RESEARCH REPORT

# Tools and approaches for resilience

Bringing users and developers together to improve practice

THE RESILIENCE SHIFT

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## ABOUT THE RESILIENCE SHIFT

The Resilience Shift exists to inspire and empower a global community to make the world safer through resilient infrastructure. More people than ever depend on the critical infrastructure systems that provide essential energy, water, transport and communications services, and underpin food, healthcare and education. When this infrastructure fails the consequences can be catastrophic.

Supported by Lloyd's Register Foundation and Arup, the Resilience Shift provides knowledge and tools for those responsible for planning, financing, designing, delivering, operating and maintaining critical infrastructure systems. Our aim is to ensure infrastructure systems are able to withstand, adapt to, and recover quickly from anticipated or unexpected shocks and stresses - now and in the future.

## DEFINING RESILIENCE

Resilience is the ability to withstand, adapt to changing conditions, and recover positively from shocks and stresses. Resilient infrastructure will therefore be able to continue to provide essential services, due to its ability to withstand, adapt and recover positively from whatever shocks and stresses it may face now and in the future.

## ACKNOWLEDGEMENTS

We would like to thank our partners who have helped us along the journey: The Schumacher Institute for bringing into our work their pioneering human factors lens to implementation of resilience, 100 Resilient Cities, Arup and Global Infrastructure Basel for convening innovative and insightful workshops, Dr Igor Linkov, Peter J Hall, Marcela Ruibal and Nancy Kete for being trusted advisors and critical friends and MMI Thornton Tomasetti for their input on developing the value-based approach. Finally, our thanks go to all the attendees to the workshops for their time and positive contributions.

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# Foreword

The Resilience Shift is a global initiative launched in 2016 to address the recommendations of the Lloyd's Register Foundation's 'Foresight review of resilience engineering'.

The Resilience Shift seeks to catalyze significant change in the way critical infrastructure is planned, designed and operated by making resilience tangible, practical and relevant. If this change happens, "engineered structures and infrastructure will be not only safer (do not fail) but also better able to assure the continuity of critical functions" under both ordinary and extraordinary circumstances.

Many professionals with a role in planning, delivering and operating critical infrastructure still struggle with this deceptively simple question:

**What can I do differently on Monday morning if I am to build or enhance resilience of the critical infrastructure that I finance/plan/procure/design/deliver/own/operate/maintain?**

A shift of resilience from theory to mainstream practice can be achieved by empowering practitioners to make better decisions and embrace different ways of thinking and working.

To enable this, we need access to the right tools and approaches to assess and enhance resilience. It is equally important to have clarity on the key concepts, goals and value created, that matter to all users along the value chain of critical infrastructure.

We are on a journey to implementation of resilience. This work provides a greater understanding of the challenges ahead and of the support that is required to put resilience into practice through wider adoption of tools and approaches for resilience.

# I. Introduction

Are you a developer of a tool that will help practitioners assess or enhance the resilience of critical infrastructure systems?

Or are you working in the critical infrastructure value chain, and looking for 'how' to assess or enhance the resilience of your system?

The Resilience Shift identified a disconnect between these two groups, and has embarked on a journey to shift practice, through connecting diverse stakeholders, raising awareness of what exists already and for who, and co-creating a collaborative platform to help.

This work aims to identify, assess and promote adoption of the tools and approaches that contribute to assessing and enhancing the resilience of critical infrastructure, making them accessible to professionals and decision makers with a role in planning, designing, operating and maintaining critical infrastructure.

The need for this work originates from a key finding from the Resilience Shift Understanding the Landscape report that identified an apparent disconnect between tools to assess and enhance resilience of critical infrastructure and those who can benefit from using them.

While the majority consulted supported the need for new tools and approaches to make resilience tangible, practical and relevant, it was found that there was very little awareness of the numerous tools and approaches already available.

This report presents the work undertaken and the key learnings on tools and approaches for resilience. The approach used to connect different stakeholders is transferable and repeatable, and we share it in Section 3 of this report, hoping that it can be taken up more widely. These key findings, in terms of the challenges that exist (Sections 4 and 5), what exists (Section 6), and how to accelerate its uptake (Section 7) should be relevant to anyone developing or searching for practical tools for critical infrastructure resilience.

# II. What did we set out to explore?

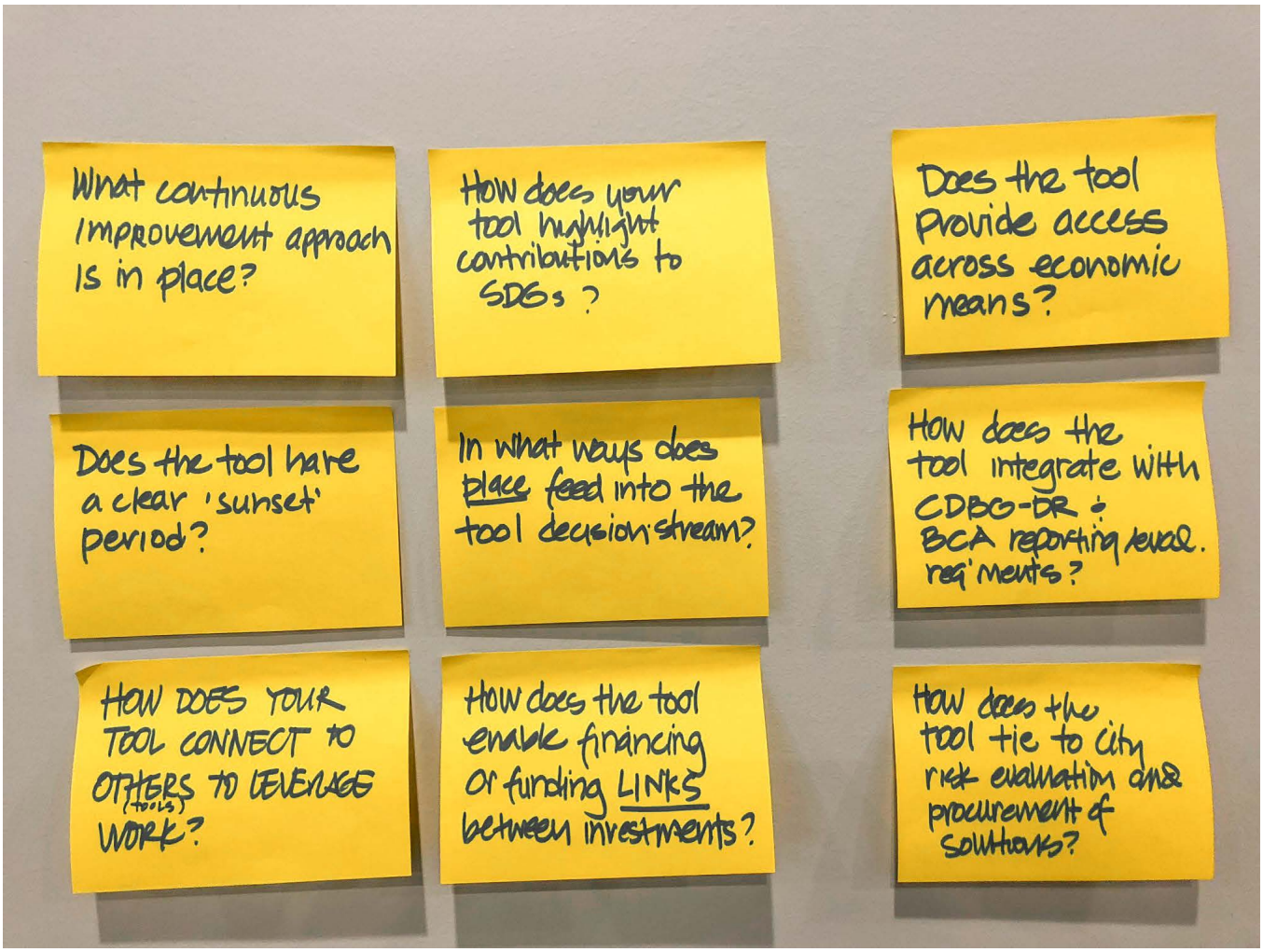
Our work set out to explore the hypothesis that an online platform, supported by a community of practice, would drive adoption of resilience tools by connecting users to the tools they need, thereby accelerating the shift of resilience from theory to practice.

The Resilience Shift could add value by providing an open-access and interactive online platform or repository of tools for resilience, with a clear articulation of their goals and the value they deliver to the users.

Current and potential users of tools for resilience, would use this repository as a trusted reference to turn to if they want to find means to assess or enhance resilience through their work, whether on new projects, investments or operations. See Box 1.

A community around resilience tools would be needed to provide support and stimulate dialogue and collaboration.

As part of this work, we introduced and tested a value-based approach as a useful means to help stakeholders on the critical infrastructure value chain to focus their resilience implementation thinking and efforts.



## Value-driven approach to resilience of critical infrastructure

A key aspect of how we are doing our work is using a value-driven approach. We think that the best way to make a shift is to think about the whole value chain of critical infrastructure.

The critical infrastructure value chain can be very useful for connecting the concepts of resilience and value, helping us to articulate why this is important. In a typical infrastructure lifecycle, where value creation is ultimately delivered to the end-users of critical infrastructure, we can create resilience value at every stage of the lifecycle. Individual stakeholders along the chain can realise the particular value and benefits for themselves. For example, for a designer value may mean reward, recognition, efficiency or optimal delivery. Through the decisions they make in their day job everyone along the entire value chain – from those diagnosing the problem to those operating the infrastructure – has a role to play in delivering resilience value.

Resilience value is the golden thread that links everyone in the value chain. This thread helps to make decisions around resilience not only matter for individual stakeholders but also for others along the value chain. If this is understood throughout the value chain, this will ensure that resilience is delivered to the benefits of all.

This value-driven approach to resilience of critical infrastructure can be helpful to connect practitioners and decision makers with the tools and approaches they need to assess or enhance resilience in their everyday jobs.

There is more detail available on the Resilience Shift website, including a video explaining how a value chain approach can help.

### BOX 1: TOOLS VS APPROACHES

In this work we differentiate between tools and approaches. **'Tools'** for assessing and enhancing resilience are the frameworks, guidance documents and standards, financial instruments, models and software products and they are usually developed by a well defined entity. Some of these 'tools' focus predominantly on risk, while others include wider resilience or sustainability aspects. Examples are: Think Hazard!, Training for Operational Resilience Capabilities (TORC) or Critical Infrastructures Relations and Consequences for Life and Environment (CIrcle).

**'Approaches'** are more generic and tend to be widely published with no definitive reference or single author. They can be helpful to practitioners in undertaking assessments or they can underpin model development. For example, Bow Tie analysis, Structured What If Technique (SWIFT) or a Hazard and Operability study (HAZOP).

# III. How did we approach this work?

The people who deliver critical infrastructure services are often overlooked in discussions about resilience. They need the tools to help them understand and perform their role in delivering resilient services. It is this interface between people and tools for resilience that we focused on in this work.

We identified two key actors that have a stake in implementation of resilience tools: the practitioners who need the tools (the users) and the developers of the tools. Interaction of these two groups is currently very little or absent. Our work is based on the assumption that bridging this gap is key to successful implementation of resilience tools, together with a better understanding and easier access to such tools.

In defining a model for implementation of resilience tools, we have structured our thinking around three key building blocks:

| | | |
|---|---|---|
| | **'Demand' from users** | What do tool users need?<br>What are their implementation challenges? |
| | **'Supply' from developers** | What is currently on the market and what is missing?<br>What are the tool development and adoption blockers? |
| | **'Support' for both users and developers** | What do these groups need to increase adoption of tools and implementation of resilience in practice?<br>How can the Resilience Shift help? |

To answer these questions, we convened three workshops with representatives from the user and developer groups from across the value chain of critical infrastructure, together with resilience experts. The first event, convened by 100 Resilient Cities in Washington DC, USA, focused on organisations representing the 'Diagnose and Conceive' section of the value chain. The second was convened by Global Infrastructure Basel in New Orleans, USA and targeted participants from the middle of the value chain, 'Design and Deliver'. The final workshop was convened by Arup in London, UK to focus on 'Operate and Maintain'.

We recognised that the 'humans in the system', the tool users and developers, had to be put at the centre of our work. However, resilience implementation is challenging and requires a shift of mindsets for those involved.

Implementation of change calls for novel thinking and ways of working. In delivering this work we have experimented the Action Learning and we have included human factors in all our considerations. See Box 2 for more details on the Action Learning methodology.

There is a need to understand the current baseline of practice and to inform this we carried out a scan of tools that take into account risk, resilience and/or sustainability and are applicable to 'lifeline' critical infrastructure sectors, e.g. water, transport, energy or communications. This helped identify gaps and is explored further in Section 6 "A lot of tools exist…".

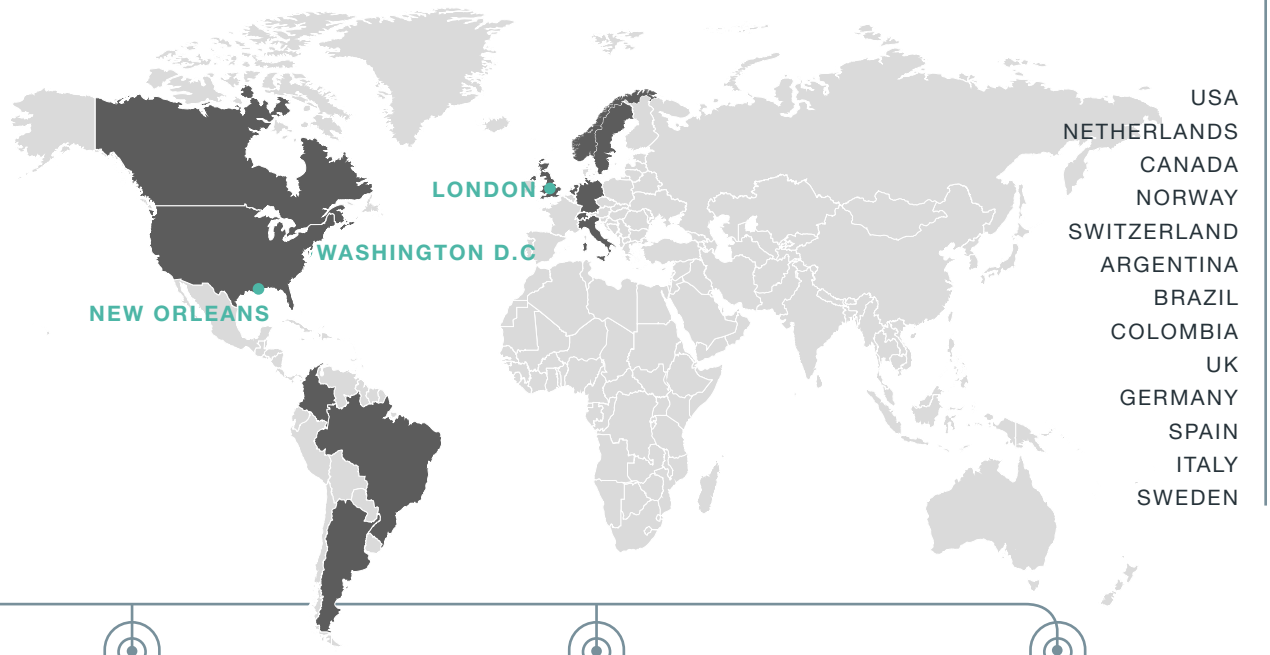
*Presentation during the London workshop*

# 3 WORKSHOPS

**79 Attendees**

**20 Tools showcased**

**13 Countries represented**




**50 Users**

**18 Developers**

**7 Experts**

We have convened around three sections of the value chain of critical infrastructure and engaged with range of stakeholders, as presented below.

| Washington D.C | | | New Orleans | | | London | | |
|---|---|---|---|---|---|---|---|---|
| **DIAGNOSE & CONCEIVE** | | | **DESIGN & DELIVER** | | | **OPERATE & MAINTAIN** | | |
| DIAGNOSE | OPTIONS | PROCURE | DESIGN/ PLAN | FINANCE | IMPLEMENT | OPERATE | MAINTAIN | DISPOSE/ REUSE |
| • Government officials at different scales<br>- City<br>- Ministry<br>- Policy<br>• Professional bodies | | | • Planners<br>• Designers<br>• Contractors<br>• Regulators (Standards)<br>• Insurers<br>• Investors | | | • Owners<br>• Operators<br>• Regulators<br>• Industry bodies | | |

### BOX 2: ACTION LEARNING

Action Learning is a widely-used technique for supporting and developing those whose job is to implement change. It helps practitioners to share and learn from implementation issues they and others face to ensure that change takes place and is embedded.

Implementation of new ideas or new tools into an organisation is a form of change management and so care must be taken in managing the human factors elements of change. As such, Action Learning was chosen as the cornerstone of the facilitation of the Resilience Shift workshops in New Orleans and London.

At the Resilience Shift workshops in New Orleans and London we introduced and used a model of implementation developed by Simon Gill and Mairi Mclean of The Schumacher Institute. The model brings together change leaders, first adopters and other leaders in a Set of approximately 5-7 people, not necessarily but possibly from the same organisation or industry. The Set has a facilitator and follows a relatively strict discipline. There is a presenter, who has an issue of implementation to resolve and must present their issue succinctly to the rest of the Set.

Set members then analyse the issue, with or without contribution from the presenter, and at this stage absolutely avoiding solutions. Once a deep analysis has taken place, with rigour, to determine why the issue is presenting difficulty, Set members ask for feedback on their analysis from the presenter and then move into brainstorming mode to seek solutions. The presenter chooses two or three ideas they will implement and reports back to the next meeting of the Set on what happened. This is not about success or failure, but about how the ideas worked or didn't.

Before the Set ends all members record at least one change to their own practice, which they will make as a result of the discussion. It is usual for Set members to find they too each replicate some of the issues raised and so can take their learning back to their own workplace. A key role of the facilitator is to maintain the discipline of the model and to offer live real-time coaching to all Set participants.

Finally, lessons for the organisation drawn from the work of the Sets could be presented to senior leadership and decision makers with recommendations for system change, thus ensuring that learning is disseminated throughout the workplace of the Set members.

# IV. What are the challenges facing practitioners?

As identified during the early phase Resilience Shift work on agenda setting, there is emerging recognition of the importance of making critical infrastructure resilient but organisations are struggling to achieve this in practice. The findings from the workshops revealed more background to this conclusion in the context of tools and approaches for resilience. These are some of the challenges and barriers to a more widespread adoption of tools:

**We are unable to find tools that are applicable to our problem**

**It's not clear what outputs and value the tool can deliver**

**There are too many tools to choose from**

**We can't fully articulate our problem**

More widely, another key barrier to implementation of resilience highlighted by practitioners was that different stakeholders in infrastructure projects, despite concerted effort, are still working in silos. To overcome this barrier, the value-driven approach to resilience of critical infrastructure could be communicated further and wider. Clarity on how creating and realizing resilience value benefits stakeholders individually, as well as being the 'golden thread' connecting them along the value chain, would be an incentive for breaking down silos.

Users strongly expressed the need to create an 'eco-system' of tools, where tools are classified and relationships between them are identified. Clarity on what tools to use at each stage in a project development and what outputs, but also what other tools to use at the following stages, would be very valuable.

Although out of scope for this work, it was found that there are other stakeholders in an infrastructure project which could inform future work of the Resilience Shift. These include voters from initiating communities, politicians, policy makers, their governments and communities who are beneficiaries of infrastructure.

Participants from government attended all three workshops and it was accepted that the importance of their role in influencing and promoting uptake of resilience in practice should not be understated. If specific methodologies and associated tools for resilience assessment are required by government, they will propagate though all user communities, including across industry. This is explored further in the Resilience Shift report The Role of Public Policy in Critical Infrastructure Resilience.

# V. What challenges are faced by tool developers?

One of the key findings at the workshops was convergence on the challenges faced by developers in developing and sustaining new and innovative tools. These include:

**Procurement of tools is a barrier, particularly for small tool developers**

**We often struggle to expand our offering into other sectors or settings**

**We don't have access to users in the development process**

**It's difficult to get our product in front of the right people**

Other barriers to adoption of tools are related to the costs associated to both developing and using the tool and the demand for customisation. Developing a tool is costly and developers often need to source funding for development separate from commercial users, stunting development and causing many to stay at an experimental level. User costs must be made clear, as they were identified as a significant driver in the choice between tools. A number of the tools explored in our workshops were popular because initial use was free to the user. Indeed, many users preferred a 'freemium' model, with some features free or at low cost with options to extend functionality at additional cost when required.

Users are drawn to customisable tools. The capability/desire of the developer to customise needs to be made clear and can be a selling point which gives them the edge in a competitive, price-sensitive market.

The tool developers we engaged with learned valuable lessons from engagement with the users, particularly around the need to better articulate the value that their tool delivers to a range of audiences and to involve the users in order to develop better tools.

> *"This (workshop) was particularly useful for me as a tool developer because it helped me to better understand the challenges that the implementers of resilient infrastructure faced so that my tool could better support them."*
>
> **Source: Tool developer**

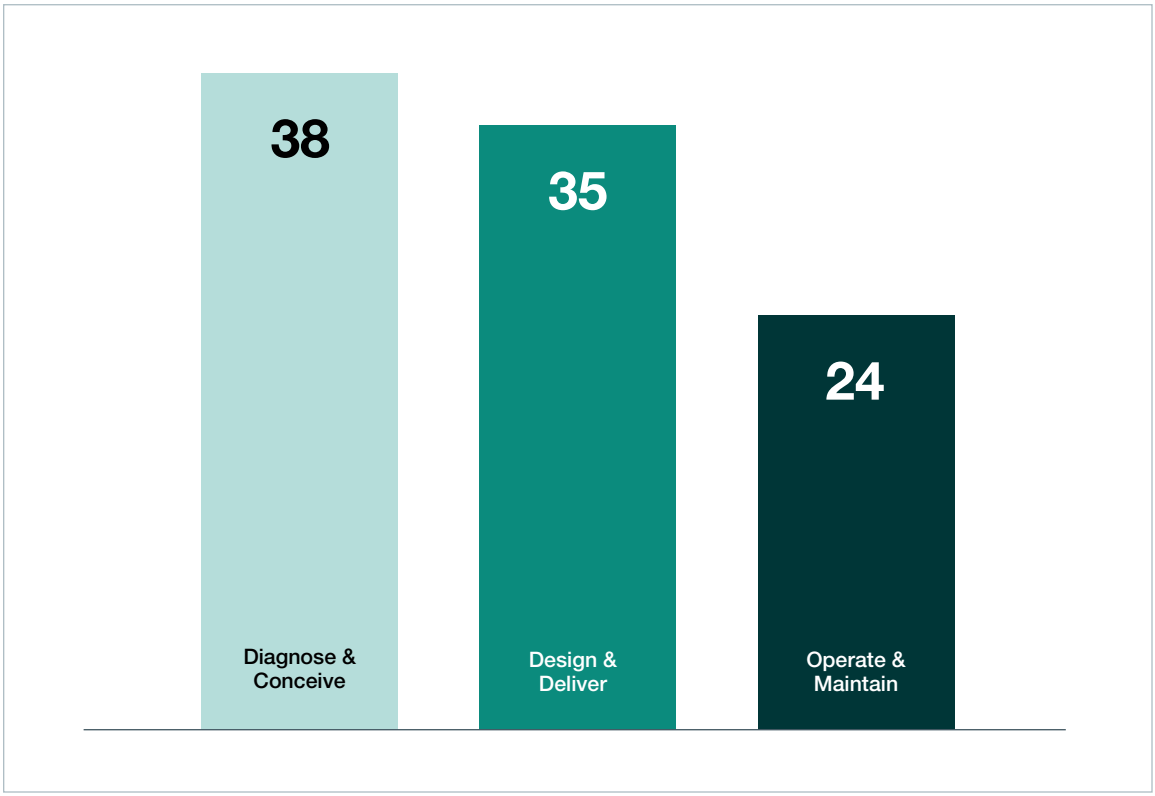
# VI. A lot of tools exist…

And this can be a challenge for identifying which tool to use, but it can also present an opportunity to build on what already exists, rather than reinventing the wheel every time. To this end, we carried out a high level scan of existing tools for resilience based on in-house knowledge and published resources. Although our scan focused on tools that are applicable to 'lifeline' critical infrastructure sectors (e.g. water, transport, energy or telecommunications), we have also looked at tools that have been developed for cities. This included assessment frameworks and guidelines, standards and certification, visualisation tools and modelling tools. Approaches (as defined in Box 1) were not included.

Over 60 tools were found and they are presented in the Appendix. Our tool scan was by no means exhaustive, but it provided a better understanding of the landscape of available and useful insights into current practice. Tools were categorised based on where they would map on the value chain of critical infrastructure and which sector they would be applicable to – so who is the tool for? - and which phase of resilience might they be used in – how does it help? – and whether there was evidence of the tool being used.

Results of mapping tools along the value chain of critical infrastructure show that, more tools are found in the early stages of a project or for strategic assessment (Diagnose & Conceive), with slightly less tools that be used to Design & Deliver critical infrastructure and a smaller proportion applicable at the Operate & Maintain stage. It should be noted that some tools are applicable to more than one section.

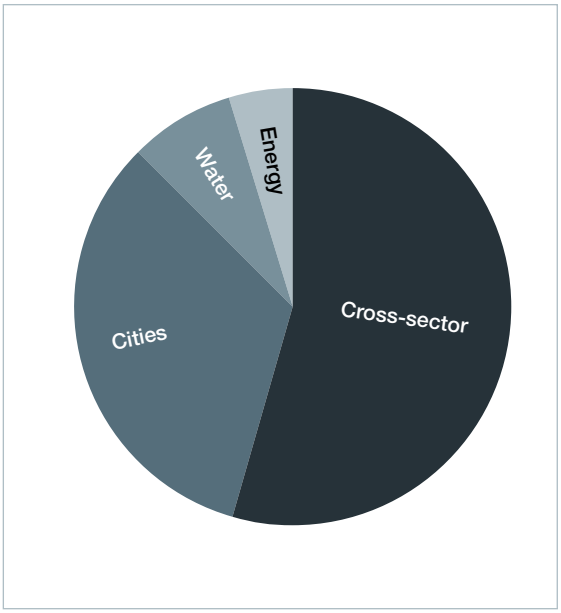
*Number of tools per value chain section*



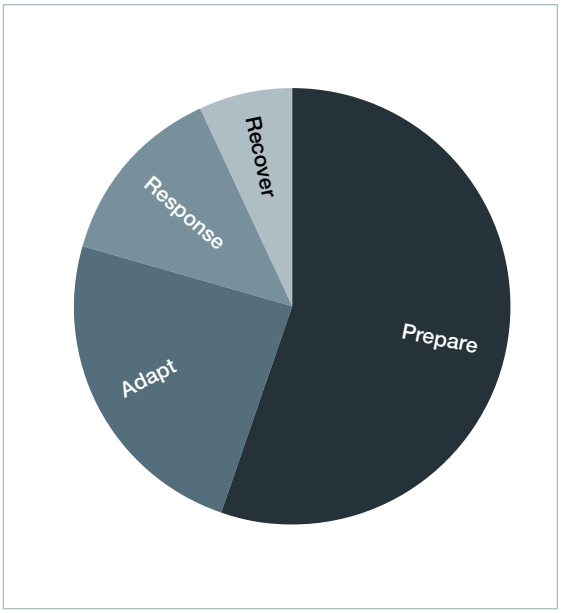
Tools with potential cross-sector applicability are the biggest group, followed by those tools that were developed specifically for cities. Only few tools specific to one sector were found. Only a few tools are developed for specific sectors. This is an encouraging finding; even if tools are not currently being used in multiple sectors, they are potentially applicable and cross-sector use should be encouraged and promoted.

We used the definition given by the National Academy of Sciences (Disaster Resilience: A National Imperative, NAS 2102) to broadly identify four application phases for resilience: Plan (before adverse event), Respond, Recover and Adapt (after the event). Tools were tagged according to relevance to the resilience phases, with the largest proportion of tools used to 'Prepare'. This is not entirely surprising because risk/hazard assessment and mitigation tools are more established, and these would fall into this category. The second largest group is made of tools that consider adaptation, in most cases specific to climate adaptation.

Finally, we were able to find published case studies for about half of the tools we found, indicating that tool uptake is still lacking. Less tools were found for the Respond and Recover phases.



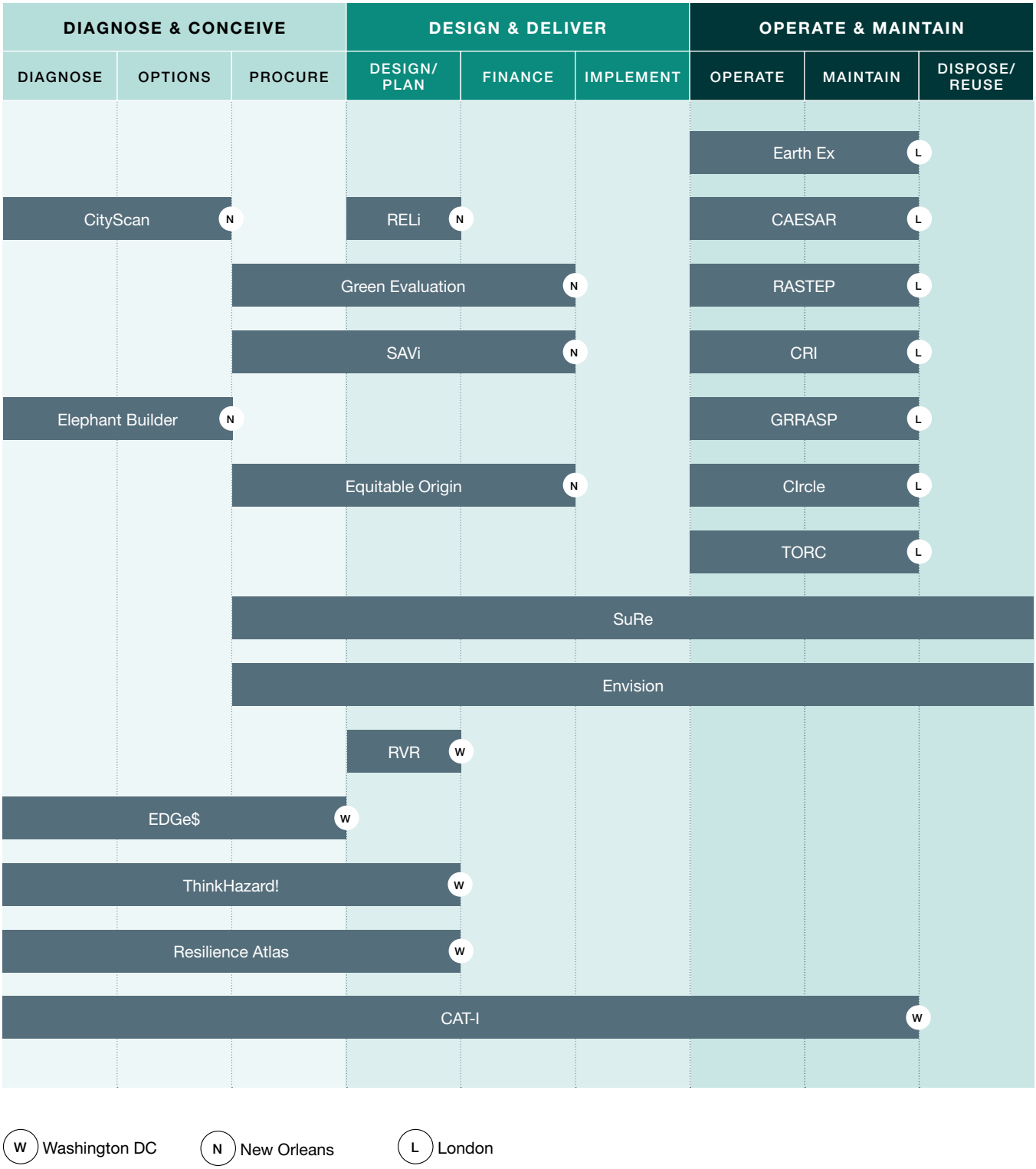

*Proportion of resilience tools by sector*




*Proportion of resilience tools by resilience phase*

In addition to the previous, twenty tools were showcased at the workshops, ranging from tools that model cascading effects of major disasters in infrastructure systems to decision support tools for emergency response organisations.

These tools have been mapped along the value chain of critical infrastructure, as shown in the figure below. More details can be found in the Resilience Shift Toolbox, the interactive tool repository we built as part of this work.

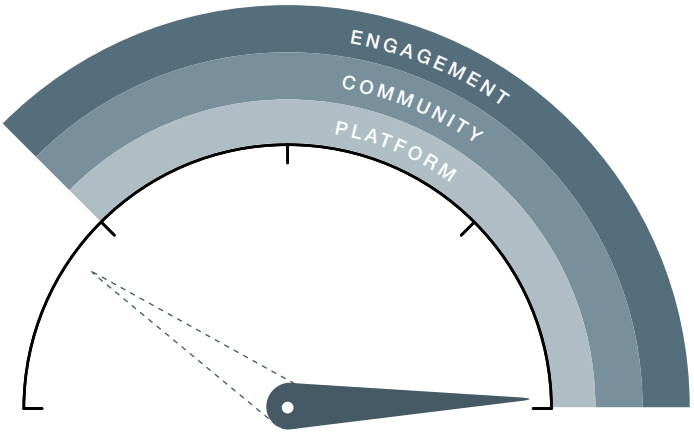


*Group photo from London tool users and developers' workshop*

# VII. What is needed to move theory to practice?

Across all three workshops the responses and comments made by tool users and developers about what is needed were similar. This similarity was notable, as was the fact that there seemed to have been little interaction between developers and users, unless they were specifically focusing on individual products, until the Resilience Shift convened these workshops and facilitated the dialogue between these two key groups. A message that came out loud and clear is that challenges on both sides have a strong 'human factors' element and that both groups need support to overcome them.

Our work helped inform what is required to 'move the needle' of resilience from theory to practice. Requirements are around the need for a platform, a community of practice and further engagement.




*Moving the needle of resilience from theory to practice*

## Platform

Our work validated the demand for an online platform or repository providing access to a wide range of tools. Such a platform would primarily allow users to identify tools to address their resilience implementation challenges and for tool developers to present their offerings.

A key finding was that that a platform should be more than just a than a repository of tools listed by developers. The key to making this platform successful would be to have a user-centred approach, e.g. an intelligent match-making service exploring user problems and tool solutions, helping users to find which tools may be applicable to them. Specific focus should also be placed on the identification of gaps that exist between demand and supply. The platform represents an opportunity to create a tool 'eco-system', mapping existing or proposed relationships between tools and highlighting where such gaps are.

There is a clear need for curation and quality assurance of the information contained in the platform. This could range from Resilience Shift providing a 'custodian' role to implement a well-defined, consistent and independent vetting process for such information, or a more open, trust-based approach. Equally, users stated a requirement for the platform to contain reviews of tools, although tool developers were reluctant, due to the effect of poor ratings and

the questionable value of simple ratings for complex tools. Both these issues would need to be considered further before this feature is added to any potential platform.

A requirement was identified to classify tools according to a pre-agreed taxonomy that would then be searchable in an interactive way. This taxonomy would include information on what sector is the tool relevant to, relevant geographic area, who the user might be (e.g. designer, investor, owner, operator etc) and any other relevant categorisation. Following this there was also an expression of the need for case studies to be linked to the tools on the platform, allowing for users to make more informed decisions.

Success of the platform requires assuring the place of multiple users within the platform so that multiple communities could benefit from broad dissemination as well as peer support in their activities. Workshop participants noted that focusing on compilation of resilience tools and creating a community of practice that contributes/uses these tools across different fields may be the niche that the Resilience Shift should fill.

There are a number of relevant platforms or tool repositories already in existence including, Resilience Tools or Adaptation Clearinghouse amongst many others. All of these have their own niche, whether it be geographical, sector or user specific, and none of them focus on tools for critical infrastructure resilience. However, there are many lessons that we can learn from the successes of these platforms and challenges they have faced. Any new offering from the Resilient Shift should add clarity to this field.

## Community of practice

Stakeholders showed a significant interest in a community of practice focussing on the implementation of resilience tools. Creation of such a community should sit alongside a platform and support tool users to share and learn from implementation successes and challenges, from their own and other sectors and from elsewhere in the value chain of critical infrastructure. Allowing users to have a meaningful dialogue with developers will support the two-way feedback of ideas and issues, help in the identification and the closing of gaps in tool provision whilst addressing the current human factors problem of limited user involvement and feedback in tool development. The community should be flexible enough to allow ‘sub-communities’ to develop, such as those around specific tools or resilience implementation challenges.

It is clear that there is a wide and diverse range of people within the global infrastructure professions who are using and attempting to use resilience tools. What is not yet clear is how to make them a community. There are also outstanding issues of definition of resilience; our work on tools and approaches confirmed, once again, the need for a common language and a common understanding, as well as for a methodology or process for implementation of resilience in practice..

> ***The innovative content and process challenged us all to think about new tools and approaches for designing and implementing resilience interventions, shifting norms and practices, and getting feedback from users, peers and stakeholders on the things that matter to them.***
>
> **Source: Workshop attendee**

Stakeholders identified a laundry list of issues, features and characteristics of a useful community of practitioners. Many of the ideas would have to be balanced against one another for an optimal solution e.g. in-person vs remote meetings, creating a new community vs tapping into an existing one, active vs passive facilitation, technical vs non-technical content, and so on.

## Engagement

Ongoing engagement was endorsed by the workshop participants, and it was noted that the platform and community were strongly interlinked: they would thrive together but alone could be challenging to sustain. It is important that the platform and community demonstrate clear benefit to the user, adding value or freeing up resources. A clear assessment of advantages and disadvantages of different formats of engagement e.g. digital communications, face-to-face events, or a hybrid solution should be carried out.

The Supply/ Demand/ Support structure we used tto define an implementation model for resilience tools, the human factors lens and the use of of the Action Learning methodology. Feedback from participants emphasised that the overall experience was more than conferences with tool demonstrations. The ability for users to discuss needs ('Demand') and developers to present solutions ('Supply') and the interactive discussion element delivered by Action Learning was critical to the success of the workshops. Participants found this method beneficial as a way of reflecting on practice, gaining others' input on issues of implementation they are facing and finding solutions. Continuing the Action Learning Sets made during the workshops was a popular suggestion. The double benefit is that once participants are suitably familiar with the concept they can extend these ideas into their own organisations, allowing the change management necessary to achieve implementation of resilience.

Action Learning, or another suitable methodology that puts humans at the centre and helps with implementation of change, could be used within a community of practitioners to break down silos between different stakeholders along the value chain of critical infrastructure. Our stakeholders noted that convening what is already available is a great approach to capitalise on the knowledge, capacity and will that already exist.

Views of practitioners from Latin American cities and North American cities were heard in the Washington D.C. and New Orleans workshops and in the London workshop there were participants from Continental Europe and the United Kingdom. Overall there were 79 attendees from 13 countries and a variety of perspectives on a number of issues. It was recommended that the Resilience Shift should explore geographically-specific aspects/factors of the demand for tools globally by using the same workshop format in new geographies, particularly in lower-income countries.

Future engagement should include stakeholder groups that were less represented at our workshops, e.g. investors and insurers.

Bringing resilience to life by telling stories of implementation through engaging communications will help build a community and attract new participants as well as encouraging continued use of the potential platform.

> ***After presenting our challenge at the workshop and interacting with the tool developers we decided to use the Resilience Value Realization tool this spring in my city!***
>
> **Source: Tool user**

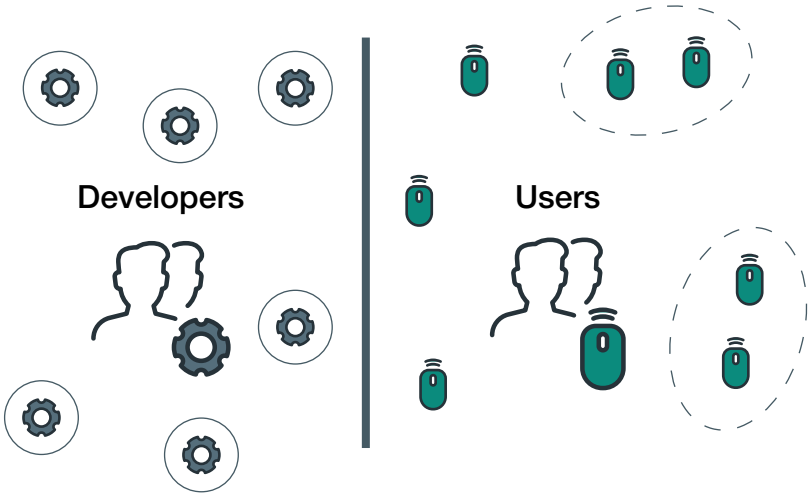
> *I was particularly impressed with the facilitation that structured discussions and debates to ensure that experts listen to feedback and rethink approaches in real time. The resilience field is full of experts who think they/we know best, so having this facilitation technique is key to ensuring the workshop made real progress in co-creating greater understand about how change can happen.*

Source: Workshop attendee

# VIII. What have we learned?

### CURRENT SITUATION

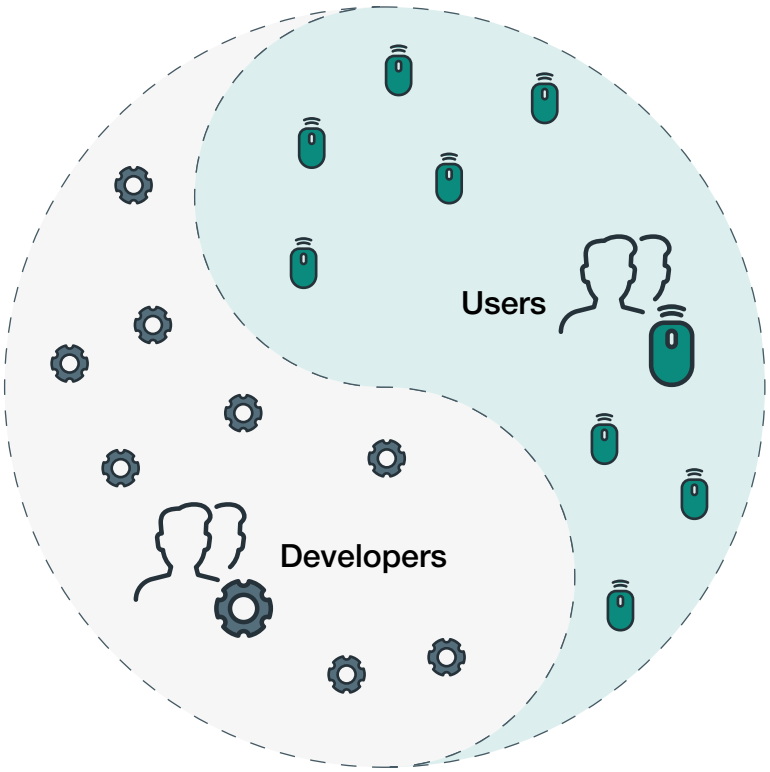
- Developers and users don't interact
- Tools are developed ad hoc and in isolation
- Users need support with resilience implementation
- Small communities of users exist but are not connected




PLATFORM
COMMUNITY
ENGAGEMENT

### IDEAL SITUATION

- Developers and users communicate
- Tools are developed around user needs
- Users are fully supported in their resilience implementation efforts
- The community of practice is thriving and tools are being used



## Lessons learned

1

Practitioners looking for a tool to assess or enhance resilience are faced with challenges such as too many tools to choose from and no clear articulation of outputs/value delivered, lack of tools applicable to their specific problem, which at times they find difficult to articulate.

2

Tool developers have little opportunity to get access to or interact with users, they often struggle to expand their tools into other sectors or settings and to get onto procurement routes. Cost of the tool and need for customization are key influencing factors in tool choice.

3

An interactive user-centred trusted platform linking users with tools and a supporting community of practice would contribute to a successful implementation of resilience in critical infrastructure. These two elements are interlinked and active intervention to integrate them would strengthen each.

4

Engagement through Action Learning, or another suitable methodology that puts humans at the center and deals with implementation of change, is an effective approach to support resilience implementation efforts. There is a real opportunity to capitalise on the knowledge, capacity and will that already exist.

5

Using a value-driven approach can help articulate to stakeholders that resilience value can act as the ‘golden thread’ connecting and benefiting all while breaking down silos. Understanding what resilience value means and how it can be realised at each stage is key.

6

A scan of tools for resilience found over 60 relevant tools, many of which had potential cross-sector applicability. Many focused on the early stages and design/build stages of infrastructure life cycle and helped prepare prior to an event. About half of them had published case studies.

# IX. Next steps

Our work has provided useful findings and valuable insights into the needs and challenges of two key groups who, for the first time, had the chance to come together and learn from each other: the users (practitioners) and the developers of tools.

Further work and action are needed to reinforce change and improve implementation of resilience through a more widespread adoption of tools. Future work will include:

- Taking forward the idea of an online platform, designed using the requirements captured through our consultation with users and developers
- Strengthening our community through follow up engagement with both users and developers
- Repeating our pioneering workshop format in a developing countries context and with financiers and investors
- Developing real use cases for tools 'in action' for different audiences and at different scales to help make resilience tangible, practical and relevant
- Amplifying our impact through working with existing communities, key organisations and individuals who can act as 'change agents'.

Implementing resilience – much like implementing any change - is not easy. It requires thinking and doing things differently, as well as continued support through change.

If our work resonates with you and you want to engage and contribute, please get in touch with us at info@resilienceshift.org

# Appendix - Resilience Toolbox

In our research, we identified over 60 tools that can be used to enhance resilience. This list is not exhaustive but it provides an understanding of the landscape of available and useful insights into current practice. To further help tool users to choose which tool is right for them, we have begun to categorise tools in ways that add value for users. These are captured in a resilience 'toolbox', shared on the Resilience Shift website.

| Tool | Developer | Description* |
|---|---|---|
| **Adaptation Wizard** | *UKCIP* | The Wizard is a 5-step process to help you assess your organisation's vulnerability to current climate and future climate change, identify options to address your organisation's key climate risks, and help you develop and implement a climate change adaptation strategy. The Wizard is also a guide to information, tools and resources. |
| **AdaptInfrastructure** | *XDI CROSS DEPENDENCY INITIATIVE* | AdaptInfrastructure is the home of adaptation analysis. Here you get to drive the analysis according to different scenario settings you need. Test the effectiveness of adaptation options – from building with different materials, raising floor levels in a flood zone or increasing the design specifications in a wind zone.<br>Features are:<br>• Specify your inputs to refine your analysis<br>• Specify the time you want to apply each action, how much it will cost and which assets will be adapted<br>• Trial adaptation options to reduce the risk to your assets<br>• Compare the performance of adaptation pathways in terms of customers, cashflow, net present value and other KPIs<br>• Combine adaptation options to develop an optimal adaptation pathway |
| **ARGOS** | *PDC and DEMA* | ARGOS is a software system to support the emergency organization to make the best possible decisions in case of incidents involving atmospheric dispersion of hazardous CBRN-materials.<br>ARGOS is useful throughout the entire disaster life cycle:<br>During the Preparedness phase for planning, dimensioning and training - including evaluation of various 'What-if' scenarios<br>During the Response phase by calculating prognoses about how the situation will evolve; what can be the consequences of the dispersion; what the proper emergency or evacuation zones are; etc.<br>During the Recovery phase; what will be the effect of applying possible countermeasures; etc.<br>In the Evaluation phase to study what could have been done better and how could the situation have evolved? |

*Source: tool webpage.*

| Tool | Developer | Description* |
|---|---|---|
| **Capacity Assessment Tool for Infrastructure (CAT-I)** | *UNOPS* | UNOPS provides a tool, called CAT-I, for government users to assess the capacity of governments to plan, deliver, and manage infrastructure systems.<br>CAT-I identifies gaps in capacity to delivery and manage infrastructure systems. The assessment will evaluate a country state, city or ministry's ability to identify the need for new assets or upgrades to a current asset, manage risk within the built environment, properly design and construct infrastructure projects, safely manage and operate infrastructure systems, and to safely decommission assets at end of life.<br>The tool is web based and requires registration and user approval by administrator.<br><br>The specific objectives of CAT-I are to:<br>• Create a common language and framework for infrastructure capacity development;<br>• Identify capacity gaps to plan, deliver, and manage infrastructure systems;<br>• Support the identification of potential solutions to build capacity;<br>• Create a pipeline of programmes and projects to build capacity for the partner government; and<br>• Show progress against a measured baseline |
| **Cascading Effect Simulation in Urban Areas to Access and Increase Resilience (CAESAR)** | *Fraunhofer EMI* | The CAESAR (Cascading Effect Simulation in urban Areas to assess and increase Resilience) tool addresses the need to better understand the cascading effects of major disasters in connected and interdependent urban infrastructure systems. CAESAR has the capacity to identify the most vulnerable components within individual infrastructure grids and it allows to assess potential damages within the grid as well as within coupled grids. In addition, the tool is capable to simulate mitigation strategies and their effectiveness beyond single grid boundaries. Required input parameters can be adjusted to the level of the available information enabling analyses on varying levels of detail. The tool can be applied to vital infrastructure grids such as energy, transport and telecommunication. |
| **CDIA PROJECT SCREENING TOOL** | *Cities Development Initiative for Asia (CDIA)* | CDIA aims to help cities identify and profile investments, particularly those prioritized in climate resilience strategies, to enhance opportunities for downstream finance. CDIA focuses on developing investments in urban infrastructure and service between city-level urban strategies and implementing specific infrastructure projects with domestic, international, public, or private financing. |
| **City Resilience Actions Inventory and Stakeholder Perception Review** | *100 Resilient Cities & Arup* | It documents and analyzes existing plans, policies and projects in the city. Establish a baseline of where the city is taking action across the 12 drivers of resilience and identify efforts the City Resilience Strategy can further develop and/or advance. |
| **City Resilience Index (CRI)** | *Arup* | The City Resilience Index is the first comprehensive tool for cities to understand and assess their resilience, enhancing their ability to build sound strategies and plans for a strong future. Through an online platform, it uses a comprehensive, holistic framework that is applicable at the city scale – one that combined the physical aspects of cities with intangible aspects associated with human behaviour which are often relevant in the context of economic, physical and social disruption. It is developed by Arup with support from The Rockefeller Foundation. |
| **City Resilience Profiling Tool (CRPT)** | *UN Habitat* | The City Resilience Profiling Tool (CRPT) is a self-assessment tool primarily addressed to municipal leaders, managers, urban planners, and other personnel with a responsibility for ensuring the safety, maintenance, and security of all aspects and functions of an urban area, including critical infrastructure and services, health facilities, transport and telecommunications networks, sanitation, water, etc.<br>The City Resilience Profiling Programme (CRPP) designs this tool for generating metrics for urban resilience in order to establish baselines (or 'profiles') upon which to integrate resilience based inputs to sustainable urban planning, development, and management processes in cities and other human settlements throughout the world. The main goal of the CRPP is to support local governments and their stakeholders by transforming urban areas into safer and better places to live in, and improve their capacity to absorb and rebound quickly to any and all potential shocks or stresses. |
| **City Scan** | *The World Bank* | Rapid urbanization is transforming the planet and the way we live. The City Scan is an assessment tool and framework that provides a rapid assessment of the critical development challenges that cities face using publicly available data. The City Scan aims to serve as a conversation starter between the World Bank task team and client city to assess cities' investment priorities and financing needs |

| Tool | Developer | Description* |
|---|---|---|
| **CityStrength Diagnostic** | *The World Bank* | CityStrength is a rapid diagnostic that aims to help cities enhance their resilience to a variety of shocks and stresses. A qualitative assessment developed with support from the Global Facility for Disaster Reduction and Recovery (GFDRR), the diagnostic takes a holistic and integrated approach and encourages collaboration between sectors to more efficiently tackle issues and unlock opportunities within the city. CityStrength is flexible and can adapt to different needs of clients in terms of depth and breadth, and can be implemented in any city or combination of cities within a country regardless of size, institutional capacity, or phase of development. |
| **Climate Bonds Standard** | *Climate Bonds Initiative* | The Climate Bonds Standard and Certification Scheme is a labelling scheme for bonds. Rigorous scientific criteria ensure that it is consistent with the 2 degrees Celsius warming limit in the Paris Agreement. The Scheme is used globally by bond issuers, governments, investors and the financial markets to prioritise investments which genuinely contribute to addressing climate change. |
| **Climate Lens** | *Infrastructure Canada* | The Climate Lens is a horizontal requirement applicable to Infrastructure Canada's Investing in Canada Infrastructure Program (ICIP), Disaster Mitigation and Adaptation Fund (DMAF) and Smart Cities Challenge. It has two components the GHG mitigation assessment, which will measure the anticipated GHG emissions impact of an infrastructure projects, and the climate change resilience assessment, which will employ a risk management approach to anticipate, prevent, withstand, respond to, and recover from a climate change related disruption or impact. |
| **Climate Risk And Adaptation Framework And Taxonomy (CRAFT)** | *Arup* | CRAFT is a reporting standard integrated into the CDP Cities and carbon Climate Registry reporting platforms which allows cities to share the status of their climate adaptation planning efforts. Developed by Arup and C40 with support from Bloomberg Philanthropies, it establishes a platform for city officials to report the unique conditions their cities face and their planning responses. CRAFT provides:<br>• a framework for cities to perform robust and consistent reporting of climate hazards and associated adaptation planning and implementation that is required by the Compact of Mayors;<br>• a means to monitor and evaluate adaptation planning progress to help cities improve adaptation efforts by enhancing knowledge of best practices;<br>a means for cities to identify priorities and target advocacy for climate adaptation resources;<br>• the data to improve the ability for cities and their partners to identify peers and aspirational examples to help inform their own adaptation planning process and implementation. |
| **Climate Risk Informed Decision Analysis (CRIDA)** | *AGWA* | CRIDA provides stepwise planning guidance for water resources planners, managers, and engineers to implement robust water management as promoted by the AGWA network — particularly for water managers working in the developing world. CRIDA will initially launch as a publication, and support a community of practice to rapidly scale up implementation. |
| **Coastal Resilience Mapping Portal** | *Mississippi-Alabama Sea Grant Consortium and NOAA's Coastal Storms Program* | Coastal Resilience is a global network of practitioners who are applying an approach and web-based mapping tool designed to help communities understand their vulnerability from coastal hazards, reduce their risk and determine the value of nature-based solutions.<br>This online, interactive tool helps users visualize future flood risks from sea level rise and storm surge. The tool identifies areas and populations at risk and provides a better understanding of potential ecological, social, and economic impacts. This information is particularly helpful to officials involved in coastal planning, zoning, and land acquisition who must take into consideration rising sea levels and increased storm intensity and frequency. |
| **Community Resilience Assessment Methodology (CRAM)** | *National Institute of Standards and Technology (NIST)* | A concept paper for a community resilience assessment methodology (CRAM). The goal is to assess community resilience by measuring the preparedness of different resource areas and infrastructure systems on which communities depend (e.g. communication and transportation). Built on research and stakeholder dialogues conducted to support the development of a disaster resilience framework, CRAM places a strong emphasis on the interconnection between infrastructure and social systems and complements NIST's ongoing effort to support community resilience planning.<br>This is an ongoing development with plan till FY 2019. |

| Tool | Developer | Description* |
|---|---|---|
| **Critical Infrastructures Relations and Consequences for Life and Environment (CIrcle)** | *Deltares* | CIrcle is a tool to support the analysis of domino effects of critical infrastructure failure. It gives insight into how the effects of shocks and stresses on one type of infrastructure can lead to subsequent effects on other types of critical infrastructure.<br>Users define the dependencies between Critical Infrastructures and CIrcle facilitates the discussion between interdependent stakeholders, building trust and stimulating future partnerships.<br>CIrcle's approach:<br>• Gather (open) data on critical and vulnerable infrastructure<br>• Gather expert knowledge on direct impacts and dependencies<br>• Combine data with expert knowledge to conduct cascading effect analyses<br>• Complement risk assessments with gained insights on indirect effects<br>• Increase cooperation between stakeholders<br><br>Users are governmental organizations and agencies, network operators, emergency response organizations as well as large industries who are interested in the dependencies between Critical Infrastructures. |
| **Disaster resilience scorecard for cities** | *United Nations Office for Disaster Risk Reduction (UNISDR)* | The Scorecard provides a set of assessments that will allow local governments to monitor and review progress and challenges in the implementation of the Sendai Framework for Disaster Risk Reduction: 2015-2030, and assess their disaster resilience. It is structured around UNISDR's Ten Essentials for Making Cities Resilient. |
| **EARTH EX** | *Electric Infrastructure Security (EIS) Council* | EARTH EX simulates global-scale disruption, with long duration power outages and cascading failures of all other infrastructures. It offers executive and senior level operational decision makers the opportunity to review critical decision-making policies, processes, roles and responsibilities – essential to the success of all other response and recovery operations. The exercise is designed for self-evaluation, with distributed play conducted using electronic tools, and local facilitation for feedback and execution. |
| **EDGe$ - (Economic Decision Guide Software)** | *National Institute of Standards and Technology (NIST)* | "EDGe$ provides a transparent and flexible economic methodology based on best-practices for evaluating investment decisions aimed at improving the ability of communities to adapt to, withstand, and quickly recover from natural, technology, and human-caused disruptive events.<br>The tool helps to identify and compare the relevant present and future resilience costs and benefits associated with new capital investment alternatives versus maintaining a community's status-quo. The tool is based on the process found in Community Resilience Economic Decision Guide for Buildings and Infrastructure Systems (EDGe)." |
| **Elephant Builder** | *Bellwether Collaboratory* | The Elephant Builder is Bellwether Collaboratory's collaborative modeling tool for multi-stakeholder planning processes. Governments and non-profits use the Elephant Builder to engage experts and community members in an authentically inclusive manner, as stakeholders build and analyze causal models of the community systems of interest.<br>The modeling process requires little training and can accommodate stakeholders across a broad range of technical sophistication and confidence: models are built node by node, the Elephant Builder asking simple cause-and-effect questions. Once the model is completed, the Elephant Builder guides stakeholders through the identification of causal pathways, system vulnerabilities, feedback loops, and recommended actions. Users can also parameterize the model with quantitative variable-states and probabilistic causal relationships, allowing the Elephant Builder to act as an AI-backed scenario-testing tool.<br>The Elephant Builder has been used to examine critical lifeline interdependencies in Los Angeles (Susanne Moser Research and Consulting and U.S. Geological Survey), food systems in New York state (SUNY Albany School of Public Health), and community resilience in Larimer County, Colorado (Larimer County Office of Emergency Management). |
| **Envision** | *Institute for Sustainable Infrastructure* | Envision is a ground-breaking resource for professionals involved in planning, designing, building, maintaining civil infrastructure. As a rating system for sustainable infrastructure, Envision is supported by a wide array of respected organisations involved in infrastructure design, construction, and operation.<br>Envision provides guidance on sustainable best practices at no cost to users, and serves not only as a planning and design tool, but also as means of evaluating infrastructure project once complete. |
| **Equitable Origin Platform** | *Equitable Origin* | The Equitable Origin (EO) Platform is a one-stop resource that provides energy companies, utilities, investors, and corporate power purchasers with essential tools to effectively implement and track due diligence and compliance within their operations, supply chains, and investment portfolios. The EO100™ Performance Assessment provides a quick, easy, and efficient way to measure the performance of energy and energy infrastructure projects and suppliers of energy against a comprehensive and customizable range of environmental, social and governance (ESG) indicators. |

| Tool | Developer | Description* |
|---|---|---|
| **FHWA P3 Toolkit** | *U.S. Department of transportation Federal Highway Administration (FHWA)* | The Center for Innovative Finance Support provides information and expertise in the use of different P3 approaches. The P3 Toolkit includes analytical tools and guidance documents to assist in educating public sector policy-makers, legislative and executive staff, and transportation professionals in implementation of P3 projects. The P3 Toolkit forms the base of a broader P3 capacity-building program which includes a curriculum of courses and webinars. The P3 Toolkit addresses Federal requirements and four key areas of P3 implementation: Legislation and Policy; Planning and Evaluation; Procurement; Monitoring and Oversight. |
| **Framework for Acting under Uncertainty and Complexity (FAUC®)** | *GloComNet* | The FAUC framework focuses on Five Capacities of an Organization:<br>• Entrepreneurial<br>• Alert<br>• Adaptive<br>• Resilient<br>• Creative<br>It helps to find weak spots and enables organizations to act effectively in complex and uncertain environments.<br>The FAUC® is delivered through two products: FAUC® PLAY and FAUC® Assessment. The approach of the FAUC©PLAY is interactive. The FAUC©PLAY uses structured dialogue, playing and the wisdom of people involved. The FAUC© assessment uses both quantitative and qualitative information and the wisdom of people involved. |
| **GeoNode** | *OSGeo* | GeoNode is a web-based application and platform for developing geospatial information systems (GIS) and for deploying spatial data infrastructures (SDI). Government and Private companies are able to make official data publicly available while maintaining the ownership of their data. |
| **Geospatial Risk and Resilience Assessment Platform (GRRASP)** | *European Commission* | Geospatial Risk and Resilience Assessment Platform (GRRASP) is a World Wide Web oriented architecture bringing together geospatial technologies and computational tools for the analysis and simulation of critical infrastructures. It allows information sharing and constitutes a basis for future developments in the direction of collaborative analysis and federated simulation. It takes on board security concerns in the information sharing process, thanks to its ability to manage users and roles consistently. Based entirely on open source technologies, the system can also be deployed in separate servers and used by EU Member States as a means to facilitate the analysis of risk and resilience in critical infrastructures. GRRASP can be used for the analysis of complex networked systems taking into consideration cross-sectoral and cross-border interdependencies. It can be used for analyses of CI disruptions at local, regional, national, international level. GRRASP follows a tiered approach according to which Tier 1 modules can be used for the analysis of critical infrastructures at sectoral level, Tier 2 modules for cross-sectoral analyses (interdependencies), and finally Tier 3 modules for high level economic impact of CI disruption at state level. |
| **Green Evaluation** | *S&P Global Ratings* | An S&P Global Ratings Green Evaluation is an asset-level environmental credential which aims to provide investors with a more comprehensive picture of the green impact and climate risk attributes of their portfolios.<br>We base our evaluation of an adaptation project on the increase in resilience the project is likely to provide for the covered geographical area or asset base. This results in the adaptation score.<br>First, we quantitatively evaluate the benefit of the added resilience, relative to the amount of the financing's proceeds, on a five-point scale. The benefit is the forecast reduction in the cost of expected damages caused by extreme weather events. It is based on an entity's analysis, to which we may apply quantitative adjustments.<br>Second, we modify the evaluation score determined in the first step, based on our qualitative view of the adequacy of an entity's quantification approach to determining the resilience benefit.<br>Third, we may apply additional adjustments in certain cases--for example, for projects that are in developing countries for which the resilience benefit may be understated because the likely significant social benefits are difficult to quantify. |
| **GRESB Resilience Module** | *GRESB* | The GRESB Resilience Module has been developed in response to organisations that are developing a capacity to assess, manage and adapt in the face of social and environmental shocks and stressors.<br>The Resilience Module seeks to provide investors with information needed to understand how real estate and infrastructure companies and funds are preparing for potentially disruptive events and changing conditions, assessing long-term trends, and becoming more resilient over time. The Module seeks to evaluate the capacity of organizations to assess and respond to risks and opportunities related to climate, environmental, social, economic, technological and geopolitical changes through asset resilience and the organization's management capacity. |

| Tool | Developer | Description* |
|---|---|---|
| **HAZUR ®** | *Opticitis* | HAZUR is a piece of software designed to support the design, implementation and management of cities resilience strategy.<br>It helps to summarize all city data, to analyze interdependencies in service networks, to assess impacts aftermaths and cascade effects. It also enables the identification and prioritization of potential improvement projects, facilitates the definition of crisis management protocols and supports a strategy development process. |
| **Hazus** | *Federal Emergency Management Agency (FEMA)* | Hazus is a nationally applicable standardized methodology that contains models for estimating potential losses from earthquakes, floods, and hurricanes. Hazus uses Geographic Information Systems (GIS) technology to estimate physical, economic, and social impacts of disasters. It graphically illustrates the limits of identified high-risk locations due to earthquake, hurricane, flood, and tsunami.<br>Hazus is also used for mitigation and recovery, as well as preparedness and response. Government planners, GIS specialists, and emergency managers use Hazus to determine losses and the most beneficial mitigation approaches to take to minimize them. |
| **ICLEI ACCCRN Process Workbook** | *ICLEI and Rockefeller Foundation* | The ICLEI ACCCRN Process (IAP) enables local governments to assess their climate risks in the context of urbanisation, poverty and vulnerability and formulate corresponding resilience strategies. The ICLEI ACCCRN Process has been designed in a step-by-step format, divided into 6 phases. Phases 5 and 6 that guide cities in the implementation and monitoring phases will be included in the following edition of the IAP toolkit. The process is also designed to be a continuous cycle of review and refinement, rather than a closed cycle. |
| **Local Climate Impacts Profile (LCLIP)** | *UKCIP* | LCLIP is a simple tool designed to help organisations to assess their exposure to the weather. It can be used as a standalone tool, or as a step in a risk-based framework such as the Adaptation Wizard.<br>The LCLIP process shows how prepared an organisation is to deal with severe weather events. For example, one LCLIP uncovered £16.4 million of unplanned costs over a decade due, to emergency provisions, insurance claims and road repairs after weather events. Understanding your current vulnerability to the weather can be a powerful catalyst to further awareness and action on preparing for the future climate |
| **National Infrastructure Systems MODel (NISMOD)** | *UK Infrastructure Transitions Research Consortium (ITRC)* | NISMOD is the UK's first national infrastructure system-to-systems modelling platform and database. By 2020, the UK Infrastructure Transitions Research Consortium (ITRC) national infrastructure portal will open to academia and industry as well as policymakers, providing access to infrastructure datasets, simulation and modelling results.<br>We investigate infrastructure and its interdependencies in energy, digital communications, solid waste, transport, waste water, water supply and infrastructure governance.<br>NISMOD-Int is a series of open-source analysis tools for the application of evidence-based decision making to developing counties. These tools will allow recipient countries to develop and assess alternative infrastructure transition strategies for meeting their future sustainable development goals. |
| **Oasis Loss Modelling Framework (Catastrophe Modelling)** | *Oasis* | Catastrophe modelling is the process of using computer-assisted calculations to estimate the losses that could be sustained due to catastrophic event such as hurricane or earthquake. Oasis an improve risk assessment through more models, different view of the risk, transparency, performance, and innovation. The Oasis Loss Modelling Framework provides an open source platform for developing, deploying and executing catastrophe models. It uses a full simulation engine and makes no restrictions on the modelling approach. Models are packaged in a standard format and the components can be from any source, such as model vendors, academic and research groups. |
| **Open Data for Resilience Index (Beta)** | *GFDRR* | The Open Data for Resilience Index is a tool to identify, assess and compare, for any country, the availability and ease of use of datasets that are considered to be key for disaster risk management. Anyone can submit a dataset. The result is a crowdsourced-database providing the state of open data for disaster risk management for any country. |
| **Opportunity Assessment Tool (OAT)** | *Independent Project Analysis (IPA)* | Using data from thousands of actual exploration and production (E&P) projects, OAT is able to quickly and easily assess the viability and marginality of upstream opportunities during bidding, exploration, or early development. The application helps companies understand an opportunity's true development costs, thereby ensuring only the highest return opportunities receive increasingly scant capital funds.<br>In less than 15 minutes, OAT can provide a full set of key decision metrics (using data from thousands of actual E&P projects), including charts, to compare individual opportunities in a portfolio. |

| Tool | Developer | Description* |
|---|---|---|
| **Participatory Capacity and Vulnerability Analysis (PCVA)** | *Oxfam* | Oxfam's participatory capacity and vulnerability analysis (PCVA) tool is a risk analysis process designed to help staff and partner organisations engage with communities in contexts where natural disasters are significant drivers of poverty and suffering. PCVA has its roots in two proven social development methodologies. First, it stems from capacity and vulnerability analysis (CVA) methodology. This has long enabled development and humanitarian aid workers to design programmes based on a community's capacities as well as its vulnerabilities. It recognises that vulnerable people have capacities to cope with adversity and can take steps to improve their lives, however difficult their situation may be. Second, it is rooted in the belief that enabling communities to genuinely participate in programme design, planning, and management leads to increased ownership, accountability and impact, and is the best way to bring about change. PCVA draws on a wide range of participatory learning and action (PLA) techniques and tools that are designed to channel participants' ideas and efforts into a structured process of analysis, learning, and action planning, with the overall aim of reducing a community's disaster risk. |
| **Quick Risk Estimation (QRE) Tool** | *United Nations Office for Disaster Risk Reduction (UNISDR)* | The Quick Risk Estimation tool is designed for the purposes of identifying and understanding current and future risk/ stress/ shocks and exposure threats to both human and physical assets. The QRE tool is not a full scale risk assessment, rather a multi-stakeholder engagement process to establish a common understanding. Taking into account the actions or corrective measures already undertaken, the QRE will produce a dashboard-style risk assessment advising the risks and hazard to human and physical assets, impacts of identified main risk and associated perils on the specified location and/or particular assets. |
| **RApid Source TErm Prediction (RASTEP)** | *Lloyd's Register* | RApid Source TErm Prediction (RASTEP) is a tool for decision support to emergency response organisations in the event of an accident with potential radioactive releases.<br>It works in the following way:<br>The user answers questions on the ongoing event, and the underlying model uses the given answers together with advanced data modelling to predict the most likely outcome in a database of pre-calculated consequences. We think this tool has potential to be generalized to other situations with uncertain outcome in complex systems, e.g. climate change, volcanic eruptions, epidemics, market development etc. |
| **Realising European ReSILiencE for Critical INfraStructure (RESILENS)** | *H2020 RESILENS Project* | RESILENS will develop a European Resilience Management Guideline (ERMG) to support the practical application of resilience to all CI sectors. Accompanying the ERMG will be a Resilience Management Matrix and Audit Toolkit (ReMMAT) which will enable CI systems (encompassing assets and organisations) to have their level of resilience quantitatively and qualitatively indexed. |
| **Reliability Workbench** | *Isograph* | Reliability Workbench is Isograph's flagship suite of reliability, safety and maintainability software. You can use Reliability Workbench to display which maintenance or design changes will improve system reliability, predict the reliability of systems and create maintenance plans accordingly. The custom built report designer allows you to create reports with any amount of detail, high level right down to component specific information. Add a whole new level of detail to your system reliability presentations. The Enterprise edition of Reliability Workbench allows collaboration between colleagues on projects. Limit access to projects and folders to appropriate users and allow managers to approve or reject changes to projects with version control. |
| **Resilience Atlas** | *Conservation International* | The Resilience Atlas was developed with funding from the Rockefeller Foundation to identify where projects should take place and allow users to derive insights of their own based on data. The developers believed that policymakers and donors needed to know where problems were occurring to know where to make investments.<br>The Resilience Atlas is an interactive analytical tool for building:<br>1. understanding of the extent and severity of some of the key stressors and shocks that are affecting rural livelihoods, production systems, and ecosystems in the Sahel, Horn of Africa and South and Southeast Asia;<br>2. Insights into the ways that different types of wealth and assets (i.e. natural capital, human capital, social capital, financial capital and manufactured capital) and combinations among these - impact resilience in particular contexts.<br>The tool is a web-based open source mapping platform.<br>To date, the tool has been used at the national level, but there are opportunities to use the data at a more localized level. Data is available for all countries. This tool is primarily used in places where capacity for remote sensing and GIS is lower. |

| Tool | Developer | Description* |
|---|---|---|
| **Resilience Garage** | *100 Resilient Cities & Roland Kupers* | The Resilience Garage assembles a group of 20-25 experts from across sectors and disciplines with the aim to peer review and to identify opportunities to better understand or solve challenging problems. This is done through either specific resilient projects (projects that have multiple benefits and address multiple issues) or by developing key focus areas for further consideration. It is practical – aiming for concrete recommendations – as well as fundamental – rigorously applying a rich resilience toolset. It applies the learning and tools developed following a two-year collaboration that explored how to make resilience more actionable. |
| **Resilience Value Realization (RVR)** | *ValueLab* | The Resilience Value Realization (RVR) methodology was developed by ValueLab through funding from The Rockefeller Foundation to be used by city governments with project owners identified.<br>RVR is a customized approach to project planning, pre-development, and development that was designed to identify, catalyze and protect the delivery of resilience value to public and private stakeholders in a project. The RVR approach comprises working with project teams and resilience champions to be very specific about how the opportunity can create resilience and to address, as an integral part of project development, any challenges impacting the delivery of resilience value. The workshop is structured to start with understanding where things are today, then asks participants to develop an opportunity statement around where they want to be in the future, which leads to development of a roadmap for realizing that opportunity.<br>The tool is flexible and has also been used to identify and empower a project owner.<br>This tool is delivered as a workshop, but requires pre-work including interviews, data gathering, and data representation (drawings, maps, figures, etc.). This tool can be used in all geographic regions. |
| **Resilience.io** | *Ecological Sequestration Trust* | Resilience.io is designed as a computer-based platform that provides an integrated systems view of a city-region. It will be an analysis and decision-support tool for collaboration and resilience decision-making. The resilience.io platform combines computer representations of resource flows, human and business activities and infrastructure systems. The platform contains a growing library of process models of typical human, industrial and ecological systems, the relevant ones of which are used in a local instance to create a tailored integrated systems model for a city-region. |
| **Resilience-based Earthquake Design Initiative (REDi)** | *Arup* | The REDi Rating System is developed by Arup's Advanced Technology and Research team, proposes a framework for owners, architects, and engineers to implement 'resilience-based earthquake design' to new development. It describes design and planning criteria to enable owners to resume business operations and provide liveable conditions quickly after an earthquake, according to their desired resilience objectives. It also presents a loss evaluation methodology for assessing the success of the adopted design and planning measures in meeting the resilience objectives. |
| **RiskSpectrum** | *Lloyd´s Register* | RiskSpectrum® is the product family name of one of the most advanced risk and reliability analysis software in the world.<br>It includes tools for fault tree and event tree modelling and analysis, documentation, risk monitoring, Human reliability assessment and failure mode and effect analysis. |
| **Sea Level Rise and Extreme Sea Level Analysis Service** | *Climate Central* | This app exposes information from global climate models combined with datasets on vertical land movement on a local level, and shows this with local population density information (which clearly shows the extent of coastal cities), offering opportunities for data presentation previously unavailable to a wider audience.<br>Extreme sea levels analysis tool includes the latest historical storms surge data for the globe, high tide events, and sea levels changes caused by lower atmospheric pressure and severe winds during storms in climate scenarios. |
| **SIM-CI Platform** | *SIM-CI* | SIM-CI is a simulation software that allows to calculate the cascading effects using various impact indicators, from number of people affected to projected costs. A variety of techniques are used to visualize the scenarios, including standard reports, 2D and 3D interfaces and full-blown virtual reality representations. |
| **SmartScan** | *Global Infrastructure Basel* | The SuRe SmartScan contributes to action items addressing two challenges (Capital Investment Planning Poor, and/or Non Climate-Smart, Local Development Planning Poor, including Resilience) of the City Creditworthiness Self-Assessment & Action Planning Toolkit of the World Bank. The GIB SmartScan allows you to assess your projects based on its Environmental, Social and Governance (ESG) issues and helps to efficiently flag risks and opportunities for improvements of your project. This process helps you to identify and therefore eliminate risks and to improve the ESG aspects of the assessed project, which is increasingly a mandatory consideration for investors in their investment decisions. |

| Tool | Developer | Description* |
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| **Standard for Sustainable and Resilience Infrastructure (SuRe®)** | *Global Infrastructure Basel* | SuRe® - the Standard for Sustainable and Resilient Infrastructure is a third-party-verified, global voluntary standard, which drives the integration of sustainability and resilience aspects into infrastructure development and upgrade by providing guidance for infrastructure project developers, financiers and public-sector institutions. The Standard assesses infrastructure throughout the project life cycle at the design, construction and operational phases.<br>SuRe® consists of 14 themes covering 61 criteria across environmental, social and governance (ESG) factors in addition to two general reporting requirements for impact measurement.SuRe® can be applied to all types of infrastructure, including critical infrastructure systems and infrastructure services.<br>SuRe® development followed the ISEAL Alliance Codes of Good Practice for standard setting, and as of October 2018, SuRe® is the first infrastructure standard to be an Associate Member of ISEAL, the global membership association for credible and good practice in sustainability standards. Implementation Phase 2018-2019 whereby projects will be assessed on all SuRe® material criteria and, if compliant, be awarded a SuRe® certification. |
| **Sustainable Asset Valuation (SAVi)** | *International Institute of Sustainable Development (IISD)* | SAVi is a tool to make the investment case for sustainable infrastructure. It incorporates 3 fundamental features:<br>Valuation: SAVi values in financial terms, the material risks and co-benefits of infrastructure projects. We work with governments and investors to identify the risks material to their projects and design appropriate simulation scenarios.<br>Simulation: SAVi is unique in that it combines the results of systems thinking and system dynamics simulation with project finance modelling. We work with governments and investors to identify the material risks of each infrastructure project. We also identify co-benefits that contribute towards realising the UN sustainable development goals. We then determine the simulation scenarios.<br>Bespoke: The application of SAVi is bespoke. We customise SAVi to each individual infrastructure project. Such an approach is required as each project is characteristic of distinctive opportunities and risks. |
| **The IS Rating Scheme** | *Infrastructure Sustainability Council of Australia (ISCA)* | The IS Rating Scheme (IS) is Australia and New Zealand's only comprehensive rating system for evaluating sustainability across the planning, design, construction and operational phases of infrastructure programs, projects, networks and assets. IS evaluates the sustainability performance of the quadruple bottom line (Governance, Economic, Environmental and Social) of infrastructure development.<br><br>The IS rating scheme aims to:<br>Provide a common national language for sustainability in infrastructure.<br>Provide a framework for consistent application and evaluation of sustainability in tendering processes.<br>Help in scoping whole-of-life sustainability risks for projects and assets, enabling smarter solutions that reduce risks and costs.<br>Foster efficiency and waste reduction, reducing costs.<br>Foster innovation and continuous improvement in the sustainability outcomes from infrastructure.<br>Build an organisation's credentials and reputation in its approach to sustainability outcomes. |
| **The PREPData tool** | *Partnership for Resilience and Preparedness (PREP)* | PREPdata is a map-based, open data online platform that allows users to access and visualize spatial data reflecting past and future climate, as well as the physical and socioeconomic landscape for climate adaptation and resilience planning. The platform is continuing to evolve through the input of PREP partners and PREPdata users. It is a flexible tool for climate adaptation planning, designed to address many of the gaps and challenges adaptation practitioners face.<br><br>Distinguishing elements of PREPdata:<br>A visual, map-based platform that is user-friendly and customized to different contexts and skill levels;<br>Active curation of datasets focused on climate resilience, streamlining the process of accessing and navigating to relevant data;<br>A commitment to global coverage, with an emphasis on increasing access to datasets for the Global South, and support for applications across different scales and geographies; and<br>A user-needs based strategy for platform development, utilizing the knowledge and network of the partners and platform users to enable continuous improvement. |

| Tool | Developer | Description* |
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| **The Resilience Action List (RELi) standard** | *U.S. Green Building Council, Inc. (USGBC) et al* | The RELi 2.0 Rating System (RELi 2.0) is a holistic, resilience-based rating system that combines innovative design criteria with the latest in integrative design processes for next-generation neighborhoods, buildings, homes and infrastructure. By selectively bundling existing sustainable and regenerative guidelines with RELi's ground-breaking credits for emergency preparedness, adaptation, and community vitality, RELi 2.0 is the most comprehensive reference guide and certification available anywhere for socially and environmentally resilient design and construction.<br>Since 2017, RELi has been managed by the U.S. Green Building Council, Inc. (USGBC) which, in conjunction with Market Transformation to Sustainability, is leading the evolution of RELi 2.0 to synthesize the LEED Resilient Design pilot credits with RELi's Hazard Mitigation and Adaptation credits. RELi 2.0 certification is based on a point system. The number of points that a project earns determines the certification level it receives. |
| **The Resilience Adaptation and Transformation Assessment Framework (RAPTA)** | *Commonwealth Scientific and Industrial Research Organisation (CSIRO) in partnership with STAP* | The RAPTA is a unique tool to build ideas of resilience, adaption and transformation into project from the start, to ensure outcomes that are practicable, valuable and sustainable through time and change. The RAPTA guidelines give practical guidance on the application of RAPTA in project design. The guidelines are targeted at practitioners working with local stakeholders to devise effective development projects that build resilience to shocks, stresses, and major external change. |
| **The Urban Community Resilience Assessment (UCRA)** | *World Resources Institute (WRI) and Cities Alliance* | The Urban Community Resilience Assessment (UCRA) helps cities incorporate individual and community capacities—social cohesion, familiarity with local climate risks, early warning systems and disaster readiness—into broader urban resilience evaluations. By analyzing these local capabilities, the UCRA provides a snapshot of preparedness behaviours, risk perception and the strength of neighborhood relationships. These findings enable individuals to identify context-specific adaptation actions and allow policymakers to engage community members in urban resilience planning. |
| **ThinkHazard!** | *The World Bank/ GFDRR* | GFDRR, a unit within the World Bank, has developed a web-based tool ThinkHazard! to enable non-specialists (decision makers, planners and government staff) to consider the impacts of disaster on new developments of project.<br>Users can quickly assess the level of river flood, earthquake, drought, cyclone, coastal flood, tsunami, volcano, and landslide hazard within their project area to assist with project planning and design. Users are only required to enter their project location – national, provincial or district name. The results interface shows a user whether they require high, medium or low awareness of each hazard when planning their project.<br>The interface provides links to additional resources such as country risk assessments, best practice guidance, and additional websites. ThinkHazard! also highlights how each hazard may change in the future as a result of climate change.<br>The tool is a web-based open source mapping platform allowing other developers to improve or alter the platform.<br>This tool is available in English, French, and Spanish. Data is available for all countries, but the information is most relevant for less developed countries as GIS datasets are more advanced in more developed countries. |
| **Training for Operational Resilience Capabilities (TORC)** | *SINTEF* | The Training for Operational Resilience Capabilities (TORC) approach addresses three distinct training arenas; operational training addresses the exploration of the necessary margin of manoeuvre in the ""compliance vs resilience"" space, managerial training addresses the assessment of a reasonable and accountable space of manoeuvre, while integrated training addresses the active reconciliation of margin and space of manoeuvre. This facilitates a continual process of updating of rules based on the enhanced knowledge about the professional competence and craftsmanship in the organization at hand.<br>The TORC approach is designed to be applicable in different contexts; in a normal operation context where pre-existing rules and procedures form the expectations of compliance, in an emergency context in which emergency plans form the presumptions of compliance, and in a ""managing the unexpected"" context in which the applicable set of rules and procedures must be collected and formed instantly and situation-dependently. |
| **Waterfront Edge Design Guidelines (WEDG)** | *Waterfront Alliance* | WEDG employs an evidence-based approach, focusing on three key pillars of excellent waterfront design:<br>Resilience: Reduce risks or be adaptable to the effects of sea level rise and increased coastal flooding, through setbacks, structural protection, and other integrative landscaping measures.<br>Ecology: Protect existing aquatic habitats and use designs, materials, and shoreline configurations to improve the ecological function of the coastal zone, and strive to be consistent with regional ecological goals.<br>Access: Be equitable and informed by the community, enhancing public access, supporting a diversity of uses, from maritime, recreation, and commerce where appropriate, thereby maximizing the diversity of the harbor and waterfront. |

| Tool | Developer | Description* |
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| **World Bank Climate & Disaster Risk Screening Tools** | *The World Bank* | Self-assessment tools provide a systematic, consistent, and transparent way of considering short- and long-term climate and disaster risks in project and national/sector planning processes. The tools target a range of sectors (both national/ policy and project levels): national plans, agricultural, coastal flood protection, energy, health, roads, water, etc. |
| **XDIGlobe** | *XDI Cross Dependency Initiative* | XDI Globe allows users to review your climate impact risks using a spatial interface, from a general area view down to an individual asset. This enables an easy overview, quickly highlighting areas at risk from each or all hazards.<br>Features are:<br>• See high risk areas at a glance<br>• Zoom in on individual assets to understand what they are and why they're vulnerable.<br>• Compare the same results through Asset View or Area View<br>• Identify relative impacts of each hazard<br>• View different times slices<br>• Interrogate individual assets for risk cost over time |

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