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CONCLUSIONS

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The urban metabolism approach by BRIDGE

This book aimed at presenting the work and the impacts of the Framework Programme 7 (FP7) funded project BRIDGE, focusing on its main outcomes: the definition and assessment of urban metabolism based on energy, water, carbon and pollutant fluxes and the development of a spatial Decision Support System (DSS) for sustainable urban planning, which takes account of urban metabolism.

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Chapter 1 gave a broad introduction to urban metabolism, and the urban metabolism from micrometeorological and urban climate perspective was presented in Chapter 4. The framework of decision support tools in urban planning was described in Chapter 2. As was discussed in detail in Chapter 3, most urban metabolism studies to date use coarse, or highly aggregated data (i.e. top-down approach), often at the city or regional level, that provide a snapshot of resource or energy use, and that can't be correlated with specific locations, activities or people. The inputs and outputs of food, water, energy and pollutants have been studied across multiple cities and at the scale of the individual city. An alternative approach is the 'disaggregated approach' (i.e. bottom-up approach), which involves detailed data (or initially disaggregated data) being used; for example scaling up from individual properties to a neighbourhood. By relating the spatially explicit flows with the relevant census data and human activities, the inputs and the associated outputs generated can be assessed. Significant progress has been made in tracking energy and material flows at the building scale. The challenge ahead is to design sustainable neighbourhoods and cities by directly influencing their urban metabolism processes.

As presented in Chapter 3, the main objective of the BRIDGE bottom-up approach was to provide a structured assessment of urban metabolism processes (restricted to energy, water, carbon and air pollutants) in different planning alternatives, as well as to provide methods for comparative analysis, ranking and selection, in support of urban planning decisions. Chapter 3 also described the BRIDGE case studies, located in five selected cities in different European regions: Helsinki, Athens, London, Firenze and Gliwice. A part of each city that needed intervention and 'real life' planning alternatives was identified and discussed.

The Community of Practice (CoP) participatory approach that was used to facilitate the interaction between urban planners and BRIDGE scientists, as well as to support the collection of socio-economic data, was described in Chapters 12 and 13. To evaluate specific bio-physical models in BRIDGE case studies, *in situ* (Chapter 5) and remote sensing (Chapter 6) observations were performed. These measurements included standard meteorological data and direct observations of the fluxes of energy, water, carbon dioxide (CO_2) and air pollutants using the Eddy Covariance approach. The major modelling effort in BRIDGE presented several challenges, as described in Chapter 7: the need to downscale the model results to a scale relevant for urban planning; the need to connect models for different environmental components, such as energy, CO_2 and water; the need to respect the constraints in computing time and to ensure the validity of model outputs; and the need to provide comparable reference outputs for the planning alternatives in all case studies in the same time frame. Models ranging from meso-scale air quality to urban canopy models were combined, using a cascade modelling technique from large to local scale to estimate air pollutants (Chapter 8), energy (Chapter 9), water (Chapter 10) and carbon fluxes (Chapter 11). To determine the future distribution of city-wide land uses, a cellular automata model was used to account for the broader effects of planning decisions.

Chapters 14 and 15 presented in detail the Multi-Criteria Analysis (MCA) approach that was used to address the complexity of urban metabolism issues reflected in a wide set of sustainability indicators, most of them developed in the framework of the project. In the framework of BRIDGE, the MCA enabled comparison of planning alternatives, through the structured prioritization of a nested set of variables, concerning specific components of urban metabolism: sustainability objectives, criteria and indicators, defined for energy, water, carbon and air pollutant fluxes as well as for socio-economic variables relevant for the plans under evaluation. It also enabled the weights and scores for all indicators to be combined into a total assessment index, providing a basis to rank urban planning alternatives.

The DSS that was developed in BRIDGE, based on Geographical Information Systems (GIS), was presented in Chapter 16. More specifically, Chapter 16 described in detail how the DSS can lead the end-user through specific steps to produce: indicators maps for each planning alternative; spider diagrams that show the comparative performance of each planning alternative for each sustainability objective; and a total assessment index for each alternative. The use of the BRIDGE methodology and the DSS to evaluate different planning alternatives in the framework of different future strategic scenarios was discussed in Chapter 17. Finally, Chapter 18, presented guidelines for sustainable urban development that were derived in the framework of the project.

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Improving urban planning: the BRIDGE impact

The main impacts of BRIDGE can be divided into three different categories. At the level of impacts on society, it redefined the urban planning exercise to focus on citizens' quality of life through the improvement of environmental quality and reduction of socio-economic costs related to current urban structure and its development. At the level of improved understanding, it brought together different scientific disciplines providing different forms of analysing cross-European variation of physical environments and socio-economic conditions and linking human aspirations and urban design to material and energy fluxes. At the level of information flows, it developed the means of communicating multidisciplinary research findings to urban planning practices and, conversely, communicating real planning problems to research focusing on urban issues, providing therefore the means to close the gap between bio-physical sciences and urban planning and illustrating the advantages of accounting for urban metabolism in planning.

A strategic approach to a sustainable community urban plan involves the redesign of local and regional legislative and political structures and needs to be based on community participation and support. BRIDGE contributed to the formalization of sustainability objectives and provided practical tools for reaching them. Thus, it supported the development of sustainable planning strategies seeking an optimal fit between the urban area and its environment through the creation of a long-term vision, goals and strategies for the allocation of resources and monitoring impacts, as well as detailed action plans. This requires sustained cooperation and exchange of information between different expert groups, which was most effectively accomplished within BRIDGE with the creation of a controlled framework, which forced experts to communicate.

The impact assessment model developed and applied in BRIDGE is based on decision-making theory and impact assessment principles promoting a participative, systematic and coherent approach. The combined integration of environmental, urban metabolism and socio-economic considerations and parameters in the DSS facilitated a comprehensive and holistic approach to sustainability assessment, applicable to varied urban and planning contexts. Furthermore, although it is widely recognized that traditional urban planning models and approaches have contributed to the present environmental situation, it is also clear that addressing environmental issues at city level will not be possible without taking into account climate change. BRIDGE enabled the evaluation of urban planning alternatives in the future scenarios' context by allowing modifications of sustainability objectives and indicators conditional to specific future climate scenarios and then by generating quantitative outcomes for each scenario.

The European Commission's Thematic Strategy on the sustainable use of natural resources highlights the importance of using natural resources in an efficient way, which reduces environmental impacts. The Directive under the Thematic Strategy on the prevention and recycling of waste clarifies the obligation for European Union (EU) Member States to draw up waste prevention programmes at the most appropriate geographical level. The Thematic Strategy on air pollution was developed with the objective of attaining levels of air quality that do not give rise to significant negative impacts on, and risks to, human health and the environment. The urban metabolism approach proposed by BRIDGE is expected to substantially support the implementation of the Thematic Strategies and the related Directives. This is possible because the spatial DSS developed has the potential to interlink the different scales of analysis, from regional to site level, facilitating the comprehension of the underlying mechanisms that drive environmental problems in cities, which in turn can benefit from a site level perspective and thus support the identification of priorities for policy intervention at the city and regional level.

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In a framework of sustainable urban planning, actions are needed to adopt an integrated urban metabolism approach and inter-disciplinary research and innovation in developing innovative strategies for waste prevention and management. The DSS can be adapted in order to address aspects not covered within the scope of the project with the main requirement being input of available data. The BRIDGE approach can be extended to highlight how city typologies, drivers and lifestyles can influence urban metabolism, through socio-economic analysis, and highlight the possible benefits to be derived from ecosystems services and green infrastructure. It can be also extended to support science-based decision making and planning for waste management and land use as an integral part of urban development, promoting eco-innovative urban management and re-naturing cities, thus enhancing both the environmental resilience of urban areas and quality of life.

BRIDGE enabled comparisons of the effects of different planning alternatives on physical flows of urban metabolism aspects. The evaluation of the performance of each alternative was done in a participatory way. This interactive process allowed the end-user to gain an understanding of the relative importance of each sustainability objective and indicator. The combined performance and relative importance of indicators were used to rank planning alternatives and the DSS was used to assist the end-users to select objectives and indicators and to define their relative importance. A tool like the BRIDGE DSS may not simplify the urban planning process, but it can help urban planners to deal more adequately with its complexity. Although implementation of the DSS during planning processes may be constrained by lack of resources and skills at municipalities, practitioners can gain significant insight for more informed decision making. The approach could seamlessly be integrated through a proactive attitude towards sustainability and basic upgrading of both planning staff and private sector consultancy skills in municipalities (e.g. GIS and DSS capacity building).

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