Development of an Integrated Sustainability Assessment Toolkit

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ABSTRACT

Integration of environmental, social and economic issues is still a key challenge for the delivery of sustainable development and accordingly sustainability assessment. In attempting to address this challenge in relation to the built environment, SUE-MoT (a consortium of academic, public and private partners) has been formed with a particular focus on developing holistic metrics, methods and tools in a way that reflects stakeholder values. Currently SUE-MoT is working to develop an Integrated Sustainability Assessment Toolkit (ISAT) that brings together many approaches, allowing key decision-makers to identify the most appropriate for their project and to combine the results based on their values. The objective of this paper is to report on the principles of developing the ISAT so that it will allow a range of key decision-makers to systematically and transparently make holistic sustainability assessment decisions for a variety of projects. This paper begins by defining the principle of sustainability assessment and describing the ISAT framework process, highlighting the major stages and the general tasks involved at each stage. The ISAT's major structures including the spatial scale of assessment, the life cycle, sustainability issues and their impact, the sustainability assessment tools database, stakeholder values and finally the mechanisms for stakeholder engagement throughout the process of assessment are also described. The sustainability impact assessment methodologies (based on principles of environmental impact assessment, social impact assessment and cost and benefits analysis) are briefly discussed.

Key words: integrated sustainability assessment, impact assessment, urban development

INTRODUCTION

More than 17 years after the concept of sustainability gained international recognition through the Brundtland Commission (World Commission on Environment and Development, 1987), it continues to arouse much debate about how it should be defined, interpreted and assessed. It has generated a wealth of research and policy discussion on the meaning, measurability and feasibility of sustainable development. Sustainable development can be defined in a number of ways (Pezzey, 1989). Fowke and Prasad (1996) have identified at least 80 different, often competing and sometimes contradictory definitions while Parkin et al. (2003) report over 200 definitions reflecting the complexity and uncertainly over what is to be sustained, by whom, for whom and what is the most desirable means of achieving it (Agyeman and Evans, 2004). Although there remains much confusion and disagreement about the precise meaning of sustainable development, there is a broad consensus that the concept draws together economic, environmental and social objectives with a commonly rehearsed definition being that from the Brundtland Report, where it is suggested that sustainable development means "development that meets the needs of the present generation without compromising the ability of the future generations to meet their own needs" (WCED, 1987). The UK Government has defined sustainable development as "ensuring a better quality of life for everyone now and for the future generations to come" through the pursuit of five objectives (DEFRA, 2005):

- Living within environmental limits
- Ensuring a strong, health and just society
- Achieving a sustainable economy
- Promoting good governance
- Using sound science responsibly

These suggest that sustainable development is a multidimensional concept with concerns in three broad themes: environmental, social, and economic. These themes are interconnected. Thus actions that address only environmental, only social or only economic aspects and concerns are fundamentally insufficient for sustainable development. Accordingly it is suggested that sustainability requires a form of multi disciplinary thinking that encourages integration between policies, programmes, plans and projects, linking issues and impacts across spatial and temporal scales in a way that is compatible with the decision-making process.

Critical to such an integrated approach are the provision of compatible metrics, models and tools that can provide robust information to this decision-making process in order that society can monitor contributions to sustainable development. This need has been recognised at the highest levels and particularly true in relation to the urban environment, where human activity is increasingly concentrated.

This paper reports on the initial findings of the SUE-MOT research programme funded by the UK Engineering and Physical Sciences Research Council (EPSRC) within their "Sustainable Urban Environment" programme. SUE-MOT is a consortium of 4 academic institutions (Dundee, Glasgow Caledonian, Loughborough and St Andrews Universities) and 18 industrial partners.

The research programme is a large-scale four-year study consisting of 8 work packages which commenced in May 2005. Its vision is to develop a *comprehensive and transparent framework that encourages key decision-makers to systematically assess the sustainability of urban developments taking account of scale, life cycle, location, context and all stakeholder values*. A key output of the work will be an Integrated Sustainability Assessment Toolkit (ISAT) for urban sustainability assessment which can bring together various metrics, models and tools to promote the required integration across issues and scales and within the decision-making process. This paper reports on the initial development of the ISAT.

URBAN SUSTAINABILITY

Urban areas have special importance within the broader context of sustainable development. Approximately one third of the world's six billion people currently dwell in urban areas. It is projected that by 2050, when the world's population will have increased to nine billion, two thirds will live in urban areas (Bos et al., 1994; United Nations, 1993).

Of particular importance within urban areas is the built environment which includes buildings and structures of all types, such as offices, shops, factories, residential buildings, transport infrastructure, public utilities and other man-made modifications to the natural environment (Lombardi and Brandon, 1997). The built environment refers to buildings, structures, spaces and their supporting infrastructure and applies to a range of scales from functional units within buildings to entire urban areas. The sustainability of the built environment is dependent on a fundamental shifts in how resources are used (from non renewable to renewable, and from high levels of waste to high levels of reuse and recycling) and from projects based on lowest initial cost to those based on whole life value and full cost accounting (Kibert et al.., 2000). The built environment directly and indirectly is responsible for the consumption of large amounts of natural resources, energy and the production of significant quantities of pollution. Huge direct and indirect social, economic and environmental consequences are thus associated with the way we design, build, operate, maintain and ultimately dispose of buildings and their support systems.

URBAN SUSTAINABILITY ASSESSMENT

Given the wide and increasing recognition that human development urgently needs to take a more sustainable path, it is imperative that systems exist to identify related goals and measure, assess, monitor and audit progress towards their achievement (Mitchell *et al.* 1995) - a process broadly referred to as sustainability assessment (Therivel *et al.* 1992).

Pope et al.., (2004) defined sustainability assessment as a process by which the implication of an initiative on sustainability is evaluated. Therivel et al.. (1992) defined it as a formal process of identifying, predicting and evaluating the potential impacts of a wide range of relevant initiatives (such as legislation, regulations, policies, plans, programmes, and specific projects) and their alternatives on the sustainable development of society. Devuyst (2001) defined sustainability assessment as "a tool that can help decision-makers and policy-makers decide what actions they should take and should not take in an attempt to make society more sustainable", while Verheem suggested that the aim of sustainability assessment is to ensure that plans and activities make an optimal contribution to sustainable development (Verheem, 2002).

The need for robust assessment mechanisms is especially important and challenging in the context of sustainability. Its inherent breadth and complexity requires consistent protocols that will illuminate attendant issues and enable decision-makers and planners to gather, compile and analyse data in a way that supports sustainable planning and design (United Nations, 2001). The need for information to guide decision-making at all levels was recognised by the WCED (1987) as well as the Rio Summit (United Nations, 1992), and has been reaffirmed by the 'Rio +10' conference held in Johannesburg, South Africa, 2002, which called for 'specific activities, tools, policies, measures and monitoring and assessment mechanisms' to aid sustainable decision-making and to gauge progress towards sustainability (United Nations, 2002).

The Bellagio principles for assessment are guidelines for undertaking and improving assessment toward sustainable development (Hardi and Zdan, 1997). A holistic perspective is one of the Bellagio principles of sustainable development assessment. This principle includes a review of the whole system as well as its parts; considers the well-being of human, environment and economic sub-systems and their component parts and the interaction between parts, and considers both positive and negative consequences of human activity, in a way that reflects the full cost and benefits for human and ecological systems, in monetary and non-momentary terms (iisd.org website). Assessment must be able to integrate several dimensions (Jakeman and Letcher, 2003):

- the consideration of multiple issues and stakeholders
- the key disciplines within and between the human and natural sciences
- multiple scales of system behaviour
- cascading effects both spatially and temporally
- models of the different system components
- multiple databases

Pearce et al.. (1989, 1990) recognise and make explicit the importance of adding the dimension of time to sustainability assessment. Hoffmann et al.. (2000) described the important features and the challenges of assessing sustainability:

- No solutions are sustainable in themselves “the best solution is dependent on its context”.
- A sustainable solution demands a transparent decision process with a wide range of criteria such as economic, environmental, social, technical, and political.
- The involvement of all the relevant stakeholders in the decision process will secure the viability of a programme or project.

Good assessment forces stakeholders to rethink priorities (Hardi and Zdan, 1997). By providing tangible information on key aspects of urban sustainability, assessment can help to clarify and enhance understanding of urban sustainability - an otherwise vague and fuzzy concept. It can provide guidance on the design of measures to improve sustainability whilst increasing the transparency of decisions and facilitating participation. When used to decide on alternatives, for example, it can show how a choice is reached, enable pros and cons to be clearly viewed, and allow open negotiation (Bentivegna, 1997). Overall, by providing a sense of direction for decision-makers and stakeholders, assessment can provide a clear basis for planning future actions and the formulation of policy and design choices that aid movement towards sustainable urban development (Kelly, 1998).

Since these early calls much effort has gone into the development and use of relevant tools including numerous indicator suites, models, simulators, check-lists and frameworks as well as a plethora of related guidance materials. For sustainability assessment in relation to the urban and built environments, tools based on life-cycle analysis, impact assessment and building rating systems have become increasingly common with considerable variation in their coverage and complexity and thus the resources required for their use (Walton *et al.* 2005). Such tools adopt, to a greater or lesser degree, one or both of two broad underlying approaches to sustainability assessment: the baseline-led approach and the objectives-led approach. In the baseline-led approach, as seen for example in Environmental Impact Assessment, the likely state of the urban system (with its built, natural and human components) without the proposed intervention (for example a building or road) is established and the likely departure from this “baseline” state as a result of that intervention is assessed. In objectives-led approaches, common to building rating systems, the assessment determines the extent to which the proposed intervention adopts certain “sustainability friendly” products and processes. Both approaches have generated considerable discussion as to their effectiveness (Pope *et al.* 2004) with baseline-led approaches offering, in principle, the possibility for referencing cumulative impacts on the carrying capacities of social, economic and environmental systems at a number of scales although the practical complexities and uncertainties in doing so are extensive. On the other hand, while objectives-led approaches tend to be less complex and so less resource intensive - an important consideration for practitioners - critics argue that the assessment is relative in nature, measuring performance against suggested best practice or reflecting policy goals and so do not provide information on the absolute contribution that the project makes towards sustainable development by way of its positive and negative impacts (Cole, 1999).

In addition to concerns about the underlying approach to assessment taken by specific tools, there have, over time, been numerous calls for greater integration both during and across assessments in a way that reflects the complex and interdependent nature of sustainability (Bailey P 1996; Lombardi and Brandon 1997; Eggenberger and Partidario 2000; Bentivegna *et al.* 2002; Pope et al. 2004; Kaatz et al. 2006) although Scrase and Sheate (2002) caution that certain forms of integration could actually undermine sustainability efforts. Salder, 1999, suggests a number of avenues for increased integration including:

- Substantive aggregation of each of the main type of impact (economic, environmental and social) linking together each separate impact assessment which is undertaken at different stages in the policy, planning and project cycle;
- Horizontal integration of assessments, bringing together in a single measure different types of impact into a single overall assessment at one or more stages in the planning cycle.

These are reiterated by Lee (2006) who suggests greater integration could occur: between the assessments of related policies, plans and projects; between the assessment of social, economic and environmental impacts of a policy, plan or project; and between assessments and the decision-making process to guide the development of particular policies, plans and projects. Extending this last point, Kaatz *et al.* (2006) predict that future assessment tools are likely to put greater emphasis on the building process enhancing opportunity during decision-making for mediation, shared learning and empowering stakeholders, whilst a recent review of the UK Sustainable Development Research Network found that sustainability valuation methods increasingly combine interpersonal deliberation with quantitative methods and that both the type of evaluation and the institutional context in which it occurs can influence assessment outcomes (SDRN, 2007). Such findings suggest that it is through the social processes associated with the use of assessment tools, and not just through the use of their final output, that change for sustainability is likely to occur – something developers and users of such tools should be aware of. Importantly, earlier work by the SUE-MOT consortium found that urban decision-makers suggested that integration could be best delivered not through another new tool but through an integrating framework that could order component tools within a consistent assessment philosophy identifying the correct assessment tools for a given context, an approach recently proposed by Cole (2006).

Accordingly the SUE-MOT programme vision is to develop a *comprehensive and transparent framework that encourages key decision-makers to systematically assess the sustainability of urban developments taking account of scale, life cycle, location, context and all stakeholder values*. A key output of the work will be an Integrated Sustainability Assessment Toolkit (ISAT) for urban sustainability assessment which can bring together various metrics, models and tools to promote the required integration across, issues, scales and within the decision-making process. This work is now described in greater detail.

SUE-MOT'S APPROACH TO DEVELOPING AN INTEGRATED SUSTAINABILITY ASSESSMENT TOOLKIT FRAMEWORK

Figure 1 provides a visual representation of the ISAT system and its integration with the components of a supporting knowledge management system (outlined in Thomson et al., 2007), structured to reflect the phases of a developed sustainability assessment protocol which itself is aligned with the decision-making process commonly associated with an urban development. Developing the ISAT around this structure aims to assist the user of the system in the delivery of sustainability assessment throughout a development project's lifecycle. As shown the framework has six stages: a "the assessment context"; "select and prioritise sustainability issues/themes/impacts", "tool selection and prioritisation"; "assessment", "assessment integrator"; and "output assessment and the decision made" stages. These stages may be repeated as needed throughout the project life-cycle.

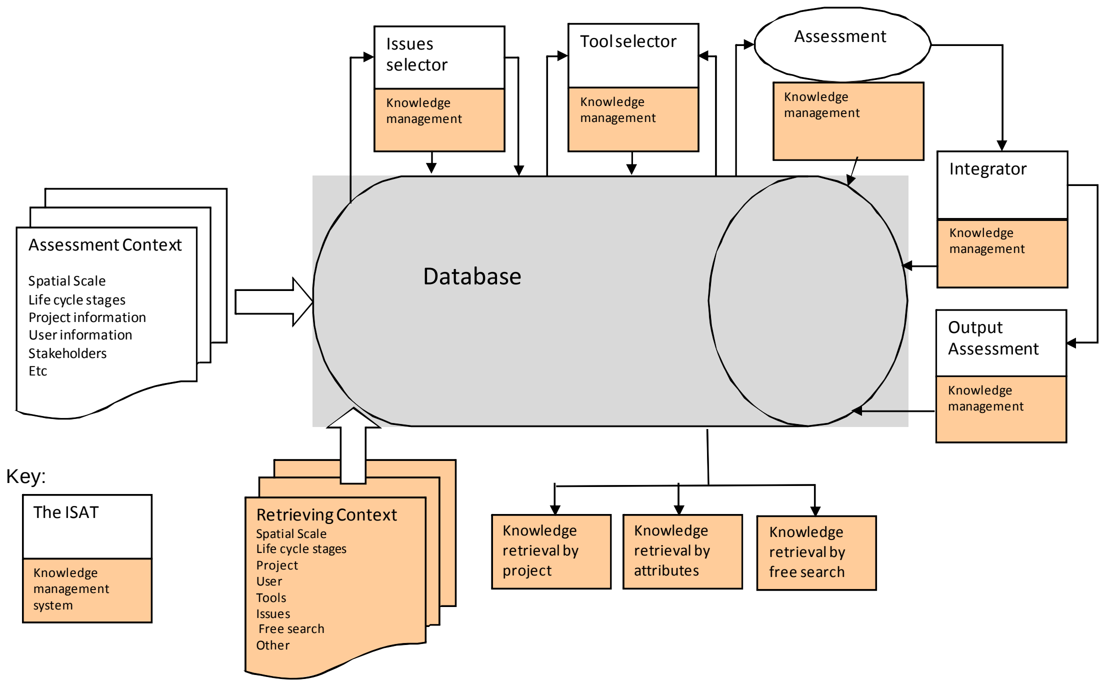

Figure 1: Diagram illustrating the integration of the toolkit and the components of the knowledge management system forming SUE-MoT's ISAT system

For each of the stages the system suggests various tools, guidelines, codes and procedures that can support and facilitate the stage and the likely stakeholders to be involved. It will also recommend various tools for stakeholder identification and engagement. The system is structured so that the user can capture and store the outcome or output from these activities within the ISAT system database, thus creating an accessible record for future consideration. The aim of the database is to capture the key information, data and the ISAT user's knowledge throughout the ISAT process. The database will work together with the user interface so that both knowledge input by the user and knowledge from past sustainability assessments is captured and retrieved respectively. The ISAT system stages are briefly described below:

Stage 1: The ISAT assessment context

A scoping study carried out by SUE-MoT team has identified most of the key determinants of an assessment context such as the project type, spatial scale and lifecycle stages. This information provides the ISAT assessment context structure which can be interrogated via the ISAT toolkit in order that the correct urban sustainability themes/issues/impacts can be identified. The user of the ISAT system will select from the list of assessment attributes described below.

Assessment Scale

A key to effective urban sustainability assessment is an understanding of the scale and the boundary of the assessment. This understanding will help the user of the ISAT system to collect data and information at the appropriate level. Bottom-up scaling consists of taking information at smaller scales (material level) to derive processes at larger scales (built environment). The proposed scales coverage of the ISAT is shown in Table 1.

Table 1. Built Evironment: scale of assessment

Assessment scale
Urban Development (e.g. town /city)
Built Environment (e.g. housing scheme)
Building (e.g. house, road, infrastructure)
Product for building element
Materials

Life Cycle
Every scale of the built environment has a different life cycle defined as the set of stages from inception to decommissioning at the end of its useful life. The life cycle stages of a construction project are broken down into planning and design (inception, feasibility outline, scheme and detailed), construction, facilities management (operation, maintenance and reuse), and decommissioning at the end of its life.

Table 2. Life cycle of a construction project

Building life cycle stages
Planning
Design
Construction
Operation and maintenance
Decommission

The design stages can be further broken down into sub-stages as shown in Table 3.

Table 3. Sub-stages of planning and design stage

Planning and design stage
Inception
Feasibility
Outline proposal
Scheme design
Detailed design

Other assessment context attributes including building type (such as school, house, hospital etc.) and project information (such as location, size, etc.).

Stage 2: Select and prioritise sustainability issues
An extensive literature review on urban sustainability undertaken as part of an earlier study by Walton et al. 2005 and El-Haram et al. 2006 has identified 650 sustainability issues (environmental, social and economic) associated with each life-cycle stage of buildings, open spaces and on-site infrastructure of an urban development including those relating to the manufacture and transport to-site of construction materials. These and sustainability issues which will be identified through tools evaluation activity will form the issues database A sample of sustainability issues of the construction phase of a building is shown in Table 4. A database

containing a comprehensive set of the issues (environmental, social and economic) relevant to urban sustainability will be developed.

Table 4: Sample sustainability issues associated with construction phase of a building (El-Haram et al. 2006)

Environmental Issues	Social Issues	Economic Issues
Energy consumption Land use Materials use and performance Pollution (to air, water and ground) Waste generation Water consumption Ecology Noise and vibration (on and around site) Lighting and thermal environment (working conditions)	Safety Security Health and well-being Employment Workforce education, training and skills Culture and heritage issues	Whole life costs (e.g. energy cost, land cost, water cost, materials cost, plant cost, labour cost, pollution costs "prevention measures", waste management cost, security costs, etc) Social costs (associated with the social impacts) Productivity Economic growth

Once the context of assessment is selected then the ISAT system will provide a list issues that are related to the assessment context. The user will assign different levels of importance to the selected issues based on the stakeholders' values. The ISAT system allows the user to add or delete any issues and priorities the final list.

Stage 3: Tools selection and prioritisation

A scoping study carried out by SUE-MoT team has identified more than 600 sustainable development assessment tools, both nationally and internationally. These were developed for varying reasons and therefore focus on different scales, different stages of the project life cycle and on different sustainability issues/themes/impacts. The research team is currently working in selecting relevant tools which will be included in the ISAT system. Each tool will be evaluated based on the following criteria:

- Spatial scale
- Object of assessment
- Sectors of use
- Life-cycle phase
- Sustainability issues
- Tool type
- Project type
- User interface
- Operating platform
- Type data input
- Type and from of the output
- The intended primary user of the tool

A sample from the list of sustainability metrics, models and tools identified during the scoping study is shown in Table 5.

Table 5: A samples of Metrics, Models and Tools

BRE SC	BREEAM	Living Standards Measurement Survey	Multi-scale Integrated Analysis of Sustainability
CSA	HK-BEAM	PRAM	Full Cost Accounting
SPARTACUS	BRE EPs	Sustainability Balanced Scorecard (SBSC)	Whole Life Costing
SEEDA SC	ATHENA	QUEST	Building for Environmental and Economic Sustainability
SCALDS	Boustead	LASALA	Life Cycle Assessment: Sima Pro 5
CITY Green	GaBi 4	Quality of Life Assessment	ENVEST
PLACE^{3}S	TEAM	Community Profile	PoleStar
ECOTECT	EcoPro	Genuine Progress Indicator	P2/FINANCE
DOE 2.2	CEEQUAL	Community Impact Assessment	E2/FINANCE
BDA	Social Capital Assessment Tool (SOCAT / SCAT)	Dashboard of Sustainable Development	EXMOD
GBTool	Index of Sustainable Economic Welfare	Corporate Sustainability Assessment (SAM)	EXMOBILE
LEED	Social/ Human Capital Rapid Appraisal Model	Community Sustainability Assessment	NI Equality Impact Assessment
SPeAR	ISCAM	Sustainability Calculator	Strategic Environmental Assessment
MSDG	UN Human Development Reports/ Index	Wellbeing Index	Natural Step
EcoCal	Social Capital Assessment Tool	Social Impact Assessment	SIGMA

The ISAT system will map the output from the issues prioritiser on to the rated tools database to identify a short-list of tools which are considered most suitable for the decision-maker’s needs. The tools database will include data about the specification and capabilities of each tool, so that the user can obtain all necessary information before making a final choice of one or more tools. This stage of the ISAT system is similar to existing toolkits such as Advanced Tools for Sustainability Assessments, BEQUEST, BTS Tools Directory, Annex 31, SBIS, PETUS, and others. However the differences are that the ISAT system will not stop at suggesting the appropriate tools for a given context. It will provide the mechanisms for integrating the outcome of the individual tool assessments into a summary of the results from which the decision maker will then be able to make final decisions about the project, taking into account stakeholders values. Other key differences are: it allows the user to capture, store and retrieve both the explicit and tacit knowledge generated in delivering each stage of the ISAT system and it recommends a level of engagement with relevant stakeholders during each of the associated activities of the relevant stage (Thomson et al. 2007).

Stage 4: Assessment
Once the user selects the relevant tools then the user or the user's agent carries out the sustainability assessment of the project. The implementation of tools will be done outside the ISAT system. The ISAT system will only use the issues assessment as part of the integrator.

Stage 5: Assessment integrator
Once the user carries out the sustainability assessment of the prioritized issues, the results will then be entered into the ISAT integrator interface. There will be two options for developing the assessment integrator: 1) to produce a summary from all the individual assessment into a combined report; 2) to convert a variety of individual assessments into a common unit of measurement. The research team is currently in the process of developing both options.

Stage 6: Output assessment and the decision made
Those involved in the decision-making process can use the system to make comparisons between the sustainability criteria displayed in the assessment outputs, and then either make adjustments to the design or construction alternatives being considered. It is hoped that through the provision of the identified stakeholders and appropriate engagement tools, an understanding of what makes a facilitating environment within which to conduct an assessment and consider its implications will be presented within the system. The output of the assessment will be captured and stored within the project database.

At each stage of the ISAT system the user will be requested to consider stakeholders' engagement and participation and take into account their values. Figure 2 shows a summary of the broad urban sustainability stakeholder types. The list can be classified into three main categories: a) those who affect the project; b) those who are affected by the project; and c) others who may be interested. It should be noted that some stakeholders may belong to more than one category. The method which will be used to identify the stakeholder is adopted from INVOLVE (Involve, 2005)

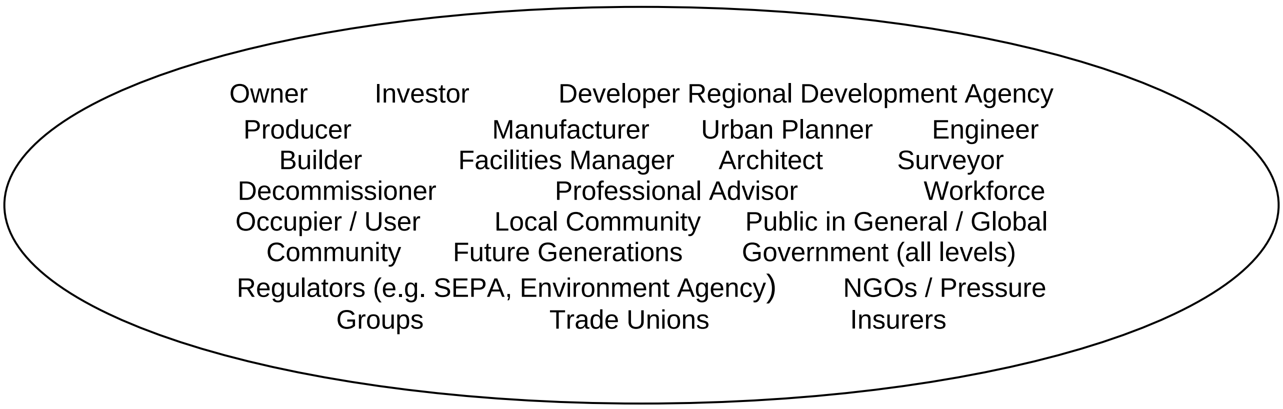

Figure 2. Stakeholders in an urban development

FUTURE RESEARCH

Over the next 15 months a web-based implementation of the ISAT system will be developed. The toolkit will be developed though with following components: tools database containing all the relevant tools, stakeholder engagement mechanisms, guides, codes and support material; tools selection mechanisms; and two potential integrator options. A user interface for the ISAT system will be designed. The knowledge management system described in Thomson et al. 2007 will link to the ISAT system to provide the knowledge management that is associated with the each stage of the ISAT process

CONCLUSIONS

This paper reports the initial development of an integrated sustainability assessment toolkit framework for an urban development. The toolkit aims to facilitate the selection of assessment tools appropriate to the scale, lifecycle, location and context of a development project and to integrate their outputs in a meaningful manner. The research team is currently working on the development of the components of the ISAT system, which will be web based. A tools database will be developed containing all the relevant tools, stakeholder engagement mechanisms, guides, codes and support material, together with the mechanisms required to provide the knowledge management system described in Thomson et al. 2007. An interface for the system will be established that is compatible with the contextual requirements of the user.

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