THE SUSTAINABLE URBANISATION GLOBAL INITIATIVE

FOOD-WATER-ENERGY NEXUS CALL

Project Results Catalogue

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Project Results Catalogue

THE SUSTAINABLE URBANISATION GLOBAL INITIATIVE – FOOD-WATER-ENERGY NEXUS CALL

This catalogue is part of the JPI Urban Europe Projects Catalogues series issued since 2016.

CONTENT

INTRODUCTION

The Food-Water-Energy Nexus Challenge
Food, water, energy: in terms of creating sustainable cities, they are virtually impossible to separate. Optimising outputs for one relies on efficient resource management for all three, intrinsically locked as they are in a nexus. For too long cities have approached food, water, and energy with silo thinking. We need to shift to a joined-up approach. By equipping ourselves with data, securing a local supply of resources, and establishing circularity to extinguish waste we can develop robust, resilient cities that more than meet growing demands without compromising equity or ecology. This is the Food-Water-Energy Nexus challenge in a nutshell. The SUGI projects' results catalogue highlights some of the results and outcomes from 15 research and innovation projects that started in 2017 with a focus on the food, water and energy challenges in urban area.

The SUGI FWE Nexus Call
The ERA-NET Cofund call Sustainable Urbanisation is a first of a kind global initiative supported by the European Commission, the Belmont Forum and the JPI Urban Europe defined at a global scale to deliver the Food-Water-Energy nexus in cities. The SUGI FWE Nexus Call was launched in 2016 to support research and innovation with the ultimate goal to rapidly evolve the knowledge base needed for a comprehensive understanding of the interconnectivity between food, water, and energy in an urban environment, advance indicators and assessment tools and offer innovative solutions for sustainable cities.

Call topics
Robust Knowledge, Indicators and Assessments
Multi-level Governance and Management
Managing Strategies and Solutions

SUGI is a visionary initiative for various reasons. It involves 26 funding agencies from all around the world in a collective effort to deliver impacts on the ground through knowledge exchanges and replication of good practices across the globe.

Even more, it looks at the city from a systemic point of view, not as a space defined by its geography, but as a living changing environment constantly interconnected with other dynamic dimensions. For this reason, the outcomes generated by the 15 funded projects pave the way to a different way of addressing urban challenges and policies, based on a systemic and transdisciplinary approach rather than vertical 'inside the box' thinking.

The SUGI approach to innovation
The Expert Committee on Innovation and Impact Delivery (ECIID) was put in place to support the SUGI project, to review reports, give advice and initiate discussions on innovation and impacts at projects' midterm and final events, i.e., asking the projects in what sense

Participating countries and national funding agencies

JPI URBAN EUROPE
Argentina: MINCyT
Austria: FFG
Belgium: FWO, Innoviris
Cyprus: RPF
France: ANR
Germany: BMBF
Latvia: VIAA
The Netherlands: NWO
Norway: RCN
Poland: NCN
Romania: UEFISCDI
Slovenia: ARRS
Sweden: FORMAS, SWEA
Turkey: TUBITAK
United Kingdom: AHRC, ESRC, Innovate UK

BELMONT FORUM
Brazil: FAPESP
Chinese Taipei: MOST
Japan: JST
Qatar: QNRF
USA: NSF
USA/Africa: START

their approaches were innovative and what short term and long term impacts they expected from their activities.

The concept of 'urban innovation ecosystems', central to SUGI, downplays 'application' and 'solutionism', or linear plug-and-play approaches, and foreground intentional and coordinated activities by stakeholders. Therefore, after reading the projects first year reports, ECIID concluded that projects could make more efforts in scaling innovative strategies and shape broader impacts by stakeholder engagement. Most likely, important long-term impacts from the SUGI initiative are related to better suited processes and capacity-building, rather than ready-to-use solutions, even if the SUGI projects also have developed tools, instruments, and models e.g., forecasts, scenario visualizations and concrete advice on how to optimize

Table 1: The ECIID proposed to cluster the 15 SUGI projects (by acronyms) in three categories for knowledge exchange and discussions in workshops and projects events.

Group 1: Modelling tools, hardware and software technologies for urban FWE development	**Group 2: Circular Economy considerations**	**Group 3: Aspects of FWE Nexus and Green Economy considerations**
CRUNCH	CITYFOOD	ENLARGE
FUSE	CREATING INTERFACES	IFWEN
GLOCULL	FEW METER	METABOLIC
IN SOURCE	WASTE FEW	SUNEX
M-NEX		URBANISING IN PLACE
VERTICAL GREEN 2.0		

greenery and buildings etc. ready to be implemented in urban areas.

Read more about synthesized learnings from SUGI in the Future Earth reports from the SUGI projects' mid-term valorization event and the final event. Learn more about the outcomes including tools and instruments developed by the SUGI projects in this catalogue and at the Urban Europe website.

Explaining the Food-Water-Energy Nexus

The SUGI researchers soon discovered how difficult it is to communicate about the complex and abstract nexus approach with stakeholders. Could one overcome language barriers by way of developing narratives that highlight concrete examples and start from one of the food, water and energy sectors? This suggestion lies behind a series of seven articles explaining the food, water and energy nexus approach to a non-academic audience and a series of 15 articles featuring each of the SUGI projects. Read all the articles at the Urban Europe website.`

What's next?

While SUGI FWE Nexus ended in 2022, topics related to food, water, and energy in urban environments will continue to be high on the agenda in the context of the European partnership Driving Urban Transitions to a sustainable future and its Circular Urban Economies transition pathway as well as in future Belmont Forum calls.

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.).

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.

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.

How to make cities resilient with the Food-Water-Energy Nexus

Against a backdrop of climate change, urban population growth, and global supply chains that are limited in their ability to function in times of global health crises, we ask: how can the nexus make a city more resilient? How can it be put into policy and practice?

While the case for the FWE nexus concept is relatively clear to make in a theoretical, academic context, translating it to urban reality can be a struggle. At its core, implementing the food-water-energy nexus in your cities means reducing inefficiencies through collaboration all while striving to fulfil your citizens' most basic needs. Though complex at first, there is a lot to gain by intertwining goals and action plans of the respective departments.

The guidance below derives from seven articles produced as part of a pilot effort between JPI Urban Europe and CityChangers platform to explain the urban food-, water- and energy nexus approach to a non-academic audience. For more guidance read the full articles at the Urban Europe website.

Acknowledge the Connections and Assess Your Status Quo

The nexus is all about understanding how food, energy, and water relate in an urban context and how to use them more efficiently, intertwined. The first step to dealing with existing inefficiencies is acknowledging the interconnection and putting it into your local context;`failing to recognise`the consequences of one sector on another can lead to notable inefficiencies in the entire system. Use the nexus as a tool that helps you look at the city's infrastructure through a collaborative lens and evaluate the status quo. It is necessary to include not only technical and financial, but also organisational and social factors into the assessment. For all (at least three – water, energy, agriculture) involved departments, it is necessary to identify system interdependencies, review key local stakeholders and processes, define strengths and weaknesses in the city's resilience, define priority areas and develop an action plan.
Read more

Enable Cross-Departmental Collaboration and Stakeholder Engagement

When it comes to complex, intertwined sectors such as food, water, and energy, it is absolutely crucial to get all stakeholders involved and communicating with each other. Silo-thinking is one of the strongest roots for inefficiencies. The way forward is to install a consortium of different stakeholders or install a coordinator with decision-making power whose job it is to communicate with all parties involved. Each group offers a unique insight into the workings and failings of the nexus in its current state; a state which is likely to be in flux. In this way, systems can be viewed holistically, and synergies can be used meaningfully.
Read more

Data & Policy: Interpreting the Food-Water-Energy Nexus

Almost everything we do has consequences for the environment. This is certainly true for our part in the food-water-energy nexus; generally speaking, we are net users of each of these three resources. If we have a clearer picture of how these are interdependent, and the ramifications of not viewing them as such, we can put appropriate controls in place. Ideally, this is the role policy plays. But effective policy must be fed by facts. Information and communication technology may hold the key to understanding the nexus in the context of cities and for developing governance that tightens our grip on managing resources. Could it be that data is the secret ingredient to true FWE sustainability?
Read more

PROJECTS

Each project can be categorized in one or more of the four themes listed here.

- Circular Economy considerations
- Use of modelling tools, hardware and software technologies for urban FWE development
- Aspects of the FWE Nexus and green economy considerations
- Urban Living Labs

CITYFOOD

CITYFOOD makes the case for bringing food production into our cities.

The CITYFOOD project (Smart integrated multitrophic city food production systems – a water and energy saving approach for global urbanisation) investigates the feasibility of food production in cities, assessing the environmental impacts and advantages of production systems in different regions.

Upscaling aquaponics can meet the City of Berlin's food demand

The project successfully identified if upscaling aquaponics in Berlin to meet the city's food demand was a sustainable proposition. Its findings show that by using approximately 370 aquaponic facilities covering 224 hectares, Berlin's demand for freshwater fish, tomatoes and lettuce could be met whilst saving two million m^3 of water. The project also identified ambiguous causal relations which cannot be determined by a general model, either because they are too complex or because they need to be analysed on a case-by-case basis. Knowing which causal relationships are ambiguous allows policy-makers at the city-level to know what kind of things can generally be assumed and what kind of things require context-specific knowledge.

What it takes to make aquaponics a commercially viable option for meeting food demand

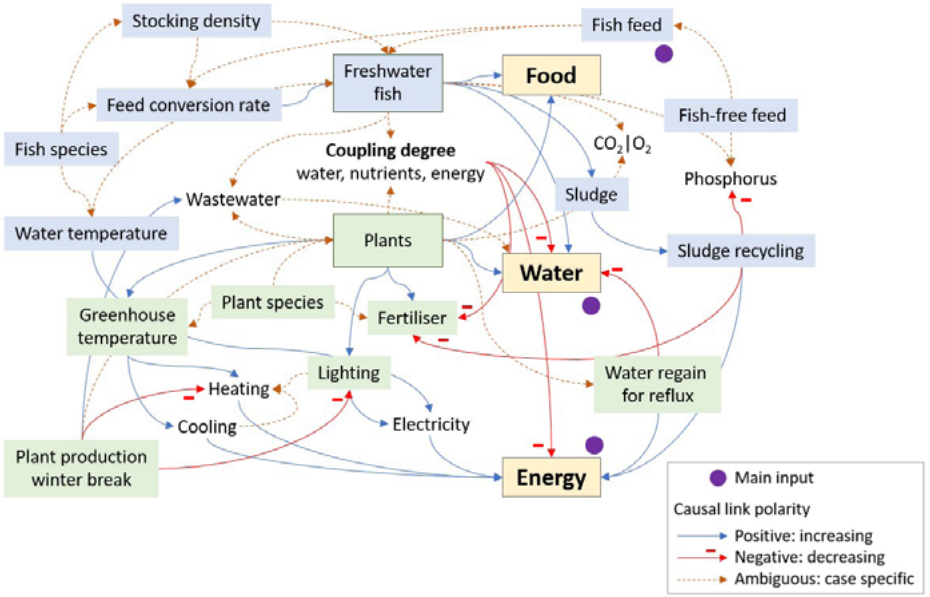
Another key output of the project was a cost-benefit analysis showing that professional aquaponics in Berlin can be profitable. This analysis identified a scenario which could recover initial investments and start-up costs within twelve years by using about 2,000 m^2 of the city's space for aquaponics facilities. The model case can be made economically viable provided favourable credit conditions are given, direct sales are facilitated, and no major production outages take place. Furthermore, the analysis also identified that there is room for further optimisation by paying attention to fish stock choices, labour conditions, and disease prevention. In terms of implementation, location and how aquaponic facilities are implemented are key factors for success. Additionally, decision-makers being sensitive to market prices and doing research on consumer behaviour and their perceptions of aquaponics were also identified as key issues. Perhaps, one of the most important considerations is that it takes seven years for this option to break even, making endurance a key prerequisite for successfully implementing this model.

More info

CITYFOOD

- The Aquaponic Knowledge Base

Read the full article



"CITYFOOD's work in Berlin shows that specific production conditions in food systems must be valued alongside food miles."

CREATING INTERFACES

Integrated food, water and energy systems makes it easier to achieve climate goals and at the same time involve both citizens and decision makers.

Envisioning the Food-Water-Energy (FWE) Nexus is difficult, especially its interrelations with everyday household concerns. It is complex and relies on the buy-in of both policy makers and citizens. But it is worth the extra mile. When an urban area's food, water and energy systems are integrated, waste is reduced, efficiency is improved, and climate goals become easier to achieve. Therefore, the Creating Interfaces project (building capacity for integrated governance at the Food-Water-Energy-Nexus in cities on the water) carried out "citizen science" (scientific data gathered by the general public, or "public participation in scientific research"). This way, you can both generate popular consent and knowledge, and at the same time help citizens voice their views and needs in sustainability transitions. Creating Interfaces has involved partners from three countries and performed case studies in Tulcea, Wilmington and Slupsk.

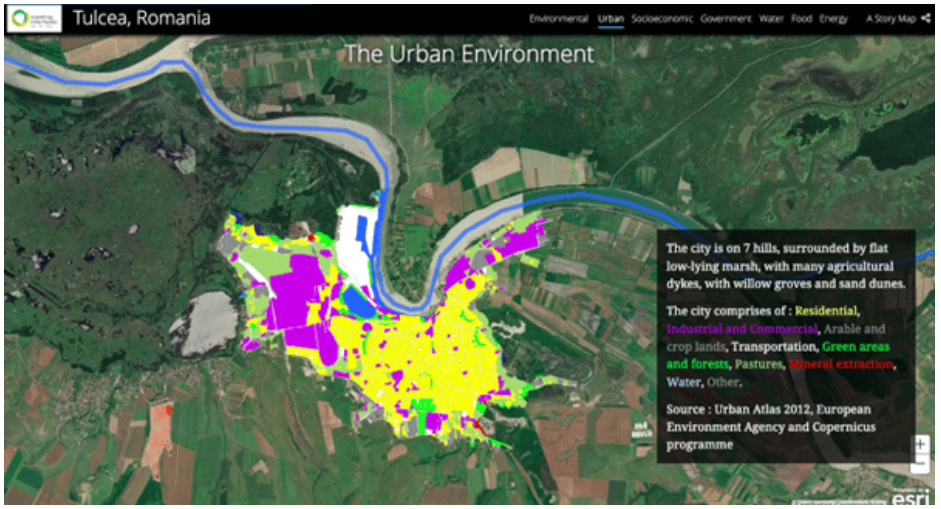
A transferable and open-source citizen science tool

The citizen science tool is an app where inhabitants contribute to more sustainable, efficient, and integrated energy systems in their cities and neighborhoods. The app collects and provides data, and at the same time links citizens with decision makers. That way, decision makers can gain understanding of what citizens, in very concrete terms, need to lead a more sustainable life. The app also informs citizens of their local food, energy, and water systems- and how they interact.

GIS and interviews showed decision makers the benefits of going local

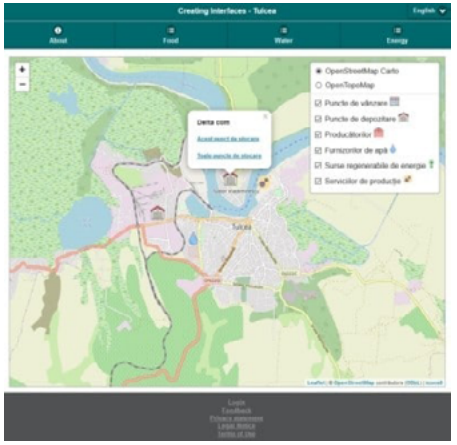
The Tulcea team combined GIS software with interviews to produce a storymap that gives decision makers a clear overview of the food producers' energy- and water needs. The map displayed the geographical position of producers, their potential markets, and their potential customers. Decision makers can now use this information to calculate the costs of producing an irrigation system and the energy costs of maintaining that system and bringing products to the market.

The researchers also produced story maps for Slupsk, Tulcea, and Wilmington. Story maps are interactive maps and stories that show the complex relationship between a place and its Food-Water systems and display the geographical position of producers, their potential markets, and their potential customers. Decision makers can now use this information to calculate the costs of producing an irrigation system and the energy costs of maintaining that system and bringing products to the market. The story maps make the nexus concept less abstract and grounds it in local concerns using familiar maps and images. They are living documents that can be edited at any time, also beyond the lifetime of the project.



A different governance of joint resources?

In the short term, the projects have shown how the nexus concept can be approached in practice to gain benefits for cities, small businesses, and citizens' daily life. In the long term, they have broken down barriers between citizens and decision makers. Co-creating integrated food, water and energy systems seems to bring mutual benefits and synergies and, in a way, Creating Interfaces explored and introduced a different governance of joint resources.



More info

CREATING INTERFACES

- StoryMaps
- Visualizing Food-Water-Energy Nexus tool
- Creating Interfaces project video

Read the full article

CRUNCH

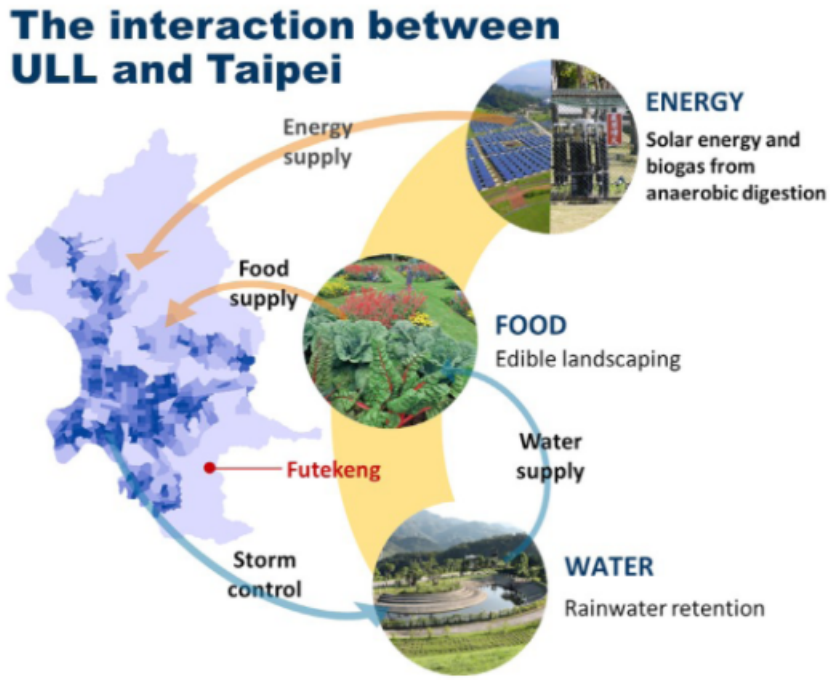
With the right tools, complexity is not a barrier to implement urban sustainability in the Food-Water-Energy Nexus.

The CRUNCH project (Climate Resilient Urban Nexus Choices) investigates food, water, and energy as one complex system, leading to increased knowledge and discoveries that cannot emerge when investigated in silos. When urban policymakers approach the daunting task of integrating a city's food, water, and energy system, they are faced with a great deal of complexity which could potentially overwhelm them.

Two core elements of the project are the understanding of how urban design and citizen engagement can positively impact food, water, and energy integration. The project is achieving both core goals by using the Urban Living Lab (ULL) methodology. This method creates physical spaces in cities to work with citizens to co-design urban design solutions and to gain data about how they feel about a range of proposed urban design choices and solutions for their city. Therefore, the project has both quantitative and qualitative dimensions. On the one hand, the project is generating useful numbers for policy makers, such as how much energy can be generated with solar panels with a given building design in a particular climate, informing them what kind of urban design choices are optimal, and on the other hand, it is seeing how citizens react to certain design changes through the ULLs.`

A tool that brings data into ecological urban designs

A vision for the future is that urban design can be done in a much more sophisticated way. Today, urban design thinking does not have precise enough data on how food, water and energy can create systems. The project's IDSS could significantly mitigate this issue. For example, if a building were to install solar panels on its rooftop, then batteries would be required since only 25% of solar energy can be used directly. However, rainwater can be collected to create a dynamo for a building's solar energy system. The IDSS would allow any policy maker to see how much water would need to be collected and if this were feasible in this case. Another strength of the IDSS lies in its simplicity. The project claims that existing tools typically require a week of training in the best-case scenario, whereas CRUNCH'S IDSS does not. This is because their IDSS relies heavily on machine learning models that are invisible to the user. This permits the user to simply play around with different innovations in their food, water, and energy systems in an intuitive manner without worrying about complex calculations. Despite its simplicity, the IDSS is still able to reflect highly local conditions. This is evidenced by the fact that all six ULLs, which all represent very different environments, have been able to successfully use the IDSS for their local context.



The long-term impact of the project is predicted to show that is possible to develop tools for policy makers that control the complexity presented by food, water, and energy systems. If these systems can be integrated and the public are engaged in the process, then a transition can be made where instead of adding ecological elements on top of the urban landscape, it can be designed to be intrinsically ecological.

More info
CRUNCH
• IDSS tool

Read the full article

ENLARGE

ENLARGE pave the way for sustainable urban heating, tailored to neighborhood needs without compromising energy resilience or social justice.

Combining data and modelling with an ethnographic approach, the ENLARGE project (Enabling large-scale adaptive integration of technology hubs to enhance`community resilience through decentralized urban FWE nexus decision support) demonstrates why a nexus approach to urban heating (integrating energy and water systems) can decrease reliance on oil and gas, increase energy security, and mitigate risks such as water stress and social conflict.

A comprehensive evaluation of existing energy technologies

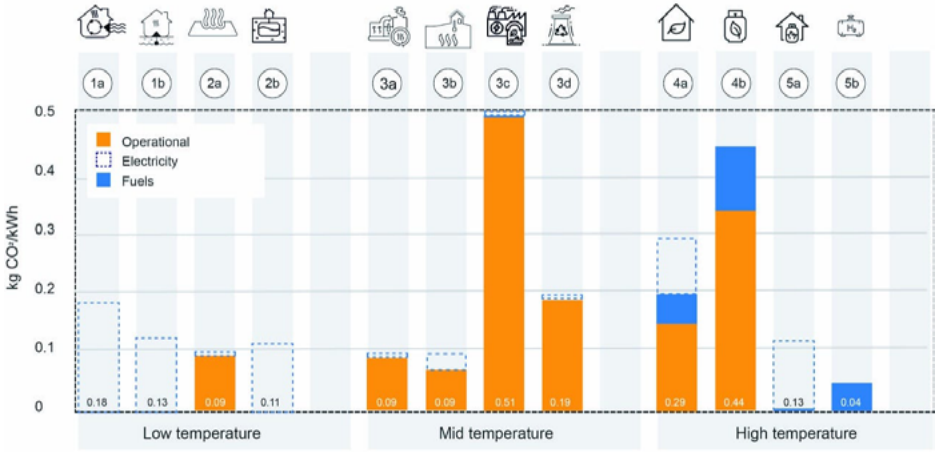
The project produced an extensive evaluation of existing technologies to answer this question. It shows that one option is the use of district heating: taking thermal energy generated by power plants, biomass heaters, industrial actors and data centres, and then combining it and distributing it via a heat network. The project also highlights the benefits and disadvantages of options such as burning biofuels or extracting thermal energy from the air or extracting it from ground water. It is important to note,

"You cannot transition heating sustainably and equitably without considering interrelations with other systems and questions about energy justice"

a resilient energy system would not rely on any single heating technology, doing so may replicate the vulnerabilities faced today. Instead, adaptive heating infrastructure planning requires a mix of different heating technologies and energy sources working together. Additionally, neighbourhoods, for example within historic city centres and newly built areas, differ from each other in their availability of building stock, space in the underground and the capacity of the power grid, influencing which heating options are the most economically viable and practically possible. Within the ENLARGE project's evaluation work, the impacts of all these technologies were considered at multiple levels (global, national, urban) to analyse the multi-scalar (multi-scale) impacts of different technology mixes on both water use and carbon emissions.

An optimisation model for determining the right mix of heating technologies

The ENLARGE team has built an optimisation model to establish which heating technologies produce the least carbon emissions per neighbourhood for different rates of building insulation and decarbonisation of electricity supply. Since the municipality organises participation for decision-making on a neighbourhood scale, the modelling framework is also applied on a neighbourhood level, generating information at decision-relevant scales, which can be aggregated to city level emissions. ENLARGE considered a rich mix of supply systems and energy sources that are currently under consideration within national policy forums and practices. This use of the neighbourhood scale is significant as cities across the world are now seriously considering decentralised decision-making structures for energy provision. The results of the optimisation model show that ambitious insulation rates for buildings and the decarbonisation of the electricity grid can significantly decrease carbon emissions by 2050. Therefore, setting ambitious plans for the insulation of buildings and the decarbonisation of electricity supply are the most important factors for reducing CO_2 emissions produced by space heating (heating for homes, offices etc).

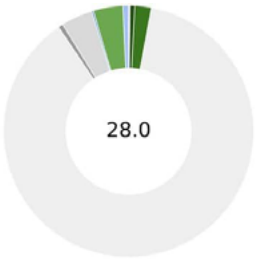


More info

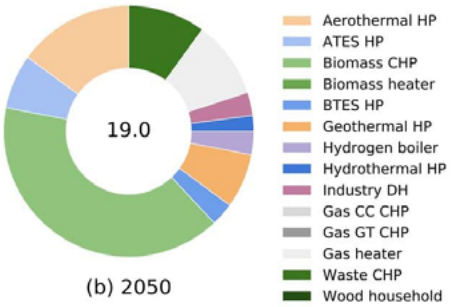
ENLARGE

- Policy brief – Enlarge the focus
- System Dynamics model: Final Publication Study 1 and Final Publication Study 2

Read the full article



(a) 2015



(b) 2050

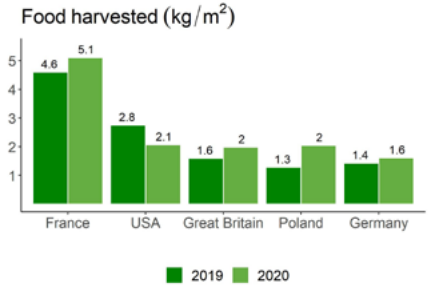
FEW METER

An integrative model to measure and improve urban agriculture towards circular urban metabolism.

The FEW-meter project (an integrative model to measure and improve urban agriculture towards circular urban metabolism) aims at measuring the efficiency of urban agriculture in terms of resource consumption, food production and social benefits. Each one of the five countries involved in the project, UK, France, Germany, Poland and USA, focused on a specific type of urban agriculture and a particular city.

Data from five countries gives insights on making urban agriculture resource efficient

One of the first findings to come out of FEW-meter was proving citizen science is a viable strategy for large-scale data collection. Farmers and gardeners from 74 sites within the five case study countries diligently inputted over 50,000 entries into project diaries which were collated and added to the FEW-meter database, while researchers added data on the infrastructure used and from a survey they conducted. Researchers now have a wealth of data on urban agriculture's resource efficiency and productivity. The database provides data on fertiliser usage, water usage, electricity consumption, infrastructure type, growth yields, and the market travel distance of urban agricultural produce.



Food productivity per country, credits:Erica Dorr

Infrastructure longevity is a key factor for sustainable urban agriculture

The project has also shown policy-makers, implementing urban agriculture without proper consideration of infrastructure is not necessarily environmentally sustainable. FEW-meter produced this understanding by conducting a life cycle assessment (LCA) along the three types of urban agriculture studied in this project (individual gardens, collective/ community gardens, and urban farms). The assessment shows the environmental impacts of collective gardens and community gardens are significantly higher than conventional farming's impacts, but it also has to be acknowledged that collective gardens and community gardens usually have other goals besides food production. The results point to significant variation in the carbon footprint between different types of urban agriculture.

Roadmap with detailed guidance to policy-makers and urban planners

The roadmap created by the project offers policy-makers and urban planners detailed guidance on implementing sustainable urban agriculture. It shows how synergies between urban agriculture and the existing Food-Water-Energy Nexus in cities can be developed to create sustainable urban agriculture by the year 2050. The roadmap identifies seven key factors for making urban agriculture sustainable: political frame conditions, economic regime, urban growth dynamics, urban planning policies, land-use patterns, climate change, and technical trends. For each of these, the roadmap offers recommendations that will make urban agriculture sustainable. The value of the roadmap to policy-makers is likely to increase since the importance of environmental topics, the value of green infrastructure, and food insecurity are all increasing, making sustainable urban agriculture more and more attractive.

Gardeners workshop, photo:Runrid Fox Kamper

"Policy-makers must consider infrastructure options that last for at least ten years when aiming to make urban farming sustainable."

More info
FEW METER
• FEW-meter Final Report

Read the full article

Raised bed, photo:Runrid Fox Kamper

FUSE

The most detailed and comprehensive national water model on earth, assisting decision-makers to choose the best strategies for tackling water scarcity.

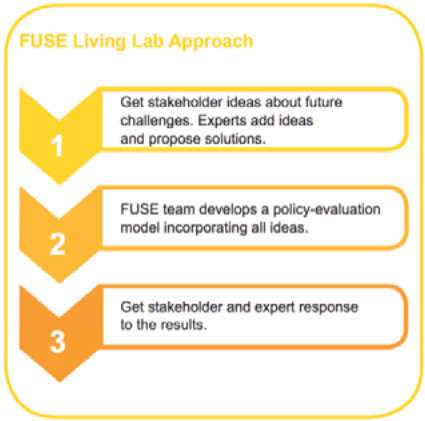
Water scarcity is one of the key policy challenges of the 21st century. According to one assessment, by 2050 the percentage of the global population facing water scarcity will have risen from 33% to 50%, and other research shows that four billion people are already living under conditions of severe water scarcity for at least one month every year. And climate change and urbanisation are exacerbating the existing global water insecurity. This is an especially troubling fact for countries like Jordan and India because both countries are already experiencing water scarcity issues and are expecting increasing urbanisation and population levels.

The Jordan Water Model (JWM) – a policy-evaluation tool for water managers

The key outcome from the FUSE project (Food-Water-Energy for Urban Sustainable Environments) in Jordan was the creation of the Jordan Water Model (JWM). The JWM offers planners water allocation projections for four plausible scenarios: an optimistic one with moderate climate change; one centred on drier climate conditions, one on population growth, and a crisis scenario in which Jordan sees severe climate change, a future refugee wave, population growth, crop price increases, and reduced transboundary river flows from Syria. The model distinguishes the expected water allocation for the poorest 10% of Jordanians from the rest of the population, it also shows planners the expected disparity in per capita water usage, and the expected duration of water shortages for each demographic group in Jordan. Using these metrics, water planners have been given important information for assessing water security intervention options.

A model that treats Pune's food, water and energy system as a holistic nexus

In India, FUSE has produced a conceptual model and a preliminary integrated model for the city of Pune and the Bhima basin, identifying 22 key challenges for its food, water, and energy systems. The model treats Pune's food, water, and energy systems as a single holistic Food-Water-Energy Nexus. This nexus approach is reflected in the conceptual model itself, showing how one system connects with another. For example, it visually demonstrates that the environmental impacts of the energy system influence land use change for food production. The model also distinguishes between exogenous pressures, such as population growth, which decision-makers do not have control over, from endogenous ones, such as agricultural groundwater over-abstraction, where decision-makers may have regulatory authority to create a direct intervention. The conceptual model has aided the project by identifying where efforts should be concentrated as model development continues.



Workshop participants at Gokhale Institute for Politics and Economics

"The JWM is arguably the most detailed and comprehensive national water model anywhere on Earth."

More info

FUSE

- 3-minute video describing FUSE
- Policy blog on Jordan's water crisis

Read the full article

GLOCULL

Cities need to go beyond the local level for a rich perspective of urban innovation's sustainability impacts.

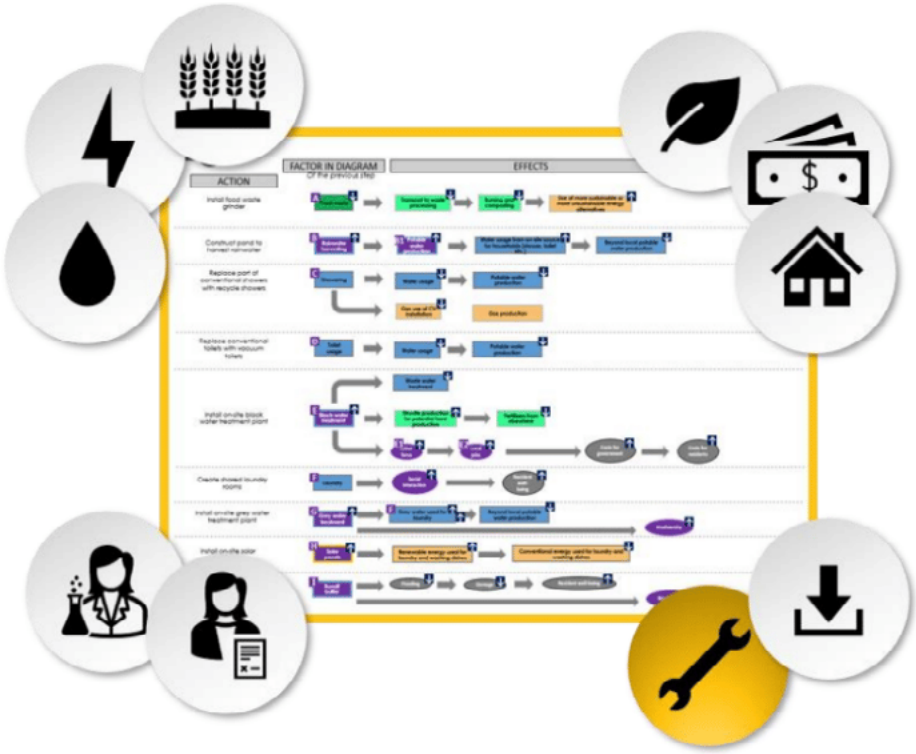
Since scarcities in food, water and energy are ever-increasing and global in dimension, the GLOCULL project (Globally and LOCally-sustainable Food-Water-Energy innovation in Urban Living Labs) aimed to overcome this weakness by producing a toolkit that allows ULLs to create and assess city-level development scenarios for their impacts beyond the local level.

A valuable assessment tool for urban living lab coordinators

At the beginning of the project, GLOCULL's researchers quickly found out there were no global assessment tools which ULLs could use in participatory assessment. Most of the existing tools were found to be inaccessible, redundant, and designed without a clear idea of their potential users. Critically, none of them had been designed to be a part of the participatory assessment process. This sentiment about using existing resources is reflected in the project's toolkit. The toolkit is intended to be flexible and applicable in any setting where participatory assessment and cocreation are the key goals. To ensure that a variety of ULL contexts can use the toolkit, it comes with a manual which explains the three modules that enhance the workflow of participatory assessment sessions. Specifically,

"The project's new quantitative assessment tool calculates the potential impacts of a proposed innovation on the FWE interrelations within a city in addition to offering an overall impact score."

Black water treatment system



the toolkit enhances two aspects of participatory assessment: stakeholder knowledge about the Food-Water-Energy Nexus and the assessment tools for evaluating a potential city-level innovation's impacts beyond the local level.

A tool for calculating the potential impacts of proposed FWE Nexus innovations

Providing critical understanding at the city-scale, GLOCULL's system overview tool shows participatory planners how a potential innovation would impact the FWE Nexus interrelations within a given city. In the first step, the tool produces a picture showing the different components of the FWE Nexus for a particular city, this picture includes the flows of energy and matter between all these components (farms, waste processing facilities, power stations etc.). As participatory assessment continues, the tool produces a new picture showing what would happen if a proposed innovation were added to the city's FWE system. This new quantitative assessment tool calculates the potential impacts of a proposed innovation on the FWE interrelations within a city in addition to offering an overall impact score.

More info
GLOCULL
• Project´s toolkit

Read the full article

IFWEN

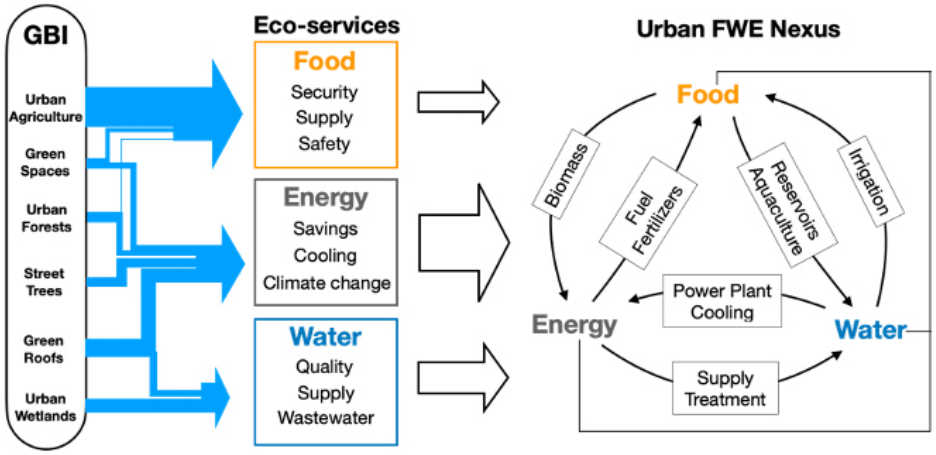
Understanding Innovative Initiatives for Governing Food, Water and Energy Nexus in Cities.

IFWEN's (Innovation in Food-Water-Energy Nexus) work show decision-makers why Green and Blue Infrastructure (GBI) is a natural fit for urbans systems integration. GBI is rooted in using nature-based solutions for urban development, and since nature does not recognise man-made boundaries, nature-based solutions naturally tend to impact multiple urban systems. Urban agriculture, for example, in its efforts to increase food security will always impact water and energy as well. GBI is consciously and carefully used in urban systems integration, it could be a strong tool for making the nexus both well-optimised and environmentally friendly.

A conceptual framework to guide decision-making for more integrated and resilient cities

IFWEN's conceptual framework is designed to help policy makers clearly understand the positive and negative impacts of different types of nature-based infrastructure. Besides demonstrating risks and benefits, the framework shows the kinds of ecoservices that different types of natural infrastructure produce and their relevance to nexus building. For example, the visual representation of the framework demonstrates that planting trees along streets provide a natural cooling service, decreasing energy demand for building refrigeration. The framework also highlights the degree of connectivity between each nexus element and their relationship with seven distinct types of GBI. For instance, it shows that urban energy systems are connected to multiple types of GBI, whereas urban food primarily connects to a single form of GBI, urban agriculture.

The project also carried out an extensive analytical review of GBI research in 120 cities from across the world, identifying trends and innovations in developing countries. The global scope of the review and its focus on developing countries was especially important since two-thirds of the world's population currently live in these countries. Mitigating climate change will depend heavily on the trends adopted in urban centres within these middle-income countries.



"Since nature does not recognise man-made boundaries, nature-based solutions naturally tend to impact multiple urban systems."

So, good GBI practises found within one of them is likely to be widely applicable and beneficial to sustainable development.

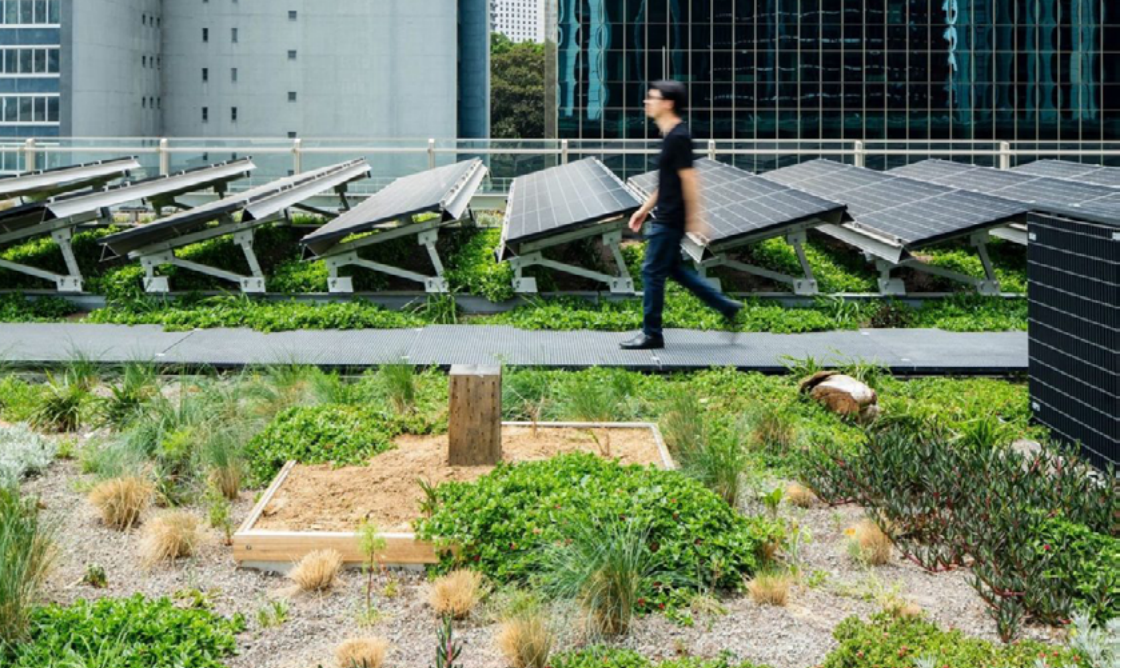
Uncovering the importance of sectoral diversity in creating transformative change

IFWEN created a model showing statistically that internal local government learning mechanisms, such as hiring expertise or internal training, are only positively associated with incremental change. Whereas external learning mechanisms, like training delivered by NGOs and research produced by universities, are significant in producing transformative change. The model also shows that when there is *no* sectoral diversity, external learning has a *negative* impact on transformative change.

More info

IFWEN
- Guidebook
- Atlas of FWEN Innovation and Green and Blue Infrastructure
- ICLEI cases
- Special Issue in the Journal of Cleaner Production: "Innovations in Urban Green and Blue Infrastructure: Tackling local and global challenges in cities"

Read the full article



IN-SOURCE

A shared urban data and modeling framework to help decision makers identify, quantify and visualize FEW systems and their interrelations for urban strategic planning and FEW infrastructure investments.

Findings from the IN-SOURCE (INtegrated analysis and modelling for the management of sustainable urban FWE ReSOURCEs) project shows decision-makers that it is possible to find solutions that tackle the food demand and energy requirements of cities at the same time.

IN-SOURCE's model, FEW CityGML ADE, was made to be widely applicable and easy to understand. It was created using the application domain extensions for an existing data model called CityGML. The base form of CityGML is normally used to simulate spatial designs for the built environment. With IN-SOURCE's revised model, policymakers can now predict food, water and energy demand at the municipal level and simulate how productive and economically viable a municipality's land assets would be in different future land use scenarios for food and energy production. A new feature of this model is that it can show decision-makers the potential outcomes of planning scenarios at different scales, such as the neighbourhood and regional scales. This will be useful in assessing which scenarios hold the most promise.

Unexpected synergy between solar panels and roof greening

The project also uncovered an unexpected synergy between roof-based photovoltaic (PV) systems and urban roof greening. The project's researchers had predicted that green rooftops would be detrimental to PV systems, as they expected plant material would obscure the photovoltaic panels, decreasing their efficiency. Yet, their simulation work shows combing roof greening with PV is technically feasible and slightly increases power generation. Their results show roof greening had a cooling effect on the PV panels which made them more efficient, increasing photovoltaic yields by 0.3%, decreasing space heating demand by 0.1%, and reducing rainwater runoff by 30%.

The first water demand simulation tool for all building type

Another key outcome from the project is an innovative method for accurately simulating the stress urban water demand puts on local resources. This will allow decision-makers to plan sophisticated water provisions policies that account for the variation in their city's building stock. Although there are already several existing tools and methods for calculating urban water demand, IN-SOURCE's method has two potentially ground-breaking features: their model can simulate water demand down to the scale of a single building as well as the regional level without losing any detail. This is the first water demand simulation tool that can account for all building types. So, policy-makers can use one tool instead of many.

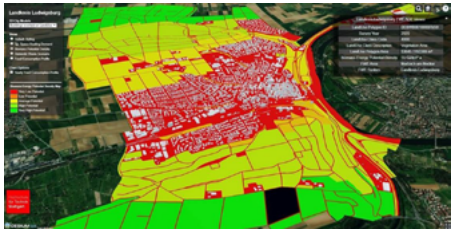
Food, heat and water demand for every individual building in a city

Potentially the most important project outcome from a stakeholder engagement perspective is the creation of the Vistoolbox. Within the Vistoolbox, users can use the CityGML model to generate a 3D rendering of a neighbourhood, town, city or even a municipal region, depicting food, heat, and water demand for every individual building. In the long-term, the Vistoolbox could have a great impact on communicating with the public about complex land use scenarios and gaining their support for land development scenarios.

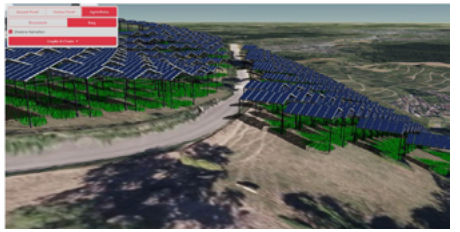
"Policymakers and citizens have to come together to decide on their priorities."

More info
IN-SOURCE
• Vistoolbox
• IN-SOURCE video

Read the full article



CityGML-FEW-ADE



AgriPV in Weinstadt

METABOLIC

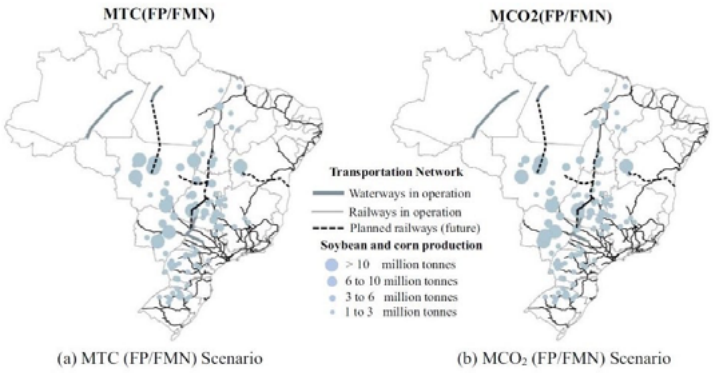
Intelligent Urban Metabolic Systems for Green Cities of Tomorrow: an FWE Nexus-based Approach.

Building on more than 30 published academic papers and extensive modelling the METABOLIC project (Intelligent Urban Metabolic Systems for Green Cities of Tomorrow: an FWE Nexus-based Approach) proves possible energy- and water gains from treating food, water and energy as interrelated systems and delivers recommendations to policy makers on national as well as local level in Brazil, Taiwan and Japan.

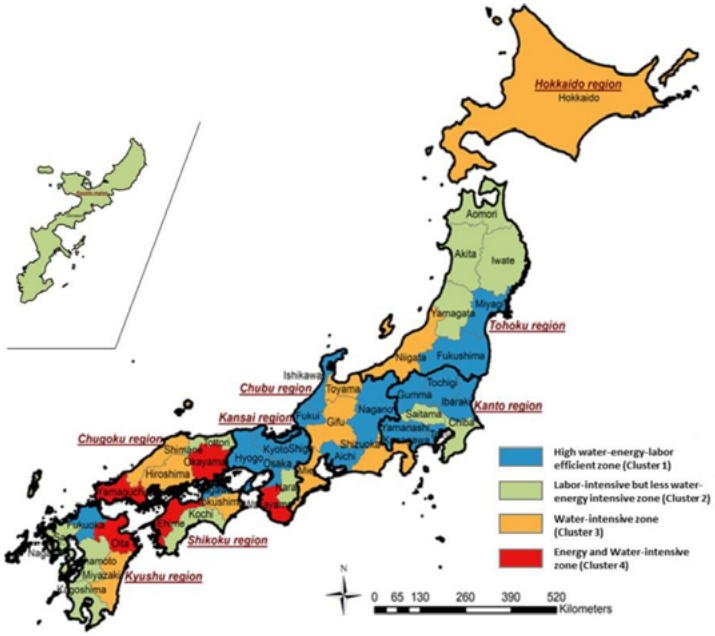
An evaluation showing the environmental advantages of Green Transport Corridors

A key output of the project's work in Brazil is a set of recommendations for Green Transport Corridors that would cut 37% of the carbon dioxide emissions associated with freight transportation by 2025. Green Transport Corridors (GTCs) are freight transportation infrastructure, designed to be environmentally friendly and connected to economically relevant areas. This work tackles the metabolic issue of food security whilst addressing broader environmental aims. The Brazilian research team adopted a nexus approach to its analysis of GTCs: a nexus approach is one where food, water and energy are seen as interrelated systems. This approach was highly effective, evidenced by METABOLIC's policy recommendations, which, if adopted, would increase Brazil's general food security by connecting food transport routes with key economic hubs and decrease national carbon dioxide emissions by forty-one million tonnes per year. The project's work has also led to the development of a highly innovative Logistics Composite Index for determining which GTC options are the most efficient and eco-friendly.

Examples of GTC for soybeans



(a) MTC (FP/FMN) Scenario (b) MCO_2 (FP/FMN) Scenario



"If a city really is like a human body, then it is worth remembering no two human beings have the exact same metabolism, which is why the diverse issues tackled within the project will come together in a broadly applicable toolkit that can address common problems cities face in the 21st century whilst accounting for their individual metabolic differences."

Using artificial intelligence to increase synergies between water and energy management

In Taiwan, the project has provided policy makers with feasible strategies for optimising water management and deploying small-scale hydropower systems. The project has done this by creating a model for the Taipei metropolitan area that compares an optimised multi-objective approach with a non-optimised approach to water management, hydroelectric power, and photovoltaic systems (floating solar farms). Results show that an optimised approach improves water storage by 13%, food production by 13.3% and energy output by 15.1%. Since the work took place in the Tamsui watershed, its outcomes are relevant to over eight million people, representing between 25-30% of Taiwan's entire population.

More info

METABOLIC

• List of publications

Read the full article

M-NEX

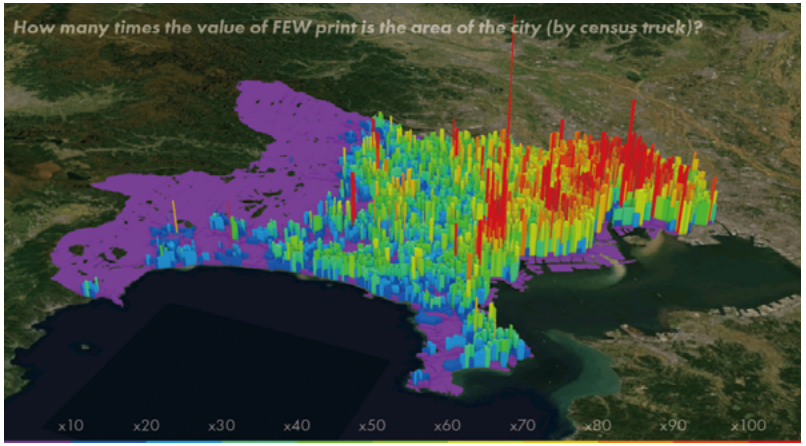
The project, based around urban design practice, sees urban agriculture as a key facilitator of the nexus, needing water and energy to become productive.

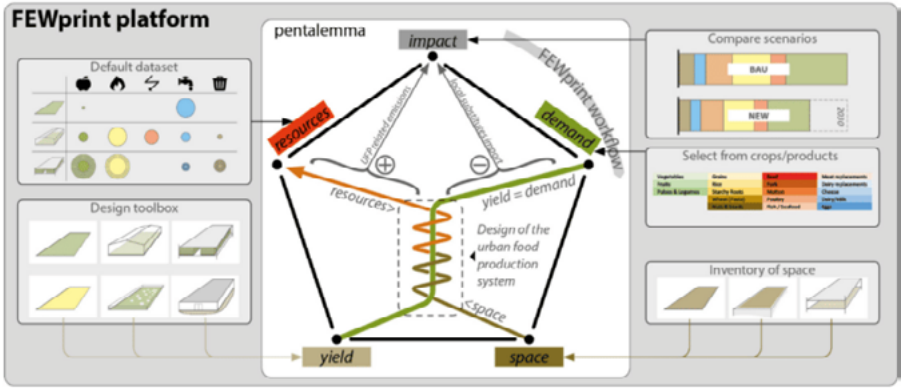
City planners and decision-makers were lacking a metric for comparing the CO_2 emissions produced by food, water and energy systems in individual city districts and neighbourhoods. Not only were they lacking an appropriate tool for measuring emissions within a small geographic boundary, but they were also lacking a viable metric for quantifying the relationship between FEW usage and CO_2 emissions.

M-NEX (The Moveable NEXUS: Design-led urban food, water and energy management innovation in new boundary) has provided both things by creating the FEWprint metric which allows them to measure CO_2 performance at the neighboured scale, that allows urban policy-makers to pinpoint and quantify exactly which neighbourhoods produce the most CO_2 – a system that provides a nine-step methodology to reduce carbon emissions. The main purpose of this system is to provide a key performance indicator that policymakers could use to see precisely where the local potential for food, energy and water production was to reduce CO_2 emission.

Urban greening and urban agriculture reduce CO_2 emissions

One key finding of the projects is the substantial potential of urban greening to reduce CO_2 emissions; this is achieved using urban rooftop gardens and vertical wall greenery on buildings. Efficient use of vacant urban spaces for agricultural purposes could drastically reduce the transportation cost of fruits and vegetables to urban areas, which generally rely on production outside of the city. Even in densely populated areas, rooftop gardens and urban farming offer promising opportunities, particularly when combined with new technologies. Urban greening and urban agriculture are not just futuristic plans, they are already being put into practice across many cities. One other major aspect of the project is the breaking of boundaries between public and private. Many cities are managed by the government, but land is owned privately, as are services for food and transport. The project offered an opportunity for many of these actors to talk to each other for the first time as the sectors have been very silo based before.





"If policymakers knows where the highest demand for food, water and energy are, they can concentrate on creating resources for green energy, green building and urban agriculture accordingly"

Breaking boundaries between public and private

A key feature of this project has been the collaboration between stakeholders. Governmental actors, urban managers and developers are expected to be the primary users of the M-NEX tools by using them to meet CO_2 reduction commitments. However, private actors such as construction companies and energy suppliers are also big players in the project as the tool let them see where their consumers are and where their demand is. In the short run, the project has managed to generate enthusiasm from stakeholders who interacted with the project.

In terms of long-term impact, the project has generated enough excitement that they can continue to refine and improve their tool.

More info

M-NEX
- FEWprint tool
- Brochure of M-NEX platform
- Publications

Read the full article

SUNEX

An integrated modelling framework to capture FWE interdependencies and maximize synergies through a nexus view that endorses efficient solutions for food, water and energy for urban regions.

In the long-term, will sustainable development options for urban food, water, and energy be able to match or outperform existing systems? The SUNEX project (Sustainable Urban FWE Nexus) takes a nexus approach to this question (an integrated approach looking at all three systems together).

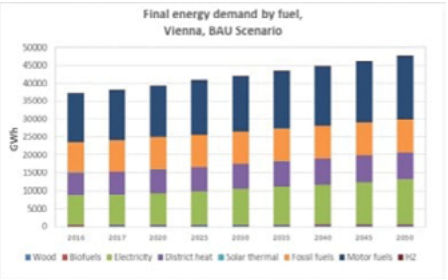
A framework for assessing the long-term performance of alternative development pathways

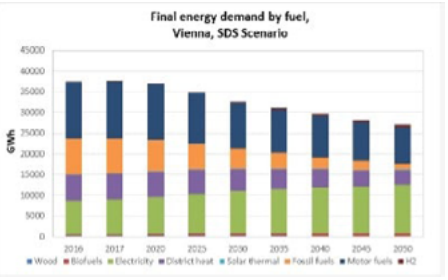
SUNEX produced an integrated modelling framework that enables preparation for long-term development scenarios for sustainable food, water and energy systems in SUNEX's four pilot cities: Berlin, Bristol, Doha and Vienna. The modelling framework focused on constructing alternative development pathways and their impacts on supply and demand for food, water and energy and their key nexus-effects. The first pathway is a 'business as usual' scenario that describes a continuation of historical trends, including recently enacted FWE policy trends without additional measures on sustainable development. The second pathway is a 'sustainable development scenario,' where modelling is done to reflect an active transition towards efficient, sustainable and low-carbon FWE-systems. Both scenarios are developed following consistent assumptions on expected future socio-economic and technological developments of the pilot cities considered. Scenarios are developed to include a participatory process involving key city stakeholders. In this way, modelling both scenarios can inform decision-makers of the advantages and disadvantages associated with low-carbon options when evaluating future development trajectories.

Guidelines offering 'win-win' solutions for the climate and food, water and energy optimisation

The strength of SUNEX's policy guidelines is that instead of focusing on trade-offs between climate change goals and optimisation goals, they offer co-benefit solutions that address multiple issues. These 'win-win' scenarios can be achieved with an integrated approach to policy. For example, attaining the policy objective of improving urban health and wellbeing with integrated thinking on transport and energy policy can produce 'liveable neighbourhoods' with co-benefit effects. These spaces could have attractive, well-networked walkways and cycle lanes that connect intuitively with public transport hubs. Such spaces would not only improve public health but also produce the co-benefits of reducing energy demand for transportation, increase the amount of space available for urban food production, and deliver on climate change mitigation imperatives. SUNEX's policy guidelines identify six interlinked policy areas where an integrated approach can produce these co-benefits, offering guidance on the appropriate strategies for each policy area and outlining the type of co-benefits that could be produced as well as the trade-offs that should be avoided.

"Good policy guidance alone will not make 'win-win' sustainable development scenarios a reality. This requires a real change in governance practises."



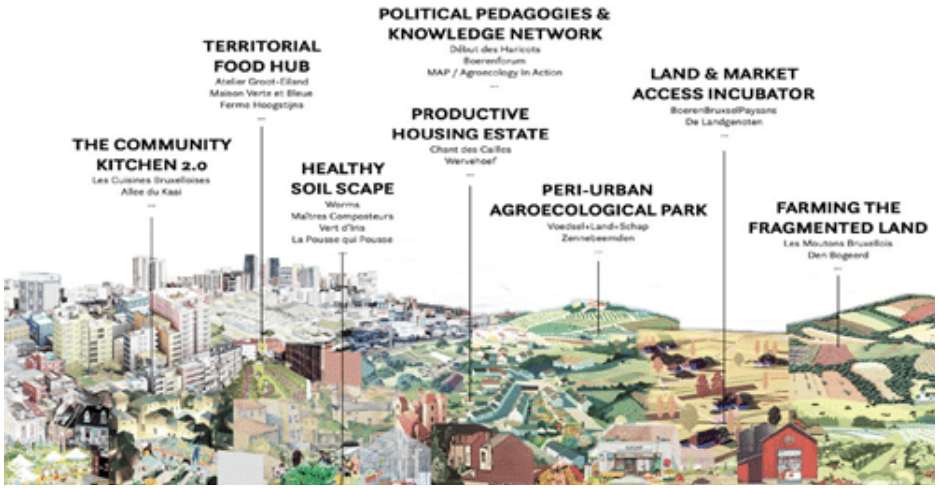


Separate from SUNEX's policy guidelines, the project has also produced a policy concept model that can help cities overcome their food security and energy vulnerabilities. The model offers decision-makers clear insights into the food, water and energy considerations necessary for both of these objectives, in terms of food security in the context of climate change mitigation strategies. The model also goes into detail about the importance of supporting urban agriculture, reducing food waste, and transforming land-use planning.

More info

SUNEX
- SUNEX-IMFA
- SUNEX policy guidelines
- Key Nexus Indicators (KNIs)

Read the full article



URBANISING IN PLACE

Defining components of an agroecological urbanism, which places food, metabolic cycles and ethics of land stewardship, equality, and solidarity at its core.

The Urbanising in Place project (Building the Food-Water-Energy Nexus from Below) seeks 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. The project explain how agroecological farming offers a model for supporting smallholder farmers whilst increasing soil health and meeting social justice goals. To help overcome the knowledge gap on agroecological practices, the project has identified eight building blocks offering the direction necessary for implementing agroecological urbanism.

Agroecological farming benefits smallholder farmers, the environment and urban liveability

One of the key project findings is that at present there is little connection between much of the movement for sustainable food planning within cities and the agroecological farming movement. Most sustainable food planning initiatives are conceived within academic and policy contexts and overfocussed on the consumption side of the urban food question. The project's analysis shows the disconnection between the sustainable food planning and the agroecological movements stems from their differing origins. To address the knowledge gap on agroecological practices, the project has identified eight building blocks offering the direction necessary for implementing an agroecological urbanism. These building blocks will be connected to a modular online resource, demonstrating the practical application of each block to one of the project's cities. The project's contribution is not just identifying that "organic waste improves soil," but rather establishing the missing links that policy makers need to understand if they want to create an agroecological urbanism. This resource will highlight the kinds of infrastructure, knowledge, institutional capacity, and the types of risk sharing that are necessary for success.

"We have to look at farmers not as communities of people on the way out, but as communities of people on the way in"

Constructive and educational conversations in cities is one of the long-term impacts of Urbanising in Place

Reflecting on the long-term impacts of the project, three important outcomes have been identified. Firstly, several cities have been brought into constructive and educational conversations easing the identification of critical issues for decision makers. Secondly, one of the partner regions, Brussels Capital Region, has understood that if it is to meet its goal of producing 30% of its food locally by 2035, it must build capacity for agroecology. Lastly, Urbanising in Place has contributed to the development of two important follow-up projects in the UK, a coalition of key players lobbying policy makers to promote agroecological fringe farming within several large cities , and internationally, the SOIL NEXUS project, which will design policy tools for using water and waste for urban soil remediation.

More info
URBANISING IN PLACE
• 8 building blocks

Read the full article

VERTICAL GREEN 2.0

Vertical greening for liveable cities – co-create innovation for the breakthrough of an old concept

The Vertical Green 2.0 project (Vertical greening for liveable cities – co-create innovation for the breakthrough of an old concept) has developed tools to predict the cooling potentials of vertical greenings and their water demands to better understand and manage vertical greening (VG) as a viable source of food and energy. The project approaches the different chances and challenges associated with VG together with citizens affecting or being affected by it to maximize VG's acceptance.

Two new tools available for energy saving and water uptake calculations

The project has produced two very useful tools that demonstrate the viability of vertical greening. One tool calculates what amount of cooling energy saving benefits can be gained with vertical greening. What is particularly striking is that the pre-existing literature had indicated that the buildings with the lowest insulation would be the ones that mostly benefit from vertical greening. However, in simulations with this tool, they found that even newer and better insulated buildings, such as prefabricated buildings from the fifties or insulated buildings, greatly benefit from the shading and the evapotranspiration cooling impact of vertical greening. To predict the impact of VG, you must go into the specific building, the overall morphology of the building and the structure of its walls and location. The Vertical Green 2.0 tool will help policy makers with these complex calculations.

Another key outcome of the project was the development of an adapted model that determines the water demand of VG. This required taking the established method for evapotranspiration normally used in horizontal agricultural contexts and adjusting measures for elements such as wind and solar radiation to consider vertical contexts. This has led to the creation of the ETovert model, which can be used by policy makers and planners to calculate how much rainwater run-off and grey water (reusable domestic wastewater from showers, baths, washing machines etc.) can be upcycled by façade greening. The model has already been applied to compare the cities of Berlin, Copenhagen, Lisbon, Tel Aviv, Istanbul, and Rome to see how factors such as climate and architecture affect the water demands of façade greenery and what sources of water could be used.

Solid data and a promising future

Overall, the project has contributed to generating a large amount of data about the impacts of vertical greening, which is essential for the long-term prospects of vertical greening systems. Before this project, there was only limited short term data gathered under very specific meteorological conditions. Vertical Greening 2.0 has also started a living lab in the form of a demonstration follow-up project, which aims to show the public twelve different vertical greening systems installed in a well-visited area in Berlin. In addition, the project has inspired a second project called "U-Green", which builds on the findings of Vertical Greening 2.0.

"The project has shown that vertical greening can help create a nexus (a system which integrates food, water and energy for efficiency and circularity)"

More info
VERTICAL GREEN 2.0
• Vertical green tool 2.0

Read the full article

WASTE FEW ULL

Mapping and Reducing Waste in the Food-Water-Energy Nexus

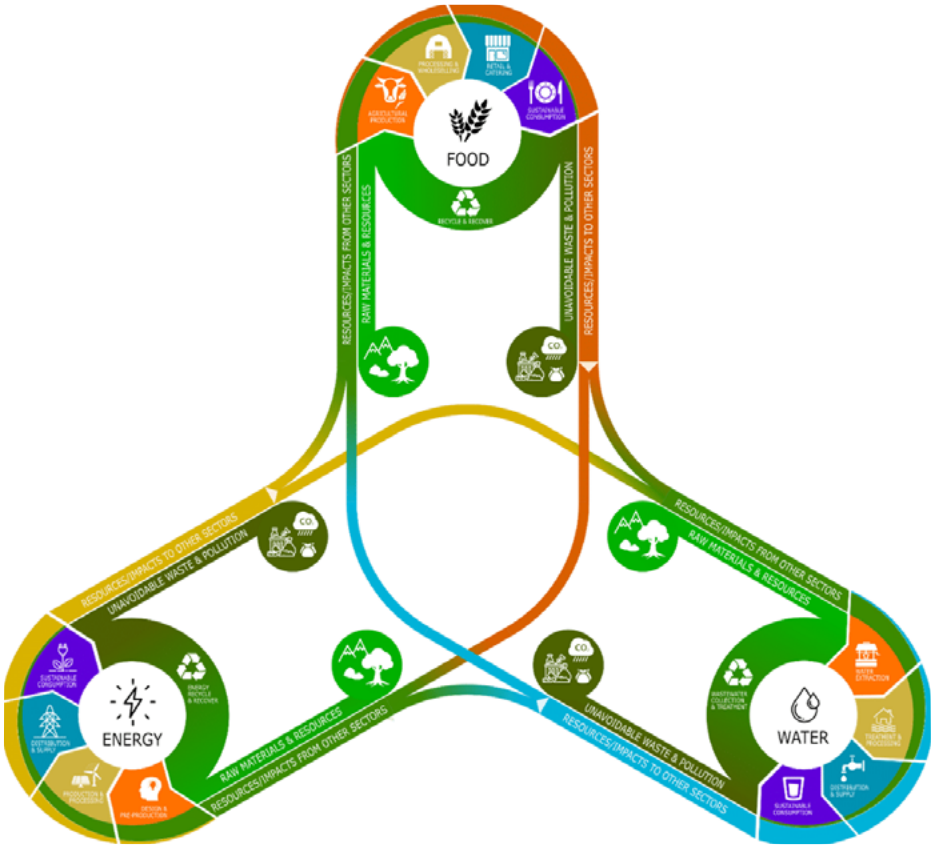
The models and conceptual framework developed in the WASTE FEW ULL project (Waste Food-Energy-Water Urban Living Labs) offers valuable insights on how food waste impacts other systems and identifies the decision-makers that determine policy. Existing policies pay insufficient attention to how waste management impacts other vital urban systems (like water and energy) or the economy. WASTE FEW ULL seeks to address these overlooked issues by developing and testing new integrated approaches from the fields of economics, systems dynamics, and participatory scenario analysis, working with key city experts, infrastructure owners, processors, and stakeholders.

"Existing policies pay insufficient attention to how waste management impacts other vital urban systems (like water and energy) or the economy"

New frameworks combining recycling and waste minimisation

An important project output was the development of a new conceptual framework. The CE-Nexus framework leverages the waste minimisation advantages of the Nexus Approach without losing the recycling advantages of existing models. The CE-Nexus framework does this by integrating the Circular Economy (CE) model with the Nexus Approach. The CE emphasises recycling and reusing raw materials, produce, components and products. Unfortunately, the weakness of the CE model is that it can contribute to the Waste-Resource Paradox, whereby waste commodification creates businesses and infrastructure reliant on increasing or maintaining waste streams. On the other hand, the Nexus Approach focuses on reducing waste production by maximising the efficiencies generated by integrating food, energy, and water systems. Since eliminating waste production entirely is impossible, this conceptual framework offers decision makers and academic researchers a starting point to develop systems that take advantage of both models.

The project brought into focus the many dilemmas faced when changing urban systems. The drive to reduce inefficiencies is in tension with efforts for sustainability, as well as maintaining the resilience of the systems involved: their reliability and safety, such as their impact on public health and social justice led to the development of the Hexalemma framework. It highlights six aspects of systems that conflict and co-operate at the same time and looks at quality, care, and allocation of scarce resources. This offers a systems approach to understanding the conflicting demands in the nexus, vital for policy development and decision making to minimise unintended consequences.



Modelling offers insights on how food waste impacts other systems and identifies the decision-makers that determine policy

Along with these conceptual frameworks, the project created a resource flux model showing how food moves through the supply chain and interacts with other critical urban systems. This model can show a user how altering a single variable, such as waste production, can impact the amount of biofuel produced or water consumed. This offers a systems approach to understanding the conflicting demands in the nexus, vital for policy development and decision making to minimise unintended consequences.

More info

WASTE FEW ULL

- Summarizing podcast
- Final project report
- CE-Nexus framework

Read the full article

PROJECT PARTNERS

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M-NEX
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METABOLIC
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SUNEX
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VERTICAL GREEN 2.0
Technische Universität Berlin, National Taiwan University, Urban planning institute of the Republic of Slovenia, University of Natural Resources and Life Sciences Vienna, Green4Cities Vienna

WASTE FEW ULL
Coventry University, University of California, CICERO Senter for klimaforskning, University of Bath, University of Reading, Wessex Water Services, Bristol Food Network, GENeco, The Schumacher Institute, University of Campinas, University of Cape Town, Erasmus University Rotterdam, ERWAT, Isidima Design & Development, BlueCity

Sustainable Urbanisation Global Initiative (SUGI)
FOOD-WATER-ENERGY NEXUS

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This catalogue provides an overview of the results from the 15 projects funded in the call. This catalogue is part of the JPI Urban Europe Projects Catalogues series issued since 2016.

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