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COMMUNITY OF PRACTICE APPROACH TO DEVELOPING URBAN SUSTAINABILITY INDICATORS

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In the urban context the quest to enhance economic growth and social well-being is challenged by the need to protect and manage natural resources. In order to promote sustainable urban planning, sustainability objectives are commonly embedded into planning policies, and the associated indicators used to evaluate planning interventions and monitor implementation of such objectives. The applicability of indicators is commonly

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tied in to their ability to address context-specific issues and monitor progress towards definite goals set at the local level. This paper presents the findings of a participative methodology applied in five European cities to develop a set of sustainability indicators with the aim of optimising their applicability for assessing planning alternatives affecting urban metabolism (i.e. the exchange of materials and energy within cities). The results indicate that engagement of researchers and practitioners through Communities of Practice (CoP) helped bridge the gap between science and practice, and facilitated the selection of consistent and meaningful indicators to be used as a tool for decision-making. However, the results also revealed that planning priorities can significantly shape the extent and scope of sustainability indicators, and that a CoP approach may not always be sufficient to guarantee continuity of collaboration.

Keywords: Communities of practice; indicators; sustainability; urban planning.

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Introduction

Sustainable development strives to meet current human needs through adequate and prudent use of local and global natural resources; and ensuring that such resources and the carrying capacity of natural ecosystems is maintained to support future generations (UNWCED, 1987). Increasing support for environmental conservation (Leiserowitz *et al.*, 2005) and behavioural changes relating to environmental concerns (Rogerson *et al.*, 2009) are driving the integration of environmental protection with social issues and economic development (the three pillars of sustainable development) in political agendas. Achieving sustainability partly depends on societal behaviour, but also on the suitable provision of urban infrastructure and services (Karvounis, 2009). In this context, the critical role of urban planning lies in the protection and improvement of urban environments, through the appropriate delivery and management of land, water, energy, transport, and waste, while at the same time safeguarding biodiversity, water and air quality, in addition to promoting economic prosperity, social equality and human well-being for current and future generations. The integration of all these considerations, taking account of the limitations set by the physical and economic characteristics of a given plan or project, is often a complex and challenging task. It is argued that sustainability is difficult to achieve particularly in the urban context (Rees and Wackernagel, 1996). Nevertheless, as the majority of the world population lives in urban areas, the assessment, monitoring and mitigation of effects on natural resources due to new or changing urban environments are regularly used as tools in urban planning to ensure more sustainable living.

Several approaches have been developed to provide systematic and comprehensive methods for supporting sustainable urban planning. Sustainability appraisal (UKP, 2004), impact assessment at plan, programme and project level (CEC, 1997, 1985, 2001), and additional specific legal instruments for the protection of natural resources (e.g. CEC, 1992, 2000, 2007, 2008), represent critical drivers in the incorporation of sustainability considerations into urban planning. Addressing such legislative requirements has significantly shaped planning processes; which, as a result, need to evaluate the environmental viability of proposed planning interventions and monitor implementation to ensure that any potential negative impacts are avoided, mitigated or remedied.

Impact assessment processes are facilitated by the development of indicators which help evaluate and monitor progress towards established sustainability objectives or officially set targets/thresholds. In the quest to achieve sustainability, several indicator sets have been made available to monitor environmental, social and economic sustainability (e.g. AI, 2003; EEA, 2005; Bardos *et al.*, 2009). Among these, the core set of environmental indicators developed at European level (Smeets and Weterings, 1999; EEA, 2005) and the European common indicators set (AI, 2003), which focuses on urban sustainability, are of particular importance given the monitoring procedures put in place, the wealth of data collected, and the shared practices, experiences and knowledge accumulated in accounting for urban sustainability. The advantage of referring to indicators from existing consolidated sets derives from the consistent and periodically available measurements, as well as from cross-national comparability — valuable aspects which are normally not provided by ad-hoc indicator sets. In contrast, ad-hoc indicators have the potential to measure more precisely and more accurately address the problem at hand than established "generic" indicators. This dichotomy between generic and case-specific indicator sets represents a common problem when addressing sustainability at the local level. This is apparent from the more specific national indicator sets that followed European initiatives, which were adapted to priority policies, objectives and targets (e.g. EPA, 2008; DEFRA, 2009; FNCSD, 2009). These considerations become more critical when defining a practical tool which is applicable to different urban contexts and decision making processes. In all cases, selected indicators need to be representative of the problem at hand and yet straightforward enough to be effectively measured and easily understood.

Alberti (1996) noted that there is no single definition for sustainability equally applicable to all urbanised areas; therefore, it can be argued that there is no single set of sustainability indicators applicable to all urban environments. The composition of indicator sets and the relative importance given to each indicator are context-specific and need to be formulated to address the planning framework: focusing on relevant environmental and socio-economic priorities and issues, providing an adequate level of detail for the assessment, ensuring measurability

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within set time-frames and existing resources, and effectively informing decision-making (Nicholson and Fryer, 2002; Donnelly *et al.*, 2006a; Rais and Sharma, 2008). In the light of this, it can be argued that the applicability and selection of indicators from established indicators sets largely depends on the scope of the assessment, and that such indicators may need to be complemented with additional case-specific indicators to accurately address the issue/s under consideration.

In the context of urban metabolism, indicators relate through complex physical, chemical and biological interactions that represent a common structure which assures a high degree of transferability. Significant progress has been made in exploring and defining these interactions, and several numerical models have been developed to define the linkages between indicators (e.g. Borrego *et al.*, 2003; San José *et al.*, 2006; Rodriguez *et al.*, 2008; Wang *et al.*, 2008; Grimmond *et al.*, 2009). The integration of these models enables examination of the urban metabolism concept (i.e. the description and analysis of the flows of the materials and energy within cities). This integration is being pursued by the EU-funded FP7 project BRIDGE (sustainaBle uRban plannIng Decision support accountinG for urban mEtabolism), which aims to evaluate the sustainability of urban planning alternatives, mainly focusing on urban metabolism aspects such as water balance, energy fluxes and air pollutants (Chrysoulakis *et al.*, 2009).

The BRIDGE project aims to provide a standardised method, based on a Decision Support System (DSS) that integrates numerical models of environmental fluxes (e.g. air pollutants) and spatial data within a Geographic Information Systems (GIS) framework. The DSS enables quantification and comparison of environmental and socio-economic indicators between planning alternatives in order to inform decision-making of urban interventions. The DSS is currently being tested in five European cities: Athens (Greece), Firenze (Italy), Gliwice (Poland), Helsinki (Finland) and London (UK). The varying planning systems, geographical extent, and historical, cultural, social and economic characteristics of these five cities provide a spectrum of urban systems, where different development goals are prioritised and different planning strategies are applied to achieve sustainability. The development of the DSS required the integration of a set of indicators to operationalise the tool in order to mediate the assessment. Environmental and socio-economic indicators represent the interface between the sustainability objectives set by the DSS end-user and the underlying spatial data and numerical models, and thereby used to assess planning alternatives (Fig. 1).

Cognisant of the availability of a range of indicators at international and national level, the BRIDGE project opted for the identification of case-specific indicators that were able to address practitioners concerns related to specific planning issues. As the DSS-based assessment of alternatives requires consideration

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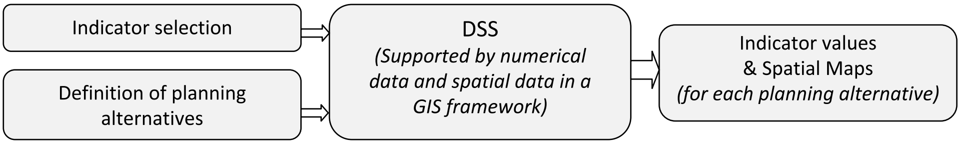

Figure 1. Simplified representation of the process of using the DSS developed in the BRIDGE project.

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of a significant number of environmental and socio-economic criteria, a multi-criteria assessment method based on the Analytical Hierarchical Process (AHP) was applied. The AHP, developed by Saaty (1980), provides a comprehensive and rational framework for structuring a decision problem. The technique entails breaking down the decision problem into a hierarchy of more easily comprehensible sub-problems, each of which can be analysed independently. Therefore, this multi-criteria assessment approach implemented in the DSS requires end-users or decision-makers to define the problem hierarchy by structuring it in tiers, commonly including a generic goal (i.e. urban sustainability in the BRIDGE context) that branches out into associated objectives, criteria and indicators. Subsequently, decision-makers determine the relative importance attributed to each of the parameters (e.g. objectives and indicators) in the problem hierarchy. These hierarchical values are used to assign significance weights to each parameter in the decision problem and, thus, prioritise key issues of concern. The weighting of parameters is left to the discretion of the individual DSS end-user and, therefore, the grounds for establishing such relative values are not examined in this paper.

A participative and semi-structured approach (i.e. guided by a number of questions but with the flexibility to allow new questions to be incorporated based on the context and the feedback of participants) to the development of sustainability indicators was adopted to ensure that indicators were fit for purpose. Such a participative approach was based on the notion of Communities of Practice (CoP). CoP are naturally emerging and self-organised groups of professionals who meet regularly to share experiences and learn from each other (Wenger *et al.*, 2002). In the context of BRIDGE, CoP meetings were organised to bring together researchers and practitioners (e.g. urban planners, architects, environmental experts, decision-makers) with the purpose of reaching a common understanding on sustainable urban development, determining planning priorities to move towards sustainability, and developing indicators in order to evaluate the sustainability of planning interventions. In addition, CoP were to provide insight into what aspects would be important for future BRIDGE DSS end-users, as well as to create a space for broader debate on urban sustainability and a medium for making scientific knowledge available to local practitioners.

Sustainability aspects (i.e. environmental and socio-economic) were an integral part of both the methodology and the CoP debates; however, this paper mainly focuses on the environmental factors of water, energy and air pollutants associated with the key BRIDGE research areas. It presents a methodology applied in five European cities to develop a set of sustainability indicators in close collaboration with local planning professionals. The resulting set of indicators is included in a DSS for use by these local planning authorities to facilitate sustainable planning decisions to be made. In addition, the paper aims to evaluate the effectiveness of employing such participative methodology to select indicators. Special attention is given to the effectiveness of CoP as an underpinning methodological concept.

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Methodological Framework

The methodological framework for the development of objectives and indicators integrated: (a) a driver-pressure-state-impact-response (DPSIR) framework, applied to define the core goal and associated objectives that set the indicators selection structure; (b) the decision-support framework proposed by Donnelly *et al.* (2006b) to filter the information, define criteria and identify potential indicators; and (c) the SMART concept to assure indicators are Specific, Measurable, Achievable, Relevant and Time-bound (Schomaker, 1997), thus applying a set of common criteria to validate and select individual indicators.

The participative process was based on the CoP approach where groups of people come together on the basis of a common interest or concern, to work in a shared learning mode (Wenger *et al.*, 2002). Thereby, CoP membership implies expertise (drawn on practice) and commitment to a specific domain (e.g. urban sustainability). In pursuing their interest in the domain, members regularly engage in joint activities and discussions. Particular attention is paid to interactive knowledge sharing, building relationships that enable them to learn from each other and, as a result, improving understanding and practice in a given topic/sector (Wenger *et al.*, 2002). There is no set of standard rules to establish a CoP as it develops organically (Bouma *et al.*, 2008). However, three basic principles — namely the *domain* (e.g. common interests), the *community* (e.g. networking practitioners) and the *practice* (e.g. methods, activities of CoP members), provide the basis for the creation, development and evaluation of a CoP.

During the period 2009–2010, the CoP members of the BRIDGE case studies came together twice in each city to share experiences in urban planning and discuss sustainability issues. A final Umbrella CoP meeting brought together representatives from each city to exchange ideas and knowledge on urban sustainability across Europe, and jointly develop a common set of indicators for inclusion in the DSS — used to evaluate the sustainability of planning interventions. CoP participants included BRIDGE researchers and local practitioners; efforts were made to gather a similar number of participants from both groups. Practitioners were invited based on the project's domains of interest (e.g. sustainable planning, energy fluxes, water balance and air pollutants). Although the content and structure of the meetings were prepared by the research team, local practitioners also had specific input, contributing their expertise and insights through programmed presentations as well as during the open debate sessions. The scope and objectives of the BRIDGE project focused discussions at these meetings, particularly during the first and second round of CoPs; the meetings concentrated on the development and selection of decision-making criteria in the form of sustainability indicators for the DSS. Nevertheless, during the Umbrella CoP time was allocated to enable participants to freely exchange ideas and voice queries and concerns in relation to urban sustainability, the DSS and the project in general.

Figure 2 illustrates the steps taken, representing the basis of the underlying causal network, and the questions that were used to aid the establishment of sustainability objectives, criteria and indicators during the CoP meetings in each of the cities. The first round of CoPs focused on the planning practices and priorities for the city: discussing drivers, pressures, opportunities and challenges for sustainable urban planning and, based on these perceptions, developing preliminary sustainability objectives and indicators for the city in question. Collated observations were reviewed, and preliminary objectives and indicators were examined at the second round of CoP meetings on the basis of a selected project (and its alternatives) within the city. Subsequently, these objectives and indicators were revisited and scrutinised by BRIDGE researchers to align them with the scope and requirements of the specific planning alternatives in each case study. The resulting indicators were subject to the selection criteria and thus validated by the research team to establish an initial set. This set of indicators was further discussed at the Umbrella CoP meeting where the final set of indicators was agreed for inclusion in the DSS. In order to provide a systematic and comprehensive tool which could be used in different contexts, the urban sustainability indicators agreed and included in the DSS were categorised as core (i.e. common to all contexts) and discretionary (i.e. specific to one or several urban systems).

The DPSIR approach provided a systematic basis for selecting an indicator set based on a domain of interest, as well as framing it within the boundaries of the system object of study. In the case of BRIDGE, the domain of interest was sustainable urban development, and the boundaries were determined by the receptors being analysed (i.e. water, energy and air pollution, and the associated socio-economic considerations). The identification of the drivers and pressures for

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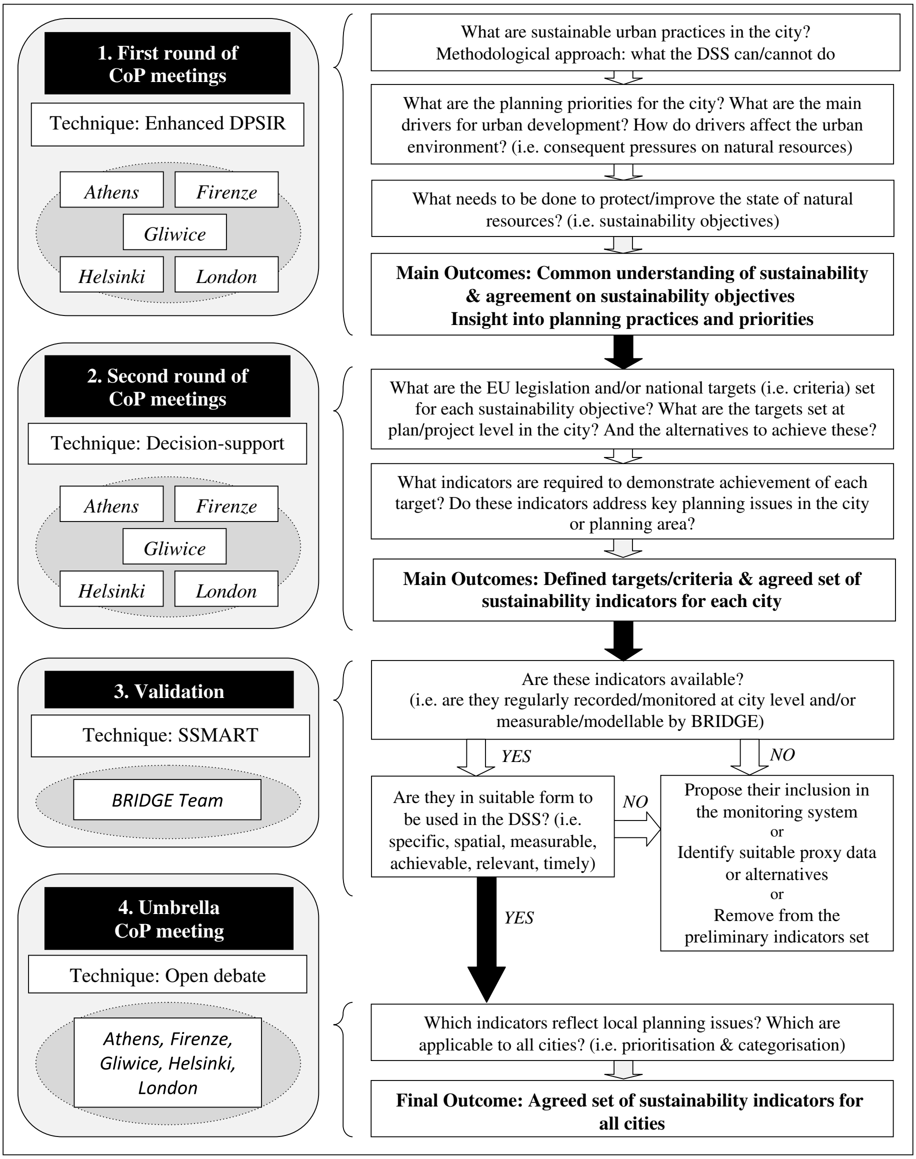

Figure 2. Framework for establishing criteria and indicators through the participatory Communities of Practice process.

each case study determined the aspects to be considered for the definition of assessment criteria. Although the DPSIR approach enables the logical analysis and the subsequent monitoring of complex interactions, it entails the definition and monitoring of indicators for each of its components (e.g. D = quantity of energy consumed; P = volume of greenhouse gases produced, S = changes in air

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pollutant concentration; I = number of people affected; R = % of energy from renewable sources) and can produce quite complex and onerous causal diagrams. Consequently, a more simplified and practical methodology was applied, limiting the indicators to those relating to state and impacts, which facilitated the process and encouraged practitioners to devise specific indicators suited to their particular urban and planning contexts.

Once the core objectives were established through the DPSIR process, the potential impacts associated with the drivers and pressures were addressed for each receptor, to determine whether or not the particular receptor required further attention. The decision-support methodology proposed by Donnelly *et al.* (2006b) was applied to the environmental and socio-economic receptors for the definition of criteria and indicators. According to the level of policy under discussion in each of the case studies, it was presumed that local partners already had a conceptual framework in mind. This helped them tracing back from pressure or state-indicators to processes to be modified (i.e. objectives) and *vice versa*, facilitating the subsequent definition of criteria and indicators. Therefore, it was anticipated that this systematic and logic-oriented decision framework could help practitioners focus on relevant and significant issues, optimising assessment and monitoring systems (Donnelly *et al.*, 2006b). To assist the definition of sound criteria existing legislation was first addressed, looking at time limits and/or thresholds used as a measure against which impacts could be assessed (e.g. the ambient air quality Directive — CEC, 2008, establishes that a concentration of PM_{10} of 50 $\mu g/m^3$ is not to be exceeded more than 35 times in any calendar year). Based on these, specific indicators were expected to be easy to define and easily understood by participants (e.g. in the light of the air quality Directive, PM_{10} concentration values).

The indicators proposed at the CoP meetings were validated and filtered using the following SSMART selection criteria, based on Schomaker (1997) with added spatial considerations:

- Specific: the indicator is clearly and unambiguously defined.
- Spatial: the indicator links measurements to a location. This was imperative as the DSS is based on GIS and urban planning has strong spatial connotations.
- Measurable: the indicator is quantifiable and measured on a regular basis without entailing excessive cost (i.e. monitoring procedures should be in place or could be planned).
- Achievable: the indicator can be measured, collated or modeled within the project.
- Relevant: the indicator is user-driven and addresses the sustainability objectives and criteria in the specific urban context.

- Time-bound: the indicator can provide information sensitive to change (generated by the planning intervention) in a timely manner within the planning and/or decision-making processes.

The initial step in the validation of the proposed indicators included cross-checking them with existing sustainable development indicator sets at European and national/regional level (e.g. Smeets and Weterings, 1999; AI, 2003; EEA, 2005; DEFRA, 2009; FNCSD, 2009) to ascertain if indicators were appropriately defined, and to verify data availability or measurability. This procedure was particularly valuable for those indicators which could not be modelled within the BRIDGE project. Where an indicator was identified at the CoP but was not measurable/modellable with the available resources, it was still judged to be valid if included in existing indicator sets as it was considered that indicator values were available and thus they could be potentially gathered and assessed. The validated and relevant indicators were presented to key practitioners from all the representative cities and subject to a final review through open debate.

Developing Sustainability Objectives and Indicators: Communities of Practice Results

The first and second round of CoP meetings differed among the five cities in terms of number and background of participants and the thematic aspects covered (Table 1). The number of experts and researchers was larger in the first round of CoPs, ranging from 19 in Firenze to 38 in Athens. The meetings gathered, on average, a similar number of BRIDGE researchers and local practitioners. The majority of practitioners in each city had a link to the relevant local authorities' planning section; several planners, engineers and architects as well as environmental, transport, forestry, energy and water experts (mainly from the public but also from the private sector) attended the meetings. Although the number of participants generally decreased in the second round of CoPs (e.g. 14 in Firenze and 29 in Athens), with the exception of Gliwice where the same number of participants was recorded, the majority of these participants had attended the first meeting. The smaller size of the groups gathered during the second meeting, together with a better understanding of BRIDGE goals by participants, facilitated a more focused discussion. Once the ten CoP meetings were completed (two in each case study), an Umbrella CoP meeting was held, which brought together two representatives from each case study together with 13 BRIDGE researchers.

Each of the CoP meetings was a full day event. A significant amount of time (i.e. approximately half a day) was dedicated in the first round of meetings to

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Table 1. Summary of planning priorities and alternatives considered.

	Planning Priorities & Alternatives	
	1st CoP	2st CoP
ATHENS	Planning priorities at city level: Public transport, air quality, quality of building, energy consumption and thermal discomfort.	Planning alternatives at project level: Re-development of Thivon Avenue and its immediate surroundings using different materials and planting schemes, to address thermal discomfort and to provide green spaces, car-parking and improved urban infrastructure.
FIRENZE	Planning priorities at city level: Transport, air quality, protection of green spaces and energy efficiency.	Planning alternatives at project level: Refurbishment and restoration of Cascine Park with various layouts and planting schemes, to protect its natural and heritage features, enhancing its function as a key amenity area.
GLIWICE	Planning priorities at city level: Transport and mobility, air quality, energy efficiency urban expansion and water management.	Planning alternatives at project level: Provision of new services in the academic district, including alternatives for an access road, a sports hall, a centre for new technologies, and developing all above urban features.
HELSINKI	Planning priorities at city level: Housing, public transport, protection of green spaces and sustainable energy sources.	Planning alternatives at project level: Development around Meri-Rastila Metro station (various layouts, housing types and densities) to provide housing, address social polarization and improve accessibility to nature areas.
LONDON	Planning priorities at city level: Economic development, public transport, provision of green and physical infrastructure and services, and climate change adaptation.	Planning alternatives at project level: Consolidation of the London Central Activity Zone with alternatives to increase green-space, improve air quality, reduce heat-island effect and prevent flash-floods.

setting the city's development context and to get to know each others' perceptions on urban planning practices and sustainability issues. Although time constraints affected the discussion around sustainability objectives, the meeting yielded a clear set of planning priorities to improve urban sustainability (Table 1). Preliminary indicators were briefly discussed; in some cases these preliminary indicators were proposed by BRIDGE researchers based on the established planning priorities and sustainability objectives.

Table 2. Summary of environmental objectives and indicators proposed during the CoP meetings.

	Objectives (1st CoP)	Indicators (2nd CoP)
ATHENS	Improve air quality and reduce emissions	• Concentration of pollutants: NOx, SOx, PM_{10}, $PM_{2.5}$ ($\mu g/m^3$) • CO_2 emissions (tonnes or % of reference value) • Source of emissions (% *per* building/sector type) • Number of days above established air quality thresholds • Effects of meteorological conditions (e.g. temperature) on pollutant concentrations
	Improve energy efficiency	• Energy consumption for lighting the avenue (kWh/m^2) • Percentage of energy from renewable sources such as solar panels (%)
	Reduce thermal discomfort	• Average outdoor air temperature (°C) and humidity (% RH) • Average surface temperature in roads, buildings, etc. (°C) • Wind speed (m/s)
	Optimize water use	• Volume of water used for irrigation (m^3)
FIRENZE	Improve air quality Improve energy efficiency	• Concentration of pollutants: PM_{10}, $PM_{2.5}$, NOx, CO ($\mu g/m^3$) • Urban temperature outdoors — compared to rural temperatures (°C) • Potential renewable energy from the volume of biomass produced (% of total biomass volumen)
GLIWICE	Improve air quality	• Spatial distribution of pollutants: PM_{10}, $PM_{2.5}$, NOx, SOx, CO_2 ($\mu g/m^3$ *per* m^2) • Contribution from single boilers to total pollutant emissions (%) • Relationship between pollutant concentrations and wind direction
	Improve energy efficiency	• Energy demand (kWh/m^2 or % change) • Heating demand (kWh/m^2 or % change) • Percentage and structure of thermo-insulation (%)
	Improve water management	• Urban water supply and use (m^3/capita) • Percentage of wastewater treated and houses connected to WWTP (%) • Flooding zones (location and extent in m^2)
HELSINKI	Improve air quality	• Concentration of pollutants: O_3, PM_{10}, $PM_{2.5}$ ($\mu g/m^3$) • CO_2 and other greenhouse gas emissions (tonnes) • Emissions from transport and split *per* type — private and public (%)
	Optimise energy consumption	• Energy demand — electricity consumption (kWh/m^2) • Energy balance in buildings (i.e. % energy required for heating) • Percentage of energy from renewable sources (%)

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Table 2. (*Continued*)

	Objectives (1st CoP)	Indicators (2nd CoP)
LONDON	Protect water balance	• Water balance: surface run-off, evapotranspiration, and filtration (mm^3/m^2 or m^3/m^2)
	Improve air quality	• Concentrations of pollutants: PM_{10}, $PM_{2.5}$, NOx, NO_2 and O_3 ($\mu g/m^3$) • Number of days above established air quality thresholds
	Decentralize energy generation	• Percentage of energy created (%) • Additional heat generated (W/m^2)
	Mitigate heat islands effect	• Ambient temperature at 1 m above street level (°C) • Number of days above 33°C/per area ("heat waves")
	Reduce flood risk	• Number and extension of flood risk areas (location and extent in m^2).

The results in Table 2 show a correlation among the cities in relation to some of the sustainability objectives identified during the first CoP meetings — note that only urban metabolism aspects (i.e. environmental) are presented in this table. These environmental sustainability objectives were directly linked to the planning priorities previously defined (Table 1). Improving air quality was considered to be one of the key objectives (with particular emphasis in reducing emissions from health-damaging contaminants such as particulate matter), followed by the need to improve energy efficiency (mostly related to the poor insulation and poor energy performance of aging built infrastructure) and to mitigate the effects of climate change (in relation to both temperature increases and flooding events). It is worth noting that water supply and water consumption were rarely viewed as issues during the first round of CoPs. The case studies also highlighted mobility and green space issues, stressing the need to improve such aspects to promote sustainability. These objectives were outside the scope of the project as existing modelling capacities did not allow for the necessary simulations.

During the second round of CoPs, local practitioners provided new and valuable insights with regards to existing and potential issues related to the proposed planning alternatives (Table 1). As a result, the initial sets of indicators were extensively discussed and, in many cases, reshaped according to the specific characteristics of the case study (Table 2); the majority were reconsidered and/or reformulated to fit the context and scale of the assessment, and new indicators were proposed to address anticipated specific changes resulting from the planning interventions. For instance, the implications for the green area in the Firenze case study yielded additional indicators such as number of trees *per* person *per* hectare,

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accessibility to the green area and number of services available *per* person. The regeneration plan for improving thermal comfort in Athens also shaped the discussion with a significant focus on indicators that addressed the type and reflectance of building materials used (i.e. albedo) and the number and type of trees planted. Similarly, the urban development and regeneration alternatives considered as case studies in Helsinki, Gliwice and London, defined the scope of the discussion at these locations. Socio-economic issues were also examined: financial cost of the intervention, land use changes and mobility (associated with key indicators such as urbanised area, increase/decrease in open spaces, road transport intensity and public transport use) were considered to be critical factors in all cities; human well-being and social inclusion (with indicators such as access to housing, number of residents affected by flash-floods or inhabitants affected by air pollution and heat waves) were mainly prioritised in Athens, Helsinki and London.

Despite the differences in the debated issues and the sustainability priorities pursued, all proposed indicators were consistent in that they targeted the most significant considerations — to be assessed and monitored in order to ascertain the success/failure of the planning interventions in question. The results indicate that certain environmental and socio-economic considerations and, therefore, indicators remain common to all the cities (possibly due to the existing correlation between sustainability objectives — Table 2). For instance, key pollutant emissions and concentrations, together with their relative sectoral share, were the main proposed indicators for air quality. Energy consumption and demand, as well as percentage of supply coming from renewable sources, were suggested as indicators to monitor energy performance. Flooding events was the most widely suggested indicator to monitor water balance. Therefore, it could be concluded that despite context-specific considerations (such as differences in seasonal energy consumption rates related to local climate), this set of indicators is indicative of crosscutting urban sustainability issues in all the analysed urban contexts and assessment levels. Accordingly, it could be argued that this set of indicators could potentially be used in urban metabolism assessments for other European cities outside the case studies — particularly those indicators which are also included in EU indicator sets, such as concentration of (acidifying) pollutants, sectoral energy consumption or annual urban average temperature.

Indicators were reviewed based on the SSMART selection criteria and validated by the research team before being presented as a starting point for discussion at the Umbrella CoP. The proposed objectives and indicators were, therefore, subject to a final review by case study representatives. An overview of planning and sustainability considerations in each of the cities was provided at this meeting; the shared understanding of emergent issues facilitated the identification of the common and most critical objectives across all cities. The results correlate with the findings of the first and second CoP meetings (Table 2). This is apparent, for example, in the final set of indicators agreed for the air quality criteria, as improving air quality is a clear sustainability objective for all participant cities. Although some emphasis was given to the correlation between emission dispersion and climatic conditions (e.g. in Gliwice and Athens) or the contribution of certain sectors to GHG emissions (e.g. single boilers in Gliwice and transport in Helsinki), these were context-specific indicators and were, subsequently, removed from the final core set as illustrated in Table 3. Air quality indicators applicable and transferable across all the case studies included concentration of pollutants, GHG emissions and exceedance of air quality thresholds, which highly correlate to those defined for the individual cities.

There was consensus among participants for the incorporation of these core objectives and indicators sets in the DSS, agreeing that these were critical in promoting overall sustainable development. The remaining relevant objectives and indicators were classified as discretionary, not for their lack of significance but

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Table 3. Final set of environmental objectives and indicators agreed at the Umbrella CoP meeting.

Objectives	Indicators
Common Aspects (*Core*)	
Improve air quality	• Concentration of pollutants: PM_{10} and $PM_{2.5}$, O_3, NOx ($\mu g/m^3$)
	• CO_2 and other GHG emissions (tonnes or % of reference value)
	• Number of days above established air quality threshold (days)
Improve energy efficiency	• Energy demand (kWh/m^2)
	• Potential for renewable energy (type of renewable sources)
	• Additional heat generated (W/m^2)
	• Percentage of energy created from renewable sources (%)
Anticipate climate change (Flooding)	• Flooding zones and risk areas (location and extent in m^2)
Optimize water use & Mgmt	• Surface runoff, evapotranspiration and filtration (m^3/m^2 or mm^3/m^2)
	• Water consumption *per* capita (m^3)
City-Specific Aspects (*Discretionary*)	
Increase green space areas	• Density of green areas (m^2/m^2 or % of total)
	• Canopy/green surface or area newly created (m^2)
	• Accessibility to green areas (no. inhabitants within 500 m of green area)
Thermal comfort	• Ambient & surface air temperature (°C)
	• Number of days above established threshold (days)
Optimize materials used	• Volume of material re-used/recycled (m^3 of total)

rather for their city-specific nature. Examples of these include the indicator addressing the city-specific concern in relation to emissions from coal heating proposed in Gliwice and the indicators on social usability of public areas (e.g. number of crimes, distance from residential areas to public open spaces) put forward in Firenze. During the Umbrella CoP, these indicators were deemed not applicable to all urban contexts, but provided valuable information for a given decision-problem and, consequently, were maintained in the final set. The DSS was developed with the flexibility to accommodate additional indicators referring to local criteria and, thus enabled the assessment parameters to be adapted to specific local needs (i.e. the end-user can incorporate additional objectives and indicators).

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Effectiveness of a CoP Approach to the Development of Indicators: Lessons Learnt

A number of advantages and disadvantages of applying the methodological framework through a CoP approach were observed during the case studies. These are examined within the three basic principles of a CoP: domain, community and practice (Table 4).

Contributions to the domain

Scientific and local knowledge sharing and integration have been widely acknowledged to facilitate collaborative learning (e.g. Bouma *et al.*, 2008; Morgan and Matlock, 2008; Letsela *et al.*, 2010). This is commonly the case in CoP, which are practice orientated and, over time, members develop a unique perspective on the domain of interest contributing to improved knowledge, procedures and methods (Wenger *et al.*, 2002). The rationale behind the CoP approach within BRIDGE was the early involvement of practitioners and end-users of the DSS to share knowledge and experiences on sustainable urban development (i.e. the domain of interest) across Europe, with particular emphasis on the understanding and assessment of urban metabolism components. Project researchers, municipal departments and external organisations within each city, as well as among the case studies, interacted and exchanged ideas and expertise on sustainable urban management. The meetings facilitated the exploration of commonalities and divergences between the case study cities, as well as means to improve the sustainability of urban environments and planning interventions. Therefore, the project achieved the target of enhanced understanding and the CoP helped provide the practitioners' perspective to the research team.

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Table 4. Advantages and disadvantages of applying a Communities of Practice approach to the development of sustainability objectives and indicators.

Domain	Community	Practice
Advantages		
Increased insight into urban sustainability issues, and exploration of commonalities and divergences across the case studies.	Opportunity to closely engage stakeholders and DSS end-users from different organizations and build a professional network.	Development of participants' professional capabilities by building and exchanging knowledge and experience.
Improved understanding of urban metabolism and agreement on sustainability objectives and indicators.	Opportunity to bridge the gap between science and practice in the field of sustainable urban planning.	Improved understanding and awareness of the implications of sustainable urban design and planning.
Disadvantages		
Representatives solely from certain sectors and meeting outcomes voiced by a minority, significantly shaping the development of sustainability objectives and indicators.	Participation and interaction based on willingness to contribute; participation based on different reasons and in different ways.	Trying to reconcile the nature of CoP (to explore additional common interests) with strict project requirements.
Interests and priorities of stakeholders not always merging with the scope of BRIDGE objectives.	Limited resources and time within the project restricting further CoP interactions, therefore hindering their full potential and realization of additional benefits.	Lack of monitoring affecting the evaluation of the effects of incorporating newly acquired knowledge/experiences into practice.

The bottom-up approach enabled CoP members to learn from each other and gain insights into sustainable planning issues in their own city, contributing to the development of a shared understanding on sustainability issues across Europe. The identification of specific planning interventions at city level and the agreement reached at the Umbrella CoP meeting on the core and discretionary sustainability objectives and indicators contextualised and prioritised issues. This consistent set facilitated the incorporation of critical considerations into the DSS, enabling the development of a tool that responds to the sustainability objectives and indicators in each city, as well as to the specific needs of end-users.

Nevertheless, a significant disadvantage was in trying to reconcile the nature of CoP and the requirements of a project such as BRIDGE, which had strict deadlines and set outputs. The scope of the project determined the domain of interest.

Moreover, the identified objectives and indicators, were largely shaped by the professional background and personal perceptions of certain case study representatives. The key issues and concerns, in the form of planning priorities, that arose during the first and second CoP meetings confirm this (Table 1); in particular, planning priorities and resulting sustainability objectives were based on those aspects highlighted by the invited speakers (i.e. key CoP participants). It was considered that the limited participation of urban planners represented a notable limitation to the project — given the planning rationale and the end-purpose of the DSS. Similarly, it was considered that the participation of representatives solely from certain sectors resulted in less emphasis being placed on other key considerations (e.g. land contamination, biodiversity, etc.). Therefore, it can be argued that the inclusion of a wider range of practitioners and a more structured participative approach would have increased the effectiveness of the methodology and the meaningfulness of participation, with the potential to render more diverse indicators (albeit constrained by the scope of the project) and obtain the support of a wider group of urban planning professionals on critical aspects of the domain of interest.

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Establishing a community

The application of a CoP approach enabled the creation of a community of professionals interested in urban sustainability issues and facilitated establishing important communication channels between BRIDGE researchers and local practitioners. These communication channels initiated and facilitated the exchange of information among the project team and the practitioners who were potential DSS end-users (i.e. the community), bridging science and practice. Information exchanged between researchers and practitioners outside the CoP meetings mainly related to clarifications on project goals and requirements, the capability of the DSS and the availability of modelled results, in addition to planning structures and current/planned projects for each city. The existence of such communication channels also resulted in increased exchange of information among participants in each city (e.g. transfer of spatial data between local authorities and project partners).

Community interactions were based on each participant's willingness to partake and contribute. Efforts were made to actively involve potential end-users early in the process and, in this way, to increase the usability of the methodological framework and the DSS developed in BRIDGE. Despite such efforts, the meeting outcomes were often voiced by a minority of representatives — as is commonly the case with workshops and other group engagement methods (Connor, 2001; Cooke and Kothari, 2001; Carver, 2003). This difference in the levels of

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participation is considered to be common in CoP as people participate in a community for different reasons and in different ways (Groot *et al.*, 2009). Moreover, it was observed that in each of the case studies, a different culture towards participation exists, as in some cities it was considered more common to interact on an equal basis.

The aforementioned friction between the CoP and project requirements also affected the establishment of a community. CoP are different from other organisational groups such as formal working groups, project teams or informal networks. They are voluntary and self-directed and their purpose is to develop members' professional capabilities by building and exchanging knowledge and experience. Commonly there are no set structures or agendas, and interactions develop naturally and occur based on the interest and willingness of members to do so (van Winkelen, 2009). However, defined commitments and strict deadlines within the BRIDGE project required that key participants (i.e. urban planners, engineers, environmental consultants and decision-makers) were identified and formally invited to the first round of meetings. Therefore, CoP were created by BRIDGE initiative rather than relying on existing groups. Although the open nature of CoP also had implications for the implementation of the methodological framework (due to the common lack of a formal structure and time-constraints), the framework provided semi-structured interactions between participants through open debate and group work. Nevertheless, the limited resources within the project restricted the networking and learning opportunities to two CoP meetings in each city and one generic Umbrella meeting, potentially constraining the realisation of their full potential. The maturing and continuity of the CoP established and coordinated during the BRIDGE project, that is, the viability of CoP and the interest of participants to coalesce and network on a regular basis in the future, is unknown due to its open-ended nature.

Improving practice

CoP enabled the creation of learning networks; participants increasingly perceived CoP as a means for enhancing knowledge and improving sustainable planning practice. The project confirmed that, supporting Fraser *et al.* (2006) and Holder (2011), the participative identification of sustainability indicators not only provided reliable grounds for making planning decisions, but the process of involving people also presented learning opportunities, and contributed to shared understanding and urban governance.

Despite the learning opportunities and enhanced understanding of the implications of urban metabolism in urban planning, practitioners' interests and concerns were not limited to urban metabolism aspects; they included other considerations such as public health, infrastructural capacity and governance. As the free exchange of ideas and concerns between participants was limited to the Umbrella CoP, the contribution of BRIDGE to promoting further dialogue among CoP participants outside the scope of the project remains uncertain. Moreover, the project did not encompass any process to monitor the extent to which CoP participants incorporated newly acquired knowledge/experiences into practice. As a result, it is unclear whether the CoP meetings had any effect on planning practices. Nevertheless, CoP input contributed to the research strategy, supporting the development of a DSS tool aimed at enhancing planning practice.

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Applicability of Indicators: The Issue of Context and Scale

Indicator sets evolved throughout the CoP due to the fact that during the first round of meetings city-wide issues were examined while the second round of meetings focused on the local context, addressing case-specific considerations related to planning interventions. Some of the differing aspects also related to very different political and economic development junctures of the countries involved. Contrasting views on sustainability and approaches to urban development were apparent, for example, between Finland and Poland — illustrated by the prioritisation of public transport effectiveness *versus* the need to develop additional road infrastructure to improve competitiveness. Such perceptions visibly shaped the city's planning priorities and, consequently, the definition of objectives and indicators. The fact that a set of indicators becomes partly dependent on the opinions of a small group of practitioners at a given point in time entails the risk of limited applicability in other contexts. For instance, in London only a few air quality indicators were high on the political agenda. If the development of the DSS was to be based on such priorities only, new insights or shifts in policy priorities would rapidly outdate the tool. Such limitations were overcome by combining the results of the five cities, incorporating the experience of BRIDGE researchers and by linking to the scientific debate on sustainable urban planning, in order to provide a more holistic approach to urban sustainability. Moreover, the DSS was conceived to enable the integration of new indicators as these become a priority and/or available and, thus, provides the flexibility to adapt to changing political and planning agendas.

The local identification of planning interventions enabled a more detailed examination of potential problems, exposing the issue of scale. The case study alternatives to be evaluated by the DSS differed significantly between the cities (Table 1); some entailed new urban development (e.g. residential area in Helsinki

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and academic campus in Gliwice) and others focused on the improvement of existing areas (e.g. greening London city centre and enhancing open spaces and urban infrastructure in Athens). The more specific the plan (e.g. local area plan), the larger the scale and the greater the level of detail required in the spatial datasets used in the assessment (González, 2010). Therefore, in the context of a GIS-based DSS platform, the scale of application incorporates new considerations into the applicability of indicators. Data-driven approaches that are conditioned by the geographical scope and values of indicators available may limit the extent and level of detail of the assessment (Niemeijer, 2002; João, 2007; González, 2010). This potential scale issue was overcome in BRIDGE by the incorporation of a cascade modelling technique (from city-wide to local scale models) in the DSS — which enabled estimating indicator values at different assessment levels (San José and Pérez, 2009). Nevertheless, the selection of the final set of indicators was subject to the project's context and requirements: the boundaries determined by the scope of the project (i.e. water, energy and air pollutants), and the availability of data and models. Thus, the indicators were verified against the selection criteria and validated to ascertain their applicability. The scope of BRIDGE constrained, in principle, the applicability of indicators and the detailed assessment of additional sustainability issues, particularly socio-economic aspects such as mobility and human well-being identified as important during the CoPs, due to the lack of both detailed data at the local level and availability of specific models within the project. As previously noted, this limitation can be addressed through the DSS's flexible and dynamic approach to the incorporation of parameters: the end-user can incorporate additional objectives and indicators when these are relevant and applicable, and where data are available.

In general, the planning issues discussed during the first round of CoPs were connected to the international debate on urban sustainability issues, and are potentially common to a wide range of cities. Consequently, it could be argued that the sustainability objectives defined during the BRIDGE project are, in principle, transferable to other European cities, enabling comparability. These objectives commonly relate to indicators which are also reflected in international indicator sets used for cross-national assessments of urban sustainability (e.g. EEA, 2005) making the case studies' performances comparable among each other as well as among other European cities. In contrast, the indicators defined in the second round of CoPs were only able to reflect some of the generic and long-term sustainability objectives defined at the city level in the previous round of CoPs, given the more limited range and scale of the spatial and sectoral plans proposed as case studies. Therefore, these indicators do not allow for comparability across case studies, as planning problems identified were not similar among the case studies, neither in scale nor in kind, and trends and values observed varied between single applications. Although the scope of the project required that indicators were specifically fitted to given planning interventions, and crucial decision-making criteria, the indicators identified at the local level could contribute to establishing an operative indicator set for sustainable planning and assessment of urban metabolism within a city. The tiered approach adopted in the methodological framework (where objectives were defined at city level and, in contrast, indicators at project level) determined the scope and level of detail of selected objectives and indicators, representing a potential limitation to the research.

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Conclusions and Final Remarks

A participatory approach to the development of sustainability indicators was employed in this research to bridge the gap between environmental science and urban planning practices. The approach assisted in enhancing the knowledge of planners and scientists on sustainability in urban planning and enabled the establishment of new networks and the expansion of existing networks (e.g. between researchers and local authorities, and within the research community). This is exemplified by the information exchanged between researchers and practitioners outside the CoP meetings, as well as the creation of new collaborative opportunities outside the scope of the project (e.g. London Greater Authority and Kings College London on the subject of green areas and flood risk). The CoP meetings yielded new insights into what constitutes urban sustainability in a range of European cities, enabling the identification of patterns to improve urban development, enhance quality of life and protect natural resources, and better inform planning decisions. The identification and validation of sustainability indicators through the methodological framework presented in this paper aided structuring interactions between researchers and local practitioners. Although CoP members' expertise and background influenced indicator selection, developing indicators through participatory approaches improved their applicability by combining scientific and local knowledge, by tailoring them to context-specific objectives and by making them understandable by both scientists and practitioners. Moreover, the incorporation of end-user perceptions and needs supported the research by facilitating the development of a functional and practical DSS to assist planning and decision-making processes.

The CoP approach rendered valuable results for the BRIDGE project but the contribution of the meetings, and the information flow, was often one-sided mainly due to project requirements and time constraints. The CoP approach was found to be valuable in promoting participation and end-users' interaction within the project

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but no mechanism was provided to ensure continuity of collaboration outside the scope of the project. Therefore, and despite the legitimate intention to create a longer term interaction between researchers and practitioners, as well as among practitioners themselves, it can be argued that the ambitious goal of creating viable CoP in the case study cities was not fully achieved and that CoP have limited capacity to fully evolve in the context of objective-driven projects (e.g. with clear time-frames, scope and outputs). In this context, further research is needed to identify opportunities for an earlier and more efficient engagement of local practitioners in research projects and, in particular, examine the constraints imposed by the local capacities for organisation and facilitation, as well as to define mechanisms to maintain the viability of CoP for continued involvement in decision-making.

These research results illustrate the complexity of addressing sustainable urban planning and of developing a set of indicators that are widely applicable. The final set of indicators agreed in BRIDGE was linked to the domain of interest (i.e. sustainable planning), was context-specific and critical for decision-making (i.e. addressed core issues of planning interventions), had high usability and could be monitored (i.e. DSS-compatible and measured on a regular basis). Nevertheless, the common tendency to focus on sustainability issues high on the political agenda has to be overcome through flexibility to adapt to change (as in the case of BRIDGE DSS indicators) to provide a robust and functional tool to support urban planning. This is crucial for indicator-based assessment tools to meet the diverse urban planning contexts and sustainability principles, particularly as assessment (and monitoring) efforts tend to take place at local or project level.

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References

AI (2003). European common indicators: Towards a local sustainability profile. Ambiente Italia.

Alberti, M (1996). Measuring urban sustainability. *Environmental Impact Assessment Review*, 16(4–6), 381–424.

Bardos, P, A Lazar and N Willenbrock (2009). A review of published sustainability indicator sets: How applicable are they to contaminated land indicator-set development? London: CL: AIRE.

Borrego, C, O Tchepel, AM Costa, JH Amorim and AI Miranda (2003). Emission and dispersion modeling of Lisbon air quality at local scale. *Atmospheric Environment*, 37(37), 5197–5205.

Bouma, J, JA de Vos, MPW Sonneveld, GBM Heuvelink and JJ Stoorvogel (2008). The role of scientists in multi-scale land use analysis: Lessons learned from Dutch communities of practice. *Advances in Agronomy*, 97, 175–237.

Carver, S (2003). The future of participatory approaches using geographic information: Developing a research agenda for the 21st century. *Urban and Information Systems Association Journal*, 15, 61–71.

CEC (1985). Directive 85/337/EEC, of 27th June, on the assessment of the effects of certain public and private projects on the environment. Commission of the European Communities. *Official Journal of the European Union*, L0337, L175, 5.7.1985.

CEC (1992). Council Directive 92/43/EEC, of 21th May, on the conservation of natural habitats and of wild fauna and flora. Commission of the European Communities. *Official Journal of the European Union*, L206, 22.07.1992.

CEC (1997). Council Directive 97/11/EC of 3rd March 1997 amending Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment. Commission of the European Communities. *Official Journal of the European Union*, L073, 14.03.1997.

CEC (2000). Directive 2000/60/EC of the European Parliament and Council, of 23rd October, establishing a framework for community action in the field of water policy. Commission of the European Communities. *Official Journal of the European Union*, L327/1, 22.12.2000.

CEC (2001). Directive 2001/42/EC, of 27th June, on the assessment of the effects of certain plans and programmes on the environment. Commission of the European Communities. *Official Journal of the European Union*, L197/30, 21.7.2001.

CEC (2007). Directive 2007/60/EC, of 23rd October, on the assessment and management of flood risks. Commission of the European Communities. *Official Journal of the European Union*, L288, 6.11.2007.

CEC (2008). Directive 2008/50/EC, of 21st May, on ambient air quality and cleaner air for Europe. Commission of the European Communities. *Official Journal of the European Communities*, L152/1, 11.6.2008.

Chrysoulakis, N, R Vogt, D Young, CSB Grimmond, D Spano and S Marras (2009). ICT for urban metabolism: The case of BRIDGE. In *Proceedings of EnviroInfo2009: Environmental Informatics and Industrial Environmental Protection: Concepts, Methods and Tools*, V Wohlgemuth, B Page and K Voigt (eds.), pp. 183–193. Berlin: Hochschule für Technik und Wirtschaft.

Connor, DM (2001). *Constructive Citizen Participation: A Resource Book*. 8th ed. Canada: Development Press.

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Cooke, B and U Kothari (2001). The case for participation as tyranny. In *Participation: The New Tyranny*? B Cooke and U Kothari (eds.), pp. 1–15. London: Zed Books.

DEFRA (2009). Sustainable development indicators in your pocket. An update of the UK Government strategy indicators. Dept. for the Environment, Food and Rural Affairs. Retrieved: http://www.defra.gov.uk/sustainable/government/progress/documents/SDIYP2009_a9.pdf

Donnelly, A, E Jennings, P Mooney, J Finnan, D Lynn, M Jones, T O'Mahony, R Thérivel and G Byrne (2006a). Workshop approach to developing objectives, targets and indicators for use in SEA. *Journal of Environmental Assessment Policy and Management*, 8(2), 135–155.

Donnelly, A, M Jones, T O'Mahony and G Byrne (2006b). Decision-support framework for establishing objectives, targets and indicators for use in strategic environmental assessment. *Impact Assessment and Project Appraisal*, 24(2), 151–157.

EEA (2005). European environment outlook. European Environment Agency, EEA Report No 4/2005. Retrieved: http://www.eea.europa.eu/publications/eea_report_2005_4.

EPA (2008). Ireland's environment. Environmental Protection Agency: Johnstown Castle, Wexford, Ireland. Retrieved: http://www.epa.ie.

FNCSD (2009). Sustainable development indicators. Finish National Commission on Sustainable Development. Retrieved: http://www.environment.fi/default.asp?node=15131&lan=en.

Fraser, EDG, AJ Dougill, WB Mabee, M Reed and P McAlpine (2006). Bottom up and top down: Analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. *Journal of Environmental Management*, 78(2), 114–127.

González, A (2010). *Incorporating Spatial Data and GIS to Improve SEA of Land Use Plans: Opportunities and Limitations — Case Studies in the Republic of Ireland*. Germany: Lambert Academic Publishing.

Grimmond, CSB, M Best, J Barlow, AJ Arnfield, JJ Baik, S Belcher, M Bruse, I Calmet, F Chen, P Clark, A Dandou, E Erell, K Fortuniak, R Hamdi, M Kanda, T Kawai, H Kondo, S Krayenhoff, SH Lee, SB Limor, A Martilli, V Masson, S Miao, G Mills, R Moriwaki, K Oleson, A Porson, U Sievers, M Tombrou, J Voogt and T Williamson (2009). Urban surface energy balance models: Model characteristics and methodology for a comparison study. In *Urbanization of Meteorological and Air Quality Models*, A Baklanov, CSB Grimmond, A Mahura and M Athanassiadou (eds.), pp. 97–123. Verlag: Springer.

Groot, A, J Klostermann and E Moors (2009). Protocol for developing communities of practice in the context of BRIDGE. Document deliverable D.2.3. Sustainable Urban Planning Decision Support Accounting for urban Metabolism, EU Seventh Framework Programme. Retrieved: http://www.bridge-fp7.eu.

Holder, M (2011). Public participation and local sustainability: Questioning a common agenda in urban governance. *International Journal of Urban and Regional Research*, 35(2), 312–329.

João, EM (2007). The importance of data and scale issues for strategic environmental assessment. *Environmental Impact Assessment Review*, 27(5), 361–364.

Karvounis, A (2009). Protocol to assess differences between knowledge supply and knowledge needs in the Field. Document deliverable D.2.2. Sustainable Urban Planning Decision Support Accounting for urban metabolism, EU Seventh Framework Programme. Retrieved: http://www.bridge-fp7.eu.

Leiserowitz, AA, RW Kates and TM Parris (2005). Do global attitudes and behaviors support sustainable development? *Environment*, 47(9), 22–38.

Letsela, L, A Pelser and M Seaman (2010). A participatory sustainability assessment process for biodiversity conservation in Lesotho. *Journal of Environmental Assessment Policy and Management*, 10(3), 307–331.

Morgan, R and M Matlock (2008). A collaborative learning matrix for combining science with stakeholder involvement to prioritize watershed implementation in Arkansas' nonpoint source state management plan. *Journal of Environmental Assessment Policy and Management*, 10(3), 307–331.

Nicholson, M and R Fryer (2002). Developing effective environmental indicators — does a new dog need old tricks? *Marine Pollution Bulletin*, 45(1–12), 53–61.

Niemeijer, D (2002). Developing indicators for environmental policy: Data-driven and theory-driven approaches examined by example. *Environmental Science and Policy*, 5(2), 91–103.

Rais, M and DC Sharma (2008). Characterising indicators of sustainable land management in Indian Himalayan sloping lands. *Journal of Environmental Assessment Policy and Management*, 10(4), 431–460.

Rees, W and M Wackernagel (1996). Urban ecological footprints: Why cities cannot be sustainable — and why they are a key to sustainability. *Environmental Impact Assessment Review*, 16, 223–248.

Rodriguez, F, H Andrieu and F Morena (2008). A distributed hydrological model for urbanized areas — model development and application to case studies. *Journal of Hydrology*, 351, 268–287.

Rogerson, R, R Bellingham and Y Shevtsova (2009). Changing behaviour and attitudes to sustainability: A report for the Department of Enterprise, Trade and Investment. Retrieved: http://www.detini.gov.uk/changing_behaviour_and_attitudes_to_sustainability_a_report_for_the_department_of_enterprise_trade_and_investment.pdf.

Saaty, TL (1980). *The Analytic Hierarchy Process*. New York: McGraw-Hill.

San José, R, JL Pérez and RM González (2006). Air quality CFD and mesoscale modelling simulations: Madrid case study. *WSEAS Transactions on Environment and Development*, 2, 1291–1296.

San José, R and JL Pérez (2009). Model selection report. Document deliverable D.4.1. Sustainable Urban Planning Decision Support Accounting for urban Metabolism, EU Seventh Framework Programme. Retrieved: http://www.bridge-fp7.eu.

Schomaker, M (1997). Development of environmental indicators in UNEP. Paper presented at the Land Quality Indicators and their Use in Sustainable Agriculture and Rural

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Development, January 25–26, Rome. FAO, pp. 35–36. Retrieved: http://www.fao.org/docrep/W4745E/w4745e07.htm.

Smeets, E and R Weterings (1999). Environmental indicators: Typology and overview. European Environmental Agency, Report no. 25, Copenhagen.

UKP (2004). Planning and compulsory purchase act. United Kingdom Parliament. Retrieved: http://www.legislation.gov.uk/ukpga/2004/5/notes/contents.

UNWCED (1987). Our common future. United Nations World Commission on the Environment and Development, Brundtland Commission, A/42/427. Oxford: Oxford University Press.

van Winkelen, C (2009). Inter-organizational communities of practice. Retrieved: http://www.elearningeuropa.info/doc.php?id=1483&lng=1&doclng=1.

Wang, J, TA Endreny and DJ Nowak (2008). Mechanistic simulation of tree effects in an urban water balance model. *Journal of the American Water Resource Association*, 44, 75–85.

Wenger, E, R McDermott and W Snyder (2002). *Cultivating Communities of Practice: A Guide to Manage Knowledge*. Boston: Harvard Business School Press.

J. Env. Assmt. Pol. Mgmt. 2011.13:591-617. Downloaded from www.worldscientific.com
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