MARCH, 2022

# Pushing the Boundaries of Innovation in Sustainable and Resilient Infrastructure

International Coalition for Sustainable 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. We bring together a coalition of partners committed to bold action to solve the systemic problems that exist at the intersection of climate change, ageing infrastructure, and underinvestment.

ICSI is the voice of the engineering community on infrastructure sustainability, resilience and climate action. We place engineers at the forefront of climate action, harnessing their ability to provide solutions and matching it with urgent demand. The solutions we develop and promote will deliver impact on the ground, where it is needed most.

ICSI was created to bring the practical, science-based and solution-oriented perspective for which engineers are known to solve the systems-level problems surrounding infrastructure underinvestment, climate change, and resilience. From its origin, ICSI has been committed to driving action towards instilling sustainability and resilience as the cornerstone of every decision in the infrastructure lifecycle.

ICSI delivers industry change through its action tracks. ICSI is doing this by engaging members and their organizations through action tracks that seek to understand the gaps and barriers, responding with specific actions that can address these challenges, and engage and involve those stakeholders who are instrumental in delivering actions and adopting new resources, practices, and behaviors.

ICSI International Coalition for Sustainable Infrastructure

ASCE AMERICAN SOCIETY OF CIVIL ENGINEERS

ARCADIS



Cover image: Rijnhaven, Rotterdam, by Nick Vernij on Unsplash.

**AUTHORS:**

**Lead author:** Andrew O'Connell, Administrator, ASCE Foundation

**Innovation Action Track leads and contributing authors**: Jerry Buckwalter, Chief Innovation Officer, ASCE; Edgar Westerhof, Director for Flood Risk and Resilience North America, Arcadis

**ACKNOWLEDGEMENTS:**

| | |
|---|---|
| Andy Deacon | Global Covenant of Mayors |
| Anusha Shah | Institution of Civil Engineers (ICE) |
| Asma Jhina | Global Covenant of Mayors |
| Breanna Gribble | STV |
| Caroline Field | Arup |
| Christine Williams | ASCE Foundation |
| Emily Feenstra | American Society of Civil Engineers (ASCE) |
| Franco Grimes | Conrovia City Corporation |
| Gemma Cowan | International Coalition for Sustainable Infrastructure (ICSI) |
| Joel Conkling | Google |
| John Loughhead | Former Chief Scientific Advisor at BEIS |
| Kancheepuram Gunalan | AECOM |
| Michael Loose | Retired, U.S. Naval Facilities Command |
| Nancy Kralik | Fluor |
| Rachel Skinner | WSP |
| Rebecca Moore | Google |
| Robert Fields | STV |
| Rohit Aggarwala | Google Sidewalk Labs |
| Roland Hunziker | World Business Council for Sustainable Development (WBCSD) |
| Savina Carluccio | The International Coalition for Sustainable Infrastructure (ICSI) |

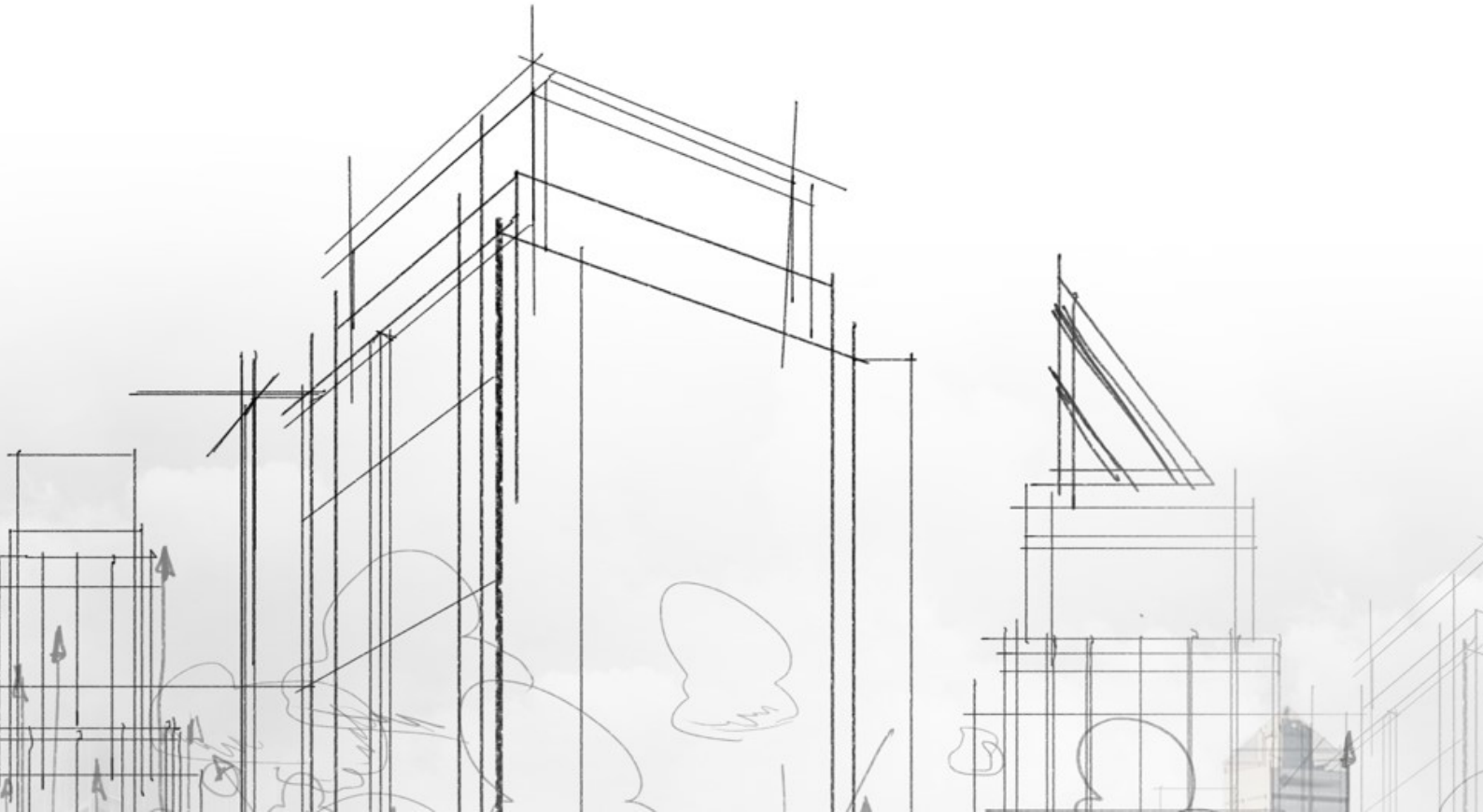
# Contents


| | | |
|---|---|---|
| **1.** | **Introduction** | **5** |
| 1.1 | The Innovation Action Track | 6 |
| 1.2 | The ICSI Innovation Champion label | 7 |
| **2.** | **The ICSI Innovative Project Database** | **8** |
| 2.1 | The Ecosystem of Innovation | 8 |
| 2.2 | Purpose of the Database | 9 |
| 2.3 | Data Collection | 9 |
| 2.4 | Limitations | 9 |
| 2.5 | Review and Ranking Process | 10 |
| **3.** | **Database Analysis** | **11** |
| 3.1 | Characteristics of the Top Projects | 11 |
| 3.2 | Areas of High Innovation | 12 |
| 3.3 | Initial Gap Identification | 13 |
| **4.** | **Discussion** | **14** |
| 4.1 | Systems Approaches | 14 |
| 4.2 | Financing | 14 |
| 4.3 | Governance | 15 |
| 4.4 | Addressing Gaps | 15 |
| 5.1 | Key Takeaways | 16 |
| **5.** | **Taking action to accelerate innovation** | **16** |
| 5.1 | Key Takeaways | 16 |
| 5.2 | Taking Action | 17 |
| References | | 18 |
| Appendix A | | 19 |


# 1. INTRODUCTION

**The ICSI Innovation Action Track aims to support projects that enhance innovation in both sustainability and resilience practices and solutions. This paper summarizes key findings of this work, allowing stakeholders across the infrastructure lifecycle to access and learn from real-world approaches to embedding sustainability and resilience in infrastructure.**

**The projects highlighted in this report can facilitate others to build towards quality, fast-paced, and replicable innovations that will help to accomplish the UN Sustainable Development goals and address the growing demand for climate-resilient infrastructure.**



# 1.1 The Innovation Action Track

**The ICSI Innovation Action Track works to:**

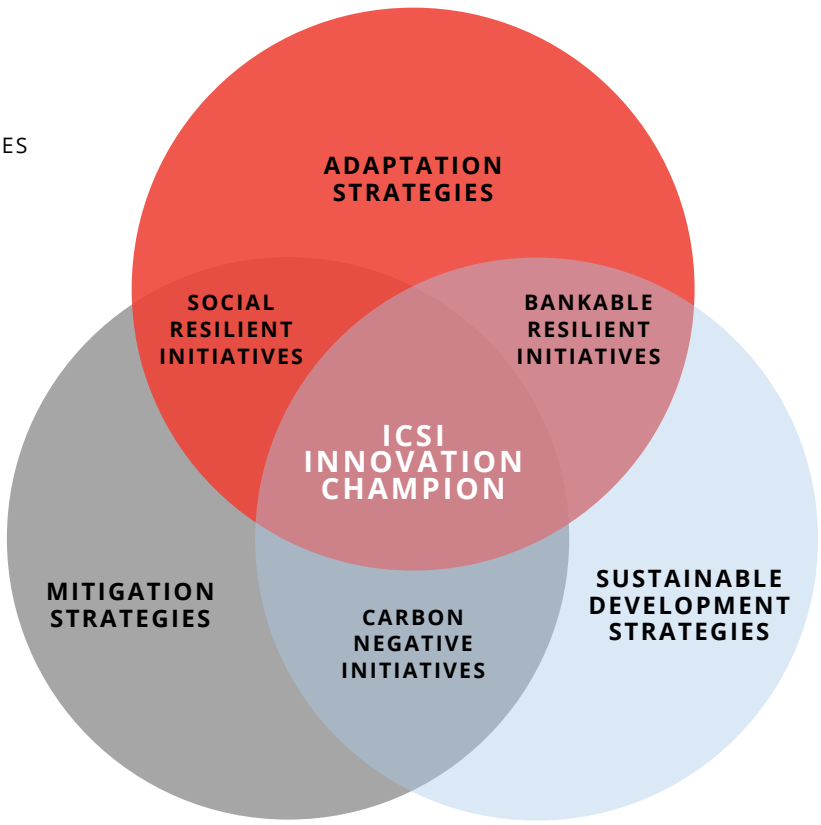
- Establish an overview of global climate adaptation and sustainability best practices based upon unique performance criteria and communicate findings. The overview is meant to evolve and further mature over time, capturing ongoing societal trends and innovative engineering solutions globally.
- Create a project database of those practices and key innovation values as a searchable document for all interested parties to use as a reference document.
- Provide insights and strategic advice on which future trends provide the opportunity for innovation to address these issues and highlight programs that drive innovative thinking.
- Foster communication of evolving results at global venues and pursue implementation of emerging values through the partner network.

**The Innovation Action Track has delivered work through two working groups:**

### THE CHAMPION SEARCH WORKING GROUP

Group focused on identifying current and planned infrastructure projects that address climate-related and natural phenomena exacerbated by human activity. This includes infrastructure projects related to, but is not limited to, climate-driven and climate-impacted sea-level rise, land use, heat, urban fires, energy, and human action (e.g., global competition for natural resources, carbon footprint). It seeks to highlight and communicate best-practice examples.

FIGURE 1: ICSI INNOVATION CHAMPION STRATEGIES DIAGRAM



### THE FUTURE TRENDS WORKING GROUP

Group is researching global trends and honing the work already done by the global community to identify those trends that most impact climate-related and natural phenomena exacerbated by human activity. It seeks to provide insights and strategic advice on which future trends provide the opportunity for innovation to address these issues and programs that drive innovative thinking.

Utilizing a multifaceted approach to achieve our objectives, the Champion Search group has taken a bottom-up approach while the Future Trends Working Group takes a top-down approach. To optimize the value of these efforts, the information gathered deliberately and strategically flowed between the two working groups and focus areas to emphasize the most pressing issues that will benefit from our work and increased attention. Specifically, the Future Trends Working Group utilized the knowledge and practice of our Champion Search Working Group to find innovative projects and people that are addressing the innovations necessary to drive the greatest global societal benefit.

## 1.2 The ICSI Innovation Champion label

Our work has defined a comprehensive set of innovation criteria by which we have identified 'best in class' projects and best practices.

In light of the threats to infrastructure posed by climate change and natural hazards, the need for infrastructure that addresses both sustainability and resilience issues is increasingly urgent. Projects that achieve this joint ambition through innovative means should be recognized and championed.

Through our work, we identify and showcase the best examples of projects, solutions and practices that sit at the intersection of adaptation, mitigation, and development strategies, with a view to ultimately accelerate the implementation of sustainable and resilient infrastructure.

To this end, we have defined an ICSI Innovation Champion as a project or individual that is pushing the boundaries and advancing systems-oriented sustainable and resilient solutions through the utilization of adaptation, mitigation, and/or development strategies (Figure 1).

These criteria could be used to define, assess, and measure pilot projects in cities around the globe. This also provides organizations such as the Global Covenant of Mayors (GCoM) more definitive methods to add innovation to their collaborative global city model.

### DEFINITIONS[1]

**Sustainability** – The ability to meet and address the needs of the present and future society in parallel.

**Resilience** – The capacity for individuals, communities, and systems to prepare for, adapt to, withstand, and recover from changing conditions, stress, and disruptions.

**Innovation** – The process of utilizing new technologies, techniques, practices, collaborative approaches, and materials to address the needs and problems a solution or project seeks to address or resolve in the pursuit of increased usefulness, performance, resilience, sustainability, affordability, and societal adoption.

**Infrastructure** – The systems, facilities, and assets that provide the basis for society and communities to connect, provide, and thrive.

# 2. THE ICSI INNOVATIVE PROJECT DATABASE

**All projects, individuals, or knowledge resources that meet the ICSI Innovation Champion criteria have been collated into a consolidated resource by the Champion Search Group. This will function as a living resource, with more projects added over time, and with the aim of providing insight and inspiration to infrastructure specialists around the world as they endeavor to incorporate sustainability and resilience into their own work.**

## 2.1 The Ecosystem of Innovation

This database is compiled to provide insight into the current state of innovation in sustainable and resilient infrastructure globally. While the primary focus of the working group was on the projects themselves, the team was also cognizant to note the location and context of the projects so that we could recognize hotbeds of innovation, known as ecosystems of innovation. Granstand and Holgersson define the concept as "the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors."[2] The set of actors within the ecosystem are generally research institutions, incubators and accelerators, investors, private equity firms, governments, personal networks, local communities, artists, activists, development agencies, start-ups, and private companies[3].

An innovation can be radical or incremental in its approach; a radical innovation introduces something completely new, while an incremental innovation adapts, or builds upon, an existing process or product in order to give it new purpose. Radical innovations are typically more disruptive and carry greater financial risk than incremental innovations, but also, as the name suggests, can radically transform a firm, industry, or even society.

In the real world, a blend of both radical and incremental innovation is needed to facilitate a paradigm shift on the ground.

In the course of ICSI's work, we are aiming to work with engineers and infrastructure decision-makers around the globe to create the necessary infrastructure to facilitate the creation of these ecosystems of innovation in order to build towards quality, fast-paced, and replicable innovations that will develop the necessary projects to attain the UN Sustainable Development Goals and address the growing demand for climate-resilient infrastructure. In this vein, we have approached our work in the Innovation Action Track with the goal to provoke the discussions, identify the contextual characteristics, and cultivated participation necessary to channel ICSI, and our partners', energies into creating ecosystems of innovation[4]. This will lead to actionable criteria that can be implemented utilizing this collaborative network.

A crucial part of this effort will be to highlight the necessary funding streams and funders that are willing to accept the financial risks that can be associated with paradigm-shifting innovative projects. To address this, we have been - and will continue to - work closely with the ICSI Funding and Finance Action track to ensure that the outcomes of our activities will be practical, fundable, and actionable for infrastructure decision-makers (e.g., city leaders, infrastructure owners-operators) and funders alike.

## 2.2 Purpose of the Database

In order to seek out areas of excellence in innovation, a review of projects either built or in construction was needed. To capture this landscape of innovation, we devised a simple database of innovative projects. This database was designed to capture and categorize projects by their area of practice, geographic location, the processes and tools used, the future trends engaged with, and the societal, economic and environmental benefits provided.

## 2.3 Data Collection

To fill the database with high-quality innovative projects, we reviewed 30 industry publications within the January 2020 to April 2021 timeframe. In compiling the database, we sought out quality over quantity in an effort to draw out the qualities and characteristics of projects that encompass both innovation and sustainability and include a subset of societal values. Some projects, while representing impressive sustainability, resilient, or innovative credentials, were excluded from the database as they did not represent all three areas. This is not to say that these projects are not groundbreaking and important in their own manner, however, they were not within this study's focus area.

The organizations and publications that we utilized in the creation of the database are global in nature and span public and private sector companies (e.g., AECOM, Arcadis, Arup), industry member organizations (e.g., ASCE, ICE, WFEO), NGOs (e.g., Rockefeller Foundation), city and national governments (e.g., City of Boston, Netherlands), and industry publications (e.g., Civil Engineering Magazine, New Civil Engineer).

The database includes projects from Northern Europe on smart sustainable buildings and renewable clean energy, while the UK was represented by an initiative to use virtual reality and holographic technology to augment the modeling and construction process.

In the Southeast & South-central US, featured projects focus on renewable energy, stormwater management, and the incorporation of regenerative designs. In the West Coast, innovative codes and public policies have been implemented to incorporate sustainable and resilient practices surrounding decarbonization and procurement.

Within Asia, the research highlights innovative initiatives surrounding smart windows and harnessing tidal energy.

## 2.4 Limitations

There are some limitations to this data collection process. First and foremost, each of the projects that we reviewed were sourced from the English language press. Therefore, we have a data gap when it comes to projects not represented in the English language press.

Secondly, the contributors to this study comprise a small group of experts and are not representative of all geographies. Going forward, we will look to expand the expert pool to include more representatives from the Global South. We will also strive to achieve a more gender-balanced group of contributors. The limited size of the reviewer set means that our analysis does not represent a statistical significance, despite the key insights provided.

Lastly, the approach used to fill the database was determinately focused on finding a broad set of quality projects that are pushing the envelope on innovation. This means that while some projects represented sufficient innovation in the realm of sustainability and resilience, they may not feature in the database because they contained innovations that are becoming commonplace or are granular in the improvements that they represent.

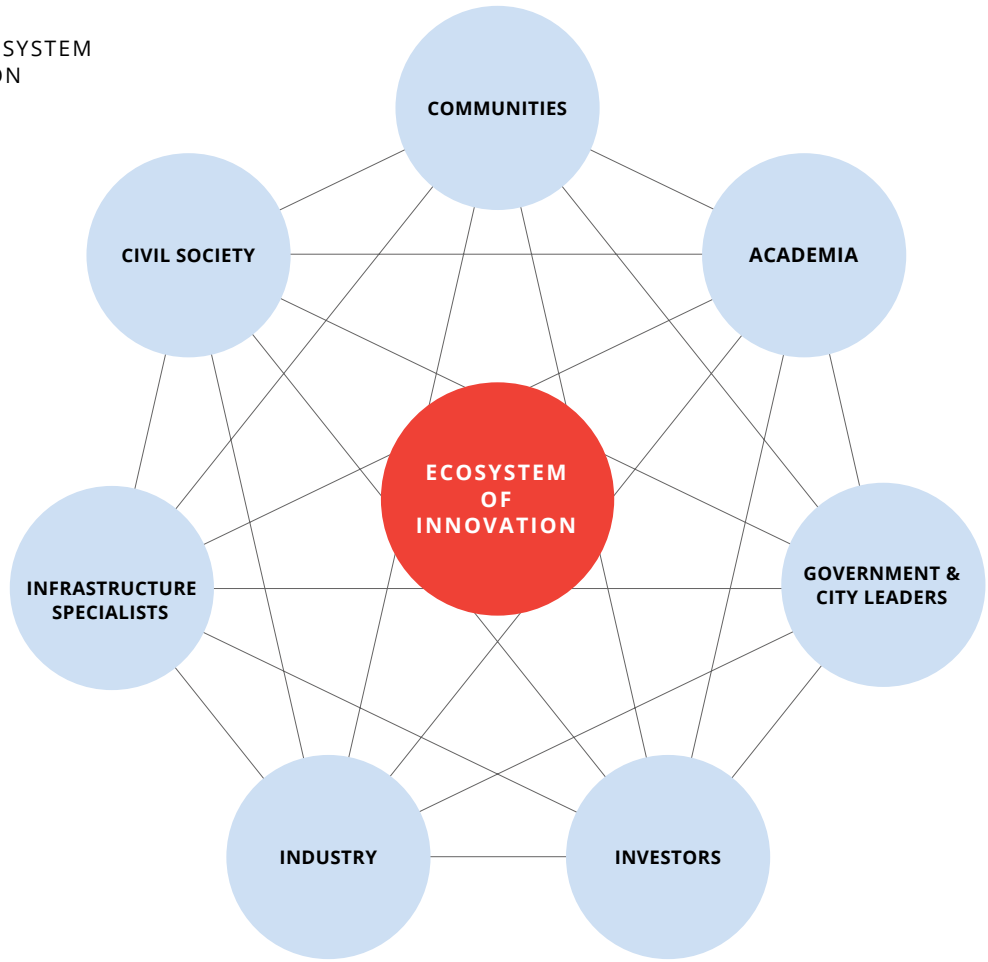
## 2.5 Review and Ranking Process

Once the database was finalized, we asked a panel of industry experts, the Champion Search Working Group, to provide their feedback and rankings on the individual projects within the database. The group was invited to give the projects an aggregated score between 1 and 4, with 1 being the most innovative. We also requested that the working group members provide comments to explain their rankings. The ranking criteria are listed as follows:

- How innovative is the project (is it pushing beyond the normal boundaries in some manner, or combining sets of solutions in different ways)?
- Does the project utilize a unique, or first of its kind, solution?
- Does the project address the root causes of the issue it is seeking to address?
- Does the project address both current and future needs?
- Does the project address ecosystem-wide solutions?
- How much of an impact does the project have in terms of sustainability and resilience?
- Does something about the project have the potential to move the industry towards improved sustainability and resilience practices?

Once we received the working group's rankings, we compiled the information in a master version of the database in which we sorted the projects by their average ranking. Once these rankings were completed, we analyzed the patterns and characteristics represented. In the next section, we will discuss the analysis and observations sparked by the database.

FIGURE 2: ECOSYSTEM OF INNOVATION



# 3. DATABASE ANALYSIS

**Through our analysis of the database and the average rankings of the projects, we found two clear groupings among the top 29 projects (Appendix A). These two groupings provide some insight into the key characteristics of innovative sustainability- and resilience-based projects and the current landscape of ongoing innovation.**

## 3.1 Characteristics of the Top Projects

Through the comment and ranking process, several characteristics arose that were common among the top projects. Many of these projects took a multidisciplinary and holistic approach that allowed the project to address multiple concerns. In doing so, these projects illuminated processes by which a project can be strengthened by analyzing the context of the system and working to develop a solution that addresses the full infrastructure system holistically. This arose in a number of reviewers responses and comments. In addressing these concerns, we noticed that several projects developed new or alternative approaches that better meet the needs of the community and environment it served, improved the lifecycle and resilience of the solution, drove positive changes for climate and the population, and strengthened impactful outcomes for the system at large. Without fail, these projects sought to balance the needs of the present and the future to ensure that the solution would continue to be viable long after the implementation was complete.

There were four general approaches that these innovative projects took to achieve this goal. To be effective, top projects needed to have broad applicability, and be scalable and adaptable to meet diverse areas of need. Further, these projects engaged broad stakeholder groups to ensure that the projects were meeting the needs of each stakeholder and that their concerns were addressed. In both issues of equity and function, embracing a broad stakeholder group enabled project teams to develop a holistic understanding of the issues they were seeking to address and the environment in which they were nestled. These projects similarly sought to reduce, recycle, or eliminate waste to the point that many were carbon negative and regenerative for their environmental context.

# 3.2 Areas of High Innovation

Our research identified several areas of high innovation, which is this context refers to those projects that scored the highest.

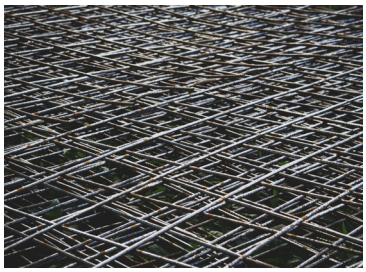
The use of AI and 3D modeling and printing technology has propelled innovations in smart buildings, modeling projects and even the construction of building materials. We observed high levels of innovation in the renewable energy space, and recognized codes and standards that embed sustainability and resilience into infrastructure practices.

### MODELING

By taking advantage of new technologies and techniques, we found several modeling projects that proved innovative in their ability to provide real-time system feedback for emergency management, expand upon 3D modeling technology to integrate site conditions, and enable AI-informed land-use planning.

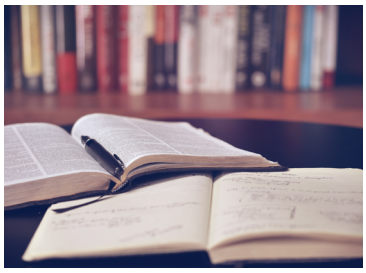
### HOLISTIC SMART BUILDINGS

These innovations focused on developing buildings that produce more energy than they consume and continue to reduce their footprint over time through AI learning capabilities; these approaches treat the buildings as microcosms of their broader environment and engage in regenerative practices.



### LIVE, RECYCLED, & 3D PRINTED MATERIALS

By growing, recycling, or constructing building materials, these projects have illuminated ways in which alternative materials can strengthen projects, drive sustainable solutions, and reduce construction costs.



### STANDARDS

As a large factor in centralizing sustainable and resilient practices into the industry, the new and forthcoming codes and standards provide avenues to incorporate sustainability into the project process, into contracts, and as a standard practice and expectation for engineers and infrastructure decision-makers globally.

### ENERGY

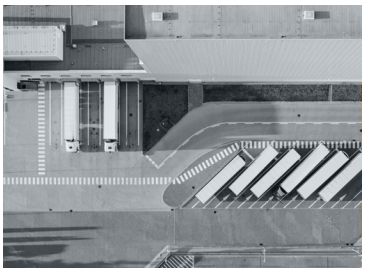
With the movement towards renewable energy, our research captured several innovative solutions including buildings that generate more power than they use, redesigns of wind turbines, heat recovery programs, wearable energy-generating products, high-efficiency fuel cells, and improved methods to capture geothermal, hydropower, and tidal energy.

# 3.3 Initial Gap Identification

We have identified initial areas where there are gaps in innovative projects, particularly in the water resources and coastal management, and transportation industries. Additionally, gaps were observed in the geotechnical discipline as well as in the connectivity between vertical and horizontal infrastructure. Ongoing gap analysis will take place as more projects are added to the database.

### WATER RESOURCES AND COASTAL MANAGEMENT

While several of the selected and reviewed coastal projects address multi-facetted challenges, we believe that with the threat of ocean level rise, waterfront, and other water infrastructure struggles, that this will be a critical area for innovation over the coming years.



### TRANSPORTATION

Despite progress made in electric and autonomous vehicles, the transportation projects included in our database were not represented among our top projects.

### GEOTECHNICAL

Some projects in this area feature in our database, however, this area remains primed for further innovative solutions and approaches.

### VERTICAL AND HORIZONTAL CONNECTIVITY

Little progress was noted in the balancing of high-rise development versus sustainable redevelopment zones, nor was there much innovation recorded in horizontal infrastructure segment interconnections.

# 4. DISCUSSION

**The Champion Search working group reviewed the findings of the database and had a robust discussion about the meaning and implications of the results. The leadership concurrently met with representatives of the Funding and Finance Action Track to solicit their expertise and examine how this research may be impacted by ongoing innovative approaches to infrastructure financing around the globe. The discussions have been broadly organized into the following categories: systems approaches, financing, and governance and addressing gaps.**

## 4.1 Systems Approaches

One of the overarching tools utilized by the project teams represented within the Innovative Project Database was a systems approach. In taking a systems perspective, project teams may develop a better analysis of the benefits and impact of the solutions they seek to implement. Combining data sources for urban water management purposes is playing a key role in the planning and engineering that aim to improve the resilience performance of our urban centers under extreme weather conditions. An example can be found in the City of Rotterdam, through the application of the innovative COASTAR tool[5] which is designed to help the city with the complex groundwater monitoring process. Rotterdam has a big ambition to increase the underground storage of rainwater through city wide water buffering and infiltration. As such, drainage of rainwater through the sewer system can eventually be prevented, and infiltrated ground water can become more widely available for multi-functional re-use. The result of a city-wide and multi-scale infiltration systems can bring various community benefits, it helps address the natural water cycle and allows for a more robust urban water-system which touches on key sustainability and resilience values in our research.

By intentionally seeking out data gaps, considering how different infrastructure user groups will be impacted, and how the infrastructure solution will interact with the broader ecosystem, planners and project teams may maximize the beneficial impact of their proposed solution while minimizing potential risks. This mindset also provides an avenue towards better integration between infrastructure solutions to provide greater cumulative benefit than would exist from solutions developed that do not address the broader infrastructure ecosystem. When seeking to upscale a solution or implement it within a different ecosystem, a systems perspective would allow the project team to draw upon the lessons learned from the original solution and adapt them to fit the unique needs and context of the broader or different ecosystem in which they are attempting to replicate the solution.

## 4.2 Financing

Without financial backing, none of the projects we have highlighted in this report would be possible. One of the hurdles to overcome for any innovative project is funding. From standard funding methods to more innovative approaches, securing the buy-in of financial partners and the owner/operators remains central to moving an innovative project forward. While we have seen initiatives (like the City Climate Gap Fund[6]) arise to address funding gaps

in the pre-development stage, funding throughout the full lifecycle of a project from early stages through implementation and maintenance will be required. In seeking to promote innovative projects we must consider how we understand and weigh risk. One way in which this may be addressed is through a collaboration with insurers and insurance underwriters to restructure insurance premiums to reduce the rates for infrastructure that addresses sustainability, resilience, and climate concerns. In this area, we would encourage readers to seek out the excellent work of our expert colleagues in the Funding and Finance Action Track. They have released a report on Green Recovery and Finance for Sustainable Infrastructure[7]. They have also recommended the 2021 State of Cities Climate Finance[8] report from the Cities Climate Finance Leadership Alliance (CCFLA) which was released in June 2021 to supplement their report and to emphasize the city-level perspective.

# 4.3 Governance

Governance plays a key role as enabler of sustainable and resilient infrastructure.

As part of this research, we selected a list of several innovative cities to highlight excellence in governance. Among these cities, several shared approaches characterized and facilitated their actualized and aspirational progress and success. These cities have integrated sustainability and resilience practices into their urban planning processes, and approach infrastructure design and implementation from a lifecycle and performance-based approach. They utilize lines of thinking and planning that recognize the current and future needs that infrastructure solutions will need to address and develop them in ways that consider the full lifecycle of the solution including procurement, installation, maintenance, usage, and eventual replacement. These cities approached infrastructure from a multidisciplinary city-wide perspective which involved stakeholders representing financing, user, owner, operator, and builder perspectives to maximize the benefit to every stakeholder base and vested party. Each of these cities was committed to developing processes and solutions that could be scaled up from localized solutions to ones that were more broadly utilized throughout their constituencies and into their broad infrastructure ecosystems and regions.

The cities we selected as ICSI Innovative Cities were Houston, Bogota, and Rotterdam. Houston was selected for its strong climate action plan and financial and political commitments following Hurricane Harvey. Bogota showcased a significant amount of leadership investment and public transportation initiatives. Rotterdam displayed impressive progress concerning stormwater management and is actively pursuing several floating city-style elements.

# 4.4 Addressing Gaps

The gaps this research has highlighted represent areas that are primed for paradigm-shifting innovative action. While there are significant ongoing sustainability- and resilience-oriented projects in the area highlighted in this research, the working group felt that there were broader opportunities and means that could be utilized to push forward systems-altering innovations that could be deeply impactful.

Through triangulating our efforts between driving incentivization of innovation, building regulator buy-in and support, and the capitalization on market forces, our efforts will be magnified and there will be more opportunities to address areas in which we have found gaps. This can be managed by a careful balancing between incremental innovations that seek to subtly shift current practices towards broadly innovative goals, and disruptive innovation that radically re-engineers the status quo to incorporate cutting-edge practices and processes. By working with policymakers and regulators, these two approaches can be utilized to move the industry to address the innovation gap through strategic incentives, favorable regulatory behaviors, and the cost-benefit analysis that drives the market.

# 5. TAKING ACTION TO ACCELERATE INNOVATION

**This paper presented the work of the ICSI Innovation Action Track with the goal to provoke the discussions, identify the contextual characteristics, and cultivate participation necessary to channel ICSI, and our partners', energies into creating ecosystems of innovation.**

## 5.1 Key Takeaways

### GOOD PROJECTS VS. INNOVATIVE PROJECTS

The projects that fell within this research represent those pushing the envelope and implementing new ideas, techniques, and approaches. Some projects held strong sustainability and resilience credentials but did not make our final list due to our primary focus on innovation. The course of this research brought us into contact with many important sustainability and resilience projects that did not meet the innovation requirement. While these projects did not make it into our database, they are no less worthy of the time, resources, and effort taken to see the projects through to completion. These programs, while not innovative, retain important lessons and guidance that can be utilized to drive holistic, innovative, sustainable, and resilient solutions.

While we acknowledge that in real life there will always be some elements of incremental innovation, bold and scalable innovation is the kind of innovation that ICSI should identify, support, and promote to accelerate implementation of sustainable and resilient infrastructure.

### PROMOTING SYSTEM APPROACHES

For innovation to be impactful, the system in which it is implemented must be considered. Systems thinking permits would-be innovators to gain a stronger understanding of the full context in which a project exists and thereby opens pathways towards new and more expansive solutions. With a clear analysis of the system in which the infrastructure problems sit, we may be able to develop solutions that address the holistic needs of our communities. By removing our projects from self-imposed isolation, we may notice opportunities that remained otherwise unexplored and unutilized. From this perspective, we can better access the impact of our solutions across the infrastructure system and find opportunities to create multidisciplinary, holistic, and sustainable innovative solutions that exceed the current need to address the full lifecycle and needs of the end-users of infrastructure and society at large.

### HARNESSING INNOVATION AND SCALING UP PROJECTS

To develop innovative scalable projects, we must cultivate mindsets and approaches that support the innovative process. With this in mind, our other working group is developing a report on global programs that are focused on cultivating and supporting innovation through a variety of means. Whether by providing guidance and certifications, supporting initiatives to scale innovative solutions, driving broader understanding and knowledge sharing, or creating new frameworks and processes, these programs provide new ways for participants to implement innovation in their work and workplaces.

### FACILITATING GLOBAL LEARNING

While each city and region of the world has unique qualities and contexts, many of the challenges surrounding sustainability, resilience, and climate are related. This research – and ICSI itself – can serve as a starting point for decision-makers such as city leaders and infrastructure owners-operators

seeking to connect with those who have excelled at addressing similar challenges. For example, a city struggling to react to the prospects of rising sea levels could turn to a city like Rotterdam to gain an understanding of the solutions – infrastructure, governance, culture, or finance-related – implemented. Armed with the lessons learned, city officials will be able to adapt proven solutions to fit the unique circumstances of their locality. While this is occurring through organizations and coalitions like GCoM and the C40, we would like to call attention once again to the importance of a collaborative approach to these challenges – to further both innovation and knowledge building alongside the development of the critical projects needed to protect and elevate public health, safety, and welfare.

## 5.2 Taking Action

### LEARNING FROM INNOVATION CHAMPION PROJECTS

The projects listed within the Innovative Project Database serve as examples of ongoing innovative projects that deliver sustainable and resilient infrastructure. We encourage readers and ICSI members to use these projects as an opportunity to reflect upon the challenges we are seeking to overcome and how the project teams represented are attempting to do so. The lessons we can draw from these projects may serve as a basis from which we can develop further innovation and projects. From their successes, we may learn from their approaches and evaluate ways in which these solutions can be built upon. From their shortcomings, we may learn what pitfalls lay in the planning, execution, and adoption of projects of a similar nature, and may find ways to modify their approach to achieve a successful result.

### DEVELOPING TEST PROJECTS

As an action-oriented coalition, we encourage our collaborators and networks of professionals to be the agents of change for sustainable and resilient infrastructure. In the sphere of innovation, this can be done in the formulation of test projects such as those represented in the Innovative Project Database. Whether inspired by one of the projects included in the scope of this research or through independent analysis and collaborations, we encourage practitioners to develop projects to test new innovative approaches and solutions, scale ongoing innovations, and contribute to building the infrastructure of the future.

## RECOMMENDED ACTIONS GOING FORWARD:

1. Expand, maintain, and promote the ICSI Innovative Project Database and solicit input and projects from communities and groups whose perspectives are not represented in the current iteration (e.g., minority and indigenous perspectives).
2. Explore highlighted innovation gaps and lessons learned
3. Highlight programs and approaches that incentivize systems thinking
4. Develop innovative test projects working closely with infrastructure decision-makers, e.g., owners-operators and city leaders
5. Capture the relevance of digital trends in contributing to innovative projects
6. Further refine the selection criteria for an ICSI Innovation Champion Project.

# References


1. Definitions were triangulated from the following sources: International Coalition for Sustainable Infrastructure; American Society of Civil Engineers; Institution of Civil Engineers; Arcadis.

2. Granstrand, O., & Holgersson, M. (2020). Innovation ecosystems: A conceptual review and a new definition. Technovation, 90-91, 102098. https://doi.org/10.1016/j.technovation.2019.102098

3. International Development Innovation Alliance. (n.d.). Actors in an Innovation Ecosystem. International Development Innovation Alliance (IDIA). https://www.idiainnovation.org/ecosystem-actors.

4. Block, P. (2008). Community: the structure of belonging. Berrett-Koehler Publishers.

5. https://www.coastar.nl/effectief-monitoren-van-de-prestaties-van-ondergrondse-waterbergingssystemen/

6. https://www.citygapfund.org/

7. https://sustainability-coalition.org/wp-content/uploads/2021/10/ICSI_Finance-Policy-Paper-GC.pdf

8. https://citiesclimatefinance.org/publications/2021-state-of-cities-climate-finance/

# Appendix A

| ICSI INNOVATION CHAMPION PROJECT | LOCATION | HOW IT PUSHES THE BOUNDARIES |
|---|---|---|
| 1. Bladeless Wind Turbine Redesign | Norway | Compact bladeless wind turbines designed for use in urban and residential areas |
| 2. Vertical Oasis Tower | Poland | Smart building capable of climate adaptation through the utilization of geometry, vertical gardens, artificial intelligence, machine learning, and renewable energy harvesting. |
| 3. Recycled Concrete Waste Bricks | Scotland | Bricks created from recycled construction waste that produce a tenth of the CO2 and use a tenth of the energy to produce. |
| 4. Kendeda Building for Innovative Sustainable Design | Georgia, USA | Regenerative energy net-positive building. |
| 5. Sewer Heat Recovery Program | Washington, USA | Combination of waste management and renewable energy production. |
| 6. Energy-Positive Building | Norway | New Positive Energy construction and retrofitting. |
| 7. Redesigned High-Efficiency Wind Turbine | Denmark | Wind Turbine redesign with significant scalable potential. |
| 8. 3D Printed Lightweight Structural Beams | Spain | Easily customizable 3D-printed construction materials that provide significant savings on weight and construction time and eliminate risk of corrosion. |
| 9. Net Positive Energy Building | Netherlands | Net positive energy building and educational space with a people first perspective. |
| 10. Living Building Materials | Colorado, USA | Construction materials with the ability to replicate and grow with low embodied carbon and equivalent compressive strength as cementitious mortar. |
| 11. Contagion/Propagation Flood Modeling | Texas, USA | Flood modeling tool that improves emergency response, resilience, and real time information gathering. |
| 12. Low-Carbon Concrete Code | California, USA | Building code developed for the reduction of embodied carbon and greenhouse gas emissions. |
| 13. Sustainable Procurement Standard of Practice | Virginia, USA | Develops a comprehensive manual for sustainable procurement practices. |
| 14. Augmented Reality Modeling and Construction | United Kingdom | Interactive visual tool with the potential to reduce costs, increase speed, and improve quality. |
| 15. Milwaukee Green Infrastructure Partnership | Wisconsin, USA | A public-private partnership devised to plan and implement green infrastructure. |

| ICSI INNOVATION CHAMPION PROJECT | LOCATION | HOW IT PUSHES THE BOUNDARIES |
|---|---|---|
| 16. Machine Learning Software used to Develop Database of Land Cover | Texas, USA | Database of land cover using machine learning to raise funds for stormwater infrastructure through fees based on usage. |
| 17. Lunar and Mars Colonization Efforts | International | Projects investigating the cutting-edge technologies and engineering required for extraterrestrial colonization. |
| 18. Smart Windows | Singapore | Heat capturing windows that increase energy efficiency by releasing captured heat throughout the night. |
| 19. Atlanta Water Supply Project | Georgia, USA | Resilient new approach to water supply management. |
| 20. Hillsboro Micro-hydropower Projects | Oregon, USA | Scalable prototype technology that reduces water pressure, collects energy, and provides operational data for water distribution systems. |
| 21. 90% Efficiency Fuel Cell | Denmark | Significant advance in fuel cell efficiency prototyping. |
| 22. Wearable Energy Producing Technology | California, USA | Advance in wearable power generation. |
| 23. Geothermal Energy Generation | Texas, USA | Exploration into an underutilized area of energy production. |
| 24. Tidal Energy Turbine | Japan | Working towards solving tidal energy production's scalability barrier. |
| 25. Manhattan East River Flood Protection Study | New York, USA | Well-articulated sustainability goals with clear public benefits. |
| 26. Rotterdam Flood Defence | Netherlands | Established flood defense program with well-articulated public benefits. |
| 27. EcoShape | Netherlands | Organic and collaborative approach to nature-based solutions. |
| 28. Los Angeles Renewable Energy Study | California, USA | Integrated systems-level assessment of alternative energy options within a large city ecosystem. |
| 29. LA Metro Sustainable Acquisition Program | California, USA | Routine sustainability design program with a city-wide procurement guidance program and systems-integration elements. |
| 30. COASTAR Tool | Netherlands | Fresh water supply program using smart monitoring processes and infiltration to produce a more natural water cycle. |

International Coalition for Sustainable Infrastructure

**www.sustainability-coalition.org**
info@sustainability-coalition.org