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Collaborative platform to facilitate engineering decision-making

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Measures taken to address climate change and sustainability, more generally, imply a major reconfiguration of infrastructure systems and the built environment. Action across so many functions necessarily involves a range of organisations that may have differing priorities and motivations. This paper presents the concept of a decision theatre and describes how this approach was tested by co-designing, with a range of stakeholders, two events to identify the current vulnerabilities of the city of Newcastle upon Tyne to a storm event and to investigate the effectiveness of adaptation options to surface water flooding. The collaborative environment improved understanding of the physical and social vulnerabilities in the city, defined research questions relevant to society, improved the consideration of policy suggestions grounded in reality and improved the joint ownership of the issues and the facility itself. The lessons learned helped develop a long-term vision for a more widely applicable research and engagement facility for exploring and understanding decision-making with a range of stakeholders, including the general public.

1. Introduction

Urban areas are faced with a number of challenges in the context of climate change and sustainable development that need to be considered simultaneously. Climate change vulnerability, impacts and adaptation influence prospects for sustainable development, and in turn alternative development paths will not only determine the greenhouse gas (GHG) emission levels that affect climate change but also influence our future capacity to adapt to and mitigate climate change (Walsh *et al.*, 2011). Sustainability and climate issues require an integrative approach. However, governance is fragmented over a number of organisations, thus, collaborative decision-making is problematic.

High concentrations of population and the infrastructure of cities make them particularly vulnerable to climate impacts and risks. Several studies have considered the impacts of climate

change in urban areas (Dawson, 2007; Hunt and Watkiss, 2011; Wilby, 2007), which include sea-level rise, flood risk, building and infrastructure damage, water availability, urban heat island effect, effects on the urban economy, resource flows and biodiversity impacts. If not addressed, this vulnerability will continue to increase as urban areas continue to grow over the twenty-first century. In addition, these large populations and associated economic activity require services such as transportation, heating and industrial processes, all of which are energy intensive and contribute to GHG emissions. However, despite their vulnerability and their contribution to GHG emissions, cities can provide concentrated areas of opportunity for adaptation and the mitigation of GHG emissions. With over half of the global population residing in urban areas it is now recognised that cities are the first responders in adapting to and mitigating climate change (Rosenzweig *et al.*, 2010).

Both mitigation and adaptation seek to avoid the potential damages of global climate change and both seek to support the development of present and future generations in a sustainable manner. However, the spatial and temporal scales at which they are implemented and felt differ. Given the long residence time of GHG emissions in the atmosphere, mitigation efforts will not be felt immediately, although they will occur at a global scale with local benefits such as improved air quality. Adaptation measures need to take place at the local level and are site-specific, dependent on the climate risks in a particular location. Their benefits can also be evident over a short timescale, as some interventions can reduce the risk from extreme weather events. A more informed understanding of the synergies, conflicts and trade-offs between mitigation and adaptation measures would contribute to a more integrated climate policy and the more effective climate-proofing of urban environments (Dawson, 2007). Coupling this with a collective, systems-level understanding of cities will provide the evidence basis and means for collaboration within and across multiple sectors, thus initiating a step change in our understanding of urban systems and society's capacity to design and initiate the necessary transition to make our cities sustainable.

It is clear that, given the number of international and national targets and commitments, for example, the Kyoto Protocol (EC, 2002), the Covenant of Mayors (www.eumayors.eu) and the Climate Change Act 2008 (2008), mitigation strategies are far more advanced than that of adaptation. The UK's recent *Climate Change Risk Assessment* (CCRA) (Defra, 2012) reviewed evidence of the potential risks and opportunities in climate change in the UK and provided a detailed analysis of 100 of these impacts across 11 sectors, monetising them where possible (HMG, 2012). This complements the work of the Committee on Climate Change's adaptation sub-committee, which has assessed UK progress on preparing for climate change. The CCRA's subsequent economic analysis and sector engagement will inform a national adaptation plan (NAP) due to be published in 2013, which will highlight the scale and nature of the adaptation challenge, describe the respective roles of government, private sector and others in meeting these challenges and set out government's adaptation policies and actions (HMG, 2012). The CCRA presents regional analyses of climate risks but the NAP will not identify action at such a scale, instead recognising that the range of local actions needed will vary according to location.

Indeed, adaptation innovation, planning and implementation need to take place at varying local scales, involving a range of relevant actors and leading to collaborative decisions and investments. Moreover, city and local authorities can drive this agenda forward by integrating responses to climate change to bring about social, economic and environmental improvement. Their roles have been acknowledged by the government

through the recognition of the distinct contributions of both cities and local government in the NAP. Bringing these worlds of science, planning practice and climate change policy-making together in order to make sense of each other is a key challenge of tackling such so called 'wicked' issues, where the complexity of the relationships between organisations and policies addressing the issues needs to be recognised and matched by an approach to the exchange of interdisciplinary science and knowledge. The transformation of discipline-based science into collaborations that can achieve interdisciplinary breakthroughs or even the transfer of higher order concepts such as theories, understanding, knowledge or evidence, is always a complex, collective, creative and cultural achievement, rather than a purely technical algorithmic process.

With these issues in mind, the Centre for Earth Systems Engineering Research, in collaboration with the Centre for Knowledge Innovation Technology and Enterprise at Newcastle University, worked with a range of local stakeholders convened by Newcastle City Council to consider the impacts of climate change and potential adaptation options in and around the city of Newcastle upon Tyne. This was prompted and facilitated through a fortuitously timed recent impact funding award from the Engineering and Physical Sciences Research Council, which enabled a pilot project to demonstrate the feasibility of the development of a research facility and decision laboratory for exploring and understanding decision-making. The concept of a decision theatre is not new. Arizona State University's (ASU) decision theatre consists of a high-speed server with seven large fixed screens that pan 260°C in a bespoke room. Complex data, models and visualisations can be displayed to facilitate collaborative decision-making and the facility has been successful in aiding the management of water resource (e.g. Sampson *et al.*, 2011), heat waves (e.g. Winston *et al.*, 2011) and energy (e.g. Fan *et al.*, 2012) in the Phoenix metropolitan area. However, uptake of the ASU facility was slow in part, because it was technology rather than user driven in the first instance. Further development (e.g. Kerr and Pahle, 2009) has greatly increased the facility's flexibility and use. To ensure a similar facility was well used from the outset we sought to learn from the ASU team and have undertaken a number of co-creation exercises with our stakeholders.

The aim of setting up the decision theatre was to ensure that the world-leading research that takes place in academic institutions is utilised through interactive and engagement tools. The impact of such a facility could be far-reaching, ensuring the maximum impact of research from across the disciplines of science, engineering, medicine and social science. Additionally, the facility could provide a laboratory for social scientists who are interested in observing how decision-making is played out. In

Figure 1. Integrated research programme (adapted from Dawson, 2011)

future, the facility will add value to existing research, change the way in which outputs are disseminated and provide the means to evidence the impact of research. Figure 1 illustrates an integrated research programme that could be facilitated using the decision theatre environment, whereby decision-making exists in an iterative loop informed by monitoring, information, experimentation, modelling and visualisation. There are many multiple and often competing objectives in sustainability issues, problems and decisions, which lead to complexities and trade-offs that are difficult to understand and communicate. Continuous dialogue between researchers and stakeholders will provide evidence of how research is being used in decision-making and which interventions are successful. In this environment interactions and conversations can be recorded to aid future collaborations and may go some way to demonstrating the impact of research. The prototype decision theatre assisted researchers and stakeholders to co-produce projects that have led to valuable outputs and they subsequently started co-producing a scope for the full-scale decision theatre. This in itself should begin to produce a culture shift in the way scientists and engineers produce data and models and to encourage them to focus them on how their use can impact on people and organisations, rather than other scientists and engineers.

This paper describes and evaluates two events facilitated by the decision theatre approach that investigated climate risks and adaptation options for Newcastle upon Tyne. Each event is described and evaluated in turn. The paper concludes with lessons learned from the approach and points towards future developments and potential for such an approach.

2. Setting the scene and developing the events

Newcastle upon Tyne, located in the north-east of England, has a population of 292 000 (Office of National Statistics, (2010) and covers an area of 112 km². Newcastle's climate change strategy (Newcastle Partnership, 2010) presents a programme for tackling climate change that includes its commitment to reduce the city's carbon dioxide emissions by 34 per cent (of 1990 levels) by 2020, together with identifying actions to develop evidence and plans for adaptation. The *North East Climate Change Adaptation Study* (Royal Haskoning, 2006) lists the principal impacts of climate change projected for the region by 2050, as well as 12 adaptation strategies to help minimise the identified climate risks. Table 1 presents these potential impacts, along with adaptation options and suggestions for which actors should be involved in

Principal impacts of climate change projected for the north-east region by 2050

Increased frequency of flooding from rivers, streams and the sea
Increased adverse health and welfare effects during warmer summers
Increased incidents of wild fires and parkland fires
Increased frequency of flooding from drainage systems
Increase in infectious diseases in humans and livestock
Increase in pests
Increased damage to fabric and structure of buildings
Loss of business/service productivity or continuity
Increased business opportunities associated with adaptation
Increased pressure on emergency services
Increased disruption to service continuity
Increased pollution from contaminated land
Increased erosion of the coastline
Increased wildlife impacts on construction and maintenance activities
Reduce adverse health effects during warmer winters
Increased storm-related debris
Increased footpath and cycle path erosion
Changes in winter road maintenance regimes

Key adaptation strategies	Responsibility
Gather and share information on climate change trends, impacts assessments and adaptation activities across the region	Met Office, Environment Agency, UK Climate Impacts Programme, regional partnerships
Risk awareness and risk-based management plans	Businesses, services, transport operators, health service
Inspection, monitoring and maintenance of assets	Local authorities, Environment Agency, Network Rail, Highways Agency, emergency services, farmers
Physical adaptation in the use or structure of buildings and in infrastructure	Local authorities, businesses, health service, transport operators, utilities providers, research organisations, government departments
Warnings to enable preventative actions	Met Office, Environment Agency, health service, national parks
Prioritisation and delivery of adaptation actions	Regional partnerships to promote the concept. All to deliver
Resource planning and management	Local authorities, transport operators, utility providers, Environment Agency, emergency services, health service
Increased use of novel technology and the need for further innovations	Universities, businesses/industry, Environment Agency, local authorities, utility providers, transport operators
Influence long-term planning	Local authorities, Environment Agency, regional partnerships. All organisations and businesses over the medium to long term
Encourage cross-sectoral, partnership-based awareness and responses	Led by: Environment Agency, local authorities, emergency services, health service, regional partnerships. Involvement by all organisations and businesses
Exploit the opportunities presented by climate change	Regional partnerships, industry, businesses and universities
Lobby for change	All organisations and businesses

Table 1. Principal impacts of climate change projected for the north-east region by 2050 and suggested key adaptation strategies and actors (continued on next page)

Key adaptation strategies	Responsibility
Review the effectiveness of adaptation approaches and revise as necessary.	Regional partnerships and each organisation and business

Source: Royal Haskoning, 2006

Table 1. Continued

addressing and delivering them. As is discussed later, the decision theatre concept, through the two events designed, began to address some of these adaptation options suggested by the study. The decision theatre approach also allows the wide range of actors required to begin to consider, design, implement and maintain these adaptation options and to come together to be exposed to and share data and research outputs, explore feasibility and collectively assess practical solutions. Furthermore, responding to climate change needs to be sustainable. In both 2009 and 2010 Newcastle upon Tyne topped the Forum for the Future’s annual sustainable cities index, which was based on metrics relating to environmental impact, quality of life and future-proofing.

Any adaptations to climate change need to consider the environmental, social and economic components of sustainability to ensure that cities continue to develop sustainably. A decision theatre arena contributes substantially to sustainability goals. Firstly, scientific research, knowledge and tools can be presented for the better understanding of decisions being made at the appropriate scale, in this case the scale of the city. Secondly, on the societal side, it provides a mechanism for collaborative decision-making by involving a range of stakeholders including the public, which may lead to unified goals and targets and a greater understanding of the mechanisms of change. Thirdly, it enables an economically crucial consideration and multi-sector dialogue of costs and trade-offs of action versus non-action as well as setting out who pays for the adaptation and improvements.

Newcastle Climate Change Partnership, established in 2010, includes partners from the public, private, academic and voluntary sectors, all of which have a critical role to play both in reducing the city’s ‘carbon footprint’ and ensuring resilience to the effects of climate change. The partnership also aims to identify and exploit opportunities resulting from climate change, such as the development of Newcastle upon Tyne as a major centre for the research, development and manufacture of renewable energy technologies (Newcastle Partnership, 2010). As part of the cities’ climate change strategy and action plan, a subgroup of the partnership was created with a remit of focusing on adaptation. Preliminary work of this group by Newcastle City Council consisted of

conducting a local climate impacts profile (LCLIP) to raise awareness of the city’s current vulnerability to weather events. However, establishing a common agenda across the disparate membership of the adaptation subgroup proved to be difficult due to varying levels of understanding, priority and membership, demonstrating the difficulty of collaborative working and decision-making in cities. The group had already identified that an extreme weather event impacts on a range of organisations across the city and demonstrated the value of considering the impact of such an event. Understanding current vulnerability is an appropriate starting point for the preparation of an adaptation strategy (UKCIP, 2009) and therefore formed the basis of the first event. Defining the research questions of the events was a joint exercise, thereby ensuring they were of relevance to the stakeholders involved. In addition, regular consultation with stakeholders on the design of the storylines, the materials to be presented and the methods of presentation all ensured continued collaboration.

2.1 Event 1: the storm

The first event aimed to explore current vulnerabilities to climate change across the city. Based on a 1 in 100 year storm event, a scenario was developed, drawing conditions and evidence from past events, for example, from the Carlisle storms in 2004 and 2005, and from the extensive flooding events that occurred in the UK during the summer of 2007 (Environment Agency, 2007). The scenario consisted of both

Figure 2. Four interactive information screens presenting information about the storm as it unfolds

strong winds and intense rainfall impacting on transport infrastructure and services, the power supply, schools, hospitals and residential and commercial properties, and began to explore the interconnected nature of these systems and the long-term implications of decisions made by relevant organisations.

In this case, the decision theatre consisted of four screens (see Figure 2). Screen 1 presented a narrative of the storm conditions as it passed over the city. Screen 2 described the scenario and the impacts occurring through time. It also displayed interactive buttons that enabled different layers of information, for example locations of key assets and networks, to be shown on screens 3 and 4. Screens 3 and 4 showed maps of the city at two different scales: the whole city scale and a higher resolution coverage of the urban core area. Both maps highlighted the impacts on various forms of infrastructure and services during the duration of the storm event.

2.2 Event 2: exploring adaptation options for surface water flooding

The second event provided a tool for participants to investigate a range of policy options to help alleviate surface water flooding in Newcastle's city centre. The scenarios were based on results from the CityCat model (Glenis *et al.*, 2010), which is a novel and unique software tool for modelling, analysing and visualising urban surface water flooding and alleviation measures. The tool presented maps of modelled depths of surface water flooding for a 1 in 100 year rainfall event lasting 30 min and 60 min, respectively. A range of policy options, including adding permeable or impermeable surfaces and the introduction of roof storage, could be explored at 5 min intervals throughout the storm event. Stakeholders were able to interact with the tool directly to explore these options. Figure 3 shows the tool that stakeholders used to examine the way in which different adaptation options affected water depths on the two maps. The participants were also provided with time series of water depths and velocities for the duration of the event at a number of locations.

Figure 3. Extent of flooding after 30 min when impermeable surfaces and 3 cm of roof storage have been implemented. The panel on the right shows a detail near a cinema and food complex in Newcastle city centre. Users were able to select a range of viewing options, adaptation options and flood event durations

	Event 1	Event 2
Description of the event	Presentation of a 1 in 100 year storm event and how it would affect the city.	Presentation of modelling results of pluvial flooding in the city centre for a 1 in 50 year return period storm of 30 and 60 min in duration. Model also simulated water depths following the implementation of different adaptation options.
Aim of the event	To review the impacts of the weather event, and to explore the extent to which the assets and services in the city are resilient to both severe weather events and the changing climate.	To explore options to address current and future surface water flooding in Newcastle upon Tyne.
Participants	Local authority representatives: climate change, policy, technical services and resilience officers; Environment Agency; health organisations; regional climate organisation; academics.	Local authority representatives: climate change, policy, technical services; utility providers; regional climate organisation; academics.
Key outcomes	<p>Identified key datasets that would improve the presentation of the scenario but would also be valuable to share among different organisations.</p> <p>Recognised the value of sharing datasets, collating them and visualising them spatially in an easily useable and transferable platform.</p> <p>Highlighted how the scenario could be improved to make it more relevant and realistic (e.g. using data and experiences from past events).</p> <p>Recognition that vulnerability in urban areas is not only due to climate impacts but also a function of social, economic and political factors.</p> <p>Valuable discussion around the synergies and differences between emergency and adaptation planning.</p> <p>Location of where and when adaptation measures may be required. Impacts wider than the city boundary were clearly recognised by the participants.</p> <p>Collaborative identification and design of the second decision theatre event.</p> <p>Identified other partners from around the city that should be involved in future discussions and similar events.</p>	<p>Agreement to share datasets and other models to improve understanding of surface water flooding in the city.</p> <p>Determined that it would be valuable to be able to visualise flow paths, direction and speeds to better understand flood risks.</p> <p>Discussion around the presented and other adaptation options, how to compare them and are they sustainable.</p> <p>Identified multiple benefits of adaptation options (e.g. increasing green space helps alleviate increasing temperatures and enhances its value for ecology and well-being).</p> <p>Important debate about who pays for adaptation and the case for business models.</p> <p>Identified that work is needed on the secondary and indirect potential impacts of flooding in the city (e.g. costs to assets and infrastructure).</p> <p>Recognised the importance of considering climate risks in city-wide development plans.</p> <p>Identified which areas of the city may benefit from monitoring to improve understanding of flood risk.</p>

Table 2. Summary of the two events

3. Outcomes and evaluations of the two events

The overall aim of the events described above was to determine what would constitute a valuable collaborative environment for making decisions that contributed to enhancing the sustainability of the city. Focusing on climate change impacts and adaptation requires a range of organisations to be

involved, thus providing an ideal and timely context for testing the decision theatre concept. Table 2 summarises the aim, context and outcomes of the two events.

The first event focused on developing a collective understanding of the vulnerabilities of the city and region to current climate variability and extreme weather events. One of the

most valuable outcomes from this exercise was identifying datasets that could be shared between organisations to help them to quantify their risks and to advance their understanding of the multiple impacts of given conditions. It was recognised that visualising data on maps at a range of scales quickly identifies hotspots and the consequences of the impacts, and therefore pinpoints priority areas for action. For instance, one of the bridges across the River Tyne is particularly vulnerable to strong winds and is frequently closed to vehicles, and more often so to high-sided vehicles. Typically, this closure would cause significant but not insurmountable congestion across the city and region. However, the scenario forced participants to consider what the impact of closing the bridge would be when other routes were also congested and closed. Furthermore, it was recognised that with future climate projections the bridge may be closed more frequently, which led to discussions over whether the bridge could be adapted or, indeed, whether its replacement might ultimately be a more reliable and cheaper option.

Subsequent discussions focused on the flooding in the city centre highlighted by the storm scenario. Its physical impact on a range of council services, including service depots, care homes and schools; local businesses; all modes of transport in the city and access to the city's hospital were played out. Hotspots of physical vulnerability were highlighted and verified by those participating in the event as being witnessed in reality. However, the participants were also able to identify which areas were home to residents in socioeconomic vulnerable categories and stressed the importance of these types of data, which could also be included and represented spatially. This led to a more informed discussion and prioritisation of adaptation options in terms of their locations when considering cross-sector benefits, such as green space doubling as an amenity for particular communities. The debate led to the co-creation of the second event.

The second event focused on exploring adaptation options to address current and future surface water flooding in the city centre of Newcastle. This event was enabled by the modelling of pluvial flooding and the effect of adaptation options such as green roofs and permeable surfaces, carried out at Newcastle University. The CityCat model is based on standard spatial datasets – a digital elevation model and OS Mastermap, which enable the model to be run at a high resolution up to 1 m and results visualised on base maps where individual buildings can be identified (Glenis *et al.*, 2010).

This event also led to agreements to share datasets and other models to improve participants' understanding of surface water flooding in the city. It is important to gather all available sources of data and to compare different models when simulating results. Suggestions were made for the tool to

visualise flow paths, direction and speeds to better understand flood risks and to explore the value of presenting the scenarios in 3D. Given time and monetary constraints, only a limited number of adaptation options could be tested. However, a group discussion and the recording of ideas around other adaptation options, including improving drainage maintenance regimes, how they could be compared and whether they were sustainable, was particularly valuable. This discussion touched on multiple and cross-sector benefits of adaptation interventions, for example, increasing green space, thus helping to alleviate increasing temperatures and recognising its value for ecology and well-being.

4. Discussion and conclusions

The visualisation and presentation of the research findings in both events led to discussions around the three pillars of sustainability: environmental, economic and social. A joint understanding of the physical environmental impacts of the storm event and surface water flooding was the starting point provided by the academic team. Experts were able to contribute to this knowledge and identify future research directions to improve the understanding of current vulnerabilities. However, vulnerability is not just a function of physical impacts on the environment or infrastructure. Understanding the ability of society to cope or adapt completes the picture of vulnerability. In addition, understanding behavioural change and assessing the mechanisms of change are critical when setting policy agendas or incentives to change. Enabling stakeholders, including the general public, to interrogate decisions in an interactive environment could act as a stimulus for change and guide policy makers. There was an important debate about who pays for adaptation and the case for business models to fund interventions. It was clear from this event's focus on the city centre that a number of business premises are at risk from pluvial flooding and therefore need to be aware of this as well as the potential solutions for avoiding flooding. A decision theatre arena presenting scenarios of different flood events and how adaptation strategies may help alleviate them, coupled with identifying cross-sector benefits and the economic case for installing interventions, would provide the evidence and drivers that local businesses need. In addition, such information needs to be incorporated in future city-wide development plans by local authorities and investors. Coupled with this, the results showed which areas may benefit from additional monitoring to help quantify the risks, and it was recognised that adaptation monitoring post-installation was extremely important to ensure the interventions are effective and sustainable.

In summary, across the two events, the participants included a significant number of organisations suggested by the *North East Climate Change Adaptation Study* (Royal Haskoning, 2006) (see Table 1) that need to take responsibility for

adaptation strategies. Considering the adaptation strategies themselves, the study of the two events teased out the following conclusions: the importance of gathering and sharing data was acknowledged, risks were identified and highlighted, the monitoring and maintenance of assets was considered, the physical adaptation of buildings and landscape was investigated to alleviate flood risk, the importance of long-term planning was recognised, cross-sectoral conversations that could lead to improved partnerships were facilitated and the need to evaluate and measure the approaches implemented was acknowledged.

Both events have shown the value of using advanced visualisation techniques to present scientific information in a facilitated discussion environment to aid collaborative understanding and ultimately decision-making, particularly in situations in which there are multiple organisations with differing priorities. For example, stakeholders recognised how the issues discussed during the two events could improve the proposed new development plans for the area surrounding the railway station, with respect to including features that may attenuate flood waters, given the area was identified as being vulnerable during rainfall events of high intensity. Moreover, these discussions have led to spin-off activities, new collaborations and data sharing between organisations, for example, comparative modelling studies. These new relationships have led to discussions around other applications and demonstrations, for example, infrastructure supporting health provision and catchment management. Our initial approach was pragmatic, focusing efforts on working with local stakeholders as we saw them to be the most likely early beneficiaries of a decision theatre. Mobilising existing tools, datasets and relationships, we were able to develop and demonstrate a prototype of the decision theatre.

Following the two successful pilots, we have been invited to organise additional events by the stakeholders who participated. The events provided a valuable opportunity to discuss the design of hardware and software requirements with other stakeholders, who it is hoped will use, experience and benefit from a decision theatre in their city. Discussions included (a) the value of cloud-based computing processing power rather than on-site processing, for reducing costs and aiding the portability of the decision theatre; (b) a space with permanent big screens has a purpose but is not always appropriate and in some cases portable equipment would be better, for example, for in situ community engagement; (c) use of fully interactive touchscreen devices; (d) mobile devices and apps to facilitate greater public engagement and (e) use of web-based technologies to enable data and visuals to be easily presented.

The long-term objective is the construction of a research and engagement facility for exploring and understanding collaborative

decision-making and public engagement. This forms part of Newcastle upon Tyne's Science Central collaboration among researchers, industries and the public sector to facilitate the impact and uptake of research. Furthermore, the type of interaction enabled by the decision theatre creates the genuine co-production of research agendas and initiatives, rather than stakeholders giving a cursory reading of researcher-driven proposals that occurs in most contemporary cases. The vision of the world-leading civic university could be a very strong and explicitly visual reality. It is envisaged that ultimately the decision theatre will combine state-of-the-art visualisation, simulation tools and decision science to enable stakeholders, policy leaders and community members to address a range of current and future sustainability challenges.

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