



**AgEcon** SEARCH  
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search  
<http://ageconsearch.umn.edu>  
[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

## Putting theory into practice: market failure & market based instrument design

*Paper presented at the 51st Annual Conference of the Australian Agricultural and Resource Economics Society, Queenstown, New Zealand, 13 – 16 February 2007.*

**Authors:** Stuart M. Whitten, Anthea Coggan, Andrew Reeson and Russell Gorddard

**Contact author:** [stuart.whitten@csiro.au](mailto:stuart.whitten@csiro.au) CSIRO Sustainable Ecosystems +61 2 6242 1683

### Abstract

The use of market-based instruments (MBIs) to provide and protect ecosystem services has gained significant attention in Australia. Despite their popularity, MBIs are not appropriate for the provision of all ecosystem services. Rather, MBIs must be carefully designed given the ecosystem service outcomes desired, while meeting the needs of participants. In this paper we detail the importance of a robust theoretical structure to underpin the selection and design of an MBI. In particular, we demonstrate the role of identifying and analysing the nature of the market failures present, and their implications for instrument design. Our conclusions are illustrated using several regional MBI case studies.

**Key Words:** market failure, market based instrument, incentives.

**Acknowledgements:** The funding for the research presented in this paper has been provided by CSIRO, Joint Venture Agroforestry Program (JVAP), Rural Industries Research and Development Corporation (RIRDC), National Action Plan for Salinity and Water Quality (NAPSWQ), Goulburn Broken Catchment Management Authority (GBCMA), Blackwood Basin Group and Department of Infrastructure Planning and Natural Resources NSW. The research benefited from collaborations with researchers at Central Queensland University and within CSIRO. All errors remain the responsibility of the authors.

# 1. Introduction

Market-based instruments remain a novel policy instrument in Australia. Relatively few regional natural resource management (NRM) groups are experimenting with pilots or wider applications. Many are considering MBI potential, with particular enthusiasm for competitive tenders. Yet few regional bodies have sufficient knowledge about why, where and how MBIs operate, their potential advantages and disadvantages, and how to integrate these instruments into policy toolkits. Over the past five years The Markets for Ecosystem Services team at CSIRO has researched and developed a number of market based instruments (MBIs) intended for implementation at the regional scale. This paper sets out some key lessons from that research for regions and beyond. Our focus in this paper is on when and where to use which MBI, and on effective MBI design.

MBIs are intended to achieve more efficient or effective environmental outcomes than comparable policy instruments. They do this by harnessing the organisational strengths and the competitive pressures of markets. Markets provide an effective conduit for information about the relative costs and benefits of alternative actions. They generate incentives to achieve improved environmental outcomes through market signals rather than through explicit directives such as regulation. Markets encourage innovation and profit seeking behaviour. Effective MBIs are designed to replicate these strengths. To do so they must be designed to overcome the ‘market failures’ that have prevented an effective market from emerging for the desired environmental outcome.

The efficiencies of markets are driven by the gains to participants from voluntary exchange – the ‘gains from trade’. These gains emerge from differences or heterogeneities between market participants. Gains from trade are driven by mutually advantageous exchange in markets with buyers (sellers) discriminating between alternative sellers (buyers) on the basis of factors such as cost, location and certainty of provision. MBIs can only be effective where such heterogeneity exists and there is a socially acceptable basis for effective market discrimination.

Effective MBIs are thus an exercise in designing mechanisms that encompass and engage potential market participants and release the gain from trade. MBI form is governed by whether reforms to existing markets are envisaged to be successful (market friction instruments) or new markets would need to be created (price or quantity instruments). Prime consideration in choice of form is relative efficiency and community acceptability of alternative property right structures.

The focus in this paper is on the lessons for designing MBIs in a regional context. Many of these lessons are not new. The lessons are incomplete because there is still much to be learned about MBIs, and some aspects of design are technically difficult and require ongoing research. The paper is structured as follows. In the next section we provide a brief context by defining and describing the MBI approach. In the third section we discuss factors that should be considered in deciding why and where to apply an MBI and what form it should take. In the fourth section we describe a market failure approach to identifying critical design parameters that must be addressed in order for MBIs to be successful. Throughout the paper we illustrate our discussion of the key concepts with examples drawn from our experience. We conclude the paper with a synopsis of guidance for MBI design and some suggestions for future research.

# 2. What are Market Based Instruments?

Efforts to influence privately managed environmental outcomes have focused on one or more of four broad modes:

1. Motivational and norm based instruments (including public rewards or shaming);
2. Facilitative and enabling instruments involving no direct financial transfers, rather they focus on overcoming information and institutional constraints to production;
3. Financial instruments involving direct cash benefits or penalties; and
4. Regulatory instruments which require mandatory actions be taken or avoided.

In essence, a wholly economic model views each mode as being engineered to achieve a broadly similar outcome: private benefits that outweigh private costs. Private net benefits may be generated by any or all of: financial incentives; enhanced private benefits through personal enjoyment of one's own environmental outcomes; reduced guilt or enhanced warm glow; or threat of punitive response.

MBIs typically involve some combination of facilitation/enabling, financial, or regulatory instruments. The intention is to use MBIs as the vehicle to deliver signals about desirable environmental outcomes and provide incentives for innovation, profit, and arbitrage, in much the same way that regular markets do. Well designed MBIs in appropriate applications offer the potential to deliver outcomes at lower cost to government and with improved flexibility and lower compliance costs to landholders than alternative instruments. These outcomes are achieved in four ways:

1. Allowing flexibility in the way participants choose to respond to the instrument so each individual can choose the lowest cost means of achieving the desired outcome;
2. Encouraging greater change amongst those who can achieve change most cheaply (and less amongst expensive providers), as opposed to imposing equivalent change requirements on all;
3. Placing positive incentives on better NRM, as compared to the negative or punitive incentives evident in regulatory approaches; and
4. In combination these incentives drive innovation and continual improvements in NRM management that are the source of continuing efficiency gains through time.

### ***Types of Market Based Instruments***

The Australian literature has tended to define MBIs within a typology describing three modes of intervention: price based; quantity based; and market friction (NMBIPP 2004). This typology is shown in Figure 1 along with a brief description of the instrument and Australian examples. Some MBI types, such as tax based policies or regulatory caps, cannot be applied by regional NRM organisations. Others may be difficult to apply at a regional level because of boundary issues or skill and capacity constraints. Some aspects of these constraints will be further discussed in sections 3 and 4.<sup>1</sup>

Price based MBIs either assign or impact directly on the *price* of the desired environmental outcome. Individuals and firms then respond to the modified market signals and adopt the resource use or management practice that offers them the greatest benefit. While these instruments cannot guarantee the *extent* of changes, they act to cap the *costs* incurred under the instrument.

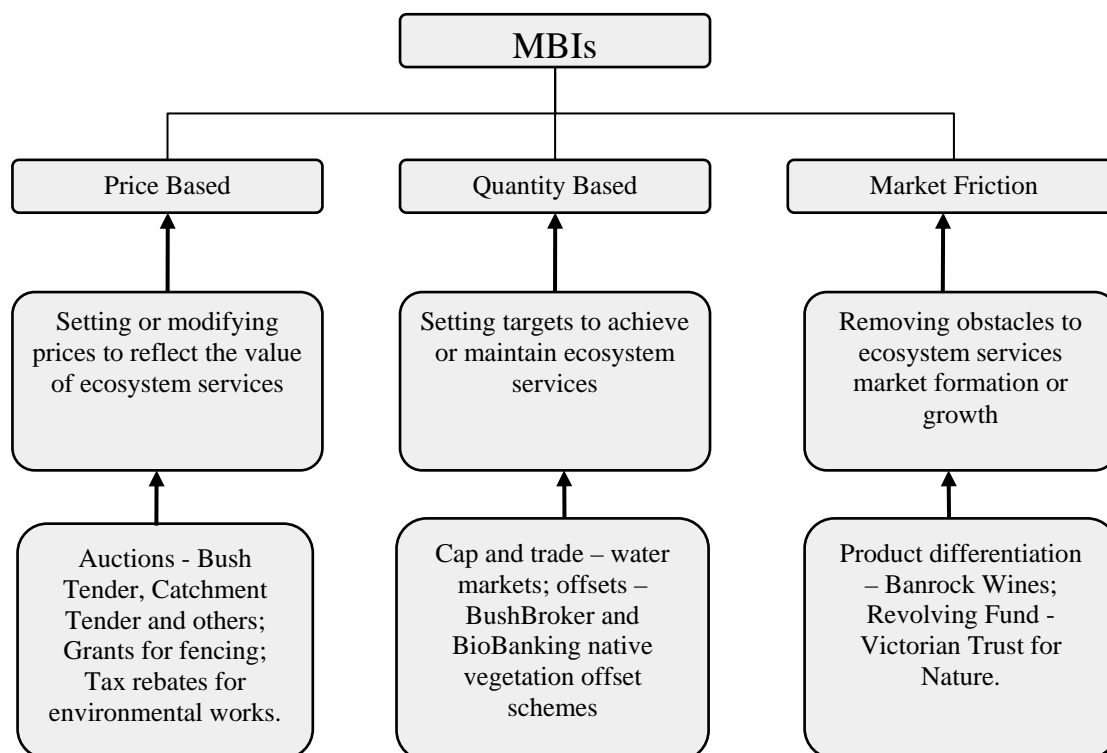
Quantity based or 'tradeable rights' instruments create a market in the rights to engage in either a damaging activity (greenhouse gas emission), or more often to access a scarce resource (water). In some cases, rights to valued new environmental commodities are created (such as rights to carbon sequestration). Tradeable rights instruments tend to be used when it is important to get a defined environmental outcome. Government or a designated authority must determine the total quantity of the good to be expressed in the rights, who can own the various rights, the initial allocation of rights, the conditions under which trade can take place, and how rights will be monitored and enforced (Murtough *et.al.* 2002).

Market friction mechanisms are a catch-all term for instruments designed to improve the efficiency of an existing market for the desired ecosystem service. Market friction instruments primarily work by reducing transaction costs and thus increasing the accessible gains from trade. For example, improving water market efficiency through the introduction of brokers or simplified trading arrangements would constitute a market friction MBI.

---

<sup>1</sup> For a more complete discussion of MBIs including examples interested readers should visit the National Market Based Instruments Pilots Program website: [www.napswq.gov.au](http://www.napswq.gov.au); or see Whitten, Stoneham and Carter (2004).

**Figure 1:** Market Based Instrument typology



### 3. Why, where and which MBI?

Successful early MBI applications have stimulated regional NRM group interest, particularly given their limited resources and the inadequate effectiveness of many existing instruments on private lands. Three main questions arise:

1. What information is needed to support decisions about MBI suitability?
2. Why and where will MBIs work?
3. Which MBI is best?

In a theoretical sense the answers to these questions are simple! MBIs should only be considered where there are gains from trade. They will only work if designed to capture gains. And the best type of MBI is that which most effectively leverages the available gains in a form acceptable to the community. To answer these questions pragmatically for any particular issue is obviously more complex.

#### ***Information for policy design***

Good instrument design is reliant on a sound understanding of the biophysical issue and policy context regardless of whether MBIs or other policy options are being considered. This is generally well recognised, but may be even more important for MBIs with their emphasis on creating dynamic and ongoing incentives for improved environmental management.

For a market to work it must not matter from whom the desired outcomes are sourced. That is, the desired outcomes must be substitutable, at least within constraints such as duty of care requirements or rules preventing hotspots and similar perverse outcomes. Basic biophysical information must therefore indicate:

- Where the desired ecosystem services are produced (that is, the spatial boundary);
- Possible management interventions that could increase ecosystem service production; and

- The degree of substitutability of sites or actions in terms of ecosystem service production.

Three examples of salt management demonstrate different aspects of the biophysical context that will need to be understood before moving into formal MBI consideration and design.

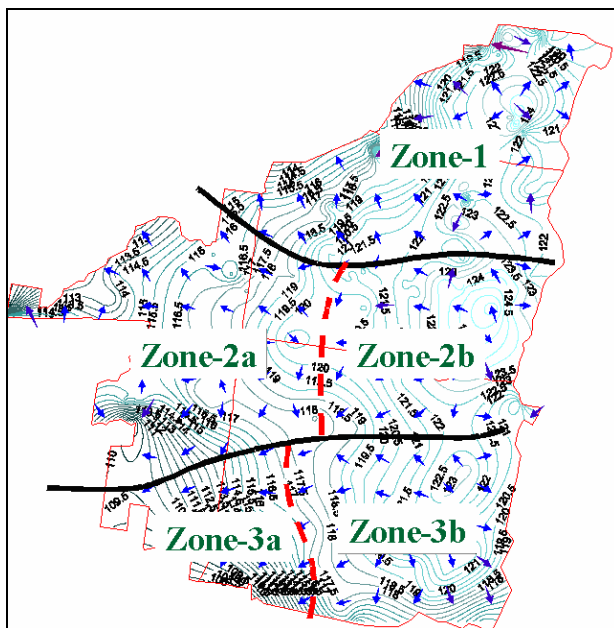
*Example 1: Reducing instream salinity in the Wimmera River*

The policy objective was to reduce the instream salinity in the Wimmera River at Horsham. Instream salinity is generated by discharge from saline aquifers into upstream tributaries. The critical biophysical information is the source of salt entering streams and the management changes that could reduce these discharges. Within these bounds all upstream sources of reduction of instream salinity can be regarded as substitutable.

*Example 2: Managing irrigation salinity in the Coleambally Irrigation Area*

The policy objective is to reduce the incidence of irrigation induced soil salinisation and waterlogging in the Coleambally Irrigation Area (CIA).<sup>2</sup> The aquifer underlying the CIA is partitioned into a number of functionally separate areas as shown in Figure 2. Undertaking actions in one zone would not impact on the desired outcome in other zones. Therefore, actions in zone 1 are not substitutable at all with actions in zones 2 or 3, and actions in zone 2a are only partially substitutable with actions in zone 2b.

**Figure 2:** Possible groundwater management zones in the Coleambally Irrigation Area



Source: Khan and Rana (2005)

*Example 3: Protecting roads from salinity and waterlogging in the Blackwood Basin*

The policy objective is to reduce the impacts of salinity and waterlogging on roads. Damage is usually confined to local aquifer impacts where roads run across valley floors. Impacts are generally dependent on the actions undertaken upstream of road crossing points. The upstream catchments where change can cost-effectively be achieved are mostly small; usually limited to one or two landholders, all of whom would need to change management. Actions in one catchment are not substitutable with actions in another with respect to individual damage sites. However, if funds are scarce, then benefits from treating any individual site are substitutable with the benefits from treating other sites.

<sup>2</sup> The largely self-contained aquifers and the small surface outflows from the CIA mean that external impacts are small compared to the impacts on agricultural production, local infrastructure and local environmental impacts.

The potential for substituting management intervention is different in each case. In the Wimmera, all upstream salt sources are substitutable. In the CIA, substitution is possible within any one zone. In the Blackwood Basin, locations are not substitutable for the protection of a particular site.

The relevant biophysical information must be linked to social and institutional information about likely market impacts in order to assess potential intervention impacts and effectiveness. Three examples are provided below to illustrate the kinds of market information that are important in policy design.

#### *Example 4: Ecosystem services and rural residential development in Murrindindi Shire*

Goulburn Broken Catchment Management Authority (CMA) and Murrindindi Shire Council desire enhanced ecosystem services from the catchment. Any reforms intended to increase ecosystem service protection or production take place within a congested institutional landscape. Overlapping regulatory requirements are imposed at the local and multiple state level agencies, with provision for further oversight at the regional level (see Coggan, Whitten and Langston 2005). These requirements must be clearly understood in order to identify the potential for MBI development and implementation.

#### *Example 5: Who drives the Australian native seed market?*

The difficulties experienced by many revegetation projects in sourcing seed have lead to suggestions that the market is dysfunctional and in need of reforms. To local projects the most obvious market participants are local suppliers; but these are dominated by suppliers to mining revegetation projects. Failing to consider the acceptability and response of mining companies and their suppliers is likely to render reform on a local scale ineffectual or inappropriate.

#### *Example 6: The potential implications of linked markets*

Salinity and waterlogging issues in the Coleambally Irrigation Area are primarily driven by water management. Failing to consider the impacts of water prices on CIA water use decisions, and therefore for waterlogging and salinity in the region, could render intervention irrelevant. The potential impact in the CIA was assessed by modelling the threshold water price at which, in an unrestricted market, sufficient water would be sold from the region to eliminate the problem.

Each example shows where inadequate understanding of the market context could lead to poor policy outcomes. In each case there are important players present that can impact on policy effectiveness. In Murrindindi Shire, the cluttered regulatory context will limit and shape interventions. Major, but largely unseen market participants in Australian native seed markets will need to support any proposed change for it to succeed. In the CIA external market influences that raise water market prices could render a policy intervention redundant.

### **Why and where to consider MBIs?**

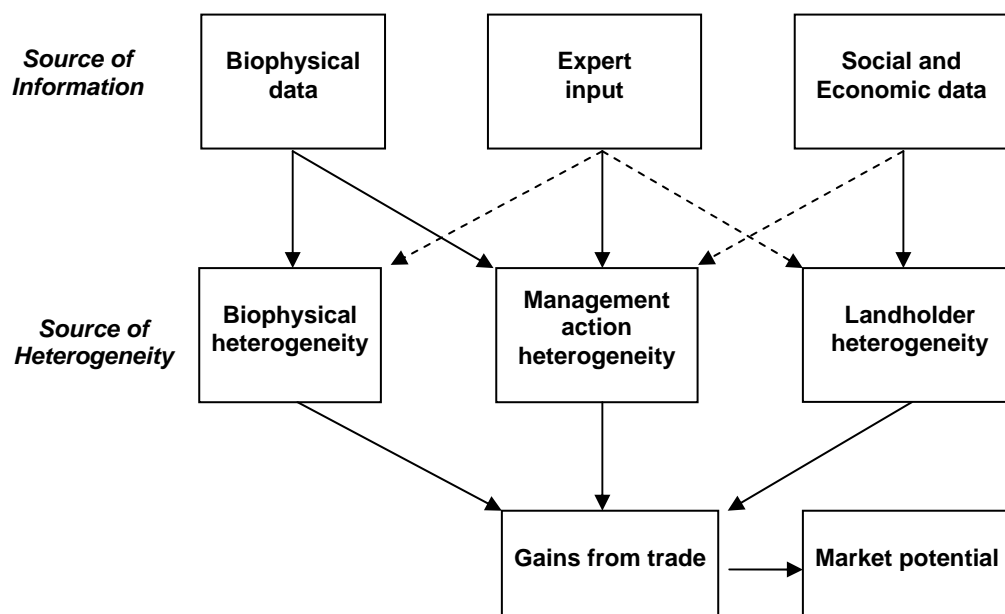
MBIs offer enhanced efficiency and effectiveness over alternative instruments when well designed and applied in the right context. Specifically, MBIs are likely to outperform other instruments where:

1. There are large variations in the ability of potential participants to provide the desired outcome;
2. There is flexibility in the range of responses that will deliver the desired outcome;
3. Regulatory or other approaches are difficult to design, implement and administer; and
4. There is greater scope for innovation in improving NRM management.

The 'gains from trade' that drive markets are primarily derived from differences, or heterogeneities, amongst the participants' preferences, resources or production opportunities. These differences must be harnessed through a market mechanism that provides continuing incentives to reduce costs and produce better products. It follows that the level of heterogeneity, and the possible gains from trade, should be considered to decide if an MBI approach is warranted over alternative policy approaches. Shelton, Langston and Whitten (2004) developed a rapid assessment tool for thinking about the nature of

heterogeneity in NRM environments that is illustrated in Figure 3. Biophysical differences can often be assessed through available mapping of relevant surrogates to the desired outcome or ecosystem service. Management flexibility can be assessed through careful consideration of the range of management options available (and attractiveness to landholders) and the degree of cost variation in their application between landholders and across the landscape. Landholder heterogeneity can be assessed by considering the variation in social and economic characteristics within the target community.

**Figure 3:** Conceptual approach to rapid assessment methodology



Quantitative estimates of the scale of the available gains from trade should also be made where possible. As an example consider the estimation of the likely gains from trade from changing management under alternative policy scenarios in the CIA (Robinson *et.al.* 2005). Five policy options were compared, four of which could achieve the desired reduction in recharge and the fifth was ‘business as usual’ (Table 1).

**Table 1:** Potential recharge management policies in CIA

Scenario	Economic theory / policy	Impact on agricultural production
1. Business as usual	Open access (current rice area quota continues)	Yield declines via an assumed linear damage path
2. Rice cap	Input cap on most damaging process – rice production	No further yield decline.
3. Water cap	Input cap on most damaging input – irrigation water	No further yield decline.
4. Cap and no trade	Cap on net recharge at the farm scale but no trading allowed	No further yield decline.
5. Cap-and-trade	Cap on net recharge with trade allowed.	No further yield decline.

Policy options were compared within a calibrated model designed to capture variation in the landscape and available management actions of farms in the CIA.<sup>3</sup> Modelled gains from trade amounted to a net present value (NPV) of \$3.4m or just 1.4% of the NPV of total income over the next 20 years when compared to ‘business as usual’. Realised gains from trade are likely to be lower again as indicated by

<sup>3</sup> Modelling was undertaken using SWAGMAN Farm<sup>®</sup> (Robinson *et.al.* 2005, Madden and Prathapar 1999). The goal was to identify whether the agricultural production impacts were sufficient to drive a recharge credit market, therefore non-production benefits of recharge mitigation were not included.



the experimental economics results from simulation and laboratory trials (Ward 2005). The conclusions illustrate the importance of carefully considering heterogeneity: gains from trade were small and unlikely to drive a recharge credit market. However, all other policies performed worse than ‘business as usual’ illustrating the importance of designing policy to harness the gains from trade.

## ***Deciding which form of MBI is best***

### *Price, quantity, or market friction?*

Market friction instruments target poor market design or opportunities to reduce transaction costs within existing markets. In some cases existing government interventions may cause perverse market outcomes and these should always be assessed before more complex interventions are considered. The market failure assessment process described in the next section provides a suitable framework for identifying opportunities to design and implement market friction instruments.

In the absence of existing markets regional bodies face a choice between price and quantity based MBIs. Weitzman (1974) notes that price and quantity based instruments will result in identical outcomes in circumstances of perfect information and competition. In practice there are a number of complications in design and application that may lead to one being preferred over the other. Reasons for preferring price or quantity based instruments are summarised in Figure 4.

**Figure 4:** Summary of rational for preferring price or quantity based instruments

Price based	Quantity based
- Fixed budget	- Physical targets
- High cost of additional services	- Large benefits of extra services
- Small benefits from extra services	- Low costs of extra services
- Community should pay for services	- Presence of thresholds with high NRM damage
- Cost-sharing to achieve targets	- Community has right to desired outcome
- NRM outcomes quick to change	- Long time to change NRM outcomes
	- Protection of existing outcomes

Marginal costs and benefits of additional ecosystem services are rarely known with certainty. Weitzman (1974) identifies several cases where price or quantity based instruments may be preferred based on uncertain costs and benefits. If the marginal costs curve is steep relative to the marginal benefit curve at the optimal production level then price instruments will tend to be preferred because of the high cost risk of incorrect quantity targets. Similarly, if marginal benefits are steep relative to marginal costs then quantity instruments will be preferred. For similar reasons Weitzman notes that price instruments are preferred where there is a threshold (corner) in the marginal cost function (perhaps because a new technology is reached) and *vice-versa*. Weitzman also considers the impact of additional suppliers and concludes that the more potential suppliers the greater the case for a price-based instrument. Weitzman’s conclusion can be extended to argue that the more potential buyers the greater the case for a quantity based instrument.

There are also several important non-economic reasons to favour either a price or quantity based instrument. These include:

- **Property right expectations:** the polluter pays principle equates to a quantity based approach where targets are set and polluters must meet targets at their own cost. The contrary beneficiary pays framework equates to a price-based mechanism. Clear property right expectations may favour one or other approach;
- **Jurisdictional powers:** legislation is usually needed to create or modify property rights that underpin quantity based instruments. In contrast, price-based instruments can be implemented using contractual arrangements between the parties;
- **Time to produce desired outcomes:** Quantity based instruments may be preferred for protecting long term outcomes while price based approaches may only be effective so long as budgets remain

available. Other design parameters such as purchasing quantities (via covenants on property rights for example) or restrictions on trades to ensure long term production may also be relevant;

- **Transaction costs of mechanism:** transaction costs tend to increase the larger the number of participants within the instrument, the more complex the engagement with the instrument, and the greater the ex-poste monitoring required amongst many other factors; and
- **Degree of change required:** Expectations may change depending on the degree of cost imposed. Mixed instruments may be favoured in such settings.

### *Multiple or single service MBIs?*

The critical factor in deciding when to consider multiple-issue versus a single-issue market is the degree to which individual sites provide multiple ecosystem services combined with the potential for a single management action to generate multiple outcomes. When each site provides multiple services and each management action contributes towards multiple targets, a single integrated MBI may be more cost-effective than multiple instruments. However, this is only the case, *if* the increased complexity, and establishment and ongoing transaction costs of including multiple issues within a single MBI are offset by an increase in the magnitude or efficiency of the outcomes achieved. The single versus multiple service MBI dilemma is summarised in Figure 5. Multiple-issue MBIs are likely to be most appropriate when there are numerous options available to change management on potential sites, but only some deliver multiple outcomes.<sup>4</sup> For example, farm forestry may deliver salinity benefits but not necessarily biodiversity outcomes, whereas mixed plantings may deliver both.

**Figure 5:** One MBI or many?

		Management options generate multiple outcomes	
		Yes	No
Sites likely to deliver multiple ecosystem services	Yes	1. Multiple outcome MBI	2. Multiple outcome MBI possible – encourage innovation so that management actions deliver multiple outcomes
	No	3. Consider increasing geographic area to attain sufficient sites with multiple ES potential.	4. Multiple outcome MBI unlikely to succeed – consider separate MBIs.

Source: Adapted from Shelton, Langston and Whitten (2004).

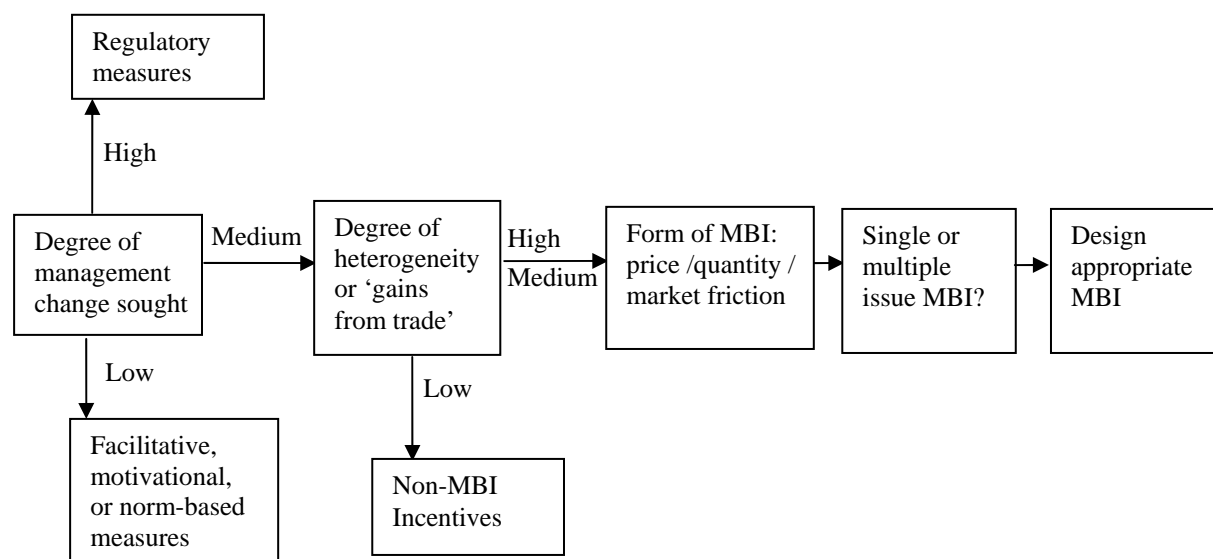
Single versus multiple issue framework tests in the Muttama and Jugiong sub-catchments of the Murrumbidgee River indicated that few parts of the catchment were likely to deliver multiple ecosystem services. Furthermore, few of the available management actions were able to deliver multiple outcomes. In this case the benefits of a specialised MBI for each targeted ecosystem service would likely to outweigh any cost savings in combining these into a single instrument. This conclusion may not be the case elsewhere (see for example the Victorian EcoTender trials – Eigenraam *et.al.* 2005) and so simple tests should always be undertaken to identify the likely mix of benefits from target sites.

### ***A framework for thinking about market based instruments***

The information gathered by considering the issues discussed in this section can be used to systematically think about the benefits of an MBI approach compared to alternative options (if any) as shown in Figure 6. Additional information (such as specific design requirements) may cause earlier decisions to be reviewed or different conclusions to be drawn, so this would in practice be an iterative process not the linear one shown. After gathering and considering this information a decision can be made about whether an MBI approach is likely to succeed and if so, what kind of MBI is appropriate.

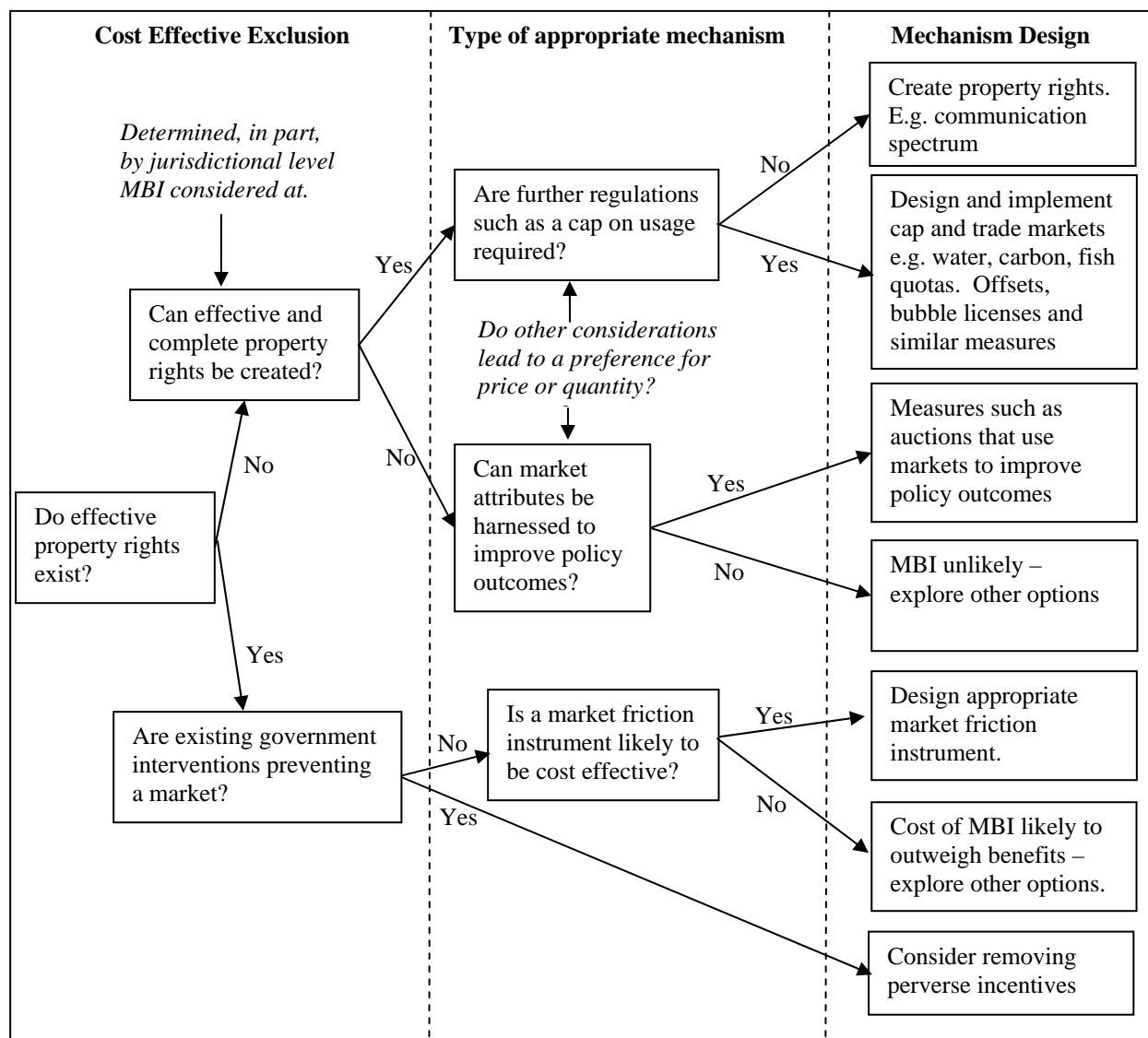
<sup>4</sup> Note that if management changes and sites produce a similar mix of outcomes, just in different total quantities, a single outcome MBI is equivalent to a multiple outcome MBI.

**Figure 6:** Synopsis of MBI decision points



To a large extent, technical design decisions about MBIs at the regional level are reliant on whether effective property rights or entitlements can be created for the ecosystem service. An alternative decision tree focusing on the role of property rights in MBI design is presented in Figure 7. The key attributes of property rights that would need to be in place for various MBI forms to succeed are discussed in the next section along with other MBI design issues. The final form of MBI is *designed* via a process of identifying and overcoming market failures rather than via selection from a menu. Hence, the focus is on a process-based guidelines for MBI design and implementation rather than a menu-based discussion of how to deliver each MBI form.

**Figure 7:** Decision tree identifying common MBI forms.



## 4. A market failure approach to designing effective MBIs

### *Market failure analysis as a tool for MBI design*

MBIs are used where markets have failed to emerge or fail to operate effectively. Effective MBIs require impediments to markets to be overcome. Our experience has repeatedly emphasised the importance of using a systematic analysis of the market failures. MBI design is then framed with solutions to these impediments in mind. Our focus is on market failures but the potential for government failure and policy failure to impact on instrument design should also be considered.

A summary of potential market failures is presented in Table 2. A number of other design issues that are not strictly market failures but which may be important to market success and should be considered in mechanism design are listed in Table 3. Additional issues specific to instruments or applications may be identified. Incomplete property rights combined with information asymmetries were found to exist in all cases which we studied.<sup>5</sup> Other market failures and design issues were less common, though constraints to participation, market structure, potential for interaction with other instruments, and linking outcomes to incentives should always be considered.

<sup>5</sup> See Stoneham *et.al.* (2003) for a good theoretical discussion of asymmetric information with respect to the design of the BushTender program and Murtough *et.al.* (2002) for a discussion of property right attributes.

**Table 2:** Summary of possible market failures and issues

Market Failure	Issues	Considerations
Incomplete property rights	1. Definable	Create and define property rights.
	2. Measurable	Develop metric to describe relevant attributes.
	3. Excludable	If free-riders cannot be excluded, empower public agency to purchase ecosystem service.
	4. Transferable	Create right that can be transferred separately from other rights (such as separation from land title).
Information (lacking, or asymmetrically held)	1. Ecosystem service production function unknown	Develop metric to link land management actions with ecosystem service production.
	2. Benefits of management actions unknown to buyer	Metric applied by buyer/public agency to calculate public benefits of management actions by landholders. Non-market valuation to capture public non-use values.
	3. Benefits of management actions unknown to producer	Apply metric and extension programs to inform landholders how to produce ecosystem service, and of the associated private benefits.
	4. Scientific uncertainty	Incorporate 'risk premium' into metric. Further research to reduce uncertainty.
	5. No common market place	Create marketplace.
Market structure	1. Thin markets	Expand scope of market to bring in more traders. Work to maximise participation rates.
	2. Market power	Expand market scope to bring in more competitors. Regulate to prevent cartel formation.
Linking payment to outcomes	1. Principal-agent problem	Performance-based payments. Monitoring. Fostering trust in contracting.
Constraints to market participation	1. Capital	Upfront payments.
	2. Transaction costs	Public agency to provide information and advice. Minimise complexity of rights and bidding/trading process.
	3. Inexperience with mechanism	Provide training on market mechanism.

**Table 3:** Some other market design issues of importance

Design issue	Description
1. Multiple ecosystem service outcomes	Consider multiple outcome market Facilitate access to other markets (e.g. carbon)
2. Interaction with other incentive programs.	May be perverse incentive for strategic playing off of one program against another and/or double dipping.
3. Interaction with other non-incentive programs	Existing rules and regulations will need to be considered in the design of any new instrument.
4. Changes to stakeholder expectations	Stakeholders stop providing a free service for the public good and expect instead a relatively high payment through a market. This behavioural change may be effectively irreversible.
5. Risk if no change	If target not achieved will any irreversible loss to ecosystem services occur?
6. Spillovers to other ecosystem services	Unconsidered impacts on other ecosystem services e.g. revegetation for biodiversity may reduce stream flow.
7. Permanent versus temporary change	Likelihood of management changes being reversed versus cost to permanently protect.
8. Multiple actions in a single market place	Can or should participants engage in the instrument in multiple ways? For example, multiple bids in a tender.
9. Treatment of coalitions of participants	Should joint activities be allowed or encouraged? For example, joint bids within auctions (see market power in Table 2).

### *An example in Wimmera Catchment, Victoria*

An example of a market failure analysis is shown in Table 4. The most important design issues for an MBI intended reduce salt loads to upper Wimmera Catchment Streams are set out. Additional design issues identified were: interactions with existing policy; changes to stakeholder expectations; permanent versus temporary change to service delivery; and treatment of joint or multiple bids within auctions. The additional design issues are often specific to the instrument. For example, multiple bids are only an issue in a competitive tender or similar situation. Often uncertainty remains about the significance of market failure. For example, lack of landholder knowledge about techniques to revegetate the landscape and potential participation concerns were less important than initially assessed in the Wimmera example (as identified in a design workshop – see Whitten and Shelton 2005).

**Table 4:** Summary of Wimmera market failure analysis

Market failure	Implications in the Wimmera context
Property rights – the need for clear definition, allocation and measurement	Rights to redistribute salt in landscapes are unclear. Duty of care requirements are only indirectly related to salt and water balances and there is a lack of effective rights relating to land management and salinity control. Consistent measures of the salinity impacts of alternative land management actions did not exist (but were developed from existing information).
Property rights – desired ecosystem services are non-excludable	Landholders reducing salt export have no way of identifying who will benefit and ensuring beneficiaries pay for these services. Government could act on behalf of potential buyers to remove this problem.
Asymmetric information – about landholders' costs of changing management	There is no market price for reduced salt loads that could be used to purchase changes to land management. Therefore, the CMA does not know what price or which landholders to pay to change land management.
Asymmetric information – salt benefit from changing management	Governments know, or can estimate, the likely reduction in salt movement from changing land management but landholders do not. Landholders need information about what changes to make where in the landscape.
Information failure – tools and techniques	The tools and techniques required to establish and maintain landuses that reduce salt movement may be unfamiliar to landholders. Government has collected best practice information that could be used in this context.
Information failure - scientific uncertainty	Uncertainty remains about the absolute and relative outcomes for salt movement from alternative land management actions.
Difficulty measuring and monitoring success	Successful implementation of the management actions can only be measured well after they have taken place but costs are incurred up-front. Therefore, it is difficult to design payment structures that give appropriate incentives for best practice implementation without intensive monitoring.
Market power	Too few landholders may be interested in participating to allow competitive outcomes under an MBI solution.
Market entry constraints	Up front costs of changing land management are high and will need to be considered in any payment mechanism.

Source: Adapted from Whitten and Shelton 2005.

### ***Designing effective MBIs***

The specific needs and context of each MBI will differ based on the market failures present and the biophysical and market context. Our conclusions therefore take the form of examples and general guidance that can be applied in a variety of settings. Costly expert input is often needed at this point to facilitate good design: but failures can be costly, both financially and in lost goodwill.

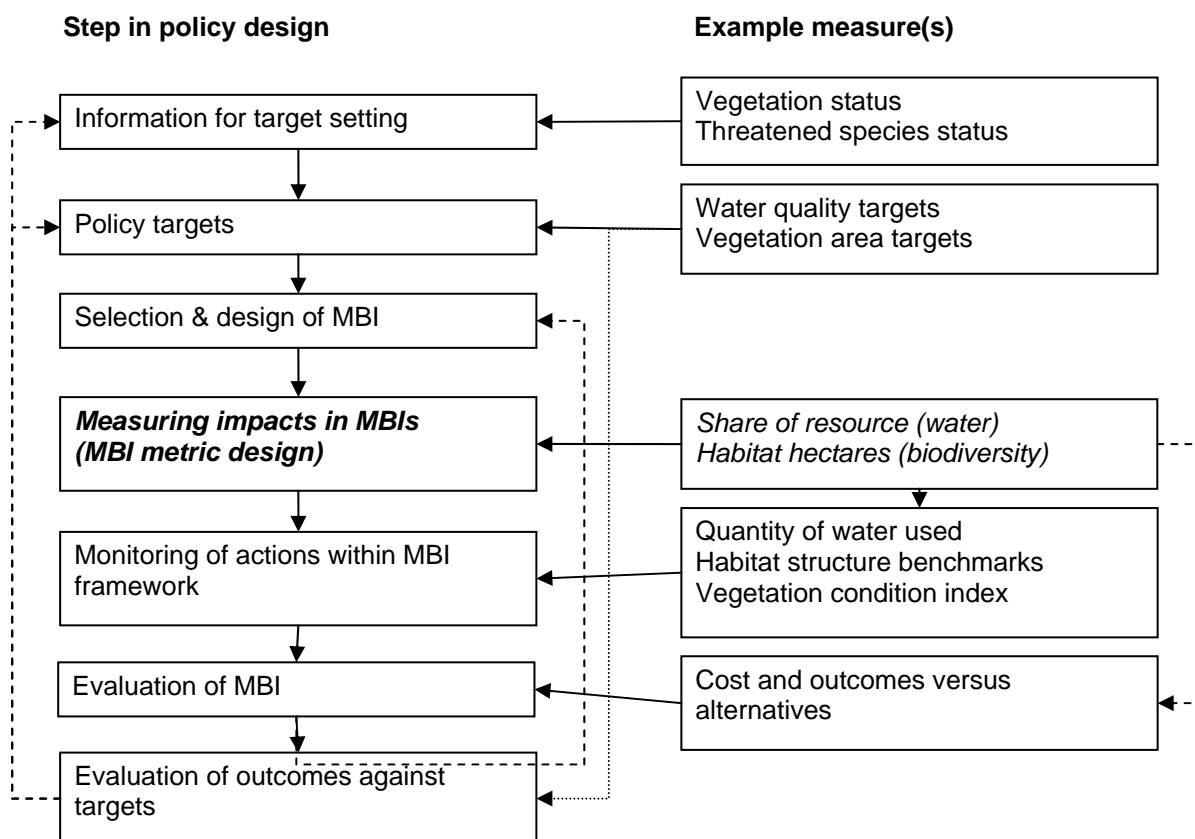
### *Metric design*

Clear rights or entitlements are needed to commodify services and underpin exchange. A measure or metric is usually needed to define the new commodity. Metric design principles are critically important to overcoming incomplete property rights. The role of the metric in an MBI is often confused because of the multiple roles that measurements of ecosystem services and actions play in the NRM sphere. A

sample of these roles is presented in Figure 8. MBI metrics are specialised tools that are used to quantifying what is to be paid for in a way that can be directly compared across individuals. Only rarely will the same measure be suitable for multiple purposes within the policy design framework.

The creation of a suitable metric remains an impediment to the implementation of most MBI instruments. Metrics represent a complex bundle of trade-offs and are not simply a question of estimating a measure of biophysical change (which in itself is extremely complex) but often must also take into account other drivers of values. For example, the location of change may be important. The core of metric design is the conversion of spatially distributed and differing degrees of outcome change into a single, cardinal, comparable unit. That is, the metric must indicate how much better one proposal is than another.

**Figure 8:** Natural resource measures and metrics in MBIs



Notes: See Whitten *et.al.* (2006) for more discussion on the role of the metric in MBIs.

Nine principles that should be considered in designing a suitable metric are shown in Table 5. The core physical measure of ecosystem service production is often adjusted by subtracting what would happen anyway (creating a measure of marginal change), or via subtraction of a duty or care or minimum standard level of provision. Location, timing and risk are generally incorporated by weighting the basic measure. Irreversibility and spillovers are often included as filters.<sup>6</sup> Note also that some metric design issues may be incorporated elsewhere in instrument design. For example, limiting eligibility to specific sites or sub-regions reduces the need for a separate location component. Multiple output MBIs will also require metrics for each service targeted to be normalised and weighted in order to combine them into an aggregated measure.

<sup>6</sup> Weights modify the quantity/quality value estimated for the target ecosystem service while filters are used to screen out undesired options from further consideration.

**Table 5:** Principles of metric design

<i>Design principle</i>	<i>Description</i>	<i>Wimmera salinity reduction auction recommendations</i>
1. Quantity/Quality	<ul style="list-style-type: none"> <li>- A metric is a physical quantity or cardinal index of a biophysical outcome.</li> <li>- There are usually a number of measures that deliver different messages to landholders and represent different outcomes.</li> <li>- Direct measurement of outcomes is preferred but usually estimated using a proxy based on changes to inputs.</li> </ul>	Estimate salt impact of alternative management changes in tonnes of salt at Horsham. Management impacts are incorporated using input-based proxy measures for vegetation type at the proposed site.
2. Spatial relationships	<ol style="list-style-type: none"> <li>1. Do any packages of management change generate synergistic outcomes? For example, corridors over scattered vegetation, revegetation in the neighbourhood of existing large remnants compared to more scattered activities? and</li> <li>2. Are there any biophysical thresholds that are likely to be created crossed or impacted in different pathways?</li> </ol>	While spatial relationships do exist they are likely to be relatively small and very difficult to incorporate. Recommended they be ignored in the initial application.
3. Change relative to a baseline	Important if the goal of policy is to improve outcomes from a baseline, rather than some absolute maximum ongoing quantity. The baseline is usually defined as the higher of a specified duty of care and the actual outcome where management change is unlikely.	Change should be measured relative to a uniform benchmark for the salt export impacts of business as usual (annual pasture). This creates an implied minimum duty of care. Bids in areas with scattered trees may complicate this baseline.
4. Location – relative values	<ol style="list-style-type: none"> <li>1. Locations closer to the community might be valued more highly;</li> <li>2. The production of the ecosystem service is intrinsically greater in some places; or</li> <li>3. The change may generate differential service outcomes depending on impact pathways (such as for water quality).</li> </ol>	Estimate impact of proposals at a single downstream point (Horsham). The path or stream contributing to that point was not identified as being important, only the aggregate impact at the downstream point.
4. Timing	All things equal, earlier outcomes are preferred over later ones.	A steady state estimate is favoured due to the relatively short time horizons predicted for outcomes on steep hill country and the uncertainty about actual time needed to achieve outcomes.
5. Risk / certainty of implementation success	Some management changes may be more likely to succeed than others. The key factor in success may be the initial establishment or the on-going management. Likelihood of success can either be considered within the metric design or the payment mechanism.	Consider weighting by estimated probability of successful implementation (aspect may be important for revegetation).
6. Risk / certainty of outcome success	Even with successful establishment of the management change there may be uncertainty about the eventual impacts on outcomes. For example, this may be the case with management changes for which less is known about their impact on recharge.	Eligible actions and sites restricted but if expanded consider weighting by estimated probability of outcome being achieved.
7. Irreversibility	Irreversibility is related to risk. Where thresholds are anticipated, such as extinction of species, there is a case for favouring less risky actions that achieve change sooner.	No irreversibility issues identified.
8. Spillover impacts	Spillover impacts are adverse consequences caused by management change that could lead to a perverse outcome either locally or elsewhere in the system (such as increased fire risk from large scale revegetation).	Tree planting will reduce base-flows in streams and rivers in the catchment but is not likely to increase downstream salt concentration or significantly impact on water availability.



Table 5 includes an example drawn from summary recommendations for a metric developed by Wimmera CMA to support an auction to reduce salt loads in Wimmera River (Whitten and Shelton 2005). Some principles will be less important for some applications and may not be included. In this example location and time are not regarded as important in their own right, and no irreversibility or spillover impacts of sufficient importance were identified. Metric construction may also avoid formal separation of components. Despite the apparent simplicity of the approach, the complexity of estimating a broad quantity / quality measure should not be underestimated. For example, the biophysical model underpinning the metric is based on years of biophysical and modelling research and takes several hours of computer processing time to optimise.

### *Overcoming market failures and other design issues*

Market failure analysis will likely reveal a number of market failures that MBI design will need to address. In many cases supporting instruments such as extension support (a facilitative instrument) or regulations are necessary. Indeed information and extension programs are a feature of most competitive tender (auction) approaches implemented to date. It is critical to note that the outcome of market failure analyses will be specific to the problem studied, and often to the local context as well. Therefore, caution should be exercised in transferring mechanisms to new locations or issues.

An example of a completed market failure analysis with a menu of potential design solutions identified is shown in Table 6 for the investigation of a cap and trade approach to managing recharge to groundwater aquifers in the CIA. The examples show a number of different but overlapping design parameters that needed to be considered in the form of market investigated for implementation including: right or entitlement allocation and ownership; interaction between the metric and market; and penalty arrangements.

**Table 6:** CIA cap and trade market failures identified with potential solutions

Market failure	Definition	Potential solutions
<i>Property rights – definition and assignment</i>	Rights to shared aquifers are not defined leading to farm management decisions being confounded by common property resource and free riding behaviour.	<ul style="list-style-type: none"> <li>• Allocate rights to farmers.</li> <li>• Social contracts formalising non-market agreements.</li> <li>• Assign rights to beneficiaries.</li> </ul>
<i>Property rights - entitlement distribution</i>	Irrigators hold <i>de facto</i> rights at present. Auction of rights is theoretically most efficient mechanism but procedural fairness makes <i>de facto</i> more likely.	<ul style="list-style-type: none"> <li>• Assign property rights and associated obligations to farmers.</li> <li>• Distribution of entitlements determined by community.</li> </ul>
<i>Property rights and implied risk assignment</i>	Two risks could be faced by irrigators: a) stochastic events such as rainfall variability; and b) free riding by other farmers	<ul style="list-style-type: none"> <li>• Normalised performance reduces stochastic risk.</li> <li>• Effective rights and monitoring remove free riding risk.</li> </ul>
<i>Information constraint</i>	Information constraints may limit engagement and adoption of recharge management options.	<ul style="list-style-type: none"> <li>• Communications strategy to facilitate engagement.</li> <li>• Use trials to improve information.</li> </ul>
<i>Scientific uncertainty</i>	Accuracy of modelling, including rates of recharge and management impacts.	<ul style="list-style-type: none"> <li>• Periodic review of models with care not to undermine security of rights.</li> </ul>
<i>Market power - thin markets</i>	Few buyers and sellers imply difficulty trading. Can lead to market power and hoarding behaviour.	<ul style="list-style-type: none"> <li>• Numbers may be sufficient - test.</li> <li>• Centralised trading point.</li> <li>• Introduce external trader.</li> </ul>
<i>Monitoring - performance incentive failure</i>	Performance based approach (using non-compliance penalty) provides stronger ongoing incentives for recharge management than input incentives.	<ul style="list-style-type: none"> <li>• Tiered monitoring depending on level of threat.</li> <li>• Create effective individual penalties that reflect damage.</li> </ul>
<i>Market entry - capital constraint</i>	Capital constraints may limit adoption of recharge-reducing management options.	<ul style="list-style-type: none"> <li>• Consider providing alternate finance arrangements if considered significant.</li> </ul>
<i>Mismatched annual supply and demand</i>	Stochastic rainfall events can lead to systemic under or overachievement of recharge targets: farmers incur excess credits or debits, regardless management.	<ul style="list-style-type: none"> <li>• Normalise performance leading to constant recharge credit allocations.</li> <li>• Allow time-limited credit banking and borrowing.</li> </ul>

Source: Adapted from Whitten *et.al.* (2005).

There are usually a number of other market design issues not directly related to identified market failures, but rather related to the attributes of the particular form of MBI chosen and the context in which it is applied. An example of the design issues specific to a particular context and mechanism is afforded by the auction for reducing in-stream salinity from steep hills in the Upper Wimmera Catchment (Table 7). Most of these relate to the design and implementation of a competitive tender mechanism. Others are generic, such as managing impacts on other incentive programs, community acceptance of the mechanism, and to some extent managing changes to stakeholder expectations.

**Table 7:** Wimmera auction design issues (not market failures) and suggested solutions

Mechanism Design Issue	Suggested Solution
Bidding procedure	Sealed bid, discriminatory price competitive tender suggested.
Managing risk of overpayment	Set a confidential, pre-auction reserve to reduce CMA risk
Community acceptance	Effective communication (plan and implement strategy).
Interaction with other incentives	Remove overlaps as far as possible.
Changes to stakeholder expectations impact on future success of existing mechanisms	Communicate the tender as a flexible new way of achieving land management change rather than explicitly as payments for ecosystem services.
Treatment of services for which other markets may exist.	Only contract for defined actions and outcomes, all other ecosystem services remain the property of the landholder.
Minimum participant numbers	Set a participation target taking into account: budget; anticipated costs of changing management and bid size; eligible landholders within region; participation in prior schemes; and other factors in important to outcomes. More info: Whitten <i>et.al.</i> (in progress 2007).
Permanent versus temporary land management change	Consider risk of future removal of vegetation – if high use covenants where possible to secure ongoing service provision.
Cost to landholders to participate.	Bid payments could be considered if costs likely to be high; experience suggests payments unnecessary.
Treatment of multiple and group tenders	<ul style="list-style-type: none"> <li>• Accept group tenders and treat as an individual tender.</li> <li>• Multiple tenders from individuals be accepted but prohibit overlaps across tenders to reduce assessment complications.</li> </ul>

### ***Other aspects of MBI design and implementation***

Successful MBIs usually incorporate supporting policy instruments to function effectively. Quantity based instruments tend to require regulatory underpinnings to create effective property rights or entitlements. Auction success is dependent on effective extension support for bid development. Combinations of MBIs are also possible – for example use of auctions to create offset banks has been proposed in a number of settings. Little formal analysis has been undertaken on strategies and pitfalls in mixing instruments. Economic theory suggests a trade-off between the additional costs involved in combining additional instruments and the additional ecosystem services produced. In some cases it is clearly necessary and desirable to combine additional instruments. In other areas careful assessment is advisable.

Mechanism design should also consider the potential to nest design needs amongst existing programs and initiatives in order to reduce cost and increase effectiveness. The main rationale for instrument nesting is the potential to significantly reduce participant and administrative transaction costs. In practice, nesting involves a trade-off between incorporating aspects of less than perfect existing instruments with the cost of designing and implementing new ones. For example, the apparent feasibility of the cap and trade approach in the CIA rested on nesting it into the pre-existing regulatory platform provided by water supply contracts, including environmental provisions and monitoring arrangements, administered by Coleambally Irrigation Cooperative Limited (CICL). Similarly, consideration of development offsets in Murrindindi Shire required careful consideration of opportunities and constraints imposed by an already cluttered legislative and regulatory planning environment. Particular emphasis was given to sharing processes in order to minimise transaction costs imposed by duplication and facilitate a consistent approval process.

## 5. Conclusions

Our goal in this paper has been to set out the key lessons for regions and beyond from five years of research by the Markets for Ecosystem Services team at CSIRO. Our research has yielded practical advice on how to identify where MBIs will perform well, insights into MBI design needs and issues to consider in implementation. It is now well known that some MBI forms are impractical at regional level, including most quantity based instruments and those price based instruments that use the taxation system. Our results give confidence that widespread application of MBIs that are practical at the regional level will yield substantial economic and environmental benefits. They also reinforce that MBIs must be well designed in order to deliver on the early promise they are showing.

Many of our findings emphasise the importance of known factors such as good information about biophysical and institutional context. Our conclusions are not, and could not be a recipe book. While robust templates for successful implementation of specific MBI forms have begun to emerge, effectiveness is strongly influenced by regional and local contexts. Therefore, it will usually be necessary for regions considering MBIs to seek specialist advice. The level of advice needed will of course differ depending on the complexity of the issue being addressed and the nature of the MBI under consideration.

MBI benefits result from harnessing the 'gains from trade'. Gains are derived from differences, or heterogeneities, amongst landholder preferences, resources or production opportunities. Future gains are captured by creating positive incentives to improve management rather than to avoid regulation, and encourage innovation. Where these gains cannot be harnessed an MBI will perform no better, and may perform worse than other measures. Good information underpins assessment of potential gains from trade. It identifies the degree to which actions on different sites can be substituted in order to achieve the desired outcome and therefore the selection of spatial boundaries.

A decision between MBI forms is initially based on whether existing markets are present and can be modified: which would necessitate a market friction instrument. Decisions between price and quantity based MBIs are based on economic and non-economic factors. Economic factors are relative marginal costs and benefits, thresholds in cost or benefit functions, and number of market participants (Weitzman 1974). Non-economic factors include property right preferences (duty of care, polluter pays or beneficiary pays), time lags in production, jurisdictional powers, and transaction costs of the instrument.

MBIs are intended to overcome market failures to release gains from trade. Market failures present should be systematically identified as a basic input into the MBI design process. Incomplete property rights and information failure or asymmetry are likely to be present in all cases. Core property right and information asymmetry issues tend to be compounded by a other market failures and design issues.

Explicit design advice is complicated by the specific needs and context of each MBI. Property right issues are an important issue in the design of any MBI and will be complicated by measurement issues. The role of the measurement metric in an MBI is often confused because of the multiple roles that measurements of environmental assets, ecosystem services, and management actions play in the NRM sphere. The MBI metric is the basis for measuring relative and absolute outcomes, and consequently who benefits and who pays. Nine principles were identified that should be considered in metric design.

MBI design must incorporate the necessary supporting mechanisms needed to ensure success, such as regulatory change or communication and engagement programs. Opportunities to nest MBIs in order to reduce transaction costs should also be identified. We have illustrated

these design issues using examples but recognise the difficulty in practical application faced by many regional NRM groups with limited access to specialist skills in the area.

Our findings reinforce the message that MBIs show considerable promise in delivering improved environmental outcomes. Achieving that promise requires attention to aligning instruments and policy options; concurrent or prior removal of perverse incentives; and a focus on design detail. Our findings are steps towards more effective policy at the regional level. Yet many aspects of MBI design, development, implementation, adoption and effectiveness are still not well understood and promising opportunities remain. Three areas identified were:

- Instruments for specific biophysical or landscape outcomes such as corridors, core habitat areas and mosaics or for environments with biophysical thresholds and discontinuities;
- Specific design criteria such as how much and how certain does market information need to be; and
- How to mix MBIs with other instruments, particularly with a focus on evolution to more efficient instruments in the future.

## References

- Coggan, A., Whitten, S.M., Langston 2005. *Nesting MBIs in current institutions and structures – can it be done and what are the implications?* Paper presented at the 49th Annual Conference of the Australian Agricultural and Resource Economics Society, Coffs Harbour 8-11 February 2005.
- Eigenraam, M., Strappazzon, L., Lansdell, N., Ha, A., Beverly, C. and Todd, J. 2006. *EcoTender: Auction for multiple environmental outcomes*, Report to the National Market Based Instruments Pilots Program, Department of Primary Industries, Victoria.
- Khan and Rana. 2005. *Biophysical modeling for linking farms with regional recharge targets, Tradeable recharge credits in Coleambally Irrigation Area*. CSIRO report to NAPSWQ.
- Madden, J. C. and Prathapar, S. A. (1999) *Net Recharge Management SWAGMAN Farm® - Concepts and Application to the Coleambally Irrigation Area*, Consultancy Report for Coleambally Irrigation. Consultancy Report 99-11, CSIRO Land and Water, Griffith.
- Murtough, G.; Aretino, B., and Matysek, A. 2002. *Creating Markets for Ecosystem Services*. Canberra: Productivity Commission Staff Research Paper, Ausinfo.
- NMBIPP 2004. 2004 *Managing our Natural Resources: Can Markets Help?*. National Action Plan for Salinity and Water Quality – National Market Based Instruments Pilots Program. Australian Federal Government. Canberra.
- Robinson D., Whitten S., Khan S., Collins D., and Ward J., (2005) *Economic impact of tradeable recharge credits and other net recharge abatement policies for the Coleambally Irrigation Area*. Report to the National Market Based Instruments Pilots Program, CSIRO & BDA Group.
- Shelton D., Langston A., and Whitten S.M., (2004) *Market Based Instruments – A rapid assessment technique for identifying the potential for MBI application*. A report for the RIRDC/Land & Water Australia/FWPRDC Joint Venture Agroforestry Program. CSIRO.
- Stoneham, G., Chaudhri, V., Ha, A. and Strappazzon, L., 2003. 'Auctions for conservation contracts: an empirical examination of Victoria's BushTender trial' *Australian Journal of Agriculture and Resource Economics*, 47:4, 477-500.
- Ward, J. (2005) *Tradeable Recharge Credits in Coleambally Irrigation Area: Laboratory Tests of Alternative Institutional Frameworks*, CSIRO Sustainable Ecosystems, Report to the National Market Based Instruments Pilots Program, CSIRO and BDA Group.
- Weitzman, M.L., 1974. 'Prices vs. Quantities', *Review of Economic Studies*, 41(4): 477-491.
- Whitten, S.M., Stoneham, G., Carter, M. (Eds.) 2004. *Market-based Tools for Environmental Management*, Proceedings of 6<sup>th</sup> Annual AARES Symposium, 2004, RIRDC, Canberra.
- Whitten S., and Shelton D., 2005. *MBI Implementation - An implementation plan for establishing an MBI in the Steep Hill Region of the Wimmera Catchment*. Report 2 of 2 to the Wimmera Catchment Management Authority, CSIRO Sustainable Ecosystems, Canberra.
- Whitten S., Khan S., Collins D., Robinson D., Ward J. and Rana, T., 2005. *Tradable recharge credits in Coleambally Irrigation Area: Experiences, lessons and findings*. Report to the National Market Based Instruments Pilots Program, CSIRO & BDA Group.
- Whitten, S.M. Coggan, A., Reeson, A., and Shelton, D. 2006. *Market Based Instruments: Applying MBIs in a regional context*, Draft report to JVAP / RIRDC, CSIRO Sustainable Ecosystems.