The potential role of market-based instruments in safeguarding the water quality in Darwin Harbour

Report to the Northern Territory Department of Natural Resources, Environment, The Arts and Sport

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Executive summary

This report was commission by NRETAS as part of the development of a Water Quality Protection Plan for Darwin Harbour.

The principle purpose of the report is to explain the concept of market-based instruments (MBIs) in general, describe different MBI categories and discuss in generic terms how MBIs may play a role in supporting the reduction of pollutants in the Darwin Harbour catchment.

Choosing the 'right' policy instruments for water quality protection from the vast array of market-based and other instruments is inherently difficult. In addition to making the right choice, good instrument design is equally essential in achieving desired environmental objectives. Both, choice and design of MBIs must be tailored to the characteristics of the pollution problem.

There is no single instrument, which is superior across all criteria relevant to policy choice—including feasibility, effectiveness, efficiency, equity and fairness, precaution, continuing incentive and political and community acceptability.

Pollution problems such as water pollution are complex and multi-causal and may require a combination of instruments to rectify them. Market-based instruments offer many benefits over purely regulatory approaches. However, they do require a regulatory basis and instrument choice and design need to be carefully tailored to the problem. In addition, the policy implementation process and adaptive design are critical for the success of new policy instruments, and phasing may help to maximise effectiveness.

MBIs have been successfully applied in the management of many environmental problems, including air pollution and depletion of fisheries resources. In the area of water quality control, MBIs, particularly quantity-based instruments, seem to have had lesser success.

Regarding the situation of managing water pollution in the Darwin Harbour catchment with market-based instruments, the current situation calls for caution despite the institutional feasibility of implementation. There are reasons for caution. Firstly, the information base about pollutant loads for key pollutants and sources of pollution is at best patchy and ill equipped to support instrument design. Secondly, the Darwin Harbour catchment is geographically small and the number of (heavy) polluters is limited, which reduces the scope of market instruments. In addition, much of the urban and industrial pollution is aggregated into few waste water treatment facilities, which are all managed by the same operator.

Despite these caveats, there are steps the Northern Territory Government can take towards the inclusion of MBIs in a policy mix to safeguard water quality in Darwin Harbour. These steps include the introduction of a comprehensive and systematic discharge monitoring program, at the polluter level, expansion of the existing licencing system, disclosure of discharge data, small-scale instrument testing and data collection to explore likely polluter responses to different instruments and designs, and adoption of some no-regrets options.

Theory about market-based instruments

General context

This chapter explains the concept of market-based instruments (MBIs) in general, describes different MBI categories and illustrates various instruments. It discusses in generic terms how MBIs can play a role in supporting the reduction of pollutants in the Darwin Harbour catchment.

MBIs, sometimes described as "economic instruments", seek to bring market opportunities and processes into areas that have been traditionally controlled by direct regulation, information and motivational processes. MBIs are grounded in the notion that environmental problems, such as water pollution, biodiversity loss and climate change, are the result of market failure and that the introduction of markets or market-like mechanisms can correct this failure (Lockie, 2010).

MBIs encourage behavioural change through market signals rather than through explicit directives (regulations) regarding e.g. pollution levels or production methods. They encourage firms and/or individuals to undertake pollution control efforts that are in their own financial interests and that collectively meet environmental policy goals.

In comparison to traditional regulatory approaches, MBIs offer the potential to achieve environmental objectives more efficiently (i.e. at lower cost to both government and polluters) by creating a financial incentive for individuals, households and firms to create better environmental outcomes. By revealing agent responses to an instrument, MBIs also improve the ability to coordinate environmental management. Plus, they increase flexibility and adaptability to changes in conditions (Windle et al., 2005).

The suite of instruments is extensive and includes, inter alia: product charges, subsidies and tax concession, emission taxes, environmental liability, effluent pricing, tradeable permits, financial incentives, performance bonds, codes of practice and rebates.

Good instrument design is essential in achieving desired environmental objectives. As with any type of policy instruments, including regulatory, suasion or other, the choice and design of MBIs must be tailored to the characteristics of the pollution problem. Young and McColl (2005) stress that MBIs must be designed to be consistent with two principles and one theorem, namely the:

1. Tinbergen Principle: To achieve dynamic efficiency, a separate instrument must be used to address each policy goal, objective or target. The Tinbergen Principle suggests that the answers to the design of tradable property entitlement, allocation and resource use management systems lie more with robust separation arrangements than they do with the development of integrated (fuzzy) natural resource management systems;
2. Mundell's Assignment Principle: To achieve dynamic stability and improve leverage, instruments need to be paired with the objectives on which they have the most influence; and the

3. Coase Theorem: Robust and dynamically optimal outcomes—i.e. adjustment to socially optimal outcomes based on changing values, costs, technology and understanding—are achieved only when transaction costs are low. If they are high, initial entitlement allocation will influence the outcome.

It is also important to realise that MBIs are not stand-along policy instruments. MBIs must be supported by regulatory and monitoring frameworks in order to be effective and realise the potential benefits, and they must be well communicated. After providing an overview and illustrations of a suite of MBIs, this chapter reflects on the effective and efficient application of MBIs in the context of safeguarding water quality in the Darwin Harbour. The chapter builds on and updates the experience of the MBI pilot program of The National Action Plan for Salinity and Water Quality (Action Salinity & Water Australia, 2002).

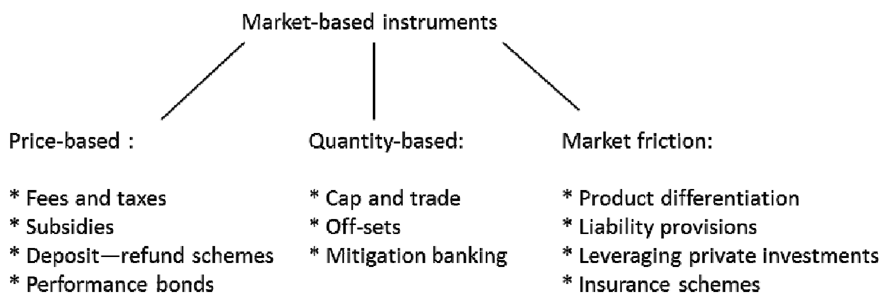
Types of MBIs

MBIs are typically separated into three categories (OECD, 2007; Stavins, 1998):

- *Price-based mechanisms* set or modify prices, e.g. in the form of taxes and payments;
- *Rights-based mechanisms* set quantity targets (positive and negative) and develop associated property rights; and
- *Market friction approaches* remove obstacles to market formation and growth.

Within each group, a range of instrument options exist, as illustrated in Figure 1.

Figure 1: Categories and examples of MBIs discussed in this chapter



Price-based mechanisms

Price-based approaches adjust the price or cost of either polluting or mitigating activities. Broadly, price based approaches broadly entail subsidies and charges.

Subsidies are financial incentives for actors (individuals, households, firms) to create positive environmental services such as prevention, control or remediation of pollution. Subsidies reduce the cost of performing environmental services for the actors, thereby encouraging wider adoption. Subsidies can take the form of grants, low interest loans and tax allowances. Subsidies are the preferred instrument in the natural resources management domain by government in Australia, with various programs funding landholders to undertake conservation and remediation activities on their land. Payment-for-environmental-services (PES) schemes are one such permutation. Subsidies can also apply to households, e.g. through subsidies given for the installation of solar energy generation.

Charges are financial dis-incentives which increase the cost of a polluting activity in order to discourage its application. Charges can e.g. take the form of environmental taxes. Environmental taxes, also referred to as 'Pigouvian taxes' can be applied to production inputs that are associated with environmental harm (e.g. excessive application of fertilizers) to encourage firms to reduce their application.

Deposit-refund systems such as the 'Cash for Containers Scheme', which came into effect in the Northern Territory in January 2012 (NTG, 2011), are also price-based mechanisms. Deposit-refund schemes work by encouraging the polluter to properly dispose of or recycle waste via a financial rewards per unit item (Stavins, 2002). The extensive 'teething problems' associated with this scheme (ABC, 2012) highlight the critical importance of a sound conceptual understanding of the problem and supporting data in tailoring instrument design.

Performance bonds are another price-based mechanism. They are a monetary security which developers are required to set aside to ensure that adequate funds are available for (i) rehabilitation of a site in the event the activity is abandoned by the developer and (ii) clean-up of adverse downstream effects associated with the activity (Greiner et al., 2000). Performance bonds are already in use in the mining sector.

Price-based mechanisms can use existing markets or they can create new markets, such as payments for environmental services (Lockie, 2012). According to Windle *et al.* (2005), price-based mechanisms are most appropriate when:

- the quantity of environmental improvement is not critical because the precise outcome in terms of quantity is determines by market forces, and
- it is desirable to maintain the existing system of property rights.

Two principal approaches exist for determining the level of subsidy or charge to be applied:

1. The level can be determined ex ante to be equal for all firms or subsets of firms that meet certain criteria, or activities that meet certain criteria. The Australian Government has chosen a fixed price approach in the form of a 'carbon tax' in its Carbon Pollution Reduction Policy, with a price of $23 per tonne of carbon emission applicable from 1 July 2012 for the 500 largest carbon polluters in Australia (AG, 2012). Similarly, in relation to water quality, some European countries introduced fertiliser taxes to reduce the nitrogen load to the environment (Rougoor et al., 2001).
2. The level can be determined in a competitive fashion, e.g. through an auction or tender process, resulting in business-specific levels of tax or subsidy. This approach is commonly employed for determining stewardship payments or payments-for-environmental-services. Firms are asked to submit a tender stipulating the extent of service delivery they propose to undertake and the cost charged. On the basis of this information, the program administrator can select the most cost effective bids among those tendered. Examples of this approach exist e.g. in biodiversity conservation (e.g. (Stoneham et al., 2003) and water quality control (Rolfe et al., 2011). Tender-based determination of payment levels leads to significant cost efficiencies compared to fixed price approaches (Windle and Rolfe, 2008).

While they are technically identical in terms of pollution control effect, user charges and pollution taxes differ with respect to the use of the revenue generated. Taxes tend to add to consolidated government revenue while user charges can be administered by a non-government entity and used for the proper disposal of pollutants or of the management of the resource (Stavins, 2002).

Quantity-based mechanisms

Quantity-based approaches typically involve the imposition of a limit or 'cap' on pollution or polluting activities, either by specifying a total pollution limit or by establishing firm-based limits. In doing so, quantity-based approaches develop new property rights and thus contain a regulatory element. The market element is associated with the introduction of trade in the pollutant in order to generate efficiencies and generate an ongoing incentive for firms to reduce pollution. Trade in pollution permits enables firms to reduce pollution mitigation costs by purchasing pollution permits or offsets that are cheaper than making improvements within the firm (O'Shea, 2002) while polluters who can efficiently reduce pollution are able to sell excess permits (Greiner et al., 2000).

The creation of new property rights needs to meet a number of conditions for the approach to be effective (Godden and Peel, 2010; Murtough et al., 2002; Ostrom and Schlager, 1996): Property rights must be clearly defined, verifiable, enforceable, valuable and transferable. In addition, there must be low scientific uncertainty and low sovereign risk.

Quantity-based approaches are extensively being used to control air pollution, regulate commercial fisheries and also to manage water quality (Colby, 2000). For example, the USA introduced a cap-and-trade system for sulphur dioxide and nitrogen oxides in 1990 to combat the phenomenon of acid rain. Lessons learnt include the need for stringent emissions monitoring, enforcement and stiff penalties for non-compliance, sophisticated trading rules e.g. in relation to the need to impose geographical restrictions to trade (Colby, 2000; Schmalensee et al., 1998; Schwarze and Zapfel, 2000).

Water quality trading exists also, mostly in the USA with some applications in Canada, Australia and New Zealand (Selman et al., 2009). Water quality trading schemes are cap-and-trade approaches and work through the setting of water pollution caps and implementation of transferable discharge permits for water pollutants (Cline et al., 2006; Woodward et al., 2002). In Australia, active schemes include the Hunter River Salinity Trading Scheme, the Murray-Darling Basin Salinity Credits Scheme (in which the states rather than agents hold salinity credits) and the South Creek Bubble Licensing Scheme Zealand (Selman et al., 2009). After a feasibility study conducted in 2005, a Morton Bay Nutrient Trading Scheme remains 'under consideration' (Queensland_Government, 2006). A review of water quality trading schemes found that, unlike air quality trading schemes, they had limited success and mostly displayed no or limited trading activity (Newburn and Woodward, 2012). Unless restrictive regulatory conditions apply individual dischargers and aggressive enforcement is provided, there remains an absence of willing buyers and seller (King, 2005). Also, administrative costs of complicated schemes may become excessively high where simple markets do not lead to environmentally effective outcomes (Connell et al., 2005).

Design and implementation challenges include e.g. balancing use levels with resource condition and determining the size of the cap, equity considerations associated with initial assignment of rights, implementing trading mechanisms that facilitate transactions among market participants minimise transaction costs, and ensuring adequate monitoring (including for leakage, i.e. the creating of unintended consequence caused by participants shifting from a regulated activity to a non-regulated activity).

Key criteria for operating successful pollutant cap-and-trade policies are (Van Bueren, 2001):

1. Understanding the scientific dimensions of the problem;
2. Ensuring caps are measurable and enforceable;
3. Starting from scratch (instead of making changes to existing programs);
4. Understanding the potential market (see above);
5. Involving stakeholders in the design; and
6. Keeping trading rules simple.

Bubble schemes represent a version of a cap-and-trade mechanism where the group of emitters is small. For example, the South Creek Bubble Licensing System, introduced in 1996 in the South Creek area of the Hawkesbury-Nepean River system in New South Wales allowed the three participant sewage treatment systems to adjust their individual discharges, provided the total pollutant load limit for the scheme was not exceeded (Environment_&_Heritage, 2011). The bubble licence required an 83% reduction in total phosphorus and a 50% reduction in total nitrogen by 2004 when compared to a 'business as usual' scenario.

Offsets are another quantity-based mechanism. The idea behind offsets is to encourage actors to produce environmental net improvements by off-setting environmental damage caused, e.g. by development, with environmental restoration, possibly of a different nature or in a different (geographical) area. Offset activities may be carried out by the agent, another private party or a government entity (Hahn and Richards, 2010). Offsets are often employed in the context of wetlands (Kiesecker et al., 2009) and are targeted at reducing existing sources of emissions. The incentive for polluters to get involved in offsets are rules that specify a 'no net increase in emissions', including those from new developments. Development is enabled by establishing trading ratios so that the environmental impacts of a polluting activity at one site can be equated to the environmental benefits of a mitigating activity (offset) elsewhere (Windle et al., 2005). An offset program enables trading to occur between enterprises and even between different sectors without the establishment of a full trading market.

Market friction measures

Market friction measures can be used to support the design and implementation of new markets and improve the functioning of existing markets by removing obstacles to market formation and growth. Market friction measures work on the notion that information can alter market and consumer behaviour (Godden and Peel, 2010).

Market friction measures work by (i) providing relevant information to market participants, (ii) improving accountability and transparency of market function through e.g. the introduction of liability rules and (iii) encouraging private investment in activities that directly or indirectly help reduce pollution. Market friction instruments include the creation of new markets, liability rules and information programs (Stavins, 2003).

Eco-labelling of products belongs into the category (Jordan et al., 2003) as it (i) allows consumers to choose products that have been produced in more environmentally benign manner and (ii) enables producers with higher environmental standards to thus pass on higher production costs to consumers (Godden and Peel, 2010).

Debt-for-conservation swaps are another market friction measure (Windle et al., 2005). A debt-for-conservation swap intends to break the cycle of increasing debt and environmental degradation by providing debt relief for firms with high debt (Greiner and Lankester, 2007). To work effectively, this measure requires banks to be involved. While the measure has been implemented in developing country contexts, no application exists in Australia with Greiner and Lankester (2007) warning of substantial implementation challenges and a potential of debt-for-conservation swaps to be causing perverse outcomes.

The explicit definition of an environmental duty of care represents a liability rule in that agents who pollute may find themselves in breach of their duty of care and may be prone to prosecution (Lockie, 2012). The duty of care is equivalent to a safe minimum standard approach to industrial activity and may result in industries defining voluntary codes of practice so minimise risk of breaches and litigation.

Market friction instruments have a regulatory basis as disclosure requirements and duty of care need to be legislated.

Darwin Harbour Catchment water quality issues

The economic dimension of water pollution

This section provides a short but relevant analysis of the pollution problem in Darwin Harbour as a foundation for developing MBIs that can help safeguard water quality.

Water pollution implies the addition of substances to water that are harmful to humans and other organisms and may restrict the way in which water can be used by humans. Water pollution can also mean any action or alteration of a receiving water body that impairs its integrity such as the removal of riparian vegetation and hydraulic modifications such as drainage of wetlands. Here, we are focused on the matter of addition of harmful substances.

To find effective and efficient solutions to water pollution, including through the use of MBIs, instruments need to consider the pollution impact and be tailored to the pollution characteristics (Sterner, 2003). A clear diagnostic understanding of environmental problems within their social-ecological systems context is therefore a necessary condition of effective policy design for problem (Cox, 2011). In other words, it is important to understand the environmental dimensions of a pollution problem and it is equally important to understand the drivers—social, economic, technical and other—that cause agents to engage in pollution activities.

Darwin Harbour is the receiving water body of a cocktail of pollutants ranging from sediments and nutrients to heavy metals and chemical compounds. The question at hand is whether there is resulting pollution impact.

Pollution impacts are generally considered on the basis of ‘beneficial uses’, i.e. the question of what water quality is required to support current and/or future uses of the water body. Water bodies with high environmental or recreational use values, for example, have higher requirements for water quality than water bodies that are used exclusively for shipping or other industrial uses. Guidelines defining minimum standards of water quality for different beneficial uses are contained in ARMCANZ and ANZECC (2000). For Darwin Harbour, the criterion ‘environmental beneficial use’ applies, which sets the ‘most stringent’ water quality conditions—its intention being that health of aquatic ecosystems be maintained and other, including recreational and cultural uses being safeguarded (Fortune, 2010).

Regarding pollution characteristics, pollution problems are commonly categorised on the basis of identifiability of individual polluters and measurability of pollution. Two types of pollution are differentiated: point source and diffuse-source pollution. These types are subsequently explained and illustrated with focus on operational rather than legal criteria.

Point-source and diffuse-source pollution

The term ‘point source pollution’ refers to pollutant discharge into a receiving water body at an identifiable single-point location or identifiable multiple-point locations (Novotny, 2003). While there are differences between legal and operational definitions, point source pollution generally includes:

- Municipal and industrial wastewater effluent;
- Runoff and leakage from solid waste disposal sites;
- Runoff and leakage from concentrated animal feeding and raising operations;
- Runoff from industrial sites;
- Runoff from construction sites;
- Runoff and drainage water from active mines and from oil and gas fields;
- Stormwater and sewer outfalls from urban centres;
- Sewer overflows and bypasses;
- Other sources, such as discharges from vessels, damaged storage tanks and storage piles of chemicals; and
- Dredging of waterways.

Non-point source pollution is, by definition, pollution other than point source. It is often termed ‘diffuse’ pollution as the entry point into the waterway is not (easily) traceable. We use both terms interchangeably. Diffuse source pollution includes:

- Return flow from irrigated agriculture and horticulture;
- Agricultural runoff and infiltration;
- Silvicultural runoff and runoff from logging operations, including logging roads and transportation;
- Runoff and infiltration from pastures and rangelands;
- Urban runoff from small communities with storm sewers;
- Urban runoff from un-sewered settlement areas;
- Outflows and overflows of septic tanks;
- Wet and dry atmospheric deposition over a water surface;
- Flow from abandoned mines, including inactive mining roads;
- Activities on land that generate wastes and contaminants such as wetland drainage, land development other than construction, and military training, manoeuvres and shooting ranges; and
- Mass outdoor recreation and gathering.

Reasons for the lack of traceability include complexity of the production relationships between pollution and the biophysical processes, and influence of weather on fate and transport of pollutants (Kling, 2011). The question of traceability or identifiability of pollution is of direct relevance to the types of policy approaches that may be appropriate (O'Shea, 2002) and their cost effectiveness (Kampas and White, 2004).

Discharge of pollution from point sources may be readily observed and monitored at source, making point-source pollution suitable for regulatory (command-and-control) approaches. Indeed, most point source pollution into water and the air is regulated in developed countries, with emitters requiring pollution permits and emissions being monitored by either the polluter and/or regulator. Among market-based instruments, cap-and-trade approaches are commonly used. Regulation is still required to set appropriate pollution caps and generate the property rights conditions (tradable permits, trading rules) to facilitate a market in pollution rights. Caps can apply to individual pollutants or groups of pollutants. It is then for polluters to use the trade in pollution permits to optimise their individual position. The price per unit of pollution will reflect the marginal benefit of pollution to the polluter. Stringent monitoring and enforcement is required to ensure polluters adhere to their pollution permits. Market friction mechanisms by government may also be required to facilitate market functioning, e.g. by imposing and enforcing liability of polluters, publishing transaction records and/or minimising transaction costs to market participants.

Non-point source pollution is not amenable to cap-and-trade approaches due to (i) the opaqueness of the biophysical relationships and resulting imperfect information, (ii) the often large number of polluters involved, (iii) an often random distribution of pollution and (iv) information asymmetry among polluters and between polluters and government (Segerson, 1988).

In particular, the inability to observe emissions at the source requires policy approaches which overcome the need for direct monitoring. While there may be ways of indirectly measuring pollution via input-based surrogate measures (Kling, 2011), ambient taxes and input-based incentives are often better suited to dealing with nonpoint source pollution (Xepapadeas and Bergh, 2002).

Point and diffuse sources of water pollution in the Darwin Harbour Catchment

Pollutants that have been identified in Darwin Harbour include sediment, nutrients, heavy metals, hydrocarbons, pathogens and chemicals (Drewry et al., 2010). There are multiple sources and pollution types for each pollutant, and each type of polluter releases a diversity of pollutants (Table 1).

Pollution is subject to spatial variability across sub-catchments and temporal variability. Annual rainfall it is highly variable in the monsoonal climate conditions of the Top End of Australia and drives temporal variability of pollutant loads. Pollutant loads increase with rainfall due to the increased runoff volume and more runoff resulting in more pollutant transport (Skinner et al., 2009). Pollutant discharge is typically 3-5 times higher in high rainfall years (2700mm) compared to low rainfall years (1000m).

Table 1: Conceptualisation of pollutants and pollution sources in Darwin Harbour

		Pollutants								
	Emitters and sources of pollution	Sediments	Phosphate	Nitrogen	Pesticides, herbicides, etc	Heavy Metals	Hydrocarbons	Anti-foulants	Pathogens	Antibiotics etc
Point-Source Pollution	Wastewater treatment plants	x	x	x					x	x
	Industrial operations and areas	x			x	x	x		x	
	Stormwater drains	x	x	x	x	x	x		x	
	Golf courses and race courses		x	x	x					
	Airports	x				x	x			
	Hospital and surgeries								x	x
	Development and construction	x	x							
	Refuse and waste disposal sites	x	x	x	x	x	x		x	x
	Harbour loading facilities					x	x		x	
	Dredging operations	x				x				
	Ships						x	x		
	Feedlots	x	x	x						
	Aquaculture operations		x	x						
	Marinas					x	x	x	x	
Diffuse Pollution	Urban gardens	x	x	x	x					
	Urban households – internal use		x						x	x
	Agriculture & horticulture	x	x	x	x		x		x	
	Small-scale industry				x	x	x			
	Parks, sporting fields	x	x	x	x					
	Roads and other sealed surfaces	x				x	x			
	Septic tanks		x	x					x	
	Recreatioinal boating						x	x		

Table 2: Relative estimated contribution to pollutant discharge into Darwin Harbour for 2006/07

Note: Calculated from Skinner et al. (2009; p.28); nitrogen (N), phosphorus (P), total suspended sediment (TSS), volatile suspended sediment (VSS); 'rural' includes rural and undeveloped land
[1)] Aquaculture discharge for year 2011 (email J. Fortune on 2 May 2012)

	Pollutants			
Sources	TSS	VSS	N	P
Wastewater treatment plants (licenced)	4.6%	13.1%	30.8%	70.8%
Aquaculture (licenced) [1)]	0.0%	0.0%	0.4%	0.1%
Urban (diffuse)	47.6%	36.9%	20.8%	16.0%
Rural (diffuse)	47.8%	49.9%	48.4%	13.2%

The conceptualisation of pollution is further complicated by the fact that waste water treatment plants act as aggregators of the loads discharged by several point polluters and also accumulate discharge from various sub-sections of diffuse pollution, particularly in urban areas.

Information about the pollution discharge into Darwin Harbour is limited. Data are available for wastewater treatment plants for the year 2006/07 and for aquaculture operations for the year 2011. These point source polluters are licensed and monitored. For all other polluters, estimates exist only at an aggregate land-use level: urban and rural (including undeveloped land). Based on calculated annual pollutant load discharges for 2006/07 (Skinner et al., 2009), wastewater treatment plants emit a majority of phosphorus, while diffuse sources contribute the majority of total (and volatile) suspended sediment and nitrogen (Table 2). There are four licenced aquaculture operators, whose combined contribution to nutrient loads is below one per cent.

Applicability of MBIs for water quality control in Darwin Harbour

The complexity of pollution issues observed in Darwin Harbour poses a challenge for pollution control and management, but it is a challenge which management agencies for many coastal water bodies have in common. The complexity may provide opportunities for the targeted application of market-based instruments to address specific pollution issues—bearing in mind the Tinbergen and other principles.

Choosing the most appropriate mix of instruments to control water quality is not a trivial task and inherently context specific. It is therefore helpful to develop a framework, which utilises the attributes of pollution types and conditions needed for instruments to work effectively. Hatton MacDonald et al. (2004) propose a screening process to offer a sufficient basis for answering three questions:

1. Which MBIs are feasible in the existing institutional setting?
2. How effective are different MBIs likely to be in addressing a specific environmental goal?
3. How efficient are different MBIs likely to be?

We complement this list by a further question, based on the findings by (Gunningham and Sinclair, 2005):

4. What are important process considerations in the selection and staging of instruments?

Feasibility

In relation to the question of feasibility, it is relevant that Darwin Harbour, being classified as ‘inshore water’, is exclusively under the jurisdiction of the Northern Territory (NT) Government. Similarly, the entire catchment area is located within the Northern Territory. This means that the NT Government can bring its entire legislative and management powers to bear on the issue of water quality control—within the realms of the National Water Initiative—as outlined in the NT Water Act (Northern Territory of Australia, 2011).

The NT Water Act has an inclusive definition of water pollution, meaning any direct or indirect change to the “physical, thermal, chemical, biological or radioactive properties of the water so as to render it less fit for a prescribed beneficial use for which it is or may reasonably be used, or to cause a condition which is hazardous or potentially hazardous to (a) public health, safety or welfare; (b) animals, birds, fish or aquatic life or other organisms; or (c) plants” (Water Act Part 4). The definition of ‘beneficial uses’ is similarly inclusive, including commercial uses, human consumption, environmental and cultural uses.

Section 16 of the NT Water Act prohibits the pollution of water. However, Section 74 enables the Controller of Water Resources to authorise waste discharge by granting polluters a time-limited waste discharge licence. Other than providing a maximum licence term, the nature of the licences is unspecified. Currently, only two types of polluters that discharge into the Darwin Harbour catchment are regulated in this manner. They are wastewater treatment plants and aquaculture operations. Monitoring is provided by the polluters as part of the licencing agreement.[1] All wastewater treatment plants are operated by Power and Water, a NT Government owned corporation. A large proportion of total pollutant load is accumulated and discharged through waste water treatment plants while the total load contribution of the four licenced aquaculture enterprises is small (Table 2).

The load-based licencing provisions under the NT Water Act therefore provide, theoretically at least, the information stream and establish the database for many instruments described in this chapter. The specification of property rights for polluters can help limit the impact on the environment, minimise conflict and maximise the sustainability of the resource when multiple uses are involved (Greiner et al., 2000). Load-based licences are the regulatory foundation for the introduction of tradeable emissions rights systems and emissions charges (Young and McColl, 2005).

On the basis of beneficial uses, water quality objectives for Darwin Harbour need to be derived, if required in a spatially explicit manner, and temporal load targets determined that satisfy beneficial uses.

Effectiveness

Effectiveness relates to whether an instrument is technically suitable for achieving a specified goal and whether it will deliver a desired target even when knowledge about likely responses is uncertain (Greiner *et al.,* 2000). It is possible to assess the likely effectiveness of instruments *ex ante* by reviewing design principles in the context of given bio-physical and technical problem description—the purpose of this sub-section. Ultimately however, performance indicators are needed to monitor the effects and effectiveness of policies.

The matter of effectiveness requires consideration of the beneficial uses in the context of existing and likely future pollution. It is unclear, for example, to what extent licences act as a pollution cap. It is also unknown what proportion of total load for pollutants other than sediment, nitrogen and phosphorus is thus covered. Moving from a purely regulatory to a cap-and-trade approach to (certain) point source pollutants requires that a majority of pollutant load is covered the cap to provide an effective framework for reduction of pollutant discharge and that there is an incentive for polluters to seek to trade in discharge licences.

For the NT Government to be able to consider a quantity-based MBI-based approach to pollution management, the key requirement is data from systematic and comprehensive monitoring. Effective design and application of MBIs requires not only an understanding of the bio-physical and chemical dimensions of pollution, but also a quantitative understanding of the relative contributions by point and non-point emitters, preferably including spatial and temporal variability.

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[1] A current directory of wastewater discharge licences can be gleaned from http://www.nretas.nt.gov.au/environment-protection/waste/waste.

The current level of disaggregation of pollution sources (Table 2) is insufficient to support MBI design. Discharge needs to be quantifiable for all relevant pollutants for all relevant polluters. Detailed pollution data would allow the generic pollution chart provided in Table 1 to be populated with quantitative data. If details about pollutant loads were known and licences issued at the source level (emitter) rather than the aggregator/discharge level (wastewater treatment plant), cap-and-trade could be considered as an option.

Nutrients are a key cause of pollution impacting beneficial uses of Darwin Harbour, e.g. by causing algae blooms. Darwin's four[2] sewage treatment plants contribute a majority of annual total phosphorous load (71%; Skinner et al., 2009), so at first glance it might appear conceivable to have a bubble scheme operating whereby the total discharge of the four plants is capped and the operators trade among themselves to meet the cap. However, as all treatment plants belong to the same operator, no trade would occur under a total cap. Allowing other polluters in particular aquaculture operators, to trade with Power and Water, would also be ineffective because of their very small pollutant contribution. Consequently, a regulatory approach, preferably through a total wastewater discharge cap and/or the prescription of higher standards of waste water treatment are currently the only effective measures to target point source pollution.

The rapid pace of urban and industrial development in the Darwin Harbour catchment is expected to lead to substantial increases in pollutant loads (Skinner et al., 2009), particularly in heavy metals. Performance bonds—provided they are set sufficiently high—may be an effective tool to ensure that urban and commercial developers comply with the Water Act and minimise the potential impact during and post construction on beneficial users.

The introduction of any new instrument would require regulatory change and additions to the Water Act to bestow on the Controller of Water Resources the necessary powers to create such instruments.

As for diffuse source pollution, a majority of nitrogen pollution appears to be from diffuse sources as only a minority (31%) of total nitrogen is attributed to sewage treatment plants (Skinner et al., 2009). Approximately half of total nitrogen load is attributed to 'rural diffuse' sources. Assuming that this load is associated with the use of nitrogen fertilisers on agricultural land, it might be effective to employ market friction instruments, e.g. by educating farmers of the comparative effects of different types of fertilizer, split applications and other measures. There might also be scope for price-based mechanisms by providing positive incentives (i.e. subsidies) for landholders converting land management practices to embrace e.g. no-till methods or precision farming technologies. Many NRM programs provide such subsidies, and it has been shown in the case of the Burdekin Water Quality Tender that they can be effective (Rolfe *et al.,* 2011). In this case, farmers were offered incentives to e.g. implement on-farm water retention and re-use infrastructure or purchase machinery that improved tailoring of fertilizer and chemical application—and thereby reduce total amount applied and therefore diffuse emissions. Again, however, better data as to the specific diffuse pollution

[2] The Larrakeyah wastewater outfall was recently closed and wastewater is now treated at Ludmilla.

sources for the Darwin Harbour catchment are required to design effective price-based and market friction MBIs.

Efficiency

The key argument in favour of using MBIs for resource management, compared to traditional regulatory approaches, is that they supposedly offer efficiency improvements. The term 'efficiency' is multi-dimensional. Greiner et al. (2000) distinguish between the effect of an instrument on the productive efficiency (i.e. profitability) of industry and collective economic efficiency of resource use. In most cases the term efficiency simply relates to cost efficiency and therefore the size of (environmental) outcome achieved for a given program cost.

Cost efficiency can be achieved, in theory at least, irrespective of who ultimately bears the costs and the starting point, but cost allocation is critical to the consideration of equity (Gunningham and Sinclair, 2005). Efficiency therefore specifically looks at transaction costs and direct costs to one or more of the parties.

Efficient design requires attention to detail by (i) aligning policy, instruments and pollution characteristics, (ii) removing perverse incentives, (iii) addressing the entire suite of pollutant sources including non-point source problems and (iv) ensuring instruments are performance based rather than overly prescriptive (LaFlamme, 2007). Efficient management further requires (v) sound monitoring and stringent enforcement, (vi) minimisation of transaction costs, and (vii) transparency.

For example, an input tax on nitrogen fertilizer would have to apply equally to golf courses and farmers, the latter being likely more price sensitive (having a higher elasticity of demand) and therefore responsive in terms of reduction of nitrogen application. The questions are (i) would an input tax at a certain level achieve desired pollution reduction, (ii) would alternative instruments achieve the same level of reduction more cheaply give associated administrative costs, and (iii) what are the true costs to the most affected sectors? Spillover effects can further affect efficiency. In this case, it would be impossible to discriminate between nitrogen users inside and outside the catchment area. Alternatively, users could also purchase nitrogen in other states where the input tax did not apply. A nitrogen tax would therefore be an inefficient measure in the context of Darwin Harbour.

The Northern Territory has limited experience with pollution regulation through licensing and a very sparse data foundation to support design of complex MBIs such as cap-and-trade schemes. A cap-and-trade scheme could prove effective and efficient for major pollutants in Darwin Harbour if, and only if, (i) all major source polluters are regulated, (ii) point sources provide the majority of pollution load, (iii) the existing pollution load affects beneficial uses, (iv) property rights are adequately defined and trade in pollution rights is enhanced, (v) monitoring and enforcement of licences are taken seriously, and (vi) transparency of the system is guaranteed. In setting up a water quality trading scheme, it would be prudent to give detailed consideration to the international experience with water quality trading schemes to maximise the chances of success. The small size of the Darwin regional economy also raises the question whether the number and diversity of polluters is such that differential in pollution abatement cost would be large enough to entice trade in permits.

As for the management of diffuse pollutants such as nutrients, the questions are (i) whether they impact on beneficial uses—including the spatial dimensions of the impact—and (ii), given the various challenges associated with managing diffuse pollution, whether a simple input-based approach, e.g. an environmental tax on nitrogen fertilizers, may be superior to a complex load-based system (O'Shea and Wade, 2009). Again, the magnitude and complexity of the problem need to be understood in detail before any move to a MBI is warranted. The closest directly comparable scheme to a potential water quality scheme in Darwin Harbour is the Morton Bay Nutrient Trading Scheme. If interest existed in such a scheme, it would be important to understand why, despite years of feasibility and pilot studies, this scheme has not as yet been implemented.

Process considerations

In addition to considering the type and specific design of instruments, building a policy strategy is a process. As Gunningham and Sinclari (2005; p.76) state "much of our knowledge about what policy instruments work and when, is tentative, contingent and uncertain. We usually do not know how effective a particular instrument will be until it is tested in the field, and even then, the outcome is often context-specific". They also warn of perverse outcomes (i.e. unintended consequences) including free-riding by some polluters. They conclude that a phased and adaptive approach to policy development is needed to facilitate learning and re-design and that new measures should be accompanied by a clearly defined timetable and performance benchmarks. If these are not met, more interventionist measures should be introduced. With respect to MBIs for the control of diffuse source pollution, Gunningham and Sinclair (2005) differentiate two phases:

- Phase 1: Persuasion and positive incentives.
  A beneficiary pays approach is implemented for (landholder) actions with majority community benefits, particularly changes to land use patterns and farm management practices in targeted areas. Particular emphasis is given to political acceptability and interference with property rights justifies compensation. The supporting role of suasive instruments (education, information) is critical.
- Phase 2: Compliance and negative incentives.
  Should Phase 1 fail to deliver the desired outcomes, a polluter pays approach is implemented. This includes mandatory specification standards, levies and charges, and bans on high-impact activities.

The water allocation reform process in Australia bears testimony to the importance of getting the process of policy development and implementation right. Process is critically important for policy success as sound process can minimise unnecessary angst about impending policy changes and maximise the incentive from the instrument combinations and sequences (Young et al., 2006). A possible element of process is the testing of policy instruments.

Additional design considerations

There are other considerations, too, which ought to come into play in the choice and design of instruments (e.g. Goulder and Parry, 2008). In their evaluation of incentive instruments for marine management, Greiner *et al.* (2000) also consider:

- Equity: examines the distribution effects of a policy instrument within and among generations. Equity tends to relate to fairness of outcomes, but can also relate to opportunities or procedures (Gunningham and Sinclair, 2005). At an industry and individual level, equity requires an assessment of who are the winners and who are the losers when a new instrument is introduced and what are the regional employment impacts and flow-on effects to other sectors of the economy. Intergenerational equity asks whether future generations may be disadvantaged by the introduction of a management system. Perceptions of fairness are critically important for the political acceptability of an incentive instrument and affect the compliance of people and firms with the rules of the instrument (Winter and May, 2001).
- Precaution: assesses whether an instrument avoids the chance of serious or irreversible consequences. This criterion is particularly important where pollution and its effects are not linearly related and where crossing thresholds can permanently change the state of a system. Precaution is particularly important in matters such as biodiversity conservation and impacts on human health.
- Continuing incentive: addresses the question whether an incentive instrument encourages experimentation and change and provides an ongoing incentive for improvement of industry efficiency and environmental improvement beyond a set target. In general, because they are designed to save costs and improve efficiency in the use of natural resources and the environment, some market-based instruments and administrative systems based on co-management principles provide an ongoing impetus to improve environmental technologies and management practices. Intrinsic motivation plays a key role in ongoing motivation. It is a characteristic of agents who are already complying. In the design of MBIs, it is important to get other agents to change their behaviour without crowding out the behaviour of those who are intrinsically motivated individuals.
- Administrative feasibility and cost: evaluates whether there are impediments to putting a policy mechanism into practice, assesses the risk of government and administrative failure, considers transaction costs, and assesses the efforts involved in administering and policing the instrument.
- Political and community acceptability: addresses the cultural, historic and social understanding of a society and is a necessary condition for the durability of a policy. Is the mechanism consistent with previous commitments and philosophies of the parties in power and not likely to contribute to the loss of a subsequent election? Are the industries involved and community in general willing to support the policy? Effective, efficient, transparent and equitable policies reduce political and bureaucratic rent seeking, hereby reducing the risk of government and bureaucracy failure.

Concluding comments

Choosing the 'right' policy instruments for water quality protection from the vast array of market-based and other instruments is inherently difficult and bad choice constitutes a form of government failure (Goulder and Parry, 2008):

- There is no single instrument, which is superior across all criteria relevant to policy choice and instrument ranking often depends on the circumstances involved.
- Significant trade-offs are involved in the choice of instrument. For example, assuring a reasonable degree of equality in the distribution of impacts, or ensuring political feasibility, often requires a sacrifice of cost-effectiveness.
- Pollution problems such as water pollution are complex and multi-causal and may require a combination of instruments to rectify them (Lehmann, 2012).
- Adverse interactions can occur between different policy instruments, which cause unintended consequences and reduce instrument effectiveness and efficiency.
- Market-based instruments offer many benefits over purely regulatory approaches. However, they do require a regulatory basis and instrument choice and design need to be carefully tailored to the problem.

The review of MBIs offered in this chapter is conceptually based within the 'beneficial uses' framework, which operates on the basis of pollution causes and effects. It ignores matters of impact, hazard and risk, which are equally important for prioritisation of policy intervention, but arguable sufficient for a technical evaluation of different types of mechanisms.

Market-based instruments provide an important suite of tools for government in the quest for safeguarding environmental quality, including water quality. Theoretically at least, MBIs offer efficiency gains over regulatory-only approaches. However, "MBIs are not the panacea for all environmental problems. Any policy approach aimed to achieve a better supply of environmental and cultural goods needs to be carefully designed according to the outcomes sought, the nature of the market failure faced and the nature of the natural and human environment in which the policy will operate. Furthermore, all policy interventions are costly, in terms of design, delivery and any incentives provided. These costs should always be compared against the alternative of doing nothing. That is, in many cases the costs of acting to remedy environmental degradation may be greater than the costs of the degradation to the community" (Coggan and Whitten, 2005; p2).

The foundation for any effective policy design is a diagnostic understanding of the causality of the environmental problem to be addressed within its social-ecological systems context (Cox, 2011). Effective and efficient design of instruments demands a high degree of instrument tailoring (Novotny, 2003).

The policy implementation process and adaptive design are critical for the success of new policy instruments, and phasing may help to maximise effectiveness.

MBIs have been successfully applied in the management of many environmental problems, including air pollution and depletion of fisheries resources. In the area of water quality control, MBIs seem to have had lesser success.

Regarding the situation of managing water pollution in the Darwin Harbour catchment with market-based instruments, the current situation calls for caution despite the institutional feasibility of implementation. The reason for caution is twofold.

1. The information base about pollutant loads for key pollutants and sources of pollution is at best patchy and ill equipped to support instrument design. Even basic data for licenced polluters are not readily available because while there is an obligation on polluters to monitor, there is no obligation to disclose.
2. The Darwin Harbour catchment is geographically small and the number of (heavy) polluters is limited, which reduces the scope of market instruments. Particularly with respect to wastewater treatment plants, which are the majority emitters of phosphorus, lack of potential market participants due to a water treatment monopoly by Power and Water provides the key constraint.

Despite these caveats, there are steps the Northern Territory Government can take towards the inclusion of MBIs in a policy mix to safeguard water quality in Darwin Harbour.

- Introduce a systematic process of pollution monitoring at source, covering all pollutants of concern, with monitoring ideally conducted by independent monitors to maximise data accuracy and timeliness.
- Make pollution discharge data publicly available to facilitate access by stakeholders and researchers.
- Expand the inclusion of polluters and pollutants in the licensing framework, in particular large-scale industrial and harbour facilities, and including e.g. heavy metals and hydrocarbons.
- Commence and focus 'no-regrets' instrument development at areas of anticipated areas of pollutant increase, such as development and construction, and dredging. No regrets instruments are those for which benefits, such as from reduced pollution, equal or exceed their cost to society. In other words, they are measures worth doing anyway.
- Focus on diffuse pollution where it is the major source of certain pollutants such as nitrogen, and implement research to test likely responses of diffuse-source polluters to different instruments and instrument combinations, and to variations in instrument design.
- Conceive a staged process that allows for instrument testing.
- Conduct well-conceived and systematic instrument testing, particularly relating to development and constructions and urban diffuse pollution to determine instrument performance against policy criteria.
- Learn from local experiences with MBIs in other areas, e.g. the 'cash for containers' scheme, and anticipate the impacts of new sources of pollutants, e.g. dredging, by looking at other harbours such as Gladstone.

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