Understanding Pressures on the Future of Roads

A Sustainable Built Environment National Research Centre (SBEnrc) Discussion Paper by Curtin University and the Queensland University of Technology

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Synopsis

According to the Australian Government, when combined with expected population growth and internal migration, expected changes in temperature and rainfall are expected to increase road maintenance costs by over 30 percent by 2100. This presents a significant future economic risk, in response, this paper will discuss the potential for roads to improve their resilience to the impacts of climate change and other key pressures. The paper will also highlight how such measures can inform state and national main road infrastructure planning and reduce future associated risks and costs.

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1. What will be the increasing pressures on the '*Future of Roads*'?

In the coming decades the design, construction and maintenance of roads will face a range of new challenges - that in many ways will bear little resemblance to the challenges previously faced - and as such will require a number of new approaches. Such challenges will result from a growing number of interconnected environmental, social and economic factors, which are set to apply significant pressure on the future of roads. For instance, environmental pressures will include the impacts of climate change on rainfall patterns and temperature profiles; economic pressure will be affected by shifting global economic balances and flows, and will include materials and resources shortages, along with predicted increases in energy and resource prices globally,[1] and social pressures will include potential shifts to lighter vehicles, reduced use of cars due to higher fuel costs, and political pressure to respond to climate change.

When considering the impact on the world's economies of such pressures it is sobering to consider that the distance covered by roads around the world is more than 34 million kilometres,[2] nearly 90 times the distance from the Earth to the Moon. Given that roads typically have a design life of 20 to 40 years, with bridges being designed for up to 100 years, the level of consideration of future environmental impacts, economic risks, and social trends associated with roads will have a significant impact on the long term associated costs and impacts. With this in mind a number of Australian state governments are investigating the likely influences on the future of roads and considering how a strategic response can be informed – the impetus for this project.

The SBEnrc '*Future of Roads*' project is a collaboration between academia, government and industry to combine world class research with both operational understanding and policy experience to inform the consideration of the increasing pressures that will face roads in the future. A key step in the early stages of the research project comprised a literature review to ascertain various advances in the world in the area. Following this the team held its first stakeholder engagement workshop in Perth (Hosted by Main Roads Western Australia) in July 2011 to discuss the potential future pressures that will influence roads, pressures that may or may not be currently taken in to consideration, as shown in Table 1. The second stakeholder workshop is to be undertaken in Brisbane and to be hosted by Queensland Government Department of Transport and Main Roads.

Table 1: *A brainstorm of increasing pressures on the future of roads*

– Climate change,* – Rising price of oil,* – Resource shortages,* – Water scarcity*, – Increased community action*, – A price on carbon,	– Waste reduction and harnessing, – Rapid urbanization, – Peaking of food production, – Growing environmental awareness and cooperation, – Increased understanding of the need for resilience,

– Aging Population, – Increased complexity, – Biodiversity collapse, – Species depletion, – Intensified rainfall, – Loss of agricultural land, – Technology Innovation, – Increased automation, – Professional integration,	– Increased social networking, – Increased use of smart applications and technology, – Increased Public, Private, and Community Partnerships, – Population increase, – Growing middle class, and – Modal shifts (personal transport and freight).

Note: Participants were asked to identify the most influential increasing pressures on the future of roads, listed first and designated by a star.

Source: SBEnrc Stakeholder Workshop, Hosted by Western Australian Main Roads, Facilitated by Curtin University and QUT, 12 July 2011, Perth.

As part of the provocation to consider the increasing pressures on the future of roads the participants were provided with a list of the preliminary themes from the Australian Green Infrastructure Council (AGIC) Rating Tool that is currently under development, as shown in Table 2.

Table 2: *Australian Green Infrastructure Council Rating Tool (Preliminary Themes)*

– Purchasing & Procurement – Reporting & Responsibilities – Making Decisions – Climate Change Adaptation – Knowledge Sharing & Capacity Building – Value For Money – Economic Life – Energy Use Water – Materials Selection & Use – Greenhouse Gas Management – Discharges to Air Land & Water	– Land Management – Waste Management – Functioning Ecosystems – Enhanced Biodiversity – Participatory Processes – Positive Legacy – Urban & Landscape Design – Knowledge Sharing – Capacity Building – Increased Knowledge and Applied Sustainability and – Equity.

Note: Four sub-categories are yet to be decided and are currently under review.

Source: Australian Green Infrastructure Council[3]

As the tables show there are a growing number of increasing pressures on the future of roads, some clearly understood and some newly emerging. Both the impact on roads and their contribution to such pressures represents a significant challenge and an exciting opportunity. The research project seeks to demonstrate that by embracing new technology and innovations effectively and strategically, governments can ensure that roads not only minimise their impact on the environment and contribution to climate change,[4,5] but also make significant contributions to society, such as through enhancing Australia's efforts to mitigate and adapt to climate change.

Considering the case of 'climate change' as a pressure on the future of roads, the most recent Intergovernmental Panel on Climate Change (IPCC) assessments

suggest that '*warming of the climate system is unequivocal*', and will have significant impacts on the worlds' cities and infrastructure. Such impacts are increasingly being felt with Australia experiencing marked declines in regional precipitation levels along the eastern and western coasts in the early parts of the last decade.[6] Such changes to precipitation levels will have impacts on the future of roads and will influence soil moisture contents, pavement moisture levels and design life, and design loads on storm water infrastructure associated with roads.

The environmental, financial, and social impacts of climate change represent one of the most pressing global issues, which will directly and indirectly impact current and future road infrastructure. The solutions to such a challenge will need to be dynamic and flexible to successfully navigate the inevitable changes to the environment, society, and the economy. The unprecedented nature of the potential impacts from climate change on roads is such that the existing assessment and planning frameworks are likely to be insufficient and will need updating. Further, the potential interaction of the many concurrent pressures and events is such that there is an urgency to develop an understanding of the future of roads within these contexts, and design appropriate assessment and planning frameworks to ensure that road design and construction is resilient and responsive to the future.

2. Roads and Climate Change Mitigation and Adaption in Australia

The Australian road network spans a wide variety of geographic areas and according to the BITRE extends a distance of 814,000 kilometres[7] - enough to circle the Australian Coastline 31 times.[8] Furthermore, the value of road construction in Australia has been estimated to be in the order of $17.5 billion per year, and road maintenance costs estimated to be in the order of $5 billion per year and rising. According to the Australian Government for example, when combined with population growth and internal migration, changes in temperatures and rainfall are expected to increase road maintenance costs by over 30 per cent by 2100.[9]

Road building is inherently an efficient practice that seeks to minimise costs related to construction and maintenance, with a range of considerations given to current and future environmental issues. Such practices include balancing earthworks to optimise cut and fill levels, utilising local sources to minimise the import of materials, ensuring impacts on the local environment and biodiversity are appropriately managed, optimising pavement thickness for anticipated conditions, and through effective scheduling of associated capital expenditure. These practices have enhanced Australia's extensive road infrastructure over the last two decades and will be a key part of road building in the coming decades as part of the response to a changing climate. In order to compliment such practices a range of new practices will be developed in response to a range of new design and performance considerations, in areas including material extraction, transporting, earthwork and paving.

Roads currently contribute significantly to climate change through their construction, maintenance and use. Imbedded within this, however, is a key opportunity for road designers to contribute to climate change mitigation efforts through the use of

innovative design and technologies. Currently, efficiency measures and alternatives to a range of materials can reduce the impact of road construction, while investments in alternative automobile fuels, increased automobile fuel efficiency, and alternative transport modes and options, can minimise the impact of road use. Rethinking the layout, design and regulation of roads may enable greater efficiencies in road use through reduced kilometres travelled and minimised congestion.

There may furthermore be opportunities for roads to go beyond reducing negative environmental pressures to provide net climate change mitigation benefits. For example, alternative road base materials may provide opportunities for sequestering carbon, or roads may be designed to enable electricity generation through capturing solar or kinetic energy. Roads may be designed in ways that encourage pedestrian transport, and enable the existing amount of road surface to be reduced and replaced by green space. Considering the breadth of concurrent pressures facing road design, construction and use, can reveal opportunities for such holistic, whole-system innovations in roads that may provide significant environmental, social and economic benefits.

Roads are a vital component of our social and financial systems, providing mobility corridors for people, enabling freight networks to transport food, goods and services and distributions paths for emergency services and disaster relief teams. Climate change is likely to impact road infrastructure and use as climatic conditions become more extreme in many areas of Australia, threatening the viability of essential services and systems that rely on them. A key challenge for road designers is to understand the impacts of climate change and reduce the vulnerability of road services. Further, roads may enhance the resilience of human settlements and systems by reducing the risk of, for example, bushfires by acting as a firebreak, or providing mobility during extreme climatic events such as floods or cyclones. Roads provide access for emergency services and the consequences are life threatening when this access is compromised. In the face of increasing frequency in natural disasters such as floods, cyclones and bushfires, roads become a nation's lifeline to affected communities and will need to be able to resist inundation, heat and stress damage. Understanding how climate change will affect Australia will need to underpin the future design of roads to ensure that the services that rely on them will still be viable during such events.

Determining a road's level of susceptibility to the effects of climate change, and its ability to adapt to and mitigate these climatic effects, is an important part of investigating the future of roads. Table 3 provides an outline the impacts of climate change, matched with specific implications for roads and road construction.

Table 3: Impacts of Climate Change on Road Infrastructure

Issue	Implication for Roads
Temperature increase & severe droughts	– Increased road maintenance of surface cracking due to changing landscape topography caused by evaporation. – Maintenance caused by increased wear and tear of road surfaces due to temperature increasing the fragility of the road surface.

	– Increased rehabilitation of road surfaces due to surface cracking, warping and asphalt bleeding (flushing).
Increased extreme rainfall events & flooding	– Increased amount of road maintenance caused by potholes being created when water enters the road surface. – Increased road rehabilitation due to flooding events affecting large expanses of roadways. – Decreased ability for maintenance and rehabilitation to take place due to extreme wether events affecting construction days and access. – Road flooding putting pressure on road network and drainage systems.
Population increase	– Demand for new road infrastructure and maintenance – Demand for upgrading existing infrastructure.
Sea Level Rise	– Implications of salt-water corrosion of roads due to flooding increasing the water table and sea level rise. – Increased storm surge and wave impact on coastal and low-lying coastal areas.
Increased Cyclones	– Increased debris on roads causing road damage and traffic hazards.
Peak Oil Costs	– Increased costs of road infrastructure and maintenance. – Increased cost of fuel and effect on private vehicle use behaviour,

Source: Whistler, L. (ongoing) *Masters Thesis*, Queensland University of Technology.

Existing efforts to adapt road building practices to address the threats of climate change are being enhanced by a number of emerging rating schemes for infrastructure, on our shores and abroad. The research team is in the process of investigating a number of such schemes and tools, for instance:

– The Australian Green Infrastructure Council (AGIC)[3] are preparing to release an assessment scheme to the industry in late 2011 applicable to many types of infrastructure including roads.

– VicRoads have released 'INVEST' (Integrated VicRoads Environmental Sustainability Tool), a tool that enables assessment of the equality of the sustainability considerations and practices that are included in on road construction projects.[10] The tool promotes projects which advance the state of sustainable transport solutions, and requires independent verification of certification. Early outcomes of INVEST have been reported to be the driving and achievement of reductions in greenhouse gas emissions from road construction projects.

– Roads Australia, the national peak body for the road transport sector, has developed a Sustainability Chapter to emphasise and address sustainability in major road construction projects. This has resulted in a number of non-price based criteria to rate and rank the overall sustainability of complex road infrastructure projects.[11]

– Infrastructure Australia has developed a number of tools and reports related to improving the infrastructure in Australia.

– In the US, the 'Greenroads' rating scheme is a sustainability rating system for roadway design and construction. The tool assesses both mandatory practices (ie minimum requirements for green roads) and 'voluntary credits', which may be predefined or created through individual projects. In this way, the Greenroads rating scheme is able to rank and rate projects and encourage new and innovative construction practices and paradigms.[12]

3. What is the focus of the '*Future of Roads*' project?

As part of the first stage of the project, through till September 2012, the team intends to develop a number of key outcomes supported by undertaking a review of literature, publications and case studies, that will be complimented by selected semi-structured interviews and stakeholder workshops, in order to:

(a) **Investigate ways to reduce environmental pressures from road building**, and the project aims to identify best practices related to:

- road materials (*including the extraction, crushing, transportation and placement of traditional and alternate materials and aggregate replacement options*);
- the use of concrete (*including aggregate alternatives, cement alternatives, placement and carbon storage options*);
- the use of bitumen (*including raw aggregates, mix design, warm and cold mix technologies and placement*); and
- impacts on watersheds and biodiversity (*including toxicity, leachate, runoff pollutants and groundwater pollutants, erosion issues, changes to hydrology, changing stability of road and surrounds, and changing porosity of road and surrounds*).

(b) **Investigate the potential for adaptation to future pressures such as climate change and peak oil**, and the project aims to develop of a base framework for a '*Sustainability Assessment Framework for Road Infrastructure*' (SAFRI) model. The new model will be used to undertake a preliminary comparison of current national practices to identify opportunities for improvement. Project partners will be invited to nominate projects implement the assessment framework as part of its development. The framework will tie in closely with the AGIC framework.

As part of the second stage of the project beginning in October 2012 the research team intends to expand SAFRI and undertake a comprehensive comparison of current national practices to identify opportunities for improvement to inform recommendations as to potential legislative and policy adjustments and to investigate potential impacts and benefits of such adjustments.

(c) **Investigate the opportunity for utilising road areas to contribute to the mitigation of climate change and strengthening infrastructure and economic resilience**, and the project aims to develop an '*Innovative Scenarios for Sustainable Road Infrastructure*' (ISSRI) scenario planning methodology.

Using the ISSRI scenario planning methodology will be used to interrogate a range of innovative scenarios to consider the availability, reliability and cost of existing and emerging options, considering the likelihood of adoption and appropriateness of each scenario in the context of various socio-economic and environmental conditions.

As part of the second stage of the project beginning in October 2012 the research team intends to expand ISSRI to consider a wider range of potential scenarios in collaboration with partners.

4. References

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