



 Sustainable
Urbanisation
Global
Initiative
(SUGI)

FOOD-WATER-ENERGY NEXUS

Developing and Implementing the Design-led Nexus Approach for Sustainable Urbanization

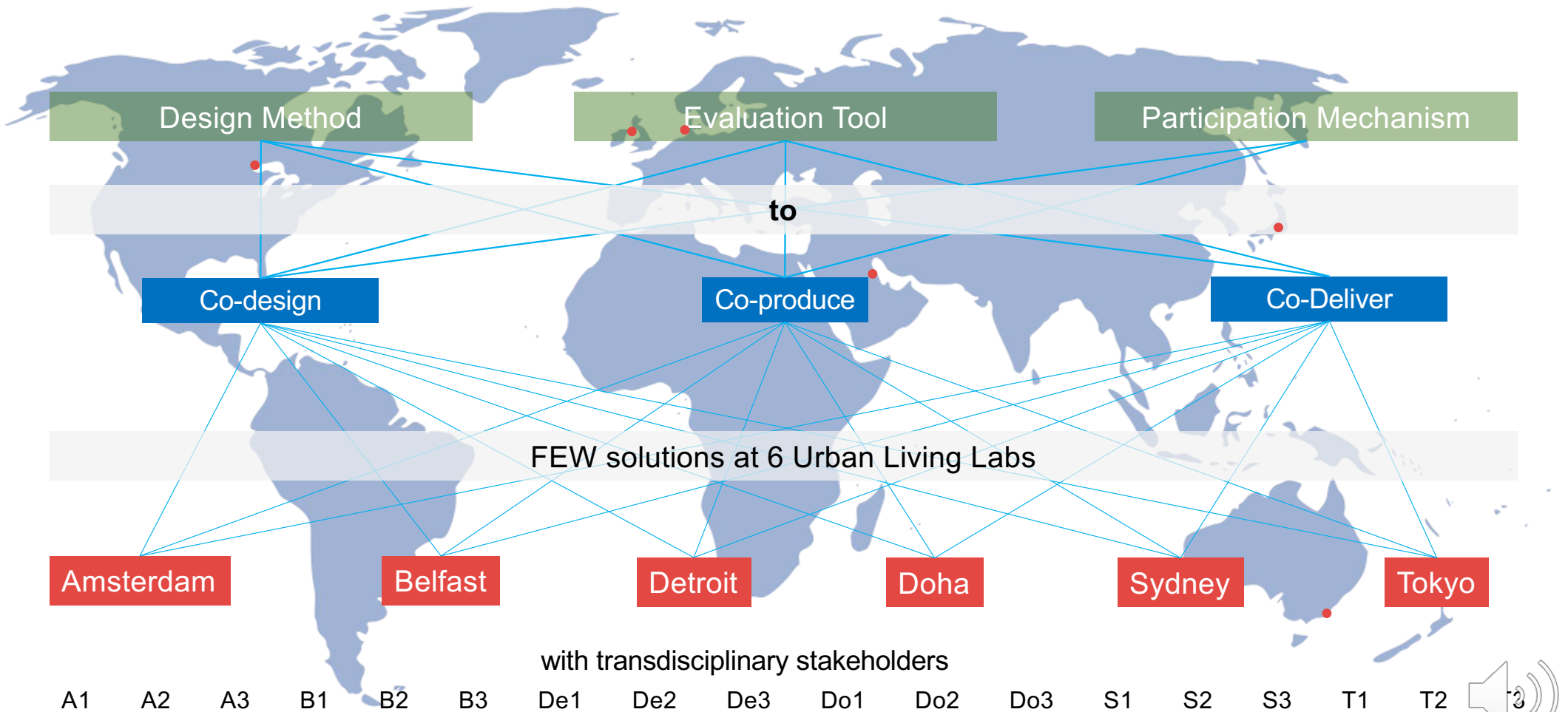
Wanglin Yan, Andy van den Dobbelsteen, Greg Keeffe, Geoffery Thün, Rob Roggema

The M-NEX International Consortium:

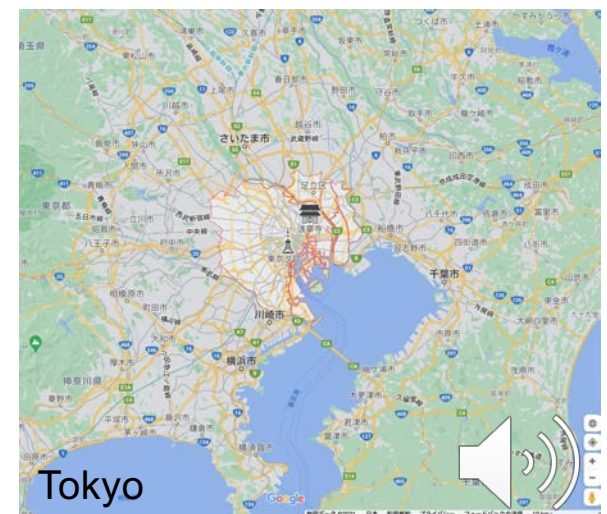
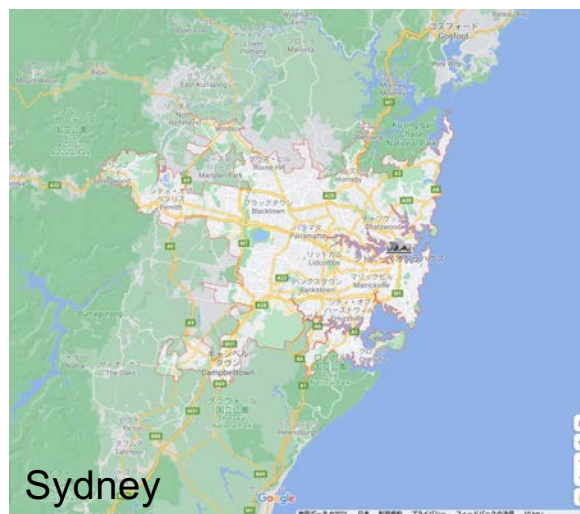
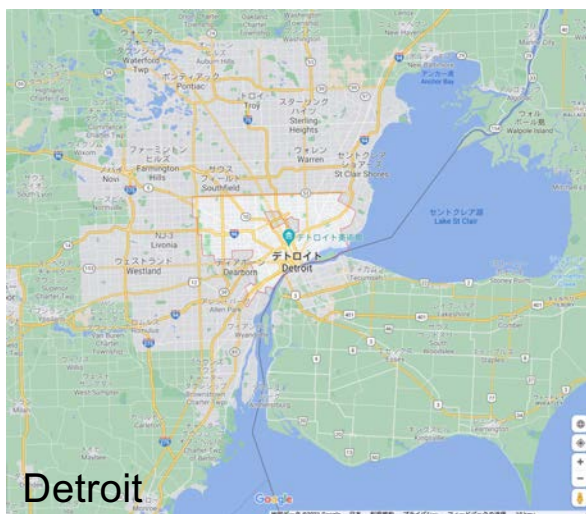
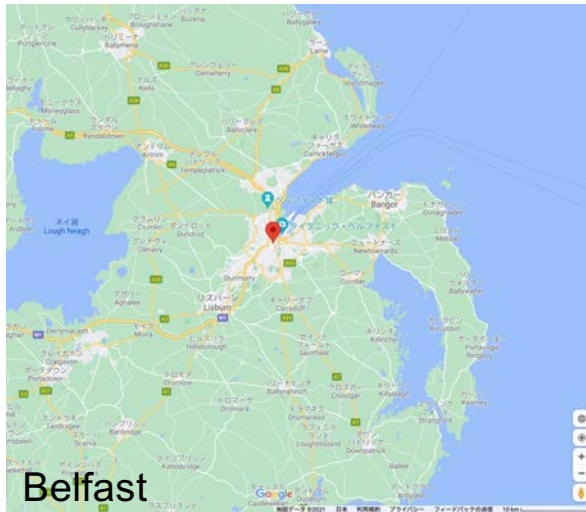
“The Moveable Nexus: Design-led urban food, water and energy (FEW) management innovation in new boundary conditions of change”



The M-NEX international Consortium

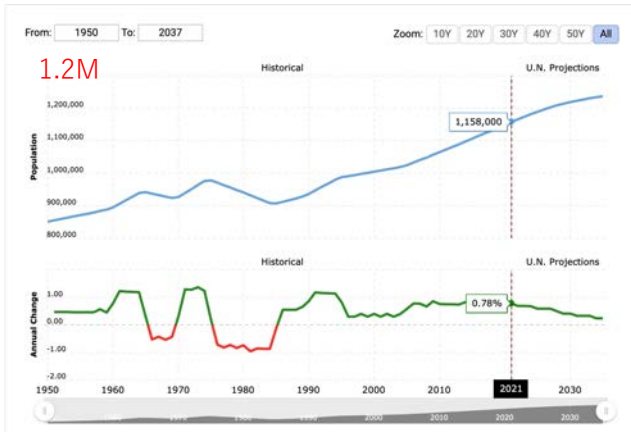


The Six Cities of the M-NEX project

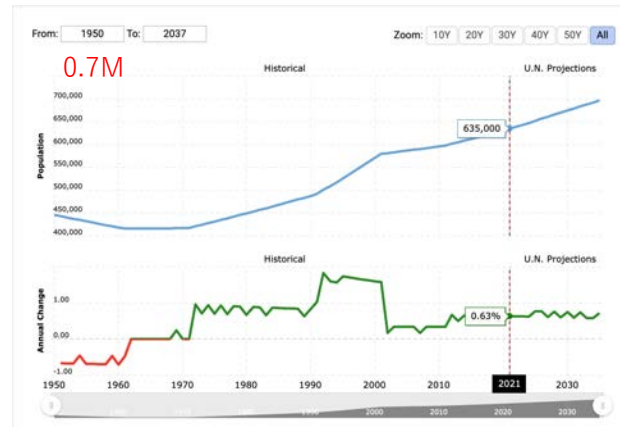


(Map source: Google Map)

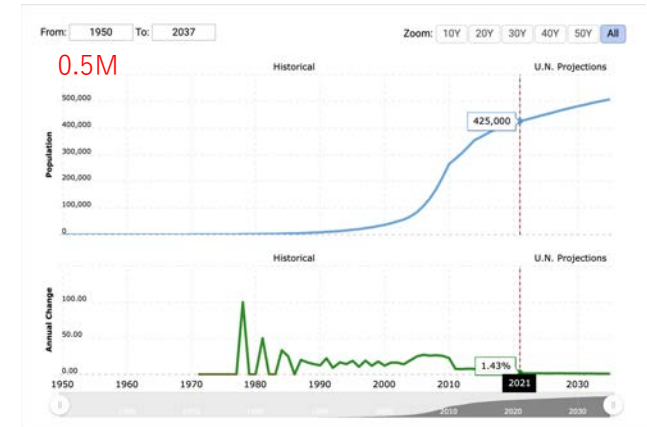
The Population of the 6 Cities (1950-2020)



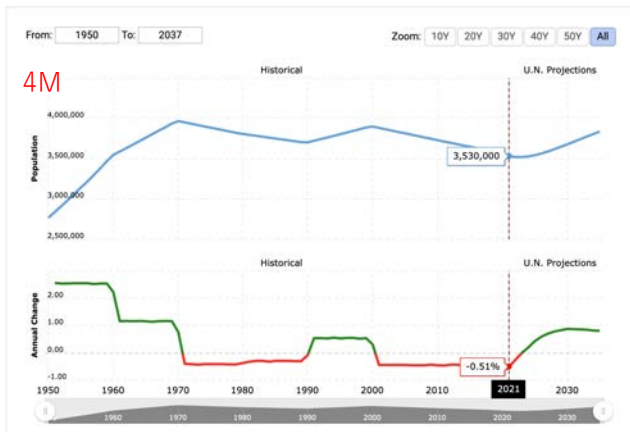
Amsterdam



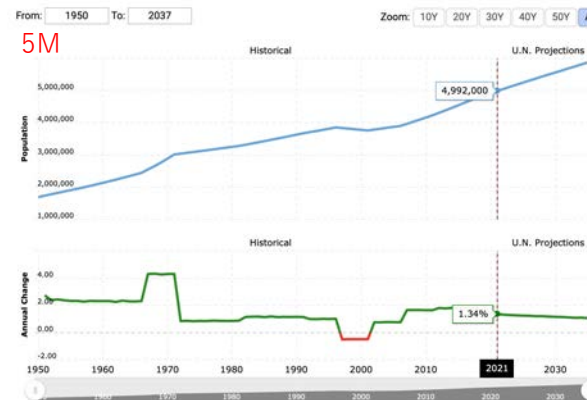
Belfast



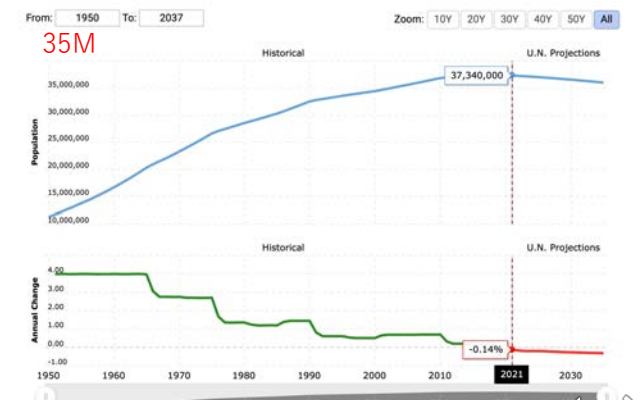
Doha



Detroit



Sydney

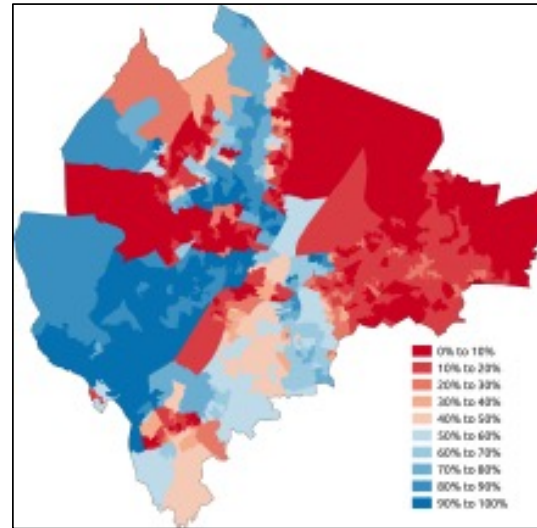
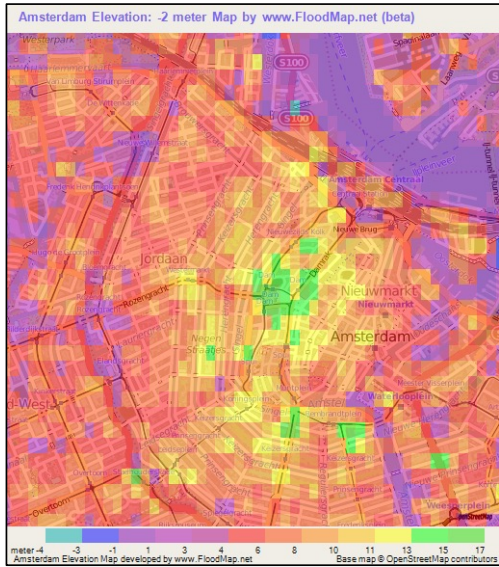


Tokyo

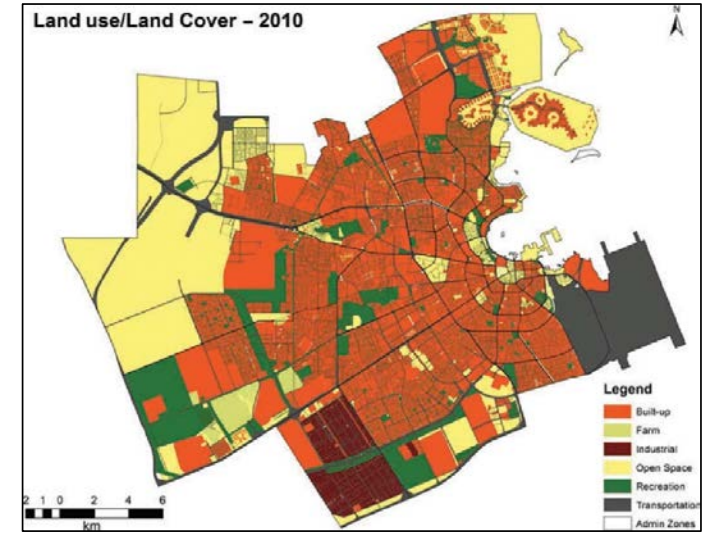
(Data source: the work bank)



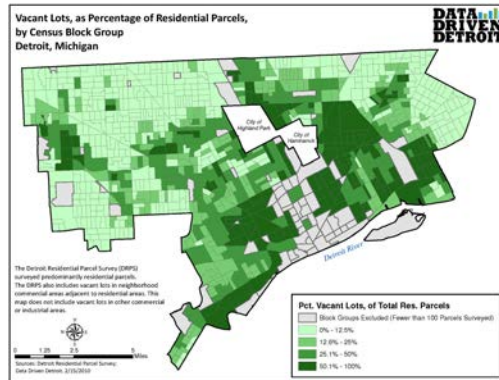
The social characteristics of the 6 cities



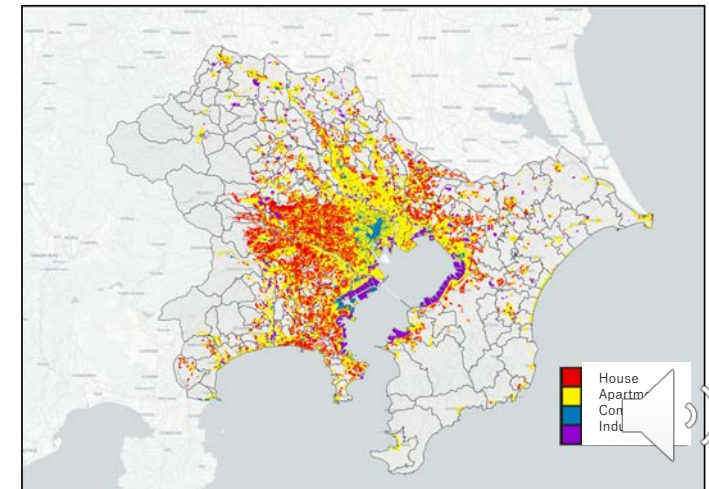
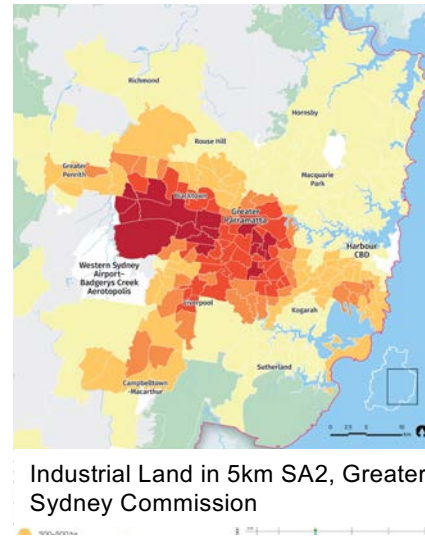
Percentage Catholic or brought up Catholic



Annals of GIS 21(3):1-15



<http://detroitenv.org/environment-land-water-infrastructure/>



Challenges to apply the nexus approach in urban design

- Long list of scientific nexus research but less practice
 - FEW nexus, wicked problems (scales, sectors, actors, ...)
 - No one solution fits to all. Solutions are context-dependent (nature, development stage, policy, culture and religions etc.)
- Many quantitative and qualitative analysis to the past and present, less future-oriented solutions
 - Cities change all the time. Problems won't be solved by the same method when we made them.
- Gaps between the call for project and implementation for Interdisciplinary and transdisciplinary engagement
 - Nexus is a jargon difficult for stakeholders to understand
 - Lack of tools for communications

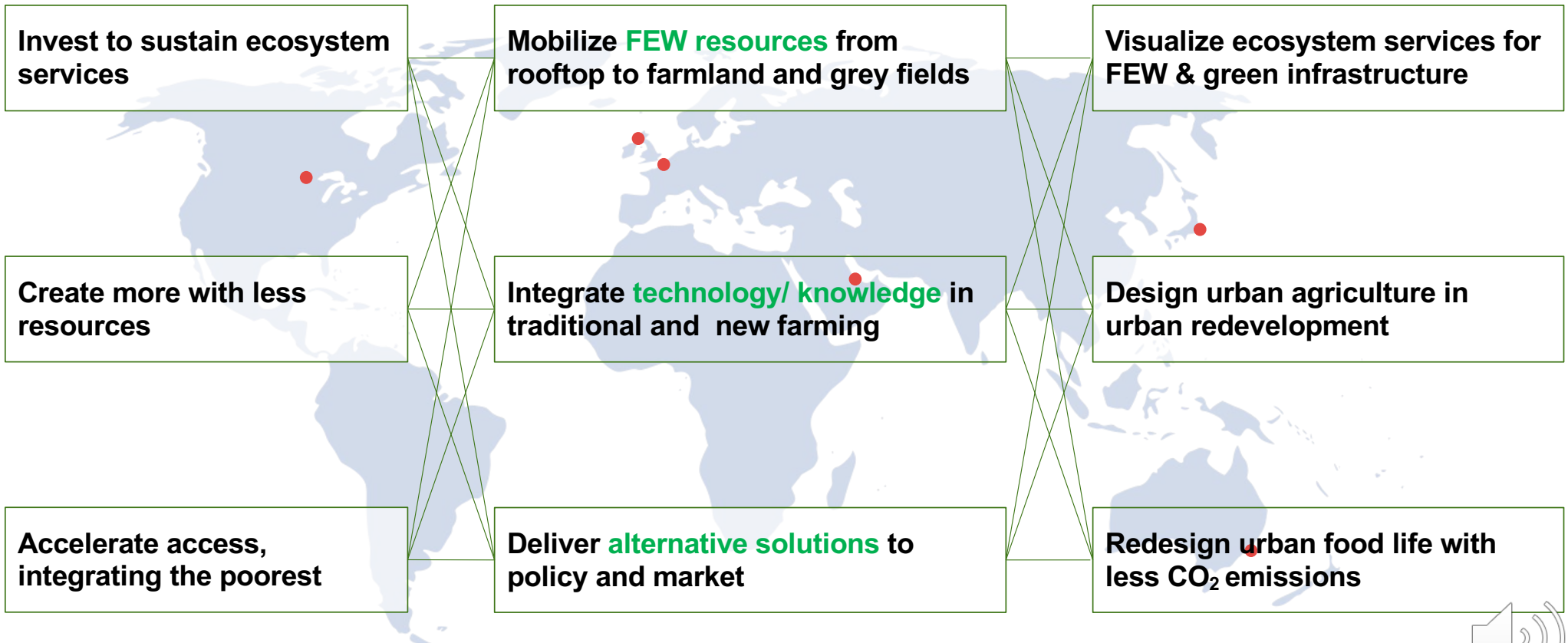


M-NEX Design-led nexus approach

Nexus Principles

Moveable Nexus principles

Design Solutions



(Yan and Roggema, 2019)



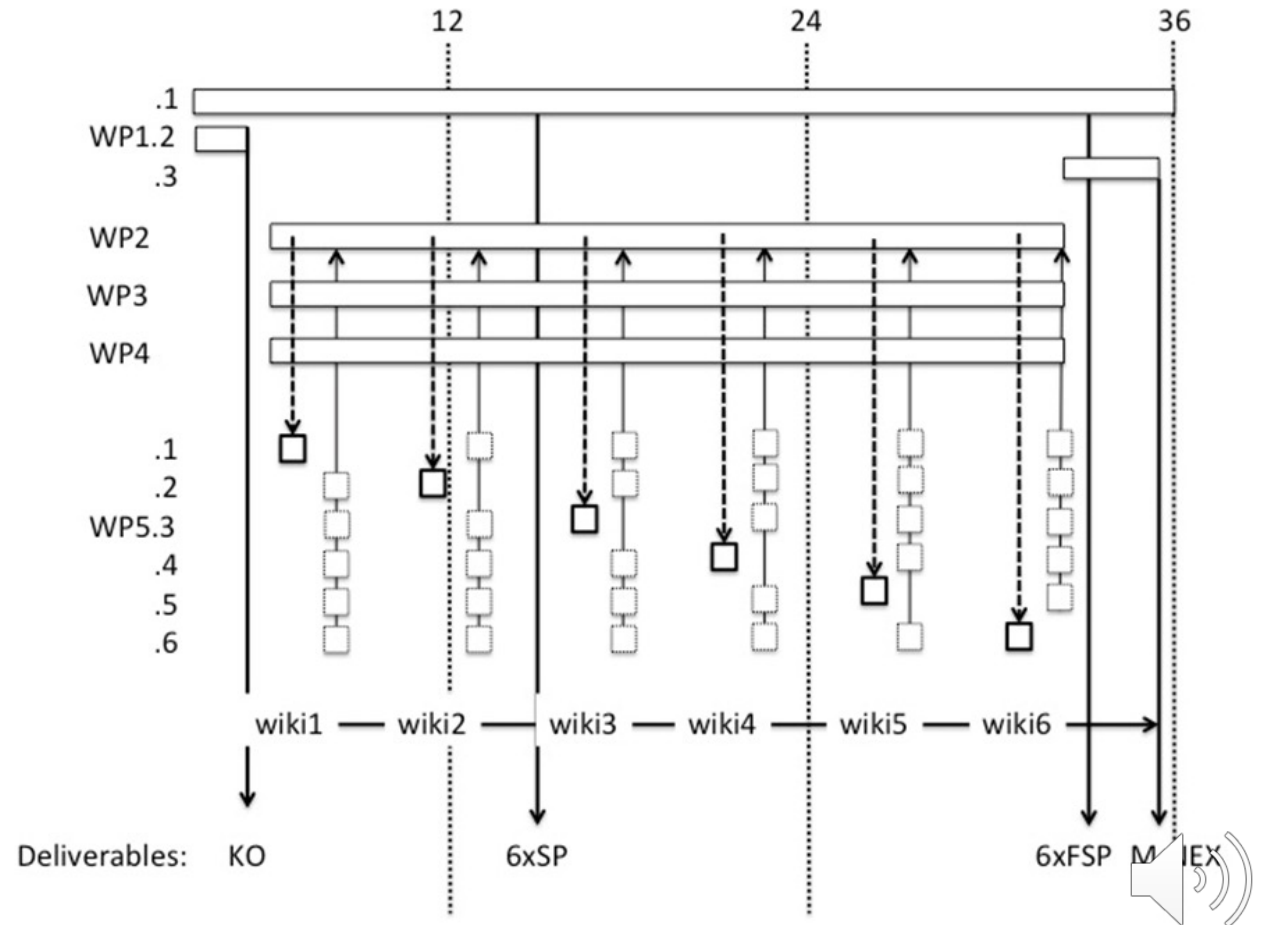
M-NEX, the Design-led nexus Approach

By using design workshops as Integrator at the 6 living labs, 1) to harvest knowledge of urban FEW nexus in various contexts, 2) to explore integrated solutions with design language, 3) to engage stakeholders with visual communication tools.

- WP.1 Project management
- WP.2 Design Platform
- WP.3 Evaluation Platform
- WP.4 Participation Platform
- WP.5 Living Labs
 - WP5.1 Belfast, UK
 - WP5.2 Doha, Qatar
 - WP5.3 Detroit, USA
 - WP5.4 Sydney, Australia
 - WP5.5 Tokyo, Japan
 - WP5.6 Amsterdam, Netherlands

Note:

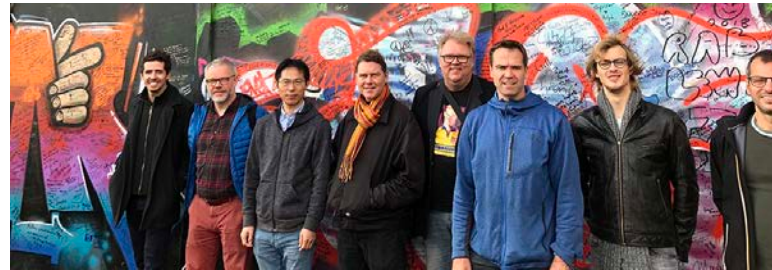
- KO : Kick-off
- SP: Strategic Plan
- FSP: Final Strategy Plan
- wiki1~6: incremental M-Nex platform by wiki-like ICT tools.



M-NEX Design Workshops in a row



M-NEX Consortium Kick-off: Sydney
[2018.05.12 – 2018.05.16]



M-NEX Design Workshop: Belfast
[2018-10.08-2018.10.12]



M-NEX Design Workshop: Qatar
[19.02.22 – 19.02.28]



M-NEX Design Workshop: Detroit
[19.06.30 – 19.07.05]



M-NEX Design Workshop: Sydney
[19.11.02 – 19.11.09]



M-NEX Design Workshop: Groningen
[2020.03.02 – 2020.03.06]



M-NEX Design Workshop: Amsterdam (virtual) [20.10.03 – 20.10.5]



M-NEX Design Workshop: Tokyo (virtual) [21.02.08 – 21.02.10]

+ Living Lab activities with stakeholders



UK Team, Design food factory (Aquaponic system)

Greg Keeffe Professor of Architecture + Urbanism School of Natural and Built Environment Queens University Belfast.

Building



Window systems



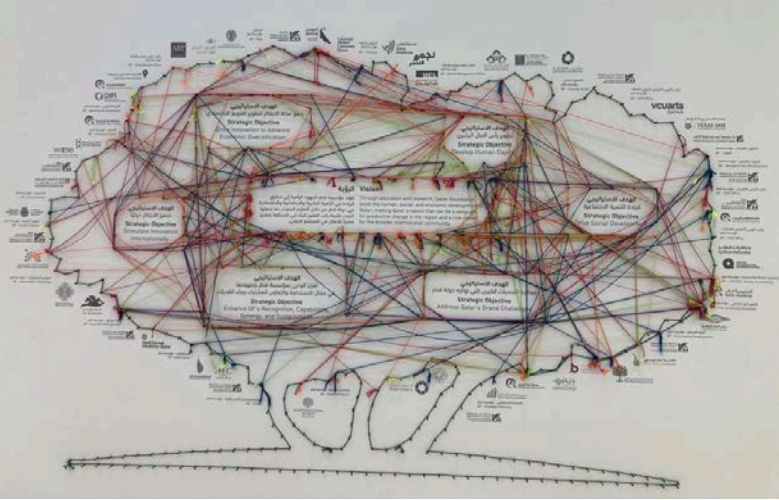
Neighborhood



Urban Farming in Arid Climate

QU Team, Design the Self-cooling Greenhouse and Applied in University Campus

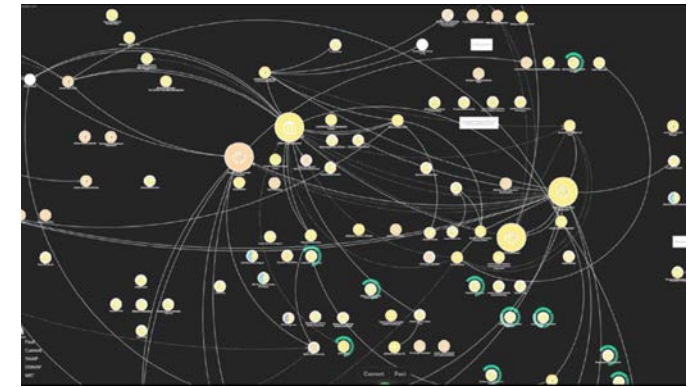
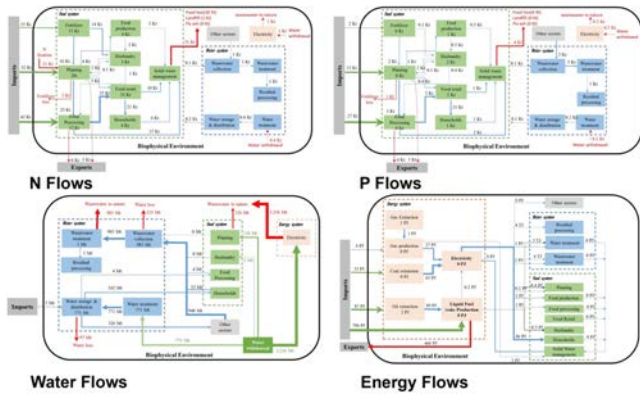
Sami Sayady, Professor, Center for Sustainable Development, Qatar University.



Urban Agriculture in the Post-industrial City

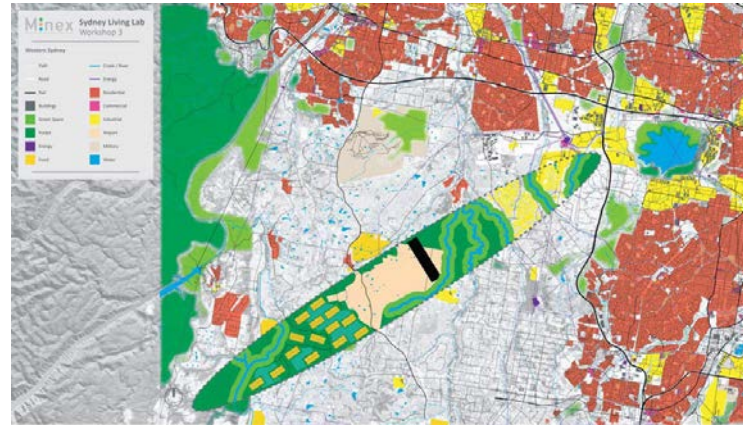
UM Team, Design the Urban Farm (Vegetable Factory on ground and under ground in Neighborhood)

Geoffrey, Thün, Professor of Architecture, University of Michigan

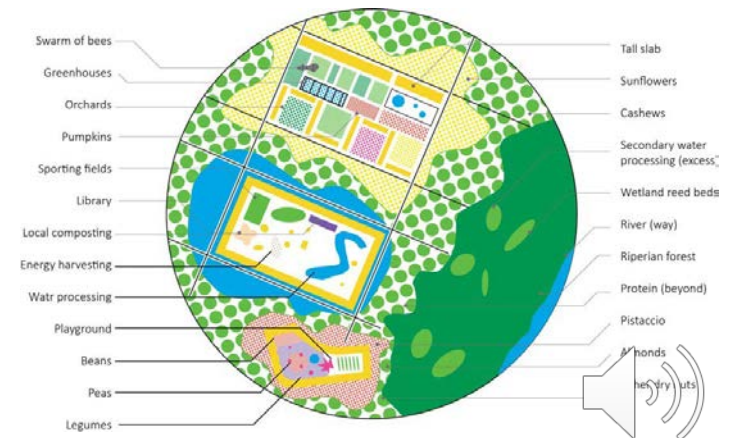
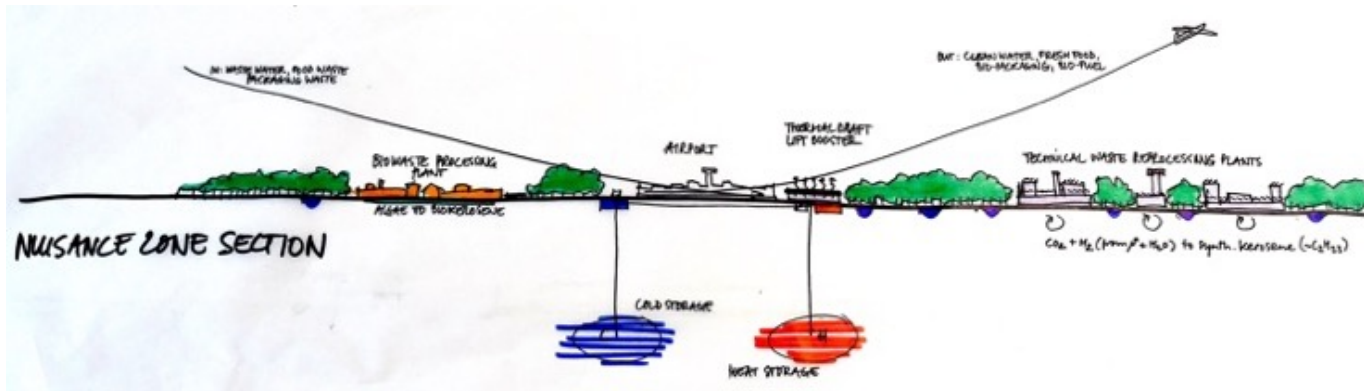
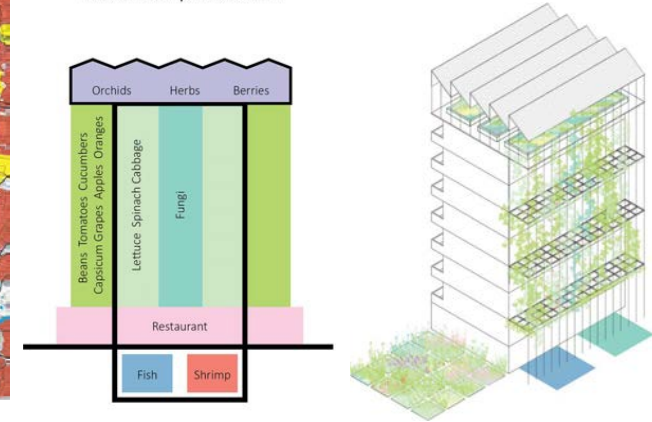


Sydney Team, New development (Food industrial park, the new int'l airport, Sydney)

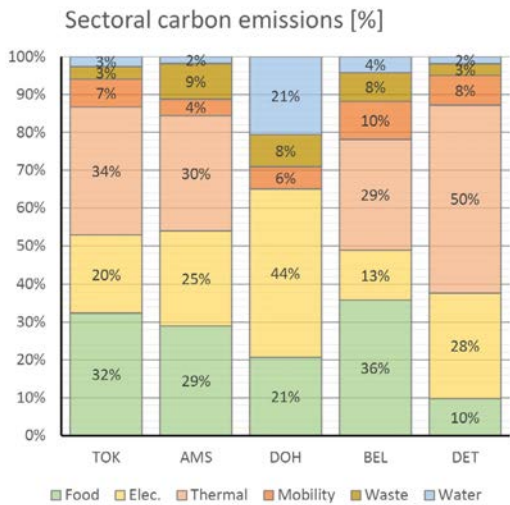
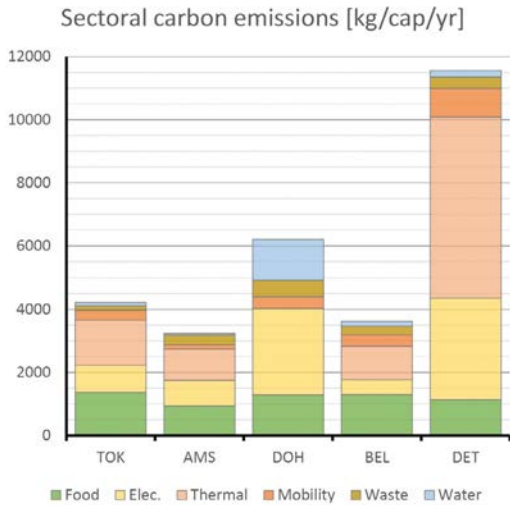
Roggema, Rob and Monti, Stewart



Maximum production



DU Team, Develop FEW print and apply to Redevelopment Project in the Harbor Area
 Andy van den Dobbelsteen, Professor, The Delft University of Technology.



FEWprint | Scen. 3: Diet alternative: biowaste as animal feed

assume 75% local production

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
[Progress bar for Red meat]										
[Progress bar for White meat]										
[Progress bar for Dairy]										

Total electricity demand	613 MWh _e /yr
Total thermal energy demand	2103 GJ _t /yr
Total water demand	6420 m ³ /yr

Carbon emissions FOOD sector:	3176	→	1649	ton/yr
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open field farming	greenhouse horticulture	plant factories	animal feed farming	animal housing	swill anim
12,8	8600	2550	1,6	834	14
[ha]	[m ²]	[m ²]	[ha]	[m ²]	[ha]

M-NEX Evaluation Tool–FEWprint

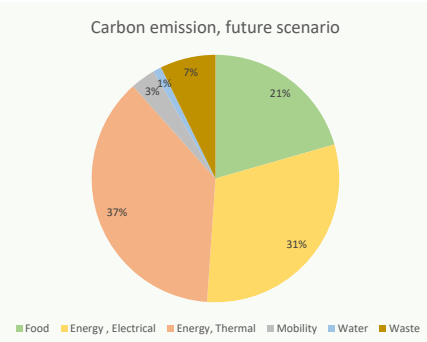
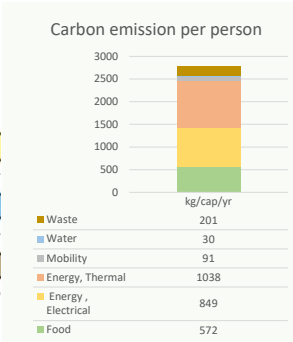
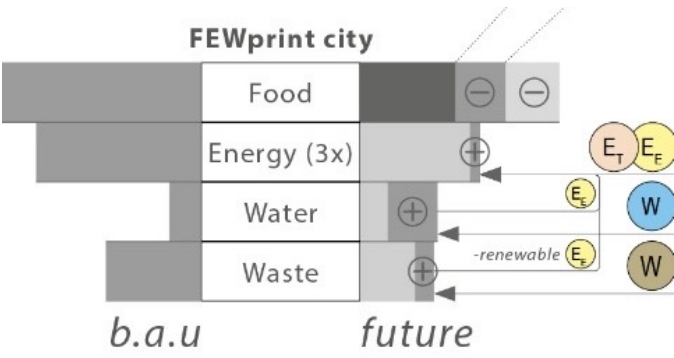
Measuring CO2 reduction by design solutions in food, electricity, thermal, mobility, water, waste as carbon footprint.



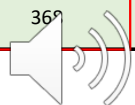
Select pre-set years:
Present, 2030, 2050 or 2080

Scenario comparison:
Status-quo vs. Future scenario

FEWprint:
Calculate shares of CO₂ emission
Where it lies the potential for improvement?



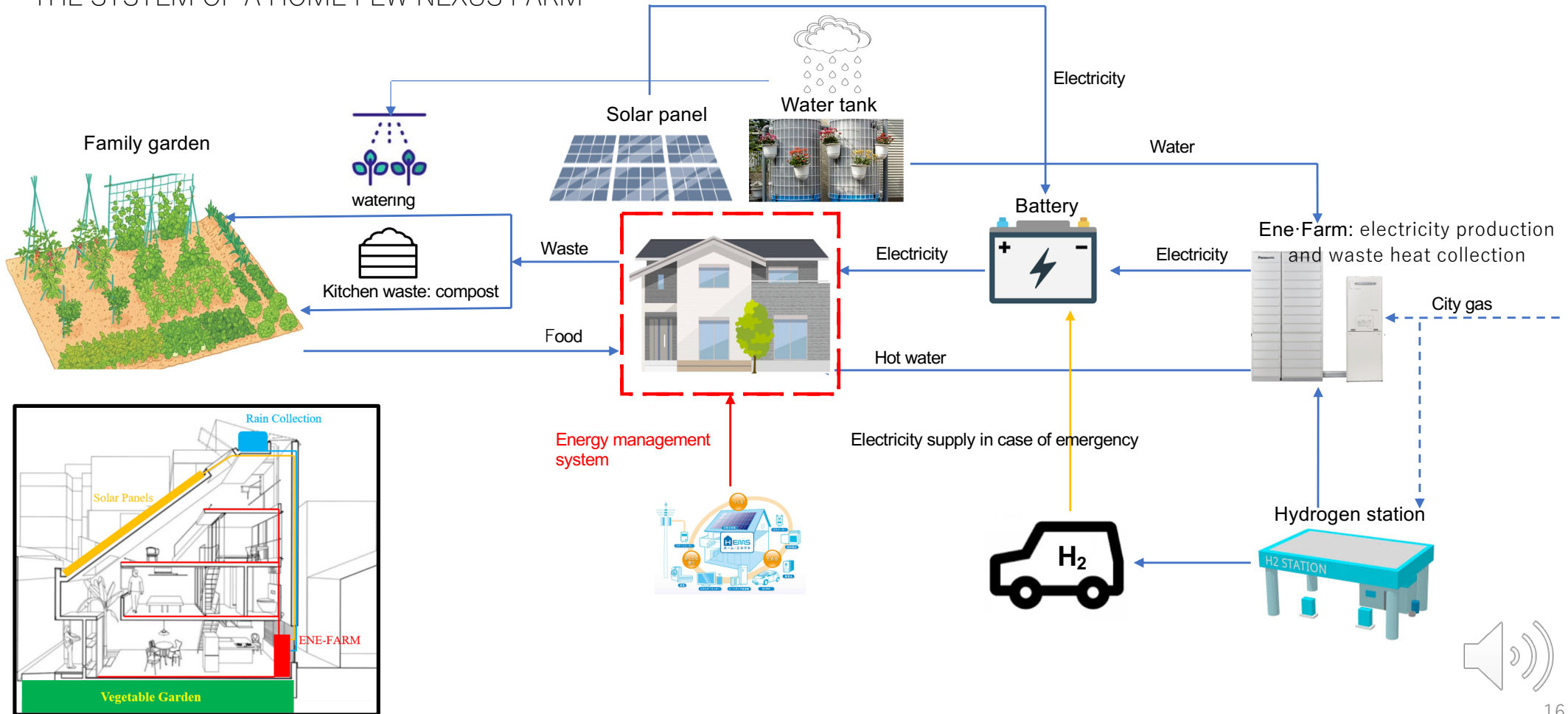
FEWprint		
Food, Energy & Water carbon footprint		
The Netherlands		
Amsterdam		
Amsterdam Kanaleneilanden		
Kattenburg		
Population:		1801
Households:		1001
Future scenario		2030
Business as Usual		Future scenario
<i>ton</i>		<i>ton</i>
1518	Food	1030
1529	Energy, Electrical	1529
1869	Energy, Thermal	1869
163	Mobility	123
55	Water	55
620	Waste	363
5754	Total carbon emission [ton]	4968
-	Difference [ton/yr]	786
3195	Per capita [kg]	2758
100%	Difference [%]	-14%
426	Carbon sequestration [hect]	36
	Forestry - Newly planted	



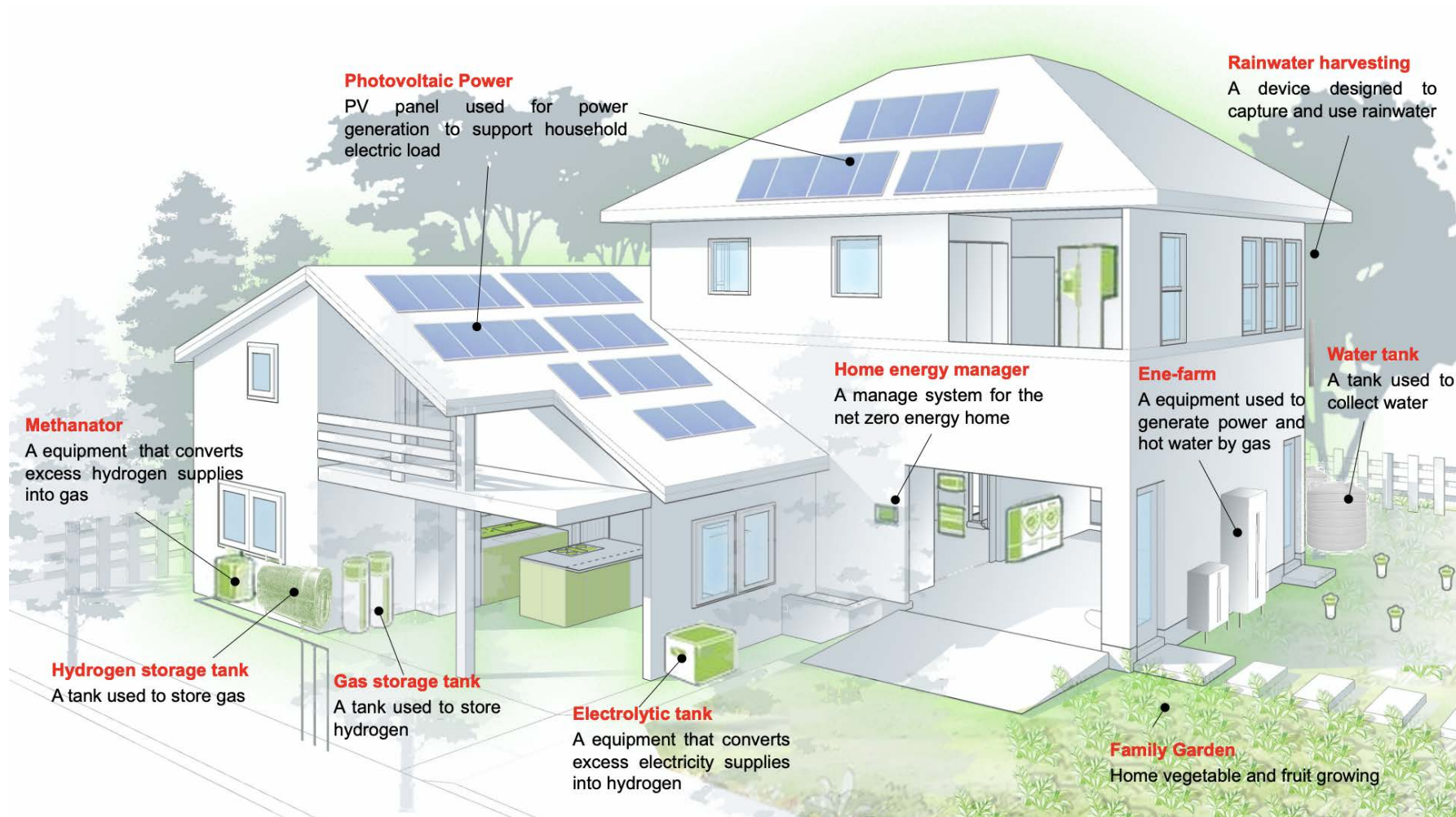
Tokyo Team —FEW Nexus FARM in Suburban, Tokyo

Wanglin Yan, Professor, Keio University

THE SYSTEM OF A HOME FEW NEXUS FARM



A detached house with FEW Nexus FARM



Tokyo Team—FEW Nexus FARM in Suburban, Tokyo

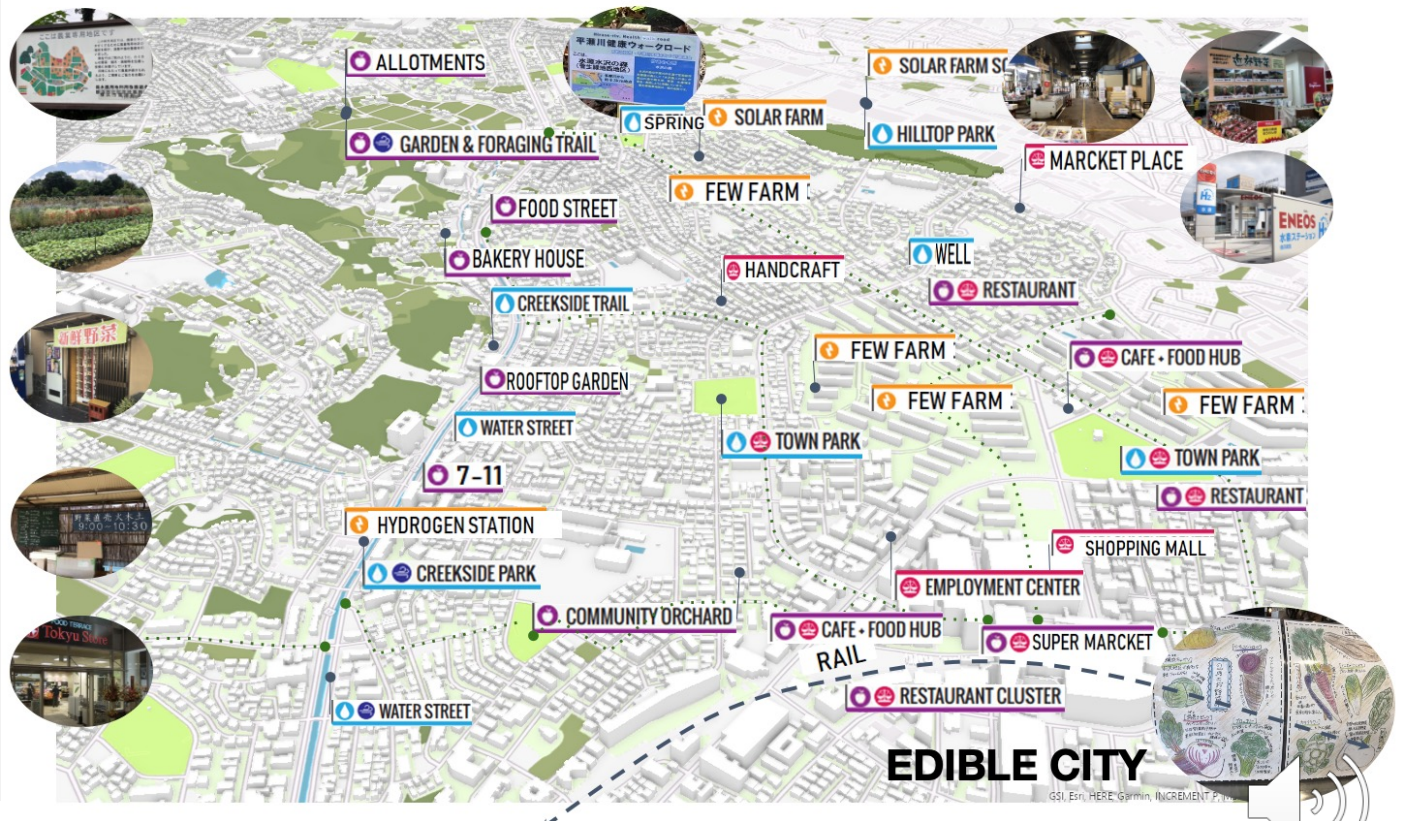
Wanglin Yan, Professor, Keio University

Building

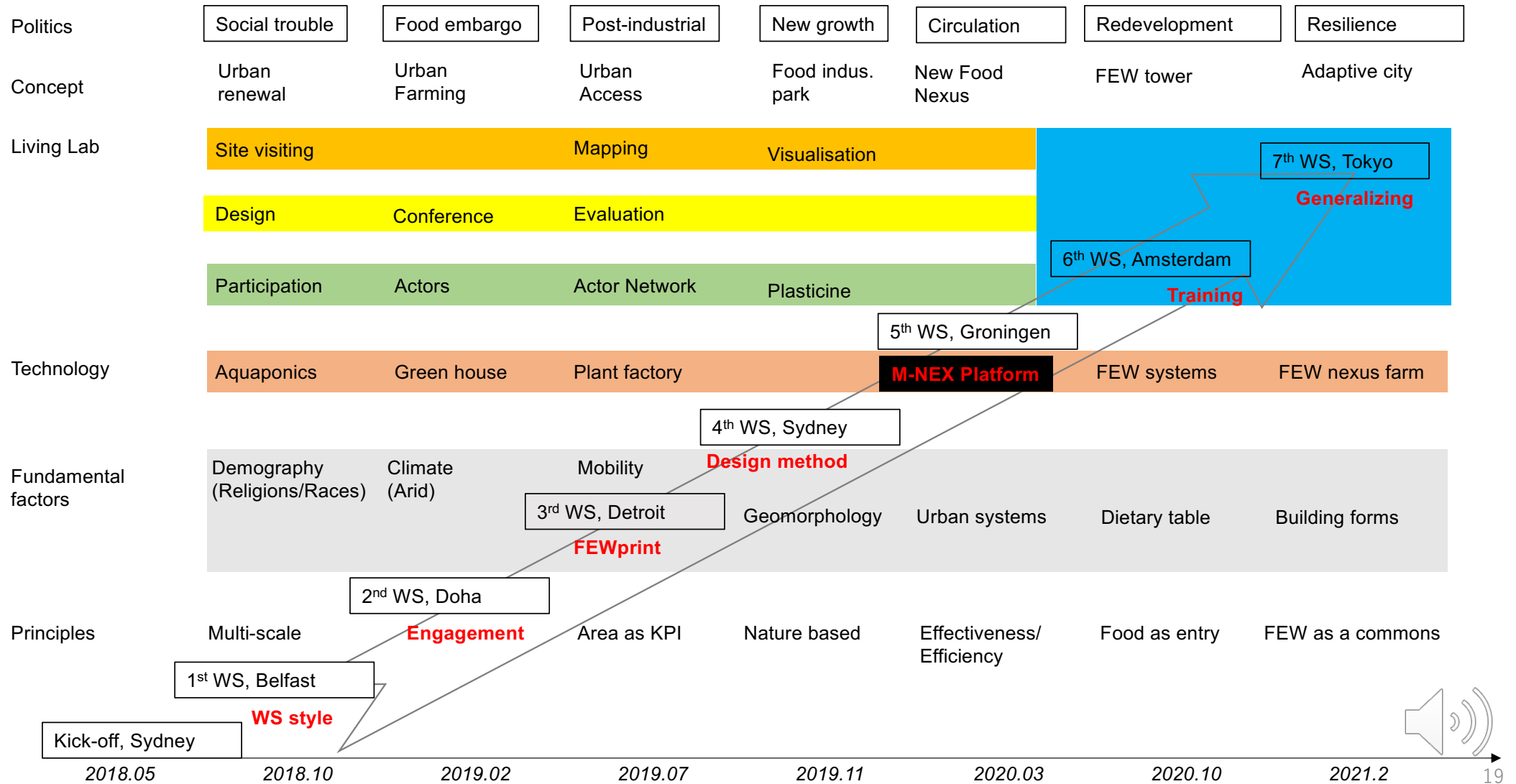
TRANSFORMATIONS OF THE CURRENT CONDITION TOWARDS FEW

	EXISTING TYPES/OPPORTUNITIES	ADD TO THE EXISTING	CREATE NEW
DETACHED HOME			
APARTMENT			
CONDO			
EMPTY LAND			
CONVENIENCE STORE OR OTHER			

Neighborhood

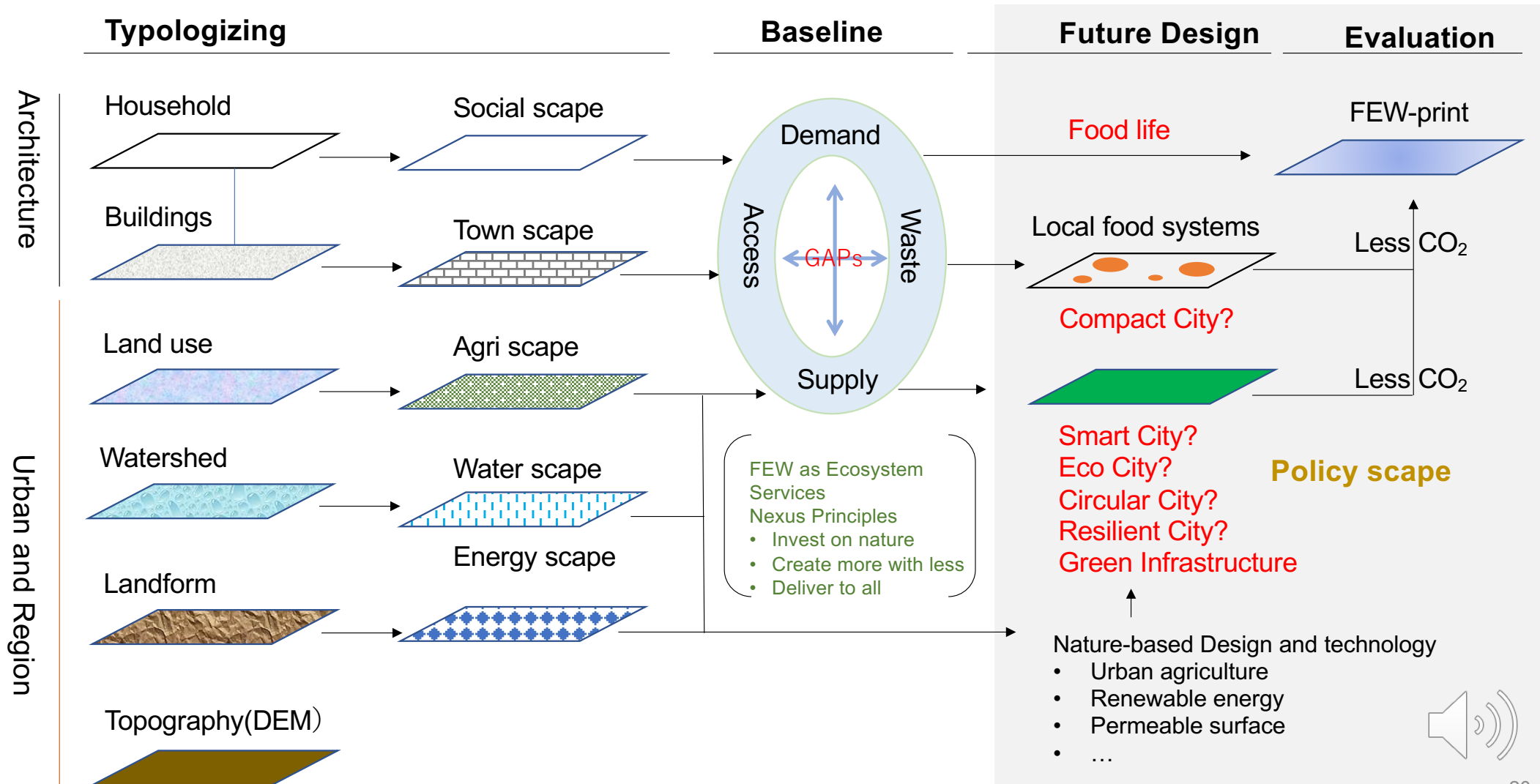


Results: Design as a learning process for the development of M-NEX method

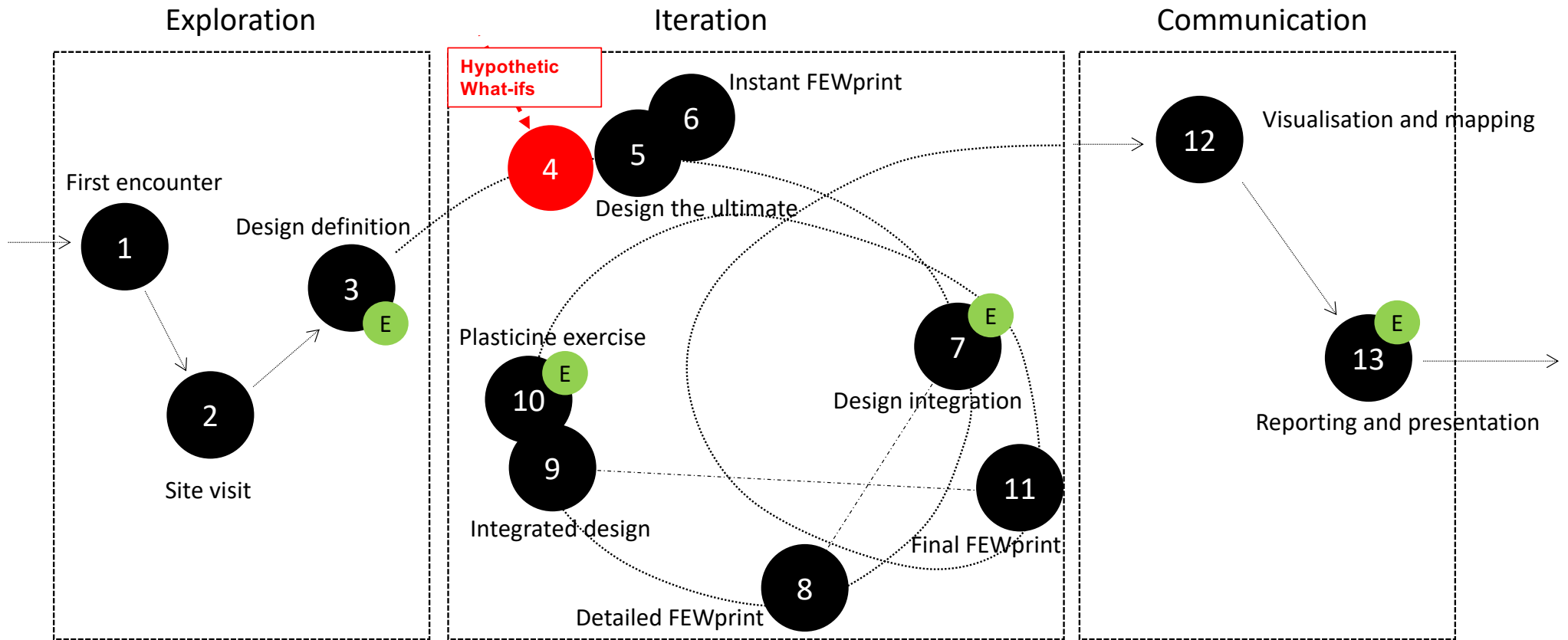


Discussion-1:

Design solution is an integrator to bridge to gaps in supply/demand and access/waste of FEW in cities.



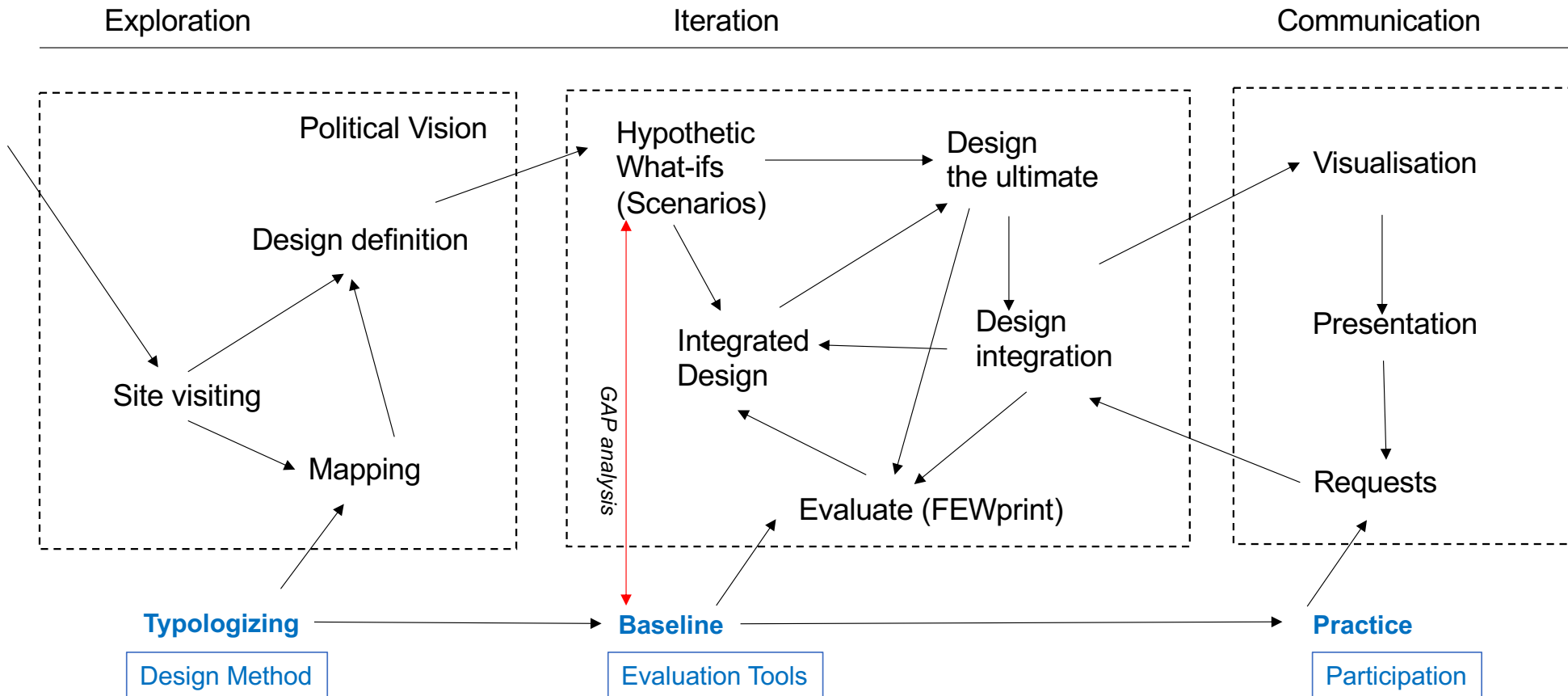
Discussion-2 Design is a non-linear process



The design-led nexus approach can be generalized as the interaction of the three phases.



Discussion-3:
Design must be supported by scientific knowledge and technologies.



M-NEX Platform is developed as design support toolkits



Design Support Platform for Carbon Neutral and Sustainable Cities

M-NEX

through Food-Energy-Water Nexus

1 The Lens of Food (F)-Energy (E)-Water (W)

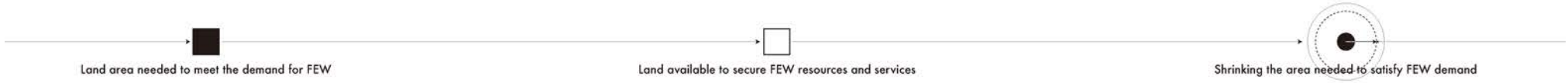
M-NEX is a design support platform considered through the lens of the food-energy-water (FEW) nexus and aimed towards achieving SDGs and a carbon neutral society.

2 Food-Energy-Water and the Reduction of CO2

Urban area occupies 70% of CO2 emission globally while FEW takes 60% in all of sectors, in which 80% comes from domestic consumptions.

3 Transformation to A Circular Economy Through Nexus Thinking

Redesign the efficiency of FEW resources and quality of services by solving the complexity of FEW nexus for circular cities



The FEW print is an index used to analyze the current status of the target area and to evaluate design proposals. It is expressed as the sum of two areas: (1) the land area required to meet the demand for food, energy, and water recharge, and (2) the equivalent area of forest needed to absorb the CO2 emitted in the process of acquiring FEW.

1. Site analysis
2. Understand political goals
3. Define design concept

The process begins with an investigation of conditions including land, buildings, and social structure at the city, neighborhood, and block levels to identify SWOT (strengths, weaknesses, opportunities, and threats) of the area. Based on this information, we launch projects to achieve national and local policy goals and develop design concepts.

City	Case	Concept Design
Japan Team	Edible City	
UK Team	Aquaponic City	
USA Team	Urban Food Security	
Netherlands Team	Redevelopment through FEW	
Qatar Team	Food infrastructure in Arid Cities	
Australia Team	Food Industrial Zone in New Urban Development	

There are two possible productive area sources available to respond to existing and new FEW needs. Land area that is already available, and land that will be created through spatial design and/or through the use of new technologies. The resulting increase or decrease in the area of forest for CO2 absorption will be incorporated into the FEW print.

4. What if and scenarios
5. Design and evaluation
6. Iteration of the design process

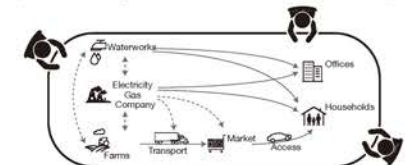
Known trends and unknown risks are identified and adaptation scenarios are devised. Various design proposals are created, and compared by integrating available knowledge and future technologies that can respond to those scenarios at multiple scales. Performance is evaluated by using the key performance indicator, the FEW print.

	Business As Usual	Incremental	Transformative
Building			
Neighborhood			

Shrinking the distance that FEW needs to travel to support a community can be achieved by increasing local production. To make this a reality, players from government, business, and citizens meet in Living Labs to engage in creative solutions and to develop supporting business plans.

7. Engaging players
8. Setting up Living Lab
9. Promotion of Co-design

Living Labs act as a base to discuss design proposals that embody the propositions of the FEW nexus. They are also key to organizing the relationship of each player involved in the supply and demand of FEW in an actor network, quantifying their roles and responsibilities in the FEW print, and visualizing their contribution to SDGs and to carbon neutrality.



TOOL

Intensity Data (statistics, papers)

- Dietary table by age and class
- Electricity, gas, water by building form
- Permeability by land use

Typologizing urban forms in GIS

- Households size, age
- Buildings Structure, built years
- Lands Land use and zoning

FEW print NOW as baseline

TOOL

Technological Innovations with functions and specs

- New energy
- Green infrastructure
- Urban agriculture

Prediction scenarios corresponding to dynamic urban renewal

FEW print NEW as Key Performance Indicator

TOOL

Analysing the connections of actors

Visualizing the commitment of actors to SDGs

Supporting participation with Tangible GIS

Design Support Platform for Carbon Neutral and Sustainable Cities

4

Incremental approach in low-rise suburban residential area

Suburban low-rise residential areas are popular for their spacious living environment, but they are also the center of FEW consumption. We believe that we can significantly reduce the environmental impact of FEW by increasing local production of FEW as homes are updated and remodeled and lifestyles change. The following is a case study of the current status of FEW print and an estimate of the design effects for the Tama Plaza area, Yokohama City.



Legend	Farmland	Protected farmland	Allotment	Special agri-zone	Flat rooftop	Private garden
Area(m ²)	191,455	125,761	10,887	102,775	772,673	2,527,169

Item	Demand	FEW print
Vegetables	9.8 [t/ha/year]	18.5 ha
Electricity	11103.3 [kwh/ha/year]	22.5 ha
Gas	1289.2 [m ³ /ha/year]	0.6 ha
Water	7674.0 [m ³ /ha/year]	

It can be seen from the FEW print that there is a large environmental burden associated with vegetable demand in this region. Therefore, in order to promote an edible city (*), the vegetable production potential of the area was clarified. By improving under-used land, the sufficiency area of vegetable demand in the area can be significantly reduced.

* Edible city refers to a city where residents can revitalize the relationship between food and agriculture and cultivate the land within the city.



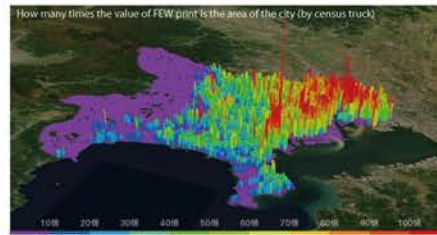
WISE Living Lab, a center for co-creation at Tama Plaza of Yokohama City, is a partner of M-NEX. Together with various stakeholders in the community, we have begun to develop a planned edible community



5

The transformative approach in a high-density developed city center

Densely built areas in urban centers have weak infrastructure, and urban remodeling is promoted due to concerns about disaster risks. FEW print calculations using GIS show the environmental impact of dense urban areas is high. On the other hand, it is also a city loved by people because of its many unique food services. Therefore, we consider the creation of a space where people can enjoy food from the perspective of FEW by incorporating light, water, and greenery into urban redevelopment project. The following is a case study of the redevelopment of the Oimachi area in Shinagawa City, Tokyo.



The planned redevelopment site and the surrounding area will be considered as a whole, and through the restoration of streams and greenways, and introduction of plant factories, and food markets, we will make the city more livable and workable.



Based at the "Future City Lab" run by Keio University SFC Research Institute, we have held international design workshops and proposed urban regeneration that takes advantage of local nature and culture.



M-NEX Int'l Design Workshop(2019.11.10-12)



Int'l Architecture Design Workshop(2019.7.19-22)



Design Support Platform for Carbon Neutral and Sustainable Cities

M-NEX

through the food-energy-water nexus

M-NEX is the acronym of the project "The Moveable Nexus: Design-led Urban Food, Water and Energy Management Innovation in New Boundary Conditions of Change" which is granted by the "Sustainable Urbanisation Global Initiative: Food-Water-Energy Nexus", Belmont Forum during 2018-2021. M-NEX is the developed design support platform with design method, evaluation tool and participatory mechanism through the lens of food-water-energy nexus. The platform has been grown up through a series of international design workshops at the 6 urban living labs including Amsterdam, Belfast, Doha, Detroit, Sydney and Tokyo. For more information, please access to our web site: m-nex.net.

EcoGIS Lab, KEIO UNIV. | M-NEX

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Conclusions

- **Achievements of the M-NEX project:**

- New research style through participatory design workshops at the living labs for the integration of knowledge, technology, and engagement.
- The FEWprint tool to visualize the effect of urban design through the lens of FEW.
- The design support platform M-NEX for iterative process of design, evaluation and communication.

- **Future works**

- Theoretic development for Urban Nexus Science.
- Outreach of the M-NEX platform in urban design practice.



Acknowledgements

- M-NEX is a grant project of the Collaborative Research Area Belmont Forum (No. 11314551) implemented by a consortium of partners from Japan, including Keio University and the Institute for Global Environmental Strategies; Qatar University; University of Michigan; Delft University of Technology; Queens University Belfast, and MacCreaonor Lavington. Local governments, companies and communities were involved in the activities of the national teams.
- We are grateful for JPI Urban Europe to initiate the Sustainable Urbanization Global Initiative—Food-Water-Energy Nexus and make the M-NEX project possible.