Demonstrating Sustainable Development

Sustainable Development Monitoring Report
Dundee Central Waterfront

Draft

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Executive Summary

The scale and importance of the Central Waterfront Development requires adherence to the principles of sustainable development and this must be demonstrated to the Scottish Executive, European funding bodies, private investors and the public. Sustainable development is increasingly important at a policy and strategy level in Scotland, UK and EU.

This is the first of three monitoring reports produced as an output of the University of Abertay Sustainable Enhancement Framework. This report provides values of the baseline indicator set for monitoring the sustainable development of the Central Waterfront prior to the commencement of the masterplan infrastructure provision.

The report explains what the indicators measure and considers the influence of time on the indicator set and future proofing of the indicators. The report also explains how the indicators will link to the sustainability enhancement activities and help drive decision processes.

The programme of work for 1 January 2008 to 31 December 2008 is proposed and recommendations are given on the future development of the baseline indicator set and dissemination of the project outputs.

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1 Introduction

The scale and importance of the Central Waterfront Development requires adherence to the principles of sustainable development and this must be demonstrated to the Scottish Executive, European funding bodies, private investors and the public. The UK Government and the Scottish Executive have recently reviewed their approach to sustainable development and are continually refining their approaches and guidance. Sustainable development is increasingly important on a policy and strategy level in Scotland, UK and EU.

Sustainable development assessment provides a mechanism for the transparent inclusion in the decision making process of all the facets of a development through its use of diverse social, economic and environmental indicators [i,ii]. Currently, whilst there is a considerable body of research into sustainability assessment, there are no standard methodologies for the assessment of major regeneration projects. The Central Waterfront Development provides a unique opportunity for the Partnership not only to demonstrate their application of the principles of sustainable development, but also to develop and promote a methodology for wider use.

1.1 Purpose of report

The Phase 1 scoping study[iii] identified stakeholders involved in the Waterfront Development, reviewed current sustainability indicators in the UK and Europe related to infrastructure and identified emerging indicators from Scottish Executive, EU Commission and research groups. From these activities a list of indicators suitable for monitoring the sustainable development of the Central Waterfront was identified.

This report provides values of the baseline indicator set for monitoring the sustainable development of the Central Waterfront prior to the commencement of the masterplan infrastructure provision.

In addition the report will:

- explain what the indicators measure;
- consider the influence of time on the indicator set, in terms of the life of Central Waterfront, and future proofing to be compatible with emerging methods of reporting.

The report will also explain how the indicators will link to the sustainability enhancement activities and help drive decision processes. A full report on the enhancement process activities will follow in December 2007.

Finally the programme of work for 1 January 2008 to 31 December 2008 is proposed and recommendations are given on the future development of the baseline indicator set.

1.2 Outline of the approaches taken and methodology used

The methodology used in Phase 2 was presented in the Phase 1 scoping report in September 2006[iii]. The approach involves two parts, an enhancement framework to enhance the inclusion of sustainability concepts in the Central Waterfront and a tool to monitor its sustainable development. Figure 1 shows how the enhancement framework and monitoring contribute to the sustainable development of the Central Waterfront.

The monitoring tool consists of a number of social, environmental and economic benchmark indicators developed to monitor the sustainable development of the Central Waterfront. The indicators are designed to be used annually during the development process to monitor the progress of the development and how it compares with the aspiration embodied in the Waterfront master plan and the consultation exercises[iv].

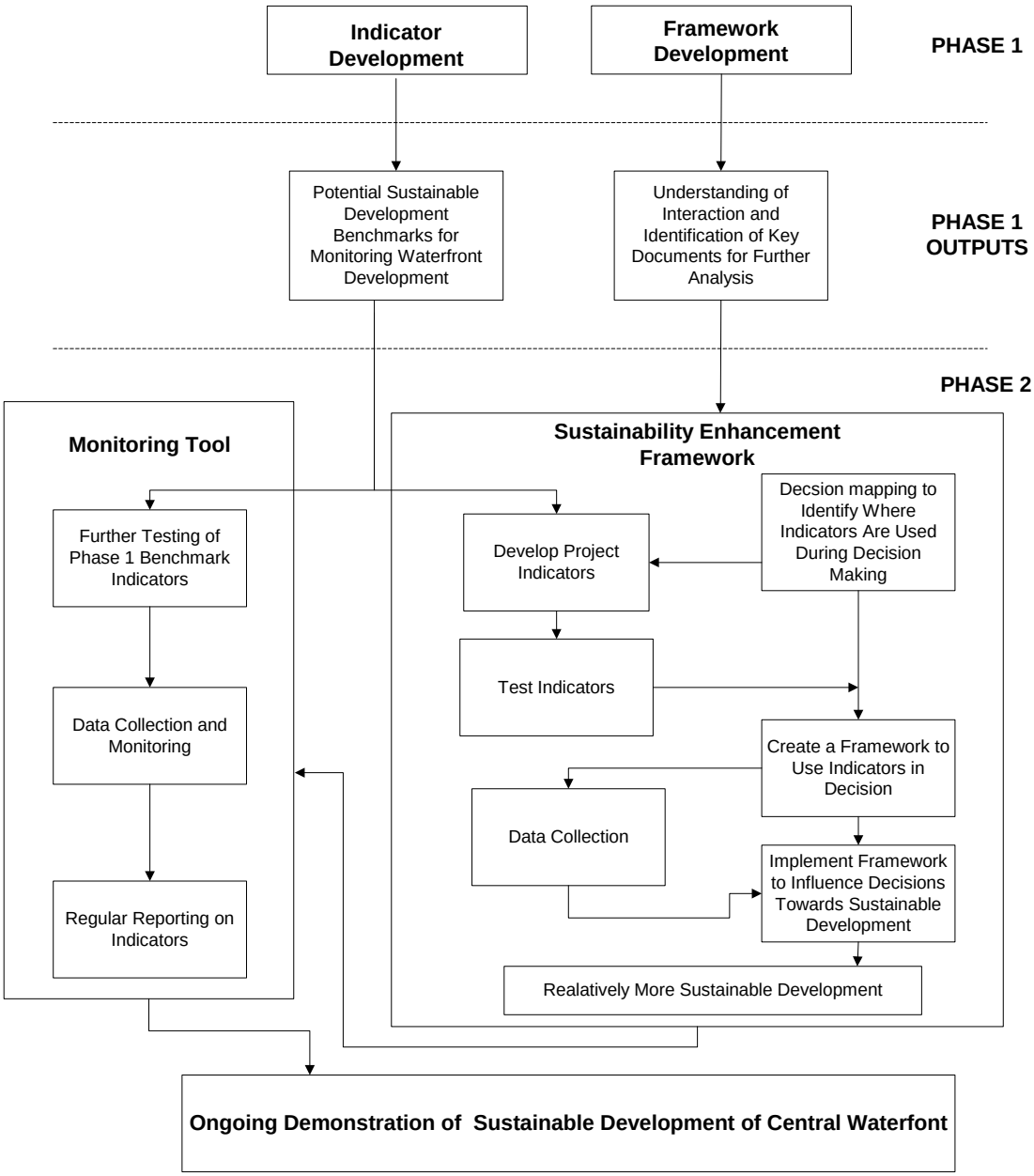

Figure 1 Sustainable enhancement methodology

2 Sustainable development monitoring

2.1 Indicator use and development

A set of indicators were developed and presented as part of the Phase 1 scoping study. These have been tested as part of the Phase 2 work and data have been collected where appropriate. These will provide a benchmark for identifying, reporting and communicating the sustainable development of Dundee Central Waterfront. Indicators help to break down the sustainable development concept to give it a clearer definition and hence make it more comprehensible. Simply put, an indicator is something that helps us understand where we are, which way we are going and how far we are from where we want to be. [v]

The process of indicator development is an iterative one. The process is shown in Figure 2 and consists of three main activities, literature review, interviews and document analysis. Each document specifying indicators and policy document was reviewed and the relevant indicators shortlisted. Each indicator on the shortlist was reviewed to identify its appropriateness to the Central Waterfront, in relation to its scale, geographical area, unit of measurement, focus and direction. Indicators were then grouped into three categories, Economic, Environmental and Social. A definition for each indicator was then assigned together with draft units.

During the literature based development stage, the indicators were designed to align as closely as possible with Scottish Executive indicators to provide a basis for tangible reporting to the Scottish Executive, whilst providing clear and easily understood indicators for internal monitoring at the strategic level.

Where Scottish Executive and UK Government indicators did not exist, specific indicators were developed. These were based on the authors' experience of sustainable indicator development[vi,vii] and on a range relevant sustainable urban development research papers. Unfortunately, most of the

papers presented a conceptual understanding of the urban environment and identified key components of sustainability[viii,ix,x] rather than presenting indicators. However, these key components were developed into indicators, which balanced economic, environmental and social aspects of sustainable development.

2.2 Indicator testing

Well chosen indicators should focus on materiality and accessibility[xi]. Materiality concerns the information stakeholder want and accessibility refers to ability of stakeholders to acquire and understand the information contained in indicators. Indicators should also have the following four characteristics[xii]:

Comprehensiveness

The indicators should cover the three categories of economic, environmental, and social in order to ensure that account is being taken of progress towards sustainable development objectives. The indicators chosen need to have the ability to demonstrate movement towards or away from sustainable development according to these objectives.

Tractability

Sufficient reliable numerical or qualitative data should be available to enable the estimation of spatial and temporal trends.

Transparency

The indicators should be chosen in a transparent way so as to help stakeholders to identify why indicators are being considered.

Practicability

The indicators must be practical in terms of time and resources available for any analysis and assessment.

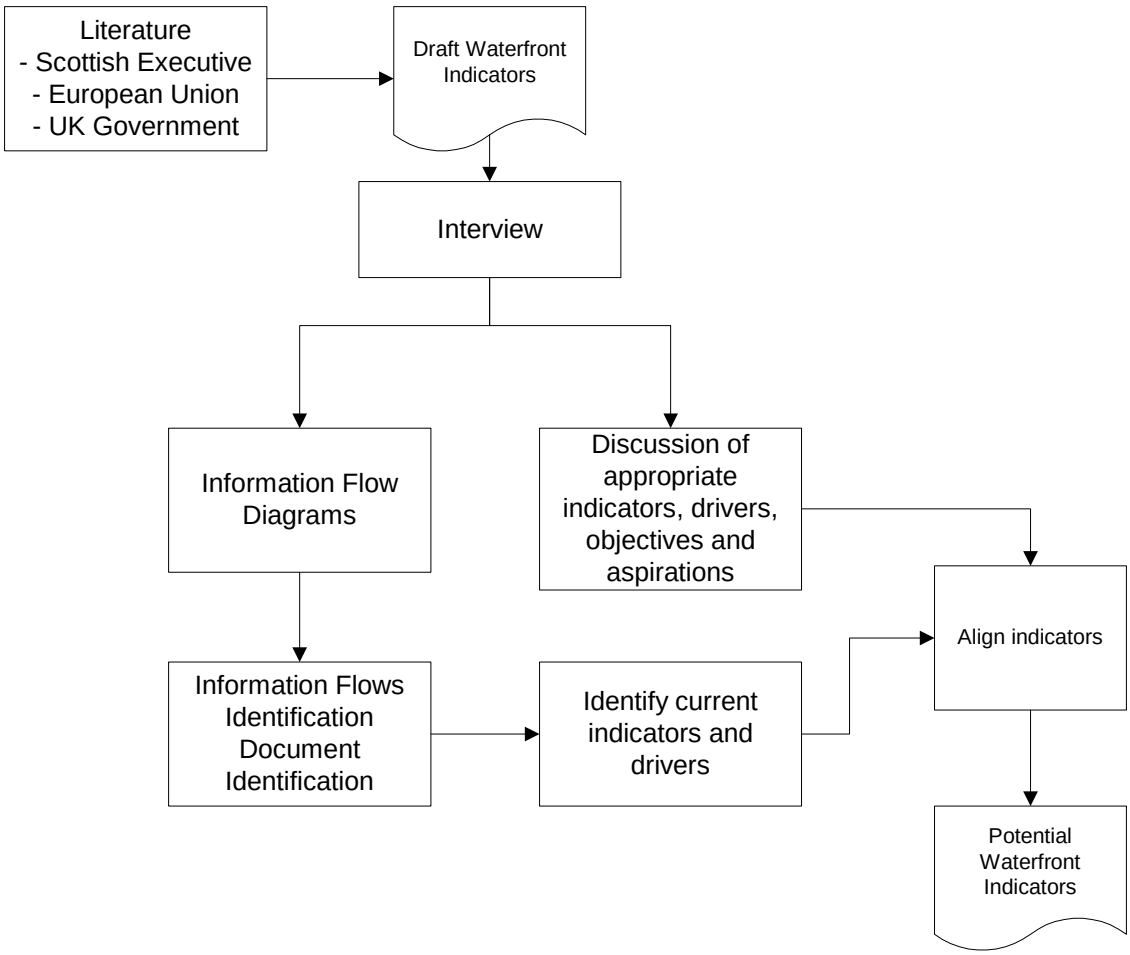

Figure 2 Indicator development

3 Benchmark Indicators 2007

The indicators shown in Tables 1-3 are the proposed benchmark indicators for monitoring the Central Waterfront. Values, where available, are presented as baseline data for 2007 prior to infrastructure provision. A column will be provided in 2008 and in subsequent reports to show the trend between the 2007 baseline and data from the current year. The * denotes that the indicator is based on the UK Government Framework Indicator or Scottish Executive Sustainable Development Indicator Set, but in most case the definition has been adjusted to be more relevant to Dundee Central Waterfront.

There is still a period of indicator development to be undertaken to verify some of the indictors where data is not readily available, in particular for some of the social indicators. A period of consultation throughout the council is required to further test these indicators and ensure their robustness. This will be undertaken by working with individuals and groups throughout the council departments and should be complete by December 2007.

3.1.1 Explanation of how the indicators work

The benchmark indicators can be categorised into two groups based on the geographical scope of the indicator; either Waterfront specific or city/region wide. Waterfront specific indicators data are focussed on the development area, whereas city/region wide indicators data are based on the impact of the Waterfront Development at a city/region scale. An example of the latter type of indicator is Retention of Skills Base, where an attribution of the change due to Central Waterfront will be required.

One of three forms of baseline data exist for each indicator:

1) An initial baseline value for 2007, e.g. population 142,170,
2) A value of 0 as a datum for 2007, e.g. Number of jobs created since 2007,
3) N/A (not available) where the indicator is not measurable at this time e.g. Per capita water consumption of new buildings as the area has not yet been developed.

Blanks are shown in the table in place of indicator data that is still being sourced. These data will be collected by December 2007.

The indicators will have different responsiveness to changes in the development. For some indicators there will be a change in the indicator only at infrastructure stage or the plot development stage, whereas some indicators will change at some or all of the development stages. For example, an indicator such as Air Quality will be influenced at each stage of the development but Retention of Skills Base, which monitors graduate retention rate, will only be influenced at the plot development stage.

Section 4 defines each indicator in detail and gives information regarding the purpose of the indicator, its origin and the expected influence of the stage of development on the indicator. It also identifies how indicators relate to UK Framework and Executive indicators of sustainable development and comments on future proofing and data information sources.

Table 1 Sustainable Development Benchmark Indicators - Economic

Category		Benchmark indicators	Definition of indicator	Units	Baseline Data	Desired direction/ Target	Source
Economic	1a	Demographics*	Population retention	Population number	142, 170	UP	DCC
	1b	Retention of skills base	Graduate retention rate	Graduate population	33 %	Up	SET
	1c	Knowledge based employment	Knowledge based employment	%	15%	Up	SET
	1d	Employment*	Employment rates	% Population	75%	Up	SET
	1e	Capacity to stimulate investment*	Total inward investment	£ Inward investment	0	Up	DCC/SET
	1f	Tourism	Tourists visiting city centre locations	Number	58,872/60,639	Up	Discovery /Sensation
	1g	Regeneration	Increased property value	% Increase	0	Up	DCC/SET
	1h	Job creation	Number of jobs created	Number	0	UP	DCC/SET
	1i	Economic output*	Economic output	GVA per Head	£14584	Up	SET

Table 2 Sustainable Development Benchmark Indicators - Environmental

Category		Benchmark indicators	Definition of indicator	Units	Data	Desired direction/target	Source
Environmental	2a	Biodiversity*	Nesting Swift Population	New Roost site created	0	UP	DCC
	2b	Green space/public space*	Local environmental quality	Under development		Up	DCC
	2c		Tree population/numbers	Under development		Up	DCC
	2d	Waste*	Construction waste recycling	% of projects where waste re used/ recycled	N/A	Target - to match national best practice	Design specification
	2e	Air*	Air emissions continually monitored union street, Seagate	Emissions of , NO_2 average $\mu g/m^3$	36.6/59.9	Down	DCC
	2f	Water*	Per capita water use	l/head/day P.E.	N/A	Target - to match national best practice	Design specification
	2g	Noise *	Noise level impact	Number of noise complaints	0	Down	DCC
	2h	Energy*	Energy consumption	Energy use/CO_2 per M2 of property	N/A	Target - to match national best practice	Design specification
	2i	Travel*	Public transport use	% Journeys	20%	Up	DCC
	2j		Bicycle Use	Number of journeys		UP	DCC

Table 3 Sustainable Development Benchmark Indicators - Social

Category		Benchmark indicators	Definition of indicator	Units	Data	Desired direction /Target	Source
Social	3a	Housing provision	Residential development	% of residential development	21%	21%	DCC
	3b	Health & Well being*	Economic opportunity?	16-19yr olds unemployment as %	4.64	Up	SET
	3c	Community*	Neighbourhood satisfaction	Qualitative	N/A	Up	DCC
	3d	Social Inclusion*	Accessibility of Waterfront services	%of buildings accessible to disabled people	100	100	DCC
	3e	Participation and responsibility	Participation in sustainable decision making	% stakeholder groups involved in decision		100	DCC
	3f	Active community participation*	Informal and formal volunteering	% Population	N/A	UP	DCC
	3g	Acceptability	Acceptability to stakeholders	%	96%	Up	DCC
	3h	Confidence	Public perception of confidence	Qualitative		UP	SET
	3i	Amenity value*	Public perception of amenity of Waterfront area	Qualitative		UP	DCC

3.1.2 Future proofing indicators

The current trend for carbon footprinting is an example of a monitoring or performance indicator that has recently risen in popularity. This demonstrates that reporting requirements may vary over time with changes in the popularity of different types of information. There is enough scope in the data collected to monitor the sustainable development of the Central Waterfront to future proof the proposed indicators regardless of reporting styles.

It is recommended that indicators should not be emphasised in isolation and should be reported in the context of sustainable development. This was stated by the Sustainable Development Commission Scotland in April 2007[xiii], with specific reference to climate change and carbon footprinting, as these aspects of sustainable development should be set within the UK Framework for Sustainable Development.

The indicators could, however, support additional reporting, complementary to sustainable development monitoring. In the context of Carbon Footprinting, the terms 'Carbon emissions' and 'Carbon Footprint' refer to CO_2 emissions. DEFRA has developed a calculator, which allows an individual or a household, to calculate the amount of carbon dioxide emitted as a result of their daily action. It also includes electricity use at home and personal transportation, and is aimed at helping increase public understanding of the link between individual's actions and behaviour and CO_2 emissions and, hence, climate change[xiv]. There are recognised limitations to these approaches as indirect emissions are not currently included, i.e. emissions resulting from waste disposal (or savings from recycling), or from the production of consumables, fuels, etc.

Therefore, based on the current DEFRA calculator, the proposed indicator Energy Consumption can be used to report CO_2. The energy consumption measured in kWhrs can be converted to CO2 to by using 100 kWhrs = 0.05 tonnes of carbon. Supplementary data would be required to allow Carbon

Footprinting e.g. on modes of transport, this could be collected from householders as required.

As part of the development process it was important to establish that there was sufficient scope in the variety of indicators to be robust to changes in reporting. Following an extensive review as part of indicator development in Phase 1, checks made with the Scottish Executive confirmed that they do not foresee any changes to their Sustainable Development indicators for 10 years.

The wide scope of the indicators should prevent them from being superseded and allow additional data to be collected, if required by the Partnership, to measure topical aspects of sustainable development. Continuous monitoring of the Scottish Executive and UK Framework for any developments will ensure that the monitoring indicators reflect any changes in sustainable development reporting practice.

3.1.3 The influence of the sustainability enhancement framework on the indicators

Mechanisms were established within the enhancement framework to influence the future direction of the indicators. The enhancement framework combined several activities in 2007, and these will be developed over the period of the research until 2010. A report on the enhancement activities undertaken will follow in December 2007, but a brief review of the current framework activities follows.

3.1.3.1 Sustainable development issues register

This is the main overarching activity, which involved identifying sustainable development issues arising during the design and phasing meetings that required further consideration. From January 2007 the researchers sat in on relevant design meetings with the consultants White Young Green and Dundee City Council (DCC). During these meetings the issues driving the design in relation to sustainable development were identified. These were then either raised and dealt with during the meeting or identified in the sustainable issues register to be fed back to design team through the 4Project management system and CDM processes.

3.1.3.2 Sustainable proforma development

A proforma was developed which listed project based sustainability indicators that were identified during Phase 1. This was issued to the consultants who were requested to provide data for the values of the indicators for their design options during the initial design approval process. Due to the timing of University of Abertay Dundee (UAD) appointment, the influence the proforma was limited as it was not used fully. There is a potential for the proforma to be used in optioneering during the design process at future stages.

3.1.3.3 Waste management and WRAP

Waste management support was provided through the sustainability brief to identify opportunities to recycle materials in the construction process. The aim of this activity was to link an understanding of the phasing of the project and the identification of opportunities for the specification of recycled materials during the design stage, to ensure best practice in recycling of materials in the tunnel strengthening project. Assistance included developing a strategy to identify quantities and types of waste arising from the tunnel strengthening programme, identifying the management options with reference to the waste hierarchy and monitoring the waste arising and maximise recycling to inform future waste management approaches.

3.1.3.4 Incorporation of existing activities in DCC

There are a number of documents such as the Dundee Sustainable Development Guide for construction[xv] which could be incorporated into the enhancement process for the next stage of Central Waterfront infrastructure design. These internal DCC documents may not currently be used in the decision process. The enhancement framework will encourage the use of these, and other guidance currently being developed such as the Sustainable Checklist, during the design process. Further recommendations on this will be given in the full report on the enhancement framework.

4 Understanding the indicators

This section gives further information on each of the Economic, Environmental and Social indicators to ensure their transparency and usefulness. Information is given on their purpose, on how they relate to UK Framework and Scottish Executive indicators of sustainable development and comments are given on future proofing and the sources of data. Finally, the influence of the existing enhancement activities (presented in section 3.1.3) on each of the indicators are identified.

4.1 Economic Indicators

4.1.1 Demographics (1a)

This indicator measures the Central Waterfront Masterplan objective of population increase within Dundee City Council boundary. This is a city/region wide indicator.

- When will the indicator change?
  Mainly at the plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues such building type, quality, number of residential areas during the design process and ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  This is a well established indicator with data sourced from General Register Office for Scotland. It is a contextual indicator for the UK Framework and Executive Sustainable Indicator set.

4.1.2 Retention of skills base (1b)

This indicator measures the Central Waterfront Masterplan objective in relation to graduate retention rate. This is a city/region wide indicator.

- When will the indicator change?
  Mainly at the plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues such building type, quality, employment type during the design process and ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator
  This is a well established indicator: data source NOMIS - Labour force survey.

4.1.3 Knowledge based employment (1c)

This indicator measures the Central Waterfront Masterplan objective in relation to knowledge based industries in Dundee. This is a city/region wide indicator.

- When will the indicator change?
  Mainly at the plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues such building type, quality, employment type during the design process and ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  This is a well established indicator: data source NOMIS – Annual business enquiry.

4.1.4 Employment (1d)

This indicator measures the sustainable development objective of employment rate as identified in UK framework indicators and Scottish Executive sustainable development indicator set. This is a city/region wide indicator.

- When will the indicator change?
  Mainly at the plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues such building type, quality, employment type during the design process and ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator
  This is a well established indicator: data source NOMIS – labour force survey.

4.1.5 Capacity to stimulate investment (1e)

This indicator measures the objective of encouraging investment as identified as an objective of the Waterfront Masterplan. This is a Waterfront specific indicator.

- When will the indicator change?
  Mainly at the plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues such building type and quality during the design process and ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  This is a well established indicator: data source NOMIS – labour force survey. It is not a UK government framework indicator but is in line with their strategy indicators.

4.1.6 Tourism (1f)

This indicator measures the affect that the Waterfront Development has on the number of tourists visiting city centre locations. This is a Waterfront specific indicator.

- When will the indicator change?

  At infrastructure provision and plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues during phasing of infrastructure, access to tourist locations, car parking, and information to public. Register will identify issues during plot development stage, access, publicity about regeneration and connectivity with the Waterfront and ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  This indicator uses data collected by Moffat Centre/Visit Scotland to monitor visitor numbers at visitor attractions. It is proposed to use visitor numbers at two locations discovery and sensation as indicators.

4.1.7 Regeneration (1g)

This indicator measures the effect of regeneration of the area through increased property value. This is a Waterfront specific indicator.

- When will the indicator change?
  Mainly at the plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement Activity	Influence
Sustainable Development Issues Register	The register will identify issues such building type and quality during the design process and ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator
  This indicator proposes using data collected by Scottish Enterprise Tayside (SET)/DCC.

4.1.8 Job creation (1h)

This indicator measures the Central Waterfront Masterplan objective in relation to Job creation. This is a Waterfront specific indicator.

- When will the indicator change?

  Mainly at the plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues such building type and quality during the design process and ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  This is an indicator measured by SET.

4.1.9 Economic output (1i)

This indicator measures the sustainable development and Central Waterfront Masterplan objective in relation to economic output. This is a city/region wide indicator.

- When will the indicator change?
  Mainly at the plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues such building type, quality and job creation during the design process and ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  This is a well established indicator recorded by SET and is a UK framework indicator and a contextual indicator for the Executive Sustainable Indicator set.

4.2 Environmental indicators

4.2.1 Biodiversity (2a)

This indicator measures the sustainable development of the Central Waterfront Development in relation to biodiversity. This indicator is Waterfront wide.

- When will the indicator change?

  At plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues during plot development stage in particular building design with respect to habitat creation and ensure the sustainability and Waterfront objectives are maintained in the design.
Existing activities DCC	Sustainable building guide

- Future proofing of indicator

  This is a well established indicator recorded by Tayside biodiversity action group and as a protected species is monitored on a regular basis. It is an indicator species suitable for representing the biodiversity of an urban area where building design directly affects the roosting numbers. Biodiversity is a UK framework indicator and the Scottish Executive use bird populations as an indicator for biodiversity.

4.2.2 Green space/public space (2b) and (2c)

This indicator measures the sustainable development of the Central Waterfront Development in relation to quality of green space and is a UK Framework indicator of environmental quality. This indicator is Waterfront specific.

- When will the indicator change?

  At infrastructure provision and plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues during design and phasing of infrastructure, tree removal during construction; green space provision and quality to ensure the sustainability and Waterfront objectives are maintained in the design. Register will identify issues during plot development to ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  2b is an indicator under development by Dundee City Council. As well as addressing the size of the green/public space the quality will also be assessed by qualitative scale under development.

2c is an indicator under development by Dundee City Council using tree numbers as an indicator of green space quality.

4.2.3 Waste (2d)

This indicator measures the sustainable development of the Central Waterfront Development in relation to Waste and it in line with UK Framework Indicators and Scottish Executive Sustainable Development indicators. This indicator is Waterfront specific.

- When will the indicator change?

  At infrastructure provision and plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues during design and phasing of infrastructure, identify opportunities to recycle material in construction. Register will identify issues during plot development in particular in materials used in building design and ensure the sustainability and Waterfront objectives are maintained in the design.
Waste management WRAP	Waste management approach to specify during the design stage, ensure best practice to maximise the use of recycled materials and ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  This is an indicator which monitors the effective use of material during recycling and is compatible with recycling objective on a national and

council level. Targets will be set with respect to the % of recycled material that will be used in the construction period

4.2.4 Air emissions (2e)

This indicator measures the sustainable development of the Central Waterfront Development in relation to air quality. This indicator is in line with UK Framework Indicators and Scottish Executive Sustainable Development indicators. This indicator is Waterfront specific.

- When will the indicator change?

  At infrastructure provision and plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues during design and phasing of infrastructure traffic routing and traffic management Register will identify issues during plot development traffic movement and air quality and ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  The air quality monitoring programme is on going at several locations in the Waterfront area as part of an air quality management. These locations will be continuously monitored. Data from DCC.

4.2.5 Water (2f)

This indicator was measures the sustainable development of the Central Waterfront Development in relation to water use. This indicator is Waterfront specific.

- When will the indicator change?

  At plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues during plot development building design in particular design specification, to ensure the sustainability and Waterfront objectives are maintained in the design.
Sustainable proforma	This can be developed to be used at building design stage to ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  This indicator is in line with UK Framework indicators in relation to water resource use.

4.2.6 Noise (2f)

This indicator measures the sustainable development of the Central Waterfront Development in relation to noise impact. This indicator is Waterfront specific.

- When will the indicator change?

  At infrastructure provision and plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues during design and phasing of infrastructure, and during the construction process and identify opportunities to mitigate noise. The register will identify issues during plot development for noise mitigation and ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  Noise is currently managed and complaints recorded by Dundee city Council.

4.2.7 Energy (2h)

This indicator measures the sustainable development of the Central Waterfront Development in relation to energy and associated carbon monitoring/carbon footprint. This indicator is in line with UK Framework Indicators and Scottish Executive Sustainable Development indicators. This indicator is Waterfront specific.

- When will the indicator change?

  At plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues during plot development building design in particular building specification to minimise energy requirements and ensure the sustainability and Waterfront objectives are maintained in the design.
Sustainable proforma	This can be developed to be used at building design stage to and ensure the sustainability objectives are maintained in the design.

- Future proofing of indicator

  This indicator is in line with UK Framework indicators in relation to resource use and CO_2 emissions.

4.2.8 Travel (2i) and (2j)

These indicators measure the sustainable development of the Central Waterfront Development in relation to public transport, non car use, and green transport use. These indicators are in line with UK Framework Indicators and Scottish Executive Sustainable Development mobility indicators. This indicator is city/region wide.

- When will the indicator change?

  At infrastructure provision and plot development stage

- How does the sustainability enhancement process influence the indicator?

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues during design and phasing of infrastructure in particular traffic routing and disruption to services and ensure the sustainability and Waterfront objectives are maintained in the design. The register will identify issues during plot development in particular traffic routing and disruption to services and ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  2i The % of bus journey to work is currently monitored and reported to the Scottish executive.

  2j DCC Green transport plan exists and this monitors the number of cycle journeys.

4.3 Social Indicators

4.3.1 Housing provision (3a)

This indicator measures the sustainable development of the Central Waterfront Development in relation to housing quality and reflects the masterplan objective of increasing the number of city centre residential properties. This indicator is Waterfront specific.

- When will the indicator change?

  At plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues during plot development building design in particular design specification, to ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  There is an aspiration of high quality residential development as part of the masterplan. This indicator is in line with UK strategy Indicators.

4.3.2 Health and wellbeing (3b)

This indicator was developed to monitor the sustainable development of the Central Waterfront Development in relation to health and wellbeing. This indicator is in line with UK Framework Indicators and Scottish Executive Sustainable Development indicators. This is a city/region wide indicator.

- When will the indicator change?

  At plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues during plot development building design in particular building type, to ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  There is an aspiration of improving the health and wellbeing of the population as part of the masterplan. This indicator is a UK framework indicator which is still under development. An indicator of economic opportunity has been used as data is available and is relatively easily understood. As Executive and UK indicators are developed, this indicator will be developed accordingly.

4.3.3 Community (3c)

This indicator measures the sustainable development of the Central Waterfront Development in relation to community. This indicator is in line with UK Framework Indicators and Scottish Executive Sustainable Development indicators. This is a Waterfront specific indicator.

- When will the indicator change?

  At plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	Register will identify issues during plot development building design in particular building specification, to ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  This indicator is a UK framework indicator and Executive indicator which is to reflect community regeneration and connectivity.

4.3.4 Social inclusion (3d)

This indicator measures the sustainable development of the Central Waterfront Development in relation to accessibility and social inclusion of Waterfront services. This indicator is in line with UK Framework Indicators and Scottish Executive Sustainable Development indicators. This is a Waterfront specific indicator.

- When will the indicator change?

  At plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues during plot development building design in particular building specification, to ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  This indicator is a UK framework indicator and Executive indicator which reflects social inclusion in the form of accessibility.

4.3.5 Participation and responsibility (3e)

This indicator measures the sustainable development of the Central Waterfront Development in relation to participation in sustainable decision making. This is a Waterfront specific indicator.

- When will the indicator change?

  At infrastructure and plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues during infrastructure design and phasing as opportunities to engage with stakeholders in the decision process and ensure the sustainability and Waterfront objectives are maintained in the design. The register will identify issues during plot development building design as opportunities to engage with stakeholders in the decision process and ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  This is an indicator which is to reflect participation in the decision making process which should lead to a more transparent decision making process.

4.3.6 Active community participation (3f)

This indicator measures the sustainable development of the Central Waterfront Development in relation to active community participation. This indicator is in line with UK Framework Indicators. This is a Waterfront specific indicator.

- When will the indicator change?

  At plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement Activity	Influence
Mechanism to be developed	The mechanism will influence community spirit and increase voluntary and community engagement and ensure the sustainability objectives are maintained in the design.

- Future proofing of indicator

  This indicator is a UK framework indicator and executive indicator which reflects community spirit and increase voluntary and community engagement.

4.3.7 Acceptability (3g)

This indicator measures the sustainable development of the Central Waterfront Development in relation to acceptability. This is a city/region wide indicator.

- When will the indicator change?

  At infrastructure and plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues during infrastructure design and phasing as opportunities to engage with stakeholders in the decision process and ensure the sustainability and Waterfront objectives are maintained in the design. The register will identify issues during plot development building design as opportunities to engage with stakeholders in the decision process and ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  This indicator will monitor the acceptability of the Waterfront Development at various stages of masterplan completion.

4.3.8 Confidence (3h)

This indicator measures the sustainable development of the Central Waterfront Development and the masterplan objective of confidence building. This is a city/region wide indicator.

- When will the indicator change?

  At infrastructure and plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Mechanism to be developed	Mechanism to influence confidence and ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  This indicator is designed to reflect the aim of the masterplan to increase confidence as a result of the central waterfront. Confidence levels survey through SET.

4.3.9 Amenity value (3i)

This indicator measures the sustainable development of the Central Waterfront Development in relation to amenity value of the area. This indicator is in line with UK Framework Indicators and Scottish Executive Sustainable Development indicators satisfaction in local areas. This is a city/region wide indicator.

- When will the indicator change?

  At infrastructure and plot development stage

- Influence of the sustainability enhancement process on the indicator

Existing enhancement activity	Influence
Sustainable Development Issues Register	The register will identify issues during infrastructure design and phasing in relation services, green space and ensure the sustainability and Waterfront objectives are maintained in the design. The register will identify issues during plot development building design as opportunities to engage with stakeholders in relation to services and greenspace provision, quality of environment and ensure the sustainability and Waterfront objectives are maintained in the design.

- Future proofing of indicator

  This indicator is a UK framework indicator executive indicator which is to reflect the amenity value of the Waterfront area.

5 Recommendations

5.1 Proposed work programme

To December 2007

There is still a period of indicator development to be undertaken to verify some of the indictors where data is not readily available, in particular for some of the social indicators. A period of consultation throughout the council is required to further test these indicators and ensure their robustness. This will be undertaken by working with individuals and groups throughout the council departments and should be complete by December 07.

January 08 - July 08

It is proposed that the next stage of indicator development is a further verification exercise with key stakeholders. The process will involve checking indicators in detail with the project team, identifying where the indicators can be improved, identification of alternative data sources and agree data collection methodologies. Where specific data is not already collected, resource implications will be identified at this stage.

A stage of wider verification is recommended to give an opportunity to engage with other departments in DCC, in particular where data is being sought for the benchmark indicators. This should increase the wider council involvement in the monitoring and enhancement process. Following this period of verification it is recommended that Dundee Central Waterfront Board formally agree these indicators to ensure high level buy in. It is proposed to undertake this activity from January 2008 - July 2008.

2008 monitoring indicator data collection and reporting will be undertaken from July – October 2008. A draft report comparing benchmark 2007 indicators with data collected 2008 will be submitted to council in October with the final report December 2008. Sustainable Enhancement Framework

activities will continue along side the monitoring activities and will be reported in details annually in December 2008**.**

5.2 Dissemination Activities

Workshops are proposed for council, consultants and SET to demonstrate how the indicators work and how the activities on the Central Waterfront affect the indicators. This should allow a wider understanding and awareness of the sustainable development implications of activities on the Central Waterfront.

A poster or presentation will be prepared for public events to illustrate thinking with regards to sustainable development and the due cognisance the Council is giving to sustainable development.

Wider dissemination activities of the monitoring benchmark indicators are recommend and the Phase 2 project proposal included an allowance for dissemination activities, some of which would be cost-reimbursable to UAD. Dissemination activities already undertaken include a paper on the framework approach as reported in Phase 1 scoping study report. This was presented at an academic conference 'International Conference on Whole Life Urban Sustainability and its Assessment' at Glasgow Caledonian University. This was well received and has been requested for submission to the Institution of Civil Engineers: Municipals Journals which should allow a wider audience to be engaged. The paper is included in Appendix A.

It is proposed that the report authors write an academic paper on the Sustainable Development Benchmark Monitoring Indicators for Dundee Central Waterfront for a peer reviewed journal such as the Institution of Civil Engineers Sustainability Journal. In addition to the journal, presenting the monitoring indicators as conference paper will also provide a robust test of the indicator and widen the dissemination of the activities which the council are undertaking.

The University of Abertay is undertaking a parallel project to develop an effective way of engagement with the public throughout the decision making process. A prototype visualisation tool is being developed to allow stakeholders to understand, interact with and influence decisions made regarding urban design. There is a large overlap between this project and the framework enhancement project and collaboration with the Council is already underway. It is hoped that this tool can be used to disseminate information to stakeholders as part of the Central Waterfront communication. A paper explaining the role of visualisation effective sustainability assessment is included in Appendix A.

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Appendix A

Dissemination Papers

International Conference on Whole Life urban Sustainability and its Assessment.
M Horner, C Hardcastle, A Price, J Bebbington (Eds)
Glasgow, 2007

A Sustainability Enhancement Framework for the Dundee Central Waterfront Development

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The paper presents ongoing research to develop a Sustainability Enhancement Framework for the major Dundee Central Waterfront urban re-development project. The enhancement concept recognises a need to ensure that sustainability is considered in decision making at all stages of major projects to ensure a more sustainable outcome overall. The paper will describe a set of procedures, developed by the authors and drawn from IT and knowledge management fields, to ensure the effective incorporation of the sustainability throughout the Waterfront Project decision making processes. The procedures include the production of Information Flow Diagrams to identify the wide range of stakeholders involved in the project and their means of interaction and Decision Flow Maps to identify and categorise the use of the information by the stakeholders. The paper will review current sustainability indicators related to infrastructure provision in the UK and Europe, emerging indicators from Scottish Executive, EU commission and research groups and will present a set of indicators suitable for enhancing the sustainability of the Waterfront Project. Two related sets of Indicators are proposed - Strategic 'Sustainable Development Benchmark Indicators' to monitor the overall sustainability of Waterfront Development as it progresses and 'Project level Indicators' to help make each decision within individual projects relatively more sustainable. Conclusions are drawn on the appropriateness of the indicators for assessing sustainable infrastructure provision and on the success of implementing the Sustainability Enhancement Framework

Key Words: Knowledge management, stakeholder participation, sustainability metrics and indicators

1 INTRODUCTION

The scale and importance of the Dundee Central Waterfront Development requires adherence to the principles of sustainable development and this must be demonstrated to the Scottish Executive, European funding bodies, private investors and the public. Sustainable development assessment provides a mechanism for the transparent inclusion in the decision making process of all the facets of a development through its use of diverse social, economic and environmental indicators. Currently, whilst there is a considerable body of research into sustainability assessment, there are no standard methodologies for its application to major regeneration projects.

The 30yr multi-million Dundee Central Waterfront Development to re-integrate the central waterfront with the city centre provides a unique opportunity not only to demonstrate the application of the principles of sustainable development, but also to develop and promote a methodology for wider use. The Central Waterfront development is an example of a major urban development project where typically strategic decisions are made early in the project, in this case in the form the Dundee Central Waterfront conceptual masterplan (Dundee City council, 2001). Whilst the master plan provides the basic direction for the sustainability of the development, the waterfront development itself will comprise of a number of sub project over the life of the development.

Decisions taken at various levels; outline design; option appraisal; detailed design, will influence the overall sustainability of the whole development. Therefore, an approach was developed which recognised that, in addition to monitoring overall sustainability of a large scale regeneration development, there was a requirement to develop a mechanism for ensuring that each sub project was undertaken in the most sustainable way.

This paper reports the findings of a scoping study which aimed to identify stakeholders involved in Dundee Central Waterfront Development, demonstrate how they interact, to review current sustainability indicators in the UK and Europe related to infrastructure and to identify emerging indicators from Scottish Executive, EU Commission and research groups. From these activities a list of indicators suitable for monitoring the sustainability of Dundee Central Waterfront was developed. Consequently, the scoping study provided the basis for the development of a procedure, which puts sustainable development theory into practice. The sustainable enhancement procedure identified ways to use sustainable development indicators to drive decision processes in the Waterfront Development in the most sustainable way. It will also provide a monitoring tool for demonstrating the sustainable development of the Dundee Central Waterfront.

2 SUSTAINABLE DEVELOPMENT

Sustainable development is a vision of progress, which integrates immediate and longer term needs, local and global needs, and regards society, environment and economics as inseparable and interdependent. However for many, sustainable development is often seen as a complex issue that is not definable in practical terms. The difficulty lies in defining sustainable development consistently due to its very broad nature; often any definition occurs in political statements that are rather general and open-ended. More focused definitions reflect the specifics of diverse fields ranging from agriculture, ecology, economics, construction, particular stakeholders and countries and therefore differ considerably (Dalal-Clayton and Bass, 2001).

In addition, interchanging terminology make the concept more difficult. For instance, the difference between sustainability and sustainable development has to be defined. Forum for the Future (2005) distinguishes between sustainability and sustainable development - sustainable means something has the 'capacity for continuance' and sustainability is therefore a 'quality'. Sustainable development is the process over time by which we achieve sustainability.

In its own definition of sustainable development, Forum for the Future emphasises this "*A dynamic process which enables all people to realise their potential and improve their quality of life in ways which simultaneously protect and enhance the Earth's life support systems".* The definition also highlights a key point often missing from other definitions, that a sustainable society is for *all people* and policy towards sustainable development should ensure that everyone has the opportunity to fulfil their potential and enjoy a high quality of life and is about equity, fairness and justice (Parkin, 2000)

Therefore, if any development can be described as sustainable, it must integrate economic, social and environmental issues. Although a large body of work has been undertaken to conceptualise sustainable development and there is a wide awareness of it, it is generally accepted that the real challenge lies in understanding how to put it into practice, i.e. to operationalise sustainability.

3 METHODOLOGY

The approach taken to enhance the sustainable development of Dundee Central Waterfront was the development of a sustainability enhancement framework and a monitoring tool. These approaches are based on the use of indicators in two different ways, firstly, to strategically monitor the overall sustainability of the development and secondly as a key part of the decision process. The core part of the enhancement framework approach is to identify and develop indicators that are appropriate and aligned with the current decision making process.

Indicators were developed to strategically monitor the overall sustainability of the Central Waterfront Development as it progresses. These benchmark

indicators will be used to monitor the whole development over time and to inform the Dundee Central Waterfront management group and funding bodies. The sustainability enhancement framework ensures that sustainable development has been considered at the project level to enhance the overall sustainable development of the Dundee Central Waterfront using indicators at the project level as part of the decision process.

An important aspect of the success of the enhancement framework is to ensure that it is formally imbedded in the decision process. Figure 1 shows the activities undertaken in scoping study and their outputs.

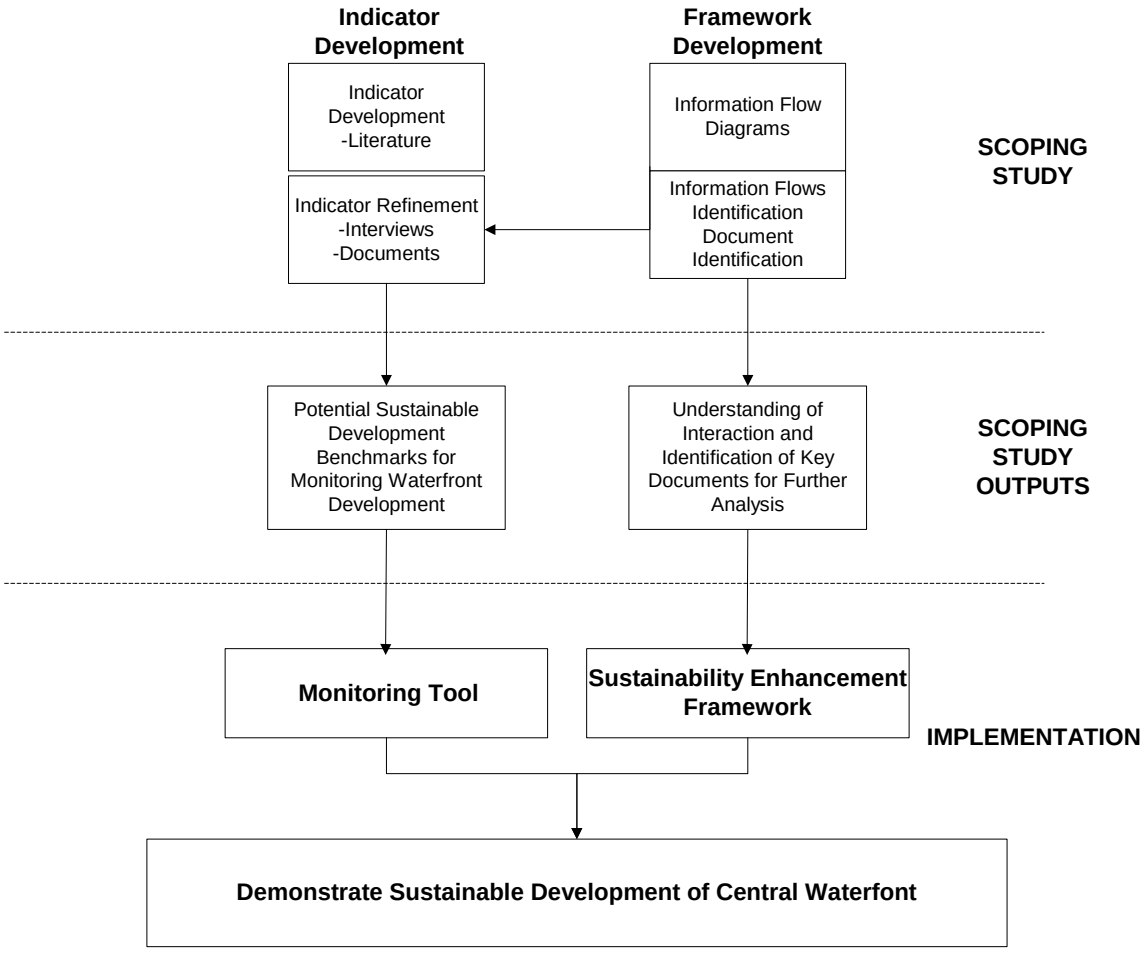

Figure 1: Activities undertaken in Phase 1 Scoping Study

3.1 Process of indicator development

The process of indicator development is shown in Figure 2 and consists of three main activities, literature review, interviews and document analysis. Indicators were developed using this process for both the benchmark indicators and the sustainability enhancement framework.

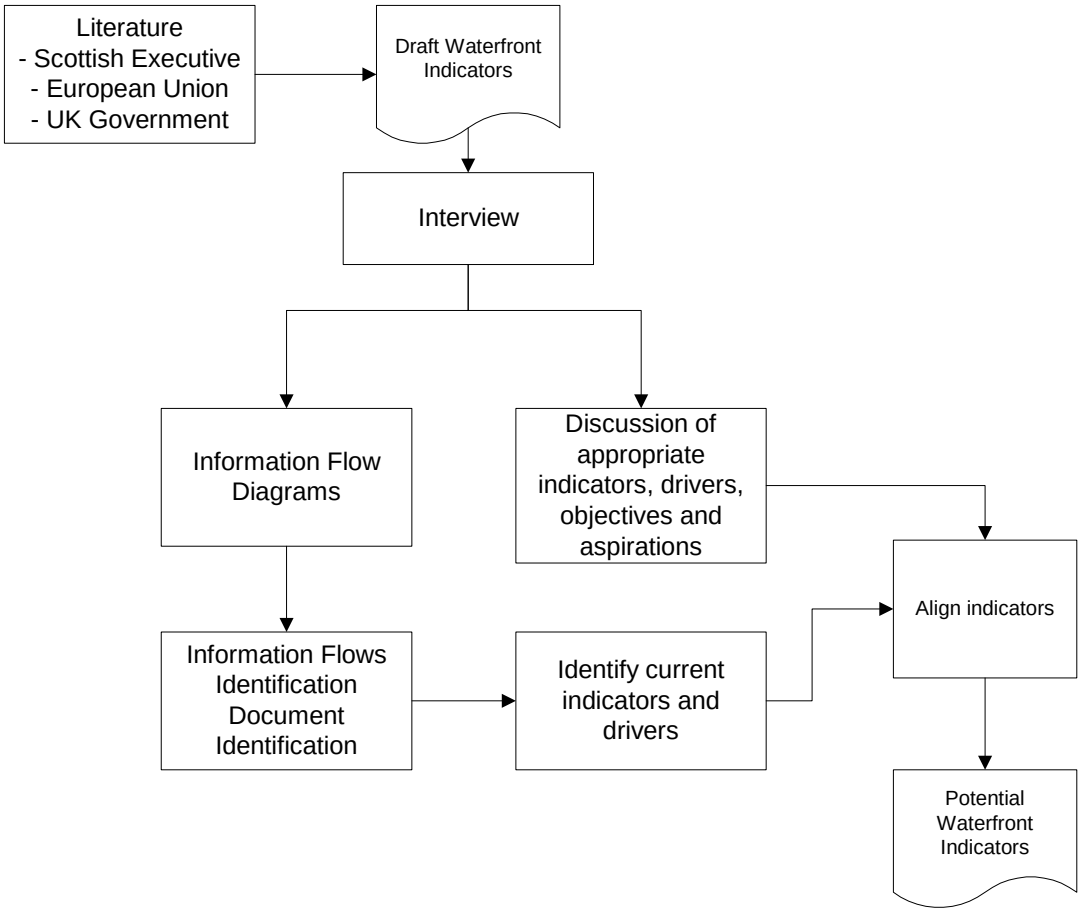

Figure 2: Process of indicator development

3.2 Literature review

3.2.1 Scottish Executive strategy for sustainable development

The scoping study reviewed sustainable development policy from EU, UK Government, Scottish Executive and Local Government, with respect to how objectives and aspirations have been interpreted into policy. Of direct relevance to the Dundee Central Waterfront Development is the Scottish Executive's position as stated in 'A Partnership for a Better Scotland (Scottish Exdecutive, 2003) "We want a Scotland that delivers sustainable development; that puts environmental concerns at the heart of public policy and secures environmental justice for all of Scotland's communities". The Scottish Executive further committed itself to this goal and the principles of sustainable development by publishing "Choosing our future –Scotland's sustainable development strategy" (Scottish Executive 2005) with four priorities for Scotland in response to the challenge of sustainable development. Figure 3 shows the context of the delivery of sustainable development in Scotland.

Figure 3: Governance and Delivery -the context for sustainable development
(Source: Scottish Executive 2005a)

3.2.2 Local Government Requirements

The main statutory guidance on Best Value and sustainable development is set out in s1(5) of the Local Government in Scotland Act 2003 (Scottish Executive , 2004). The legislation builds on work that Councils are currently undertaking, including their activities as part of Local Agenda 21 and Ministers consider that the legislation provides a special opportunity to embed sustainable development at the heart of local government in Scotland (Sustainable Scotland Network, 2005). It is also consistent with conclusions from the Earth Summits at Rio de Janeiro and Johannesburg in which local authorities have the vital role in delivering sustainable development. S1 of the Local Government in Scotland Act 2003 sets out the duty of local authorities to secure Best Value. S1(5) states that:

'The local authority shall discharge its duties under this section in a way which contributes to the achievement of sustainable development.'

This statutory requirement for local authorities to engage with sustainable development is new. Its location in the first section of the Act, which sets out the overall duty of Best Value – to secure continuous improvement in all aspects of local authority functions – emphasises its importance (Sustainable Scotland Network, 2005). The Local Government in Scotland Act 2003 establishes sustainable development as one of three cross-cutting themes, sitting alongside equal opportunities and joint working.

3.2.3 Indicators

The Potential Benchmark Indicators for the Central Waterfront Development have been developed from the literature reviewed. These are developed to reflect the UK Government Sustainable Development Strategy and the Scottish Executive Sustainable Strategy. A very large number of indicators are used across government to monitor the outcomes of policies. Experience from the 1999 Strategy suggests that the 147 indicators were in practice too difficult to use to determine overall progress (Scottish Executive, 2006). The other approach tried at that time was to have 15 headline indicators. These were used in the reporting process but could only provide an overview. A balance between these approaches is therefore needed.

In response to this, the UK Government Strategy has established a set of 68 indicators consisting of 20 UK Framework Indicators and a further 48 indicators to monitor progress. The framework indicators are relevant for Scotland and will be collected and reported by UK Government. The Scottish Executive have their own set of indicators 'Sustainable Development Indicator Set' (Scottish Executive, 2006) based on the policy in 'Choosing the future' (Scottish Executive, 2005a), their previous indicator set "Meeting the needs" (Scottish Executive, 2005b) was reported from 2003-2006. All three sets of indicators have been used to develop Central Waterfront Development Benchmark Indicators.

Each indicator document and policy document was reviewed and the relevant indicators shortlisted. Each indicator on the shortlist was reviewed to identify its appropriateness to the Waterfront Development, in relation to its scale, geographical area, units of measurement, and focus and direction. Indicators were then grouped into three categories, Economic, Environmental and Social. A definition for each indicator was then assigned together with draft units.

During the literature based development stage, the indicators were designed to align as closely as possible with Scottish Executive indicators to provide a basis for tangible reporting to the Scottish Executive, whilst providing clear and easily understood indicators for internal monitoring at the strategic level.

Where Executive/UK government indicators did not exist, specific indicators were developed. These were based on the authors' experience of sustainable indicator development (Smith 2002, Butler et al 2003, Foxon, et al, 2002) and on a range relevant sustainable urban development research papers. Unfortunately, most of the papers presented a conceptual understanding of the urban environment and identified key components of sustainability (McAlister 2005, Bartlet and Guthreie 2005, Boyko, et al., 2005) rather than presenting indicators. However, these key components were developed into indicators, which balanced Economic, Environmental and Social aspects of sustainable development.

3.3 Interviews

The draft literature based Benchmark Indicators were then refined through the process of interviews with key stakeholders with reference to the specific drivers, aspirations and objectives of the Dundee Central Waterfront Development. Interviews were held with members of staff to discuss the indicators and seek their views on their relevance. Each indicator was addressed in turn to verify relevance and improve their definition.

In addition, the interviews began to identify stakeholders' involvement in the Waterfront Development. The interviews collected data to illustrate the network of stakeholders for each role holder through the development Information Flow Diagrams. Each of the numbered information flows had a number of documents associated with it e.g. data, reports, meeting minutes. The Information Flow Diagram process was thus used to identify documents within the information flows, for analysis to enable further refinement of the indicators.

The series of interviews allowed the development of a number of Information Flow Diagrams for different stakeholders. This built up a picture of the stakeholders and their means of interaction. These were analysed to identify the best way to develop and implement the proposed framework.

In addition to Dundee City Council and SET personnel, the indicators have also been discussed with the Scottish Executive's Indicator Unit to review their suitability, and to establish any future developments they foresee in indicator use.

3.3.1 Interviewee 1 Project Coordinator

Interviews were undertaken with several participants, the example used in this paper is the Project Coordinator for the Central Waterfront Development. These were undertaken to refine the draft benchmark indicators and establish his network of stakeholders and the type of interaction he has with them. These are shown in the Information Flow Diagram Figure 4.

The project coordinator has responsibility for all facets of the project, as can be seen in the Information Flow Diagram. The interview identified the information flows and their nature (e.g. verbal communication, letter, meeting minutes, reports) and where appropriate, documents relevant to refining the indicators. Of particular relevance was the Dundee City Council Community Plan (2005), which was used in the document analysis phase. Other potential key flows were identified with the Urban Design Group, Development Quality, and Architect and Developers.

All the Information Flows are shown in Tables 1 and 2.

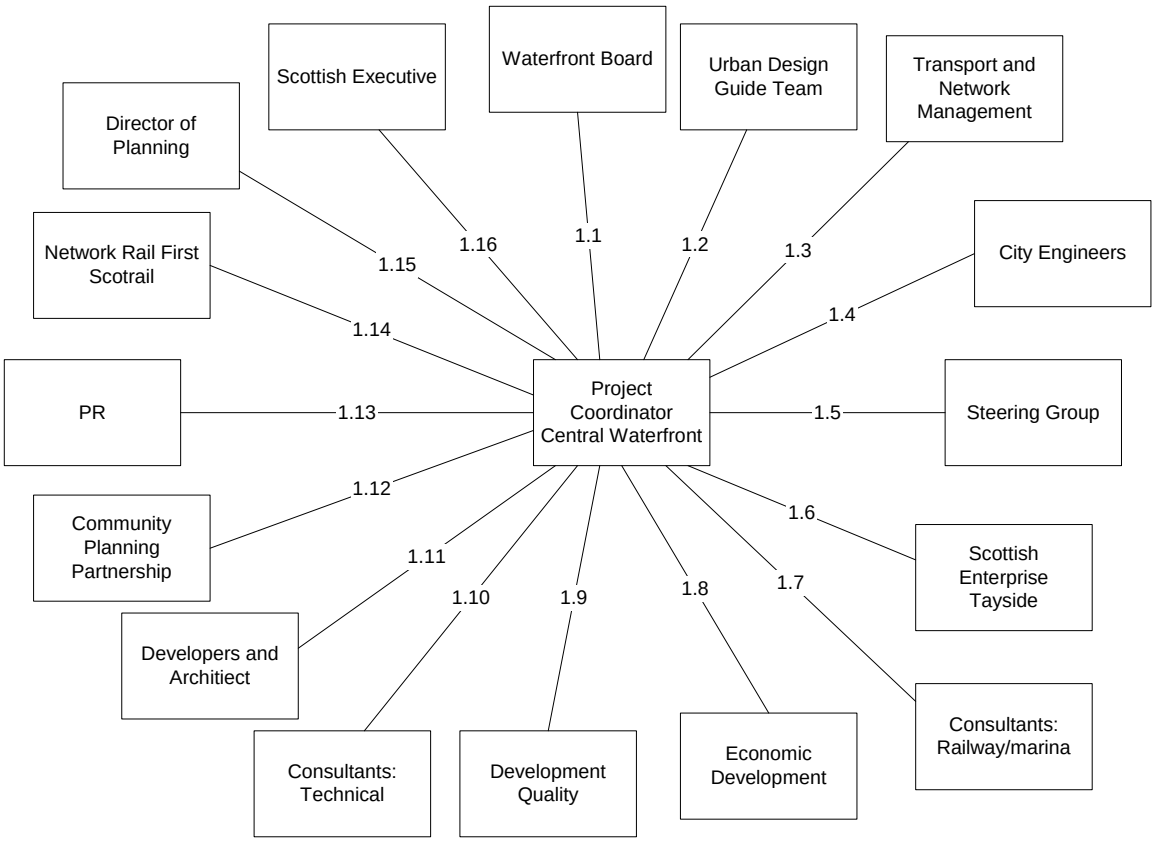

Figure 4 Information Flow Diagram - Project Coordinator Central Waterfront

Table 1 Information Flows Project Coordinator

Ref Number	Information flow	Ref Number	Information flow
1.1	**Waterfront Board**	**1.10**	**Consultants: Technical**
1.11	Report progress	1.101	Consultants report
1.12	Grant fund review	1.102	Data
1.13	Marketing update	**1.11**	**Developers and Architect**
1.2	**Urban Design Group**	1.111	Development quality
1.21	Guidelines	1.112	Brief from urban design guidance
1.22	Principles	1.113	Bid
1.23	Workshop results	1.114	Development control process
1.24	Urban design guide	**1.12**	**Community Planning Partnership**
1.25	Website sections	1.121	Reports
1.3	**Transport and Network Management**	1.122	Presentation
1.31	Departmental process	1.123	Updates
1.32	Capital plans	**1.13**	**PR & Marketing**
1.33	Marketing	1.131	Current economic development and marketing
1.34	Advice notes	1.132	PR department update

Table 2 Information Flows Project Coordinator (continued)

Ref Number	Information flow	Ref Number	Information flow
1.35	Public transport	1.133	Community council meeting
1.4	**City Engineers**	1.134	Briefing meetings
1.41	Copy emails	**1.14**	**Network Rail Scotrail**
1.42	Feedback	1.141	Property business development report
1.43	Updates	1.142	Briefing
1.44	Feasibility Report	1.143	Urban design guidance
1.45	Consultants reports	1.144	Negotiable
1.5	**Steering Group**	**1.15**	**Director of Planning**
1.51	Operational issues	1.151	Briefing notes
1.52	Progress reports	1.152	Cities growth fund annual report
1.53	Land transfer	1.153	Potential development
		1.154	Updating sharing information
1.6	**SET**	1.155	Urban design guide
1.61	Economic appraisal reports	1.156	Workshop results
1.62	Partnership arrangements	1.157	Meetings with developers
1.63	Property use	1.158	Development plan/proposals
1.64	Land receipts	**1.16**	**Scottish Executive**
1.7	**Consultants: Marina**	1.161	Annual reports-city growth fund
1.71	Consultants reports		
1.8	**Economic Development**		
1.81	Economic Reports		
1.9	**Development Quality**		
1.91	Developer proposals		
1.92	Design manual		
1.93	Meetings		

3.4 Document Analysis

Three key working documents have been used refine potential indicators in addition to the interviews. These were identified during interviews with Dundee City Council and SET personnel where several documents were identified for each information flow.

The documents were reviewed to identify potential indicators already in use and associated data availability. They were also used to develop indicators, which match the objectives and aspirations stated in the documents, and verify the potential relevance of indicators under development.

Each document has been used to align the benchmark indicators so that their wider relevance is assured.

4 POTENTIAL SUSTAINABLE DEVELOPMENT BENCHMARK INDICATORS

The potential Sustainable Development Benchmark Indicators for the Waterfront Development are given in Tables 3 to 5. The * denotes that the indicator is based on the UK Government or Scottish Executive Framework Indicator, but in most cases the definition has been adjusted to be more relevant to Dundee Central Waterfront. In some cases an indicator has been identified but not yet developed, with the definition requiring further work in Phase 2.

5 CONCLUSIONS

The aim of the scoping study was to identify stakeholders involved in the Waterfront Development, to demonstrate how they interact, to review current sustainable development indicators, and to develop a list of indicators suitable for monitoring and enhancing the sustainable development of Dundee Central Waterfront. The Information Flow Diagrams have identified the wide range of stakeholders involved in the Waterfront Development and their potential means of input to the Waterfront projects. The diagrams also reveal a high degree of public engagement on the process, which is essential for the assessment of the social aspects of sustainable development.

The review of current sustainable development indicators in the UK and Europe and of emerging indicators from the Scottish Executive, EU Commission and research groups enabled an appropriate list of relevant benchmark indicators for monitoring sustainable development to be developed, refined and proven to be robust via interviews. Additionally, project based indicators for the Sustainability Enhancement Framework were identified which will be used to influence decisions taken in all stages of the project.

The success of the enhancement framework depends on its ability to influence the decision making process, rather than to just monitor the overall sustainability of the Waterfront Development. The scoping study has ensured that the framework will be effective and fit in with current decision making processes. Information flow diagrams have been used to identify stakeholders' means of interaction and the diagrams and tables demonstrate the information received and passed by the interviewees. This information will be analysed more fully in an implementation stage over the next three years. Decision mapping techniques will be used to identify how stakeholders use the information and hence identify crucial decision points. This will guide the framework to further ensure its real world applicability its full integration with the Waterfront Development decision making processes as an integral part of the sub-projects design approvals process.

The development of the enhancement framework continues but there is sufficient evidence from the scoping study that the framework will influence sub-project level decisions and will provide an effective means of enhancing the overall sustainability of the Dundee Central Waterfront Development.

Table 3 Potential Sustainable Development Benchmark Indicators - Economic

Category	**Benchmark indicators**	**Definition of indicator**	**Units**
Economic	Demographics*	Population retention	Population number
	Retention of skills base	Graduate retention rate	% Student staying
	Capacity to stimulate investment*	Total investment	£ Inward investment
	Tourism	Number of tourists visiting Dundee	Number of visits
	Property Value	Increased property value	% Increase
	Job creation	Number of jobs created	Number
	Whole life cost of infrastructure	Capital and recurrent cost of infrastructure	£ Over life of infrastructure
	Economic output*	Growth over economic cycle	£

Table 4 Potential Sustainable Development Benchmark Indicators - Environmental

Category	Benchmark indicators	Definition of indicator	Units
Environmental	Biodiversity*	Priority Habitats	Number of habitats
		Priority Species	Number of species supported by habitat
	Green space/public space	Local environmental quality	Unit to be developed
		Design of safer places	Unit to be developed
	Waste*	Waste recycling	% of waste reused/recycled
		Waste arising by sector	Volume
	Air*	Air emissions	Emissions of CO2, NOx
	Water*	Loads to receiving water	Unit to be developed
		Domestic water consumption	Unit to be developed
	Noise	Noise level impact	Unit to be developed
	Energy*	Energy consumption	Unit to be developed
		Renewable energy	%
		Embedded energy	Unit to be developed
	Travel*	Public transport use	% Journeys

Table 5 Potential Sustainable Development Benchmark Indicators - Social

Category	Benchmark indicators	Definition of indicator	Units
Social	Housing provision*	In relation to housing quality standard	% of houses of high quality
	Health & Well being		
	Employment*	Employment rates	% Population
	Social cohesion	Community spirit	Qualitative
	Social Inclusion*	Accessibility of waterfront services	% Population
	Participation and responsibility*	Participation in sustainable decision making	% Population involved in decision
		City centre action groups	
		Individual action for sustainable development	% Taking action
	Active community participation	Informal and formal volunteering	% Population
	Acceptability	Acceptability to stakeholders	Qualitative
	Confidence	Public perception of confidence	Qualitative
	Amenity value		

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The Role of Visualisation in Effective Sustainability Assessment

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ABSTRACT

Sustainable decision making in urban design is a complex and non-linear process that requires the interaction of a wide variety of stakeholders. A number of sustainable decision support tools have previously been developed but a major barrier to the implementation of these tools is the complexity of the environment in which decisions are made. In particular, engagement with the general public throughout the decision making process presents challenges. These include communicating the complex and interdependent facets of sustainability and also demonstrating the short and long term implications of alternative courses of action.

This paper describes the underlying concepts of a prototype visualisation tool (S-City VT) that will allow stakeholders to understand, interact with and influence decisions made regarding sustainability of urban design. The Dundee Waterfront Development Project will be used as a case study. The S-City VT simulation will model the relationship between the various sustainability indicators and the effect of choosing a particular set of indicators will be brought to life through an animation-based simulation. The model can also be used to identify possible trade-offs between the facets of sustainability.

Key words: Urban Sustainability, Virtual City, Modelling, Visualisation

1. INTRODUCTION

Sustainable decision making in urban design is a complex and non-linear (iterative) process and requires the interaction of wide variety of stakeholders. Effective sustainability assessment is, therefore, dependent on genuine stakeholder contribution during the decision making process, but the current prevailing practice is for decision makers to seek agreement for proposals once the key decisions have been made (Geldof, 2005). Tools to support the decision process are commonplace but there applications are dominated by the perceptions of "expert" decision makers (e.g. planners, architects, and design engineers).

Many researchers have concluded that a major barrier to the development and implementation of tools to support sustainability assessment in urban design is the complexity of the environment in which decision are made (Bouchart, et al, 2002, Hull &Tricker, 2005). In particular, engagement with the general public throughout the urban design process presents challenges in communicating not only the complex and interdependent facets of sustainability in decisions, but also in providing an understanding to stakeholders of the short and long term implications of alternative courses of action. The flow of information between the "expert" decision makers and the wider stakeholders communities is shown in figure 1.

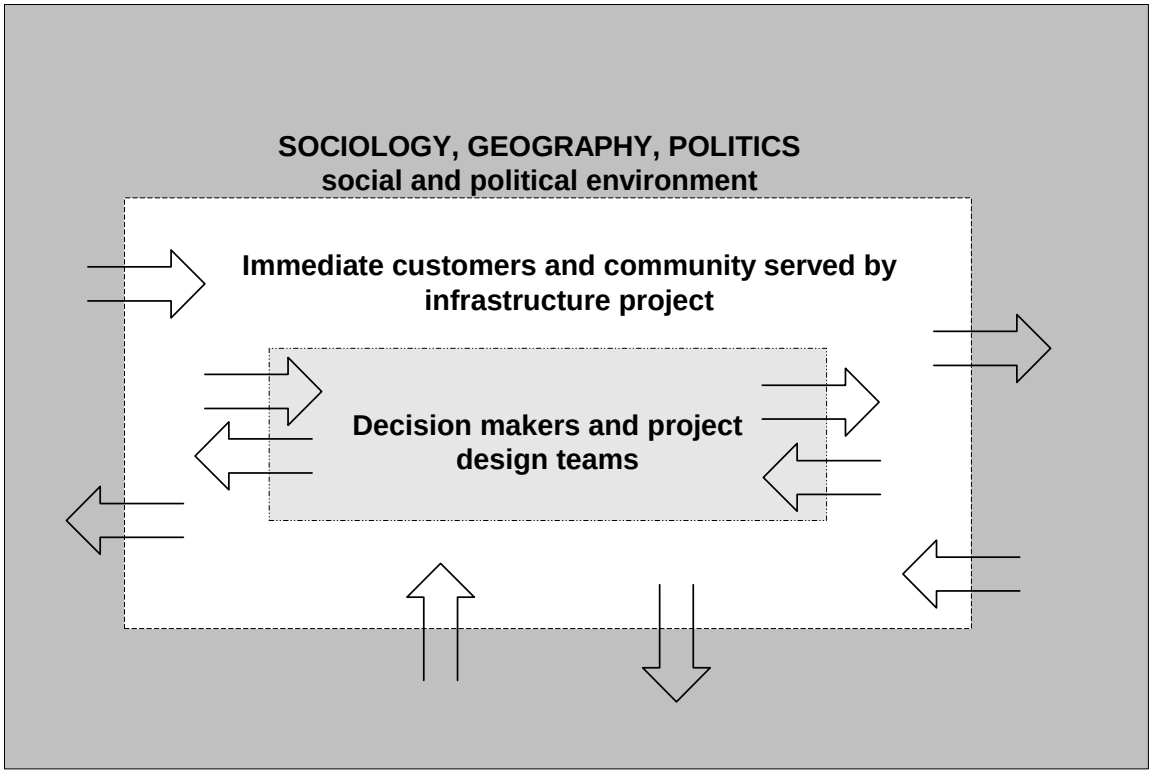

Figure 1: Stakeholders, boundaries and information flows (Adapted from Gilmour et al., 2005).

The centre of the figure (the first tier) represents the decision makers and project design teams, usually technical or planning specialist within local or national government organisation or within consultants engaged by these bodies. The second tier represents the immediate customers and the communities served by the infrastructure and the third tier represents the societal, geographical and political frameworks within which the customers and communities are located. The arrows represent the required information flows across the possible boundaries if all aspects of sustainability are to be considered by the decision makers and design teams.

It is therefore believed that there is a need for new decision support tools that can deal with the complexity of urban design and which go beyond the technical orientation of previous tools (Sahota & Jeffery, 2005) to enable a robust assessment of sustainability within the decision-making processes.

The key component of such tools is visualisation to aid interaction between stakeholders. Visualisation has been used to visualise and analyse changes in the urban design arena (Shellito et al., 2004, Semboloni et al 2004) and to model the best options for sustainable transport systems (Kurt, 2004). However, none have been used to communicate to and integrate the various stakeholders to improve sustainable decision-making and stakeholder interaction.

2. HIVE PROJECT

The Haptic Intelligent Virtual Environment (HIVE) has been developed at the University of Abertay Dundee to create an immersive visualisation suite. The aim of the HIVE is to allow a user or group of users to interact fully with the virtual environments created. The research project described here is one of four interdisciplinary studies that will use the HIVE facility to develop novel visualisation approaches for complex data sets. Specifically, an aim of the research is to develop and validate a prototype visualisation tool that will enable the engagement of wider stakeholders, who would not otherwise understand the overall complexity and interaction between the facets of sustainability, to allow iteration on the virtual development before the real development is created. The decisions will be brought to life through an animation based simulation through time of the case study project. The research team will use the HIVE to develop a prototype visualisation tool that will enable stakeholders to understand, interact with and influence decisions made on the sustainability of urban design, based on a major urban redevelopment case study.

3. DUNDEE CENTRAL WATER FRONT DEVELOPMENT.

In 1998, the Dundee City Council and Scottish Enterprise Tayside formed the Dundee Partnership to look at potential options for re-developing the Dundee Central Waterfront to enhance its integration with the City Centre. The

outcome was a 30-year Masterplan to completely remodel the area as shown in Figure 2 to remove one of the last remaining major blights on the city's image and townscape. It will create a high-quality, mixed-use, riverside urban-quarter right in the heart of the city. Dundee City Council have adopted this Masterplan for the purposes of controlling future development in the Central Waterfront area; all applications for planning permission will be expected to be in conformance with the Masterplan in order to protect the long term development potential of the area.

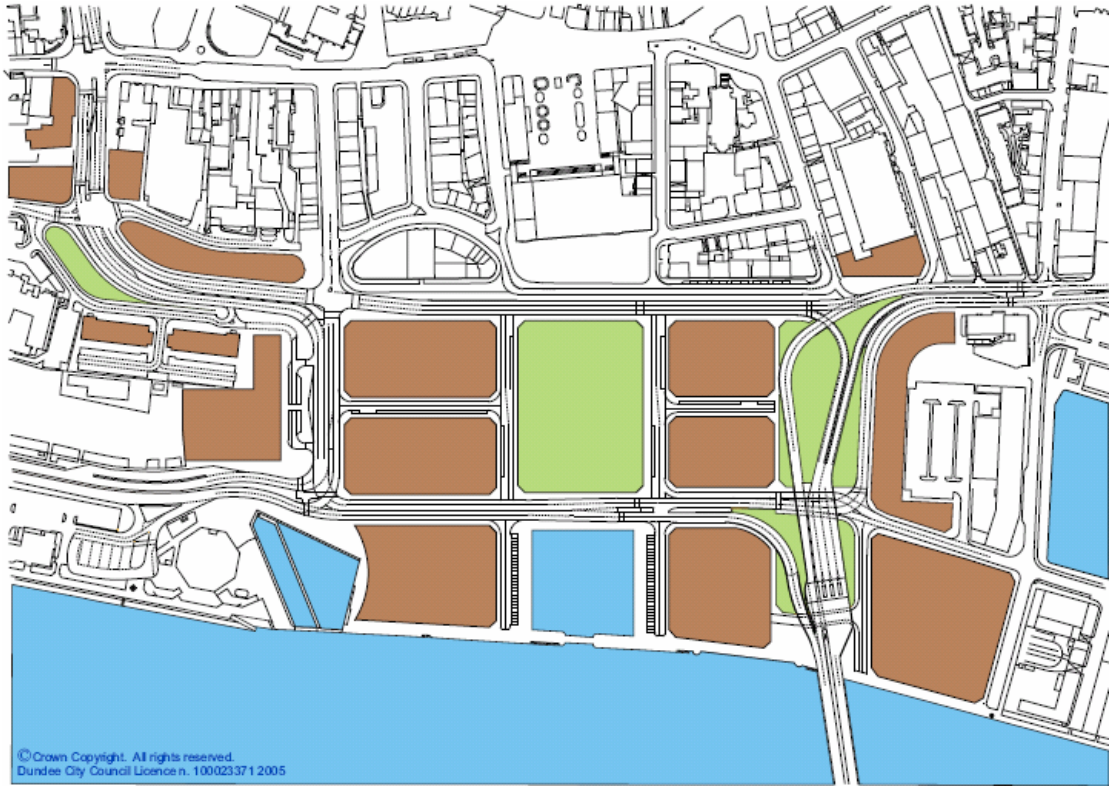

Figure 2: Dundee Central Waterfront Development Plan.

The main components of the development are; the extension of the city centre down to the waterfront, the creation of a new grid iron street pattern, improved provision for walking, cycling and buses, the reduction of the effect of cars and parking, the removal of some of the Tay Road Bridge ramps, the creation of a pair of east/west tree lined boulevards, provision of sites for a variety of mixed use developments, the formation of a major new civic space and re-opened dock, the provision of a new rail station and arrival square. The research team has been commissioned by Dundee City Council to develop a sustainability enhancement framework for the development (Gilmour et al., 2007) and the visualisation tool will form part of the framework.

4. REVIEW OF EXISTING VISUALISATION MODELS

A number of decision support tools have been created to address the complex issues involved in sustainability assessment within the decision making

process for urban developments. There has been huge effort and resources put into creating these DSTs, yet despite this most are never or hardly ever used (Sahota & Jeffrey, 2005). There are a number of reasons for this lack of uptake, usually the decision support tools are designed for a single purpose, to investigate transport issues for example, or that the systems become so generic that any detailed results are lost. Some existing decision support tools are outlined below.

4.1 The BEQUEST Toolkit

The BEQUEST (Building Environmental Quality Evaluation for Sustainability through Time) toolkit is a modular system designed "to support decision maker concerned with urban sustainability" (Bequest, 2001). The toolkit is composed of 4 modules: protocol, assessment methods, advisors and glossary.

BEQUEST is a web-based system that provides generic information about sustainable development. The toolkit provides the users with textual results such as assessment techniques, which can be used to examine the development at different stages or a list of advisors who could advise about the relative sustainability of a specific part of the development. The toolkit provides a good level of integration across the problem domains; however it does not contain any scenario, impact analysis or policy options.

4.2 STEEDS (Strategic Transport Energy Environment Decision Support)

STEEDS is a "Decision Support System (DSS) able to assist the policy makers in exploring the influences on market take-up of different transport technologies" (Brand et al. 2001). Steeds is based around a set of scenario and policy options, combined with five interacting subsystem models, the results of the model are then collected as a set of alternatives. The alternatives provided by the model can then be investigated in graph form or evaluated using multi-criteria analysis (Brand et al. 2001).

Although the subsystems approach STEEDS implements, provides extensive scenario and policy options coupled with impact analysis, these are based solely on environmental aspects of the transport sector. This severely limits the systems effectiveness in anything but transport developments, and even then STEEDS does not account for social and economic aspects.

4.3 SUTRA (Sustainable Urban Transportation)

"The primary objective of SUTRA is to develop a consistent and comprehensive approach and planning methodology for the analysis of urban transportation problems, that helps to design strategies for sustainable cities" (SUTRA, 2006). SUTRA is a web-based system which uses an indicator based simulation model combined with social, environmental and economic impact analysis. (SUTRA, 2006). Similar to STEEDS, SUTRA provides the user with extensive scenario and impact analysis support however Sutra's

main advance over other decision support systems is the way in which the results are presented to the user.

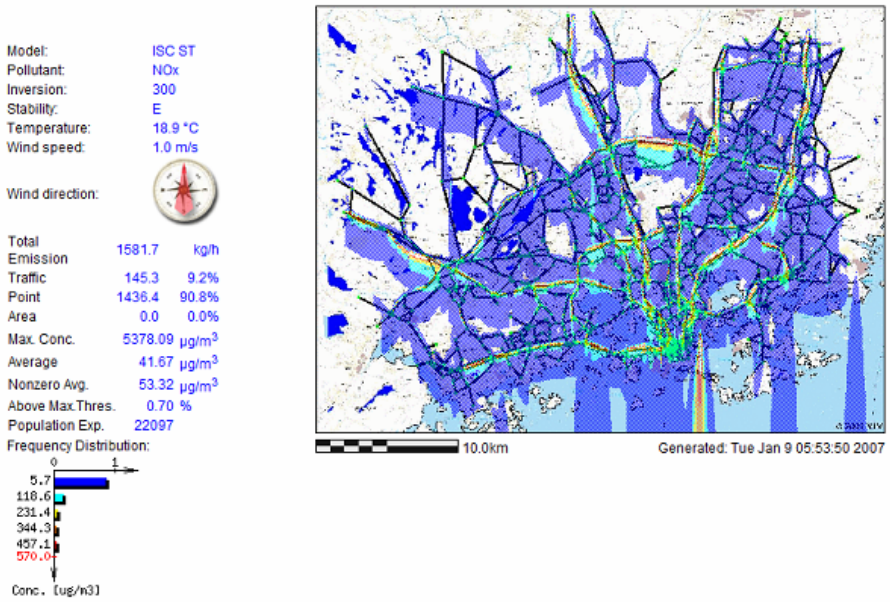

Figure 3: SUTRA Simulation Screen (SUTRA, 2006).

Using SUTRA the user is no longer presented with complex graphs or tables but instead can view the impact of decisions they have made in real-time, projected on a map of the area or city being investigated. Figure 5 shows an example simulation of NOx release from traffic in Helsinki. This approach of animated, visual results opens the system to use by non-expert stakeholders, e.g. the general public. SUTRA is however limited due to the fact it is only designed to simulate transport issues and not overall urban development, there is also little suggestion or ranking of alternatives.

4.4 AUSTIME (Assessment for Urban Systems Through Integrated Modelling and Exploration)

The AUSTIME methodology was designed to combine “systems analysis, sustainability assessment based on system thresholds and multiagent simulation for scenario exploration” (Daniell et al, 2005). The methodology describes how to create a decision support system to provide sustainability assessment of a specific scenario.

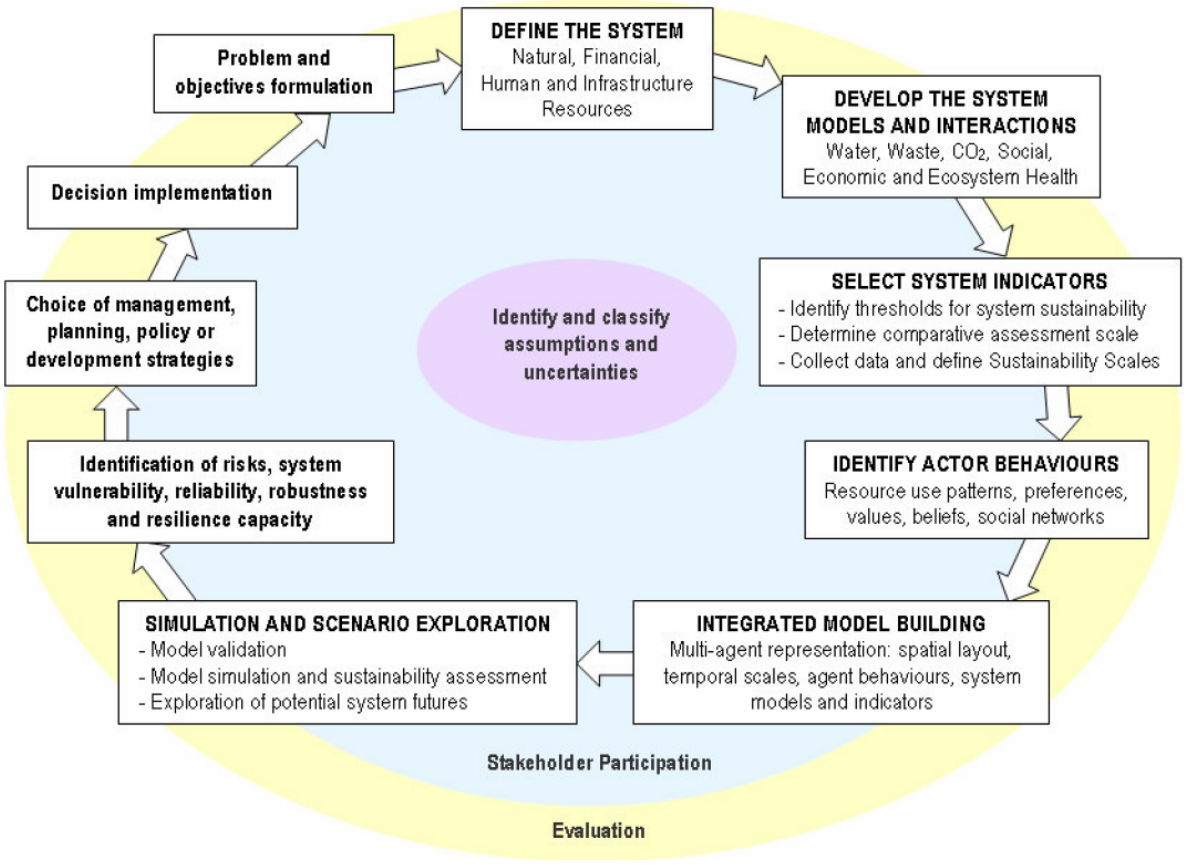

Figure 4: AUSTIME development methodology. (Daniell et al, 2005).

AUSTIME was used to create a prototype model and perform a sustainability assessment of a development in Adelaide, Australia called Christie Walk. The model produced contained six sub-system models (water, CO_2, waste, eco-system health, economic and social) each of which could act independently to simulate their respective aspects, the sub-systems were then combined to create a single integrated model which could simulate the sustainability of the development as a whole. The results of the prototypes application to the Christie Walk development were used to show, using graphs, what affects changes in some of the sustainability aspect , water use or CO_2 output for example, would have on the developments over-all sustainability. (Daniell et al, 2005).

The prototype created using the AUSTIME methodology for the Christie walk case study seems to effectively simulate the sustainability of the development for the aspects which were included in the model. The prototype however was weighted towards environmental aspects possibly due to the fact that the Christie walk development was specifically designed “demonstrate the vision for an ecological city” (Daniell et al, 2004). The prototype also used very few indicators, one in each subsystem, and only allowed the simulation of changes in these indicators on a fixed development. There was, for example no provision for moving an entire building, or changing a building material and

exploring this changes affect on the developments sustainability. The user would be required to know the affect of their actions on the included indicators to enable them to determine the results of their actions, this makes the system extremely hard, if not impossible, to be used effectively by non experts.

5 S-CITY VT

The review of the existing sustainability decision support tools has shown that there is no single tool which can effectively support the decision making process for every aspect of a whole sustainable development. This project aims to create a prototype tool, S-City VT which will allow stakeholders, involved in the urban planning process to understand, interact and influence decisions made regarding the development of sustainable urban environments. As a proof of concept the prototype will attempt to model the sustainability of the regeneration development of Dundee's waterfront.

The development of the prototype is twofold. Initially a simulation model will be developed which integrates and combines the sustainability indicators from the various social, economic and environmental domains. Secondly a front-end visualisation tool will be developed which will demonstrate the evolution of a 'potential' development for a given set of indicators.

5.1 Prototype Requirements

The development of the prototype will adhere to a number of criteria outlined in Kapelan et al. 2005. been used to create a number of requirements which the prototype should fulfil.

The requirements for the simulation model are to enable:

- a high level of integration across different domain criteria and indicators;
- detailed impact assessment of proposed action and developments;
- modelling of possible future urban scenarios;
- the inclusion of pre-built policy options, government & council laws or guidelines;
- an evaluation of solutions to problems based on a user selected criteria ranking system;
- calibration and validated using sufficient quantity/quality of observed data;
- computational efficiency without reducing usefulness.

The requirements for the simulation model are that it should:

- Include 3D/virtual reality visualization techniques.
- Provide spatial and temporal scales.
- Include a 'rich', graphical user interface to allow use by non-experts.
- Allow the possibility of group decision making and communication.

5.2 Development of the Prototype

Figure 5 shows the structure of a prototype system which fulfils the requirements outlined in the previous section.

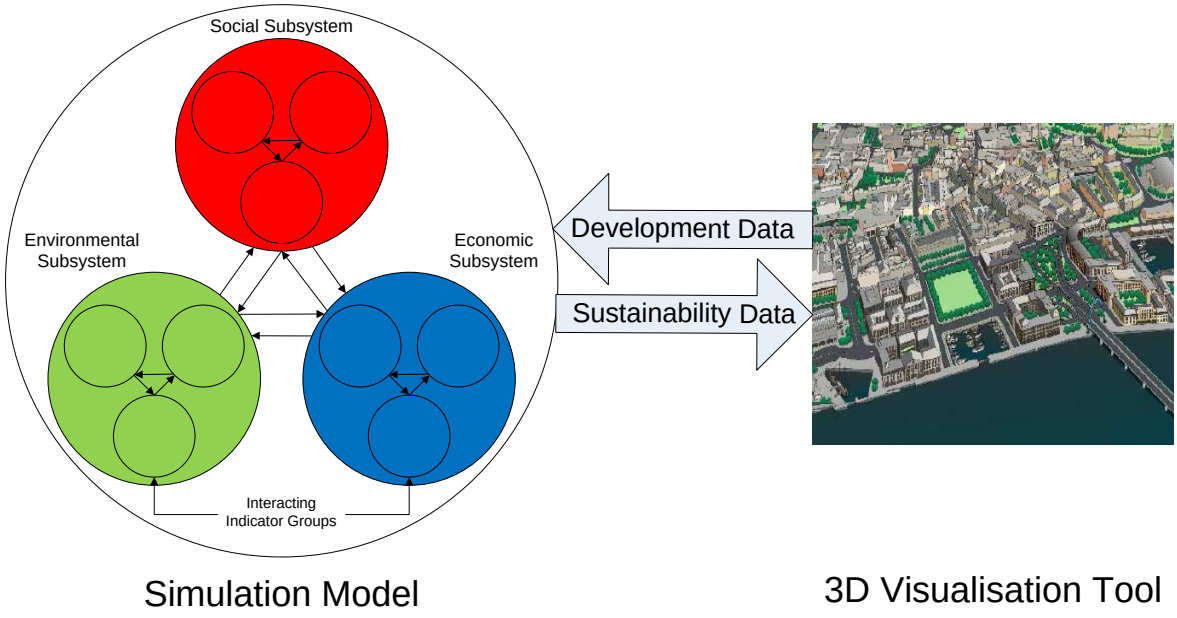

Figure 5: Structure of the proposed prototype.

The development of this prototype will require the following steps.

Identification of indicators

The economic, social and environmental sustainability criteria will be sourced directly from Dundee City Council. This will involve discussions with the council stakeholders about which criteria they require and whether the modelling and visualisation of these criteria is possible. The indicator values used to measure these criteria will also come mostly from council data. However it may be necessary to acquire some of the data, especially for social aspects, from other sources, such as through the development and use of questionnaires for the general public.

Identification of indicator scales and weightings

The indicator data will be used to develop scales of sustainability for each indicator. An example of how this can be achieved is shown in fig 4. Each indicator will also be examined to determine how strongly it affects the other indicators, i.e. its weighting.

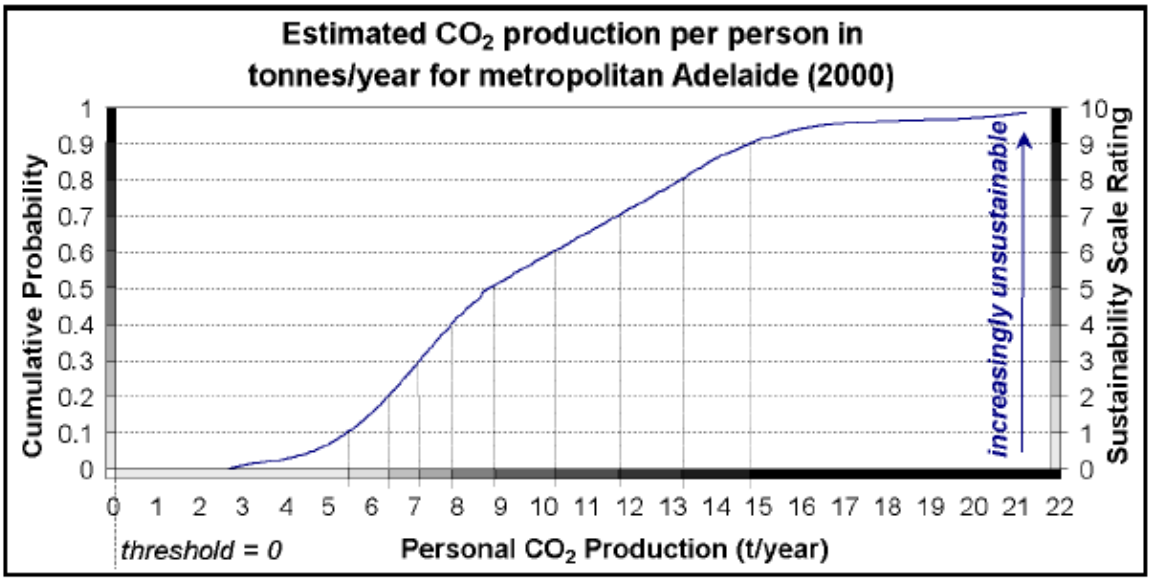

Figure 6: Example indicator scale. (Daniell et al, 2005).

Development of subsystem models.

From the indicator data collected, relationships and interactions among the indicators will be identified. These interactions will be described by algorithms which will model how changes in one indicator affect the others, effectively creating small models of each part of the system. It is envisaged that subsystems will be developed for different aspects of the overall system. There will be at least 3 subsystems relating to social, economic and environmental indicator groups.

Determination of actor behaviour.

At this point in the model development it will be necessary to determine how the behaviour of the actors (residents or workers), who will be using/living in the proposed development will affect the model and the indicators used. This investigation may include more public surveys to determine behaviour patterns of the general public, for instance, how far a person is happy to walk to resources such as bus stops or shops. These actor behaviours will affect the simulation model as a whole and may not be adequately described by a single subsystem.

Development of integrated model.

An integrated model can now be designed by combining all the smaller system models together with the affect of actor behaviour. It is hoped that it will be possible to view results for the entire development area (the waterfront) and allow a scaling ability down to a single street or building. Temporal scales should now also be considered; the model should allow data to be modelled from the present day up to the project proposed completion date, approximately 30 years time. (Dundee City Council, 2001).

Exploration & development of scenario options.

The model will now be able to simulate the current system with no changes; however it is the purpose of the prototype that will be able to assist in planning decisions of the stakeholders involved in the development. As this is the case it is necessary to introduce scenario modelling and impact assessment components into the integrated model. As has already been stated in the requirements, the model should contain a number of built-in scenarios. The development of the built-in scenarios will require research into the affects, or projected affects, of different types of global scenarios such as nearby factory closures or global warming, or local scenarios such as the position of traffic lights or residential buildings, on the indicators. These built-in scenarios will allow the stakeholders to enter the minimum amount of data, such as position of traffic lights or projected temperature rise, but receive a detailed description of the effect that these scenarios will have on the development. (Brand et al., 2001). The model must also allow a stakeholder to create their own scenarios, such as drastic changes in population types. This will involve a detailed user input describing the affect of the scenario on one or more criteria, the model will then create the scenario and determine its affects on the other indicators and so the over-all sustainability of the system. (SUTRA, 2006).

Investigation and Development of policy options.

The model must be able to describe the affect of changes in government policy on the indicators and hence their affect on the proposed development. Should the council for example introduce a citywide recycling policy, the model should be able to show the affects that this policy will have. Proposed government and council policies should be investigated to determine how they would affect the indicators and the subsystem models. The model should also allow the user to create their own policies to describe the affects of unforeseen government policy introductions throughout the lifetime of the development. Again this will require detailed user input on how the new policy will affect one or more of the indicator groups.

Investigation & Development of criteria ranked solutions.

The impact assessment component of the model will display the affect of a number of solutions for proposed decision and attempt to rank them based on criteria selected by the stakeholder. This will allow the stakeholder to determine the best possible solution for them. Figure 7 shows a decision matrix, which details the suitability of a number of different scenarios for different types of stakeholders.

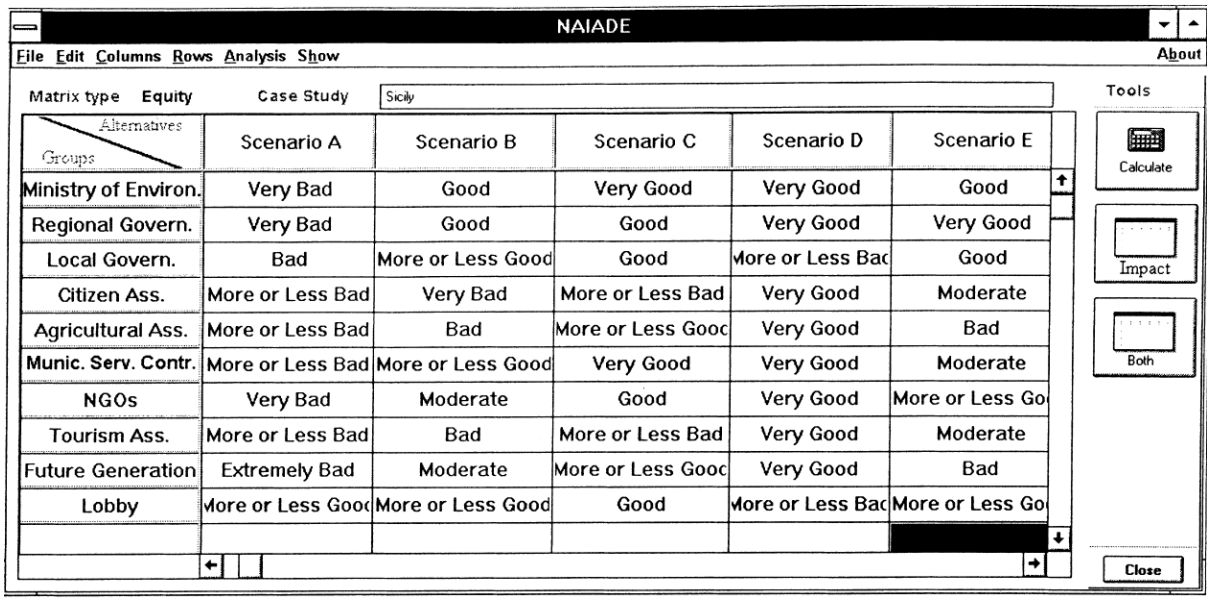

Fig 7: Example decision matrix (Hasstrup et al, 1997).

Due to the highly complex components, the indicator interactions, of each decision, the development of the impact assessment component of the model will require the investigation of different ranking techniques. As the suitability of each scenario will not be based on single factor, the ranking/organisation of the possible scenarios will require the use of complex algorithms. This may include the use of a genetic algorithm, where the solution of best fit may be found from a given data set. (Carson & Maria, 1997) Or the use of a ranking technique such as PROMETHEE (Brands & Vincke, 1985) or ELECTRE TRI. (Mousseau et al, 2000).

Model optimization

The inherent complexity of sustainable development as a consequence of the large number indicators, leads to the model, in particular the indicator interaction algorithms being computationally intensive. While it would be possible to specify a reasonable computer specification required to run the model it may also be possible to distribute some of the processing required throughout a grid system, such as the National Grid System (NGS) or the European Grid (EG). (NGS, 2006). This distributed processing would allow much faster manipulation of the data and reduce the resource use on computer running the prototype. However the effectiveness of this distribution system would have to be investigated.

Development of 3D Engine

While the development of the mathematical model can be applied to the AUSTIME methodology, the development of the 3D visualisation tool is not so clear-cut. There are numerous possibilities in which to develop a 3D virtual world that will represent Dundee's waterfront. It must first be decided which 3D technology to use, the main options being Microsoft's DirectX , open source OpenGL or the Virtual Reality Mark-up Language (VRML). All of these

technologies will allow the creation of a representation of the waterfront development; however VRML is designed as a static view for city visualisation to be viewed through a specialised web browser and so does not adequately allow for the design of real-time scenarios selected by the user (Web 3d, 2006). Both DirectX and OpenGL will allow advanced techniques such as particle effects and sound, to be used in the visualisation. This will allow factors such as air pollution to be shown as clouds of particles or for traffic noise to be represented through an audio interface. At present DirectX seems to be the most viable option due to its close connectivity to the .Net languages which will be used in the implementation of the mathematical model, as DirectX allows the use of complex low-level hardware effects, which will reduce the overhead on the computers processor (CPU) by processing the complex mathematical (matrix) operations solely on the machine's Graphics Processing Unit (GPU). (MSDN, 2006). To create the virtual waterfront it will be necessary to acquire some information about the area. This will include building and landscape data about the area to be developed. There are a number of methods by which the virtual world can be created depending on the data collected. Some possibilities include;

- Lidar data – The heights of buildings are determined by airborne laser imaging, these height maps can then be converted into meshes representing the building in the area of development (BEX, 2006).
- Panoramic Photography – Panoramic photographs are taken of the area to be developed and 3D views are created from these photographs (Katsushi et al, 2002).
- Architectural Models – CAD Models for the proposed development will be created by the developments designers to create a static view of the development. These models can be used to create the dynamic, walk through environment required by the visualisation tool.

There will be much more research needed into the creation of virtual worlds before a final decision is made on how the 3D world the visualisation tool uses will be implemented.

GUI Development.

The graphic user interface (GUI) to use the visualisation tool should be developed with constant feedback from the users to ensure that it allows easy access to the complex functions both of the model and of the visualisation tool. Standard practices regarding ease of use will also be used during the GUI development; this will entail discussions with the stakeholders, the council, about how they think the GUI should be structured to most benefit them.

Implementation of group decision making.

The possibility of group decision making is an important aspect as it will allow stakeholders to participate in the decision process wherever they are physically. One possibility is to use the Nation Grid System to store all the

data being used by the prototype, this approach will allow any number of prototypes to access the same data no matter where the prototype is actually being executed. This approach would also allow the possibility of stakeholders submitting different possible scenarios to the central storage location, which other stakeholders could then explore. (NGS, 2006)

6. CONCLUSIONS

It is clear that due to the complexity of developing sustainable urban developments, decision support tools will play an important role in their creation. Using the existing tools it is possible to describe small parts of a development, such as transportation or to describe a single feature e.g. the environment. It is however evident that no complete solution exists, and even the simultaneous use of a number of decision tools will not adequately overcome this problem. The AUSTIME development method does seem to provide a viable way of creating a decision support tool, although the only tool created using this method was tied to a single specialised residential development and so its benefit to a more generic urban scenario cannot yet be determined.

It is extremely important that the decision making process be open and available to as many of the stakeholders as possible, this should include everyone from the financial investors to the general public. Decision support tools do exist which will allow a stakeholder to view the consequences of their decisions, by projecting the results onto a representation of the actual development. This makes the tool accessible to non-expert decision makers as they can easily see the affect of their decision. However currently there are few, if any decision support tools which include an immersive virtual environment in which the development and the consequences of decisions made can be seen in situ.

The S-City VT prototype hopes to overcome the drawbacks of current decision support tools by combining an integrated simulation model with a visualisation tool. The use of an integrated simulation model, based on the sustainability indicators outlined by the government and Dundee City Council, will allow the impact of any decision to be determined across all the sustainability aspects (social, environmental and financial). What will set SCity-VT apart from currently existing decision support tools will be its use of 3D technologies in displaying the results of the model. By creating a 3D virtual representation of a proposed development, a stakeholder will be able to ‘fly’ through an animated simulation of their development and see the real life consequences of their proposed decisions over a number of years. This approach will empower the stakeholders by illustrating the possible trade-offs between the facets of sustainability in an easily understandable form and in a virtual environment they will recognise as their development.

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