CLIMATE CHANGE AND TRANSPORT INFRASTRUCTURE: ARE WE TRAVELLING IN THE RIGHT DIRECTION?

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1. Introduction

Transport infrastructure plays a fundamental role in our society. It comprises the range of installations needed to move people and goods, such as roads, railways and ports. By enabling the physical movement of individuals and goods from one place to another, transport infrastructure facilitates trade, provides customers with access to goods and enhances labour mobility. Needless to say, obstacles to the establishment and maintenance of transport infrastructure that is fit for purpose could have important economic and social ramifications.

When the challenges associated with providing and maintaining transport infrastructure at an adequate level are considered, the most common themes that emerge are increasing demand, congestion and the burgeoning cost of building and upgrading such infrastructure. Climate change has not been a high profile issue in this regard, despite growing evidence linking human activity with the concentration of greenhouse gases in the atmosphere and the widespread physical consequences, including for transport infrastructure. Moreover, when climate change has been considered in the context of transport, the focus has predominantly been on the contribution that transport makes to Australia's greenhouse gas emissions, particularly through the combustion of fuel for road transport.

Nevertheless, a looming challenge that, up until now, has received relatively little consideration by legislators, regulators and sectoral participants alike is the impact that the physical effects of climate change is likely to have on transport infrastructure. The physical effects of climate change that could pose particular challenges for transport infrastructure include higher temperatures and increased solar radiation, rising sea levels, increasing prevalence of bushfire events and storm surges and increases in storm severity, including lightning strikes, extreme winds and heavy rainfall. While the impact of climate change on transport infrastructure may vary depending upon a variety of factors, including the particular type of infrastructure in question, its location, design, age and relative usage, there will be consequences for most regulators, owners, operators and users of transport infrastructure throughout the country.

The specific issue considered in this paper is whether the regimes that regulate the ownership, management and use of transport infrastructure in Australia include tools to help address the challenges that climate change presents. The aim of the paper will be to illustrate how these existing tools could be used to combat climate change.

2. Framework for analysis

In this paper, we apply a framework for analysis of the impact of climate change on the main types of local transport infrastructure – namely, roads, railways and ports.[1] The framework assists in assessing whether the respective regulatory regimes are equipped with tools to effectively address the effects of climate change.

In particular, we:

- identify the main physical impacts of climate change on Australia's road, rail and port infrastructure to ascertain the likely consequences of climate change for these types of infrastructure;
- identify the entity/ies that will be required to take responsibility for addressing the effects of climate change;
- outline the types of powers and tools that these entities have at their disposal to combat climate change;[2] and
- identify the ways in which the regulatory environment within which transport infrastructure is owned, operated and managed might need to change to more fully accommodate the effects of climate change.

3. Roads

3.1 Profile of road infrastructure in Australia

Australia has a vast road network, which extends across the country's states and territories. In considering the impact of climate change, it will be necessary to consider the type, usage, location, ownership and management structure for the components of road infrastructure that make up this network.

There are four main categories of road infrastructure, namely:

- *Municipal roads*: Municipal roads provide access to homes, businesses, health and community service buildings and recreational facilities located within the relevant municipalities.
- *Arterial roads*: Arterial roads are main routes for the carriage of traffic, with moderate or high capacity. They carry large volumes of traffic within and between urban centres and may link freeways. Commercial buildings, shopping centres and petrol stations are located on these types of roads.
- *Freeways*: Freeways allow for the high-speed operation of vehicles. Cross traffic from other roads and rail tracks as well as access to and from adjacent properties is usually not possible on freeways.

[1] We have not included a discussion of the impact of climate change on airport infrastructure because the adaptation issues that arise in that context are not specific to the transport sector but, rather, relate more generally to large buildings and development.

[2] In reviewing the array of tools available to combat climate change, we reviewed transport regimes in New South Wales, Queensland, Victoria and Western Australia. We focused on those jurisdictions where the available regulatory tools appeared to be of most relevance and potential use in addressing the effects of climate change.

- *Tollways*: Tollways are roads for which users pay a toll for access and use (VicRoads 2010; RTA 2010).

While traffic volumes are generally greatest on arterial roads, the overall length of the municipal roads, as a proportion of the Australian road network, is greater. Freeways and tollways often form important links in the broader road network.

Generally speaking, ownership and responsibility for the management of road infrastructure lies with the public sector. More specifically, most road infrastructure in Australia is publicly owned and managed by the state or territory government through statutory authorities (in the case of arterial roads) and by local governments (in the case of municipal roads) (DITRDLG 2010). A relatively limited proportion of road infrastructure – particularly, tollways and bridges (if they are part of a tollroad) – is owned and managed privately. The federal government also has a stake in the comprising the 'National Land Transport Network (which consists only of national roads) , which is co-funded by federal and the relevant state and territory governments (DITRDLGa 2010).

The location of road infrastructure will also be relevant in assessing the likely impact of climate change. For example, roads in low lying or coastal areas will be most susceptible to the effects of sea level rise and flooding, whereas roads located in hot climate zones will be particularly vulnerable to the effects of increased temperature and solar radiation.

3.2 The impact of climate change on road infrastructure

The Table below summarises the main impacts of climate change that are likely to affect road infrastructure. It illustrates the possible consequences of climate change for owners, managers and users of road infrastructure (CSIRO *et al* 2007, ATRF Conference 2009).

CLIMATE CHANGE EFFECT	DIRECT IMPACT ON ROAD INFRASTRUCTURE	CONSEQUENCES FOR ROAD INFRASTRUCTURE
Increased temperatures and solar radiation Increased rainfall Rising sea levels Flooding Bushfires	Embrittlement and cracking of bitumen Loss of water seal causing potholing Low lying roads may be submerged Damage to road foundations as a result of prolonged drought and low rainfall	Temporary or permanent blocked road access Interruption to commercial activities that depend upon road transport Increased maintenance costs to increase resilience Re-routing to avoid climate change affected roads Increased risk of liability resulting from road damage Higher insurance costs

There have been some recent illustrations both in Australia and elsewhere of the damage to road infrastructure that might result from physical phenomena that have been associated

with climate change. For example, Cyclone Ului, which hit northern Queensland in March 2010, resulted in damage to the road network by exposing the road bed. In addition, trees and power lines that were felled as a result of the cyclone hindered road access. These consequences were exacerbated by subsequent flooding (AAPa 2010; AAPb 2010).

3.3 Regulatory framework

Regulatory frameworks for road infrastructure are typically aimed at promoting safe and efficient roads. Among other things, the relevant legislative instruments:

- identify the entities that are responsible for the management of road infrastructure;
- set out the role, functions and powers of road authorities; and
- establish the general principles that apply to road management.

We examine some aspects of these regulatory frameworks to illustrate how the powers and tools they include could be utilised to address the effects of climate change.

3.3.1 Functions and powers of road authorities

In the jurisdictions considered, there are two main categories of road authorities, namely:

- state government bodies that are dedicated to the management of the larger arterial roads, such as VicRoads in Victoria and the Road Traffic Authority in New South Wales (VicRoads 2010; RTA 2010); and
- local government councils, which are responsible for public roads within their respective municipal areas (DITRDLG 2010).

The functions and powers of road authorities typically include:

- to provide and maintain roads for use by the community; and
- to design, construct, inspect, repair and maintain roads and related road infrastructure.

In performing these functions, road authorities must take all steps that are reasonably practicable to ensure the structural integrity and safety of public roads.

Assuming that adequate funding is available, these functions and powers of road authorities could be viewed as broad enough to accommodate efforts to address the effects of climate change, although they have not as yet been invoked and applied in this context. In addition, some regimes contain specific functions and powers that could prove particularly useful in assessing and, potentially, addressing climate change. These regimes, including the functions and powers that might be useful in combating climate change, are discussed below.

3.3.2 Road management plans

Two of the jurisdictions considered – namely Victoria and Queensland – provide for the development of road management plans, which could prove an important tool in addressing climate change.

Victoria's *Road Management Act* 2004 empowers – but does not oblige – road authorities to develop a 'road management plan'. The primary purpose of road management plans is to establish good asset management practices focused on delivering the optimal outcomes for the available resources, having regard to the applicable policies and priorities. Through road management plans, individual road authorities may determine standards and policies for managing public roads that are under their control (Minister for Transport 2004).

Under Queensland's *Transport Infrastructure Act* 1994, a 'roads implementation program' must be developed and must include performance targets for road transport infrastructure. In the most recent roads implementation program for the period 2009/2010 to 2013/2014, reference was made to environmental management initiatives adopted by Queensland's state government, which formed the context for prospective road works. Such environmental management initiatives included conservation of ecologically significant areas, conservation of heritage listed sites (including protecting significant trees) and road landscaping and amenity activities (DTMR 2009).

It is conceivable that, in the jurisdictions where road management and implementation programs are currently provided for, in the future, they will expand beyond standards and performance targets that are aimed at minimising the impact of road infrastructure on the environment to include those that accommodate the impact of climate change on road infrastructure.

3.3.3 Codes of road practice

Codes of road practice could also prove a useful mechanism to accommodate the effects of climate change, which could complement road management plans.

Victoria is the only jurisdiction considered that provides for such codes. In particular, the Victorian *Road Management Act* 2004 empowers the Minister to make a Code of Practice for a road authority or class of road authorities. Among other things, a Code of Practice may establish benchmarks of good practice in relation to the performance of road management functions by road authorities, those that develop new road infrastructure as well as providers of public transport services. However, it is notable that a Code of Practice cannot impose obligations on these parties nor can they direct how any matter or thing is to be done.

A Code of Practice for Road Management Plans was issued in 2004 in Victoria. It provides that road management plans may establish the standard or target condition to be achieved in the maintenance and repair of different types of road infrastructure. The Code of Practice further provides that the road management plan may set out details of the applicable management system, the purpose of which is to discharge the relevant entity's duty to inspect, maintain and repair (Minister for Transport 2004).

In determining appropriate standards for road management, the Code states that a road authority should consider a range of factors, including:

- environmental factors and any other relevant risk factors;
- the type of road infrastructure, the volume and nature of public road usage;
- community expectations; and
- the resources available, and the competing demands for these resources (Minister for Transport 2004).

Depending upon the type, location and usage of road infrastructure, 'relevant risk factors' could include the physical effects of climate change. Moreover, accounting for 'community expectations' may involve consideration of and response to such effects to ensure that road infrastructure is capable of withstanding these effects and is fit for purpose.

3.3.4 Liability

An important issue that road authorities must account for in deciding whether, when and how to respond to the effects of climate change in the context of road infrastructure is liability.

While most road regulatory regimes do not explicitly outline the liability consequences of road authorities' acts or omissions that may cause loss or damage, the Victorian regime does provide guidance as to how this issue will be addressed.

Specifically, the Victorian *Road Management Act* 2004 addresses civil liability that might be imposed on road authorities for acts and omissions relating to the development and upkeep of road infrastructure.

The Act sets out factors that must be considered by a court of law in determining whether a duty of care exists or the duty of care has been breached. These factors include:

- the character of the road and the type of traffic that could reasonably be expected to use the road;
- the standard of maintenance and repair appropriate for a road of that character used by traffic of that type;
- the state of repair in which a reasonable person would have expected to find a road or infrastructure of that character;
- whether the road authority knew, or could reasonably be expected to have known, the condition of the road or infrastructure at the time of the relevant incident; and
- in the case where the road authority could not have reasonably been expected to repair the road or infrastructure or take other preventative measures before the relevant incident, whether the road authority did display, or could be reasonably expected to have displayed, appropriate warnings.

Despite the foregoing, the Act does contain limits on the liability that might be imposed upon road authorities. Specifically, it provides that a road authority is not

liable in any proceeding for damages in respect of any alleged failure by the road authority to remove a hazard or to repair a defect or deterioration in a road or to give warning of a hazard, defect or deterioration in a road unless the road authority had actual knowledge of the particular risk the materialisation of which resulted in the harm. Accordingly, a road authority must respond to deterioration and damage to road infrastructure, whatever its cause, to the extent that the authority is aware of the deterioration or damage.

The Act also establishes a 'policy' defence for road authorities and infrastructure and works managers. In practical terms, this means that, where a road authority acts in accordance with established policy (including a road management plan), it will not be liable for losses suffered by third parties as a result unless the policy is completely unreasonable – in other words, a reasonable road authority would not have acted in accordance with the policy.

In essence, these liability provisions suggest that road authorities need to ensure that they account for and reasonably respond to foreseeable climate change related risks that might otherwise cause loss or damage to users of road infrastructure. This approach would also be prudent in jurisdictions where explicit liability provisions of the kind found in the Victorian *Road Management Act* 2004 do not exist.

4. Rail

4.1 Profile of rail infrastructure in Australia

Rail infrastructure includes railway tracks, rolling stock, over and under-track structures, signalling and communication systems and related buildings, plant and equipment.

The rail networks in Australia's states and territories include metropolitan, intrastate and interstate sub-networks, which are used for both passenger and freight transport services (NSW Government 2010; VicTrack Access 2010).

While rail networks are usually owned by the relevant state and territory governments through governmental instrumentalities such as VicTrack in Victoria and RailCorp in New South Wales,[3] these entities are empowered to lease rail infrastructure to other statutory or private bodies that provide rail services pursuant to access arrangements, which are overseen by the relevant jurisdictional regulator. Furthermore, each of the states and territories has arrangements with the federal government for the provision of interstate and national rail services using rail infrastructure that is managed by the federal government (NSW Government 2010; VicTrack Access 2010; ATRC 2010). In particular, the Australian Competition and Consumer Commission regulates access by private operators to that part of Australia's rail track which is owned and operated by the Australian Rail Track Corporation (a federal government entity). Those wishing to access the national rail network must apply to the ACCC for access (ATRC 2010).

As in the case of road infrastructure, the location of rail infrastructure (among other things) will also be relevant in assessing the likely impact of climate change. The relevant parts of rail networks that are used to support ports and port infrastructure by connecting ports to the hinterland are likely to be susceptible to the effects of sea level rise, flooding and storm surges. Similarly, rail networks located in hot climate zones are most likely to suffer from train delays resulting from heat-affected swollen rail tracks (CSIRO *et al* 2007).

[3] Rail networks may also be owned by the Commonwealth government or by private owners.

4.2 The impact of climate change on rail infrastructure

The Table below summarises the main impacts of climate change that are likely to affect rail infrastructure. It illustrates the possible consequences of climate change for owners, managers and users of rail infrastructure (CSIRO *et al* 2007).

CLIMATE CHANGE EFFECT	DIRECT IMPACT ON RAIL INFRASTRUCTURE	CONSEQUENCES FOR RAIL INFRASTRUCTURE
Increased temperatures Flooding Sea level rise Increased intensity and frequency of storms	Buckling of tracks Low lying rail tracks and those tracks which service ports may be submerged Signal and other electrical damage Damage to rail foundations as a result of prolonged drought and low rainfall	Delays, derailments and re-routing Interruption to commercial activities that depend upon rail transport Increased maintenance and replacement costs Increased risk of liability resulting from rail damage Higher insurance costs

The intense heat experienced in Melbourne during the 2008 – 2009 summer illustrates the consequences of climate change for rail infrastructure. Soaring temperatures caused the Melbourne metropolitan railway network to swell which, in turn, resulted in significant disruptions to passenger train services for extended periods of time (Lucas 2010). Cyclone Ului also illustrates the possible consequences of extreme weather events. In addition to the impact on road infrastructure, this cyclone created disruption to Queensland's rail network, particularly that part of the network, which supports the Hay Point Dalrymple Bay coal terminals (Reuters 2010; Walsh 2010).

4.3 Regulatory framework

Regulatory frameworks for rail infrastructure in the states and territories typically include the following core elements:

- identification of rail transport corporations, which own and manage Australia's rail networks;
- establishment of regimes for access to rail infrastructure by transport service providers; and
- obligations to ensure safe rail and reliable rail transport services.

Aspects of these regulatory frameworks that may be relevant to assess the extent to which they can be utilised to address the effects of climate change are discussed below.

4.3.1 Rail maintenance and repair obligations

In most jurisdictions, statutory rail corporations have been established to own, manage and operate rail infrastructure, particularly for passenger services. The responsibility for undertaking repair and maintenance work on rail infrastructure is

generally governed by lease arrangements between the government owners of such infrastructure and the public or private lessees. Consequently, it is probable that we will see leases being used as a vehicle to ensure repair and maintenance work to address the effects of climate change in the future.

For example, the Transport Service Contract (Rail Infrastructure) Agreement between the Queensland Government and Queensland Rail (a government corporation established to provide rail transport services) provides a useful example of one such lease arrangement. Under that agreement, Queensland Rail is obliged to provide services and maintain the performance of rail tracks to standards specified in the agreement (Queensland Government 2010). In addition, the Yarra Trams Infrastructure Sublease between the Director of Public Transport and Metrolink Victoria Pty Ltd (among others) requires that the latter maintain the infrastructure such that it may be used for its intended purpose and comply with 'environmental laws'. Under the Sublease, 'environmental laws' includes laws relating to climate (Victorian Government 2010).

In the future, it is possible that the performance obligations included in agreements of this kind will explicitly require lessees to address the effects of climate change in the management and operation of rail infrastructure. These agreements could also be used to allocate responsibility for climate change risks resulting in injury and damage to property arising from disrepair or infrastructure deterioration to the manager or operator of the rail infrastructure.

4.3.2 Safety accreditation

By way of complement to obligations that may be contained in bilateral lease arrangements between owners and operators of rail infrastructure, two of the jurisdictions considered also impose statutory obligations on rail infrastructure operators to ensure that such infrastructure is safe and reliable through safety accreditation.

In particular, the Victorian *Rail Safety Act* 2006 requires accreditation of owners and managers of rail infrastructure and rolling stock by Public Transport Safety Victoria (**PTSV**). The PTSV is responsible for, among other things, the safety accreditation of rail operators in Victoria and monitoring the compliance of infrastructure (through inspections) with statutory requirements. The purpose of accreditation is to ensure that operators have the competence and capacity to manage safety risks associated with rail operations (PTSV 2010).

Similarly, Queensland's *Transport Infrastructure Act* 1994 establishes as a pre-requisite to accreditation, a requirement that the railway manager or operator has an appropriate safety management system in place.

Depending upon the type of rail infrastructure, location and age, safety and reliability of rail services may be compromised if the effects of climate change are not adequately accounted for. Accordingly, in the future, safety accreditation may be used to ensure that climate change risks are accounted for in the context of the management and operation of rail infrastructure.

4.3.3 Safety and fitness for purpose obligations

The statutory regime could also include specific obligations requiring those involved in the design, supply and installation of rail infrastructure to ensure that the

infrastructure is safe and fit for purpose, including in the context of physical conditions arising as a result of climate change.

For example, the New South Wales *Rail Safety Act* 2008 requires any person who designs, commissions, manufactures, supplies, installs or erects rail infrastructure or rolling stock must ensure, so far as is reasonably practicable, that the infrastructure is safe if it used for a purpose for which it was designed, commissioned, manufactured, supplied, installed or erected.

These types of provisions could be invoked in cases where newly installed rail infrastructure does not account for the effects of climate change and thereby renders the infrastructure unsafe and/or unfit for purpose.

5. Ports

5.1 Profile of port infrastructure in Australia

Port infrastructure exists in each of Australia's states and territories, including a mix of major commercial ports, which are used for domestic and international trade, and smaller local or community ports. The larger commercial ports are either publicly owned and operated through statutory corporations and authorities or privately owned and operated. The smaller, community ports are owned and operated by local councils or by private entities.

Unlike local ports, the larger commercial ports are usually subject to access and price regulation.

Regimes for the regulation of port infrastructure typically relate to a broad range of onshore and offshore port facilities and assets including:

- wharfs and port marine operational areas;
- shipping channels;
- bulk loading and unloading facilities;
- boat harbours and boat ramps;
- vehicle and railway ferry terminals;
- access roads and rail corridors; and
- car parking facilities.

5.2 The impact of climate change on port infrastructure

The Table below summarises the main impacts of climate change that are likely to affect port infrastructure. It illustrates the possible consequences of climate change for owners, managers and users of port infrastructure (CSIRO *et al* 2007).

CLIMATE CHANGE EFFECT	DIRECT IMPACT ON PORT INFRASTRUCTURE	CONSEQUENCES FOR PORT INFRASTRUCTURE
Increased severity of weather events (including	Corrosion	Increased frequency and duration of port closures

CLIMATE CHANGE EFFECT	DIRECT IMPACT ON PORT INFRASTRUCTURE	CONSEQUENCES FOR PORT INFRASTRUCTURE
rainfall, wind, cyclones and sea storms) Sea level rise Increased ocean swell Ocean acidification	Infrastructure damage and deterioration resulting from heavy storm activity Inundation of infrastructure	Shipping delays Damage to cargo and goods Increased costs of sea trade and shipped goods Increased maintenance and replacement costs Increased risk of liability resulting from port damage Higher insurance costs

The degree to which port infrastructure is likely to be affected by climate change depends on the port type, construction and location. The effects of climate change are likely to be more serious and damaging in areas that are already prone to tropical cyclones, including northwest Western Australia, the Northern Territory and the Queensland coast. Nevertheless, as sea levels continue to rise and the incidence of extreme weather events becomes more widespread, it is possible that port infrastructure located in other areas will also be affected (CSIRO *et al* 2007).

5.3 Regulatory framework

The regulatory frameworks applicable to Australia's ports typically:

- establish port authorities, which are responsible for the management of port infrastructure; and
- provide for the effective management and operation of ports.

Aspects of these regulatory frameworks that may be relevant to assess the extent to which they can be utilised to address the effects of climate change are discussed below.

5.3.1 Functions and powers of port authorities

In general terms, there are two main categories of port authorities – namely, those that are responsible respectively for commercial trading ports and local or community ports. The obligations imposed on the former are usually more onerous than those imposed on the latter.

Under the Victorian *Port Services Act* 2004, port corporations, which are responsible for commercial trading ports must, among other things:

- manage and develop ports in an economically, socially and environmentally sustainable manner; and
- facilitate the integration of infrastructure and logistics systems in the port with systems in place outside the port in a manner which is commercially sound and environmentally sustainable.

The Victorian regime is unique in that it expressly requires that account be taken of environmental considerations by port authorities in the management of port infrastructure, although the impact of climate change is not specifically identified. We discuss other more specific examples of requirements regarding the account that must be taken of environmental factors below.

5.3.2 Environment management plans

Part 6A of the Victorian *Port Services Act* 2004 contains another useful tool that could be useful in combating climate change. Specifically, it requires port authorities to prepare environment management plans. They must also ensure that reasonable steps are taken to implement these plans.

The Act sets out in some detail what is required in environmental management plans. Among other things, these plans must identify the nature and extent of environmental hazards, specify the measures and strategies to prevent the hazards and set out how tenants, licensees and service providers will be involved in the implementation of the environment management plan. In addition, the relevant Minister can provide guidance or direct port authorities on how the environment management plans should be developed, as well as the content and implementation of the plans.

The Act also provides for regular audits of the managements plans to ensure they are adequate. The plans need to be certified by an environmental auditor and may be the subject of audits to ensure that they are adequate and meet the Act's requirements.

Environment management plans, and the compliance framework which supports them, could be an effective mechanism through which the effects of climate change could be addressed.

5.3.3 Port management plans

More generic port management plans could also be used to ensure that account is taken of the impact of climate change on port infrastructure, such as those provided for in the context of the Queensland regime.

Under Queensland's *Transport Infrastructure Act* 1994, certain port authorities must prepare and submit to the Minister a port land use plan, which sets out the uses and intended uses of the port land. A port land use plan must specify, among other things, the desired environmental outcomes for the land, including measures that will assist in achieving the desired environmental outcomes. The purpose of plans of this kind could be extended to include reference to measures that are needed to respond to the effects of climate change.

5.3.4 Liability

Queensland's *Transport Infrastructure Act* 1994 envisages the possibility that port owners and operators could be held liable in negligence for failing to maintain a port in 'good condition to a standard appropriate to its use'. The Act provides that a '[port] facility is taken, for the purposes of all adverse civil proceedings in relation to death, injury, damage or loss, to be solely owned, occupied and under the management, control and responsibility of the manager.' This emphasises the importance of accounting for the possible effects of climate change in operating and managing port facilities.

6. Summary

Climate change is likely to pose significant challenges for owners, managers and users of Australia's transport infrastructure, including roads, rail and ports. At a minimum, the effects of climate change may require additional maintenance and repair. At worst, some types of infrastructure may become permanently unusable and will need to be replaced. The collective consequences of a climate change event could wreak havoc for the logistics supply chain if each type of infrastructure is concurrently affected. Cyclone Ului is a compelling example in this regard (Reuters 2010; Walsh 2010).

Apart from the practical difficulties that climate change presents, it may lead to considerable additional costs for owners and operators of transport infrastructure. It may also lead to liability if the risks of climate change are foreseeable but have not been addressed.

6.1 Entities responsible for climate change

In this paper, we examined the profile of transport infrastructure in various jurisdictions in Australia, including the entities that own and manage the various types of transport infrastructure considered. The ownership and management structure is important because it determines which entity will bear primary responsibility for addressing the effects of climate change.

It is notable that the ownership and management structure differs between each type of transport infrastructure considered. In general terms:

- *Roads*: Public entities – including state government authorities and local government bodies – will bear primary responsibility for responding to the effects of climate change in respect of road infrastructure.
- *Rail*: While state governments typically retain ownership of rail infrastructure, lease arrangements with statutory and private operators may have the effect of transferring responsibility for responding to the effects of climate change from owners to operators.
- *Ports*: Ports are owned and operated by a range of public and private entities, which will respectively bear responsibility for responding to the effects of climate change.

These entities need to be prepared for fully assuming or delegating responsibility (for example, to other statutory or private entities) as the effects of climate change become more frequent and pronounced.

6.2 Regulatory tools to address the effects of climate change

In this paper, we also considered the regulatory regimes applicable to road, rail and port infrastructure. We noted a range of existing regulatory tools that could be utilised to manage the risks of climate change, including:

- Infrastructure management and implementation plans;
- Codes of practice;
- Accreditation; and
- Safety and fitness for purpose obligations.

These tools could provide the context within which an assessment of the physical risks posed by climate change could be undertaken. They could also allow for the formulation of responses to these risks that are suited to the infrastructure in question to ensure the response adequately accounts for, among other things, the type, usage and location of the infrastructure. As previously noted, these factors could heighten or reduce the relative risks associated with climate change for the particular type of infrastructure.

7. Conclusions

There is clearly scope within existing infrastructure regulatory regimes for the effects of climate change to be addressed. Indeed, this paper has demonstrated that there are a number of useful tools in existing transport regimes that can be used to assist transport infrastructure in adapting to the effects of climate change.

Nevertheless, it is fair to say that these regimes do not tackle climate change head on. Indeed, none of the regimes considered explicitly recognise the risks posed by climate change. Explicit recognition of the impact of climate change in the relevant statutory instruments will clarify and, thereby, facilitate the use of existing tools to address the effects of climate change.

In conjunction with a review of the regulatory regimes, consideration needs to be given to how climate change can be more effectively accounted for to reduce the risks for transport infrastructure. Some options include:

- mandatory assessments of climate change risks by infrastructure owners and operators;
- review of the standards for transport infrastructure development to ensure that the infrastructure can withstand the effects of climate change – now and in the future
- the imposition of a use-based tax to support additional maintenance and repair measures that may be needed to address the effects of climate change; and
- establishing a direct link between revenues collected from road users and the allocation of funding for infrastructure construction and maintenance to ensure adequate funding exists to address the effects of climate change.

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