Practical and Theoretical Underpinnings of INFFER (Investment Framework For Environmental Resources)

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INFFER (Investment Framework For Environmental Resources): Practical and Theoretical Underpinnings

Abstract

INFFER (Investment Framework for Environmental Resources) was developed to help investors of public funds to improve the delivery of outcomes from environmental programs. It assists environmental managers to design projects, to select delivery mechanisms, and to rank competing projects on the basis of benefits and costs. The design of INFFER and the activities of the INFFER projects are based on extensive experience of working with environmental managers and policy makers. This experience has highlighted a number of important practical lessons, that have strongly influenced the design and implementation of INFFER. These lessons include the need for simplicity, training and support of users, trusting relationships with users, transparency, flexibility, compatibility with the needs and contexts of users, and supportive institutional arrangements. In additions, the developers have paid close attention to the need for processes that are theoretically rigorous, resulting in a tool that deals appropriately and consistently with projects for different assets types, of different scales and durations, consistent with Benefit: Cost Analysis. The paper outlines theoretical considerations underpinning the way that INFFER deals with asset valuation, time lags, uncertainty, and the design of the metric used to rank projects.

Introduction

In common with other developed countries, Australia has invested billions of dollars of public funds in projects intended to improve the condition of natural resources and the environment. However, there have been criticisms of the performance of these investments, including for their poor delivery of environmental outcomes (Auditor General, 2008; Pannell and Roberts, 2010). Reasons for this poor performance include: a tendency in some programs to distribute funds in an untargeted, unprioritised way; poor selection of priorities; poor design of projects, including poor selection of delivery mechanisms; failure to conduct feasibility analysis of projects; and poor monitoring and evaluation resulting in a failure to learn from past programs.

INFFER (Investment Framework for Environmental Resources) (Pannell et al., 2009) was developed in an attempt to help investors to improve the delivery of outcomes from these programs. It is a tool that allows users to prioritise among competing projects based on the benefits and costs of each project. It also assists with the development and design of projects, and with the selection of delivery mechanisms. It is designed to maximise the learning from experience that should occur in these programs.

In the development of INFFER we paid close attention to two crucial issues: (a) its usability, acceptability and usefulness to users, and (b) its theoretical rigour. This paper provides an outline of how and why we designed INFFER in the way we did, covering both practical and theoretical aspects.

Practical underpinnings of INFFER

Experience informing the design

INFFER is strongly founded on a practical understanding of the decision making environment for environmental managers. Prior to commencing the development of INFFER, the project team had substantial relevant experience to draw on. This experience included:

- Initiation and co-development of the Salinity Investment Framework (SIF1 and SIF2) in Western Australia. Participation in, or observation of, piloting of SIF1 with a regional natural resource management (NRM) body and piloting of SIF1 and SIF2 with three state government agencies (McAlinden et al., 2003; Sparks et al., 2006; Cleland, 2008).

- Development of Salinity Investment Framework III (SIF3) (Ridley and Pannell, 2005). Detailed piloting of SIF3 with two regional NRM bodies, one in Western Australia and one in Victoria (Roberts and Pannell, 2009; Pannell et al., 2008).

- Field tours with regional and state agency staff in the two pilot regions.

- Extensive engagement with government agencies involved in management of the environment and natural resources in four states and nationally (Pannell and Roberts, 2009).

- Good knowledge of decision processes at regional, state and national levels, including as employees of regional and state organisations. Good knowledge of policy processes in governments (Pannell, 2005).

- A survey of 17 regional NRM bodies, to understand their skills and capacities and areas of weakness (Seymour et al., 2009).

- Research into the adoption of conservation practices by rural landholders (Pannell et al., 2006).

- Research into lifestyle landholders and their responses to environmental projects (Pannell and Wilkinson, 2009).

- Development of a simple framework to select policy mechanisms for a project based on the public and private benefits that it generates (Pannell, 2008). This framework was embedded directly in INFFER.

In addition, since development of the first version of INFFER was completed in early 2008, it has been extensively modified in response to feedback from users and stakeholders. Experiences in applying INFFER that have contributed to its ongoing improvement include:

- Trialling of INFFER by 19 regional NRM bodies and several Landcare networks, including intensive engagement with the INFFER team. Most of these regions have undergone a training program in the use of INFFER, led by members of the INFFER team.

- Full adoption of INFFER by two regional NRM regions.

- Training of officers from five state agencies in two states.
- Application of INFFER to real-world problems by the INFFER team itself (e.g. the Gippsland Lakes in Victoria).
- Application of INFFER by consultants in four states (Western Australia, Victoria, Queensland and New South Wales).

Lessons learnt

The practical experiences, engagement and research outlined above revealed a large number of lessons relevant to the design of INFFER. For each set of lessons, some implications for INFFER are identified. INFFER has been designed to be consistent with all of these implications.

The first set of lessons related to the need for INFFER.

- Existing decision making about funding of environmental projects often does not involve rigorous analysis of the relative merits of competing projects. There has been a tendency to shy away from targeting of investment to projects that are most likely to deliver valuable outcomes, preferring a philosophy of broad participation, despite the limited success of that approach. The philosophy is based in part on a view that distributing environmental funding broadly is more equitable than targeting it to high-priority projects.
- Attempts to use analysis to prioritise projects have usually considered only a sub-set of the relevant information, often a small subset, and have usually not integrated the information appropriately. These weaknesses in the analysis substantially reduce its value (Pannell, 2009b).
- Many existing projects (and most projects in some programs) have employed inappropriate policy mechanisms to encourage change (e.g. Pannell and Roberts, 2010).
- The definitions of most existing environmental projects are internally inconsistent, in the sense that the planned interventions will not deliver the intended on-ground change, or the intended on-ground works are not sufficient to deliver the projects' goals, or the interventions will cost more than budgeted for, or will require ongoing funding that is not identified.

Implications: INFFER has been designed to consider and integrate all relevant information in a way that accurately indicates the relative merits of different projects. INFFER also includes guidance on the appropriate choice of policy mechanisms and includes checks on the internal consistency of projects.

The next set of lessons relate to the skills, capacities, resources and perceptions of environmental managers.

- In many environmental management bodies, there is a lack of capacity to formally integrate disparate technical and socio-economic information for decision making. Such integration as does occur is informal, and often weak. Participants are used to simplistic decision processes and can feel that a systematic, comprehensive process is unnecessarily difficult and time consuming. They are generally unaware of the very great difference to outcomes that can be made by the quality of the decision process, the choice of policy mechanisms and the project design.

- There is a lack of expertise in economics in many environmental management bodies.

- Despite the lack of analysis supporting project prioritisation, many stakeholders hold strong preconceptions about the types of projects that should be supported. If INFFER shows that a currently funded project is not likely to generate substantial benefits, there is a tendency for some stakeholders to resist the information and attribute the result to a weakness in INFFER.

- Currently, even where analyses of projects are conducted, they are almost always limited to desktop assessments drawing in existing data and opinions. Proper feasibility assessments would include targeted new data collection to confirm the merits of a favourably assessed project before finally committing to major funding. This approach is common in the private sectors, but is almost completely unheard of in environmental programs.

- There is a lack of knowledge among environmental management bodies of how to use monitoring to support learning and inform adaptive management. Most monitoring serves only reporting purposes.

- It is very common for people to misinterpret and/or misunderstand elements of the INFFER process, often leading to unfounded criticisms. It is striking that many of the people who make such criticisms have not actually read any of the documents that explain the basis of INFFER, all of which are freely available on the project web site, and a number of which are very short.

- Sometimes people claim that there is nothing new in INFFER – that they are already using an equivalent process. In all cases we have examined to date, this is far from correct. Usually, their process involves a small subset of the INFFER process.

- There are many other decision tools available that are potentially relevant to environmental managers. This sometimes causes confusion and uncertainty among managers about the relationship between INFFER and these other tools, and concerns about potential overlap.

Implications: INFFER has been designed to be as simple as possible without overly compromising its rigour and comprehensiveness. There is inevitably a trade-off between these elements. There is a need for strong training and support for INFFER users. It is clear that most users will not apply the tool well if left to learn about it from written material alone. Nevertheless, comprehensive written documentation is essential to support the trainers, to demonstrate the transparency of the approach, to support the learning of those users who do prefer to learn by reading, and to disarm critics. The risk of misunderstanding points to the need for good written responses to a set of Frequently Asked Questions. The INFFER team strives to establish a strong trusting relationship with users and to clarify the limits of INFFER: what sorts of project is it suitable or unsuitable for analysing. Where possible we also provide clarity about the relationship between INFFER and other tools that environmental managers may be using or may be exposed to. For selected projects that appear to have strong prospects based on desktop analysis, INFFER encourages the use of full feasibility assessments as the first phase of project delivery. Use of INFFER should assist managers to undertake monitoring that supports adaptive management by clarifying targets and actions that should be monitored.

The third set of lessons relate to the paradigm within which environmental managers make their decisions about project design and prioritisation.

- Related to the lack of economics expertise noted above, some employees and stakeholders hold antagonistic views towards economics, reducing the prospects for acceptance of more rigorous, systematic analysis.

- Among some participants in the environmental management process, there are problematic attitudes about the achievement of environmental outcomes by environmental projects. The Landcare program and some of its successors have apparently trained people to value participation in environmental programs by landholders for its own sake, irrespective of whether it contributes to environmental outcomes. Many respondents to a survey of prospective INFFER users did not support a strong focus on the achievement of outcomes in environmental decision processes (Marsh et al., 2010).

- Related to the previous point, some stakeholders are resistant to the idea of targeting funds to projects that are most likely to generate the largest net benefits. They prefer funds to be widely and thinly distributed to maximise participation.

- Some participants are strongly resistant to the idea of estimating the relative values of different environmental assets. They prefer to feel that all environmental assets are important, and all should be protected. Some particularly dislike the concept of non-market valuation. Even a softer approach, based on a scoring system, still makes many uncomfortable. Some express concerns about the subjective nature of any scoring system used to value environmental assets, failing to recognise that this already occurs implicitly. At the government level, we have observed at least one case where there was opposition to inclusion of environmental asset values in the decision process, in order to avoid political sensitivities and the risk of controversy.

Implications: These lessons reinforce the need for good training and support, and for developing a strong, trusting relationship with users. They show that, in part, adoption of INFFER will need to be accompanied by cultural change. This is very difficult to achieve, and will require supportive institutional changes. The antagonistic position adopted by some stakeholders increases the need for INFFER to be seen to be theoretically sound and rigorous, and for it to use a transparent and open process, in which implicit assumptions are made explicit. The INFFER team tries to respond constructively and convincingly to antagonistic criticisms.

The last set of lessons relates to the institutional context within which decisions about project design and priorities are made.

- Environmental managers often have to develop projects or plans quickly, often much too quickly to do the job properly. Although it is predictable that plans and projects will need to be developed to meet future deadlines, it rarely happens before those deadlines are looming, due to the multitude of other demands on people's time. Even if time were not a pressing concern, the number of potential projects is so large that it is not feasible to do comprehensive assessments of every one. Indeed, in practice, only a small minority of projects can be fully assessed.

- Environmental managers often have little incentive to do a more rigorous, comprehensive assessment of investment priorities. If they make weak decisions, they face little or no penalty in the current institutional arrangements, which often discourage, rather than encourage, good decision processes.

- Environmental decision makers need to be able to compare projects of different types, involving different types of environmental assets, different threats, different scales and different time frames.

- Environmental managers face requirements from their funders, organisations and masters in terms of paperwork, reporting, timing, consultation, usage of funds and so on.

Implications: INFFER is capable of comparing projects for different types of environmental assets, different threats, different scales and different time frames. While retaining rigour, it can deal efficiently with very large numbers of candidate projects, not bogging down users with too much analysis. It is intended to fit in with, or at least not conflict with the requirements that environmental managers face from their funders, their organisations and their masters. Failing that, the INFFER team tries to work with funders to identify changes in their internal processes to make them more consistent with INFFER. For this and other reasons, if there is not strong support for the use of INFFER from the leadership and senior management of an environmental organisation, there is little point in pursuing its use within that organisation. More generally, for widespread use of INFFER (or any other systematic decision tool), there need to be supportive changes in institutional arrangements, including rewards for organisations that make appropriate use of sound decision methods, and/or punishment for those who do not. It is expected that institutions that create incentives and rewards for sound decision processes will thereby encourage organisations to commence their analytical process earlier. The INFFER team works with funders and policy makers to create an awareness of this need and to support their efforts to modify the incentives facing environmental managers for improving their decision processes.

Theoretical underpinnings of INFFER

An aim of the INFFER developers was to embed economic thinking into the analysis and decision processes of environmental managers, most of whom are unaware of economic principles and their potential usefulness to their own decision making needs. As noted earlier, we sought to develop a framework that was practically useful and as simple as possible, while still being theoretically rigorous. In this section we outline several aspects of the underpinning theory that drives INFFER, and explain the theoretical basis of several compromises that were made to enhance simplicity and usability.

Broadly, INFFER is designed to be consistent with standard Benefit: Cost Analysis (BCA). The main differences are that INFFER usually does not estimate benefits in dollar terms, is designed to efficiently compare large numbers of projects, is designed and structured specifically for environmental management projects, and includes additional tools and guidance, such as the Public: Private Benefits Framework for selection of delivery mechanisms.

Stages of the process

As noted earlier, any environmental manager faces a vast number of potential projects that could potentially be undertaken – far too many for it to be possible to conduct a comprehensive assessment of every potential project. For this reason, INFFER uses a process of relatively simple filtering to identify projects that appear attractive enough for detailed project development and assessment to be worthwhile. Once projects are assessed and selected for funding, we recommend that, in most cases, a feasibility assessment be conducted as the first stage of the project. Figure 1 illustrates the three stages of project assessment, starting broad and simple, and finishing specific and detailed.

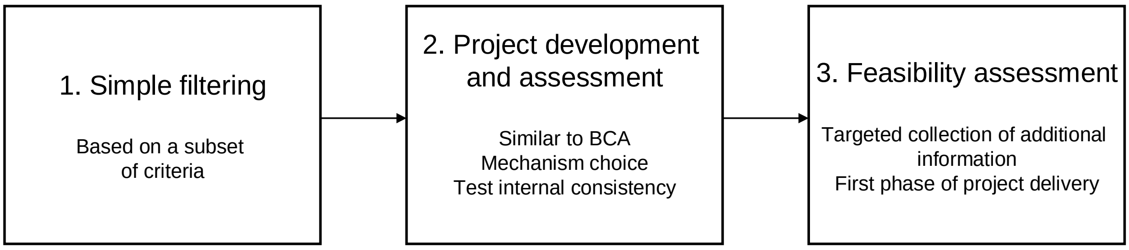

Figure 1. Three stages of the INFFER project development, prioritisation and assessment process.

At the simple filtering stage, we use only a subset of the INFFER selection criteria. The thinking behind this stage is as follows:

- There are far too many projects to fund. Therefore, it is not important to be highly precise about which projects make it through to the second stage of the process. The accepted aim is to find good projects, not necessarily the absolute best projects. Given the poor quality of existing prioritisation processes, finding good projects will represent a dramatic improvement.

- It doesn't particularly matter which of the full set of selection criteria are included in the simple filtering stage. In practice, we suggest that asset value and threat are used, as these are items about which users can make judgements relatively easily. Asset value is also an item for which community consultation and input is appropriate, so use of these criteria supports a process that involved early engagement with local stakeholders. We also have developed a simple "Pre-Assessment Checklist" that provides a further filter for users. Questions on the checklist are shown in Table 1.

The "asset-based approach" of INFFER is used as a strategy to help users to focus on outcomes from the project, which we identified as a key requirement. We start by identifying the assets because we think it helps shape the mind set of users, and it also helps with communication. In theory, there is no reason why we could not start by identifying environmental threats, but in practice, we think the asset-based approach works well to increased the focus on outcomes.

Table 1. The Pre-Assessment check list used to test whether a project that has survived the initial filtering should proceed to full assessment

Asset focus

1. Can you clearly identify the environmental or natural resource asset? Most people say they can, but then find it difficult to be very specific about what the asset is. Before you say "yes", consider whether you could draw it on a map. The asset can be large or small but needs to be identified spatially.

2. Will it be possible to define a goal for the asset that is "SMART" (specific, measurable, achievable, relevant and time-bound)?

If you cannot answer "yes" to both of these questions, it is likely that the project is not suited to being assessed by INFFER.

Cost-effectiveness

3. Is there evidence to indicate that management actions can make a real difference, sufficient to achieve a worthwhile "SMART" goal for the asset? (e.g. will it be technically possible to repair existing degradation, or prevent future degradation?).

4. If the desired management actions are mainly on private land, is it likely that those actions would be reasonably attractive to fully informed land managers ***when adopted over the required scale***? You should at least expect that adoption (or compliance) at that scale will occur readily with a realistic level of financial incentive or compensation.

5. If the project requires change by other institutions (e.g. local government, state government departments) is there a good chance that this will occur? (e.g. low political risks from changing, staff with relevant knowledge and strong interest).

For it to be worthwhile assessing a project in INFFER, you would like "yes" responses to questions 3, 4 (if relevant) and 5 (if relevant).

After the simple filtering process of Stage 1, the process proceeds to a comprehensive analysis in Stage 2, using the best available information (however good or bad that is). Often, the quality of information used in that analysis is not high, highlighting the need for a feasibility assessment in Stage 3, involving targeted collection of additional information.

Most of the theoretical issues raised in the following subsections relate to Stage 2, in which individual projects are developed and assessed using an approach closely related to BCA.

Asset valuation

In the standard version of INFFER, users are asked to provide a score out of 100 for each asset, representing the overall importance or value of that asset relative to a benchmark. The benchmark for a score of 100 is an environmental asset of high national significance, such as the Gippsland Lakes in Victoria, or the Coorong Wetlands in South Australia. The significance of each asset is scored relative to this benchmark. For example, an asset which is judged to have 10% of the value of the Gippsland Lakes would have a score of 10. This value includes the total of both market and non-market values relevant to the asset. When this scoring approach is used, a key output from the project assessment process is a Benefit: Cost Index.

Alternatively, users may provide dollar values for each asset, presumably based on market values and non-market valuation studies (if relevant). In this case, the output from the project assessment process is in fact a standard Benefit: Cost Ratio. Thus, the only difference between the usual Benefit: Cost Index (BCI) and a standard Benefit: Cost Ratio (BCR) is whether the asset is valued in dollar terms or using an index. This illustrates that INFFER is generally theoretically consistent with the standard BCA approach.

If INFFER is used to rank competing projects for different environmental assets, the results should be identical between the two approaches (BCI versus BCR) provided that the asset value scores are proportional to their dollar values. Thus the accuracy of the BCI approach depends on the ability of the environmental managers to accurately estimate asset values. Some may argue that environmental managers are unlikely to be able to accurately estimate community values. On the other hand, in the absence of evidence about dollar valuations of assets (which is the most common situation for environmental assets), environmental managers are probably in as good a position as anyone to judge the asset values. Furthermore, it might be argued that INFFER's BCI approach is actually superior to a standard BCR in some ways:

> "The INFFER process within which [BCIs] are calculated was designed to encompass a process of community consultation, and thus it provides scope to address criticisms of BCA due to the top-down manner in which it is normally applied. This consultative process allows stakeholders 'to express values and preferences for different NRM assets and to provide local knowledge about assets and their management …'. Hence, it offers potential to address criticisms of BCA for valuing environmental and natural resource assets using the principle of individual sovereignty rather than on the basis of deliberation among affected parties" (Marshall, 2009, p. 96).

In practical terms, a system based on scores elicited from stakeholders and decision makers is more feasible and far less costly than a system requiring valuation surveys for each asset. The latter approach is clearly prohibitively expensive given the large number of assets and projects to be evaluated. Although the scoring system is not easily accepted by all users, we believe that a system based on dollar valuations would be substantially less acceptable to many environmental managers.

An important feature of INFFER is that it separates out the asset valuation from other determinants of project benefits, such as the levels of environmental threats, and the technical feasibility of reducing those threats. Non-market valuation studies sometimes conflate these elements, resulting in survey respondents being asked to evaluate questions which they are not likely to be able to answer sensibly. It makes sense to ask community members about their valuation of an environmental asset, but usually not their views on the technical feasibility of protecting it from degradation. That type of information should instead be elicited from the best informed experts.

Discounting

Environmental projects are likely to involve time lags related to both the benefits and the costs. To account for time lags, standard discounting methods are used. For simplicity, users are not asked to specify the discount rate - a standard real discount rate of 5 per cent is used in all analyses.

On the benefits side, after a project is implemented, it may be some years until the bulk of the environmental benefits are generated, either because the project is preventing degradation that would not have occurred for some time, or because it takes a long time for the works to take effect (e.g. trees have to grow). This lag is elicited from users in the course of them completing the Project Assessment Form, and is used to express future benefits in present-value terms. Whether the project benefits are expressed as an index or a dollar value, the same discounting approach is used, to ensure logical consistency of the analysis.

On the cost side, a simplification in the INFFER procedure is to not discount costs occurring in the initial project that is being assessed (i.e. costs in the first 3 to 5 years). The error arising from this simplification is minor (around 5 to 10 per cent) and it perhaps helps to slightly counter the tendency of environmental managers to be too optimistic about their projects. The INFFER Project Assessment Form also asks users to specify long-term maintenance costs required to preserve the benefits generated by the current project. For example, there may be a need for ongoing payments to landholders, or for monitoring and enforcement of agreements. These maintenance costs are assumed to be required annually for 20 years beyond the current project, and the stream of costs is discounted to calculate the present value of costs.

Uncertainty

The Project Assessment Form elicits a number of probabilities, to represent risks of project failure. The probabilities collected are: the risk of technical failure, the risk that landholders will adopt adverse practices despite the project's efforts to prevent this, socio-political risks, and the risk of not obtaining required long-term funding (beyond the current project). A detailed approach would elicit a joint probability distribution for outcomes related to these uncertain variables, and use it to calculate the expected value of benefits. The INFFER approach involves a simplification in that we only allow for two possible outcomes in each case; for example, we assume that the project either will fail completely due to technical infeasibility, or it will achieve its full potential as specified in the other collected data. Similarly, project success/failure is represented as a binary variable for the other three risk factors. This simplification requires users to answer the questions in an appropriate way, subjectively defining "success" as achieving most of the expected benefits and "failure" as the complement to that.

Choice of policy mechanisms

INFFER includes an innovative framework for selection of policy mechanisms that are most likely to be effective for a particular project: the Public: Private Benefits Framework (Pannell, 2008, 2009a). Based on the levels of public net benefits (i.e. external benefits) and private net benefits arising from a project, the framework recommends a mechanisms out of extension (i.e. communication, education, etc.), positive incentives, negative incentives, technology development and no action. Potential incentive mechanisms include financial or regulatory instruments that potentially include polluter-pays mechanisms (e.g. command and control, pollution tax, offsets), beneficiary-pays mechanisms (e.g. subsidies, conservation auctions and tenders), and mechanisms that can work in either way depending on how they are implemented (define and enforce property rights, such as through tradable permits)

Figure 1 illustrates the version of the Framework that is used within INFFER, based on an assumption that any investment should generate a benefit: cost ratio of at least 2. As the framework is fully documented in other journal articles, its theoretical basis is not presented here. We simply note that it provides a rigorous tool that is easy for non-economists to understand and apply.

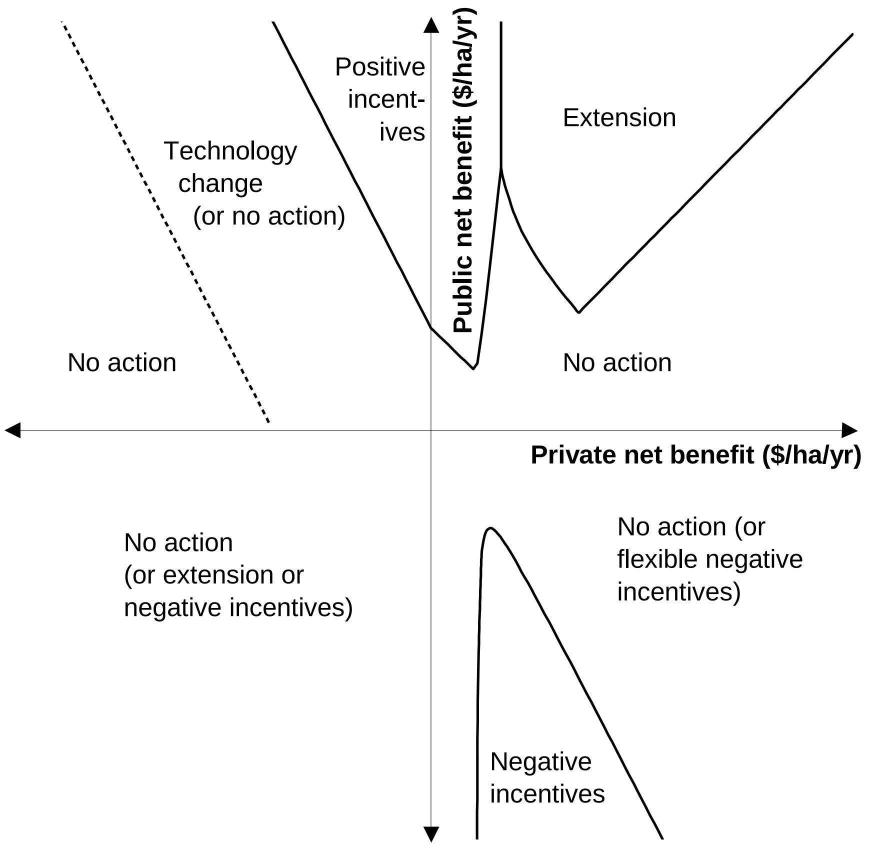

Figure 1. Public: Private Benefits Framework as used in INFFER (source: Pannell, 2009a).

Metric for project comparison

Consistent with a BCR, the broad design of the BCI is as follows:

$$BCI = \frac{\text{(Asset value or significance)} \times \text{(Proportional impact of project on that value)}}{\text{Cost of current project plus ongoing maintenance}} \qquad (1)$$

The formula is designed to allow comparison of projects of different types, scales, and durations, which has always been a challenge for managers of natural assets. It facilitates this because, respectively, it expresses benefits in a common unit of measure (a score standardised against an asset of high national significance), it divides benefits by costs to allow comparison of relative cost-effectiveness, and it discounts future benefits and costs to calculate their present values. The higher the value of the BCI, the higher the priority of the project.

Specifically, the BCI formula is as follows:

$$BCI = \frac{V \times W \times F \times A \times B \times P \times G \times DF_B(L) \times 20}{C + PV(M)} \qquad (2)$$

where

V = value of the asset

W = multiplier for impact of works

F = multiplier for technical feasibility risk

A = multiplier for adoption

B = multiplier for adverse adoption

P = multiplier for socio-political risk

G = multiplier for long-term funding risk

DF_B = discount factor function for benefits, which depends on L

L = lag until benefits occur (years)

C = short-term cost of project

PV = present value function

M = annual cost of maintaining outcomes from the project in the longer term.

Details about each of the variables is provided below.

Asset value (V): V is estimated as a score out of 100 that represents the value of this asset, assuming that the asset is in good condition. The scoring range is calibrated such that a score of 100 corresponds to an asset of high national significance (such as the Gippsland Lakes).

Impact of works (W): W represents the proportional increase in future asset value that would result if the project was fully implemented (i.e. assuming that it is fully adopted) compare to if it wasn't. W is measured as a proportion of the total value of the asset (in good condition).

Technical feasibility (F): F is the probability that the benefits generated would be as large as specified in W. In other words, it is the probability that benefits will not be significantly less than W. Like all the probabilities included in the formula, F is expressed as the probability of success, rather than of failure, so that the formula provides the expected value of benefits.

Private adoption of works and actions (A): A is the probability that the on-ground works and actions specified in the project will actually be adopted, assuming that the project is fully funded and the project's delivery mechanisms are implemented.

Preventing adoption of adverse practices (B): B is the probability that the project will not fail due to adoption of adverse works or actions, despite efforts by the project to prevent that adoption from occurring.

Socio-political risks (P): P represents the probability that other socio-political factors will *not* derail the project. This includes the risk of non-cooperation by other organisations and the impacts of social, administrative or political constraints. The latter can include resistance to the project at the political level, bureaucratic approvals that would be needed, or opposition by local government. P is the probability that the project will not be prevented from reaching its goal due to one or more of these factors.

Long-term funding risks (G): G represents the probability that essential long-term funding will be available to continue to maintain the benefits generated by this project, or to complete the essential works commenced by this project.

Time lag to benefits (L): L is the expected time lag in years until the desired bio-physical outcomes would be achieved. It represents the earliest time when a large proportion of the benefits will occur.

Discount factor ($DF_B(L)$): Benefits that occur further into the future are a lower priority than similar benefits that occur rapidly. This is captured through the use of discounting. The discount factor is calculated as follows:

$$DF_B(L) = 1/(1.05)^L \quad (3)$$

This assumes that the real discount rate (net of inflation) is 0.05. There is some debate about the appropriate discount rate to use for environmental projects. A real rate of 0.05 is a commonly used rate that is a little lower than rates commonly used for projects with financial outcomes, but not as low as argued for by a minority of the protagonists.

Up-front costs (C): C is the sum of direct costs that will be incurred within the immediate time frame of this project – assumed to be three to five years.

Ongoing or maintenance costs ($PV(M)$): Some costs may be incurred each year in the long term, such as monitoring and evaluation, or enforcement costs, or ongoing compensation payments. The annual total of these maintenance costs is M. To make them comparable to the up-front costs, we need to express them as a present value (PV), as follows:

$$PV(M) = 10.7 \text{ x } M \quad (4)$$

This assumes that the discount rate is 0.05 and the time frame for paying these costs is 20 years, commencing in year 4.

Equation (2) is rather different from a common approach to the construction of scoring metrics for environmental decision making: weighted additive scoring (e.g. Hajkowicz and McDonald, 2006). Because of the way that the variables are defined as proportions and probabilities, their impacts on the expected value of benefits are fully captured by the process of multiplication. There is no need for weights to be provided. Indeed, inclusion of weights in the multiplicative equation would make no difference to the ranking of projects, while converting it to a weighted additive formula would distort the ranking such that it no longer reflected the relative merits of different projects. Pannell (2009b) showed that, for a project ranking problem with these characteristics, using a weighted additive formula would result in loss of approximately 50 per cent of the potential environmental benefits from the investment.

The *BCI* is useful for comparing alternative projects competing for a fixed budget. If the question is whether the overall budget should be increased, we would ideally like to have dollar values for the environmental assets, rather than the score V.

The BCI formula is designed so that it behaves similarly to a BCR, in that a BCI exceeding 1.0 is desirable. This is achieved by including the 20 factor at the end of equation (2) to scale the results appropriately, based on an assumption that a *V* score of 100 corresponds to a total dollar value of $2 billion. Given that assumption, it is possible to convert the BCI to a Net Present Value (NPV) as follows.

$$NPV = (BCI - 1) \text{ x } (C + PV(M)) \qquad (5)$$

Conclusion

Development of a valid and useful investment framework for assessment of environmental projects requires close attention to issues of practicality and well as theoretical rigour. This paper has outlined how these issues have been considered and accommodated within the INFFER project.

Based on extensive experience working with environmental managers in the INFFER project and in previous projects, a number of important lessons for the design and implementation of INFFER were identified. Key implications for INFFER include the need for simplicity, training and support, trusting relationships with users, transparency, flexibility, compatibility with the needs and contexts of users, and supportive institutional arrangements.

On the theoretical side, INFFER is consistent with the theoretical underpinnings of Benefit: Cost Analysis, while fostering a higher level of stakeholder participation than is usual in BCA. A key component is a Benefit: Cost Index, which carefully designed to ensure that it is theoretically consistent with the ranking of projects that will deliver the most valuable environmental outcomes (unlike some commonly used metrics).

Usage of INFFER by environmental managers and support and interest from government agencies has increased rapidly over the past two years. Our careful attention to the design of the tool and our responsiveness to users' feedback have been important factors contributing to INFFER's success to date.

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