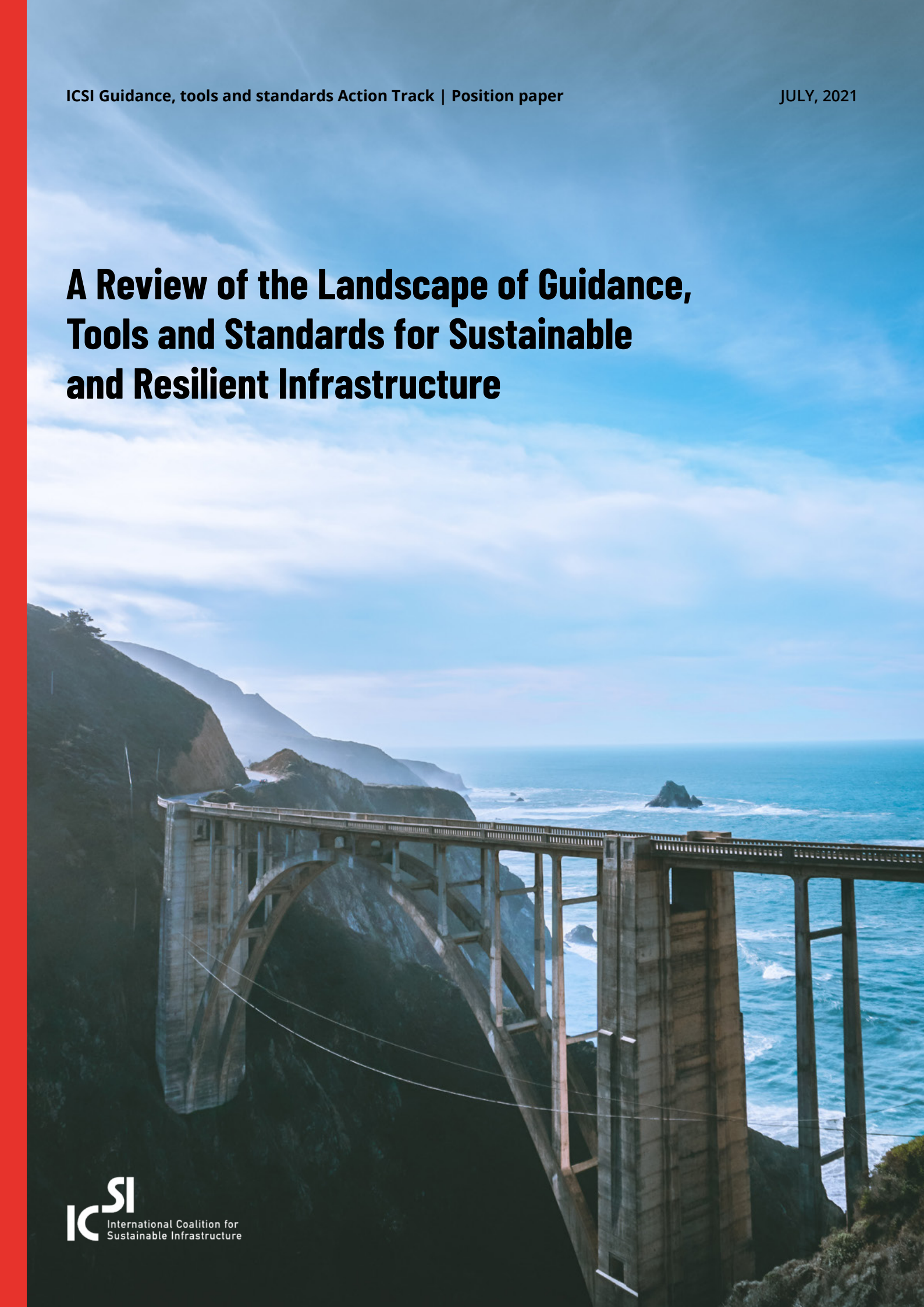


A Review of the Landscape of Guidance, Tools and Standards for Sustainable and Resilient Infrastructure



ABOUT ICSI

The International Coalition for Sustainable Infrastructure (ICSI) was founded in 2019 by The Resilience Shift, the American Society of Civil Engineers (ASCE) and its ASCE Foundation, the Institution of Civil Engineers (ICE), the Global Covenant of Mayors for Climate & Energy (GCoM), WSP and LA Metro, among others. It aims to bring together the entire value chain of infrastructure and unlock the opportunity of using engineers as a driving force for positive impact. It will give engineers a voice in ensuring that we pick the right infrastructure projects to fund and then design and build them with resilience in mind from the outset to ensure safe, sustainable and resilient infrastructure for all our futures.

ICSI delivers industry change by engaging members and their organisations through Action Tracks that seek to understand the gaps and barriers to the development of sustainable and resilient infrastructure. ICSI responds with specific actions to address these challenges, and engages stakeholders who are instrumental in delivering actions and adopting new resources, practices and behaviours.



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Cover image: Bixby Creek Bridge, also known as Bixby Canyon Bridge, on the Big Sur coast of California, USA (by Darpan Dodiya, Unsplash.com)

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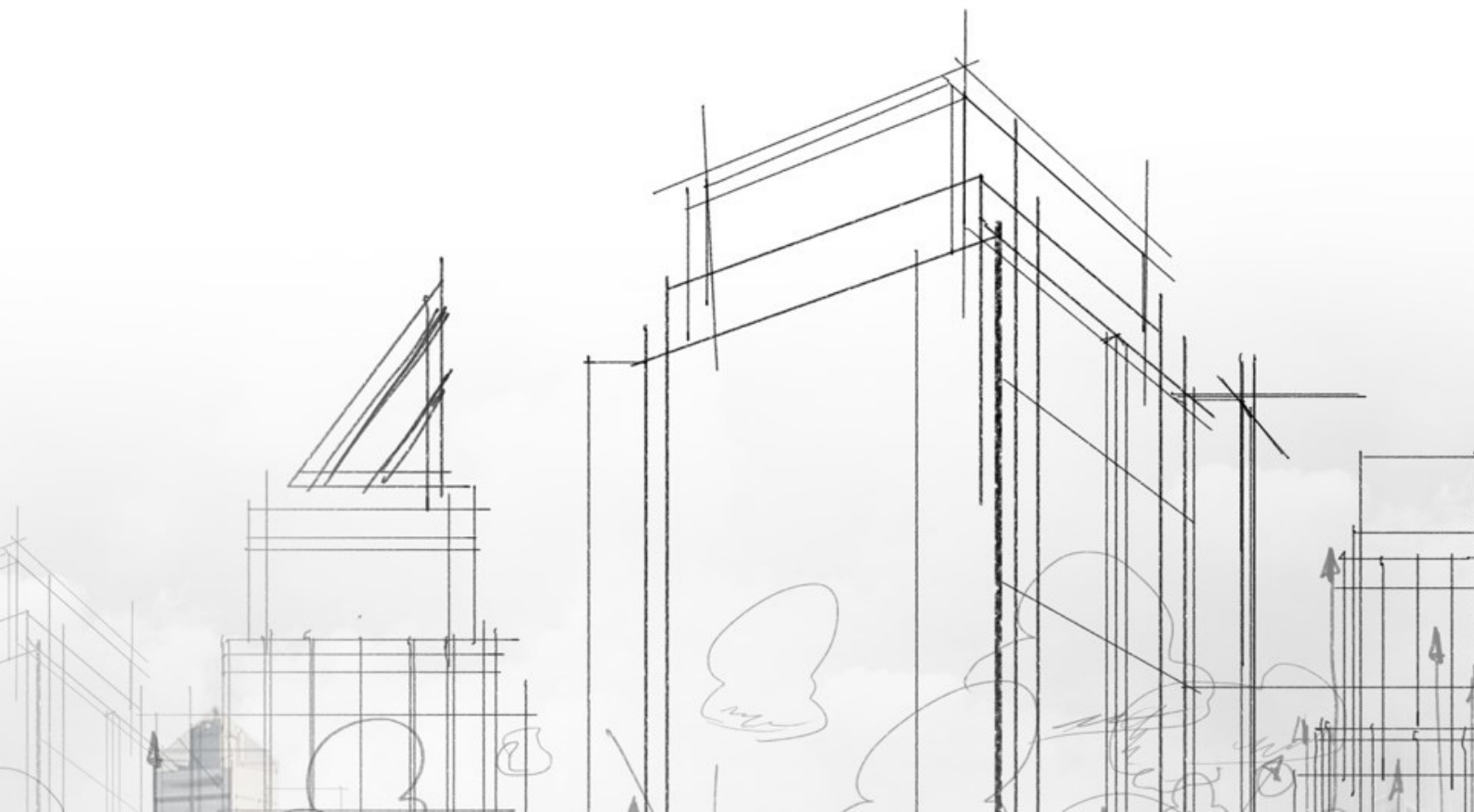
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1. Introduction

The International Coalition of Sustainable Infrastructure (ICSI) Guidance, Tools and Standards Action Track has set out to bring clarity and structure to the guidance, tools and standards that are available to practitioners and stakeholders across the infrastructure lifecycle. This will enable them to better plan, finance, design, deliver and operate and maintain sustainable and resilient infrastructure.

SUSTAINABLE AND RESILIENT INFRASTRUCTURE

Sustainable Infrastructure is planned, designed, constructed, operated and maintained, and decommissioned in a manner to ensure equitable economic, social, and environmental benefits over the entire lifecycle¹.

Resilient Infrastructure is able to withstand, adapt to, and recover from climate change and other shocks and stresses so that it can continue to serve its core function².

The Guidance, Tools and Standards Action Track set out to undertake a landscape review of existing resources to identify gaps and focus efforts where needed. This paper has been drafted using resources crowdsourced from ICSI members and it incorporates feedback from peer review and Action Track meetings. It presents the rationale, methodology and findings of a landscape analysis of existing guidance, tools and standards for sustainable and resilient infrastructure. Four key gaps are identified as the target for future actions of the ICSI Action Tracks.



2. Developing a catalogue of guidance, tools and standards

The aim of this exercise is to better understand the landscape by cataloguing and mapping what already exists, acknowledging that the list will never be exhaustive. The guidance, tools and standards included in the catalogue were collected through a process of collaboration and crowdsourcing with the ICSI membership. The Action Track working group received recommendations from ICSI members of academic institutions, engineering companies, government bodies, and international organisations with expertise across infrastructure sectors.

We also drew from prior work by The Resilience Shift, cataloguing tools and approaches for infrastructure resilience³, and from the Global Centre on Adaptation's (GCA) stocktake of climate-resilient infrastructure standards⁴. At present, a total of 207 examples have been collated to form the final catalogue. Appendix A presents the catalogue in its entirety, and the Sustainable Infrastructure Tool Navigator⁵ details these and more available guidance, tools and standards.

Taxonomy

A taxonomy framework has been used to categorise each item in the catalogue. This framework was defined at the beginning of the process and refined through feedback with ICSI members.

This approach helps to set out the existing landscape and identify gaps and opportunities for consolidation. A description of the taxonomy categories is provided in Section 3 below.

CATEGORY

The primary classification assigns each item to the category of guidance, tool or standard according to the following definitions:

1. **Guidance:** a series of steps or recommendations that infrastructure practitioners may choose to follow to improve the resilience and/or sustainability of their assets.
2. **Tool:** helps perform a specific task, following a well-defined process, with inputs and outputs. Easy examples are models, software or web-based applications, but also financial instruments and frameworks.
3. **Standard:** a widely recognised publication approved and monitored for compliance by an authoritative agency or professional or recognised body as a minimum acceptable benchmark. A set of requirements for infrastructure resilience and/or sustainability that must be followed for a project to meet the standard.

INFRASTRUCTURE LIFECYCLE STAGES

Secondly, items were classified according to where they could be applied in the infrastructure lifecycle, that comprises four key stages: Needs identification; Planning; Delivery and; Management.

We consulted with ICSI members and reviewed existing lifecycles used by other organisations to derive the infrastructure lifecycle in Figure 1. This simplified lifecycle was consistent with comments we received from ICSI members that the specifics of an infrastructure lifecycle vary substantially under differing contexts and that only a high-level lifecycle would be applicable to all. We also identified the need for a more balanced lifecycle, with examples providing greater detail often being skewed by the user’s perspective. For example, a lifecycle from an engineer’s perspective was likely to overemphasise the delivery stage. The ICSI infrastructure lifecycle (Figure 1) places equal value on all stages.

ADDITIONAL CATEGORISATION

Each reference in the catalogue was classified according to the following definitions of sustainability, resilience, and risk:

Additionally, items were classified by:

- Infrastructure sector
- Potential users
- Geography (where possible)
- Topic areas (see below)

To aid in identifying potential gaps, one or more topic areas were assigned to each item to give an indication of its potential applications. The list of topic areas is as follows:

- Resilience or sustainability assessment
- Impact or interdependency assessment or identification
- Cost-benefit assessment
- Strategy development
- Project financing
- Energy efficiency and carbon reduction
- Resilience or sustainability definitions and principles
- Asset management and the whole lifecycle
- Climate action, mitigation or adaptation
- Risk assessment and management
- Design guidelines
- Procurement guidelines
- Construction guidelines
- Capacity building

Prioritisation

A need was identified to prioritise and highlight the resources that would be the most helpful to infrastructure practitioners. Going forward, ICSI will look to support projects that facilitate access to key resources with the aim to consolidate and reduce confusion in the current crowded landscape. These resources will be made easily accessible and recognisable to stakeholders across the infrastructure lifecycle. However, as so many different resources are available, and more will inevitably be published, neither the catalogue nor our prioritised list will be exhaustive.

Figure 1: ICSI's infrastructure lifecycle



3. Review of the existing landscape

Our analysis of the existing landscape demonstrates that there is a lot of excellent guidance, tools and standards designed to help different stakeholders enhance the resilience of their infrastructure systems. However, it is evidently a crowded, confused and fragmented landscape that is difficult for people who aren't pioneers and experts in the area to follow. We know that non-experts understand that this is important, but don't know where to start.

The catalogue of guidance, tools and standards, and their categorisation is provided in Appendix A. At present, the catalogue contains 206 references, broken down into 55 tools, 32 standards and 119 guidance documents (see Figure 2 below). The items were relatively evenly divided across the lifecycle, however, the Needs Identification phase was underrepresented (see Figure 3).

This is despite Government users being tagged to 33% of the items in the catalogue. Arguably, this shows that government is also associated with the Planning and other stages of the infrastructure lifecycle.

The analysis shows that 40% of the items reviewed considered both resilience and sustainability, with 29% primarily concerned with sustainability and 31% with resilience (Figure 4). The skew towards resilience is due to the substantially higher proportion of resilience tools in the catalogue. This may represent the true landscape or might be simply the result of the resilience focus of The Resilience Shift's tools and approaches work⁶. Overall, this means that the majority (60%) of items in the catalogue focus only on either sustainability or resilience.

Figure 2: Categories of items within the catalogue

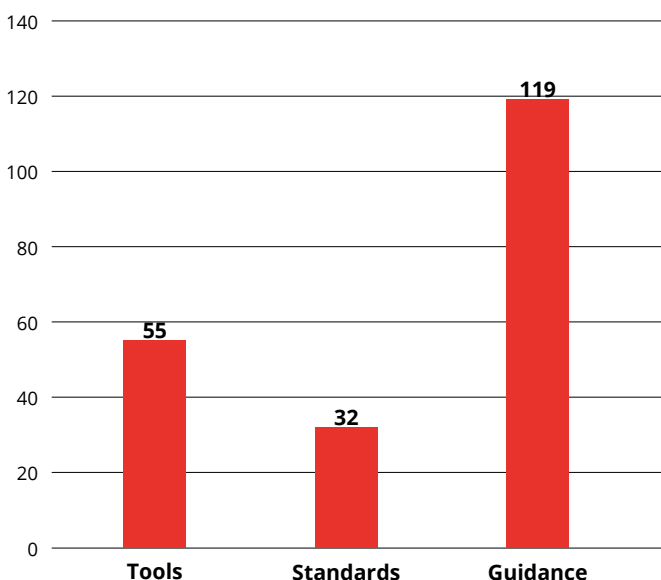


Figure 3: Categories of items within the catalogue

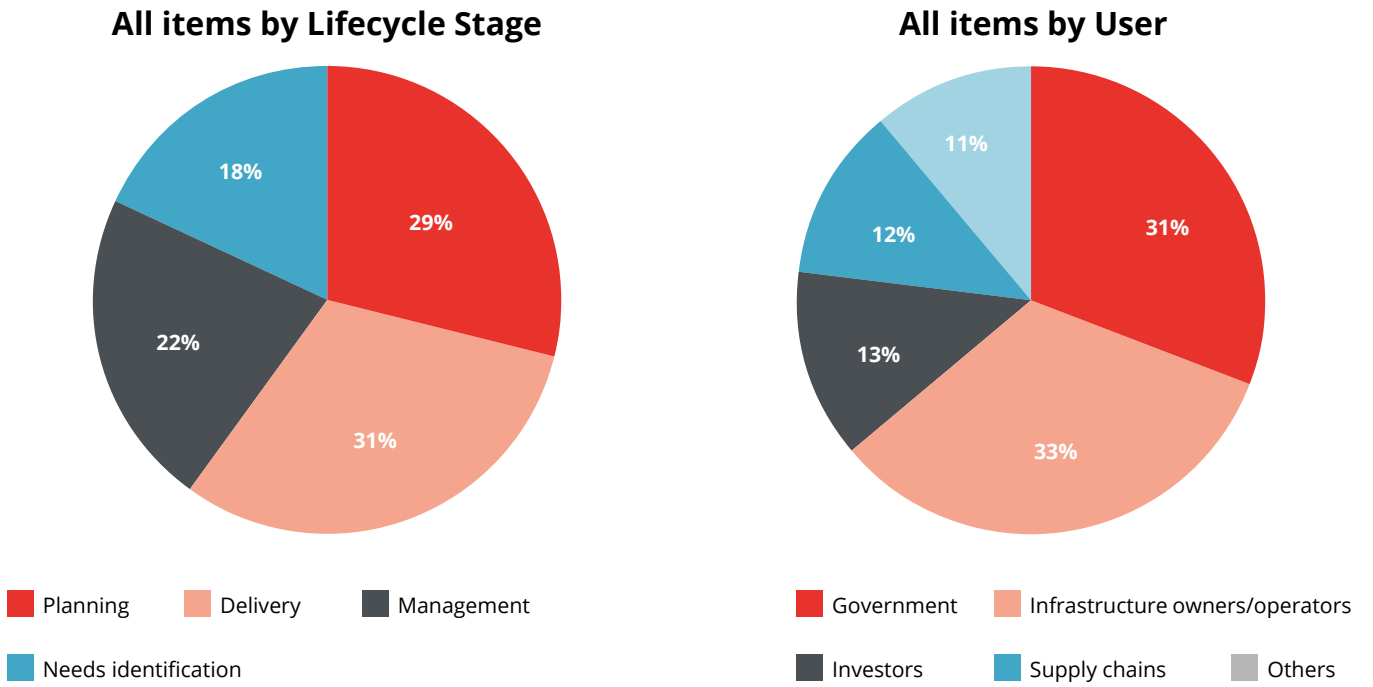


Figure 4: Proportion of items classified by whether they considered resilience, sustainability or both.

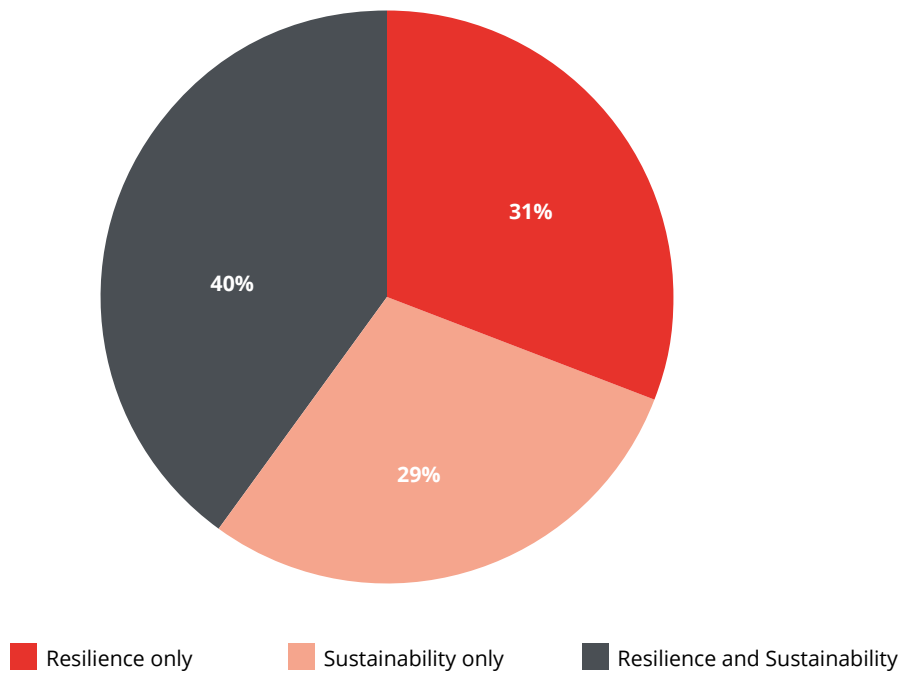
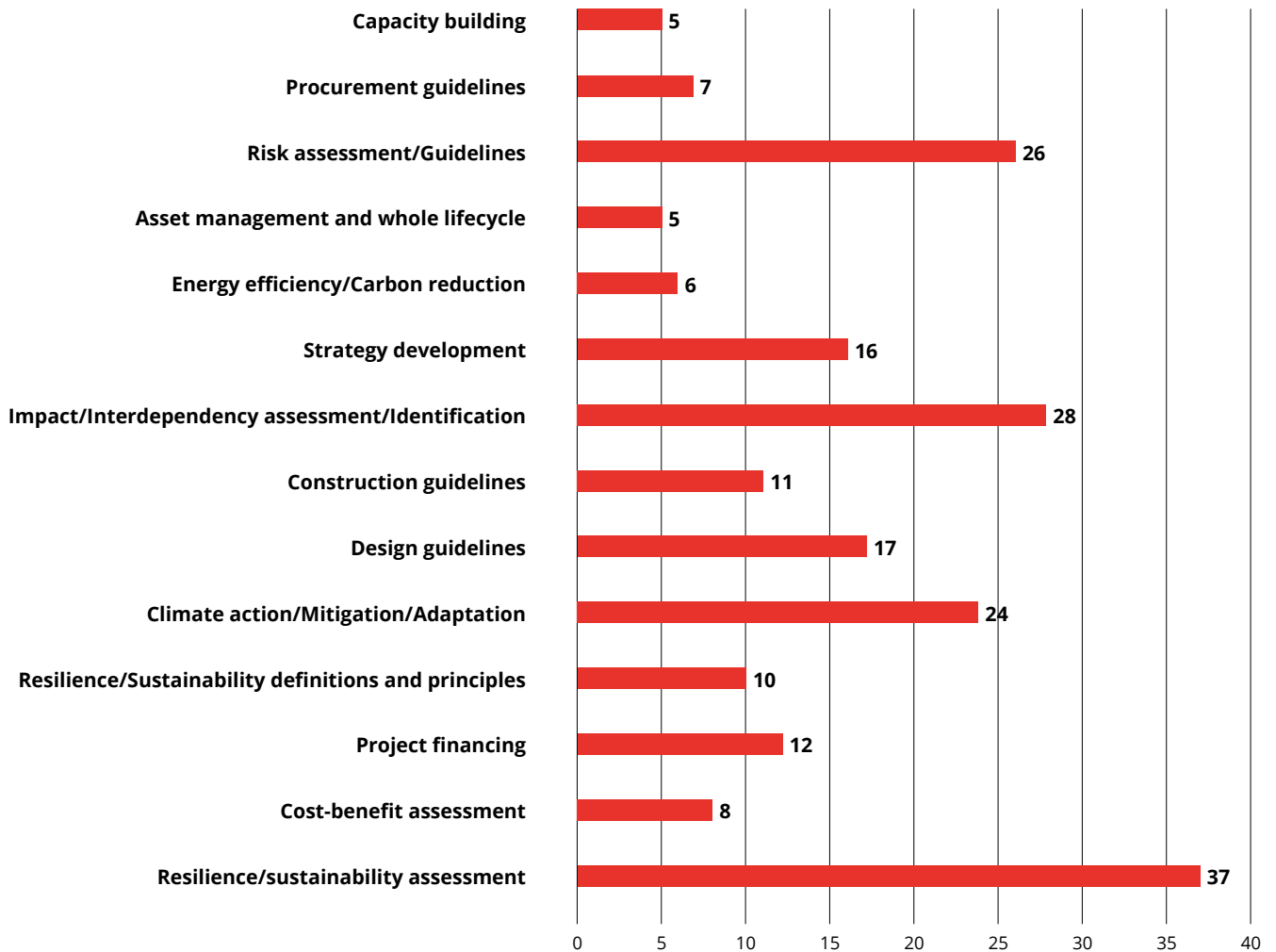


Figure 5: Combined guidance, tools and standards classified within each topic area. Note: a single item may cover multiple topics.



To have a more granular understanding of where the gaps are, the items were classified by topic areas. This showed that the least represented topic areas in the catalogue are capacity building, procurement guidelines, asset management and whole lifecycle,

energy efficiency/carbon reduction and cost-benefit assessment (Figure 5). Additionally, although the assessment of resilience and sustainability was a well-covered topic, fewer items were associated with the early stages of infrastructure development.

4. Gap analysis

Based on the observations in Section 3, and supported by discussions with ICSI members, several key gaps have been identified in the present landscape of guidance, tools and standards.

Gap 1: Line of sight for sustainability and resilience across the infrastructure lifecycle

Despite the number of good guidance, tools and standards available, this paper has identified that the landscape is crowded, confused and fragmented. There is no coherent line of sight across the infrastructure lifecycle for embedding sustainability and resilience.

Establishing a line of sight for sustainability and resilience would help bridge the disconnect between all the actors involved in infrastructure development as well as help to navigate the complex and fragmented landscape of existing guidance, tools and standards. A systems-level view of infrastructure development is required to ensure that resilience and sustainability are embedded from the early stages of the infrastructure lifecycle and they are built upon in the downstream stages.

At the core of this gap is a need for developing a common definition for sustainable and resilient infrastructure through a set of standards, criteria and indicators which can be used across the lifecycle. As stated in the ASCE Policy Statement 418⁷, we need to ensure from the outset that we 'do the right project', and that the sustainability triple bottom line (economic, environmental and social) has been considered from the Needs Assessment, through to the Planning, Delivery and Management stages.

The same level of consistency and alignment across the lifecycle is needed for the guidance that supports implementation of sustainable and resilient infrastructure. There is a need for end-to-end guidance, providing a golden thread of systems thinking, from policy through to asset management. The guidance should be accessible to the full range of stakeholders and helpful to the non-specialist, aiming to align complex multiple stages and actors in a clear manner.

Gap 2: Support in the early stages of the infrastructure lifecycle

Despite the relative abundance of guidance, tools and standards to aid the assessment and definition of sustainability and resilience in infrastructure, this review has shown that it is mostly concerned with the delivery phase or later. This finding chimes in with work undertaken by the Finance Action Track that identified a gap around creating a pipeline of bankable sustainable projects, backed by long-term strategies and guided by consistent and effective frameworks. This gap is supported by numerous publications commenting on a disconnect between financiers and infrastructure practitioners on the topic of sustainability, often pointing towards a lack of criteria to help define a high-quality sustainable infrastructure project and a lack of actionable standards to de-risk those projects (also see Gap 1). The ICE is currently planning to develop guidance on the funding and financing of infrastructure projects, building on its Enabling Better Infrastructure report⁸.

Gap 3: Procurement practices to implement sustainable and resilient infrastructure

Procurement occurs at several stages of the infrastructure lifecycle, however this paper has identified that there is a lack of advice across the whole lifecycle. Several existing items are available that provide some support to procurement, including resources from ASCE⁹, ISO¹⁰ and UNEP¹¹. However, these do not entirely address the current gap.

Sustainable procurement has significant potential for positive impacts across the entire lifecycle. The earlier in the project it is implemented, the better for project costs and schedules¹² but there are still considerable opportunities in the design phase and even into construction. The delivery phase can have intent included within procurement documents to embed sustainable and resilient approaches. However, these measures are typically new and often not consistent with standard operating procedures. Poor communication may also mean that these are not then fully considered during the bidding phase. This results in a divergence of incentives and implementation challenges during the project.

Gap 4: Integration of sustainability and resilience into infrastructure operation and maintenance

While there are many examples of good practice in this area, little practical support is available to infrastructure practitioners to help them integrate resilient and sustainable practices into the operation and maintenance (O&M) phases of the infrastructure lifecycle. This also includes a feedback mechanism to monitor and ensure that projects remain on track. Project Preparation Facilities (PPF)

are still primarily concerned with capital expenditure, while operational expenditure, and subsequently consideration of sustainability and resilience during O&M, is neglected.

Resilience value is often lost in the handoffs between design, build, operate and maintain and this remains a key area of focus to drive resilience value, cost efficiencies and ultimately projects that can best benefit communities. Longer time scales must be included and recognised in many of the tools currently being applied in the market, which do not always account for long-term changes and deterioration during the O&M phase. Interconnections and interdependencies within and across systems should be accounted for at this stage when undertaking resilience and sustainability assessments.

The social and economic benefits of infrastructure for end-users and communities are realised during this lifecycle stage. It is therefore important that infrastructure continues to provide essential services in the long term, whatever the future has in store.

5. Taking action to accelerate practice

Guidance and Standards have a key role in supporting sustainable infrastructure projects. This will ensure that the right projects get financed, developed and delivered. ICSI is taking targeted actions to address the gaps identified in Section 4 and support development of sustainable and resilient infrastructure.

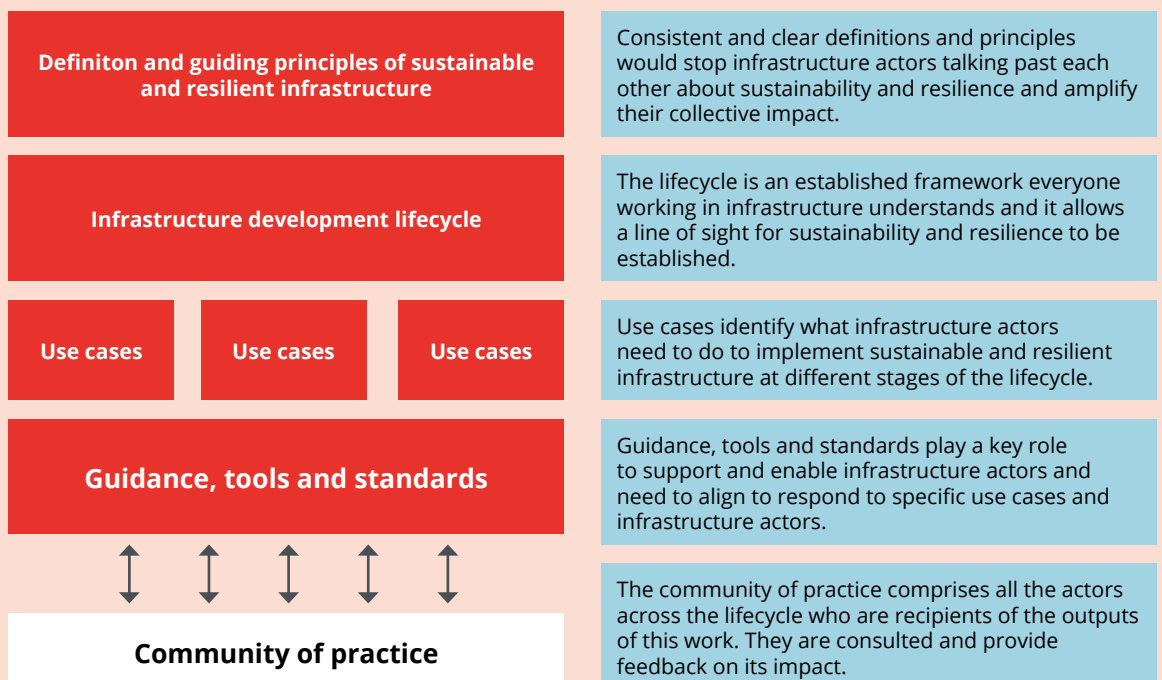
Rather than starting from scratch and developing new material, which could add further complexity to the already crowded landscape, this paper has set out to understand what resources already exist and where key gaps are, how what exists can be better utilised or promoted and what actions should be taken to close the identified gaps.

Figure 6 shows the building blocks that need to be in place collectively to support the development of sustainable and resilient infrastructure. This framework has been

developed to provide structure to the activities undertaken by ICSI's Action Tracks and to ensure that these consider all aspects of the infrastructure lifecycle.

Working from a set of initial guiding definitions and principles, it is important to retain a whole-lifecycle perspective to ensure our outputs can be clearly followed and understood within a wider context, rather than contributing to further fragmentation. To ensure that infrastructure actors are adequately supported across each of the

Figure 6: Framework for supporting development of sustainable and resilient infrastructure.



four stages of the infrastructure lifecycle, it is useful to identify suitable use cases that articulate specific situations in which guidance, tools and standards could be used, who would need them, what benefit they would deliver and where the challenges are.

As an engineering-led and action-oriented coalition with deep knowledge of sustainability, resilience and infrastructure development, ICSI plays a valuable role in supporting the users/recipients of guidance, tools and standards (the ‘community of practice’ in Figure 6 below) through targeted steps to accelerate uptake of sustainable and resilient practices for infrastructure.

Going forward, the ICSI Action Tracks will implement tangible and feasible actions toward filling the identified gaps outlined in Section 5. These actions are detailed below.

Action 1: Provide clear, actionable and consistent guidance across the infrastructure lifecycle

Owner: Guidance, Tools and Standards Action Track; Gaps addressed: Gap 1 & 4

ICSI is taking action to start addressing Gap 1 and 4 through Infrastructure Pathways, a new initiative by ICSI, led by The Resilience Shift and in partnership with Arup. The initiative brings together and maps existing resources to provide line of sight across the infrastructure lifecycle, with a golden thread of system thinking, embedding climate resilience at all stages. Infrastructure Pathways aims to provide clear and concise guidance that can be referred to by any stakeholder at any stage in the lifecycle to find key concepts, actions, inputs, and resources that would apply to them. Furthermore, the guidance is intended to inform the user on how to add resilience value and influence the rest of the project downstream, across sectors and stakeholder groups.

Action 2: Develop a common set of indicators for sustainable and resilient infrastructure

Owner: Guidance, Tools and Standards Action Track; Gaps addressed: Gap 1

The ICSI Guidance, Tools and Standards Action Track will work on developing a unified, credible and consistent definition for sustainable and resilient infrastructure and a common set of indicators to measure and monitor sustainability and resilience throughout infrastructure development. Consensus around a common set of indicators for sustainable and resilient infrastructure will be sought through consultation to obtain wider endorsement from all actors across the lifecycle of infrastructure.

Action 3: Provide support at the early stages of project development

Owner: Finance Action Track; Gaps addressed: Gap 2

The Finance Action Track focuses on creating links to multiple pre-development funds/project development facilities and offers advice and guidance to representatives of these facilities. These representatives will meet with the Action Track members to understand the offer of support from ICSI.

The ICE’s development of guidance on the funding and financing of infrastructure projects will provide clear and consistent guidance during the early stages of a project’s lifecycle, and will complement the work undertaken by the Infrastructure Pathways project (see Action 1).

Action 4: Accelerate uptake of sustainable and resilient procurement

Owner: Guidance, Tools and Standards and Finance Action Track; Gaps addressed: Gap 3

Where existing guidance exists on procurement for sustainable and resilient infrastructure, ICSI should promote and accelerate uptake through the provision of best practice examples and technical advice on how to implement (see also Action 5).

A separate paper has been prepared to set out in more detail the actions required around current gaps in procurement. Please refer to 'Procurement Gap – Position paper'¹³ for more information.

Action 5: Increase awareness of available guidance, tools and standards

Owner: Guidance, Tools and Standards Action Track; Gaps addressed: Gap 4

This analysis has identified over 100 Guidance, Tools and Standards that are available to support embedding resilience and sustainability across all stages of the infrastructure lifecycle. ICSI should promote awareness of these by releasing the details of the catalogue. Where possible, ICSI should leverage existing platforms to facilitate this, for example the 'Sustainable Infrastructure Tool Navigator'¹⁴ or the Resilience Shift Toolbox¹⁵.

References

1. Adapted from IDB https://publications.iadb.org/publications/english/document/What_is_Sustainable_Infrastructure_A_Framework_to_Guide_Sustainability_Across_the_Project_Cycle.pdf
2. Adapted from Resilience Shift <https://www.resilienceshift.org/work-with-us/faqs/>
3. <https://www.resilienceshift.org/publication/resilience-tools/>
4. https://cdn.gca.org/assets/2020-12/GCA_InfraAT_StocktakeofStandards_Final.pdf
5. <https://sustainable-infrastructure-tools.org/>
6. <https://www.resilienceshift.org/publication/resilience-tools/>
7. <https://www.asce.org/issues-and-advocacy/public-policy/policy-statement-418---the-role-of-the-civil-engineer-in-sustainable-development/>
8. <https://www.ice.org.uk/ICEDevelopmentWebPortal/media/Documents/Media/ice-enabling-better-infrastructure-report.pdf>
9. <https://ascelibrary.org/doi/book/10.1061/9780784483107>
10. <https://committee.iso.org/files/live/sites/tc207sc1/files/Whitepaper%20How%20to%20use%20ISO%2014090%20to%20support%20ISO%2014001.pdf>
11. <https://www.unep.org/resources/publication/international-good-practice-principles-sustainable-infrastructure>
12. <https://publications.iadb.org/en/what-sustainable-infrastructure-framework-guide-sustainability-across-project-cycle>
13. ICSI (June 2021) ICSI
14. <https://sustainable-infrastructure-tools.org/>
15. <https://www.resilienceshift.org/tools/>

Appendix A:

Guidance, Tools and Standards Catalogue

Table 1: Abridged catalogue entries, tools.

TITLE	LINK	SOURCE/DEVELOPER	TOPIC AREA
CRI	City Resilience Index (CRI)	ARUP	<i>Resilience/sustainability assessment</i>
Elephant Builder	Elephant Builder	BELLWETHER COLLABORATORY	<i>Impact/interdependency assessment/identification; Risk assessment/management</i>
CDIA Project Screening	CDIA PROJECT SCREENING TOOL	Cities Development Initiative for Asia (CDIA)	<i>Project financing; Climate action/mitigation/adaptation</i>
Resilience Atlas	Resilience Atlas	CONSERVATION INTERNATIONAL	<i>Project financing; Climate action/mitigation/adaptation</i>
Circle	Critical Infrastructures Relations and Consequences for Life and Environment (Circle)	Deltares	<i>Impact/interdependency assessment/identification; Risk assessment/management;</i>
Earth EX	Earth EX	Electric Infrastructure Security (EIS) Council	<i>Impact/interdependency assessment/identification; Resilience/sustainability assessment</i>
Equitable Origin	Equitable Origin Platform	EQUITABLE ORIGIN	<i>Resilience/sustainability assessment</i>
GRRASP	Geospatial Risk and Resilience Assessment Platform (GRRASP)	European Commission	<i>Impact/interdependency assessment/identification; Risk assessment/management</i>
CAESAR	Cascading Effect Simulation in Urban Areas to Access and Increase Resilience (CAESAR)	Fraunhofer EMI	<i>Impact/interdependency assessment/identification; Risk assessment/management</i>
ThinkHazard!	ThinkHazard!	GFDRR	<i>Risk assessment/management</i>

TITLE	LINK	SOURCE/DEVELOPER	TOPIC AREA
Envision	Envision	Institute for Sustainable Infrastructure	<i>Resilience/sustainability assessment</i>
SAVi	Sustainable Asset Valuation (SAVi)	International Institute of Sustainable Development (IISD)	<i>Cost-benefit assessment; Risk assessment/management; Project financing</i>
RASTEP	RASTEP	LLOYD'S REGISTER	<i>Impact/interdependency assessment/identification; Risk assessment/management</i>
EDGE\$	EDGE\$ - (Economic Decision Guide Software)	National Institute of Standards and Technology (NIST)	<i>Project financing; Cost-benefit assessment</i>
Green Evaluation	Green Evaluation	S&P Global Ratings	<i>Resilience/sustainability assessment</i>
OurWater	https://app.ourwater.city/	The Resilience Shift, Arup, Stockholm International Water Institute	<i>Impact/interdependency assessment/identification</i>
CAT-I	Capacity Assessment Tool for Infrastructure (CAT-I)	UNOPS	<i>Resilience/sustainability assessment</i>
RVR	Resilience Value Realization (RVR)	ValueLab	<i>Resilience/sustainability assessment; Strategy development</i>
City Scan	City Scan	World Bank	<i>Resilience/sustainability assessment; Risk assessment/management</i>
Coastal Resilience	Coastal Resilience	Mississippi-Alabama Sea Grant Consortium and NOAA's Coastal Storms Program	<i>Risk assessment/management</i>
GeoNode	GeoNode	GeoNode	<i>Strategy development</i>
GRESB Resilience Module	GRESB Resilience Module	GRESB	<i>Resilience/sustainability assessment</i>
HAZUR	HAZUR®	OPTICITS	<i>Impact/interdependency assessment/identification; Risk assessment/management</i>
Hazus	Hazus	Federal Emergency Management Agency (FEMA)	<i>Impact/interdependency assessment/identification; Risk assessment/management</i>
LCLIP	Local Climate Impacts Profile (LCLIP)	UKCIP	<i>Risk assessment/management</i>

TITLE	LINK	SOURCE/DEVELOPER	TOPIC AREA
OASIS Loss Modelling Framework	OASIS Loss Modelling Framework (Catastrophe Modelling)	Oasis	<i>Risk assessment/management</i>
Open Data for Resilience Index	Open Data for Resilience Index (Beta)	GFDRR	<i>Risk assessment/management</i>
World Bank Climate & Disaster Risk Screening Tools	World Bank Climate & Disaster Risk Screening Tools	THE WORLD BANK	<i>Risk assessment/management</i>
Surging Seas	Sea Level Rise and Extreme Sea Level Analysis Service	Climate Central	<i>Risk assessment/management</i>
QRE	Quick Risk Estimation (QRE) Tool	UNISDR United Nations Office for Disaster Risk Reduction	<i>Risk assessment/management; Impact/interdependency assessment/identification</i>
SmartScan	SmartScan	Global Infrastructure Basel	<i>Resilience/sustainability assessment</i>
PCVA	Participatory Capacity and Vulnerability Analysis (PCVA)	Oxfam	<i>Risk assessment/management</i>
NISMOD	National Infrastructure Systems MODel (NISMOD)	UK Infrastructure Transitions Research Consortium (ITRC)	<i>Strategy development; Impact/interdependency assessment/identification</i>
ARGOS	ARGOS	PDC-ARGOS CBRN Crisis Management	<i>Impact/interdependency assessment/identification; Risk assessment/management</i>
Simulating Critical Infrastructures	Simulating Critical Infrastructures	SIM-CI	<i>Risk assessment/management; Impact/interdependency assessment/identification</i>
Resilience Garage	Resilience Garage	100 Resilience Cities & Roland Kupers	<i>Impact/interdependency assessment/identification; Capacity building</i>
OAT	Opportunity Assessment Tool (OAT)	IPA Independent Project Analysis	<i>Cost-benefit assessment; Project financing</i>
Resilience.io	Resilience.io	Ecological Sequestration Trust	<i>Resilience/sustainability assessment; Strategy development</i>
PREP	The Partnership for Resilience and Preparedness (PREP) Data tool	Partnership for RESILIENCE & PREPAREDNESS	<i>Climate action/mitigation/adaptation;</i>
CRPT	City Resilience Profiling Tool (CRPT)	UN Habitat	<i>Resilience/sustainability assessment</i>

TITLE	LINK	SOURCE/DEVELOPER	TOPIC AREA
FHWA P3 Toolkit	FHWA P3 Toolkit	U.S. Department of transportation Federal Highway Administration	<i>Procurement guidelines; Capacity building</i>
Risk Spectrum	Risk Spectrum	Lloyd´s Register	<i>Risk assessment/ management; Impact/ interdependency assessment/identification</i>
Reliability Workbench	Reliability Workbench	Isograph	<i>Risk assessment/ management; Impact/ interdependency assessment/identification</i>
AdaptInfrastructure	AdaptInfrastructure	XDI CROSS DEPENDENCY INITIATIVE	<i>Climate action/mitigation/ adaptation; Cost-benefit assessment</i>
XDIGlobe	XDIGlobe	XDI CROSS DEPENDENCY INITIATIVE	<i>Risk assessment/ management</i>
UrbanSim	UrbanSim Modelling Methodology	UrbanSim Inc.	<i>Strategy development</i>
SimCenter	SimCenter	The Natural Hazards Engineering Research Infrastructure (NHERI) program	<i>Risk assessment/ management; Impact/ interdependency assessment/identification</i>
OpenSees	OpenSees - The Open System for Earthquake Engineering Simulation	Pacific Earthquake Engineering Research Center	<i>Risk assessment/ management</i>
CB-Cities	CB-Cities	Berkeley Engineering	<i>Energy efficiency/ carbon reduction</i>
The Civil Engineering Environmental Quality Assessment and Award Scheme	https://www.ceequal.com/	CEEQUAL	<i>Resilience/sustainability assessment</i>
GEMI Water Sustainability Tool	http://gemi.org/water/resources.htm	GEMI	<i>Resilience/sustainability assessment; Strategy development; Risk assessment/management</i>
Collecting the drops: a water sustainability planner	http://waterplanner.gemi.org/intro.htm	GEMI	<i>Strategy development; asset management and whole lifecycle</i>
SuRe	The Standard for Sustainable and Resilience Infrastructure (SuRe®)	Global Infrastructure Base	<i>Resilience/sustainability assessment; Resilience/ Sustainability definitions and principles</i>

Table 2: Abridged catalogue entries, standards.

TITLE	LINK	SOURCE/DEVELOPER	TOPIC AREA
ISO 37120:2018 Sustainable cities and communities - Indicators for city services and quality of life	-	ISO	<i>Resilience/sustainability assessment</i>
ISO 37123:2019 Sustainable cities and communities - Indicators for resilient cities	-	ISO	<i>Resilience/sustainability assessment</i>
ISO 14007:2019 Environmental management - Guidelines for determining environmental costs and benefits	-	ISO	<i>Cost-benefit assessment</i>
14008:2019 Monetary valuation of environmental impacts and related environmental aspects	-	ISO	<i>Cost-benefit assessment</i>
ISO 14030-1 Environmental Performance assessment and metrics – Green debt instrument – Part 1: Process for green bonds	-	ISO/DIS	<i>Project financing</i>
ISO 14040:2006 Environmental Management - Life-cycle assessment - Principles and framework	-	ISO	<i>Resilience/Sustainability definitions and principles</i>
14080:2018 Greenhouse gas management and related activities - Framework and principles for methodologies on climate actions	-	ISO	<i>Climate action/mitigation/adaptation</i>

TITLE	LINK	SOURCE/DEVELOPER	TOPIC AREA
ISO 14090:2019 Adaptation to climate change - Principles, requirements and guidelines	-	ISO	<i>Climate action/mitigation/ adaptation</i>
ISO/DIS 14091 Adaptation to climate change - vulnerability, impacts and risk assessment	-	ISO/DIS	<i>Impact/interdependency assessment/identification</i>
14092 Greenhouse gas management and related activities - Requirements and guidance for adaptation planning for organizations including local governments and communities	-	ISO/TS	<i>Impact/interdependency assessment/identification</i>
14097 Investments, financing and climate change	-	ISO/DIS	<i>Project financing</i>
ISO 15392:2019 Sustainability in building constructions - General principles	-	ISO	<i>Construction guidelines</i>
ISO 21929:2011 Sustainability in building constructions - Sustainability Indicators - Part 1: Framework for the development of indicators and a core set of indicators for buildings	-	ISO	<i>Resilience/sustainability assessment; asset management and whole lifecycle</i>

TITLE	LINK	SOURCE/DEVELOPER	TOPIC AREA
21930:2017 Sustainability in buildings and civil engineering works - Core rules for environmental product declarations of construction products and services	-	ISO	<i>Construction guidelines; Design guidelines</i>
Eurocodes: Basis of structural design	-	EN 1990:2002	<i>Design guidelines</i>
16309:2014 Sustainability of construction works – Assessment of social performance of buildings – calculation methodology	-	EN	<i>Resilience/sustainability assessment</i>
ISO 52000:2017 Energy performance of buildings - Overarching provision of the EPB - Part 1: General frameworks and procedures	-	EN ISO	<i>Resilience/sustainability assessment</i>
W204:2019 Flood Resilient Design for New Residential Communities	-	CSA	<i>Design guidelines</i>
S900.1:2018 Climate Change Adaptation for Wastewater Treatment Plants	-	CSA	<i>Impact/interdependency assessment/identification; Design guidelines</i>
189.1:2014 Standard for the Design of High- Performance Green Buildings except low-rise residential buildings	-	ASHRAE	<i>Design guidelines; Construction guidelines; Energy efficiency/ carbon reduction</i>
100:2015 Energy Efficiency in Existing Buildings	-	ASHRAE	<i>Energy efficiency/ carbon reduction</i>
GRI 300 Environment Standards Series			

TITLE	LINK	SOURCE/DEVELOPER	TOPIC AREA
National Model Construction Codes of	Link	GRI	<i>Impact/interdependency assessment/identification; Construction guidelines; Energy efficiency/ carbon reduction</i>
Canada 2015 (NRC, 2015)	Link	NRC	<i>Design guidelines; Construction guidelines; Resilience/sustainability assessment</i>
ASCE Developing New Sustainability Standard	Link	ASCE	<i>Resilience/Sustainability definitions and principles; Strategy development; Procurement guidelines</i>
ISO 55001 Asset management, Management systems, Requirements	Link	ISO	<i>Climate action/mitigation/ adaptation; asset management and whole lifecycle</i>
ISO 31000:2018 Risk management, guidelines	Link	ISO	<i>Risk assessment</i>
Climate-resilient infrastructure: Adaptive design and risk management	Link	ASCE	<i>Design guidelines; Risk management</i>
Taxonomy: Final report of the Technical Expert Group on Sustainable Finance	Link	EU Technical Expert Group on Sustainable Finance	<i>Project financing; Resilience/ sustainability assessment</i>
Flood resilient design and construction	Link	ASCE	<i>Design guidelines; Construction guidelines</i>
Climate Bonds Standard: Water Infrastructure	Link	Climate Bonds Initiative	<i>Resilience/Sustainability definitions and principles; Resilience/sustainability assessment</i>
ISO 20400 Sustainable procurement - Guidance	Link	ISO	<i>Procurement guidelines; Resilience/Sustainability definitions and principles</i>

Table 3: Abridged catalogue entries, guidance.

TITLE	LINK	SOURCE/DEVELOPER	TOPIC AREA
Climate Lens	Climate Lens	Infrastructure Canada	<i>Energy efficiency/ carbon reduction; Assessment of resilience/sustainability; Climate action/mitigation/ adaptation</i>
TORC	Training for Operational Resilience Capabilities (TORC)	SINTEF	<i>Capacity building</i>
RELi	The Resilience Action List (RELi) standard	Various	<i>Resilience/sustainability assessment</i>
GRAM	Community Resilience Assessment Methodology (GRAM)	National Institute of Standards and Technology (NIST)	<i>Resilience/sustainability assessment</i>
DRSC	Disaster resilience scorecard for cities	UNISDR United Nations Office for Disaster Risk Reduction	<i>Resilience/sustainability assessment</i>
The IS Rating Scheme	The IS Rating Scheme by Infrastructure Sustainability Council of Australia	ISCA	<i>Resilience/sustainability assessment</i>
RESILENS	Realising European ReSILiencE for Critical INfraStructure (RESILENS)	H2020 RESILENS Project	<i>Resilience/sustainability assessment; Resilience/ Sustainability definitions and principles</i>
REDi	Resilience-based Earthquake Design Initiative (REDi)	ARUP	<i>Resilience/sustainability assessment; Design guidelines</i>
RAPTA	The Resilience Adaptation and Transformation Assessment Framework (RAPTA)	Commonwealth Scientific and Industrial Research Organisation (CSIRO) in partnership with STAP	<i>Resilience/sustainability assessment</i>
CityStrength Diagnostic	CityStrength Diagnostic	THE WORLD BANK	<i>Resilience/sustainability assessment; Impact/ interdependency assessment/identification</i>
CRIDA	Climate Risk Informed Decision Analysis (CRIDA)	AGWA	<i>Climate action/mitigation/ adaptation; Risk assessment;</i>
FAUC	FAUC	GLOCOMNET	<i>Capacity building</i>
Adaptation Wizard	Adaptation Wizard	UKCIP	<i>Climate action/mitigation/ adaptation; Risk assessment</i>

TITLE	LINK	SOURCE/DEVELOPER	TOPIC AREA
City Resilience Actions Inventory and Stakeholder Perception Review	City Resilience Actions Inventory and Stakeholder Perception Review	100 Resilience Cities & Arup	<i>Strategy development</i>
ICLEI ACCCRN	ICLEI ACCCRN Process Workbook	ICLEI and Rockefeller Foundation	<i>Impact/interdependency assessment/identification; Risk assessment; Climate action/mitigation/adaptation; Strategy development</i>
CRAFT	Climate Risk And Adaptation Framework And Taxonomy (CRAFT)	ARUP	<i>Climate action/mitigation/adaptation</i>
UCRA	The Urban Community Resilience Assessment (UCRA)	World Resources Institute (WRI) and Cities Alliance	<i>Resilience/sustainability assessment</i>
WEDG	Waterfront Edge Design Guidelines (WEDG)	Waterfront Alliance	<i>Design guidelines</i>
Climate Bonds Standard	Climate Bonds Standard	Climate Bonds Initiative	<i>Resilience/Sustainability definitions and principles</i>
City Water Resilience Approach (CWRA)	City Water Resilience Approach (CWRA)	Resilience Shift	<i>Strategy development; Capacity building</i>
Information technology - Data center facilities and infrastructure - Recommended practices for environmental sustainability	-	EN 50600-99- 2:2018	<i>Asset management and whole lifecycle</i>
Guide for addressing climate change adaptation in standards	-	CEN-CENELEC Guide 32:2016	<i>Climate action/mitigation/adaptation; Strategy development</i>
Standardization Guidance for Weather Data, Climate Information and Climate Change Projections	-	Roy, Fournier and Huard (2017)	<i>Climate action/mitigation/adaptation</i>
Building resilience: practical guidelines for the sustainable rehabilitation of buildings in Canada	-	FPTHPC (2016)	<i>Design guidelines; Construction guidelines</i>

TITLE	LINK	SOURCE/DEVELOPER	TOPIC AREA
Developing a Stormwater Quality Management Standard (QMS) in Light of a Changing Climate	-	Engineers Canada (2018)	<i>Impact/interdependency assessment/identification; Climate action/mitigation/adaptation; Asset management and whole lifecycle</i>
Leadership in Energy and Environmental Design (LEED) Rating System	https://www.usgbc.org/leed	USGBC	<i>Resilience/sustainability assessment</i>
Resilience of the Maritime and Inland Waterborne Transport System (MIWTS)	https://www.pianc.org/publications/envicom/tg193	PIANC EnviCom TG193:2020	<i>Impact/interdependency assessment/identification</i>
Climate Change Adaptation for Ports and Inland Waterways	https://www.pianc.org/publications/envicom/wg178	PIANC EnviCom WG 178:2020	<i>Impact/interdependency assessment/identification; Climate action/mitigation/adaptation</i>
Sustainable Ports - A Guide for Port Authorities	Link	PIANC EnviCom WG 150:2014	<i>Strategy development; Climate action/mitigation/adaptation</i>
A Practical Guide to Environmental Risk Management (ERM) for Navigation Infrastructure Projects	Link	PIANC EnviCom WG 175:2019	<i>Risk management</i>
Hydropower Sustainability Assessment Protocol (HSAP)	Link	IHA	<i>Resilience/sustainability assessment</i>
Framework to Guide Sustainability Across the Project Cycle (IDB, 2018)	Link	IDB	<i>Resilience/Sustainability definitions and principles</i>
International Building Code 2018 (IBC, 2018)	-	IBC	<i>Construction guidelines; Design guidelines; Performance assessment and metrics</i>
Sustainable Procurement for Infrastructure	Link	ASCE	<i>Resilience/Sustainability definitions and principles; Project financing; Procurement guidelines</i>

TITLE	LINK	SOURCE/DEVELOPER	TOPIC AREA
Sustainability Practices and Metrics for the Construction Phase of Capital Projects	Link	CII	<i>Construction guidelines; Performance assessment and metrics</i>
Resilience by Design	Link	Hydrosystems Group, UMass	<i>Resilience/sustainability assessment; Design guidelines; Resilience/ Sustainability definitions and principles</i>
Construction Capacity Framework (CCF)	Link	Infrastructure & Cities for Economic Development (ICED)	<i>Resilience/sustainability assessment</i>
Enabling Better Infrastructure	Link	Institution of Civil Engineers (ICE)	<i>Strategy development</i>
Climate-resilient infrastructure: Policy Perspectives	Link	OECD	<i>Strategy development; Design guidelines; Procurement guidelines</i>
UK National Infrastructure Assessment (NIA)	Link	NIIC	<i>Strategy development; Project Financing; Climate action/mitigation/ adaptation</i>
Planned Relocation Guidelines: A framework to undertake climate change related relocation	Link	Fijian Government	<i>Climate action/mitigation/ adaptation</i>
Hydropower Sector: Climate Resilience Guide	Link	International Hydropower Association	<i>Climate action/mitigation/ adaptation; Risk assessments</i>
Guidelines for Climate Impact and Vulnerability Assessments: Recommendations of the Interministerial Working Group on Adaptation to Climate Change of the German Federal Government	Link	Interministerial Working Group on Adaptation to Climate Change of the German Federal Government	<i>Impact/interdependency assessment/identification; Impact/interdependency assessment/identification</i>
Resilience Engineering for Urban Tunnels	Link	ASCE	<i>Design guidelines; resilience/ sustainability assessment</i>

TITLE	LINK	SOURCE/DEVELOPER	TOPIC AREA
Climate resiliency design guidelines	Link	NYC Mayor's Office of Recovery and Resiliency	<i>Climate action/mitigation/adaptation; Risk assessment; Design guidelines</i>
Coastal Climate Resiliency: Retrofitting Buildings for Flood Risk	Link	The City of New York Mayor	<i>Construction guidelines; Design guidelines; Climate action/mitigation/adaptation</i>
Strategies for Multifamily Building Resilience	Link	Enterprise Green Communities	<i>Construction guidelines; Design guidelines; Climate action/mitigation/adaptation</i>
Sustainable water management under future uncertainty with eco-engineering decision scaling	Link	Poff et al. (2015)	<i>Recommendations and advice for resilient/sustainable operation and management;</i>
Building the Resilience of WSS Utilities to Climate Change and Other Threats: A Road Map	Link	World Bank Group	<i>Risk assessment; Climate action/mitigation/adaptation</i>
Urban Resilience Fund Project Screen and Investment Fund Support Rockefeller Foundation/Global Resilient Cities Network. 2018 to present.	-	The Rockefeller Foundation; Wood; Global Resilient Cities Network	<i>Project financing; Assessment of resilience/sustainability</i>
Decarbonization of the Built Environment - SBT Guidance for the Building System	-	WBCSD	<i>Energy efficiency/ carbon reduction</i>
Using Sustainability Cost Curves to Evaluate Urban Infrastructure in Canada	-	Hoorweg et al. (2018)	<i>Cost-benefit assessment; Assessment of resilience/sustainability; Project financing</i>
Sustainability cost curves for urban infrastructure planning	-	Hoorweg et al. (2018)	<i>Cost-benefit assessment; Assessment of resilience/sustainability; Project financing</i>

TITLE	LINK	SOURCE/DEVELOPER	TOPIC AREA
Global Review of Sustainable Public Procurement	Link	United Nations	<i>Procurement guidelines</i>
Adapting to Climate Change: The Role of Public Procurement	Link	London Climate Change Partnership	<i>Procurement guidelines; Climate action/mitigation/adaptation</i>

