Supplemental Material

For 'Evaluating Urban Metabolism Assessment Methods and Knowledge Transfer between Scientists and Practitioners: a Combined Framework for supporting Practice-Relevant Research'

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Figure S1. Simplified structure of the methodological framework used for the development of the BRIDGE DSS (adapted from Gonzáles et al., 2013).

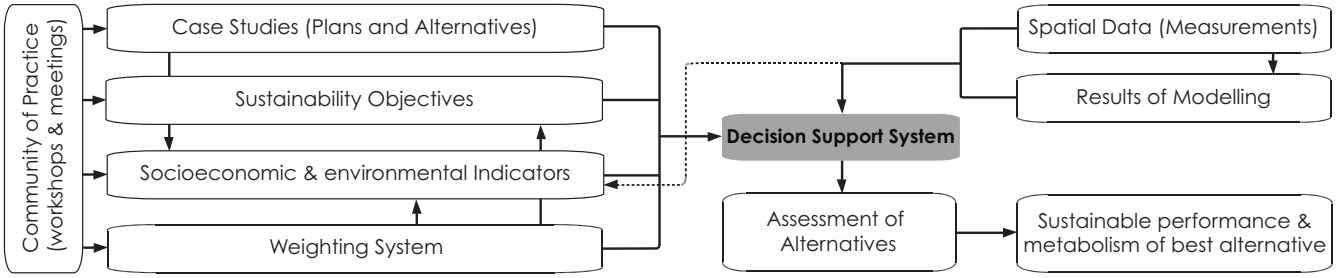


Figure S2. Flow diagram of the BRIDGE methodology (adapted from Chrysoulakis et al., 2013).

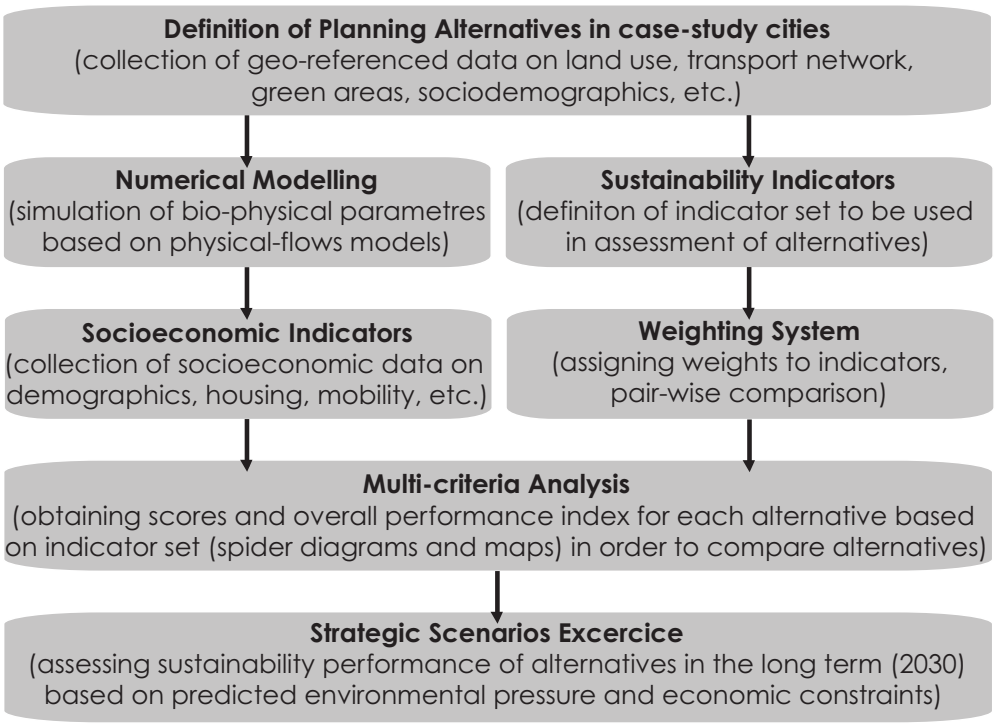


Table S1. Environmental and socioeconomic objectives and associated indicators selected for Helsinki during the 2nd CoP meeting in Helsinki, 20/01/2010 (adapted from Nikinmaa and Vesala, 2010).

	Sustainability objectives	Indicators
Environmental	Optimize Energy Consumption	- Energy demand (electricity consumption per dwelling) - Energy balance in buildings (energy for heating) - Percentage of energy from renewable sources
	Protect the Water Balance	- Water balance (surface run-off, evapotranspiration, infiltration)
	Improve Air Quality	- Concentration of pollutants (ozone, particulate matter) - Greenhouse gases and CO_2 emissions per capita - Emissions from transport type (private and public)
	Enhance Human Well-being	- Density of developments (inhabitants/m^2) - Population exposure to air pollution
	Anticipating climate change	- Carbon intake (removal of carbon sinks) - Reuse of materials (e.g. soils) - Number of zero-carbon buildings
Socioeconomic	Housing Demand	- Number and type of dwellings - Population growth - Demand for housing types - Percentage of owned and rented dwellings
	Social Inclusion	- Access to housing - Social classes and ethnical groups - Age groups of residents - Number of family households
	Accessibility (transport and connectivity)	- Travel time to work - Use of public transport
	Services/Infrastructure	*no discussion on related indicators in CoP meetings*
	Amenity/Recreation	"
	Cost/Benefits of Planning Intervention	"

Table S2. Final set of environmental and socioeconomic indicators applied across the five cities, including discretional indicators (city-specific) (adapted from Breil et al., 2010).

	Domain/Sector	Indicators
Environmental	Energy	- Energy demand for cooling and heating - Anthropogenic heat - Bowen ratio - Percentage of energy from renewable sources
	Thermal comfort	- Thermal comfort index - Air temperature - Number of days above air temperature threshold
	Water	- Water demand - Evapotranspiration - Infiltration - Surface run-off - Potential flood risk
	Greenhouse gases	- Emissions (CO2, CH4)
	Air quality	- Concentrations (NOx, PM10, PM2.5, O3, CO, SO2) - Excedances (NOx, PM10, O3, SO2) - Potential population exposure (NOx, PM10, O3, SO2)
Socioeconomic	Land use	- New urbanized areas - Brownfields re-used - Density of development
	Mobility/accessibility	- Quality of pedestrian paths - Length of cycle paths - Length of new roads - Percentage of use of public transport - Number of inhabitants with access to public transport
	Social inclusion	- Number of inhabitants with access to services (*discretionary*) - Number of inhabitants with access to social housing (*discretionary*)
	Human well-being	- Number of inhabitants affected by flash flooding (*discretionary*) - Number of inhabitants affected by heat waves and air pollution (*discretionary*)
	Other economic	- Cost of proposed development - Effects on local economy (employment) - Effects on local economy (revenue)

Table S3. Description of the three scenarios used in BRIDGE. LOW/HIGH refer to the level of concern for the three aspects considered in each scenario (climate, energy, and economy). Assumptions on environmental conditions are based on the Intergovernmental Panel on Climate Change scenarios A2, A1F1 and B1 (adapted from Castro et al., 2010).

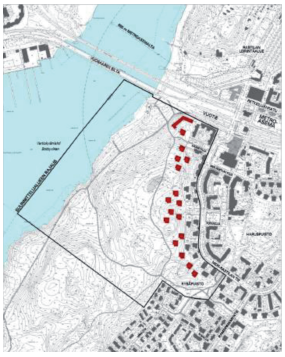
Scenario number and name	"The world in 2030" Overview	Climate change	Energy/technological development	Economy
1. '*BRIDGE in Wonderland'* Cities' success depends on their ability to attract qualified people/firms	- Gradual transition to renewable energy sources - Energy is used efficiently - Fossil energy are used as cleanly as possible - Low levels of climate change - Society is socially balanced - Economy is highly productive	LOW	LOW	LOW
2. '*Climate change is a burning issue'* Cities' success depends on their capacity to face climate change	- Energy availability is not a big problem - Economy is growing - Climate change is a serious threat - Greenhouse gases emissions need to be cut - Greenhouse gases already in the atmosphere need to be cut	HIGH	LOW	LOW
3. '*Lack of energy is freezing the economy'* Cities' success depends on low cost solutions/measures	- Non-renewable sources are reaching an end - Renewable sources are insufficient - Urban concentration is increasing due to reduced mobility - Resources for consumption (e.g. food) are reduced, since resources are mainly used to increase renewable energy generation - Social inequality is increasing due to unequal access to resources	LOW	HIGH	HIGH

Table S4. Secondary sources used in the research per category; document type, source, details and description of documents in each category.

Secondary source category	Type & source	Details & description (see article reference list and additional references below)
1. Scientific literature published by consortium at the end of BRIDGE	Journal articles and conference papers sourced via Scopus (Boolean search: BRIDGE full title in output's title, abstract or keywords)	Four journal articles: Mitraka et al., 2014; Chrysoulakis et al., 2013; González et al., 2013; Borrego et al., 2011 Three conference papers, only one accessible: San José et al., 2013
	BRIDGE book on full set of results: Chrysoulakis et al., 2015	Examples of use of chapters: Conceptual underpinnings and global approach: Chrysoulakis, 2015 CoP approach and self-evaluation of knowledge transfer: Klostermann et al., 2015 Selection of indicators, weighting system and integration in DSS: Breil & Gonzales, 2015; González et al., 2015; Mitraka et al., 2015 Strategic scenarios exercise: Marques et al., 2015
2. Grey literature produced by consortium during BRIDGE	52 documents sourced from BRIDGE website http://www.bridge-fp7.eu/ (last accessed 8 January 2019)	Deliverables of the nine work packages Yearly BRIDGE newsletters Reports of the two Helsinki CoP meetings (June 2009, January 2010) Reports of umbrella CoP meetings (May 2010, December 2010, May 2011) Presentations' slides from final seminar (October 2011)
	Additional documents shared by interviewees to exemplify statements	Internal working documents, presentations' slides, minutes of internal meetings in-between CoP meetings and outside official schedule.
3. Policy documents by Helsinki City Planning Department	Component Master Plan of Meri-Rastila Länsiranta. Source: https://www.hel.fi/kaupunkiymparisto; https://kartta.hel.fi/ (last accessed 8 January 2019)	Land Use Master Plan at neighborhood level in Finnish planning system. Drafted in 2009, submitted for public consultation in 2010, updated in 2012/13
	Environmental Impact Assessment of Component Master Plan of Meri-Rastila Länsiranta. Source: https://www.hel.fi/kaupunkiymparisto; https://kartta.hel.fi/	Drafted in 2009, updated in 2012/13
	Strategic Local Land Use Plan for Vuosaari, 2014. Source: https://www.hel.fi/kaupunkiymparisto https://kartta.hel.fi/	Land use guidelines document at district level. Approved in 2014

	New Helsinki City Plan 'Vision 2050'. Source: http://www.yleiskaava.fi/en/	Strategic Vision for the city of Helsinki. Drafted in 2013/14, submitted to public consultation in 2015, adopted at the end of 2016.
	New Helsinki Land Use Master Plan (included in the above). Source: http://www.yleiskaava.fi/en/ (last accessed 8 January 2019)	Land Use Plan at the city level (see above)

Figure S3. The three planning alternatives in Meri-Rastila Länsiranta as described in the report of the 2nd Helsinki CoP Meeting (adapted from Nikinmaa and Vesala, 2010).



Planning Alternative 1 (default case)

5-storey apartment buildings

500 residents

Minimal impact on green spaces and nature

Little effect on the character of Meri-Rastila

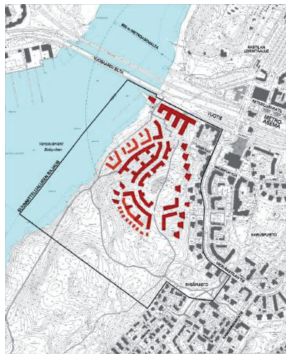
'More of the same'/minimal impact alternative

Planning Alternative 2

Compact layout
Buildings in the wood and at hedge of existing blocks

5-storey apartments buildings and
2-storey row houses
1,500 residents

Hilltop built / slope unbuilt
No connection to sea
No real improvement for the area
Stand-alone buildings in forest and no connection to exiting buildings



Planning Alternative 3

Housing by the sea (sea views) and various residential building types

1,800 residents

Residential buildings around the hilltop all the way down to the waterfront

1,000 office spaces

Some public services: primary school, day-care centre
The sea view allows increasing profitability of buildings

Additional references for Supplemental Material (not included in article reference list).

Borrego C, Cascão P, Lopes M et al. (2011) Impact of urban planning alternatives on air quality: URBAIR model application. WIT Transactions on Ecology&Environment 147: 13-24.

Breil M, Mysiak J, González A et al. (2010) BRIDGE Deliverable "Indicators Definition Report" Deliverable n. D.5.3, Issue 1.0, 30 November 2010. Available at: http://www.bridge-fp7.eu/ (accessed 8 January 2019).

Castro E, Marques M, Wolf J et al. (2010) BRIDGE Deliverable "Strategic Scenario Analysis" Deliverable n. D.7.1, Issue 1.0, 28 December 2010. Available at: http://www.bridge-fp7.eu/ (accessed 8 January 2019).

Chrysoulakis N, de Castro E and Moors E (eds.) (2015) Understanding Urban Metabolism. A tool for Urban Planning. New York: Routledge

González A, Jones M & Donnelly A (2013) The BRIDGE impact assessment framework. In Chrysoulakis N, de Castro E and Moors E (eds.) Understanding Urban Metabolism. A tool for Urban Planning. New York: Routledge, 163-174.

Mitraka Z, Diamantakis E & Chrysoulakis N (2015) The BRIDGE Decision Support System. In Chrysoulakis N, de Castro E and Moors E (eds.) Understanding Urban Metabolism. A tool for Urban Planning. New York: Routledge, 175-184.

San José R, Pérez JL and González RM (2013) Using WRF/UCM and CMAQ mesoscale models with very high resolution over European urban cities. Fresenius Environmental Bulletin 22(12c): 3815-3822.

Table S5: Clusters of questions used in the interview protocol, examples of questions within each cluster, and representative Practitioners' (P) and Scientists' (S) quotes. Key findings (in-text Table 2) were extrapolated from the Practitioners and Scientists' quotes.

Cluster of questions	Examples of questions	Representative quotes from which key findings were extrapolated
1. Roles of Practitioners and Scientists in the BRIDGE knowledge-transfer process, relations between participants, and effectiveness of the process	• In which stages of the study of Meri-Rastila/of BRIDGE in general did you take part? • What was your role in the selection of the set of indicators used to assess the planning alternatives? • How would you describe the relations between practitioners at the City of Helsinki and scientists at the University of Helsinki who took part in the study? Did any conflict of interest emerge during the research (for example when selecting the indicators)? • Did the difference in background have any influence, for example, in the discussion on the selection of the indicators? • In which step of the project was the knowledge from planners most useful for achieving the project goal? • If any, was planners' lack of knowledge on specific UM aspects an issue in the study?	*P1: 'The indicators were decided by the scientists at the University and then we agreed on them. We had no conflict of interests with the scientists when discussing the indicators. This is because there was no hidden agenda in the Meri-Rastila Master Plan.'* *P2: 'During BRIDGE we had good conversations and functional connections with the Finnish partners at the University, especially on the idea of urban metabolism and how we should learn more about these fluxes. There was a good transfer of knowledge with biologists, geographers and other physical scientists.'* *P2: 'There was a general consensus on the criteria that needed to be assessed, but not a general consensus on the indicators and on the weights to be attributed to them. This was due to the limited technical knowledge of planners on environmental indicators and also to different political orientations in each city studied in BRIDGE.'* *P3: 'The transfer of knowledge was difficult to some extent, as there were huge knowledge gaps. For the planners, for example, in understanding the complexity of all the factors involved in the analysis, and their implications in strategic planning at the city scale. It would have been better to perform a step-by-step analysis, translating complex issues in simple steps, for the practitioners to be able to adopt the methodology in their work. This is due to the education of planners in Finland. Most of them receive an architectural education and are not always trained to deal with more complex issues at the city scale.'* *P4: In terms of my role in BRIDGE, I was more passive in BRIDGE than I am in the project of another eco-efficiency assessment tool specific for Helsinki we are developing at the Department. I think this tool is more useful and easy to use for planners, as this is based on a spreadsheet to calculate the ecological efficiency of planning options.'* *P4: 'When I started working on BRIDGE I didn't expect any impacts from it on the planning process. I didn't have any clear idea of what the desired outputs from this project could be.'* *P4: 'It is important to talk about knowledge transfer in the education of planners who have an architecture background. I am not aware of the situation now, but when I was educated, the study of urban*

planning was quite limited. Sustainability at the city scale was not a main focus. The designer's education doesn't' support this kind of vision, and you need additional education when you start working on this, for example on carbon footprint analysis that can produce very useful results for planning.'

S1: 'We had a general discussion on the list of indicators, and we tried to build it in a cross-disciplinary way. We tried to build the list together with the other stakeholders involved and talking together with all the different disciplines; we had to make sure we shared a general understanding with each other. But at the end, there is a natural division between scientists from different areas.'

S1: 'I had no experience in working with planners before BRIDGE. So this was quite a new area for me. But the project was too short. I had the impression that once we started to go deeper into the business we were already at the end of the process. I think the process of knowledge transfer was not the best possible. It was more about grey knowledge transfer and more time is needed for this. Planners may not be always familiar with these socioeconomic indicators and are too busy. In some cases, they are not really interested in "academic" things. The problem can be lack of interest or probably lack of time rather than lack of knowledge.'

S2: 'The knowledge from planners was most useful later in the project, and it was important to learn how to communicate with them. This was for me one of the most important added valued at the end of the project. This allowed me to focus more on urban planning in my work, to raise awareness of locale climate conditions and learn how to communicate with city planners.'

S2: 'There was a different way of thinking between social scientists and environmental scientists regarding the set of indicators that should have been used in our framework, but the presence of social scientists in the Helsinki team was quite limited. There were more social scientists in the whole BRIDGE consortium.'

S2: 'From my perspective, there was no conflict of interest between scientists and planners. Although I, as other scientists, can see evidence that for example maintaining green infrastructure is essential in a city, we understand that building is important from a planning perspective and accept that the densification is a process that may be needed in a city.'

S3: 'The collaboration with the planners at the City of Helsinki was great; there were some very open-minded people, ready to accept new things. We had long days of discussions and no discrepancies; we could reach a good agreement on the direction in which the project should go, the intermediation between noise, nature conservation, marketing opportunities, etc. Scientists do not have a

view on what should be done in the city; we only think in terms of numbers and leave it for decision makers.'

S4: 'From my perspective, it was interesting to put together considerations on urban density, social mix in one area (links between different social classes) and needs for social housing, and link these considerations with the urban metabolism idea.'

S5: 'Before the cooperation started, it was not easy to 'sell' the project to the City of Helsinki and to get people together, even if I had worked with them before in other projects. It was not easy to make clear to them what was the main idea and purpose of BRIDGE, how the entire consortium would have worked, and what value this could bring to their practice. When we got the whole picture with the indicators and case studies, it was easier. The planners found interesting the idea to do research on Helsinki, in general, even if they did not have an understanding of some aspects of the research; in general it was unclear to them what the project was all about.'

S5: 'Within the group of scientists, we had different viewpoints on the sense of an urban metabolism analysis and the choice of indicators, depending on the academic fields we were in, if environmental or social scientists. There were no conflicts among us, however. The number of social scientists in the Helsinki team was limited, and the group was predominantly made of environmental scientists.'

S5: 'Initially, exchanges among meteorologists and forest scientists were more frequent and clear, but there was not much discussion all together on the indicators. The idea was later on discussed together and we found out some interesting links, and I could then start a real cooperation with the other scientists.'

S6: 'The environmental indicators were decided by environmental scientists, based on the costs and technical issues, and the measurement apparatus that was available on other two sites. Data were adapted to Meri-Rastila. I didn't have a clear understanding of all the topics, for example how to evaluate the CO_2 emission, or the ability of plants to absorb water, flooding and air quality. This was quite far from my field of studies and I didn't have the time to go deeper in these questions as I only participated in the early stages of the project. For the socioeconomic indicators, we operated an 'ad hoc' collection of indicators, starting from what we had and then selecting the most useful and interesting indicators for the study goals. Social scientists had a minor role in the choice of indicators, while planners had a role but only later.'

S6: 'Obviously there can be conflicts of interest between social and environmental scientists and planners. City planners develop the city, and this can be based on the assumption "the more the best"; they plan square meters. They have a broader view and tend to consider

		the whole city frame and densification goals. For example the debate now in Helsinki is on how to attract more inhabitants, so planners need to take into account that in the city there will be more cars than in the past. Planners sometimes give up to understand some local natural values and amenity, important aspects for a more sustainable urban structure. When they adopt a wider approach, they can neglect local features and local potentials. Naturally, seeing some questions like CO_2 emissions at the city level is better. For example to ensure that the CO_2 emissions that are avoided in Meri-Rastila are not shifted to another area of the city. There is a need to look more into trade-off between local benefits and general benefits at the whole city scale. Scientists can help seeing cities more locally, and explore specific questions at the local scale.'
2. Applicability of UM study in urban planning in Meri-Rastila Länsiranta	• Which were the reasons for choosing Meri-Rastila Länsiranta as study area in Helsinki? • What results of the study have informed the follow-up planning process in Meri-Rastila Länsiranta and how? • Did any aspect of the Component Master Plan of the area change following the assessment of the three alternatives?	*P1: 'Meri-Rastila is a very interesting area, because you can assess new buildings against natural values, and it is also located next to a subway station. We hoped to get some results from the assessments, and clear indications if buildings should be built or not there and how, but this didn't happen.'* *P1: 'The area was too small, so it was not suitable to provide a general view on the urban metabolism of Helsinki. It was not clear if and how you could get any meaningful result for the city when you work in such small-scale areas.'* *P2: 'It was interesting to talk about the presence of immigrant population in Meri-Rastila and the need to have more social housing as indicators in the DSS. This is important, as there was a need to re-balance the social structure in Vuosaari. Today we talk a lot about this, but back in 2009 it was not a common topic.'* *P2: 'The results were not precise in the end and so not applicable in planning. As there was almost no difference in the assessments of the three alternatives, it was not clear how the decision on the alternative to be finally adopted in the Master Plan could have benefitted from the use of the BRIDGE tool.'* P3: *'One of the most important aspect of working on Meri-Rastila was the opportunity to include the access to social housing in the analysis. This is a very important indicator.'* P3: *'Because of the presence of the forest and the need to perform an advanced appraisal of the environmental impacts of the new buildings, the time of the planning process was doubled. Democracy also slowed the process down, as the public consultation was particularly difficult in Meri-Rastila. An in-filling solution instead of building on the forest was proposed by the public.'* P4: *'Meri-Rastila was a very interesting area to work on because of the different challenges it faces: to encourage sustainable transport*

means (metro station); the loss of biomass and biotopes due to the building of the housing project on the forested area; the need to raise the land value as the architecture is old and of poor quality, through the creation of additional recreational areas and services in the neighbourhood; the need to change its status of segregated area in the city. 30% of the population speaks another language than Finnish, which is the highest percentage in Helsinki. The new development was designed to rebalance that situation. But for all these aspects, the Plan of Meri-Rastila was problematic in terms of its political acceptance. So BRIDGE didn't make much difference, the situation was difficult enough as it was. But I think that new arguments from the BRIDGE analysis would have helped supporting or rejecting the Master Plan.'

P4: *'It was not possible to use the results of BRIDGE in the Master Plan, because when the results emerged we were already in an advanced stage of the planning process. The public consultation process had already started and a citizens' association had proposed an alternative Master Plan that was compared to the planning alternatives in the City Council's Master Plan. There was also a problem due to change in the team working on the Master Plan at the City Planning Department during BRIDGE. I could only follow the first stages of the project.'*

P6: 'Meri-Rastila is a strategic area for development in Helsinki, there are many challenges to be addressed, like the low architecture quality and poor urban form, there is no proper lighting system in the streets, and the neighbourhood needs new facilities. A problem is also the too low density. The New Plan of Helsinki seeks to increase the density of the whole city and attract new inhabitants. Since the first plan in 2009, and the public consultation with the alternative master plan proposed by a citizen association, the City of Helsinki has decided to develop a special neighbourhood regeneration project in the area with the involvement of the youths, local entrepreneurs with immigrant background and the inhabitants in general. In the new regeneration process we are not taking into consideration the results of BRIDGE at all, as there will be no new buildings built on the forest and waterfront of Meri-Rastila Länsiranta, as the inhabitants strongly opposed this. This will be more an urban in-fill solution in the inner core of Meri-Rastila. This is a similar approach than the alternative master plan proposed by a citizens' association, but there will be much more detailed work than what they did.'

S3: 'Meri-Rastila had a high potential as a case study for the presence of the forest, because of the scientific view on the forest but also for the citizens' opinion and the importance of nature for Finnish people. Social segregation was also a strong argument, which for example had led to the decision of building a metro station there. So traffic and buildings' organization were among the most important aspects to investigate. The considerations about traffic were important to

		understand air and noise pollution. The City of Helsinki proposed to work on Meri-Rastila because of the public controversy about the forest, and for us it was a coherent area to investigate different aspects. The three alternatives were already elaborated and had been already discussed with the public before BRIDGE started.' *S4: 'The public debate on Meri-Rastila was strong, even on newspapers, and there was pressure to start building there and densifying Meri-Rastila. BRIDGE started somehow accidently in this context. We didn't choose the three alternatives; these came from the City, as they were already working on them.'*
3. Strengths and limitations of CoP approach and DSS tool, suggested methodological improvements	• According to your experience, was the CoP approach adopted in BRIDGE an effective way to bridge scientific knowledge of the UM and professional practice? • What were the main limitations of the CoP approach, if any? • Based on your experience, does a tool like the DSS developed in BRIDGE help dealing more adequately with UM analysis in real-world practice? • What were the main limitations of the DSS, if any? • Were there any knowledge prerequisites to use the DSS? • Is there any methodological improvement that you would suggest in order to enhance the effectiveness of the DSS and its applicability in professional practice?	*P1: 'The final meeting we had with the consortium in Brussels was more or less the last time I opened the DSS. This was a trial version of the DSS not the full version. There were also some technical issues, as you needed to have ArcGIS installed on your computer to run the tool.'* *P1: 'The main limitation in developing the DSS was that urban metabolism is a very general framework of thinking and try to explain too much at the some time, the whole world, and it tries to challenge the whole planning thinking at once. More limited concrete goals are more useful for planners as these can be used in Action Plans. For example, we develop a special tool to assess the eco-efficiency of buildings and integrate this into the planning process. So, at the beginning, the project sounded better than it was in the end, as it didn't produce targeted results as we wanted, and so it was not really possible to apply those results. It is more interesting to specify one aspect, for example how the CO2 emissions are related to all the different flows, rather than try to explain everything.'* *P1: 'It was difficult to decide some kind of average weighting system for the indicators, as the way you weight the indicators depends on your personal view and orientations, and there is always a political decision to make.'* *P1: 'The most useful tools are those that are easy to use in the implementation phase, with an interface which is as simple as possible.'* *P1: 'The CoP idea was very interesting as it provided the opportunity to discuss with people from different fields of expertise. But one of the main problems in BRIDGE, as in other projects, is time commitment. We receive many requests from the academic field to work together on collaborative projects but we don't have the time to engage in every project.'* *P2: 'BRIDGE as a tool was not that much of use because the scope was too broad, too many criteria were considered in the analysis, and it was difficult to use the weighting system. The weights that are attributed to the criteria should be checked every year for update, as*

they depend on political orientations and technological progress that change fast. For example, CO_2 emissions can be an important factor today, but if in the future more electric cars will be used, this factor won't be as important as now.'

P2: 'It was also very difficult to understand the scenarios and what was the point to put the scenarios in the tool. It would be more useful to assess the situation as it is at the moment of the analysis, but in a more precise way.'

P2: 'Staff at the Department are trained to use environmental assessment tools, but sometimes we are too busy to do this.'

P3: 'More qualitative spatial analysis would have benefitted the development of the DSS tool, for example more understanding of the relationship between land ownership, social housing and other required land uses.'

P4: 'It takes time and efforts to develop indicator tools that can distinguish situations enough to make a difference between alternatives. The results were very similar for the three alternatives, so I think the DSS tool was not sensitive enough. The choice of indicators and their values should depend on the level of the Plan. If, as for Meri-Rastila Länsiranta, this is a Component Master Plan, then the indicators need to be very specific, so that these can be useful when the plan regulation is very strict (in Strategic Plans the regulation is looser). So there should be a different assessment tool for each stage of the planning system.'

P5: 'I think that tools like the DSS should be used to develop urban plans from the beginning, in order to propose and design a better option, and not to compare existing alternatives as they are, and select one of them.'

P5: 'There is an issue with the weighting of the indicators. Who decides which factors should be more worth considering than others, and on what basis? It is always difficult to compare how different factors may harm the environment and people's health. For example between energy consumption and water consumption, is it better to save 1 kWh of electricity or 1 cl of water? Is the emission of 1 unit of CO2 harming more people's health than wasting 1 cl of water? Assumptions on how to compare such factors are difficult and tricky to make. The person who is using the tool will think about the factor that he considers as the most important. This decision can be influenced by the background of the person. For example, architects would all prioritise the same variable (energy), and will look at the results of the analysis in the same way.'

P5: 'In an assessment tool, the evolution of one factor over time is not always considered. For example energy consumption can vary over

time, and be different in 20 or 30 years. It is important to establish projections for example over 30 years.'

S1: 'The measurements were not made at the level of Meri-Rastila, because of the limited budget. So I feel it was more about "playing". The modelling we did could not answer the questions made for Meri-Rastila, as there was not enough money for the project, and I felt I had lost quite many things.'

S1: 'The CoP was a good idea, and the meetings held in Helsinki were promising. But it was not so easy to work things out and the project ended too quickly.'

S4: 'Such CoP approaches may work well. But for planners to be able to use these methods and tools, they must be involved since early stages of the project. In BRIDGE they were involved in the early stages of the analytical part and in the discussions about criteria to evaluate planning alternatives. Time and money invested in the project are the main limitations. But also schedules. There is a need to plan well in advance and to consider the timescale of planning processes.'

S5: 'A tool to assess planning alternatives based on the urban metabolism concept is a very valuable idea for urban planning. Even if I come from a different background, I have had previous experience in working on environmental questions and collaborative projects. With BRIDGE, it was interesting to bring together socioeconomic data with meteorological data. But the initial expectations were somehow higher than the results we had in the end.'

S5: 'For me, the main purpose of a DSS tool should be to empower decision makers and planners for a more complete view on basic processes in the urban metabolism. I am more in favour of this approach than providing "ready-made" analyses that are communicated to them in a simple, usable way, and which they can apply in the decision-making process. Simple tools can be more 'dangerous' as can be misleading. It is important also to differentiate if we are looking into a qualitative or a quantitative assessment. It is important that whoever develops the tool have an understanding of the practitioners' field. Practitioners cannot produce information from raw data. So it is important to understand what is the "final information" that is needed by the practitioners and be clear that the practitioners will tend to use the same tool in very different situations. This approach to the development of tools is of course much more time consuming.'

S6: 'The CoP approach was very relevant to BRIDGE, and I think this should be a very natural thing to do in urban studies in general. In the case of BRIDGE, the way the CoP was organized was different. Normally the initiative comes from the Cities, as for example in some

		urban studies networks in Finland, but in BRIDGE the initiatives came from the scientists. The first to be involved were the environmental scientists and then they contacted the social scientists.' *S6: 'It might have been useful to have more depth in socio-economic analysis. Based on my overall experience, there is a problem with behaviour assumptions that both environmental scientists and planners make, most of them have an architectural education. These assumptions are too simple, people behaviour is a quite complex issue to understand and simple assumptions are to be challenged. This sort of assessment may benefit from more in-depth analysis on socioeconomic indicators. This is my impression based on my research in general. I have worked and still work with planners at the City Planning Department, but I cannot say if this was the case in BRIDGE, as I didn't follow the whole evolution of the project.'*
4. General appraisal of the project, added value and shortcomings of the BRIDGE approach	• What is in your view the most significant added value/shortcoming of the knowledge-transfer approach used in BRIDGE, with regards to your own research/practice? (for example, compared to other projects involving collaboration between scientists and practitioners in which you participated before/after BRIDGE) • Did you have any contact with the other involved stakeholders at the end BRIDGE? • Did you hear of any further application of the DSS after BRIDGE? • *Only for practitioners:* Based on your direct experience in BRIDGE, and/or similar projects, is there any specific suggestions you can provide to make UM assessment methods more relevant to your own daily practice?	*P1: 'The real value of BRIDGE was that this was the first time we talked explicitly about urban metabolism at the Department. This is a very interesting concept. However it is too broad and the way this was assessed in BRIDGE included too many aspects to produce some practical results that can be used in planning. The idea of considering different environmental aspects like storm water management and energy efficiency is very valuable, but it is not cleat how these aspects can be assessed together because sometimes they are in competition. We always include storm water and wastewater management, and generation of renewable energy from solar panels in our planning at the level of Detailed Master Plans and in the City Plan. So the topics we addressed in BRIDGE were not new for us. It is already very difficult to assess all the environmental indicators together, and if you add also social indicators, this makes things even more difficult. It is not possible to also assess the social impacts of the planning alternatives in the same analysis, even if it is clear that social aspects have an impact on the urban metabolism. These should be assessed separately as they involve many different complex mechanisms and variables.'* *P2: 'Assessment tools in general need to be easy to use, but at the same time provide results that are very reliable and precise, so they are easy to apply in our work. The most useful thing is that planners have a checklist to consider while working on their planning options. It is not easy to change the current way we work, and plus today the use of tools is not compulsory so they must be really easy to use!'* *P2: 'For BRIDGE my feeling is that it was not very important that the figures were not precise, as the main benefit was bringing people together and create opportunities to interact with scientists and other professionals in the other cities. We had good general discussions about the issues that we had to take care of, and about the difference among cities, but it was not clear how to translate this in a complex tool.'*

P3: 'Public participation was an important aspect in this planning process, but the feedback received on the three alternatives during the public consultation process was not included in the analysis done in BRIDGE.'

P4: 'Time is a key issue in planning. Is important that DSS tools are designed to be used in initial stages of the design, when you have to assess the preliminary alternatives, and not to be used to only 'polish the design'. Major decisions are made in early planning stages.'

P4: 'A DSS should be simple enough to be used by planners, or designers or architects (who have no expertise in this), as it is not a scientist who is going to use it. The quality and scale of the data you have to input in your tool depend on the phase you are working on. If you only have to assess a final plan, as in BRIDGE, it is just a question of doing some alterations. The situation of course is very different if you are working in a preliminary phase.'

P4: 'When planning and designing you need to engage with a continuous assessment of your design. Normally, you make decision based on your individual view or the one of your group of people. It is important to receive feedback from multi-professional groups, including biologists, landscape architects, planners, architects, etc. The continuous assessment of experts on the way you are planning and designing is important. They can see and assess impacts based on their own experience, which is different from yours.'

S1: 'I think the most important added value of BRIDGE was the production of new scientific knowledge, and the idea of finding the best possible combination among different aspects of the urban metabolism by working in an interdisciplinary way. BRIDGE gave the opportunity to do hands-on experience especially to young scientists in the Helsinki team, and to get them in contact with international colleagues and with new areas of study in international urban contexts. I realize this is a science-oriented answer, as I refer to the scientific part of the project, not to the application in planning. I don't know if the DSS was used afterwards; if yes, I would say that this is the most interesting aspect of BRIDGE.'

S2: 'I think the planners didn't have a clear sense of what were the recommendations emerging from the use of the DSS and felt they didn't get a real straightforward answer to their problems in Meri-Restila. This is also because the results of the DSS depended much on the weight that was given to each indicator. The case study in Helsinki was easier than in other cities. It was clear in Meri-Rastila that there was not much to gain in building the alternatives with more density, as shown by the little difference between the assessment results. In this sense, the City Council probably didn't benefit much from the project.'

S2: 'The aims of BRIDGE were very ambitious, with all the indicators to be considered in the analysis, and four years is a relatively short time to do this. Also the budget was limited. So we couldn't do measurements in Meri Rastila but we used measurements from other sites to do the modelling. If more money were available and some extra years I would do this again. For example I am now working on another project that involves collaboration with urban planners, but the scope of this project is more limited that BRIDGE, and it concentrates on fewer aspects and indicators.'

S2: 'I had contacts with some of the stakeholders involved in BRIDGE at the end of the project to work on the book that was published on the results of BRIDGE.'

S4: 'I am not aware of any use made afterwards of the BRIDGE results as my work was and is quite disconnected from the focus of that project. I took quite soon a different direction in my work, so I didn't follow the project outcomes.'

S5: 'There was one main challenge in BRIDGE. The understanding of the urban environment as a system, as a whole, where urban metabolism occurs. This is different from the way we carry out our analyses everyday, when every person is specialized in one field: housing, transportation, meteorology, etc. etc…To do this, it was essential that each one of us put the research finding in an understandable form. Of course, the more partners you have the more difficult it is to find a clear frame for the project. Case studies are very useful in this respect. They bring big theoretical pictures in a controllable environment. The second main challenge in BRIDGE was that we all had different research cultures, coming from different fields, which is excellent, but we didn't have many opportunities to cooperate. Even if we wished to do more meetings and discussion, we had to deal with our own daily jobs. The value of urban metabolism is that it is a question that, to be addressed, needs putting different people together.'

S5: 'I think, overall, BRIDGE had a great potential because of the many different interesting research questions it brought to the table. In my view, planners and decision-makers will be more and more in need of feeding their work with research knowledge, both of quantitative and qualitative nature. They will need to have a more evidence-based approach in their work, because of the increasing urban challenges ahead. In that sense, it was good that BRIDGE was about linking research and practice. With the huge urbanization process Finland will go though in the next few years, urban metabolism knowledge will be required at the regional level, or even at a larger scale, and down to housing. Now in Finland the discussion is pretty much on the land use, so the urban metabolism thinking is not really there. For example it will be interesting to apply this system view at different scales. What does it mean thinking in terms of urban

metabolism at the scale of regions, city-regions, one city, or a part of a city? What consequences the fact of thinking in different scales will have on the way we consider and assess the urban metabolism?'

S6: 'At the local level, it is very good to combine different approaches and to bring different backgrounds together. But I am sceptical about resources and time to put in such wide projects. Planners do not have time to engage in such long-lasting projects, and often they are involved in more than one project at the same time. Outcomes are determined based on political goals, and how much research projects and their processes can change things is a question of time and politics.'

S6: 'There is a clear dilemma on how simple the results must be to be ready for use by planners vs not losing the complexity of the picture and oversimplifying the results of the analysis. If the goal is to implement some of these sustainable urban metabolism strategies in the planning process, then it is important to produce a DSS that can calculate main factors and can be integrated with other tools for spatial analysis planners use to make their plans. So the information should not be simplified but ready to be introduced in other systems that the planners already use. For example, improving features they already use in their normal working tools, and understand at what spatial resolution the information should be provided to improve one specific feature (how many square meters are enough?). They don't have time for longer processes.'

S6: 'When you take into account a broad range of factors (socioeconomic and environmental indicators), the problem is that you always lose something on the one hand, and gain something on the other hand. Social issues may be in contrast with sustainability and they are not always compatible as presented in the current discourse. For example a higher life standard for all citizens may involve more pressure on natural resources. Unfortunately, these aspects and tradeoffs are not always considered. I do not study environmental issues but am interested in the link between environmental sustainability and social factors. I am not sure urban metabolism frameworks are helpful to understand that link.'