective of language. 3 – Available for 90% of the population irrespective of language. 2 – Available for 85% of the population irrespective of language. 1 – Available for 80% of the population irrespective of language. 0 – Available for <80% of the population irrespective of language.	Cities with high numbers of different languages may need to settle for a selection of languages that reaches everyone as a first or second language. Validation will be required that 100% of population is being reached in this way.
6.5 Learning from others	6.5.1 Effort taken to learn from what other cities, states and countries (and companies) do to increase resilience	Learning activities executed with other cities and other practitioners.	5 – Regular (say, annual) exchanges with other cities and regions, specifically to share understand and capture resilience best practices, issues, responses; and examples exist of changes made in the city as a result. Supplemented by regular peer-to-peer contacts with practitioners in other organizations. 4 – Regular exchanges but may be in the context of other meetings with sharing of best	These activities are focused on learning and improving – actual coordination of response management and resilience planning is covered in Essential 1.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			practices as a side-effect. Outcomes are captured and some impact may be identified on how the city prepares for disasters. 3 – Reliance only on networking by individual practitioners in the organization with their peers in other organizations. These can be frequent, and there will be some attempt to capture and implement learnings. 2 – Occasional exchanges of a more one-off or ad hoc nature. Impact on/benefit for the city is diffuse and harder to identify 1 – Even networking is limited and learning potential is therefore also limited. 0 – No attempt to learn from others.	

Essential 7: Increase societal and cultural resilience

Social "connectedness" and a culture of mutual help has a major impact on the actual *outcomes* of disasters of any given magnitude. These can be encouraged by measures that include:

- Establishing and maintaining neighbourhood emergency response groups and training;
- Engaging and co-opting civil society organizations – churches, youth groups, clubs, advocacy groups (for example for the disabled);
- Providing community groups with "unvarnished" data on risk scenarios, the current level of response capabilities and thus the situation they may need to deal with;
- Formulation of neighbourhood plans by reference to such groups (see Essential 9);
- Offering education, training and support to such groups;
- Undertaking formal or informal censuses of those who may be vulnerable and less able to help themselves, in each neighbourhood, and understanding from them what their needs are;
- Using government "touch-points" with the public such as welfare or social services visits and offices, police, libraries and museums to build awareness and understanding;
- Engaging with employers as a communications channel with their workforces for disaster awareness, business continuity planning and training;
- Engage local media in capacity building (TV, print, social media, etc);
- Mobile (phone/tablet) and web-based "systems of engagement" (for example, crowdsourcing or disseminating data on preparedness).
- Translation of all materials into all languages used in the city.

Ensuring that the education curriculum within schools, higher education, universities and the workplace includes disaster awareness and training is a key element of social resilience – this is covered in Essential 6.

Data you will need to complete this assessment include*: list of grass-roots organizations and information on their size, roles and how they operate; details of how the city works with disadvantaged groups – for example, those in areas of high poverty; transient or nomadic communities; slum/favela residents; the elderly; physically or mentally sick or disabled; children; non-native language speakers*.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
7.1 Grass roots organizations	7.1.1 Coverage of grass roots organization(s) throughout the city.	Presence of at least one non-government body for pre and post event response for each neighborhood in the city.	5 – Grass roots organization(s) addressing full spectrum of disaster resilience issues exist(s) for every neighborhood, irrespective of wealth, demographics etc. . 4 - >75% of neighborhoods covered. 3 - >50 -75% of neighborhoods covered 2 - >25-50% of neighborhoods covered 1 – Plans to engage neighborhoods and maybe one or two initial cases. 0 – No engagement.	Grass roots organizations may include: - Those set up specifically for disaster resilience management (for example, community emergency response organizations). - Those serving some other purpose but willing and able to play a disaster resilience role: for example, churches, business Round Tables, youth organizations, food kitchens, neighborhood watch, day centers and so on. Grass roots organizations should be willing and able to contribute to disaster resilience plans for their area based on the input of their members. They need to be seen as legitimate, and to cooperate with each other and the city government. (Event response element is regularly tested at least in simulation exercises – see Essential 9)
	7.1.2 Effectiveness of grass roots network	Grass roots organization meeting frequency and attendance.	5 – For >75% of neighborhoods, one meeting per month, all personnel roles staffed and 10x formal role-holder numbers in regular attendance. 4 – For 50-75% of neighborhoods, one meeting per quarter – all roles staffed and 5 x role-holder numbers in attendance. No meetings in the rest.	Grass roots organizations defined as above.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			3 – For 25-50% of neighborhoods, semi-annual meetings, but with some gaps in roles and less than 3x role-holders in attendance. No meetings in the rest. 2 – For 25-50% of neighborhoods, annual meetings but with significant gaps in roles and less than 3x formal role-holders in attendance. No meetings in the rest. 1 – Ad hoc meetings in less than 25% of neighborhoods of a few "enthusiasts". 0 - No meetings.	
		Clear identification and coordination of pre and post-event roles for grass-roots bodies, supported by training. Roles agreed and signed off, preferably via MOU or similar.	5 – For >75% of neighborhoods, roles are defined and filled, coordination is effective within and between grass-roots bodies, and full training is both provided and attended. 4 – For 50-75% of neighborhoods, roles are defined and agreed, but some minor deficiencies in these or in training, or incomplete staffing in some cases. Coordination generally good but some lapses. No roles defined in the rest. 3 – For 25-50% of neighborhoods, most roles defined, but with more	One key issue is ensuring that there is a clear differentiation of roles between grass-roots organizations and between them and other entities such as city government – who is responsible for what? See also information sharing framework in Essential 1.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			significant omissions; some training but with gaps in coverage; coordination adequate but could be improved. No roles defined in the rest. 2 – For 25-50% of neighborhoods, a few key roles defined, but coordination is absent or poor and training notably incomplete. No roles defined in the rest, 1 – Plans in place to define roles and develop coordination mechanisms. 0 – No roles defined and no coordination.	
	7.1.3 Social connectedness and neighborhood cohesion.	Likelihood that residents will be contacted immediately after an event, and regularly thereafter to confirm safety, issues, needs etc.	5 – Sufficient volunteers are available from grass-roots organizations to give "reasonable confidence" that 100% of residents will be contacted within 12 hours of an event. 4 – 90% of residents within 12 hours 3 – 80% of residents 2 – 70% of residents 1 – 50% or less of residents 0 – No volunteers.	Social connectedness has been shown to have a major impact in reducing fatalities from disasters, and also in reducing opportunistic crime following an event. Connectedness is however difficult to measure directly. This assessment is written in terms of specifically identified volunteers and grass-roots organizations, taking these as a proxy measurement for connectedness. In addition, the "reasonable confidence" standard is inherently subjective. As well as this proxy measurement, therefore, other factors that you may also wish to take into account will include:

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
				- A history of people in each neighborhood meaningfully helping each other after previous events; - A strong fabric of community organizations in general, even if not focused on disaster resilience in the first instance.
	7.1.4 Engagement of vulnerable segments of the population.	Evidence of disaster resilience planning with or for the relevant groups covering the span of the vulnerable population. Confirmation from those groups of effective engagement.	5 – All groups are regularly engaged on disaster resilience issues and they or their representatives confirm as such. 4 – All major groups (measured by membership % of those defined as vulnerable in the city as a whole) are engaged – some minor gaps. 3 – One or more major gaps in coverage or effective engagement. 2 – Multiple major gaps in coverage or effective engagement 1 – Generalized failure to engage. 0 – No groups specifically identified.	Vulnerable segments of the population might include, as examples: - Those in areas of high poverty; - Transient or nomadic communities; - The elderly; - Physically or mentally sick or disabled; - Children; - Non-native language speakers. Engagement may be through neighborhood organizations or via specialist government organizations, charities, NGOs etc. These may also function as "grass roots" organizations (see above) (Public awareness, education and training materials – see Essential 7)
7.2 Private sector / employers	7.2.1 Extent to which employers act as a channel with employees.	Proportion of employers that pass resilience communications to employers, and allow limited time off for resilience volunteer activities.	5 – 50% of employers with more than 10 employees takes part in communicating with their workforce about resilience issues/ 10% take part in	Employees can act as an important communications conduit to employees on resilience issues, especially in the area of hazards faced and preparation – which are

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			resilience training and allow small amounts of time off for resilience volunteer activities. 4 – 40%/8%... 3 – 30%/5%... 2 – 20%/3%... 1 – 10%/1%... 0 – 0%/0%...	also likely to benefit them in the form of better continuity of operations after an event.
	7.2.2 Business continuity planning	Proportion of business with a solid business continuity plan	5 – All employers with more than 10 employees have some form of business continuity plan based on a planning assumptions validated by the city. 4 – 80%... 3 – 50%... 2 – 30% 1 – 10% or less 0 – 0% or don't know.	While business continuity plans are the concern of each business, their presence and effectiveness will play a major role in how rapidly the city's economy restarts after a disaster. Therefore cities need to be proactive in persuading businesses to undertake continuity plans, based on a shared view of the hazards and issues likely to arise.
7.3 "Systems of Engagement"	7.3.1 Use of mobile and e-mail "systems of engagement" to enable citizens to receive and give updates before and after a disaster	Use of mobile and social computing-enabled systems of engagement (supported by e-mail).	5 – All information before, during and after an event is available on mobile devices; this is supported by alerts on social media; this is also used to enable an in-bound "citizen to government" flow allowing	"Systems of engagement" is the term given to mobile device/social media and e-mail-based systems to pass information to individuals and also to capture information from them. They are usually paired with "systems of record" which are back-office and enterprise systems (such as the emergency management system).

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			crowd sourcing of data on events and issues. 4 – Extensive use is made of systems of engagement, with a few minor omissions. 3 – Some use is made, but there are larger gaps in the information available by this means and the in-bound flow works only via direct communication rather than mining of data generally. 2 – As for 3 but with no inbound flow. 1 – Only rudimentary use of systems of engagement – perhaps only via mobile access to the existing website which may not have been optimized for smartphones etc – but interest in expanding this. 0 – No use of systems of engagement.	Data capture may be directly, where a citizen directly contacts the city government, or via a data-mining – for example where some governments in Australia mine data from Twitter and SMS to gain an extra source of intelligence on wildfire outbreaks and status.

Essential 8: Increase Infrastructure Resilience

This essential addresses understanding how critical infrastructure systems will cope with disasters the city might experience (see essential 2) and developing contingencies to manage risks caused by these outcomes. This should be addressed through measures including, but not limited to:

- Assessment of capacity and adequacy in the light of the scenarios in Essential 2. Consider: possible damage to parallel infrastructure (for example, impact on evacuation capacity if one of two roads out of a city is blocked); and consider linkages between different systems (for example, impact if a hospital loses its power or water supply)
- Liaising with, and building connections between infrastructure agencies (including those that may be in the private sector) to ensure resilience is considered appropriately in project prioritization, planning, design, implementation and maintenance cycles.
- Tendering and procurement processes that to include resilience criteria agreed upon by the city and stakeholders and is consistent throughout.
- For emergency management infrastructure, assessment of "surge" capacity – ability to deal with suddenly increased loadings from law and order issues, casualties, evacuees, and so on.

Systematically triaged processes are also required for prioritization of retrofit or replacement of unsafe infrastructure. These are covered in Essential 2.

Critical infrastructure includes that required for the operation of the city and that required specifically for emergency response, where different. Infrastructure required for operation includes but is not limited to:

- transport – roads, rail, airports and other ports
- vehicle and heating fuel supplies
- telecommunication systems
- utilities systems (water, wastewater, electricity, gas, waste disposal)
- health care centres, hospitals
- schools and educational institutes
- community centres, institutions
- school facilities
- healthcare facilities
- food supply chain
- police and fire services
- jails
- "back office" administration – welfare payments, housing
- computer systems and data supporting the above

- (as resources allow, safety and survivability of cultural heritage sites and artifacts).

Infrastructure required for disaster response may include the above, plus (as examples):

- emergency or incident command centers, and associated communications and monitoring/situation awareness systems – these may include cameras, sensors and crowdsourcing mechanisms such as reading of SMS and Twitter feeds
- additional fire, police and ambulance vehicles
- national guard or other military services
- earth and debris-removing equipment
- pumps
- generators
- sports facilities, school buildings and so on that provide places of shelter
- mortuaries
- back-up computing facilities

Data you will need to complete this section of the scorecard will include*: disaster resilience plans for each infrastructure system (each may be owned by one or more separate agencies), and data on execution of those plans; location of, and relationship between, critical assets, the populations they serve, and documentation linking their loss or damage to the scenarios in Essential 2. This data is likely to come from multiple organizations and completion of this section of the scorecard will probably require engineering input.*

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
8.1 Protective Infrastructure	8.1.1 Adequacy of protective infrastructure (Ecosystem services offering protection or mitigation – see Essential 5)	Protective infrastructure exists or is in the process of construction – capabilities known to match hazards envisioned in "most probable" and "most severe" scenarios in Essential 2.	5 – Protective infrastructure fully in place designed to deal with "most severe" scenario with minimal economic or humanitarian impact. 4 – Protective infrastructure has some deficiencies relative to "most severe" scenario but designed to deal with "most probable" scenario. 3 – Protective infrastructure would mitigate most of "most likely" scenario but some impacts would be felt; deficiencies relative to "most severe" are more serious; 2 - Protective infrastructure would allow significant damage/impact from "most possible", and potentially catastrophic damage from "most severe". 1 - Protective infrastructure would mitigate some impacts but would still allow potentially catastrophic damage from "most probable" scenario. 0 –No protection in place.	Examples of protective infrastructure: - Levees and flood barriers; - Flood basins; - Sea walls (where used); - Shelters, such as tornado/hurricane shelters; - Storm drains; - Shock absorption capabilities fitted to infrastructure to deal with earthquakes.
	8.1.2 Effectiveness of maintenance	Processes exist to maintain protective infrastructure and ensure integrity and operability of critical assets.	5 – Audited annual inspection process and remediation of issues found. 4 – Audited inspections but remediation of minor items may be delayed by funding issues.	Examples of processes: - Levee maintenance; - Clearing storm drains; - Maintenance of emergency response equipment

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			3 – Audited inspections every 2 years or more; remediation may be delayed by funding issues. 2 – Non-audited inspections every 2 years or more – backlog of remediation issues. 1 – Haphazard inspections in response to incidents or reports from the public. Significant known backlog of maintenance issues such that effectiveness of infrastructure may be impaired. 0 – No regular inspections and backlog/maintenance status is unknown.	- Maintenance of back up and stand-by power or communications systems or other critical assets
8.2 Communications	8.2.1 Service days at risk of loss	"Communications loss factor". If a = estimated # of days to restore regular service area-wide b = % of user accounts affected … then communications loss factor = a x b (Example – 1.5 day's loss of service for 10% of user accounts in city = loss factor of 15%; 3 days' loss of service for 50% of user accounts in city = loss factor of 150%)	5 – No loss of service even from "most severe" scenario 4 – No loss of service from "most probable" scenario 3 – Loss factor of 1-25% from most probable" scenario 2 – Loss factor of 25-100% from "most probable" scenario 1 – Loss factor of 100-200% from "most probable" scenario 0 – Loss factor >200% from "most probable" scenario	Communications are arguably the most critical infrastructure of all, because all other infrastructures (as well as factors such as emergency response and public awareness) are likely to depend on them.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
	8.2.2 Designated critical asset service days at risk of loss from communications failure.	"Communications critical asset (CCA) loss factor". If a = estimated # of days to restore regular service area-wide b = % of critical assets affected … then CCA loss factor = a x b (Example – 1.5 day's loss of service for 10% of critical assets in city = loss factor of 15%; 3 days' loss of service for 50% of critical assets in city = loss factor of 150%)	5 – No loss of service even from "most severe" scenario 4 – No loss of service from "most probable" scenario 3 – Loss factor of 1-25% from most probable" scenario 2 – Loss factor of 25-100% from "most probable" scenario 1 – Loss factor of 100-200% from "most probable" scenario 0 – Loss factor >200% from "most probable" scenario	Critical communications assets might include, for example: - Police or armed forces communications systems - Water and energy sensing systems - Traffic control systems - Communication towers, transmitters, switches and other nodal components of public phone systems - Data- and switching-centers routing internet traffic. Service may be provided either from the asset itself or via a designated alternative/back-up.
	8.2.3 Cost of restoration.	Likely cost of loss of service and restoration of communications system(s) as % of annual billed revenue	5 – No loss of service. 4 - 10% of annual billed revenue 3 – 10-15% 2 – 15-25% 1 – 25-50% 0 - >50% of annual billed revenue.	This assessment is designed to help establish the return on investment from investing in hardening the relevant infrastructure, in reducing the burden of restoring the city to normal life after a disaster. If a communications system does not have billed revenue (for example a private radio network), calculate cost to replace as % of initial installation cost of entire system. Use same thresholds as shown left.
8.3 Electricity	8.3.1 Customer service days at risk of loss.	"Electrical energy loss factor". If : a = estimated # of days to restore regular service area-wide	5 – No loss of service even from "most severe" scenario 4 – No loss of service even from "most probable" scenario	Loss of service refers to service from the main electricity supply. It excludes the use of back up generators.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
		b = % of user accounts affected … then electrical energy loss factor = a x b (Example – 1.5 day's loss of service for 10% of user accounts in city = loss factor of 15%; 3 days' loss of service for 50% of user accounts in city = loss factor of 150%)	3 – Loss factor of 1-25% from most probable" scenario 2 – Loss factor of 25-100% from "most probable" scenario 1 – Loss factor of 100-200% from "most probable" scenario 0 – Loss factor >200% from "most probable" scenario	Loss of service should be assessed relative to the "normal" state: - If "normal" service is electricity 24 hours a day then loss of service is anything that reduces this; - If "normal" service is electricity for less than 24 hours per day, then loss of service is anything that reduces this still further.
	8.3.2 Designated critical asset service days at risk of loss from energy failure.	"Electricity critical asset (ECA) loss factor". If a = estimated # of days to restore regular service area-wide b = % of critical assets affected … then ECA loss factor = a x b (Example – 1.5 day's loss of service for 10% of critical assets in city = loss factor of 15%; 3 days' loss of service for 50% of critical assets in city = loss factor of 150%)	5 – No loss of service even from "most severe" scenario 4 – No loss of service even from "most probable" scenario 3 – Loss factor of 1-25% from most probable" scenario 2 – Loss factor of 25-100% from "most probable" scenario 1 – Loss factor of 100-200% from "most probable" scenario 0 – Loss factor >200% from "most probable" scenario	Critical electrical assets are those that are either: - Essential for the operation of some part of the energy grid for the city; - Essential for the functioning of some other critical asset (say, a water treatment plant or a rail line). Loss of service refers to service from the main electricity supply. Service may be provided either from the asset itself or via a designated alternative/back-up.
	8.3.3 Cost of restoration	Likely cost of lost service and restoration as % of annual billed revenue	5 – No loss of service. 4 - 10% of annual billed revenue 3 – 10-15% 2 – 15-25%	This assessment is designed to help establish the return on investment from investing in hardening the relevant infrastructure, in reducing the burden of restoring the city to normal life after a disaster.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			1 – 25-50% 0 - >50% of annual billed revenue	
8.4 Water, sanitation	8.4.1 Customer service days at risk of loss.	"Water/sanitation loss factor". If a = estimated # of days to restore regular service area-wide b = % of user accounts affected … then water/sanitation loss factor = a x b (Example – 1.5 day's loss of service for 10% of user accounts in city = loss factor of 15%; 3 days' loss of service for 50% of user accounts in city = loss factor of 150%)	5 – No loss of service even from "most severe" scenario 4 – No loss of service even from "most probable" scenario 3 – Loss factor of 1-25% from most probable" scenario 2 – Loss factor of 25-100% from "most probable" scenario 1 – Loss factor of 100-200% from "most probable" scenario 0 – Loss factor >200% from "most probable" scenario	Loss of service refers to service from the main water or sanitation system for the neighborhood or city, if present. It excludes the use of back up supplies or portable sanitation systems. If the *main* supply is a localized water supply or sanitation system (eg well or septic tank), this may in fact prove more disaster-resilient than a city-wide system. Loss of service needs to be assessed relative to the "normal" state. For example: - If "normal" service is potable running water in every house, 24 hours a day - then loss of service needs to be assessed as the removal or diminution of this service; - If "normal" is running water for washing but not drinking, 24 hours a day - then loss should be assessed relative to this; - If "normal" is either of the above but only for some hours a day, then the loss is relative to the "normal" number of hours – ie, where user accounts have even fewer hours a day of availability until service is restored; - If "normal" is standpipes or communal toilets, then loss is relative to this - the loss factor will be calculated by

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
				reference to the estimated numbers of households using the standpipes or communal toilets affected. - If "normal" for a neighborhood includes no sanitation at all, then focus on water alone and score that. Note – storm water systems are covered under "protective infrastructure", above.
	8.4.2 Designated critical asset service days (for example, service to hospitals or other critical assets) at risk of loss from water or sanitation failure.	"Water/sanitation critical asset (WCA) loss factor". If : a = estimated # of days to restore regular service area-wide b = % of critical assets affected … then WCA loss factor = a x b (Example – 1.5 day's loss of service for 10% of critical assets in city = loss factor of 15%; 3 days' loss of service for 50% of critical assets in city = loss factor of 150%)	5 – No loss of service even from "most severe" scenario 4 – No loss of service even from "most probable" scenario 3 – Loss factor of 1-25% from most probable" scenario 2 – Loss factor of 25-100% from "most probable" scenario 1 – Loss factor of 100-200% from "most probable" scenario 0 – Loss factor >200% from "most probable" scenario	Critical water or sanitation assets are those that are either: - Essential for the operation of some part of the water or sanitation systems for the city; - Essential for the functioning of some other critical asset (say, a hospital). Loss of service refers to service from the main water or sanitation system for the neighborhood or city, as above. Service may be provided either from the asset itself or via a designated alternative/back-up.
	8.4.3 Cost of restoration of service	Likely cost of lost service and restoration as % of annual billed revenue	5 – No loss of service. 4 - 10% of annual billed revenue 3 – 10-15% 2 – 15-25% 1 – 25-50%	This assessment is designed to help establish the return on investment from investing in hardening the relevant infrastructure, in reducing the burden of restoring the city to normal life after a disaster.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			0 - >50% of annual billed revenue.	
8.5 Gas (if applicable)	8.5.1 Safety and integrity of gas system (if applicable)	Use of fracture resistant gas pipes in seismic or flood zones, and installation of automated shut-off capabilities.	5 – Full use: automated shut-offs on every property and 100% fracture resistant pipe. 4 – >90% of properties; 90% fracture resistant pipe if applicable.. 3 – 75-90% in both cases; 2 – 50-75% in both cases 1 – 1-50% in both cases 0 – 0% in both cases.	Fracture resistant pipe: PVC pipe or similar. If no mains gas system present – omit this assessment.
	8.5.2 Customer service days at risk of loss.	"Gas loss factor". If a = estimated # of days to restore regular service area-wide b = % of user accounts affected … then gas loss factor = a x b (Example – 1.5 day's loss of service for 10% of user accounts in city = loss factor of 15%; 3 days' loss of service for 50% of user accounts in city = loss factor of 150%)	5 – No loss of service even from "most severe" scenario 4 – No loss of service even from "most probable" scenario 3 – Loss factor of 1-25% from "most probable" scenario 2 – Loss factor of 25-100% from "most probable" scenario 1 – Loss factor of 100-200% from "most probable" scenario 0 – Loss factor >200% from "most probable" scenario.	Loss of service refers to those customer premises where mains (piped) gas is available. If the main form of gas supply is bottles, this may prove more disaster-resilient than a piped (mains) supply. Bottled gas is dealt with under fuel supply, below. "Loss of service" needs to be assessed relative to the "normal" state – for example, a significant drop in gas pressure relative to normal levels. .
	8.5.3 Designated critical asset service days at risk of	"Gas critical asset (GCA) loss factor". If :	5 – No loss of service even from "most severe" scenario	Critical gas assets are those that are either:

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
	loss from gas supply failure.	a = estimated # of days to restore regular service area-wide b = % of critical assets affected … then GCA loss factor = a x b (Example – 1.5 day's loss of service for 10% of critical assets in city = loss factor of 15%; 3 days' loss of service for 50% of critical assets in city = loss factor of 150%)	4 – No loss of service even from "most probable" scenario 3 – Loss factor of 1-25% from most probable" scenario 2 – Loss factor of 25-100% from "most probable" scenario 1 – Loss factor of 100-200% from "most probable" scenario 0 – Loss factor >200% from "most probable" scenario	- Essential for the operation of some part of mains gas system for the city; - Essential for the functioning of some other critical asset (say, a power-station). Service may be provided either from the asset itself or via a designated alternative/back-up.
	8.5.4 Cost of restoration of service	Likely cost of lost service and restoration as % of annual billed revenue	5 – No loss of service. 4 - 10% of annual billed revenue 3 – 10-15% 2 – 15-25% 1 – 25-50% 0 - >50% of annual billed revenue.	This assessment is designed to help establish the return on investment from investing in hardening the relevant infrastructure, in reducing the burden of restoring the city to normal life after a disaster.
8.6 Transportation	8.6.1 Road – service from road system at risk of loss	Road loss factor – if: a = miles of major road network for city and surrounding area at risk of becoming impassable to any type of vehicle after event b = likely number of days estimated before reopening,	5 – No loss of service even from "most severe" scenario 4 – No loss of service even from "most probable" scenario 3 – Loss factor of 1-25% from most probable" scenario 2 – Loss factor of 25-100% from "most probable" scenario	Loss of service refers to general road mobility. It primarily refers to damage to road surfaces or bridges and tunnels, or from fallen debris from buildings, cliffs etc.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
		c = total of major roads in the city and surrounding area lost for one day …then road loss factor = (a/c) x b as a % (Example - 10 miles of major road likely to be lost for two days, out of total of 100 miles of major road = road loss factor of 20% ((10/100) x 2)	1 – Loss factor of 100-200% from "most probable" scenario 0 – Loss factor >200% from "most probable" scenario	
	8.6.2 Road – survival of critical access and evacuation routes	Road critical asset (RCA) loss factor. If: a = carrying capacity (vehicles per hour) of evacuation/emergency supply routes to and from the city at risk of becoming impassable after event. b = # of days estimated before reopening c = carrying capacity (vehicles per hour) of all designated critical evacuation/emergency supply routes … then RCA loss factor = (a/c) x b as a % (Example –route with carrying capacity of 1,000 vehicles per hour likely to be closed for 3 days, out of a total carrying capacity on all evacuation/	5 – No loss of service even from "most severe" scenario 4 – No loss of service even from "most probable" scenario 3 – Loss factor of 1-25% from most probable" scenario 2 – Loss factor of 25-100% from "most probable" scenario 1 – Loss factor of 100-200% from "most probable" scenario 0 – Loss factor >200% from "most probable" scenario	Loss of service on critical access and evacuation routes should if possible also include an estimate of the likely impact of traffic gridlock on access or evacuation rates.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
		supply routes of 2,000 vehicles per hour = RCA loss factor of 150% ((1000/2000 x 3)		
	8.6.3 Rail/metro (if applicable) – service from rail system at risk of loss	Rail loss factor (for rail, use tons; for metro, use passengers). If: a = carrying capacity (tons or passengers per day) of affected rail lines to the city b = # of days estimated before reopening c = carrying capacity (tons per day per hour) of all rail links to the city. … then RCA loss factor = (a/c) x b as a % Example –rail line with carrying capacity of 10,000 tons or passengers per day likely to be closed for 2 days, out of a total carrying capacity on all rail lines of 15,000 tons or passengers per day = RCA loss factor of 133% ((10000/15000 x 2).	5 – No loss of service even from "most severe" scenario 4 – No loss of service even from "most probable" scenario 3 – Loss factor of 1-25% from most probable" scenario 2 – Loss factor of 25-100% from "most probable" scenario 1 – Loss factor of 100-200% from "most probable" scenario 0 – Loss factor >200% from "most probable" scenario.	Electrified rail lines are susceptible to energy outages (see above); and diesel lines are susceptible to fuel shortages (see below). If no rail lines, omit this assessment.
	8.6.4 Air (if applicable)	Airport loss factor. If: a = estimated # of flights in and out per day possible after the disaster	5 – No loss of service even from "most severe" scenario 4 – No loss of service even from "most probable" scenario	If no airport, omit this assessment. If multiple airports, combine capacities and scores. Airports should be capable of admitting commercial airliners or military transport aircraft - omit minor airfields.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
		b = max # of flights per day in normal operations c = # of days estimated before restoration of full capacity, then Airport loss factor = (a/b) x c as a % Example if 80 flights in and out per day are possible after a disaster, compared with a normal maximum of 100, and it takes 2 days to restore full capacity, then the airport loss factor is 160% ((80/100) x 2).	3 – Loss factor of 1-25% from most probable" scenario 2 – Loss factor of 25-100% from "most probable" scenario 1 – Loss factor of 100-200% from "most probable" scenario 0 – Loss factor >200% from "most probable" scenario.	
	8.6.5 River/Sea (if applicable)	River/seaport loss factor. If: a = estimated # of dockings per day possible after the disaster b = max # of dockings per day in normal operations c = # of days estimated before restoration of full capacity, then River/seaport loss factor = (a/b) x c as a % (Example if 5 dockings per day are possible after a disaster, compared with a normal maximum of 8, and it takes 2 days to restore full capacity, then the airport loss factor is 125% ((5/8) x 2).	Per port: 5 – No loss, even from "most severe" scenario 4 – No loss, even from "most probable" scenario 3 – 0.1-1 day from "most probable" scenario 2 – 1-2 days from "most probable" scenario 1 – 2-5 days from "most probable" scenario 0 - > 5 days	If no river or seaports, omit this assessment.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
	8.6.6 Other public transport (if applicable)	(Buses and taxis effectively captured in road measures above).	5 – No loss of service even from "most severe" scenario 4 – No loss of service even from "most probable" scenario 3 – Loss factor of 1-10% from most probable" scenario 2 – Loss factor of 20% from "most probable" scenario 1 – Loss factor of 30% from "most probable" scenario 0 – Loss factor >30% from "most probable" scenario	Omit if not applicable.
8.7 Law and Order, First responders	8.7.1 Protection of critical law and order/responder assets.	"Law & Order critical asset (LOCA) loss factor". If a = estimated # of designated critical law and order assets rendered inoperable by the event b = total # of designated critical law and order assets … then LOCA loss factor = a/b expressed as % (Note – days loss of use is not relevant here as these are assets are most likely to be needed right after the event)	5 – No loss of service even from "most severe" scenario 4 – No loss of service even from "most probable" scenario 3 – Loss factor of 1-10% from most probable" scenario 2 – Loss factor of 20% from "most probable" scenario 1 – Loss factor of 30% from "most probable" scenario 0 – Loss factor >30% from "most probable" scenario	Critical law and order/responder assets include such items as: - Vehicles (fire-fighting, ambulances, police vehicles) - Helicopters and aircraft - Emergency food and first aid stocks/supplies; - Shelters; - Back-up generators; - (Communications systems – see above) - (Operations centers – see below) - (Key buildings – see below);

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
				- (Critical IT systems – see below). Service may be provided either from the asset itself or via a designated alternative/back-up.
	8.7.2 Disaster resilience of prison system	Ability of prison system to survive "most probable" and "most severe", scenarios, without releasing or harming inmates.	Under "most severe" scenario: 5 – No loss 4 – Some minor damage to facilities is probable – no less of life or loss of custody 3 – Significant damage to facilities is probable but no loss of life or custody. 2 – Significant damage to facilities and possible risk of loss of life or custody 1 - Significant damage to facilities and possible significant risk of loss of life or custody 0 – Widespread generalized failure to keep inmates in place, safely,	Includes police station cells or other detention facilities blocks as well as prisons.
8.8 Education facilities	8.8.1 Structural safety of education facilities	% of education structures at risk of damage from "most probable" and "most severe" scenarios	5 – No teaching facilities at risk even from "most severe" 4 – No teaching facilities at risk from "most probable" 3 – 1-5% of teaching facilities at risk from "most probable" 2 – 5-10% of teaching facilities at risk from "most probable"	Some schools may be assessed as critical assets as they provide shelter – see Essential 9.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			1 – 10-15% of teaching facilities at risk from "most probable" 0 – >15% of teaching facilities at risk from "most probable"	
	8.8.2 Loss of teaching time	Number of teaching days lost as % of total in academic year.	5 – No loss of teaching days 4 – 1% of annual teaching days lost from "most severe"; 0.5% from "most probable". 3 – 5% of annual teaching days lost from "most severe"; 2.5% from "most probable". 2 – 10% of annual teaching days lost from "most severe"; 5% from "most probable". 1 – 20% of annual teaching days lost from "most severe"; 10% from "most probable". 0 – > 20% of annual teaching days lost from "most severe"; >10% from "most probable".	Teaching may continue to be provided in the original facilities or in designated alternative facilities. However, this assessment needs to include an estimate of the impact of teachers either injured or unable to get to work.
	8.8.3 Education data	% of critical education data and associated applications imaged at remote site.	5 – All critical education data and associated apps routinely backed up and processable within 24 hours at a remote site not known to be vulnerable to any events affecting the city 4 – 90% or more of critical education data, with associated apps…	(Communications disaster resilience – see above).

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			3 – 80% or more of critical education data, with associated apps… 2 – 70% or more of critical education data, with associated apps… 1 – 60% or more of critical education data, with associated apps… 0 – Less than 60% of critical education data, with associated apps…	
8.9 Healthcare	8.9.1 Structural safety and disaster resilience of health care and emergency facilities (Staffing/ first responders – see essential 9)	"Bed days lost" – estimated # of beds at risk x number of days' loss under "most probable" and "most severe" scenarios.	5 – No bed days lost even under "most severe" scenario. 4 – No bed days lost under "most probable" scenario. 3 –1-5% of annual bed days lost from most probable" scenario. 2 – 5-10% of annual bed days lost from "most probable" scenario . 1 – 10-15% of annual bed days lost from "most probable" scenario. 0 –>15% of annual bed days lost from "most probable" scenario.	Healthcare may continue to be provided at the original facilities if they are sufficiently disaster resilient, or in designated alternative facilities (although moving patients is usually undesirable and the feasibility of this after a disaster needs to be considered).
		"Critical bed days lost: estimated # of bed days for designated critical services (eg ER, dialysis, intensive care – TBD) at risk under "most probable" and "most severe" scenarios.	5 – No critical bed days lost even under "most severe" scenario 4 – No critical bed days lost under "most probable" scenario 3 – <2.5% of critical annual bed days lost from most probable" scenario	Healthcare may continue to be provided at the original facilities or in designated alternative facilities (although moving patients is usually undesirable, especially for those with critical injuries and the feasibility of this after a disaster needs to be considered).

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			2 – 2.5-5% of critical annual bed days lost from "most probable" scenario 1 – 5-7.5% of critical annual bed days lost from "most probable" scenario 0 –>7.5% of critical annual bed days lost from "most probable" scenario	
	8.9.2 Health records and data	% of patient and health system data and associated apps stored and processable at location unlikely to be affected by the event.	5 – All critical healthcare data and associated apps routinely backed up and processable within 1 hour at a remote site not known to be vulnerable to any events affecting the city 4 – 95% or more of critical healthcare data, with associated apps. 3 – 90% or more of critical healthcare data, with associated apps. 2 – 85% or more of critical healthcare data, with associated apps. 1 – 80% or more of critical healthcare data, with associated apps. 0 – Less than 80% or more of critical healthcare data, with associated apps.	Healthcare data covers: - Personal medical records and histories - Dental records (may be needed for identification of victims); - Critical operating data for healthcare facilities. (Communications disaster resilience – see above). Loss of data needs to be assessed relative to what pre-existed the disaster.
	8.9.3 Availability of emergency healthcare including facilities and urgent medical supplies for acute needs.	Sufficient acute healthcare capabilities exist to deal with expected major injuries.	5 – 100% of major injuries in "most probable" scenario; and 90% of major injuries in "most severe" scenario, can be treated within 6 hours. 4 – 100% of major injuries in "most probable" scenario; and 90% of major	This assessment needs to take into account estimated losses in critical bed days, above.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			injuries in "most severe" scenario, can be treated within 12 hours. 3 – 100% of major injuries in "most probable" scenario; and 90% of major injuries in "most severe" scenario, can be treated within 18 hours. 2 – 100% of major injuries in "most probable" scenario; and 90% of major injuries in "most severe" scenario, can be treated within 24 hours. 1 – 100% of major injuries in "most probable" scenario; and 90% of major injuries in "most severe" scenario, can be treated within 36 hours. 0 – Longer than 36 hours, or no emergency healthcare capability.	
8.10 Administrative operations	8.10.1 Assurance of continuity of all critical administration functions.	Estimated # of days disruption to critical administration services under "most probable" and "most severe" scenarios, given availability of redundant facilities, support staff etc.	5 – No disruption to services even under "most severe" scenario 4 – No disruption to services under "most probable" scenario 3 - Minor disruptions (few hours or less) under "most probable" scenario 2 – Some significant disruptions for up to 48 hours or less under "most probable" scenario 1 – Significant disruptions for 48 hours – 5 days under "most probable" scenario	Critical administration functions will include those that directly affect the well being of the public or individuals. For example: - Payment of food-stamps or unemployment benefit; - Housing offices; - Reporting of damage after the disaster; - Trash collection and disposal (impacts from road closures are covered above). (Healthcare and education – see above). (Critical IT systems – see below)

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			0 – Generalized failure of services for > 5 days	The assessment of disruption is intended to apply at the neighborhood level, for example with closure of or damage to neighborhood offices.
8.11 Computer systems and data	8.11.1 Assurance of continuity of computer systems and data critical to government continuity.	% of critical applications and associated data (to include social services and other personal records) imaged at, and accessible from, remote site.	5 – All critical apps and data routinely backed up and processable within 1 hour at a remote site not known to be vulnerable to any events affecting the city 4 – 90% or more of critical apps, with associated data… 3 – 80% or more of critical apps, with associated data… 2 – 70% or more of critical apps, with associated data… 1 – 60% or more of critical apps, with associated data… 0 – Less than 60% of critical apps, with associated data…	This assessment is focused on the computer systems required for the critical administration functions identified above. (Communications disaster resilience – see above). (Health and Education data – see above)
	8.11.2 Assurance of continuity of computer systems and data critical to	% of critical applications and associated imaged at, and accessible from, remote site.	5 – All critical apps and data routinely backed up and processable within 15 minutes at a remote site not known to	This assessment is focused on the SCADA systems, PLCs, control rooms, logistics and planning systems and so on that are required

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
	any of the above infrastructure.		be vulnerable to any events affecting the city 4 – 90% or more of critical apps, with associated data… 3 – 80% or more of critical apps, with associated data… 2 – 70% or more of critical apps, with associated data… 1 – 60% or more of critical apps, with associated data… 0 – Less than 60% of critical apps, with associated data…	to maintain the operation of the infrastructure items above. (Communications disaster resilience – see above). (Health and Education data – see above)

Essential 9: Ensure Effective Disaster Response

Building on the scenarios in Essential 2, ensure effective disaster response, for example by:

- Creating and regularly updating contingency and preparedness plans, communicated to all stakeholders through the structure in Essential 1 (especially including other levels of government and adjacent cities, infrastructure operators, community groups). Contingency plans to include law and order, providing vulnerable populations with food, water, medical supplies, shelter, and staple goods (e.g. for housing repairs).
- Developing and installing detection and monitoring equipment and early warning systems and effective associated communication systems to all stakeholders and community groups.
- Ensuring interoperability of emergency response systems adjacent countries, between agencies and with neighbouring cities.
- Holding regular training, drills/tests and exercises for all aspects of the wider emergency response "system" including community elements and volunteers.
- Integration of risk reduction and emergency response with engineers, contractors, et al to be able to effectively and efficiently engage in preparedness, response and recovery operations.
- (Coordinating and managing response activities and relief agencies' inputs).
- Ensuring in advance that a viable mechanism will exist for the rapid, rational and transparent disbursement of funds after a disaster (Essential 10).
- Assigning and ring-fencing adequate contingency funds for post event response and recovery (Essential 3).

Data you will need to complete this section of the scorecard (potentially from multiple organizations and agencies) will include: *which warning systems exist and whom they will reach; emergency management plans and procedures that specifically consider the impact of the scenarios in section 3; documentation of first responder – staffing and equipment - capabilities; records of drills and practices; identification of systems where interoperability with other agencies is critical and of the standards adopted; and records of evaluations, learning points and improvements enacted.*

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
9.1 Early warning	9.1.1 Existence and effectiveness of early warning systems.	Length and reliability of warning – enabling practical action to be taken.	5 - Warnings exist for all hazards known to be relevant to the city, and will allow time for reaction (as far as technology permits). Warnings are seen as reliable and specific to the city.	The technology of disaster warnings is rapidly evolving, both in the long-term assessment of risk (for example weather risk in the coming season) and the notification period and update frequency for a specific event (for example

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			4 – Warnings exist but warning time maybe less than technology currently permits. Warnings are seen as reliable and specific. 3 - Some hazards, especially earthquakes, are excluded and warning time may be less than technology permits. (If earthquakes are the only hazard for your city, score 0). 2 – Warning time is less than technology permits and there may also be some false positives: reliability of warnings may therefore be perceived as questionable. 1 – Warnings seen as ad hoc and unreliable. Likely to be ignored. 0 - No warnings.	the progress of a flood crest down a river, or landslide risk, or tornado warnings). Improved warning may enable an improved risk assessment in Essential 2, for example, by enabling better preparation or enabling more people to move from harm's way. However, while they are the focus of much research currently, meaningful earthquake warning systems do not currently exist for practical purposes. If earthquakes are the only hazard for your city, score 0.
		Reach of warning – will 100% of population receive it?	5 - 100% reached. 4 – 90-100% reached. 3 – 80-90% reached. 2 – 70-80% reached. 1 – 50-70% reached.. 0 - <50% reached (or no warnings – see above).	Warnings should be delivered over the maximum possible notice period via multiple media, including phone, TV, radio, web, as well as sirens.
9.2 Event management plans	9.2.1 Existence of emergency response plans that integrate professional	Existence of plans formulated to address "most likely" and "most severe" scenarios, shared and signed	5 - Complete plans exist, keyed to scenarios referenced in Essential 2.	Emergency management plans will need to cover:

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
	responders and grass roots organizations. (For post-event response - see Essential 10)	off by all relevant actors (including citizen organizations	They have been tested in real emergencies. 4 – Complete plans exist as above, but may not have been fully tested. 3 - Plans exist but are not keyed to scenarios referenced in Essential 2. 2 – Plans exist are known to be incomplete or otherwise deficient. 1 – Plans exist but are known to have major shortcomings. 0 - No plans.	- Command and control - coordination with other agencies and cities, roles, responsibilities (see Essential 1); - Evacuations (including hospitals, jails, etc.); - Communication systems; - Critical asset management (including likely "failure chains" – see Essential 8); - Medical response; - Law and order response; - Fire and rescue response; - Public information; - Triage policies; - Incorporation of contributions from citizen/grass roots organization. Elements of emergency management plans may be linked to, and tested through, plans for "regular" events such as sporting fixtures, carnivals or parades (see below).
9.3 Staffing/responder needs	9.3.1 'Surge" capacity of police also to support first responder duties	Sufficient back-up or para-professional capacity to maintain law and order in "most severe" and "most probable" scenarios, in addition to supporting burden of first responder duties.	5 – Surge capacity exists and is tested either via actual events or practice drills for scenarios in Essential 2 – coverage of all neighborhoods will be possible within 4 hours. 4 – Adequate surge capacity nominally exists but is untested.	This capacity may come from other agencies such as the Army or civil defense force but needs to be confirmed via MOU or similar.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			3 – Surge capacity exists but is known or suspected to have minor inadequacies, perhaps in location, numbers. Coverage of all neighborhoods within 4-12 hours. 2 – Coverage of all neighborhoods within 12-48 hours. 1 – Coverage of all neighborhoods within 48-72 hours. 0 – No surge capacity identified.	
	9.3.2 Definition of other first responder and other staffing needs, availability – including fire, ambulance, healthcare, neighborhood support etc.	Staffing needs are defined for "most probable" and "most severe" scenarios.	5 – Needs defined, either from actual events or from practice drills for scenarios in Essential 2, taking into account the role of volunteers. 4 – Needs defined independently of latest scenarios. 3 – Some needs defined but with some gaps for specific professions or for specific areas of the city. 2 –Needs definition has more serious shortcomings. 1 –Needs definition is essentially nominal or guesswork. 0 - No needs defined (or no plan – see above).	Different national response standards may apply in this area. Parts of this capacity may come from other agencies such as the Army or civil defense force.
		Estimated shortfall in staff/responders per defined needs – potentially from multiple sources. MOUs	5 - Staffing and responders known to be available either from actual events or practice drills for scenarios in	Different national response standards may apply in this area.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
		exist for non city sources, especially from private sector.	Essential 2, in line with defined needs for "most severe" scenario. 4 - Staffing and responders known to be available in line with defined needs for "most probable" scenario. 3 – Shortfall of <5% of ideal staff numbers from "most probable". 2 – Shortfall of 5-10% of ideal staff numbers. 1 – Shortfall of >10% of ideal staff numbers. 0 - No definition of needs – see above.	
9.4 Equipment and relief supply needs	9.4.1 Definition of equipment and supply needs, and availability of equipment.	Equipment and supply needs are defined for "most probable" and "most severe" scenarios in essential 2	5 – Needs defined, keyed to scenarios from essential 2, and take into account the role of volunteers. 4 – Needs defined independently of latest scenarios 3 – Some needs defined but with some gaps for specific professions or for specific areas of the city. 2 –Needs definition has more serious shortcomings. 1 –Needs definition is essentially nominal or guesswork. 0 - No needs defined (or no plan).	Equipment includes: - Police, fire and ambulance vehicles, and fuel; - Helicopters, planes as applicable, and fuel; - Rescue equipment; - Medical supplies; - Bulldozers, excavators, debris trucks (may be supplied by private organizations); - Local emergency response IT systems, hand-held devices. (Medical/hospital needs – see Essential 8)

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
		Estimated shortfall in available equipment per defined needs – potentially from multiple sources. MOUs exist for non city sources, especially from private sector.	5 – Equipment known to be available in line with defined needs for "most severe" scenario. 4 – Equipment known to be available in line with defined needs for "most probable" scenario. 3 – Shortfall of <5% of ideal equipment numbers for key items. 2 – Shortfall of 5-10% of ideal equipment numbers for key items. 1 – Shortfall of >10% of ideal equipment numbers for key items. 0 - No definition of needs – see above.	Equipment defined as above.
9.5 Food, shelter, staple goods and fuel supply.	9.5.1 Likely ability to continue to feed population	"Food gap" - # of days that city can feed all segments of its population likely to be affected minus # of days' disruption estimated under those scenarios.	Under "most severe" scenario: 5 – Positive outcome – days of emergency food available exceeds estimated days disruption to regular supply 4 – Even – days of food available equals estimated days' disruption to regular supply. 3 - Negative outcome – estimated food gap is 24 hours. 2 - Negative outcome – estimated food gap is 48 hours. 1 - Negative outcome – estimated food gap is 72 hours.	Food = food and water Needs to include certainty that food from other agencies is available, via MOU or similar.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			0 - Negative outcome – estimated food gap is more than 72 hours.	
	9.5.2 Likely ability to meet needs for shelter/safe places	"Shelter gap" – numbers of displaced persons minus shelter places available within 24 hours.	Under "most severe" scenario: 5 – Positive outcome – shelter places available within 12 hours exceeds estimated need; 4 – Even – shelter places available equal to estimated need; 3 - Negative outcome – shelter places available less than estimated need (shelter gap) by 5%. 2 - Negative outcome – estimated shelter gap is 10%. 1 - Negative outcome – estimated shelter gap is 15%. 0 - Negative outcome – estimated shelter gap is 20%. or more	Shelter may include existing structures likely to resist the disaster in question, by virtue of their strong construction and/or their location – sports stadia, school halls, shopping malls, parking garages and so on. Shelters need to take account of separate needs of men, women, children, disabled. Signage to, and for use within, shelters is also likely to be required. Third-party owners of shelter facilities/safe places should be engaged via MOUs or similar.
		"Shelter gap" – ability of shelters to withstand disaster events and remain safe and usable.	Under "most severe" scenario: 5 – All designated shelter places are assessed as likely to safely withstand a "most severe" event. 4 – 90% of shelter places are assessed as likely to safely withstand a "most severe" event. 3 - 80% of shelter places are assessed as likely to safely withstand a "most severe" event.	This applies to shelters in which people may have taken refuge prior to an event (for example a hurricane, where there will be some hours warning); or shelters to which people may be directed after the event.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			2 - 70% of shelter places are assessed as likely to protect users in "most severe" event. 1 – 50% of shelter places are assessed as likely to safely withstand a "most severe" event. 0 – Less than 50%, are assessed as likely to withstand a "most severe "event.	
	9.5.3 Ability to meet likely needs for staple goods.	"Staples gap" - % shortfall in supply within 24 hours relative to demand	Under "most severe" scenario: 5 – Positive outcome – supply of staples available within 12 hours exceeds estimated demand. 4 – Even – supply equals estimated demand. 3 - Negative outcome – supply of five or more critical staples less than estimated demand (staples gap).by 5% 2 - Negative outcome – estimated staples gap is 10%. 1 - Negative outcome – estimated staples gap is 15% 0 - Negative outcome – estimated staples gap is 20% or more.	Cities will need to compile lists of critical staple items, as these are to some extent culturally or population-dependent. But they are likely to include: - Sanitation; - Personal sanitary supplies and diapers; - Medications and first aid supplies; - Batteries; - Clothing; - Bedding; - Bottled gas for cooking, heating; - Materials for immediate repairs or weather-proofing of housing. In some countries these may be provided via private sector retailers, operating under MOU with the city or other government agency.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
	9.5.4 Likely availability of fuel.	"Fuel gap" - # of days that city can meet fuel requirements, minus # of days disruption to regular supply..	Under "most severe" scenario: 5 – Positive outcome – days of fuel available exceeds estimated days disruption to supply. 4 – Even – days of fuel available equals estimated days disruption to supply. 3 - Negative outcome – estimated disruption exceeds days of fuel available (fuel gap) by 24 hours. 2 - Negative outcome – estimated fuel gap is 48 hours. 1 - Negative outcome – estimated fuel gap is 72 hours. 0 - Negative outcome – estimated fuel gap is more than 72 hours.	Fuel – gasoline, diesel, as required for emergency vehicles, back up equipment, and personal and business transportation.
9.6 Interoperability and inter-agency compatibility	9.6.1 Interoperability with neighboring cities/states and other levels of government of critical systems and procedures.	Ability to cooperate at all levels with neighboring cities and other levels of government.	5 – Proven interoperability of all key systems and procedures. 4 – Interoperability in theory of all key systems but yet to be tested in practice. 3 – Some minor incompatibilities exist but are being addressed. 2 – Major incompatibilities but plan exists to address them. 1 – Major incompatibilities but no plan.	Critical first response systems and procedures will include those in the areas of communications, law and order, fire, first responder, food distribution, etc). Interoperability needs to be assessed at multiple levels, including: - Communications systems; - Data; - Emergency management applications;

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			0 – Interoperability never assessed.	- Assumptions, rehearsed procedures and priorities; - Accountabilities (see Essential 1); - Territorial coverage; - Physical asset characteristics (for example, fire hose widths for neighboring fire departments; fuel compatibility for vehicles).

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
	9.6.2 Emergency operations center	Existence of emergency operations center with participation from all agencies, automating standard operating procedures specifically designed to deal with "most likely" and "most severe" scenarios. .	5 – Emergency operations center exists with hardened communications and camera-enabled visibility of whole city, and with SOPs designed and proven to deal with "most severe" scenario; all relevant agencies participate. 4 – Emergency operations center exists with hardened communications and camera-enabled visibility of whole city, and with SOPs designed and proven to deal with "most probable" scenario; all relevant agencies participate. 3 – Emergency operations center exists with SOPs designed for "most probable" scenario (but may not be proven), most agencies participating but incomplete camera visibility or communications. 2 – Emergency operations center exists but SOPs unproven, participation incomplete and poor camera visibility. 1 – Emergency operations center designated but with significant generalized shortcomings. 0 – No emergency operations center.	Operations center needs itself to be highly disaster-resilient! SOP = Standard operating procedures – pre-rehearsed processes and procedures for emergency response.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
9.7 Drills	9.7.1 Practices and rehearsals – involving both the public and professionals.	Testing of plans annually, by reference to simulated emergency and actual non-emergency events. .	5 - Annual suite of drills validated by professionals to be realistic representation of "most severe" and "most probable" scenarios. 4 – Annual suite of drills broadly thought to be realistic. 3 – Annual suite of drills but not realistic in some significant respects. 2 – Less than annual drills. 1 – Ad hoc partial exercises – not all scenarios tested, not realistic. 0 – No exercises (or no plans – see above).	Drills to include use of/response to education and healthcare facilities. Drills linked to public engagement and local training – see essential 6. Specific emergency drills may be supplemented by use of sporting events, rallies, parades and other local activities, and also minor versions of the disaster event (eg minor flooding, weaker earthquakes) to: - Practice aspects of emergency response such as crowd management; - Test carrying capacity of potential evacuation routes; - Evaluate response and access times, etc. (These may also be used for disaster awareness).
	9.7.2 Effectiveness of drills and training	Level of effectiveness of drills	5 – All professional and public participants in drills show strong evidence of having absorbed training. 4 – Most participants show evidence of having absorbed training, with some minor issues. 3 – One or more issues with training evident from outcome of drills. 2 – Several significant skills or knowledge gaps revealed.	Requires evaluation of every drill after completion. Training delivery and level of participation – see essentials 6 & 7.

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			1 – Drills indicate that city is broadly unprepared for disaster in terms of training and skills. 0 – No drills.	

Essential 10: Expedite Recovery and Build Back Better

After any disaster there will be a need to:

- Ensure that the needs of the survivors and affected community are placed at the centre of recovery and reconstruction with support for them and their community organizations to design and implement rebuilding shelter, assets and livelihoods at higher standards of resilience.
- Planners should ensure that the recovery programmes are consistent and in line with the long-term priorities and development of the disaster affected areas.

Recovery, rehabilitation and reconstruction can to a considerable degree be planned ahead of the disaster. This is critical to building back better and making nations, cities and communities more resilient to disasters than they were before the event. Pre-disaster plans for post-event recovery should cover the following and with necessary capacity building, where relevant:

- Providing shelter, food, water, communication, addressing psychological needs, etc.
- Limiting and planning for any use of schools as temporary shelters
- Identifying the dead and notifying next of kin
- Debris clearing and management;
- Taking over abandoned property
- Management of local, national and international aid and funding, and coordination of efforts and prioritizing and managing resources for maximum efficiency, benefit and transparency.
- Integration of further disaster risk reduction in all investment decisions for recovery and reconstruction.
- Business continuity and economic reboot.
- Learning loops: undertake retrospective/post-disaster assessments to assess potential new vulnerabilities and build learning into future planning and response activities.

Data you will need to complete this section of the scorecard will include: *post–event plans, potentially from multiple organizations and agencies.*

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
10.1 Post event recovery planning – pre event!	10.1.1 Planning for post event recovery and economic reboot.	Existence of comprehensive post event recovery and economic reboot plans.	5 – Fully comprehensive plans exist addressing economic, infrastructure and community needs after "most probable" and "most severe" scenario.	Comprehensive post event recovery plans will need to detail (not an exhaustive list): - Interim arrangements for damaged facilities and homes anticipated from

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			4 – Fully comprehensive plans exist addressing economic, infrastructure and community needs after "most probable" scenario. 3 – Plans exist for post "most probable" event but with some shortfalls. 2 – Plans exist for post "most probable" event but with more significant shortfalls 1 – Plans exist for post "most probable" event but with generalized inadequacy. 0 – No plan.	"most probable" and "most severe" scenarios; - Locations and sources of temporary housing (if different from emergency shelters – see Essential 9); - Triage policies for repairs and debris removal and preferred contractors; - Counseling and personal support arrangements; - Community support arrangements – re-initiation of social security, food and other benefits payments; - Economic "re-boot" arrangements – interim tax relief, incentives, etc etc; - Improvements to city layout and operations sought as rebuilding takes place, to reduce future risk; - Arrangements to ensure social equality – equality of attention, inputs, funding, priority across all neighborhoods. Plans may be from several organizations, but these should be reviewed for consistency of assumptions and priorities. (Post event organization structures – see Essential 1) (Funding – see Essential 3)

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
	10.1.2 Shadow financial arrangements for processing incoming aid and disbursing funds.	Post event arrangements exist for dealing with incoming financial aid and disbursements	5 – Arrangements exist and are believed to be workable. 4 – Arrangements have some minor gaps but are believed to be workable. 3 – Arrangements have one or more significant gaps that may compromise aspects of workability. 2 – Arrangements have more significant shortfalls that place overall workability in doubt. 1 – Partial or incomplete arrangements only. Unlikely to be workable. 0 – No plan.	May be provided by national government, if still functional, or by a private sector organization such as an accounting firm.
	10.1.3 Learning loops	Existence of a process and format for "post-mortems" on what went well and less well in the event response and post-event phases.	5 – Comprehensive plans exist that are shared by all stakeholder, and they have in fact been used after a disaster – changes have been made to plans and practices. 4 – Comprehensive plans exist but have not been used in live situations – only after drills. 3 – The need to learn is acknowledged and some attempt is planned to share learnings, but it is not systematic - there are gaps. 2 – Post event learning is planned in some stakeholders, but to varying degrees and it is not planned to be shared.	This process could be the process used for usual learning and review after drills and practices – the difference being that this is "for real".

Subject/Issue	Item measured	Indicative Measurement	Indicative Measurement Scale	Comments
			1 – Any provision for post event learning is rudimentary at best. 0 – No plans.	

Appendix 1: Glossary of Terminology as Used in the Scorecard

Acute Stress	Some natural or man-made event that causes a *disaster*. Acute stress is the direct focus of this scorecard – but the resulting disasters may be made more severe, or more frequent, or the city may be rendered less able to respond, by underlying or *chronic stress*. Acute stress is one end of a continuum – the other being *chronic stress*
Chronic stress	Environmental degradation and other natural or man-made factors that cause underlying damage without directly leading to a full blown *disaster*. Examples might include issues such as over-use of groundwater, pollution or deforestation. Chronic stresses are not directly the focus of this scorecard. They may however make disasters more likely, or more severe, or reduce the ability of the city to respond to them. Chronic stress is one end of a continuum – the other being *acute stress*.
Critical administration functions	Critical administration functions will include those that directly affect the well being of the public or individuals. For example: payment of food-stamps or unemployment benefit; housing offices; reporting of damage after the disaster; trash collection and disposal.
Critical asset	Equipment, facility infrastructure or computer system/data that is critical to the functioning of the city, maintenance of public safety or *disaster* response. Critical assets are frequently interlinked and may form *failure chains* that need to be identified and managed.
Disaster	An event leading to major loss of life or damage to assets, property or economic activity. Disasters may be man-made or natural – the latter are the primary focus of the scorecard, but it is applicable also to the former.
Disaster Resilience	The ability to mitigate and recover from *disaster* events. A subset of the wider concept of *resilience*.
Exposure	Who or what (people, land, ecosystems, crops, assets, infrastructure, economic activity) is potentially in harm's way as a result of a *hazard*. Different exposures and/or *vulnerabilities* may combine, for example where the tsunami generated by the Tohoku earthquake in Japan in 2011 badly damaged the Fukushima nuclear power plant – generating a whole additional set of exposures and vulnerabilities.
Failure chain	A failure chain is a set of linked failures spanning *critical assets* in multiple infrastructure systems in the city. As an example – loss of an electricity substation may stop a water treatment plant from functioning; this may stop a hospital from functioning; and this in turn may mean that much of the city's kidney dialysis capability (say) is lost. This failure chain would therefore span energy, water and healthcare systems.
Grass roots organizations	Organizations that exist to create *disaster resilience* at the local level, whether set up specifically for the purpose (for example, community emergency response organizations), or serving some other purpose but willing and able to play a disaster resilience role: for example, churches, business Round Tables, youth organizations, food kitchens, neighborhood watch, day centers and so on.

Hazard	Some event or phenomenon (for example, hurricane, flood, fire, earthquake, tsunami) that may lead to a *disaster*. Hazards may change over time as a consequence of urbanization and land use (for example where deforestation increases propensity for flash flooding), climate change (for example, changing rainfall or storm patterns), or better knowledge (for example, understanding of seismic threats or likely storm tracks). Thus, hazard estimates need to be updated regularly.
Peril	See *hazard*.
Resilience	The ability to mitigate and adapt to both *chronic* and *acute stresses*.
Risk Assessment	The process and outcome of compiling *scenarios* of natural *hazards* that could cause a *disaster* in the city, and the city's *exposure* and *vulnerability* to these.
Scenario	A comprehensive assessment of the severity, probability of a *hazard* and its total impact – the *exposure* and *vulnerability* of the city to loss of life, damage or other adverse impact in the resulting *disaster*. As a minimum cities will ideally have two scenarios – one for *the "most probable"* event and one for the *"most severe"*
Single point of coordination	Person or group/committee (with subgroups or sub committees as required) from which all organizations with any role in the city's disaster resilience accept direction or guidance in resilience matters, and to which they report on such matters.
Standard operating procedure (SOP)	Pre-rehearsed processes and procedures for emergency response.
Vulnerability	The potential consequences of *exposure* to some *hazard* (loss of life, property or service; physical damage; health impact, economic impact; environmental impact and so on). Different *exposures* and/or vulnerabilities may combine, for example where the tsunami generated by the Tohoku earthquake in Japan in 2011 badly damaged the Fukushima nuclear power plant – generating a whole additional set of exposures and vulnerabilities
"Most Probable"	A *disaster*-causing hazard and its severity computed to be at the midpoint of a probability distribution (preferred) or assessed as "typical;" through expert judgment and other ad hoc estimation.
"Most Severe"	A *disaster*-causing hazard and its severity computed to be in the top 10% of a probability distribution (preferred) or assessed as "worst case" through expert judgment or other ad hoc estimation.