the infrastructure that supports it, is the key to enabling sustainability aspirations into sustainability responses.

2 Involving Community: The First Challenge

To begin this discussion it is important to recognise that sustainability needs to be able to be defined. Facilitated by the work of the United Nations over the past 20 years, sustainability is now most commonly recognised in terms of the three pillars of environmental sustainability (or stewardship), social equity and economic efficiency (World Commission, 1987) which frames the principal meaning of sustainability today. An effective sustainability performance requires all three pillars to achieve complimentary outcomes rather than simply individual outcomes.

Community involvement in shaping sustainability strategy is often through participation in visioning and goals setting. For cities, one of the major challenges for sustainability is centred on the urban form, the transport characteristics and the interactions between these and the communities they support. However, when it comes to the question of which scenario should be selected, there is little scope for community to confidently help shape the choice. Without quantifiable assessment methods, the connection between scenarios and sustainability outcomes are extremely subjective to the point where little benefit may come from public discussion. Improving the visibility of these connections for community and decision makers alike would increase the opportunity for better choices.

In a new approach to sustainability analysis (Doust, 2008), a sustainability framework was formulated to bring not only the three pillars of sustainability together, but also a holistic consideration of the urban system, the urban dynamics and the resulting sustainability performance. Figure 1.1 summarises the framework, showing the interconnection between the urban system elements, the urban dynamics and identifying the three pillars of sustainability. This framework lays out the frame points for ensuring that the systems elements and interactions that drive the sustainability performance of the city are visible and measured.

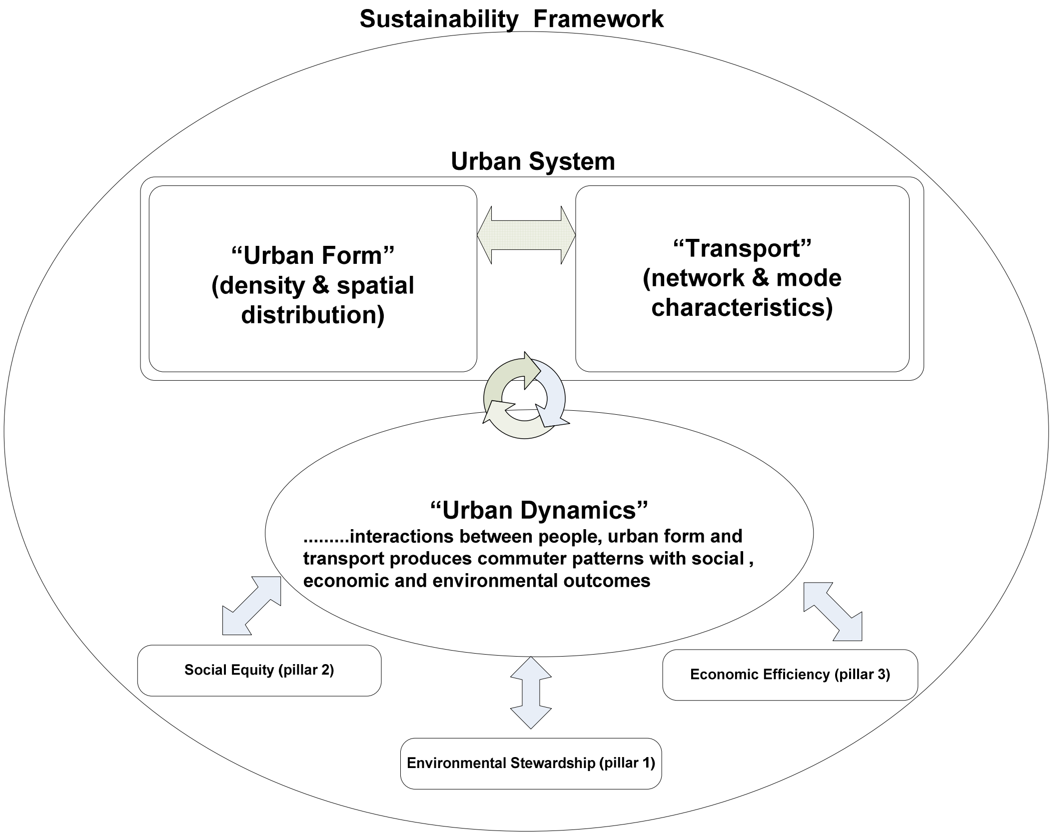

Figure 1.1 The urban "sustainability framework"

The "Urban System" is the physical aspect of the framework, consisting of the "Urban Form" and "Transport" elements which define the structural configuration of the city. Interaction between these two elements shows their interdependencies. "Urban Form" is characterised by density and spatial distribution of land-use. "Transport" on the other hand is characterised by the transport network spatial layout and the specific mode characteristics.

The system function is to provide for the needs of the community (including industry). Response of the community to the “Urban System” produces interactions that result in selection of location of residence and workplace, industry and trips and so on. These interactions are collectively known as “Urban Dynamics”. It is an iterative process as indicated by the circular arrow having feedback effect between each element. The resulting “Urban Dynamics” outcomes generate the sustainability performance in terms of the three pillars included as elements in Figure 1.1. Each pillar has a feedback to the “Urban Dynamics” and consequently the “Urban System”. This is indicated by the double headed arrows in the figure.

Most cities begin their city’s urban and transport planning with metropolitan wide strategic planning instruments. Involvement of community in visioning often begins at this front end scale. Systems thinking in terms of this framework enables methodologies used by government to be related. This gives greater visibility between the elements and traceability of what factors drive sustainability performance. A case study of Sydney has embodied this sustainability framework with both existing and new methodology to give a useful example of the usefulness of this systems thinking approach at a city wide scale. The case study research added methodology that enables community to be engaged in the optioneering of urban form and transport systems on a city wide scale by the use of a novel approach to visualising the city wide or sub regional sustainability performance effect of each option.

The visualisations make use of the new concept of environmental sustainability – accessibility space. Figure 1.2, illustrates this spatial concept and the idealised performance goal. A city’s sustainability performance in relation to the goal can be analytically quantified and simply visualised in plots for assessing the three pillars of sustainability in cities.

The environmental sustainability measure (Pillar1) can be formulated from many different parameters (e.g. traffic noise generated, ecological stress, particulate emissions, resource usage). For illustrative purposes a measure based on known fuel consumption of vehicles (see Cosgrove, 2003, p342) with speed was used to calculate CO2-e footprints for motor vehicles. Detailed operational methods were developed (Doust, 2008, Chap 4) and applied to generate a quantifiable measure. Accessibility has been identified as a useful measure in social and economic aspects of sustainability (see Expert Group on the Urban Environment, 1996; Warren Centre for Advanced Engineering, 2003; Kachi, et al., 2005; Kachi, et al., 2007). Accessibility measures were derived (Doust, 2008, Chap 4) for each travel zone pair. Separate operational methods were developed to generate worker and employer focussed accessibility measures. These are measures that are relatable to social equity (Pillar 2) and economic efficiency (Pillar 3) respectively.

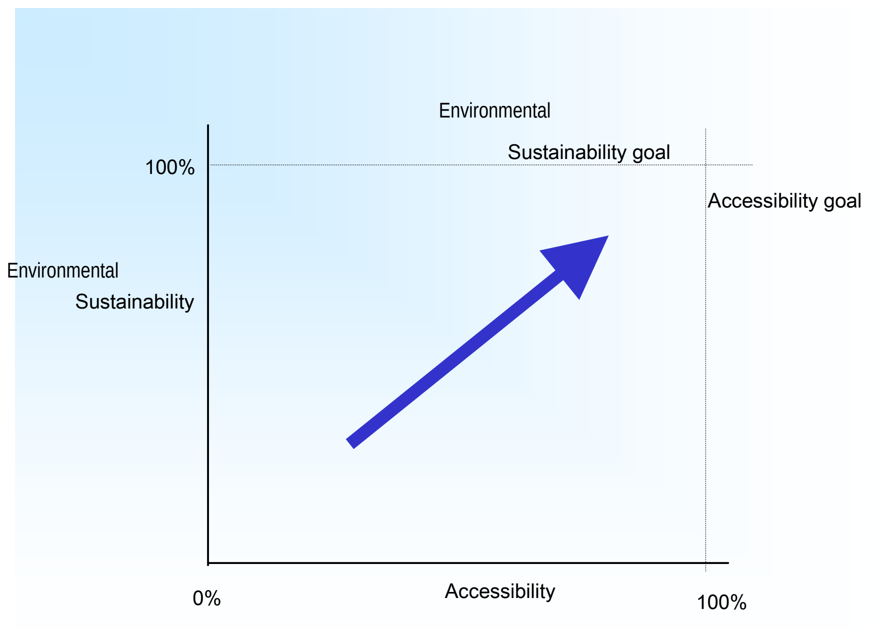

Figure 1.2 Environmental sustainability - accessibility space

The sustainability performance characteristics is judged in terms of data set shape, frequency and spread in the “environmental sustainability – accessibility space”. The following simple example provides the fundamentals for a small number of origin zone to destination zone pairs. The scatter plot shown in Figure 1.3 shows the sustainability performance against the desirable trend in sustainability. A shift to the top right hand corner and a limited spread in accessibility is identified as the theorised optimum.

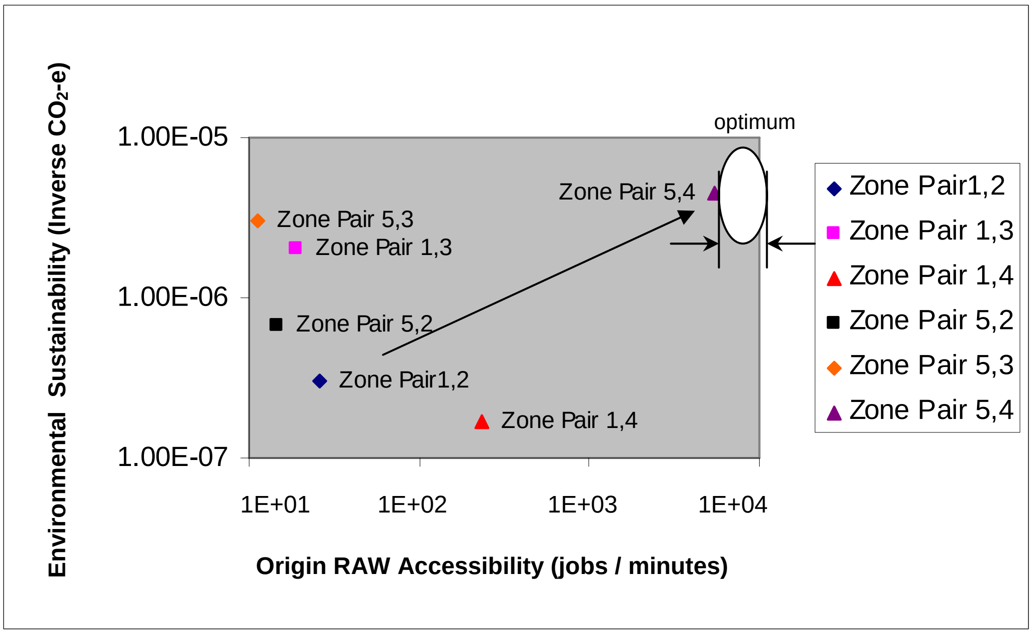

Figure 1.3 Environmental sustainability – "Raw" accessibility (Pillar3) goal

Origin RAW Accessibility is defined as the accessibility to jobs at a destination zone (TZj) from an origin zone (TZi) calculated by dividing the total attractions from all origin zones to TZj by the transport impedance from TZi to TZj. Units are workers/ minutes, where workers are a proxy for jobs.

The environmental sustainability measure is defined as the inverse of CO2 emissions from the total JTW trips between zone pairs, including an allocation of emissions from manufacture of vehicle and road infrastructure. This is calculated as a sum of the carbon dioxide equivalent (CO2-e) per unit trip km at the average speed with the shortest path trip length and number of trips. The carbon dioxide equivalent (CO2-e) is calculated as the sum of the quantity of greenhouse gas and the Global Warming Potential Index (AGO,2005,Appendix 3)

The metrics were able to be determined for large data sets for the Sydney case study (792 travel zones) by systematic analytical techniques using trip tables, network skims and car emission rates as inputs. These techniques have given the metrics a clear objective basis traceable to the source data. The visualisations although built from many thousands of pieces of data provided a simple representation giving a holistic view of the sustainability characteristics and trends.

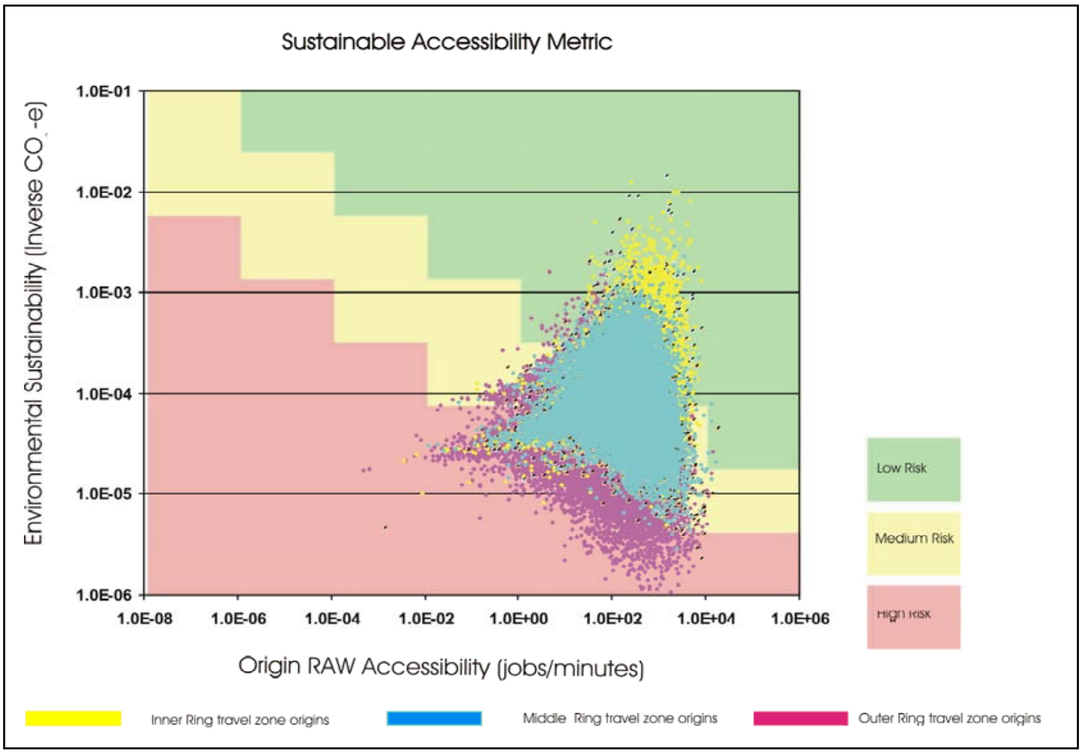

Figure 1.4 Sustainability risk visualisation

These metrics can also be applied in a way that expresses sustainability performance in terms of sustainability risk. High risk, where sustainability performance is poor, is indicated by low metric values. Low risk, where sustainability performance is satisfactory, is indicated by a higher metric value, above a community accepted minimum target. The grid concept can be likened to a risk matrix allowing each zone pair to be assigned a sustainability risk rating (Figure 1.4). The sustainability risk boundaries are specific to each city, and influenced by the population's estimated resilience. This sustainability risk rating can then be replotted back onto geographic space using GIS thematic mapping. Figure 1.5 illustrates the visual effectiveness of this technique for the outer ring of Sydney, replotting the red coloured points falling in the high risk squares in Figure 1.4

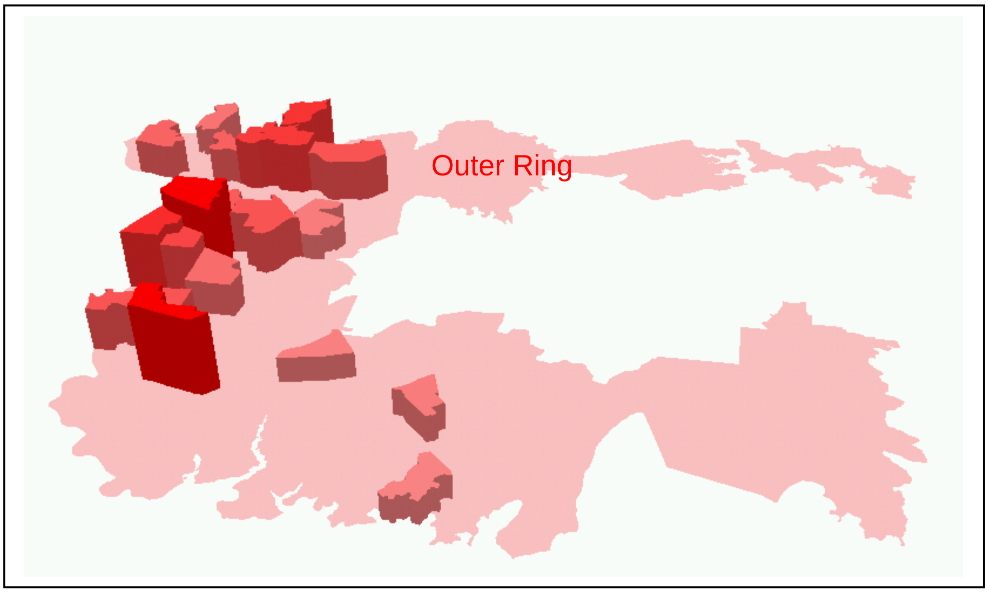

Figure 1.5 Map of High Sustainability Risk in Outer Ring

For community and decision makers these visualisation give a simple snapshot of overall sustainability performance, for each scenario being considered. Change the scenario, produce a new metric plot to see the sustainability effect. Stakeholders can see measurable change for their communities in relation to sustainability goals. The process provides another dimension to visioning and sustainability strategy development by adding the means by which community can measure and judge one transport system and urban form scenario with another.

A particular strength of using the sustainability framework and the metrics demonstrated is that they are derived from data sets that have been used by planners for many years. These are commonplace amongst transport and city planning departments in many cities.

With these inputs and the assistance of readily available GIS/T software, all of the urban dynamics and sustainability metrics are able to be derived. The sustainability framework enables the holistic picture of sustainability to be maintained during the assessment process.

An important aspect of the metric methodologies is their analytical basis. All visualisations have traceability back through the algorithms to the source inputs. This is a particular strength when checking results, making scenarios changes and applying different planning instruments. A particular benefit is that it enables community and government to work together in an interactive way.

3 Delivering the system: The Second Challenge

Transport and urban systems from the time of metropolitan strategic plan and masterplan to operations travel through a process of many years duration. Beginning at the point of decision at governmental policy level the goal then becomes that of enabling the physical system to happen. Often this is a different course for the urban form and the transport systems. Depending on the governmental policy, the course may be very hands on through the government agencies empowered to deliver, or it may be a facilitation of guiding frameworks, plans and high level contracts and alliances with the private sector.

In Australia, urban form is steered through various planning instruments which put frameworks and constraints over lower levels of government and private industry which deliver the bulk of the urban land use infrastructure. In some cases the control is held with the agencies of higher levels of government where that land use is of seen to be crucial to how an urban system functions, examples are major growth centres and special employment centres.