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# Metric Essentials

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## Purpose of the metric framework

The national market-based instruments Capacity Building Program has produced this metric framework to share information on the use of metrics in market-based instruments (MBIs). The framework aims to communicate current knowledge and recent experience in metric design and implementation, and recommend approaches to assist MBI practitioners access and use the knowledge of scientists and MBI design experts.

The framework defines metrics and their use in supporting MBIs, describes the essential elements of good metric design for MBIs, and indicates the types of metrics appropriate for different MBIs and natural resource management (NRM) issues. The framework recommends approaches to linking metric users to scientists and metric design experts. The framework is not intended as a 'recipe book', as designing an appropriate metric is a context-specific task which must take account of the policy objectives and operational environment of a program, the type of MBI being implemented, the availability of different sets of expertise and data, and historical, social and economic considerations.

Further advice and support on MBIs which have used different metrics can be found in the Designer Carrots MBI fact sheets and decision support tool on the [Designer carrots website](#) or by using the websites' [Little Orange Book](#) to contact an expert.

While this metric framework is focused on describing key elements of metric design for MBIs, it is important to point out that often a mix of policy instruments will be required to effectively manage a particular NRM issue. Metrics have many uses outside MBIs and can contribute to capacity building (education), priority setting in non-market-based projects, and monitoring and evaluation of both market and non-market-based instruments.

This document is structured to provide an overview of metrics and their use in MBIs followed by a framework for metric design for MBIs in NRM. A glossary of the more technical terms can be found on the [Designer Carrots website](#). Many of the ideas expressed in this document come from the work and experience of others. To improve the readability of the document and to synthesise ideas from many sources, individual source works are acknowledged and discussed in the accompanying literature summary. It is anticipated that this framework will be used in conjunction with the fact sheets, case studies, decision support tool and metric literature summary which have also been produced by this program. References to these and other support are made throughout the document.

## What is a metric?

*“When you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of the meagre and unsatisfactory kind.” — Lord Kelvin*

A metric is a purpose-specific expression of the quantity and/or quality of goods and services. By measuring and summarising a set of environmental goods and services into a standard metric, we can make comparisons between different sets of goods and services for ranking priorities or making investment decisions. Market-based instruments use metrics as a currency for what is being bought and sold in the market. Just as we can determine the dollar values of two bags of carrots of different quality or the dollar value of a bag of carrots compared to a bag of potatoes, we can use an appropriate biodiversity metric to estimate the potential change in biodiversity values resulting from different management activities for example, fencing grazing animals out of two different areas of native vegetation. Converting the information we have about natural resource goods or services into standard or comparable units of a metric allows us to make comparisons between different amounts, types and locations of goods and services, and their relative contributions to NRM outcomes.

The metric used in an MBI will be determined by the objectives of the MBI, the type of goods and services being measured, and the data available to construct the metric. A metric can be as simple as the number of hectares of native vegetation, or as complex as a mathematical model of multiple environmental outcomes from a set of management services.

A metric can be constructed from:

- existing data
- new measurements
- models
- expert knowledge
- community values, or
- a combination of any or all of the above.

Metrics are used in many ways to define and measure qualities and quantities of interest for the purpose of comparison between places or over time. Two metrics which may be familiar to users of this document are the Consumer Price Index (CPI) and the Dry Stock Equivalent (DSE) used to measure inflation and stock carrying capacity, respectively (see text boxes).

Metrics can be designed to describe a range of natural resource goods and services and are used in most MBIs. Metrics can take many forms and contain a range of attributes.

Market-based instruments (MBIs) are policy tools that encourage behavioural change through market signals rather than through explicit directives. There is a range of types of market-based instruments including market creation through cap-and-trade schemes, compliance offset schemes, subsidies and grants, accreditation systems, conservation tenders for stewardship payments, taxes and tax concessions, and environmental trusts.

**Consumer Price Index (CPI)** — The CPI is a metric for assessing overall inflation in the economy, which parts of the economy are contributing most to rises or falls in inflation, and price movements in different capital cities over time. The CPI is a measure of quarterly changes in the price of a 'basket' of goods and services which account for a high proportion of expenditure by the population. This 'basket' covers a wide range of goods and services including measures from: food, alcohol and tobacco, clothing and footwear, housing, household contents and services, health, transportation, communication, recreation, education, and financial and insurance services. The CPI measures, weights and combines information about the different components to produce a metric.

**Dry Stock Equivalent (DSE)** — The DSE is a metric for determining the carrying capacity or maximum stocking rate of grazing land for different types of stock (e.g. cattle, sheep, goats; or pregnant and lactating cows, calves, replacement females or bulls). The DSE is based on the feed requirements of the different types of animals compared with those of a 'standard' or 'benchmark' animal type (e.g. a 50 kg wether at maintenance). The DSE can be used to plan stocking rates and supplementary feeding, etc., but can also be used to determine value-for-money of pasture land for sale, rank different land purchase options or rank choices about which grazing animals to stock given market prices.

### **What does a metric do in supporting the implementation of MBIs?**

Achieving natural resource management outcomes usually requires a mix of policy instruments and MBIs are part of that mix. The effectiveness of different approaches and combinations of approaches should be considered before an MBI is adopted. For example, the effective implementation of an MBI may require supporting regulation and provision of extension and information. If an MBI is to be used it must be designed to make effective use of existing and past policy interventions.

An MBI can use a number of mechanisms to define and select the goods and services desired from the market. These include an assessment framework and selection (or exclusion) rules or criteria and trading rules which restrict trades leading to undesirable outcomes (e.g. problem hotspots, off-target impacts, perverse or inequitable outcomes). Metrics are one of the components of MBIs and are used to quantify the goods and services which are being sought and traded. For example, in a cap-and-trade mechanism for water the metric can be as simple as volume of water in megalitres. For a conservation tender or offset scheme the metric may combine attributes representing conservation significance and management services to determine the relative benefit of taking different actions in different parts of the landscape. The metric provides a relative measure of quantity and/or quality of alternative bundles of environmental services, which can be used to inform investment decisions.

Using a well-designed metric in an NRM MBI supports the:

- measurement of indicators of relative or absolute change
- management of risk (due to scientific uncertainty)
- definition and measurement of (some of) the rights which form the basis of contracts
- allocation of scarce funds between alternative uses
- evaluation of NRM outcomes.

A well-designed metric used in an MBI can also:

- encourage focus on clear, defined objectives
- ensure that all participants in the 'market' are treated with a level of objective fairness based on a previously agreed set of criteria for valuing goods and services (probity)
- facilitate the collection of data with potential for other uses in NRM capacity building, planning and evaluation
- improve natural resource management through knowledge and communication by creating evidence based management and
- incorporate community values, expert knowledge and biophysical data into NRM decision making
- support the setting, meeting and evaluation of regional targets.

Steps 1 and 2 of the decision support tool outline the key questions to be answered before selecting and designing an MBI. A number of these questions are also relevant to designing a metric to work in an MBI because the metric needs to be designed to support the MBI to achieve the policy and program objectives.

### What is measured by a metric?

Metrics support MBIs by defining and measuring the state and change in environmental goods and services. It is most desirable to measure the outcomes from NRM to design the metric to most closely reflect the cause and effect relationships from management and increase the effectiveness of the metric. Measuring potential outcomes also allows for greater flexibility in the approaches taken to achieve the natural resource condition change; land managers may change inputs or practices with consideration of the cost implications and outcome benefits for individual profitability and NRM. However, outcomes are not always known or easily measured (see figure 1) and it may be necessary to make assumptions about how activities lead to outcomes and measure the inputs or outputs as indirect measures of the outcomes (figure 1). Issues related to measuring change are discussed further in later sections of this document.

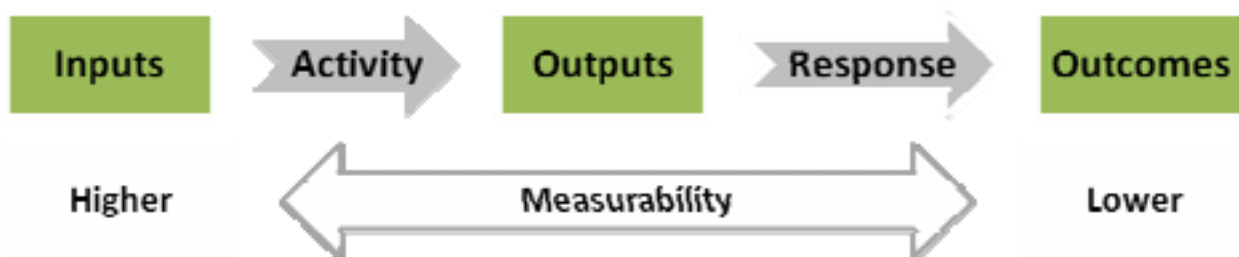


Figure 1. Cause and effect and measurability of change from NRM

### Other potential benefits of metrics

A well-designed metric which is cost-effective to measure can be used for purposes other than those described for MBIs. If the metric and its components describe the quantity and quality of goods and services, this information can be used to: focus capacity building programs; improve knowledge of natural resource condition and change; prioritise between the types and location of action in non-market-based incentive programs or even on publicly owned and managed land; and monitor natural resource condition changes and evaluate policies or intervention programs.

For example, a metric designed for use in a conservation tender could be used to prioritise sites for:

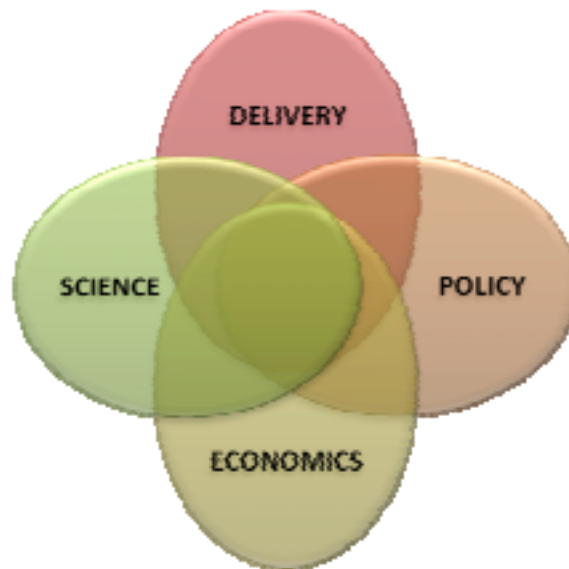
- targeted land-manager awareness, education or skill development programs
- preparation of management plans
- implementing a comprehensive monitoring program
- evaluating a past incentive scheme (compared to unfunded control sites)
- building and reporting on the knowledge base of natural resource distribution and status
- a fixed-price incentive payments scheme.

### **What are the essential elements of good metric design to effectively support MBIs?**

A metric must be appropriate for the purpose, place, scale and time of use. Some existing metrics may be modified for use in new projects or locations dealing with similar NRM issues, while other circumstances will require that a new metric be developed. To effectively support an MBI a metric needs to:

- focus on program objectives and priorities
- combine quality and quantity assessments of ecosystem services where appropriate
- provide an objective, reliable and repeatable measure of goods and services
- be simple to understand and explain to participants, and transparent enough to demonstrate fair decision making
- enable manageable calculation of net change or outcomes
- ensure design and implementation are cost-effective
- allow comparisons and discrimination between a range of realistic scenarios or groups of goods and services
- be defensible if data is limited or uncertainty high
- consider the reversibility of impacts, side effects, market interactions and chance of success
- take into account trigger thresholds or synergies that would have a major impact on the desired outcomes
- consider time lags for outcomes to be realised
- be clear about what it does not measure.

To develop a metric with these characteristics it is necessary to draw on expertise from a range of intersecting disciplines including policy and planning, economics, science and the delivery team (figure 2). The community representing users of the ecosystem services being sought should also be consulted to ensure the MBI is appropriate and the metric captures the full suite of potential values.



**Figure 2. Metric design is a multi-disciplinary activity which incorporates objectives, knowledge and skill from policy, economics, science and the MBI delivery**

### **Focus on program objectives and priorities**

Metrics should be designed to support the achievement of the objectives of the policy and program. Metrics can be designed to incorporate and weight criteria with respect to priorities, or the metric may be relatively simple and the MBI designed with decision criteria about preferences and priorities for NRM outcomes. The metric should work as part of the MBI to achieve overall objectives and avoid perverse outcomes. A program designed to reduce nutrient run-off from land used for cropping can incorporate decision criteria in the MBI design or directly in the metric by appropriately weighting indicators of reduced nutrient loss related to management practice change. The program may not want to encourage broadscale land-use change and should ensure the metric and MBI designs do not promote this type of perverse outcome. This will require an adequate regulatory framework underpinning the MBI, appropriate rules in the MBI, and weighting in the metric to prevent or deter undesirable outcomes. A good understanding of the market and market behaviour will also assist the prevention of perverse outcomes.

If the program aims to achieve multiple NRM outcomes (e.g. water quality and biodiversity conservation) the MBI needs to be designed with this focus. One way to do this is to develop a metric which measures and combines attributes from the multiple natural resource outcomes sought.

### **Combine quality and quantity assessments where appropriate**

Simple quantity metrics may be appropriate for MBIs such as water cap-and-trade schemes. A conservation auction or offset scheme may be interested in the extent, type, condition and conservation significance of vegetation or other biodiversity indicators. Indicators that accurately represent the 'quality' of vegetation are incorporated and usually multiplied by some function of the change due to management and the spatial extent of management to produce the metric.

The spatial arrangement of goods and services in the landscape is an important component of quality and has an influence on their value in the market. The location where NRM outcomes are achieved will have different benefits in terms of ecosystem

services provided. Metric design should account for the location of goods and services to ensure appropriate benefits are attributed where: a biophysical threshold is reached or impacted (more benefit may be gained in some locations); the ecosystem service benefits are remote from the site of action and the path between action and impact is important, and; some groups of goods and services provide greater benefits if other groups are also in the market (e.g. if neighbours both protect and manage adjacent lots of native vegetation).

### **Provide an objective, reliable and repeatable measure of goods and services**

When goods and services are traded through an MBI, both the buyer and seller are interested in how observable the changed management and/or outcomes are. The quantity and quality of natural resources are usually variable in space and time and measurement needs to account for this variability. A metric designed to measure the quantity and/or quality of a natural resource or likely changes from management needs to be reliable and repeatable enough to detect expected or important changes despite the variability. To do this we must use objective measures of the indicators in the metric and have reasonable confidence of the accuracy and precision of our measurement. If our measurement methods are subject to error or dispute we may not be able to verify the quality of goods and services; select between alternative offers in the market; provide confidence to market participants that the MBI is fair or that the environmental assets described by the metric will hold their value; or observe (measure) outcomes even if they occur.

Metrics often need to: use available data even when it is limited; collect data on surrogates when direct measurements are impossible or too costly; weight different attributes according to priorities and best available knowledge of the system; and estimate the outcomes from practice change even when empirical data are lacking or limited. If we are clear about our process and invest wisely in new data collection we can overcome many of these constraints. For the rest we need to tailor the metric to ensure it is defensible.

Metrics should be designed to allow for improvement when new information, scientific understanding or analysis techniques become available. This can be facilitated if metrics are constructed as small modular units which can be upgraded without the need to overhaul the entire metric or MBI design. A good example of this is the Victorian EcoTender metric which has four component metrics for change in four environmental services. If one of the component metrics is improved with new information or science, it can be substituted for the old component metric without disturbing the other component metrics.

### **Defensible if data is limited or uncertainty high**

The task of designing a metric is made more difficult when data are limited or there is high uncertainty about the appropriateness of surrogates or the causal relationships between management actions and natural resource outcomes. There may also be uncertainties from external factors such as climate variability, commodity prices and farm profitability, or even labour markets and the availability of labour or technical assistance. Designing a metric is an exercise in producing the 'best' metric for the MBI being used, though it may not be 'perfect', or perfectly technically or scientifically robust. The use of an MBI (and its associated metric) is a choice between policy instruments

(e.g. regulation, information provision), all of which have imperfections and may have inefficiencies and uncertainties which are not explicit.

Some remedy to the problem of producing a good metric when information is inadequate can be found by reducing uncertainty through appropriate use of [expert knowledge](#), data analysis and modelling. Collection of new data may be required to support the design of a new metric and opportunities may be available to collect data with uses in other programs and purposes. Data collection can be one of the most expensive components of metric design and use and decisions about the type of data necessary should consider the likelihood of new data reducing uncertainty to an acceptable level.

Other solutions include modifying a metric which has been developed and tested in a data-rich environment, reduce the relative weighting of metric attributes with high uncertainty, or seek cheaper surrogates to measure and thereby trade off some metric fidelity for greater certainty.

### **Be simple to understand and explain to applicants and transparent enough to allow fairness**

To provide guidance and confidence to participants in an MBI it is necessary to be able to explain what the program aims to achieve, what is preferred and what the priorities are. If a metric is complex it may make communication more difficult. The aim is to ensure the metric is easily communicated by keeping it simple (without limiting their power to evaluate goods and services and discriminate between offers in the market) and/or concentrating on communicating how different environmental goods and services are included in the metric. If the metric is complex it should still be possible to explain the components of the metric and the relative contribution of each component.

Metrics do not need to be completely transparent to all stakeholders; there is some evidence that revealing all information about how the metric scores and weighs attributes may reduce the cost-effectiveness and efficiency of an MBI program. However, participants in the program have a right to expect that their goods and services will be fairly appraised and that they are not unfairly disadvantaged in the market.

Communications about the metric and how it works should be informed by program objectives, the design of the MBI and metric, and a good understanding of the market.

### **Enable manageable calculation of net change or outcomes**

MBIs for NRM are interested in maintaining and/or improving the extent and/or condition of natural resources by encouraging appropriate management actions. These mechanisms evaluate the expected gain in quantity and/or quality of the resource and ascribe greater benefit to greater gain. The metrics used to do this usually include a component of current benefit or significance of the natural resource goods and services (the baseline), ensuring that value is determined based on the relative change from this position (maintaining or improving the quantity or quality of goods and services). To calculate net change or outcomes from management actions we need to calculate the likely outcomes from different suites and combinations of eligible actions and attach weights to these outcomes.

We calculate outcomes from management actions by analysing or modelling existing data, drawing on expert knowledge and opinion, and by collecting new data to demonstrate the causal links between [actions and outcomes](#). When metrics are complex or rely on complex models, we need to test the metric for sensitivity to different values for the attributes included. This can be done by using computer-sensitivity analysis or by testing a number of realistic scenarios and seeing how the results match our expectations. If computational requirements or expertise are significant for the metric, capacity should be available to test and use the model when required.

When metrics predict the outcome from management actions it is difficult to design contracts for the delivery of the goods and services because certainty and observability may be low. Outcomes may also not be evident within the timeframe for the program. These issues mean that we may not be able to contract market participants to outcomes (e.g. recharge reduction) but may use outputs (e.g. area fenced, percentage of groundcover maintained) instead. Expected outcomes used to construct the metric for change need to strongly reflect the outputs used for contracts. In this way contracts will be fair, protected from dispute and enforceable.

### **Ensure design and implementation are cost-effective**

The costs associated with metric design and implementation can account for a large proportion of the program costs for an MBI. These costs are incurred from: data collection (including expert input), analysis and modelling to parameterise the metric; data collection and management to populate the metric during implementation; and metric use. While it is desirable to have low costs for these activities, it is more important for the implementation to be cost-effective, that is low cost relative to the scale and budget of the program and relative to alternate approaches (i.e. non-MBI approaches such as regulation or extension). The costs of metric design and implementation may be justified if subsequent programs will use the metric and operate more cost-effectively as a consequence of the earlier work. Where metric development costs include the cost of additional data collection, there may be additional benefits for other planning and action programs.

Costs can be minimised by: using an [existing appropriate metric](#) including training and other supporting materials; minimising field data collection or designing data collection protocols which can be rapidly and cost-effectively applied by people with a wide range of NRM expertise; adapting existing data management systems and databases; and making decisions about the level and detail of data required to achieve an objective, reliable and repeatable metric.

### **Allow comparisons and discrimination between a range of realistic scenarios or groups of goods and services**

When a metric is calculated for different goods and services it is desirable that different groups of goods and services should be able to be discriminated. Different suites and combinations of goods and services may achieve the same metric scores if they represent the same level of overall outcome. If the outcomes are different, the metric should be sensitive enough to detect the difference. Sensitivity can be tested by repeated calculation of metrics with different combinations of scores for the different components of the metric. This can be done using sensitivity-analysis software tools which allow many calculations of many combinations of the different attribute scores. Sensitivity analysis can also be done by describing scenarios that should produce similar scores or very different scores and calculating the metric scores. In this way the

metric calculations can be examined against an intuitive understanding of the priorities and weights.

A useful exercise is to consider two participants in the market (perhaps neighbours) who have almost the same goods and services to offer but perhaps with small differences. The metric scores should be quite similar and make some intuitive sense as to which participant offers the higher benefit. Sensitivity analysis effectively tests hundreds or thousands of scenarios like this and where the differences extend to their maxima.

### **Consider the reversibility of impacts, side effects, market interactions and chance of success**

The reversibility of impacts, potential for side effects and the chance of success are all related to the level of risk involved in achieving the desired outcomes from an MBI program, without associated perverse outcomes. Risk can be considered the product of the likelihood of something happening and the consequence if it happens. Events with high likelihood and/or significant consequence are considered to be high risk. For example, if a species is threatened with imminent extinction, it is probably a riskier strategy to undertake a revegetation program for habitat restoration than to translocate some of the species to more secure habitat or start a captive breeding program. MBIs are not the solution to all problems and should take account of the likelihood of success from the actions implemented. Some metrics have been specifically designed using a risk-analysis framework.

A risk of negative side effects may occur, for example if the metric focuses on achieving gains from a limited set of ecosystem services, which in themselves may cause other natural resources to be impacted. For example, an MBI which promotes revegetation and alters catchment hydrology may compromise the ecosystem services provided by catchment flows. More recently, metrics and MBIs have been considering a broader range of ecosystem services and using multi-metrics to incorporate scores for the range of services of interest.

An MBI may seek to value and purchase environmental benefits for which there are already whole or partial markets. MBIs focused on revegetation and habitat restoration will lead to sequestered carbon, an environmental service for which there is emerging markets. Metric design should take account of whether components of the goods and services are already valued in existing markets and how the MBI interacts with those markets to maximise the benefits.

### **Take into account trigger thresholds or synergies that would have a major impact on the desired outcomes**

Ecosystem services and the ecosystems which provide them do not always operate in continuous or linear ways. For example, a stream needs a certain amount of flow before all the pools will be joined up. Once the 'threshold' flow is reached, a whole suite of ecosystem services are produced which were not being produced before; for example fish populations can mix and breed, waterborne seeds can be dispersed, and billabongs can be flushed with fresher water.

An MBI can be designed to take account of known thresholds and optimise the benefit from them (or avoid them if they are negative). This can be achieved by creating an assessment framework or rules in the MBI which account for trigger values or thresholds. Alternatively, an MBI can use the components of a metric in a dynamic

interaction with the market to benefit from thresholds through 'complementarity'. Complementarity describes the interdependencies between the groups of goods and services available, that is the value of a group of goods and services may depend on which other groups of goods and services are available in the market. In practice this means that funding one project in an MBI changes the relative value of other projects. As groups of goods and services are taken out of the market, the value of other groups changes and the weighting of attributes in the metric may change to reflect this. A number of MBIs have incorporated complementarity. For example, an MBI focussed on maintaining and improving the ecosystem services from intact native vegetation may include an attribute for location of sites with respect to other native vegetation (some measure of landscape context). The benefit of investing in managing a site near to other patches of native vegetation may be considered higher than investing in isolated patches. However, the benefit of investing in a managed site may be even greater if it is near other managed sites (management funded by the MBI program). The landscape context score for a site may depend on which other nearby sites are being funded. There is complementarity between the sites and a fixed value in the metric for landscape context would not recognise benefits which depend on prior selection of other sites for funding.

### **Consider time lags for outcomes to be realised**

Timing of outcomes from a program has an influence on metric design because it affects prioritisation (earlier outcomes are usually preferred over later ones) and because it impacts on the design of contracts. There may be uncertainty about the timing of outcomes from management and some may be likely to be produced after the program or contract period has ended. For this reason, many metrics estimate the likely outcomes within the life of the program or a specified period after the program has officially ended, but contract on the basis of outputs. By contracting on the basis of outputs it is possible to have more certainty about progress in the program implementation but perhaps less certainty about program achievements. Contracting for outputs requires the development of strong causal relationships between outputs and outcomes.

### **Be clear about what it does not measure**

One way to look at what the metric does measure is to define what it cannot measure or should not be used to measure. Most metrics focus on a defined set of indicators to be measured and often measure surrogates for complex system characteristics (e.g. surrogates for species-level biodiversity status, which would be difficult and expensive to measure). A metric may not: measure the impact of management actions below a given spatial resolution; may not be appropriate for some sites; or may not measure attributes of interest even about a defined quality (e.g. metrics assessing vegetation condition sometimes include measures of tree habitat—hollows—and sometimes do not). If substantial investment is made in design and implementation of a metric there may be interest in using it for other purposes. An explanation of what the metric can and cannot be reliably used for can prevent misuse.

### **What a metric does not measure**

Gross Domestic Product (GDP) – The GDP is a metric used to measure the size of national economies. It is the sum of consumption, gross investment, government spending, and exports – imports. US Senator Robert Kennedy spoke about what such a metric does not measure:

“The gross national product includes air pollution and advertising for cigarettes and ambulances to clear our highways of carnage. It counts special locks for our doors and jails for the people who break them. GNP includes the destruction of the redwoods and the death of Lake Superior. It grows with the production of napalm, and missiles and nuclear warheads... it does not allow for the health of our families, the quality of their education, or the joy of their play. It is indifferent to the decency of our factories and the safety of our streets alike. It does not include the beauty of our poetry or the strength of our marriages, or the intelligence of our public debate or the integrity of our public officials. It measures everything, in short, except that which makes life worthwhile.”

### **How do metrics vary according to the type of MBI?**

Metrics define and measure goods and services and a given metric should be able to be used in a range of different MBIs. Once environmental benefits can be defined and measured in a metric, the metric should be able to be used in the most effective MBI available. However, different metrics for the same goods and services have been designed for use in individual projects, locations and MBIs because each project has a different starting point, different requirements for metric design and cost-effectiveness, and different theories of how actions link to outcomes. Some metrics have been used in more than one MBI type; for example, the Victorian BushBroker scheme (an offset credit scheme) uses a consistent assessment method for scoring vegetation quality and gain through management actions designed for the Victorian BushTender metric (a conservation tender). Other MBI projects have tried a number of different types of metrics to find the most suitable type. Table 1 shows the metric types typically used for different types of MBIs (Appendix 1 shows the metric type used for example MBIs).

Using the same metric for different MBIs has multiple benefits for cost-effectiveness and learning. Different MBIs using the same metric can be compared for cost-effectiveness (i.e. environmental benefit per dollar), leading to improved understanding of the market and subsequent improvement of the MBIs used.

**Table 1. Metric types commonly used by different types of MBI**

<b>MBI type</b>	<b>Metric type</b>	<b>Also been used for</b>
<b>Subsidy and grants schemes</b>	Quality and quantity Process models and risk analysis metrics have been trialled Metric on outcomes, contracts for outputs	Stewardship payments offsets
<b>Eco-labelling and accreditation systems</b>	Quality and quantity	
<b>Stewardship payments</b>	Quality and quantity	Subsidy and grant schemes Offsets
<b>Taxation and tax concessions</b>	Quantity	
<b>Offsets</b>	Quality and quantity Metrics using risk analysis could be developed Metric on outcomes, contracts for outputs	Stewardship payments Subsidy and grant schemes Trading schemes
<b>Trading schemes</b>	Quality and quantity	Offsets

### What metrics are applicable for particular NRM issues?

Many NRM issues have common characteristics though they may relate to different natural resource problems. Common characteristics include:

- allocation of a limited resource or defined impact on a resource (e.g. cap-and-trade for water or salinity credits)
- promotion of changed management or land use (e.g. conservation, pollution or recharge tender schemes).

The components (attributes) of metrics may be different for different NRM issues but the metric type and logic may be similar. (Appendix 1 shows the metric type used for some example NRM issues.) One of the ways that metrics have been designed for different NRM issues is the conversion of some NRM issues into a 'point source' problem. This is particularly useful when the impact of land management practice occurs at some distance from the site (e.g. impact of sugar cane farming on the quality of the Great Barrier Reef). By taking the sum of the change in land management for a site and treating it as though it was a point source, metrics available for point-source problems can be used in an MBI.

### Using or adapting an existing metric

An existing metric may have much to recommend it, not least of which is the thought and expense that has already gone into developing and testing it. There may also be requirements or standards for using a metric for projects within an NRM body, jurisdiction or state. The benefits from consistency should not be underestimated and existing standards and jurisdictional requirements should be examined before deciding to design a new metric or substantially adapt an existing one. As more metrics are developed, tested and documented, it will be easier to evaluate existing metrics for suitability for new programs or use in new locations. There are some advantages and disadvantages to consider when reviewing existing metrics for modification and use (see table 2).



**Table 2. Advantages and disadvantages of using or modifying an existing metric**

Advantages	Disadvantages
Quick solution (modification times are much shorter than the time required to develop a new metric)	Risk of the metric not fitting the policy or program objectives
Cheapest or most cost-effective option	Some attributes specific or unique to the system may not be included or optimised in the metric
May be already known and understood by key stakeholders and program staff	May not take advantage of best available information and practice for the new system
May be appropriate for use in other MBI-types and programs	May not have been built for easy use outside the original institutional framework (e.g. made for state government employees with access to specific equipment, data or information systems)
Many design and operational problems have already been tested or solved—there may be an existing program for ongoing improvement	Not all datasets may be available in the new area or at the scale used in the original location
Auxiliary materials may be available for data management, communication, training, implementation, etc. (improving cost-effectiveness and time to implementation)	May not have the value-added potential the program wants (e.g. may not be designed for ongoing monitoring)
An opportunity to further test and improve the metric for use in different locations and by different managing authorities	May reduce local innovation

The following questions are recommended when reviewing an existing metric for use in a different MBI project or location.

- Is the metric design consistent with the objectives of the new program?
- Are their jurisdictional requirements or standards which direct the choice of metric?
- Are there any operational constraints to adoption of the metric (e.g. intellectual property rights, copyright, metric support requirements or data management platform limitations)?
- Can attributes specific or unique to the new program or use be included (substituted or added) in the existing metric?
- Can attribute weightings be adjusted to meet the objectives of the new program?
- Can new inputs or management actions be incorporated into the metric if required?
- Are any methods used to predict change appropriate for the new program?
- Is data available at an appropriate scale to calibrate and populate the metric for the new program, use or location?
- Will adoption of the metric assist similar projects or adjacent regions to develop cost-effective metrics and/or MBIs?
- Can any data collected for the metric be used to improve the metric and/or value-add to the program (e.g. new data on species distributions, report on current habitat condition, form a baseline for monitoring)?
- Are the modifications required for the metric to meet the program requirements a cost-effective alternative to constructing a new metric?

### What science is needed to underpin a good metric?

A good metric combines policy, economic, operational and scientific considerations to support the MBI project. The scientific considerations are discussed here to frame



metric design as a deliberate and systematic process of building on a defensible logic and the analysis of an evidence base to produce a testable tool for measuring goods and services. A scientific approach supports the objective of producing an evidence-based, repeatable and defensible metric. There are six elements in metric design and use which require a scientific approach and support from scientific investigation. The overall design of the metric should be governed by the policy and program objectives and any operational constraints.

<b>Metric logic</b>	The logic around which the metric is constructed. It includes the conceptual framework used to describe the goods and services, assumptions behind construction, and the way components are combined
<b>Metric attributes</b>	The attributes of the goods and outcomes from management which are measured to arrive at a value for change or outcome
<b>Metric evidence base</b>	The available theory, previous studies, data, models, expert knowledge and opinion which build the metric
<b>Metric validation</b>	Testing the useability, accuracy and sensitivity of the metric
<b>Metric use</b>	Implementing the metric in an MBI
<b>Metric documentation and communication</b>	Quality assurance of the metric development and use process and sharing of lessons learned and new tools

### Metric logic

Different MBIs have designed metrics with different logic or structure. The main metric types are quantity, quantity and quality, model (process model), and risk analysis. These metric types usually combine a measure of the current state of the resource and the expected change or outcome from the delivery of management services. Attributes have been combined in different ways with quality and quantity (sometimes a function of quantity e.g.  $\log_{10}(\text{area})$ ) almost always multiplied together, as increases in quality are calculated for each unit of natural resource good or service. The conceptual framework can be built on scientific theory, results from previous studies, analysis and modelling of existing and new data, multi-criteria analysis (MCA, a form of statistical analysis of the preferences and weightings of expert informants), expert knowledge, or a combination of all of these.

### Metric attributes

Metric attributes need to represent components of the goods and services being described. Attributes can range from simple measures (e.g. hectares of land) to complex surrogates for processes (e.g. extent of soil modification as an indicator of ecological resilience). The combination of attributes should be supported by scientific theory or previous research findings.

Selecting attributes can be achieved in numerous ways including:

- regression analysis—can predict how one response variable is predicted by other variables (possibly easier or cheaper to collect)
- pattern-based methods—can compare a selection of sites with different attributes and calculate a score representing the ‘difference’ between the sites
- expert opinion—can be gathered informally through discussion and workshops or brought together through processes such as a Delphi technique (structured group communication) and followed by MCA (e.g. analytical hierarchy process, or AHP, a form of MCA used to arrive at weightings).



Attributes will usually be calculated for existing goods and services and change or outcomes. Each attribute can be assigned a maximum and minimum to represent the meaningful range of possible values. Depending on the logic and attributes a metric can use:

- raw attribute values
- values transformed to a standard distribution (e.g. between 0 and 1)
- benchmark values to rate new values against an agreed standard.
- continuous or categorical values
- weighted or unweighted values.

### **Metric evidence base**

Evidence to test and compare attributes may come from theory, previous studies, existing or especially collected data, dummy or simulated data generated for the purpose, or expert knowledge. Many metrics require some spatial data for attributes but site level data is also usually required as spatial datasets are commonly too coarse to be solely relied on at the property, paddock or site scale.

Where there are data gaps it may be necessary to commission additional data collection, use expert panels to derive adequate surrogates or modify the metric logic to provide more representative measurement. Data will most often be lacking about the probability of achieving management benefits. Dedicated research programs may be required to develop or refine the accuracy and reliability of prediction over time. Implementation of a metric within an MBI is an opportunity for adaptive learning about the metric and instrument and future programs can benefit from some well-designed studies as part of implementation. A metric will only be as good as the data used in it and data gaps should be acknowledged and dealt with to avoid perverse outcomes.

To allow monitoring and enforcement of contracts, metrics and data used need to produce a sufficient indication of the outcome at the expected time to allow detection against background variation in the system. This problem is solved to some degree by designing contracts around outputs and not outcomes, but program evaluations will benefit from the use of metrics which have adequate 'power' (i.e. ability to detect a change when one occurs) to detect outcomes.

### **Metric validation**

Sensitivity analysis and scenario testing have already been discussed [above](#). The purpose of validation is to ensure that the metric accurately represents the goods and services (and property rights) of interest, is comprehensive of key components of the system, does not over or underweight important attributes and can effectively discriminate between alternative groups of goods and services. Validation also serves to test any field data collection protocols, data entry and management, and data retrieval and enquiry. Once tested, the metric should be ready to use.

### **Metric documentation and communication**

To assure quality in keeping information about the metric and to share learning, metric documentation should encompass:

- the final metric and its attributes
- rejected attributes and justifications
- data sources
- metric specifications, including specifications for data management, metadata for datasets used, specifications for data collection protocols

- process of metric development
- process of metric testing
- personnel involved in metric development, and
- lessons learned.

Communicating the metric and the process for developing the metric is a critical step in learning and sharing the learning. Writing and reporting on the process of development allows reflection on the challenges and limitations faced, especially if the process has occurred over an extended timeframe. Some of the excellent work of early metric designers has been critical to the ongoing [development and success of metrics and MBIs in Australia](#).

### Metric design guidelines

Metrics for use in MBIs are necessarily purpose-specific and universal rules for development are difficult to describe. The questions described in the following guidelines are provided as a guide to key issues in metric design and not as a substitute for rigorous discussion about the specifics of the best policy approach, MBI, or metric required for a given project. Working through the questions users should be able to document key issues for metric design and use, and develop or refine a plan for metric development.

#### Determine policy and program objectives

- What is the program context?
- What NRM issue(s) is being addressed?
- Are there known program risks?
- What are the program priorities?
- What is the timeframe for the program?
- What is the timeframe for metric development?
- How long until expected outcomes from the program will be realised?

#### Choose MBI type

Refer to the decision support tool

#### Develop metric logic

- Does the metric need to measure quantity and/or quality?
- Does the metric need to measure change due to management?
- Is the causal relationship between actions (inputs/outputs) and outcomes known and can it be measured?
- Does the spatial or temporal arrangement of goods and services in the landscape influence their value?
- Is the value of groups of goods and services dependent on the state of other groups?
- Should the metric be value-based or risk-based?
- Is the NRM issue a point-source (or can be expressed as a point-source) problem?
- Is area a factor (linear or non-linear factor)?
- Is there a suitable metric already available for modification?
- Will the metric be simple to understand and easy to explain





to the market?  
 What are the expected costs of developing and implementing the metric?  
 Are there any important risks to consider (e.g. irreversible impacts, side effects or market interactions)?



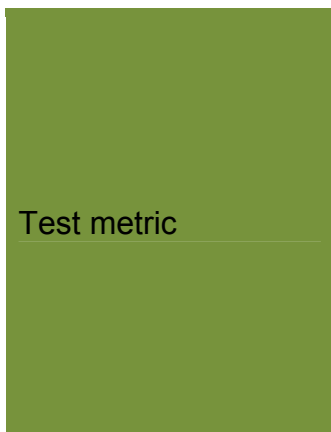
Develop metric attributes

Do previous studies of the natural resource goods and services exist?  
 Can existing data be analysed to develop attributes and a metric?  
 Are system models available?  
 Can expert knowledge be used to fill data gaps and refine attributes?  
 How will attributes be included and combined in the metric (raw values, categorical or continuous, benchmarked, transformed, weighted)?  
 Can attributes be measured accurately?  
 Are there trigger thresholds for key attributes or the processes they measure?  
 Is it clear what the metric is not measuring?



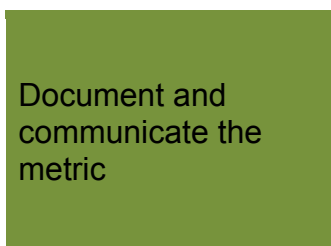
Develop metric evidence base

Are all key datasets available?  
 Does additional data need to be collected to develop the metric?  
 Can data to support the metric be collected as part of the MBI project?  
 Can expert knowledge be used to fill data gaps and refine the metric?  
 Are expected outcomes strongly linked to outputs?  
 Is the metric 'powerful' that is likely to detect important changes if they occur?



Test metric

Does the metric adequately represent all levels of goods and services of interest?  
 Does the metric reflect the tradeoffs of the different actions?  
 Has the metric been tested for sensitivity?  
 Have realistic scenarios been tested?  
 Are any attributes redundant or supporting data unreliable?  
 Can the metric be easily used and processing capability sufficient?  
 Are all data collection, entry, storage, management and retrieval systems working?



Document and communicate the metric

Has the metric and the metric-development process, including key lessons, data, meta-data and testing, been documented?  
 Has the metric and the metric development process been communicated (report, website, talks, academic articles, etc.)?



## What approaches are most useful to engage implementers, scientists and economic design experts in metric development?

Increasing experience and documentation of MBIs will help new players to access and understand the skills, resources and time required to adapt or develop an appropriate metric for a new MBI. Documentation of metrics, metric development processes and lessons learned will be critical to sharing experience and expertise.

Metric design need not be the exclusive territory of any group including scientists, economists, policy advisers, technical experts or community representatives. Metrics are designed to represent goods and services. How goods and services are represented and prioritised within a metric requires input from a range of sources. Equally, it is unlikely that only one expert from a discipline has complete and relevant knowledge for all metrics and locations, and discussion and inclusion of a group of experts may be beneficial. Access to appropriate expertise in MBI design and social, economic and scientific researchers can be difficult. It is desirable to not only use appropriate and local knowledge, but also to enlist help from other places and perspectives. This section provides recommendations on how to access, make links with and different experts for metric design, and involve experts in metric development.

### Access to expertise

Expertise in metric design may be found in Universities and research institutes, government and non-government organisations, private consulting firms and local NRM bodies and environment groups and businesses. The first step to finding the right people is to determine the skills and expertise required and then searching for it. Known experts may be able to recommend others, or likely places to look if they know the skills and experience you are seeking. It can help to involve people from a mix of organisations and discipline backgrounds to avoid 'group think', and to invite new people to participate from time to time to provide input from different perspectives, skills and theoretical backgrounds.

One place to start looking for experts is the [Designer Carrots website](#) which provides a place to network with MBI practitioners, designers, implementers and others with expertise in MBIs. The website hosts a 'Facebook'-style community of MBI practitioners and experts called the Little Orange Book. The Little Orange Book is an electronic forum for policy officers, regional NRM group staff, social and economic researchers, and other people who are interested in or working on market-based instruments for natural resource management. It promotes interaction with people interested in MBIs, and discussion and information sharing. The website also hosts discussion forums where users can post a question or share stories, access a library of MBI publications, and an events calendar where users can submit MBI-related events. Use of these resources will improve access to assist in linking different experts. Practitioners and experts may already have links with other people working in the area and may be able to enlist the help of other support.

Researchers with skills in the biophysical and social sciences used in metric and MBI design represent a key group of experts. Researchers may be interested in participating in the design phase of a metric or MBI if they see the opportunity for experimentation and ongoing study of the process. Appealing to the researcher's interest in experimentation and being prepared to engage in long-term learning about the metric may attract expertise to the project that would otherwise be difficult to find and engage.

### Working with experts

Most metrics described in the literature have been developed by project staff with input from expert panels via meetings and workshops. On a few occasions, analytical tools have been used to record and combine opinions and knowledge and subject it to statistical analysis. Other approaches have used Delphi techniques to generate potential metric attributes. With an appropriate list of experts, electronic mail can be used to receive contributions from experts to allow the program to access a large expertise set and minimise any time or practical constraints for experts to contribute (e.g. compared to face-to-face workshops). This approach can help overcome 'group think' in workshops.

Using experts to weight attributes in a metric is also useful. This can be done informally or using techniques such as MCA which enables the knowledge and opinions of experts to be statistically analysed to form an 'arithmetic consensus by contribution'. Studies have also highlighted that experts have biases and knowledge gaps (not necessarily opinion gaps). It can be useful to use processes which minimise or at least recognise the bias of expert input.

## Appendix 1. Metric descriptions from example MBIs

NRM issue	Program using metric	NRM objective	Used in MBI type	Metric components	Data sources	Metric type
Biodiversity conservation	BushTender (Vic)	Conserve remnant native vegetation	Price-discriminating auction (single sealed bid)	Species conservation status Vegetation type conservation status Vegetation/site condition (benchmarked) Landscape preference Habitat improvement	Desktop (inc. spatial) Field	Quantity /Quality
Biodiversity conservation	Landscape Linkage Pilot Program – Desert Uplands (Qld)	Conserve remnant native vegetation – vegetation corridor	Price-discriminating auction (multiple sealed bid)	Landscape linkage Species conservation status Ecosystem conservation status & diversity Vegetation/site condition (habitat improvement is a requirement – not scored in the metric)	Desktop (inc. spatial) Field	Quantity /Quality
Biodiversity conservation	Biodiversity Benefits Index (part of Environmental Services Scheme, NSW)	Conserve remnant native vegetation	Price-discriminating auction	Initial and potential conservation significance Initial and potential vegetation condition Landscape context	Desktop (inc. spatial) Field	Quantity /Quality
Biodiversity conservation	USE Dryland Salinity and Flood Management	Conserve remnant native vegetation	Offset and incentive scheme	Vegetation type conservation status	Desktop (inc.)	Quantity /Quality



NRM issue	Program using metric	NRM objective	Used in MBI type	Metric components	Data sources	Metric type
	<p>Program</p> <p>Levy/Biodiversity Offset and Stewardship Incentive Schemes (SA)</p>			<p>Vegetation/site condition (benchmarked)</p> <p>Landscape context</p>	<p>spatial)</p> <p>Field</p>	
Biodiversity and riparian values conservation	Catchment Care Auction (SA)	Protect remnant vegetation, stream geomorphology and catchment hydrology	Price-discriminating auction (single sealed bid)	Geomorphology, hydrology and vegetation value and threat (includes vegetation conservation status, condition and landscape context)	<p>Desktop (inc. spatial)</p> <p>Field</p>	Risk analysis
Biodiversity conservation and water quality	Auction for Landscape Recovery (WA)	Conserve remnant native vegetation and improve water quality	Price-discriminating auction (single sealed bid)	<p>Vegetation/site condition Vegetation complexity Landscape context</p> <p>Conservation significance</p> <p>Salt, water and soil management benefits</p>	<p>Desktop (inc. spatial)</p> <p>Field</p>	Quantity /Quality
Water quality	A water quality metric for the Great Barrier Reef Catchments	Improve water quality, reduce marine impacts	N/A	<p>Practice load reduction</p> <p>Success factors</p> <p>Landscape factor</p> <p>Delivery ratio</p> <p>Receiving environment sensitivity</p>	<p>Desktop (inc. spatial) Model</p>	Quantity /Quality
Multiple (land, water, carbon and biodiversity)	Eco Tender (Vic)	Carbon sequestration Terrestrial biodiversity	Price discriminating auction (single)	Terrestrial biodiversity significance and change, Aquatic function change, Saline land area change and significance, and carbon sequestration amount	Desktop inc.	Quality/Quantity



NRM issue	Program using metric	NRM objective	Used in MBI type	Metric components	Data sources (spatial)	Metric type
		conservation Aquatic function protection Saline land reduction	sealed bid)		Field Model	
Soil salinity	Tradable Recharge credits in Coleambally Irrigation Area (NSW)	Limit net recharge to sustainable levels	Cap-and-trade	Paddock-scale net recharge model	Desktop	Quantity
River salinity	Dryland Salinity Credit Trade (Vic)	Reduce deep recharge	Credit trading	Percent and type of groundcover	Model	Quantity

