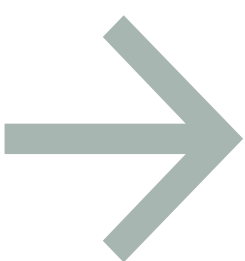


June 2022

FINAL VALORIZATION EVENT

Sustainable Urbanisation Global Initiative (SUGI)
Food-Water-Energy Nexus



Context

The interactions between the food, water, and energy sectors, both now and over the next few decades, are of paramount interest to policy, science, and society at large. By 2050, the world population is projected to increase to 9 billion and the number of people living in urban areas is expected to double.

These trends in population density and movement, coupled with land use change and climate variability, will lead to major increases in demand for resources and hold important implications for security and social justice. The reciprocal and dynamic processes of urbanisation; physical movements of populations, the build-up of city territories, transformation of economic structures, extension of suburban sprawl, and reurbanisation result in increasing regional stress on the urban food-water-energy (FWE) system.

Understanding the consequences of global urbanisation is central to understanding global change due to cities' and urban areas' links to material and energy use, land-use transformations, resource-intensive behaviors and consumption, impacts on ecosystem services, and changes driving social and cultural inequities. Many of these processes are common to cities across different regions, but there is also much specificity.

The interconnectivity between food, water, and energy remains a relatively new field. This kind of systemic thinking will be necessary for cities to transition to a low-carbon and sustainable future.

The Sustainable Urbanisation Global Initiative (SUGI)-FWE Nexus call was jointly established by the European Commission, the Belmont Forum and the Joint Programming Initiative (JPI) Urban Europe.

Future Earth introduced the call's theme, the first time it had done so. The initiative brought together the fragmented research and expertise across the globe to find innovative new solutions to the FWE Nexus challenge.

"The nexus at its core is really about how water, food, and energy in an urban context are connected," said Cornelia Forsthuber, Editor-in-Chief at Urban Future. "It's about how do I make a city more resilient by doing that."

The initiative, which opened in 2016, was groundbreaking on multiple levels.

"Never before has there been a mechanism to bring such a large number of countries, breadth of expertise, and diversity of technical, social, and business disciplines to work on those common challenges," said James Taplin, Urban Innovate UK lead, and Daniela Melandri, SUGI Innovate UK Lead - coordinators of the SUGI initiative.

The initiative helped bring the nexus concept into the mainstream, teaching policymakers about the interconnectivity between food, water, and energy and catapulting the number of research-focused nexus programs around the world.



Overview

The SUGI-FWE Nexus final event was held online on March 22 and 23, 2022 from 13:00 to 16:00, the last meeting of the 15 projects' researchers and funders.

The meeting served as the capstone to a successful joint initiative launched by the Belmont Forum and JPI Urban Europe that takes a look at the interconnectivity between food, water, and energy in an urban environment and offers innovative solutions for sustainable cities.

"I always go to SUGI projects when people want successful examples of cross-national research and innovation collaboration. This is where I go for good practices because you were doing nexus before nexus was cool. So this room is full of forward thinkers," [said](#) Executive Belmont Forum Executive Director Nicole Arbour.

During this virtual event, project researchers, funders, and other interested parties met to present important results and took the first steps toward describing and defining the legacy of SUGI-FWE Nexus.

SUGI project teams were encouraged to send three to five representatives and involved funding agencies, interested partners, and stakeholders were also invited. Partners from other JPI Urban Europe calls, with a focus on FWE-Nexus topics, were invited to join the first day.

The SUGI-FWE Nexus call was officially launched in September 2016, with proposals submitted by the following fall. 15 projects were selected from a competitive field of 88 applications. Projects were launched between December 2017 and March 2018, highlighted by the official kickoff meeting that took place in June 2018. A mid-term valorization event was held in June 2020 through Zoom. The final meeting took place this past March, with projects scheduled to wrap up between 2021 and 2022.



FIFTEEN funded *Projects*

CITYFOOD

Smart integrated multitrophic city food production systems – a water and energy saving approach for global urbanization

Creating Interfaces

Building capacity for integrated governance at the food-water-energy-nexus in cities on the water

CRUNCH

Climate Resilient Urban Nexus CHOICES: operationalising the Food-Water-Energy Nexus

ENLARGE

ENabling LARGE-scale integration of technology hubs to enhance community resiliency via DDS in various urban FWE nexuses

FEW-meter

The FEW-meter – an integrative model to measure and improve urban agriculture towards circular urban metabolism

FUSE

Food-water-energy for Urban Sustainable Environments





GLOCULL

Globally and LOcally-sustainable food-water-energy innovation in Urban Living Labs

IFWEN

Understanding Innovative Initiatives for Governing Food, Water and Energy Nexus in Cities

IN-SOURCE

INtegrated analysis and modelling for the management of sustainable urban FWE ReSOURCES

METABOLIC

Intelligent Urban Metabolic Systems for Green Cities of Tomorrow: an FWE Nexus-based Approach

M-NEX

The Moveable NEXUS: Design-led urban food, water and energy management innovation in new boundary conditions of change

SUNEX

Formulating sustainable urban FWE strategy by optimizing the synergies between food, water and energy systems

Urbanising in Place

Building the food water energy nexus from below

Vertical Green 2.0

Vertical greening for liveable cities - innovation to facilitate the breakthrough of an old concept

WASTE FEW ULL

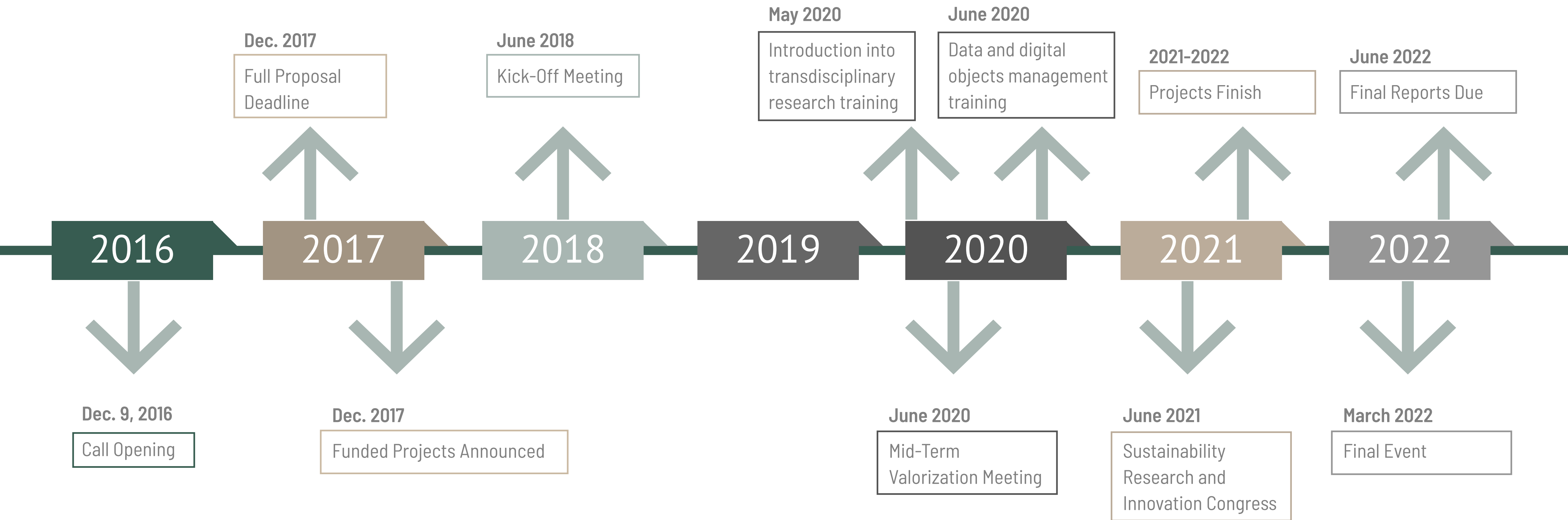
Waste Food-Energy-Water Urban Living Lab - Mapping and Reducing Waste in the Food-Energy-Water Nexus

FIFTEEN funded *Projects*

The funded projects included partners from 20 countries, six continents, 22 EU-supported funding agencies, and five Belmont Forum funding agencies. Projects created multilateral partnerships drawing from three or more countries to facilitate transdisciplinary research. Funded projects addressed at least one of three key items: (1) robust knowledge, indicators, and assessments; (2) multi-level governance and management; and (3) managing strategies and solutions. The projects were grounded in the U.N. Sustainable Development Goals (SDGs) and the global sustainability challenges identified by Future Earth's 2025 Vision.



SUGI-FWE Nexus Call *Timeline*



01

Belmont Forum

The Belmont Forum is an international partnership of the world's major and emerging funders of global environmental change research. It aims to accelerate delivery of the research needed to remove critical barriers to sustainability by aligning and mobilizing international resources.

The Belmont Forum pursues the goals set forth in the Belmont Challenge by adding value to existing national investments and supporting international partnerships in interdisciplinary and transdisciplinary scientific endeavors.

02

JPI Urban Europe

The Joint Programming Initiative (JPI) Urban Europe is a research and innovation programme established by national funding agencies in 20+ countries in Europe. The aim of the program is to create attractive, sustainable, and economically viable urban areas, in which European citizens, communities, and their surroundings can thrive. The JPI Urban Europe focuses on how to:

- Transform urban areas into centers of innovation and technology,
- Ensure social cohesion and integration,
- Reduce the ecological footprint and enhance climate neutrality, and
- Take advantage of technological solutions and realize efficient and sustainable urban systems and networks (mobility, energy, water, ICT, etc.).

03

Future Earth

Future Earth is a global network of scientists, researchers, and innovators collaborating for a more sustainable planet. Its international research program seeks to build knowledge about the environmental and human aspects of global change, and to find solutions for sustainable development. Bringing together natural and social sciences, as well as the humanities, engineering, and law, Future Earth aims to:

- Inspire and create interdisciplinary science relevant to major global sustainability challenges,
- Deliver products and services that society needs to meet these challenges,
- Co-design and co-produce solutions-oriented science, knowledge, and innovation for global sustainable development, and
- Build capacity among scholars world-wide.

Organizers & Funders

04

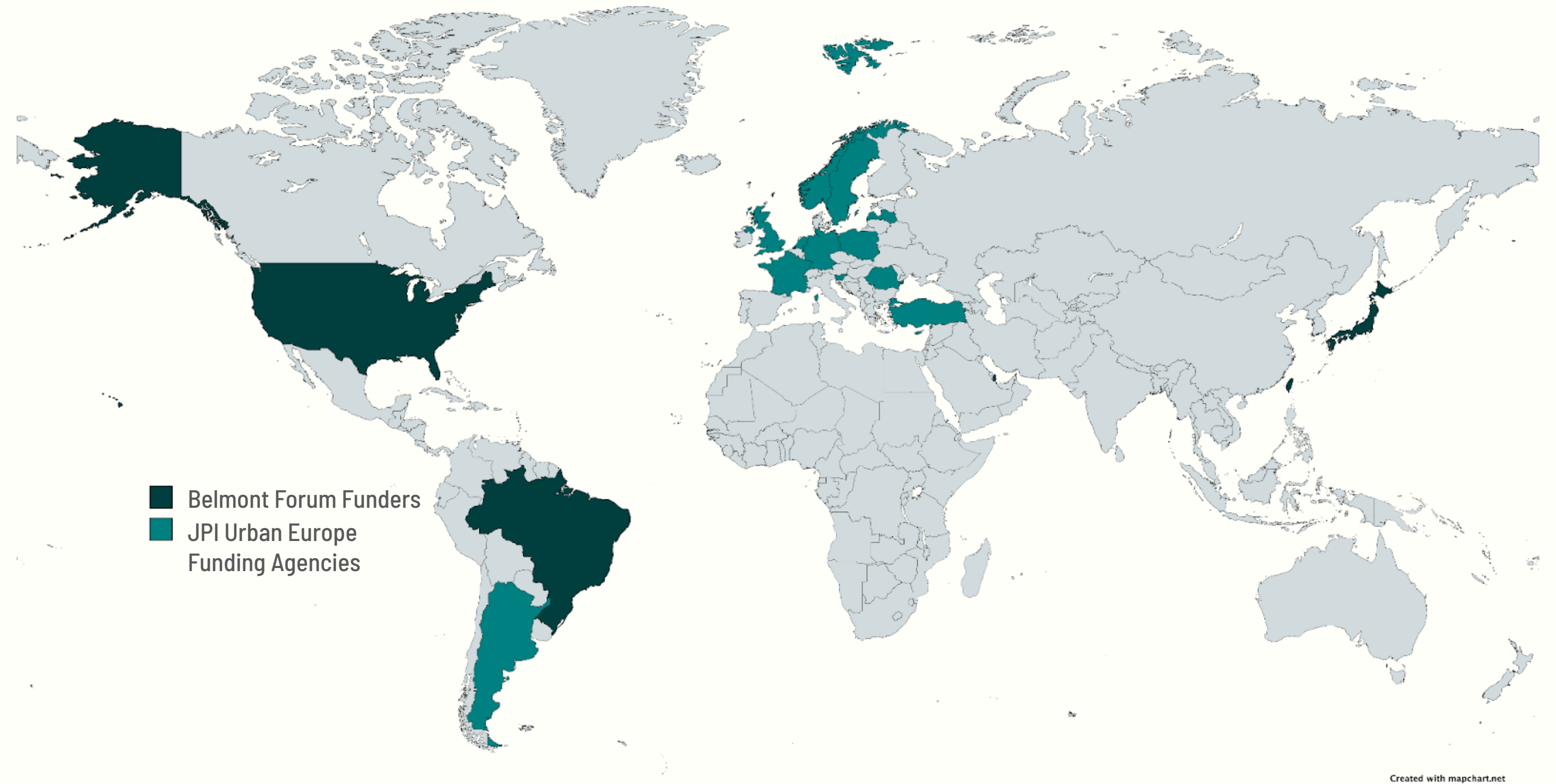
European Commission

By coupling research and innovation, the European Union's Horizon 2020 initiative focuses on excellence in science, industrial leadership, and important societal challenges. The goal is to ensure Europe produces world-class science, removes barriers to innovation, and makes it easier for the public and private sectors to work together in delivering innovation.

The initiative offers an opportunity for funding agencies, policymakers, and research and innovation actors to tackle the challenge of urban transitions and to develop connections and collaborations worldwide. SUGI-FWE Nexus was partially funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 730254.



Funders included Belmont Forum and JPI Urban Europe funding agencies topped up with extra funds by the European Commission.



Belmont Forum Funders

- FAPESP (Brazil)
- JST (Japan)
- QNR (Qatar)
- MOST (Chinese Taipei)
- NSF (USA)



JPI Urban Europe Funding Agencies

- | | | | |
|--------------------|-------------------|--------------------|------------------|
| MINCYT (Argentina) | BMBF (Germany) | NCN (Poland) | TUBITAK (Turkey) |
| FFG (Austria) | ANR (France) | UEFISCDI (Romania) | AHRC (UK) |
| FWO (Belgium) | VIAA (Latvia) | Formas (Sweden) | ESRC (UK) |
| IRSIB (Belgium) | NWO (Netherlands) | SWEA (Sweden) | Innovate UK (UK) |
| RPF (CY) | RCN (NO) | ARRS (Slovenia) | |

Open Data Policy & Principles

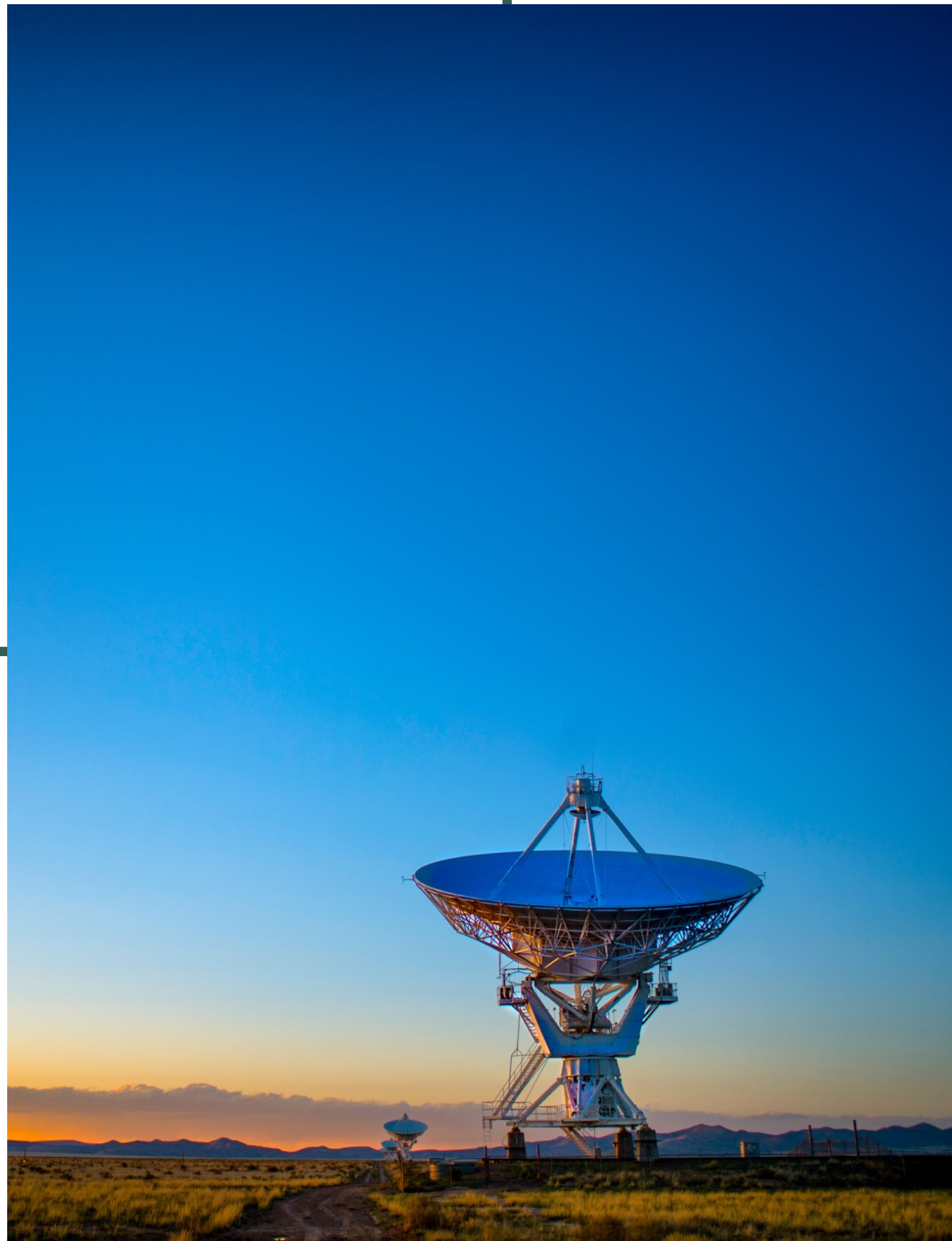
SUGI-FWE Nexus was also the first Belmont Forum call to embrace its Open Data Policy and Principles, a commitment by funders of environmental change research to increase access to scientific data. The Belmont Forum adopted this policy during its 2015 annual meeting of principals in Oslo, Norway.

The policy is based on the idea that data should be:

- Discoverable through catalogs and search engines
- Accessible as open data by default, and made available with minimum time delay
- Understandable in a way that allows researchers—including those outside the discipline of origin—to use them
- Manageable and protected from loss for future use in sustainable, trustworthy repositories

To ensure compliance with the new data policy, the Belmont Forum had to work closely with partners and project teams to provide training on open data.

*“It’s been a long hard road,” said **Erica Key**, U.S. Global Hub Director for Future Earth and former Executive Director of the Belmont Forum.*



Delivering Results

The SUGI-FWE Nexus is an example of academics, government officials, and stakeholders working together through various funding agencies, in cities around the world, to facilitate transdisciplinary research. Though not without its challenges, the initiative demonstrated the effectiveness of cross-collaboration efforts to deliver meaningful policy changes.

"SUGI-FWE Nexus will be the Collaborative Research Action that I refer to when talking about best practice," said Arbour. "It was an experiment on various levels and an experiment on the program itself."

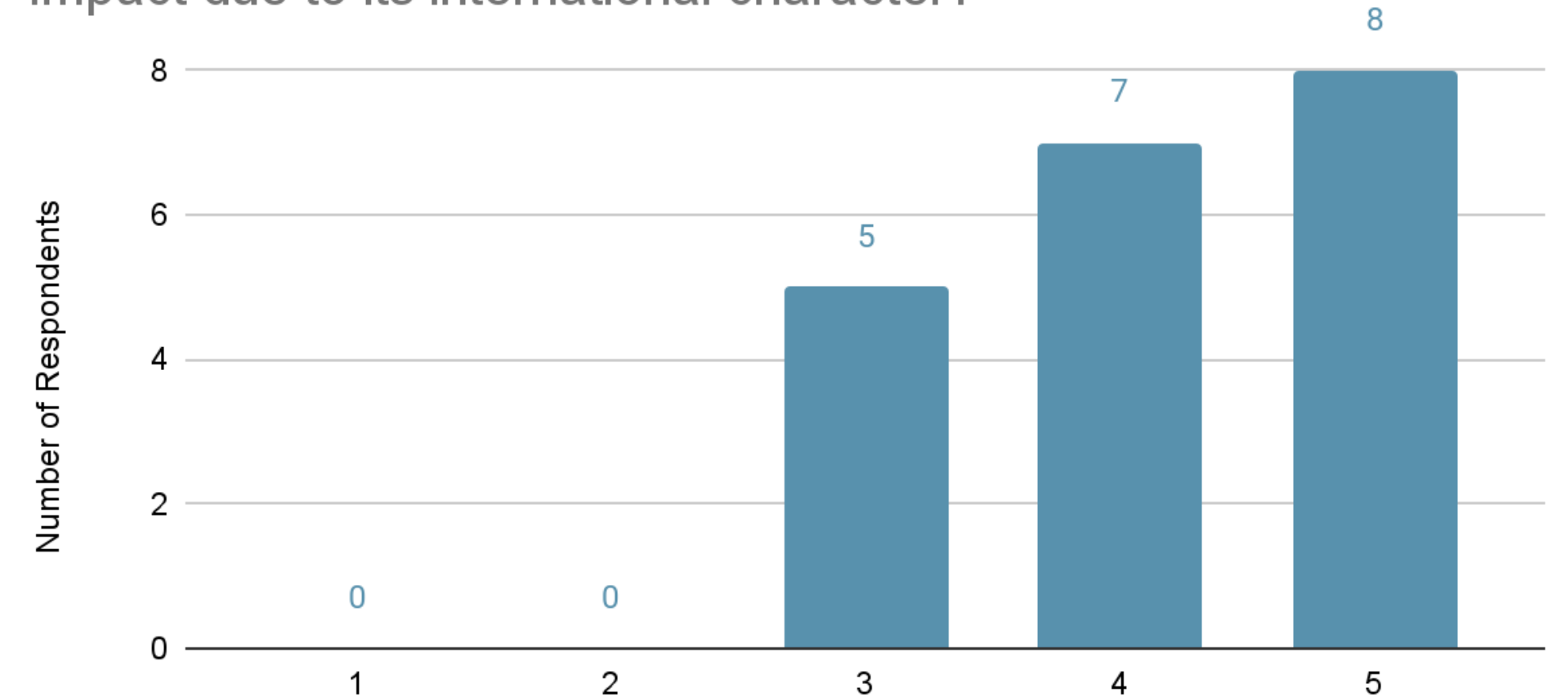
Cross-Collaboration Efforts

The SUGI-FWE Nexus initiative allowed various researchers and stakeholders to work together across different academic disciplines, thematic approaches, and urban environments throughout the globe. The call was a bold attempt to break away academics out of their silos and connect them with policymakers and stakeholders.

In the initiative's final event, researchers identified collaboration, cooperation, and networking opportunities as key indicators of success for the projects. Researchers also cited comparative research and case studies, the diversity of human and financial resources, and the richness of a multidisciplinary research team with perspectives from around the world as prime reasons why the project benefited from international collaborators.

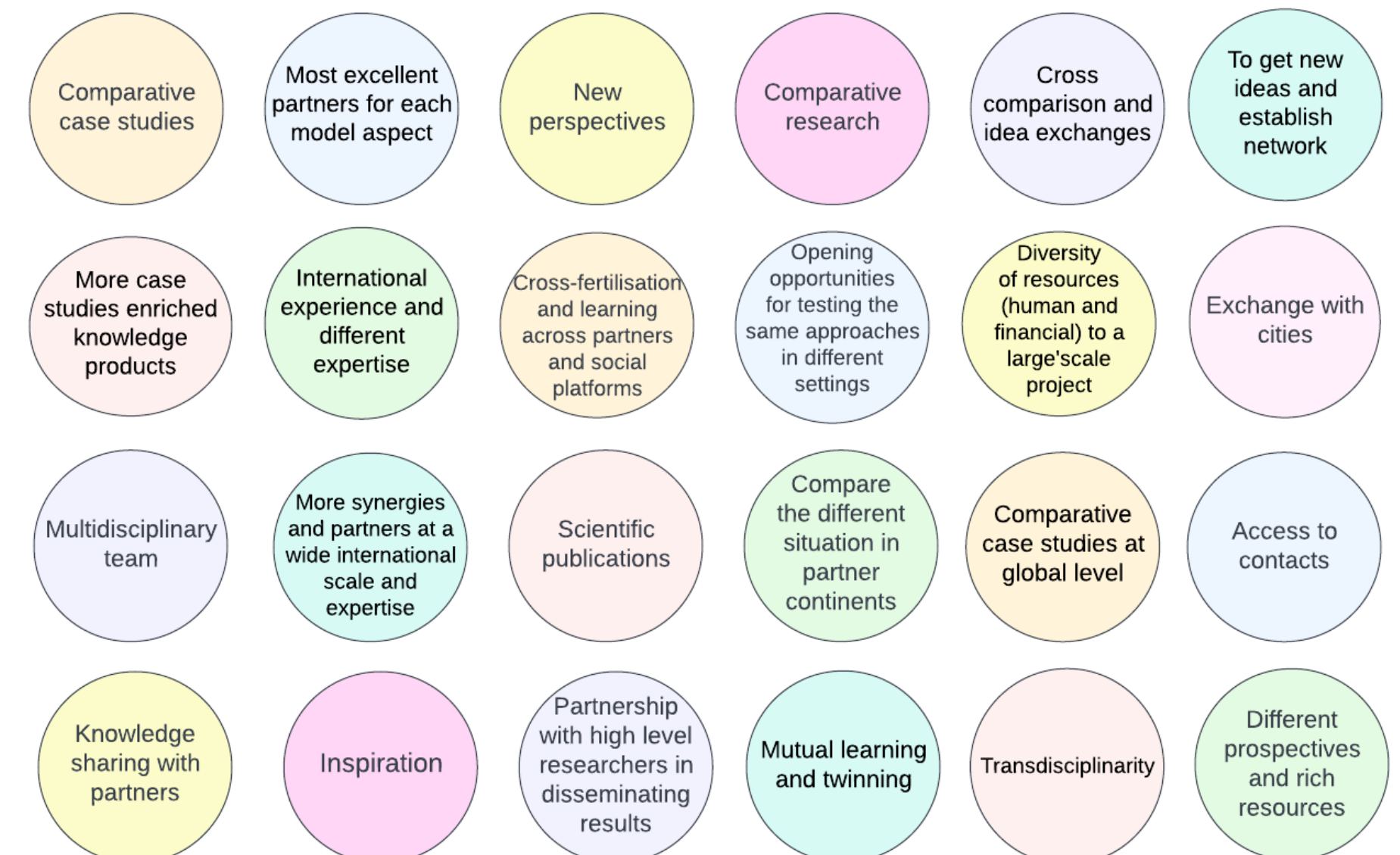
The examination of the interconnectivity between food, energy, and water helped give a "hint of global urbanisation," said Ugo Garanacci, Program Advisor to the European Commission.

To what extent did your project achieve better results and larger impact due to its international character?



Participants submitted responses on a scale of 1 to 5 with 5 being the best results and largest

How did your project benefit from international collaborations?



Outputs and Outcomes

The outputs of the SUGI-Nexus projects were wide-ranging, from in-person and virtual international workshops to scientific publications to carbon footprint calculators.

Many projects, such as M-Nex and CITYFOOD, have focused on making their publications and evaluation tools open source to be easily accessed by the public. Projects like CRUNCH, CITYFOOD, and GLOCULL were instrumental in developing decision support tools for policymakers and stakeholders.

The GLOCULL toolkit is already publicly available. It is a three module course consisting of core tools, videos, courses, a podcast, a game and a webpage to help assess FWE innovations for enterprises, partnerships or living labs. According to its authors, the project can be used on an individual basis but is ideal for a group setting.

CRUNCH's integrated decision support system (IDSS) tool is designed specifically for policymakers and stakeholders to understand how innovations would affect the FWE balance in six different urban environments.

Delivering Results

Influencing Policy

The SUGI Nexus initiative was built to create application-oriented solutions that would integrate systems across the FWE and influence decision-making to adopt sustainable planning and practices, strategies, and policies. The ability to directly influence key policymakers proved to be a major challenge for SUGI-FWE Nexus researchers.

"People who are familiar with the nexus concept are usually researchers. It's mainly an academic affair," said Joop de Kraker of the GLOCULL project.

The concept of nexus was relatively novel in 2016 and much of the policymaking around food, water, and energy has been compartmentalized. Without a basic understanding of the nexus theme, the capacity for an integrative approach in policymaking was often lacking.

"The nexus is not specifically in our legal structure and policies," said one researcher. "A lot of regulations that actually prevent beyond the experimental stage the nexus innovations. That's what we experienced."

Despite these challenges, some policy recommendations did have sway with government officials.

One notable example was how the research done in the city of Rosario by the Urbanising in Place project was instrumental in bringing about three new pieces of legislation in Argentina. Key findings from the FUSE project also contributed to the National Water Master Plan in Jordan.

The Covid Challenge

The COVID-19 pandemic fundamentally altered the trajectory of the 15 funded projects, which were in their third year of funding in March 2020. Shutdowns, travel restrictions, and strict health protocols in cities around the world meant much of the research, collaboration, and meetings would need to be facilitated in a remote or hybrid environment.



Opportunities

While remote and hybrid work environments presented a daunting challenge at the start of the pandemic, researchers, stakeholders, and funders adapted quickly to the changing environment.

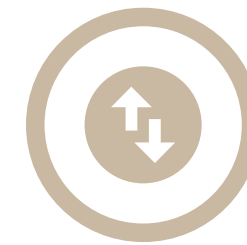
“The digital divide didn’t divide as much as we thought it would in terms of our engagement around the world,” said Key.

The disruptions in the remote work environment often yielded unexpected results, altering the power structure within the projects’ ecosystems. This change helped embolden policymakers and stakeholders researchers were working to empower.

“Because researchers couldn’t travel, they had to put the power back in the hands of the locality. They had a stronger say,” said Key. “That was something we viewed in a very positive light.”

The crisis presented both a unique set of opportunities and challenges for researchers, stakeholders, and funding agencies. Pia Laborgne, Co-Principal Investigator of Creating Interfaces, noted the project was becoming much more international as a result of the pandemic. In many respects, participation from researchers and stakeholders from the Global South was becoming easier in a virtual world.

“It’s often Western-centered and I think this was something really good,” said Laborgne.



Barriers

In the survey at the SUGI-FWE Nexus final event, eight respondents identified COVID-19 and uncertainty surrounding the pandemic as the principal challenge they faced.

The number of participants in online workshops, meetings, and seminars increased considerably during the pandemic, but the number of no-shows also went up, with up to 50% of registrants not attending. While it proved easier to arrange online workshops and webinars than face-to-face meetings, the quality of engagement was often lower.

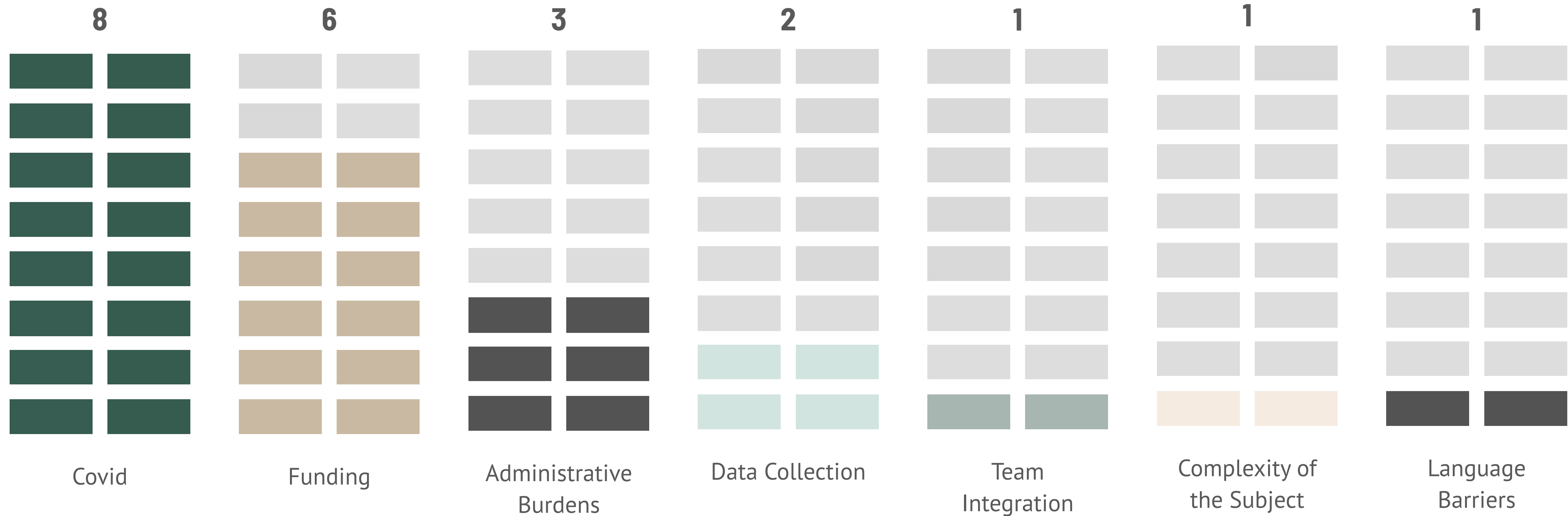
Funders found it difficult to bring in new people from the scientific community and relied more heavily on existing relationships than they had before.

“We have so many new people in this community and we were never really able to talk to them,” said Margit Noll of JPI Urban Europe. ”

The remote and hybrid formats presented some opportunities for future projects, but funders were hesitant to believe this would be the norm going forward.

“We will explore some hybrid formats, but we need to offer the space to meet people,” said Noll.

What were the main challenges



Lessons Learned

The final event offered an opportunity for researchers, funders, and partners to reflect on their work, discuss what they have learned, and offer advice for what they would have done differently.

20/20 Hindsight

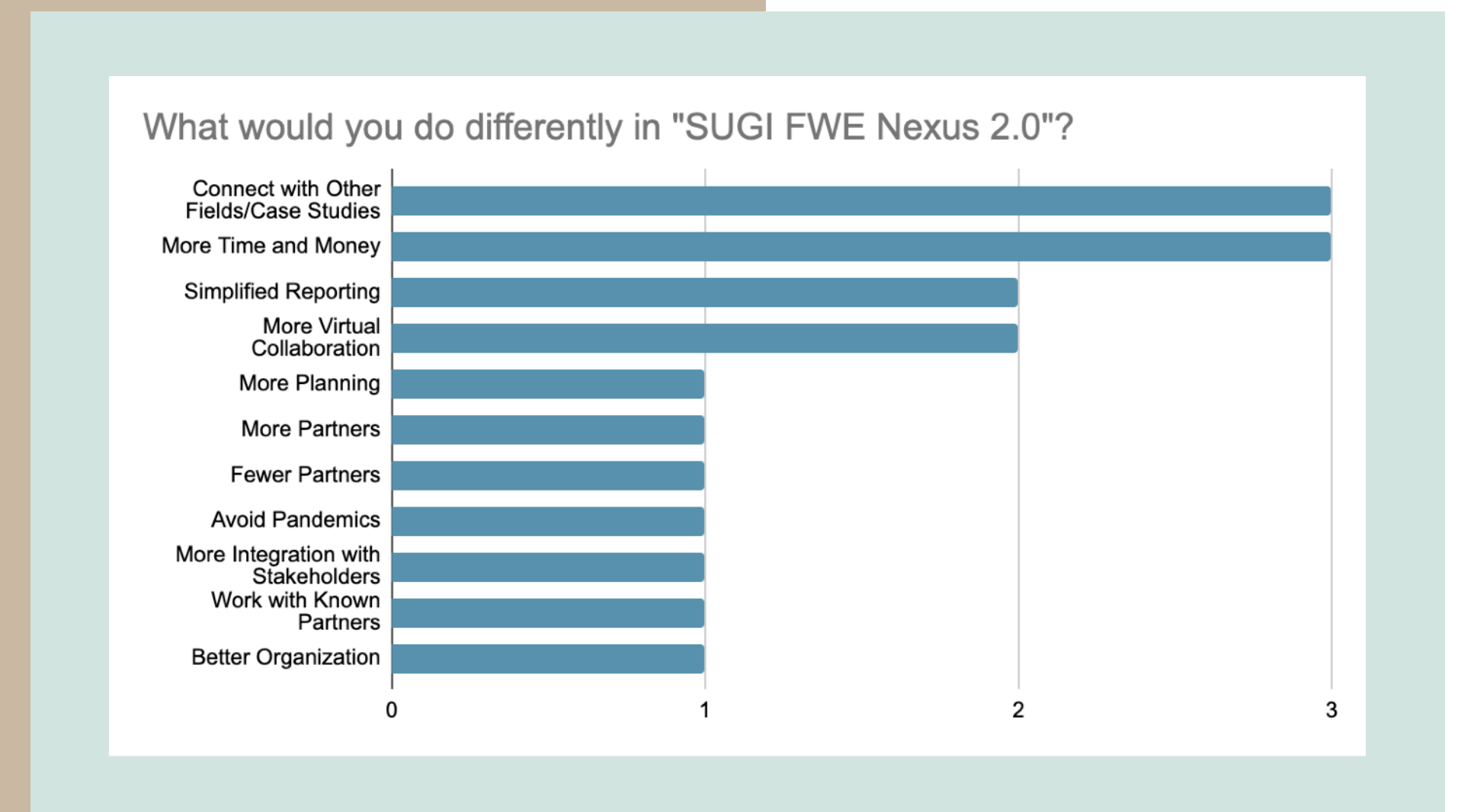
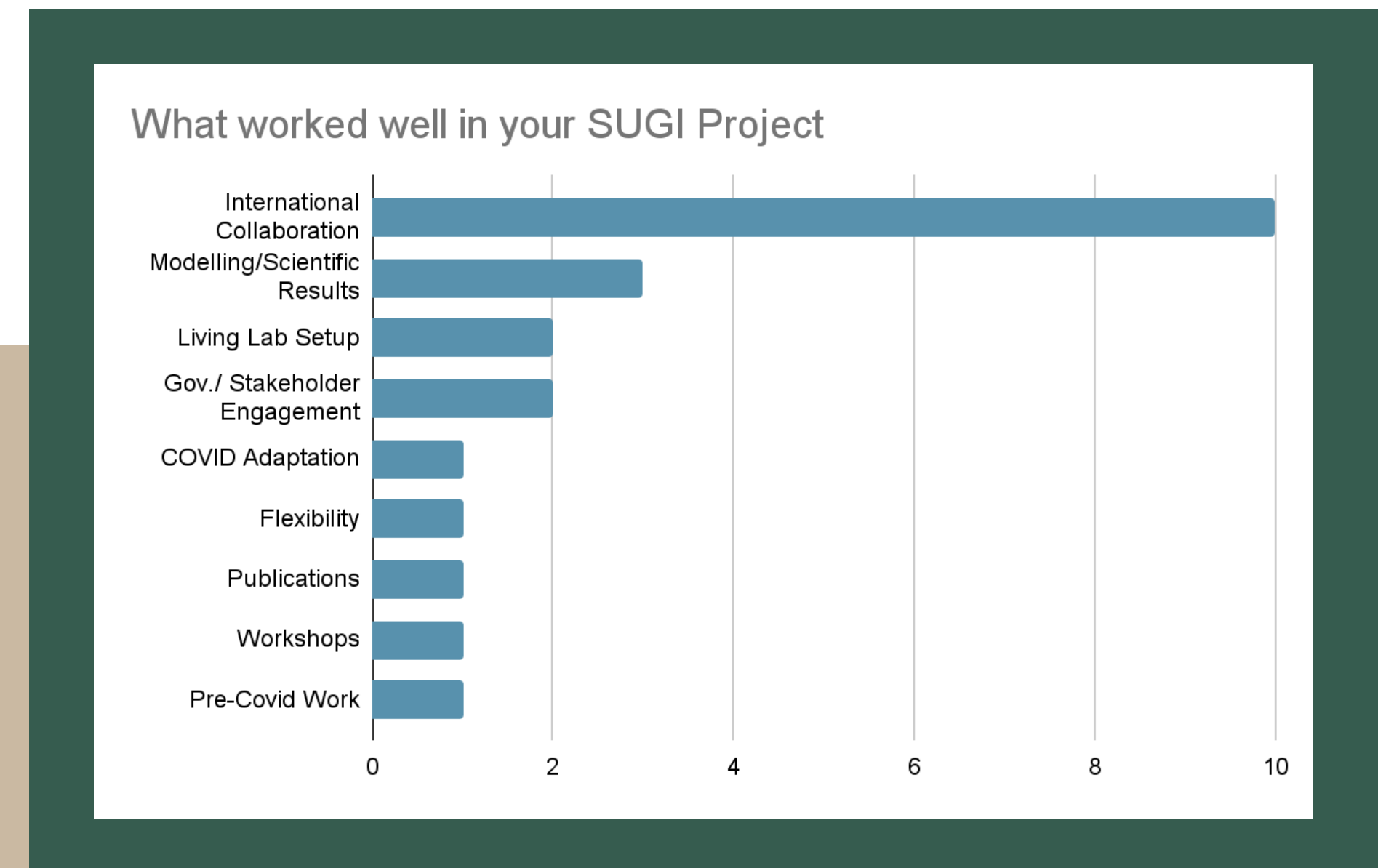
When asked what worked well on the SUGI project, the majority of respondents identified international collaboration, networking, and cooperation as keys to project success. One researcher concluded that international networking and synergies toward a nexus approach of key thematics contributed to new global networks and scientific results.

Others identified cooperation with the urban living labs setup and positive engagement with governments and stakeholders. One researcher pointed to the flexibility to shape the project with local stakeholders, while another mentioned that having the time to develop publications was a positive takeaway.

When asked what worked well and what they would have done differently at the SUGI event, researchers offered a variety of responses.

One of the major challenges of this project proved to be accessible, interoperable data. To address this and other issues, one respondent stated they would have simplified their statistical data having known what they know now.

Others mentioned they would have built more collaboration from the inception, selected teams that already had a deep understanding of the topic and partnerships in place, and organized funding sources better to manage budgets in a coordinated and integrated manner.



Lessons Learned

Connecting to the Circular Economy

While the nexus concept was relatively new in academic and especially policymaking circles, there was already some degree of familiarity with the concept of a circular economy. There are many parallels with the circular economy, which uses a system-focused approach to aim for the elimination of waste, with the FWE Nexus.

The European Union has identified the circular economy as a development priority. The European Commission adopted a new circular economy action plan in March 2020, which is intended to serve as a key component of the European Green Deal.

Several researchers suggested making the connection explicit between the FWE Nexus and circular economy. One researcher suggested that project policy recommendations should be tied to the current policies of the circular economy to better connect to that world.

Stakeholder Engagement

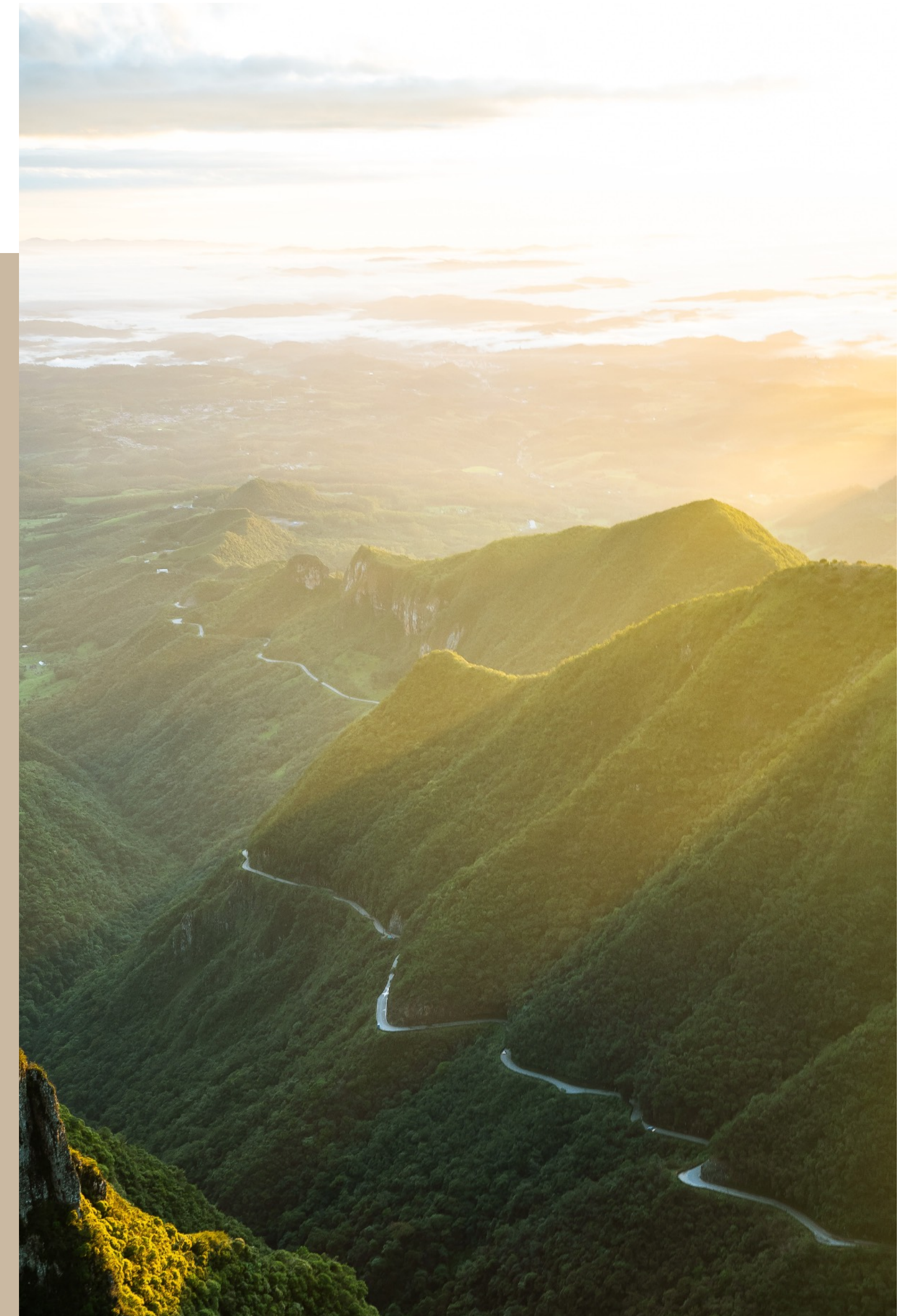
In addition to natural scientists and social scientists, stakeholders comprise the third major group for projects funded by the Belmont Forum. Teaming with urban stakeholders to enhance the impact of its research and support the exploitation of technological and social innovation is fundamental to the mission of JPI Urban Europe.

Urban stakeholders were a critical component in each of the 15 projects. Their participation is key to creating communities of knowledgeable and thoughtful actors.

“That’s the last bit of the nexus. The citizens,” said Melandri.

Bringing non-academics into an academic-heavy environment proved to be a major challenge, but many projects succeeded in putting stakeholders at the forefront. Researchers from the CITYFOOD project transferred their work in urban living labs (ULLs) to stakeholders. These labs are now being managed by a prison, a school, and universities.

Another example of successful stakeholder engagement was the FEW-meter’s team work to develop an online community of farmers to collect data and exchange knowledge by hosting a series of national workshops and international webinars, as well as publishing an open access final report.



Lessons Learned

Future Work

The SUGI-FWE Nexus projects helped elevate the nexus concept, setting the stage for future studies in the area. The trailblazing work of SUGI-FWE Nexus has helped boost the number of research-focused nexus programs around the world.

“When you say the word nexus, they will not look at you with that blank stare,” said Arbour.

Critical to the future of the Nexus work will be to see how this research moves past the pilot or demonstration phase to the implementation phase. Following up on policy recommendations and stakeholders will be key to a successful legacy of the projects.

We have already seen funders take the initiative to finance similar endeavors. JPI Urban Europe is working with the European Commission on a longer term programme called Driving Urban Transitions towards a Sustainable and Livable Urban Future (DUT). This programme aligns European and Member States’ efforts to build a critical mass for urban transitions.

The success of these 15 projects also laid the groundwork for future cooperation between the Belmont Forum, JPI Urban Europe, Future Earth, and the European Commission.





Projects

CITYFOOD

Feeding rapidly growing urban populations requires innovative solutions that ensure efficient water, energy, and nutrients management. CITYFOOD investigated quasi-closed loop integrated aqua-agriculture systems to address this global challenge.

The project took an in-depth look at decision-making caused by causal loops and developed modeling at the facility level utilizing ULLs in Norway, Germany, and Brazil. At the building level, researchers looked at five types of aquaponics operations: large commercial production, urban commercial mixed-revenue, community and education, research laboratories, and domestic and hobbyist.

To achieve this, research was done at the facility, building, and city levels.

“We have to consider decision-making on different levels when we apply aquaponics systems,” said Georg Staaks of the Leibniz-Institute of Freshwater Ecology and Inland Fisheries.

Researchers identified significant causal link chains concerning the FWE Nexus at the aquaponic facility level as well as causal relations of a production relocation to Berlin. Through interviews conducted with aquaponics farm operations, researchers developed policies needed to advance sustainability imperatives. Aquaponics helps address and create more straightforward regulatory environments. In addition, researchers identified areas of innovation and research, such as resource recovery, as key to improving operational efficiency of aquaponics.

The research done by CITYFOOD has led to over 60 scientific publications with more coming, and the open access book, *Aquaponics Food Production Systems*, which has more than 1.2 million downloads.



Creating Interfaces

Creating Interfaces addressed capacity building for the urban FWE Nexus, making the linkages understandable to the stakeholders (government, science, business, and citizens), and facilitating cooperation and knowledge exchange among them. It developed and tested innovative approaches for local knowledge co-creation and participation through ULLs in three midsize cities on water: Tulcea, Romania, Wilmington, United States, and Slupsk, Poland.

The Slupsk team focused on the food in educational institutions, particularly in kindergartens. The work in Poland sought to show what the environmental footprint was in these schools, tracking emissions tied to water use and transportation.

Research in Tulcea was centered around Zaghen Lake in the eastern half of the city, where water use is split between consumption by urban inhabitants and irrigation for agriculture. Researchers developed an online tool based on the food mileage principle.

In Wilmington, the research looked at food waste, focusing on citizens' acceptability to using alternative disposal methods like in-sync grinders, composting, and anaerobic digestion technology.

Creating Interfaces researchers focused on making their work visible to the public. Project members used texts, images, and spatial data to create StoryMaps and other interactive visualization tools. An iterative co-design process was used for the creation of visualizations.

An article published in November 2021 on enabling transdisciplinary research in ULLs Creating Interfaces researchers set forth a series of policy and practice recommendations: The articles' authors concluded: (1) ULLs need time to develop; (2) lab activities should build on and respond to local needs; (3) research programmes and projects should be built in a co-creative way and work to include stakeholders; and (4) building a sense of ownership among local decision-makers is key for the research to engage and influence policy.

CRUNCH

The CRUNCH project investigated food, water, and energy as one complex system, leading to increased knowledge and discoveries that cannot emerge when investigated separately in "silos." It combined an integrated decision support system (IDSS) and visualisation models with expert knowledge in waste, food, material flows, water, and energy management, and urban planning, architecture, and urban governance.

To help disseminate its findings, CRUNCH launched an IDSS tool to assist policymakers and stakeholders to make climate resilient urban nexus choices. Website visitors can select among six urban labs in the Netherlands, United Kingdom, Taiwan, Uppsala, Gdansk, and Miami. They can see the effects of innovations, such as solar panels, aquaponic farming, and microbial food plants within the food, water, and energy nexus.

The CRUNCH project also conducted a comprehensive literature review and published a literature database on its website. In addition, the team developed a ULL matrix to help compare projects being developed in each of the six participating cities.

CRUNCH's work was featured at the Architecture Biennale in Venice, the most prestigious event for the world's architects. The exhibition highlighted the research done in six cities to show how the FWE Nexus can enhance city resilience.

"It was a great success that we could show our approach," said Joanna Bach-Glowinska of the Gdansk University of Technology in Poland.



ENLARGE

Developing sustainable future cities depends on the opportunities to optimally integrate and mobilize FWE resources in a synergistic way to reduce water, carbon, and ecological footprints, as well as increase community resilience against challenges exacerbated by climate change, population growth, and resources depletion. Through modeling of urban development scenarios and the use of decision support tools, we can better understand how community resilience in relation to natural and anthropogenic stresses can be strengthened by the optimal integration of FWE technology hubs at varying scales.

The ENLARGE project was conceived to develop decision support tools for urban FWE Nexuses, screen and optimize FWE technology integration, generate a suite of water, carbon, and ecosystem services indicators, and increase urban reliance and reduce risk. Researchers used dynamical systems modeling and decision support tools in the case study areas of Marseilles, Orlando, and Amsterdam.

“The idea is you can build and adapt these system dynamics models as needed,” said Edo Abraham, Principal Investigator of the project.

One key output was the team’s policy brief, published in August 2021, that shares the team’s advice on creating low-carbon heating systems, sustainable water use, and social inclusion. It explains how all three are essential for sustainable heating infrastructures.

FEW-meter

As urban agriculture grows worldwide, a key need is to ensure that the nexus of food, energy, and water is optimized to utilize urban resources sustainably. This project asked farmers to measure the efficiency of urban agriculture case studies in five developed countries by quantifying usage of energy, water, and other resources.

Data gathered was used to model the resource flows of urban agriculture. This enabled the identification of methods to improve efficiency, also at a city-scale. An online platform for urban food producers will be created to share knowledge and experience gained within this project and to communicate the methods to increase resource efficiency of urban agriculture. The data gathered from the case studies and this input/output analysis showed a significant variation in carbon footprint between these different types of urban agriculture.

The project looked at more than 70 case studies of urban individual gardens, urban collective/community gardens, and urban farms in New York, Nantes, London, Gorzów Wielkopolski, Paris, and the Ruhr to create a statistical analysis of the productivity and resource consumption.

Researchers also developed a FEW-Meter methodology using quantitative and qualitative data collection to create an urban metabolism analysis and citizen science methods of research using food, water, energy, and people as indicators.

After hosting a series of four workshops, the FEW-Meter team was able to develop scenarios of optimal use of urban resources based on their analysis of urban agriculture practices in five cities.

FUSE

Novel policies and governance forms are needed to address competition for scarce resources in stressed urban food-water-energy systems. FUSE adopted an innovative living lab approach in which stakeholders: 1) produce solutions for future urban-FWE challenges; 2) engage in participatory model building; and 3) examine the merits of proposed solutions.

To help answer these questions, researchers identified 22 individual challenges by holding a series of stakeholder workshops with 75 resource users and experts. Stakeholders helped identify a mix of exogenous and endogenous pressures, including climate change, population growth, urbanization, changing dietary patterns, groundwater over-abstraction, and land use change.cn

FUSE looked at the significant supply problems exacerbated by inequalities and nexus problems on the demand side in Amman, Jordan and Pune, India. FUSE also conducted several household surveys that showed half of households suffered from water shortages and households must spend a significant amount of time, which equates to 4.2% to 13.8% of their income, to get water.

Researchers found that supply enhancement mitigates vulnerability for 90% of its population but concluded that increasing the supply of water, energy, and food was not enough. FUSE called for a reduction of inequality and a more judicious allocation of resources.



GLOCULL

Challenges in food, water, and energy systems are locally and globally connected. For local actors, including cities, it is difficult to find whether solutions to one issue in the FWE nexus is sustainable across food, water and energy systems, both at the local and the global scale. The GLOCULL project aimed to develop an ULL approach for innovations in the FWE nexus that are locally and globally sustainable.

The GLOCULL team performed an extensive literature review and conducted interviews with policymakers and practitioners. Researchers also co-created and tested with users in seven urban living labs in the Netherlands, Germany, Sweden, Austria, United States, Brazil, and South Africa. They made an integrated assessment of local-global interactions in the FWE nexus and transdisciplinary action-research.

The GLOCULL team created a toolkit to support participatory assessment of FWE innovations from a nexus perspective. The toolkit consisted of three modules: (1) awareness and opportunities; (2) system overview and interactions; and (3) quantitative assessment of innovations. The toolkit is publicly available online and is composed of two core tools, 17 videos, two courses, one podcast, one game, and one web page.

“The toolkit is applicable within various scales within the city and also beyond the city,” said Joop de Kraker, Lead Principal Investigator of the GLOCULL project. “The user is encouraged to think about the connections between lower and higher levels.”

IFWEN

IFWEN helped provide a framework and tools to assess changes in FWE Nexus, their related trade-offs, and the building of innovative capabilities in cities for developing innovative solutions to FWE and managing Green and Blue Infrastructure (GBI) at the urban level.

Researchers mapped the innovations in GBI in 82 cities to create a Local Governments for Sustainability (ICLEI) database that breaks down the type of innovation, why it was created, and its impacts. The database also broadens the understanding of institutional arrangements. Through this database, IFWEN researchers were able to conclude that cities use GBIs for different purposes and FWE Nexus implications.

IFWEN also developed a framework to explain how cities innovate in GBI and disseminated guidelines and tools for supporting cities to use GBI for the nexus approach. A guidebook, which was designed for city governments, provides information on how to develop capabilities to innovate in GBI for the Food-Water-Energy Nexus.



IN-SOURCE

As cities across the globe confront rapid change, they face common metabolic challenges to provide FWE supplies. IN-SOURCE developed a shared urban data and modeling framework to help decision-makers (such as governments, utilities, developers, investors) identify, quantify and visualize FWE systems and their interrelations for urban strategic planning and FWE infrastructure investments. IN-SOURCE is based on three case studies in New York, Vienna, and Ludwigsburg, Germany. Each examined scenarios for an integrated CO2-neutral and sustainable infrastructure, as well as the scalability and transferability of prototype solutions to other cities.

IN-SOURCE conducted a spatial analysis of the FWE sector in the three case study regions based on the following FWE nexus simulations: food demand, water demand, space heating demand, bioenergy potential, food potential, and rooftop photovoltaic (PV) potential.

The project also produced a FWE VisToolbox, which contains all the developed tools created within IN-SOURCE. A key tool was the FWE-HANPP Explorer, a web-application for analyzing the HUMAN Appropriation of Net Primary Production. IN-SOURCE also launched the Food Carbon Footprint Calculator, a tool that helps users monitor and keep track of their carbon footprint based on their diet.

METABOLIC

Effective management of urban metabolisms is the key to the health of our urban centers of tomorrow. The project helped identify key factors and define critical pathways of FWE delivery to urban centers using advanced tools, such as artificial intelligence, data mining, system dynamics modeling, agro-logistics, and scenario analysis to understand the intertwined nature of FWE in terms of lifecycles, including production, processing, delivery, consumption, and disposal. The underlying rationale is that FWE Nexus forms the basis of the urban metabolic system that sustains the development of urban centers. The primary outcome was the development of the intelligent urban metabolic systems appropriate for cities and the unique challenges for green urban centers of the future.

The METABOLIC project recently published a paper that looks at new perspectives while flourishing FWE Nexus synergies to support policymakers. The project also produced key papers on interdependent infrastructure planning under the risk of cascading disruptions. This work highlights the connectivity of community, transportation, water, and power.

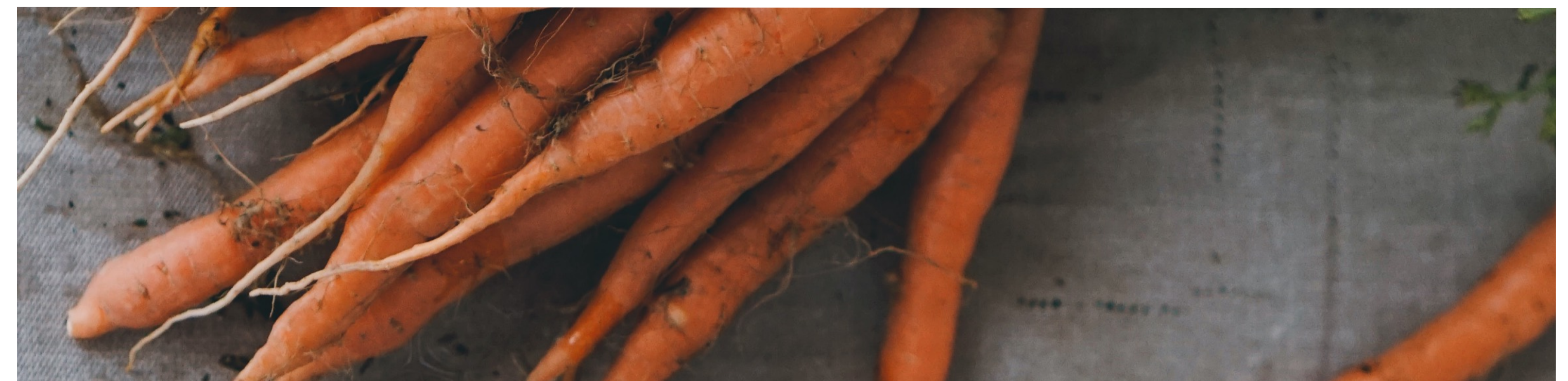
“We’ve built some game theoretical equilibrium models in order to build a multilayer infrastructure analysis to systematically investigate these systems,” said Luis Rodríguez of the University of Illinois at Urbana-Champaign.

Another important outcome was the development of a publicly available CyberGISX Platform, where students and researchers can work on reproducible systems for both education and research activity. The platform connects cyber infrastructures, geospatial analytics, and jupyter notebooks. The METABOLIC team also developed some complex nexus modeling based on system dynamics to quantify sustainable impacts.

M-NEX

Urban communities are particularly vulnerable to the future demand for food, water, and energy, and this is further exacerbated by the onset of climate change. A solution needs to be found for a FEW nexus. This internationally diverse project, based on urban design practice, sees urban agriculture as a key facilitator of the nexus, needing water and energy to become productive. Working directly with living labs in some of the most vulnerable communities in the partner cities, the team worked to co-design new food futures with stakeholders that leave them less vulnerable to forces disturbing the nexus.

The M-Nexus Project examined FWE solutions at six ULLs in Amsterdam, Belfast, Detroit, Doha, Sydney and Tokyo. Through this research, the M-Nexus team designed FEWPrint Platform, which provides the framework for a community carbon assessment with an emphasis on food. This tool was designed to help inform policymakers about food, energy, and water could help reduce greenhouse gas emissions. The FEWPrint research looked at the effects of the current diet compared to three alternate diet scenarios (100% Pesce-Pollotarianism, 100% Vegetarian, 100% Veganism).



SUNEX

SUNEX provides an integrated modeling framework of advanced tools to model and assess the FWE systems’ demand and supply sides, capture their interdependencies and maximize synergies through a nexus view that endorses efficient solutions for energy, water and food supply for urban regions. The approach applied in four case study cities reflecting different socio-economic and climate characteristics, different consumption patterns and different local and remote FWE resource shares. A monitoring and control sensor network was tested to improve water and energy savings for local food production.

SUNEX researchers used the Model for Evaluation of Energy Demand of City (MAED-City) to help determine long-term energy demand for a selected city from 2016 to 2050. Modeling compared sustainable FWE development scenarios with business-as-usual scenarios.

The SUNEX team is also developing policy guidelines to better inform city decision-making on FEW-Nexus transformation.

Urbanising in Place

Farmers and food growers can play a role in managing the urban food-water-energy nexus. The process of urbanisation today disables the metabolic agency of urban food growers. This project worked to define components of an “agroecological urbanism”: a model of urbanisation which places food, metabolic cycles and an ethics of land stewardship, equality, and solidarity at its core.

Working with communities of practice in Rosario, Riga, Brussels, and London, the project helped identify ways of structuring urbanisation that value proximity, account for the reproduction of nutrients and soils, and mobilize technologies and decommodified value chains in order to keep the control over resources localized.

Urbanising in Place's six different academic partners in four cities worked to develop a comprehensive online resource. This resource contains conversation starters and stoppers in regards to the non-conversation between farmers and urban food policy and areas of articulation for agro ecological urbanism. It also contains strategizing exercises for agroecological urbanism, policy recommendations, and academic outputs.

The Urbanising in Place team has drafted a policy brief directed at the UN policy arena and, in particular, UN Habitat,. The team has also put together a policy brief on soil care and nutrient recovery in an urban context with the Spanish network of Cities for Agroecology and partners of the SOIL NEXUS project. Team members also made key contributions to the launch of the Citizen Soil network in London, which will serve as a platform for the soil-oriented citizen science database.

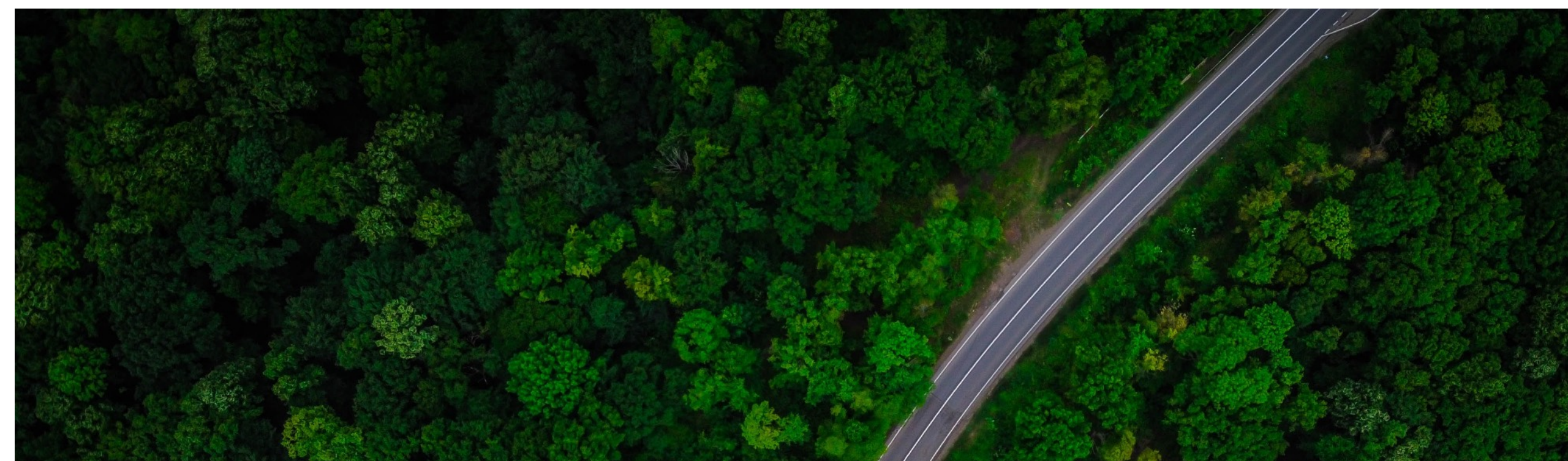
Vertical Green 2.0

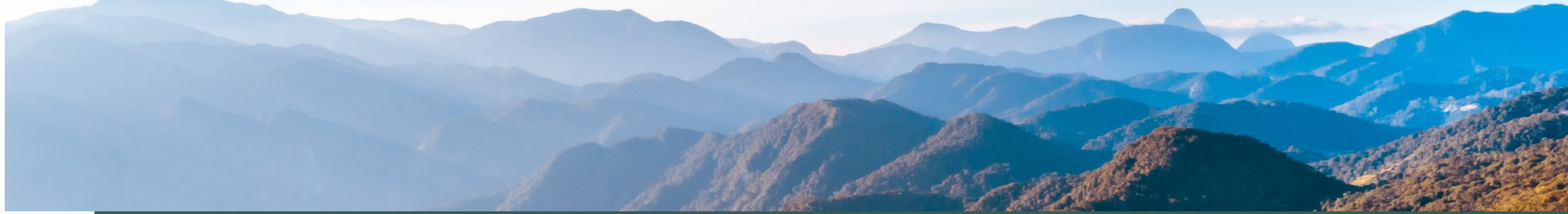
Vertical Green (VG) has a great potential to cool buildings, to recycle and upcycle wastes, rainwater and grey water, to produce food or bio-energy, and to generate green spaces nearly everywhere in cities - almost independent of available horizontal space.

The project approached the different chances and challenges associated with VG together with citizens affecting or being affected by it in order to maximize VG's acceptance. Vertical Green 2.0 re-developed VG according to stakeholder needs, adapting it to different architectures and different climates. The project also looked to reduce maintenance costs through automated machinery so that VG may unfold its full positive impacts to as many urban neighborhoods as possible.

“What makes vertical greening so interesting is that it can contribute to numerous urban transitions,” said Karin Hoffmann, one of the project's researchers.

Vertical Green 2.0 developed a number of innovations for this nature-based solution, including a building catalog, harvesting robot prototype, modeling tools, and demonstrators. Researchers have already produced a number of publications and a final summarizing project publication is in preparation with open access scheduled for May 2022.





WASTE FEW ULL

WASTE FEW ULL was created to substantially reduce waste in the food-energy-water nexus in cities across three continents: Europe, Africa, and South America. It established 4 ULLs of stakeholders to 1) map resource flows; 2) identify critical dysfunctional linear pathways; 3) agree the response most appropriate to the local context; 4) model the market and non-market economic value of each intervention; and 5) engage with decision-makers to close each loop. ULLs were located in Bristol, UK, São Paulo, Brazil, Rotterdam, Netherlands, and Langrug, South Africa.

The project was designed to contribute with policy decision support models for economically viable waste reduction, rethinking waste as a resource, as well as establishing entrepreneurship networks in each ULL to continue working after the formal end of the project.

“The project forged close ties among the ULL participants...plans and initiatives involving the FEW nexus will be smoother and more likely to succeed,” wrote the think tank, The Schumacher Institute.

The Bristol team turned its focus to waste reduction and resource recovery in the city's waste processing plant. WASTE FEW ULL's work in Bristol helped lead to the city winning the Gold Sustainable Food City status in May 2021.

São Paulo researchers developed a decision-making tool based on 13 sustainability factors and uses 3 dimensions: (1) the physical and material conditions of sustainable food solutions; (2) the attributes of community; and (3) the effects of agreements, regulatory issues, and environmental laws.

Meanwhile, researchers in Rotterdam centered their work on accelerating circular models for city or region-wide waste uptake. In Langrug, a water hub was established to experiment with nature-based solutions, such as biofiltration cells, to treat contaminated water run-off.

Researchers provided an in-depth analysis using non-market and macro-economic evaluations. In the non-market valuations, they looked at socioeconomic outcomes in food production and waste processing, comparing recycling and reduction. For the macro-economic valuation analysis, researchers broke down four hypothetical scenarios with different food waste reduction and re-spending on other goods.



Conclusion

The SUGI-FWE Nexus call helped bring the concept of the Nexus from the periphery to the mainstream, pushing for a more systemic approach to urban sustainability. The capstone event showed how far the projects have come in advancing this critical issue.

“A lot of the people are trailblazers. They are really forward thinkers,” said Nicole Arbour of those involved in the call.

SUGI Nexus’ final event gave researchers, funders, and partners the opportunity to discuss the benefits of cross-collaboration, the challenges, and opportunities created by the COVID-19 pandemic, and lessons learned from this project. The key outputs and outcomes coming from these projects have paved the way for future research and collaboration between academics and policymakers and stakeholders.

“The movement toward more sustainable cities. You have made your mark,” said Erica Key.

