Title: **Proposal of a tiered conceptual framework for sustainable design and planning of large-scale development projects in the metropolitan context.**

Morrissey, Dr., John[1] (Presenter)
Dr. Usha Iyer-Raniga
Ms. Patricia McLaughlin
Dr. Anthony Mills.

Theme: **Beyond Today's Infrastructure**

Abstract

The overwhelming threat posed by climate change means that increasingly, emphasis is being placed on the need to integrate sustainability considerations into all areas of policy making, planning and development. Actors in the built environment are progressively considering environmental and social issues alongside functional and economic aspects of development projects. However, to date in Australia and internationally, there have been few practical examples of integrated applications of sustainability principles in the built environment across design, planning, construction, operation and de-construction phases. Notable initiatives have tended to be narrow in scope, focusing on either mitigation or adaptation strategies. Integrated considerations of impacts from component and building scales to city and regional scales and across physical and socio-economic dimensions are urgently needed, particularly for long-life major infrastructure projects. This paper proposes a conceptual framework based on the principal that early intervention is the most cost-effective and efficient means of implementing effective strategies for mitigation and adaptation. A Strategic Environmental Assessment (SEA) approach is forwarded as an umbrella analytical framework, assembled from analytical methods which are strategically 'tiered' to inform different stages of the planning and decision-making process. Techniques such as Ecological footprint, Life cycle costing and Risk analysis may be applied to integrate sustainable design, construction and planning considerations which address both mitigation and adaptation dimensions, results of each analysis ultimately being collated into the overall SEA. This integrated conceptual framework for sustainable, resilient and cost-effective infrastructure development will in practice be applied to assess selected case-studies of major development projects in Australia, focusing on the area of stadium development. Practically applied and timed accordingly, the framework would allow assessments to be targeted towards appropriate decision making levels and enable better decision-making and more efficient resource allocation for major infrastructure development projects.

Key words: planning, integrated, sustainability, conceptual framework, SEA

1. Introduction

The overwhelming threat to development posed by climate change means that more and more emphasis is being placed on the need to integrate sustainability considerations into all areas of policy making, planning and development (Urwin and Jordan 2008). However, while current sustainability strategies and frameworks have focused on wider national aspirations

[1] Centre for Design at RMIT, GPO Box 2476V, Melbourne, Victoria, 3001 Australia
Telephone: +61 (0) 3 99259095. Fax: + 61 (0) 39639 3412. Email: John.morrissey@rmit.edu.au

and strategic objectives, they are noticeably weak in addressing micro-level integrated decision making in the built environment (Ugwu, Kumaraswamy et al. 2006). Undoubtedly there have been notable developments which have successfully applied sustainability principles in the Australian context, but initiatives have tended to be narrow in scope, frequently looking at embodied or operating energy or considering energy efficiency aspects at the building scale. There have been few practical examples of successful implementation of an integrated application of sustainability principles in the built environment across all stages of development, including design, planning, construction, operation and de-construction phases and across building and city level impacts.

Ravetz (2008) illustrates the difficulties in his *knowledge mapping in the built environment* schematic. This visualisation suggests that sustainable solutions need to encompass physical as well as socio-technical dimensions, and bridge scales from the micro level of the building, to the macro level of city and regional planning. Clearly, the challenge is immense.

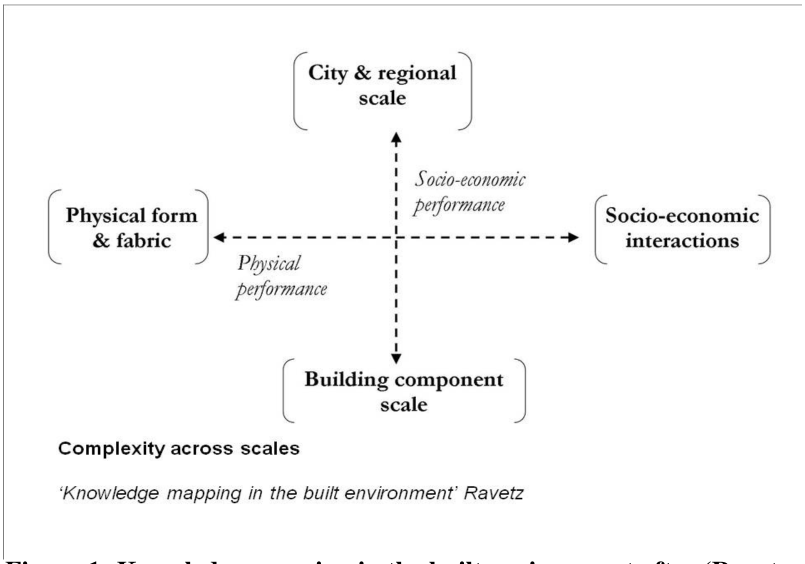

Figure 1: Knowledge mapping in the built environment after (Ravetz 2008)

In this context, (Choguill 1996) suggests that the linking of infrastructure to the sustainability debate has rarely been made in the literature, and less so in practice. The impacts of major infrastructures such as Stadia are significant, not least because of their long life and prominence within the urban fabric. Furthermore, the development of an adequate infrastructural base in urban areas is a prerequisite to the achievement of urban sustainability. Low-impact design and planning solutions are required to mitigate the environmental impacts of major infrastructures, for example. In this regard, the theory and practice of macro-development assessment to inform the design and planning of low-impact infrastructure across the life-cycle is limited. Developers have not only little practical evidence to draw upon, but appropriate assessment models are also lacking in the literature. A major challenge is the lack of integrated structured methodology and techniques for sustainability appraisal as part of infrastructure delivery (especially during design and construction) (Ugwu, Kumaraswamy et al. 2006).

2. Approach and techniques

Need for a conceptual framework

In the planning and design of macro infrastructure projects, key decisions have the potential to greatly influence subsequent opportunities to reduce building energy use (Levine et al., 2007). In this regard, techniques such as Ecological Footprint assessment, Lifecycle costing, Cost benefit analysis and Scenario analysis may be applied to provide a 'basket of indicators', covering a broad range of sustainability issues (Kitzes, Galli et al. 2009). However, to enable a comprehensive, integrated assessment these measures or techniques need to be placed within an overarching framework. Strategic Environmental Assessment (SEA) provides one option, and is proposed as by this paper as a means to address current shortcomings in decision making for sustainable outcomes in the built environment. SEA can allow a 'tiering' of analysis at appropriate levels with an overall strategic framework, for example. Indeed, the idea of tiering assessments at different planning levels (from policy and plan to program and project) pervades SEA literature (Sánchez and Silva-Sánchez 2008). Potentially, tiering of assessment could lead to better decisions and to more efficient resource allocation, as assessments would be timed and focused appropriately and incorporate levels of detail as required at the assessment level in question (Sánchez and Silva-Sánchez 2008).

The framework proposed by this paper takes a whole of life approach, considering both mitigation and adaptation aspects. The case of Stadium development is selected as an exemplar of large infrastructure, typifying many of the characteristics in question. Stadium construction and operation incur significant social economic and environmental costs to the tax-paying public, across medium to long-term life-spans, for example. They represent major focal points in the urban fabric, associated with large-scale population movements and energy use. For the purposes of this paper, an extensive review of the literature was conducted, particularly focusing on available and currently applied tools and assessment techniques for sustainability appraisal in the built environment. Each approach was critically reviewed. A conceptual framework based upon SEA was then developed, which integrated constituent analyses into a coherent whole. This section presents an overview of the reviewed literature, before the framework and its wider implications are discussed.

Assessment method 1: Ecological Footprint

The Ecological Footprint (EF) is a resource management tool that measures the land area of biologically productive land and sea required to produce the resources a given population consumes, and to assimilate the wastes it generates (GFN 2009). EF accounts answer a specific question: how much of the regenerative biological capacity of the planet is demanded by a given human activity? Activities here may refer to the consumption of resources or the provision of a service (Kitzes, Galli et al. 2009). In calculating an EF, all material and energy consumption of an economic unit, e.g. a city, or a region is compiled and converted into the land area necessary to supply material and energy needs as well as to cope with its waste. The EF then represents the environmental capital required for the activity in question (Stoeglehner and Narodoslawsky 2008). There are a growing number of applications of the EF concept in infrastructure decision making including such diverse projects as a county-level transportation network; ports development, building construction, the analysis of alternative fuels and the analysis of alternative policy scenarios for a city-region (Amekudzi, Jotin Khisty et al. 2009). EF has the advantage of being an integrated indicator which comprehensively captures the multi-faceted requirements of a sustainable development in a single indicator. Against these advantages, the EF technique has a number of limitations. Aggregate results used in isolation can create an overly simplistic view of complex systems and give the impression that improvements in one area always compensate for deteriorations in others (Kitzes and Wackernagel 2009), for example. See articles by (Kitzes and Wackernagel 2009) (Scotti, Bondavalli et al. 2009) (Stoeglehner and Narodoslawsky 2008) and (Fiala 2008) for criticisms of aspects of Ecological Footprint analysis. For the assessment of stadia, an EF method is proposed as an instrument to identify impacts of on-site features, such as lighting, energy efficiency and plumbing features together with wider systemic type impacts related to the interaction of the project with city infrastructure, for example transport and sewage.

Assessment method 2: Cost Benefit Analysis & Life Cycle Costing

CBA remains one of the most widely applied tools of economic evaluation in the public decision-making process (Simpson and Walker 1987), despite shortcomings such as those discussed by (Sáez and Requena 2007). As a Cost Benefit Analysis method, Life Cycle Costing (LCC) can be described as a standard economic approach applied for choosing among alternative products or designs that provide approximately the same service to the end-user (Utne 2009). A traditional LCC is an investment calculation that is used to rank different investment alternatives to help decide on the best alternative (Ness, Urbel-Piirsalu et al. 2007). In principle LCC is not associated with environmental costs, but costs in general (Ness, Urbel-Piirsalu et al. 2007). The main difference between traditional investment calculus and LCC is that the LCC approach has an expanded life cycle perspective, and thus considers not only investment costs, but also operating costs during the product's estimated lifetime (Gluch and Baumann 2004).

In practice, LCC seeks to optimise the cost of acquiring, owning and operating physical assets over by attempting to identify and quantify all the significant costs involved over the life-span (Woodward 1997). The development of LCC and similarly structured tools and methods has its origin in the normative neo-classical economic theory which states that firms seek to maximise profits by always operating with full knowledge (Gluch and Baumann 2004). As such LCC maintains limitations inherent in the original theory. A characteristic limitation of LCC in its attempt to express problems in one-dimensional units, generally monetary figures (Gluch and Baumann 2004). The calculation of costs related to greenhouse gas emissions are more conceptually and methodologically difficult than traditional cost accounting, for example (Utne 2009). Information from a wide range of data sources is usually required for LCC analysis making the method prone to constraints due to a lack of reliable data (Utne 2009). Despite these limitation, results from an LCC calculation may nevertheless provide an empirical indication of which strategic decisions should be made (Gluch and Baumann 2004).

Life cycle costing is proposed by this paper as an appropriate means to assess the economic case for inclusion of various technologies to enable mitigation at the construction phase. Practically, LCC may be applied to assess the life cycle cost of various renewable energy technology combinations, for example.

Assessment method 3: Scenario Analysis & Risk Assessment

(Brunnhuber, Fink et al. 2005) describe a scenario as "one of several future images". Characteristics of applied scenario analysis include (Shiftan, Kaplan et al. 2003):

- Scenarios provide storylines to alternative futures
- Scenario storylines are grounded in the knowledge and trends of current conditions
- Successful scenarios highlight areas where decision makers may direct their focus
- Scenario integrity is based on logic and plausibility.

Scenario analysis is expected to challenge conventional thinking regarding future pathways, explore the possibility of a range of alternative futures and lead to better-informed decision-making (Berkhout, Hertin et al. 2002; Swart, Raskin et al. 2004). Scenarios can contribute to general debate or establish foundations for future policy discussion (Larsen and Gunnarsson-Östling 2009). As scenarios illustrate the future under different sets of circumstances, planners can anticipate and prepare for the possibility of these futures (Coates 2000).

Successful scenarios present the gaps between the future and the present, and highlight where changes are required in bridging these gaps (Kok, Rothman et al. 2006).

Risk assessment represents a particular form of scenario analysis, one that is especially relevant for climate change adaptation decision making. In fact, risk assessment maintains a central role in climate change adaptation (Smit and Wandel 2006). To provide an example, heavy precipitation events or other predicted social–ecological effects of global climate change demand strictly set priorities for adaptation measures at high planning levels (Helbron, Schmidt et al. 2009). Risk assessment is the process of identifying, evaluating, selecting, and implementing actions to reduce risk to human health and to ecosystems from such events (Dessai, Lu et al. 2005). Risk can be defined as the combination of probability (frequency) and consequence of a certain scenario (Koivisto, Wessberg et al. 2009). Central to risk assessment therefore, is the management of uncertainties which allows the risk of something to be determined (Dessai, Lu et al. 2005). Appropriate risk assessments have an early warning function for the implementation of site-specific projects at local scale (Helbron, Schmidt et al. 2009). According to (Koivisto, Wessberg et al. 2009), the prerequisites for a successful risk assessment are :

- data on the system being analysed and on all the associated substances,
- systematic hazard identification procedure and risk estimation techniques, and
- acceptability criteria

For the purposes of this paper, the proposed risk assessment would include an analysis of potential hazards and evaluation of existing conditions of vulnerability, adopting a 'management of uncertainties' approach as advocated by the Australian Government's *National climate change adaptation framework.* Figure 2 provides an illustrative schematic.

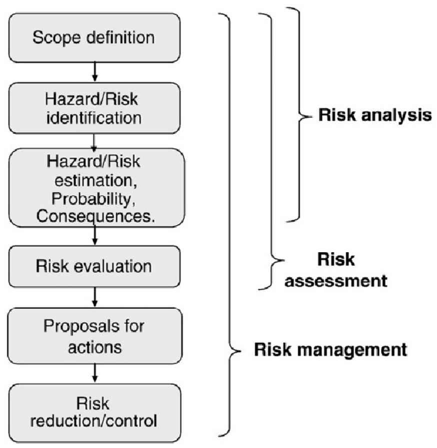

Figure 2: The process of risk analysis, risk assessment and risk management (Koivisto, Wessberg et al. 2009)

Using such an approach, identified risks can be classified as catastrophic, major, severe, or minor and can subsequently be prioritised. Risks may then be assessed against acceptability criteria, and the risk control measures planned and applied based on resultant prioritisation (Koivisto, Wessberg et al. 2009). A practical limitation of this method is the lack of systematic evaluation of the effectiveness of various risk assessment methodologies and particularly of the resulting risk reduction strategies (van Aalst, Cannon et al. 2008). In addition to this, defining adaptation to climate change is complicated because agents adapt to a number of different pressures at the same time, not just to climate change. Defining successful adaptation is even more complicated because criteria for success are generally contested and context specific (Dessai and Hulme 2007).

Assessment method 4: Stakeholder Engagement

The call for sustainable development has been a major driving force towards an increasingly multi-stakeholder planning system (Kain and Söderberg 2008). Indeed, the involvement of local stakeholders has long been considered to be particularly important for achieving the long-term goals of sustainability (Carlsson-Kanyama, Dreborg et al. 2008). In this regard, public participation is becoming increasingly embedded in national and international environmental policy (Reed, Graves et al. 2009). Decision makers are recognising the need to understand who is affected by the decisions and actions they take and who has the power to influence their outcome (Reed, Graves et al. 2009), and simultaneously, have had to accommodate participatory approaches and stakeholder involvement through transparency and clearer communication mechanisms, as discussed by (Santos, Antunes et al. 2006).

Approaches to stakeholder analysis have changed as tools have been progressively adapted from business management for use in policy, development and natural resource management (Reed, Graves et al. 2009). Different types of participation range from communication, where there is no actual participation, to negotiation, where decision-making power is shared among the various stakeholders (Pomeroy and Douvere 2008).

For this paper, the Scenario-Based Stakeholder Engagement Method as described by (Tompkins, Few et al. 2008) was selected as being an appropriate means of stakeholder engagement. The SBSE approach is essentially an adaptive, learning-based management approach which encourages stakeholders to reflect on how decisions are made (shaped by the timing of the decisions and the responsibility for decision-making) and the implications of the decisions, in terms of their impacts on risks, costs, and participation in decision-making (Tompkins, Few et al. 2008). This approach represents an action-reflection framework applied with stakeholder analysis (Figure 3).

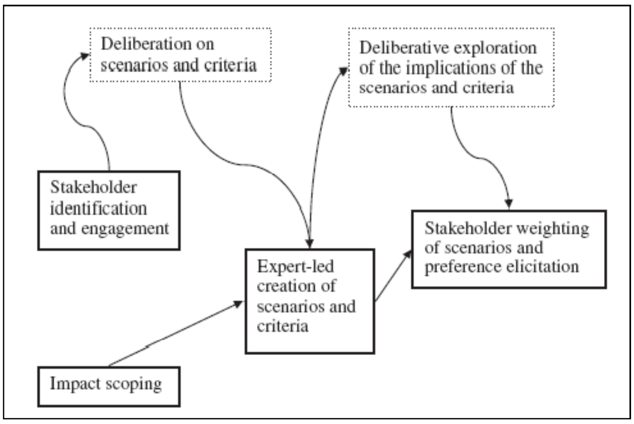

Figure 3: Scenario-based stakeholder engagement method (Tompkins, Few et al. 2008)

(Tompkins, Few et al. 2008)'s approach advocates decision support tools which offer envelopes of possibilities rather than single absolute outcomes. In practice, there are a number of challenges in achieving this. While there is increasing demand for active public involvement in decision-making, there are few examples of successful models for achieving this in the literature. According to (Sheppard and Meitner 2005), public involvement needs more effective, defensible techniques usable by managers at the ‘‘sharp end’’ of decision-making, rather than just in scoping of public concerns and in setting broad strategies (Sheppard and Meitner 2005). (Reed, Graves et al. 2009) discuss the need for more broad ranging evaluations of stakeholder engagement and analysis. Practically, participatory approaches also represent a major challenge, particularly in terms of cross-sectoral integrated planning and the achievement of multi-stakeholder consensus for collaborative joint projects (Thabrew, Wiek et al. 2009). Consensus among stakeholders is often not achieved, and processes may be conflict ridden, inefficient, and/or unsatisfactorily settled (Sheppard and Meitner 2005). For the purposes of this paper, key questions posed by (Reed, Graves et al. 2009) are of direct relevance in terms of stakeholder engagement. These include: (1) How can diverse stakeholders be adequately represented?; (2) How can the relative interest and influence of different stakeholders be taken into account?; (3) If stakeholders are defined by the issues that are being investigated, then who defines these issues?

An integrated SEA conceptual framework for sustainability assessment in the built environment

Strategic Environmental Assessment (SEA) was developed to complement weaknesses of conventional Environmental Impact Assessment (EIA) by aiming to consider a broader scope of impacts (such as cumulative, secondary and indirect impacts), and applying a tiered approach to EIA, whereby assessment begins at the most strategic policy level, taking consideration of policy alternatives and programme-wide mitigation measures (Shepherd and Ortolano 1996). SEA is presented as a means through which to incorporate sustainability principles throughout the decision-making process (Shepherd and Ortolano 1996). Stages of SEA include screening of plans and programmes, scoping of the SEA, identification, prediction, evaluation and mitigation of potential impacts and consultation, revision and post-adoption activities (Scott and Marsden 2001). The proposed approach of this paper is based on the principal that early intervention is the most cost-effective and efficient means of mitigating the environmental effects of any particular development, particularly a macro infrastructure project such as a Stadium development. Figure 5 provides an overview of the framework structure, centred on 5 key questions:

i. What are the potential direct and indirect outcomes for development X?
ii. How do these outcomes interact with the environment?
iii. What is the scope and nature of these interactions?
iv. How might environmental effects be limited through mitigation strategies and risks minimised through adaptation strategies?
v. What is the overall effect of the proposal after mitigation and adaptation strategies have been adopted?

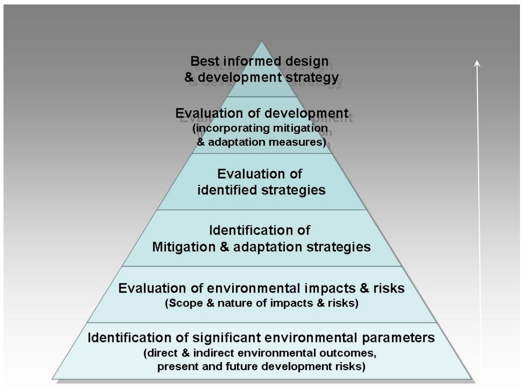

Figure 4: Application of a Strategic Environmental Assessment Framework

Key methods are proposed to be applied in a four stage assessment approach include the following, shown in Figure 6:

<u>Stage 1:</u> Ecological footprint analysis will provide the means of quantifying and assessing the baseline level of development impacts.

<u>Stage 2:</u> Mitigation strategies will be developed based on a two-part analysis: (1) consideration of plan elements and technical considerations and (2) consideration of development strategy. In consultation with stakeholders with construction expertise (architects, developers, builders etc.) a range of technical alternatives will be analysed for plan elements, applying the core technique of Life Cycle Costing (LCC). In conjunction with and simultaneous to this assessment, an appropriate development strategy will be formulated, with reference to the local development context and incorporating stakeholder consultation from the planning sphere (local government, planners, academic expertise etc.).

<u>Stage 3:</u> This stage informs the development of adaptation strategies. Through reflection on and discussion of plan elements and development strategies, stakeholder engagement and risk assessment will identify key parameters for adaptive considerations, allowing in particular, the evaluation of impact thresholds and prioritisation of proposed adaptation measures.

Stage 4: The final stage is the assessment of the final development impact where ecological footprint analysis will once again provide a means for quantifying the scale and effectiveness of mitigation and adaptation interventions, and provides a comprehensive measure to compare the post intervention development with the baseline case.

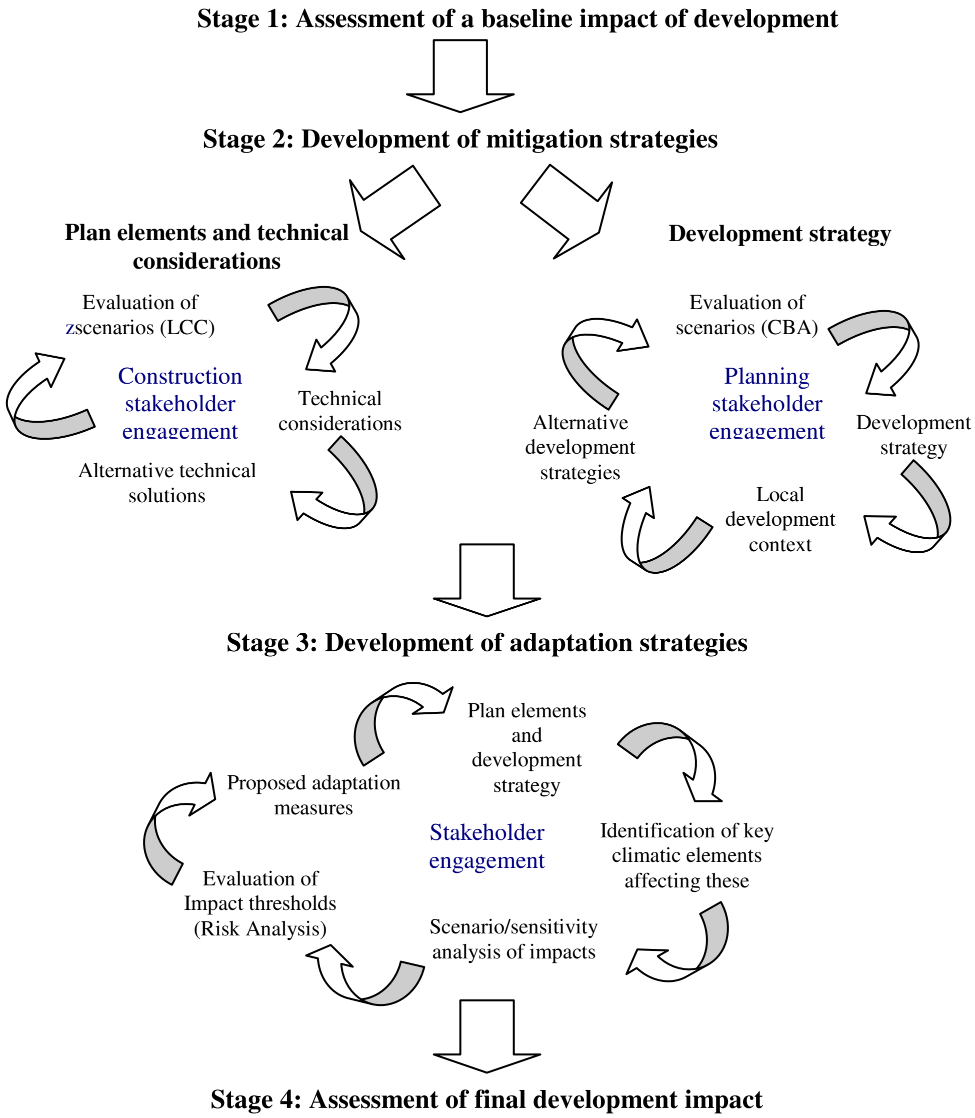

Figure 5: Four-stage SEA assessment framework for large infrastructure appraisal

Appropriate levels of analysis are applied to examine and assess suitable alternatives, directed and focused to achieve optimal outcomes. So for example, where LCC may be suitable to identify optimal decision making pathways for technological investments at the component scale, a method such as Ecological Footprint provides a more effective means of summing and communicating overall environmental impacts. These assessments are separate and discrete, yet can be complimentary if applied within a suitable overall assessment framework. In this way, the optimal, most cost-effective mitigation and adaptation measures may be identified and incorporated into the development. The proposed approach frames and contextualises results from the core techniques of *Ecological Footprint analysis*, *Lifecycle Costing* and *Risk Analysis* and incorporates more qualitative data from *Stakeholder consultation* to help to identify, quantify and assess the environmental impacts of current practice; to assess alternative development scenarios and to identify and adapt development for significant future risks associated with climate change. This represents a multidisciplinary, integrated and whole of life approach.

3. Conclusions

Conceptually, the proposed framework advances the theory and application of Strategic Environmental Assessment as a tool for large infrastructure appraisal. This is significant, particularly in light of the wide applicability of SEA to advance sustainable development practices and to facilitate early and cost-effective interventions, and at the same time, the very limited practical application of SEA in the Australian context. To expand, there are SEA requirements under the Environment Protection and Biodiversity Conservation Act 1999 (Cwlth) and the National Environment Protection Council Act 1994 (Cwlth) currently, at the federal level in Australia. These pieces of legislation have resulted in assessment of strategic proposals, primarily of fisheries plans and of National Environment Protection Measures. Four of Australia's states have legislative requirements for SEA that relate to environmental planning and protection (New South Wales, Victoria, Western Australia and Tasmania), and the two self governing territories also have some SEA provision. However experience is mixed to date, with little if any research undertaken (Marsden & Ashe, 2006). Large infrastructure and Stadia, the example used in this paper, have significant environmental impacts at local and global levels, many of which are indirect impacts which become ‘scripted’ at early design and planning stages (for example the impacts associated with transport of patrons to and from major events).

To address the environmental impact of infrastructure such as stadia, it is necessary to measure and assess the life-cycle impacts, taking consideration of construction and operation, as well as de-commissioning impacts, and to analyse both direct on-site impacts and in-direct impacts which arise because of the development and operation of the infrastructure. This paper proposes an approach to deliver an integrated conceptual framework for sustainable, resilient and cost-effective infrastructure development. The framework allows for assessment of sustainable design, construction and planning considerations across both mitigation and adaptation dimensions. In this regard, the proposed framework fills a critical gap in the literature, suggesting a structured methodology to assess sustainable development at the project level in the urban built environment.

At a practical level, the framework represents a best-practice approach to the appraisal of large infrastructure and provides a measure of guidance on this issue. This is particularly significant from a construction industry perspective. As discussed by Xing, Horner *et al.*, architects, surveyors, engineers, project managers and others responsible for making key decisions throughout the different stages in the delivery of an urban development project are increasingly concerned with wider environmental and societal issues. This is reflected in a demand for information and tools to support those decision makers in finding more sustainable solutions. In this respect, the proposed conceptual framework addresses the multidimensional nature of the sustainable development paradigm, encompassing economy, society, and environment aspects while targeting information at various strategic levels of a given development. The framework thus provides a means of ensuring that sustainability concerns are considered at multiple key stages of project development, while also facilitating project development appraisal that is at once practical, holistic and comprehensive in nature.

References

Amekudzi, A. A., C. Jotin Khisty, et al. (2009). "Using the sustainability footprint model to assess development impacts of transportation systems." Transportation Research Part A: Policy and Practice 43(4): 339-348.
Berkhout, F., J. Hertin, et al. (2002). "Socio-economic futures in climate change impact assessment: using scenarios as [`]learning machines'." Global Environmental Change 12(2): 83-95.
Brunnhuber, S., A. Fink, et al. (2005). "The financial system matters: future perspectives and scenarios for a sustainable future." Futures 37(4): 317-332.
Carlsson-Kanyama, A., K. H. Dreborg, et al. (2008). "Participative backcasting: A tool for involving stakeholders in local sustainability planning." Futures 40(1): 34-46.
Choguill, C. L. (1996). "Ten steps to sustainable infrastructure." Habitat International 20(3): 389-404.
Coates, J. F. (2000). "Scenario Planning." Technological Forecasting and Social Change 65(1): 115-123.
Dessai, S. and M. Hulme (2007). "Assessing the robustness of adaptation decisions to climate change uncertainties: A case study on water resources management in the East of England." Global Environmental Change 17(1): 59-72.
Dessai, S., X. Lu, et al. (2005). "On the role of climate scenarios for adaptation planning." Global Environmental Change Part A 15(2): 87-97.
Fiala, N. (2008). "Measuring sustainability: Why the ecological footprint is bad economics and bad environmental science." Ecological Economics 67(4): 519-525.
GFN (2010). http://www.footprintnetwork.org/en/index.php/GFN/. Last accessed, 6th July 2010.
Gluch, P. and H. Baumann (2004). "The life cycle costing (LCC) approach: a conceptual discussion of its usefulness for environmental decision-making." Building and Environment 39(5): 571-580.
Helbron, H., M. Schmidt, et al. (2009). "Indicators for strategic environmental assessment in regional land use planning to assess conflicts with adaptation to global climate change." Ecological Indicators In Press, Corrected Proof.
Kain, J.-H. and H. Söderberg (2008). "Management of complex knowledge in planning for sustainable development: The use of multi-criteria decision aids." Environmental Impact Assessment Review 28(1): 7-21.
Kitzes, J., A. Galli, et al. (2009). "A research agenda for improving national Ecological Footprint accounts." Ecological Economics 68(7): 1991-2007.
Kitzes, J. and M. Wackernagel (2009). "Answers to common questions in Ecological Footprint accounting." Ecological Indicators 9(4): 812-817.
Koivisto, R., N. Wessberg, et al. (2009). "Integrating future-oriented technology analysis and risk assessment methodologies." Technological Forecasting and Social Change 76(9): 1163-1176.
Kok, K., D. S. Rothman, et al. (2006). "Multi-scale narratives from an IA perspective: Part I. European and Mediterranean scenario development." Futures 38(3): 261-284.
Larsen, K. and U. Gunnarsson-Östling (2009). "Climate change scenarios and citizen-participation: Mitigation and adaptation perspectives in constructing sustainable futures." Habitat International 33(3): 260-266.
Marsden, S. and J. Ashe (2006). "Strategic Environmental Assessment Legislation in Australian States and Territories." Australasian Journal of Environmental Management 13(4).
Ness, B., E. Urbel-Piirsalu, et al. (2007). "Categorising tools for sustainability assessment." Ecological Economics 60(3): 498-508.

Pomeroy, R. and F. Douvere (2008). "The engagement of stakeholders in the marine spatial planning process." Marine Policy 32(5): 816-822.
Ravetz, J. (2008). "State of the stock--What do we know about existing buildings and their future prospects?" Energy Policy 36(12): 4462-4470.
Reed, M. S., A. Graves, et al. (2009). "Who's in and why? A typology of stakeholder analysis methods for natural resource management." Journal of Environmental Management 90(5): 1933-1949.
Sáez, C. A. and J. C. Requena (2007). "Reconciling sustainability and discounting in Cost-Benefit Analysis: A methodological proposal." Ecological Economics 60(4): 712-725.
Sánchez, L. E. and S. S. Silva-Sánchez (2008). "Tiering strategic environmental assessment and project environmental impact assessment in highway planning in São Paulo, Brazil." Environmental Impact Assessment Review 28(7): 515-522.
Santos, R., P. Antunes, et al. (2006). "Stakeholder participation in the design of environmental policy mixes." Ecological Economics 60(1): 100-110.
Scott, P. & Marsden, P., 2001. Development of Strategic Environmental Assessment (SEA) Methodologies for Plans and Programmes in Ireland: Synthesis Report. (Wexford) Environmental Protection Agency, Ireland.
Scotti, M., C. Bondavalli, et al. (2009). "Ecological Footprint as a tool for local sustainability: The municipality of Piacenza (Italy) as a case study." Environmental Impact Assessment Review 29(1): 39-50.
Shepherd, A. and L. Ortolano (1996). "Strategic environmental assessment for sustainable urban development." Environmental Impact Assessment Review 16(4-6): 321-335.
Sheppard, S. R. J. and M. Meitner (2005). "Using multi-criteria analysis and visualisation for sustainable forest management planning with stakeholder groups." Forest Ecology and Management 207(1-2): 171-187.
Shiftan, Y., S. Kaplan, et al. (2003). "Scenario building as a tool for planning a sustainable transportation system." Transportation Research Part D: Transport and Environment 8(5): 323-342.
Simpson, D. and J. Walker (1987). "Extending cost-benefit analysis for energy investment choices." Energy Policy 15(3): 217-227.
Smit, B. and J. Wandel (2006). "Adaptation, adaptive capacity and vulnerability." Global Environmental Change 16(3): 282-292.
Stoeglehner, G. and M. Narodoslawsky (2008). "Implementing ecological footprinting in decision-making processes." Land Use Policy 25(3): 421-431.
Swart, R. J., P. Raskin, et al. (2004). "The problem of the future: sustainability science and scenario analysis." Global Environmental Change Part A 14(2): 137-146.
Thabrew, L., A. Wiek, et al. (2009). "Environmental decision making in multi-stakeholder contexts: applicability of life cycle thinking in development planning and implementation." Journal of Cleaner Production 17(1): 67-76.
Tompkins, E. L., R. Few, et al. (2008). "Scenario-based stakeholder engagement: Incorporating stakeholders preferences into coastal planning for climate change." Journal of Environmental Management 88(4): 1580-1592.
Ugwu, O. O., M. M. Kumaraswamy, et al. (2006). "Sustainability appraisal in infrastructure projects (SUSAIP): Part 2: A case study in bridge design." Automation in Construction 15(2): 229-238.
Urwin, K. and A. Jordan (2008). "Does public policy support or undermine climate change adaptation? Exploring policy interplay across different scales of governance." Global Environmental Change 18(1): 180-191.
Utne, I. B. (2009). "Life cycle cost (LCC) as a tool for improving sustainability in the Norwegian fishing fleet." Journal of Cleaner Production 17(3): 335-344.

van Aalst, M. K., T. Cannon, et al. (2008). "Community level adaptation to climate change: The potential role of participatory community risk assessment." Global Environmental Change 18(1): 165-179.
Woodward, D. G. (1997). "Life cycle costing--Theory, information acquisition and application." International Journal of Project Management 15(6): 335-344.
Xing, Y., R. M. W. Horner, et al. (2009). "A framework model for assessing sustainability impacts of urban development." Accounting Forum 33(3): 209-224.