Advancing Ex-Post Impact Assessment of Environmental and Social Impacts of CGIAR Research

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1. Background

The success of the Consultative Group on International Agricultural Research (CGIAR) in delivering economic benefits in the form of productivity enhancements that are in excess of the costs of research and application is well documented. For instance, Feldman (no date) presents a range of CGIAR projects where impact assessments have been carried out that demonstrated positive net present values for the investments involved. Maredia and Raitzer (2006) show that across all CGIAR funded research in sub-Saharan Africa a positive rate of return has been achieved, with an aggregated benefit cost ratio in the order of 1.12 to 1.64. At the most aggregated level, Raitzer and Kelley (2008) report a benefit cost ratio of between 1.9 to 17.3 in their meta analysis of investments in the CGIAR Centres.

Central to the drawing of the conclusion regarding the CGIAR's success is the use of benefit cost analysis to demonstrate that the benefits of the research effort exceed the costs across a range of levels of aggregation. However, the conclusion is not without question. First, it is clear that only a fraction of CGIAR research projects are subjected to ex post impact assessment (epIA). Second, the broader scale meta analyses demonstrate that there have been a small number of highly successful research initiatives that help to 'carry' the portfolio of project costs, including those for which benefits have not been estimated. For instance, research into biological control in sub-Saharan Africa accounts for 80 per cent of total benefits (Maredia and Raitzer 2006). Raitzer and Kelley (2008) go further by only including benefits when they exceed USD50m per project.

Hence, in one regard, the conclusion rests on an inadequate data base of studies but in another, it is clear that the meta analyses performed have taken a very conservative stance on the inclusion of benefits whilst including all costs.

There are further grounds for questioning the success conclusion. These relate to the inadequacy of existing CGIAR epIA studies to include the full spectrum of project research benefits. Specifically, existing epIA's have focused almost exclusively on the financial benefits arising from research and the associated financial costs. Much of the effort in preparing epIA's has been devoted – and rightly so - to the development of research adoption pathways and the issue of crop productivity benefit attribution. Very little effort has been devoted to the inclusion of the full suite of benefits and

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costs including environmental and social effects. Hence, project epIAs, and their meta analyses, run the risk of systematic bias.

For instance, if productivity enhancing research on crop genetics caused such widespread adoption that environmental costs associated with crop monoculture emerged, a failure to account for such costs would result in an exaggeration of the project's success. On the other hand, if the assessment of CGIAR research on catchment management did not include the benefits to biodiversity enhancement that would flow from adoption then there would be an understatement of the net present value achieved for society.

That is not to say that environmental and social impacts of CGIAR research projects are not considered at all. Rather, there has been a growing recognition within the CGIAR that these impacts deserve recognition and inclusion for decision making to be well informed. This is especially the case given the CGIAR's mission to address poverty, food security and the environment. However, the degree of recognition and incorporation remains very limited. For instance, a review of the impacts of Natural Resource Management Research (Science Council Secretariat, 2006)[2], where it would be expected that environmental impacts are significant, notes that the rates of return calculated "without estimating positive spill-over environmental benefits, which probably outstrip benefits from crop germplasm improvement (CGI) research" (p1). Hence, while the significance of the (likely) environmental benefits is recognised, they are not incorporated. The relative performance of natural resource management research (NRMR) is thus reduced and the allocation of research funding misinformed.

With these inadequacies in mind, the goal of this report is to put forward some strategies for advancing the status of epIA in the CGIAR through the incorporation of environmental and social impacts of research.

The report begins with a brief survey of the literature on impact assessment in the CGIAR context, noting particularly the incorporation of environmental and social values. It continues in Section 3 with a review of the methodologies that have been developed by the economics profession over the past 30 years to tackle the complexities of estimating non-marketed costs and benefits. These techniques are critical to the task of incorporating environmental and social benefits into epIAs. Also introduced are techniques that are appropriate to the task of incorporating equity considerations into epIAs. Use of these techniques represents a departure from most cost benefit analysis based epIAs where only efficiency is the base of assessment. The inclusion of equity concerns is one way of tackling the incorporation of broader social impacts. Along with the techniques recommended for future application, a critique of alternative mechanisms for incorporating environmental and social impacts into decision making is provided. Finally, a specific research project where environmental impacts are evident but as yet not been incorporated into an epIA is selected as a case study.

[2] A sequence of seven impacts assessments were the focus of this review. These are reported in greater detail in Waibel and Zilberman (2007).

2. Defining Environmental and Social Impacts

Distinction is frequently drawn in impact assessment work between economic, environmental and social impacts of change. One origin of this categorisation of effects is the notion of sustainability in which policies are judged through their impacts on the 'triple bottom line' which comprises the economy, the environment and the society.

The problem with this characterisation is that the definitions of what constitute each of the classifications. For instance, economists would argue that they are interested in the well being of people in society, so that economic impacts are synonymous with social impacts. Similarly, environmental scientists argue that the environment encompasses society and the economy.

Hence it is important at the outset to clarify exactly what is implied by economic, social and environmental impacts.

First, economic effects in epIAs have tended to be limited to the impacts of change on goods and services that are bought and sold in markets. So while the discipline of economics is defined in terms of choices regarding the allocation of scarce resources, be they marketed or not, the practice in epIAs has been to consider those impacts for which values can be estimated with recourse to market data.

Social and environmental effects have therefore been taken to be associated with changes that are experienced outside the market, where dollar denominated estimates of value are not readily available.

For instance, social impacts may include public good (and bad), and hence un-marketed aspects associated with changes in health, education and other aspects of 'social capital'. But the category would not include elements that are already taken into account by 'economic' impacts such as changes in income and prices. Hence, concerns regarding absolute levels of poverty are addressed through the economic effects of income and prices. However, relative poverty is not. This comes under the rubric of 'equity' issues in economics and goes beyond the standard CBA approach of dealing with the consequences of change for the 'efficiency' of resource use. To incorporate this type of social impact where change impacts on the distribution of wealth also goes beyond market exchanges.

Environmental impacts are similarly 'outside the market'. They may relate to direct use of an environmental resource such as is enjoyed from visiting a site as a tourist or from living in an aesthetically pleasing setting. They may be delivered indirectly, say through the use of the ecosystem as an input into production (pest control offered by predatory insects or birds) or consumption (clean water from a protected catchment). They may also be enjoyed by people without any direct or indirect contact with the environment. For instance, the knowledge that an endangered species remains viable may be enjoyed by someone who is far removed from the species' habitat and who has no desire to have contact with the species.

In considering the environmental values, it is important to note that the basis of the values involved remains ‘anthropocentric’. In other words, it is the value to people of the environmental changes under examination that is relevant. In this analysis, ‘intrinsic values’ or environmental values held for its own sake are not incorporated.

What therefore differentiates social and environmental impacts from economic in epIAs is their non-market characteristics. In other words, the outcomes of research are producing changes in environmental and social conditions that do not involve goods and services that are bought and sold in markets.

This is usually the result of these goods and services not having well defined or defended property rights that enable them to be traded. In turn this results from characteristics of the good that make such property right definition and defence too costly. These characteristics often involve ‘non-excludability’ whereby a person who enjoys the good but doesn’t pay for it cannot feasibly be prevented from accessing the good. For instance, the costs of preventing a non-payer from enjoying a pleasant view, having a lower probability of catching an infectious disease, breathing dust free air, not being mugged on the streets, drinking clean water, or knowing of an endangered species’ existence may be prohibitive.

3. The CGIAR record

The history of CGIAR epIA both at project and programme level is significant. Yet the majority of studies have neglected to incorporate non-marketed social and environmental impacts. The reason for this is readily apparent. The estimation of research impacts outside market effects is complex. With epIA studies being well-established within the conceptual rigour of CBA, the inclusion of non-marketed effects requires the estimation of benefits and costs in monetary terms. This is a challenging task that has been the focus economic research for the past three decades. Hence for epIAs to include non-market benefits and costs requires not just the already challenging processes of forecasting the impacts of research outputs on the various goods and services (both marketed and non-marketed) affected but additionally the estimation of society’s values for all the forecast impacts.

It is initially insightful to review the attempts made to date within the CGIAR centres to carry out this task.

Predominantly, CGIAR epIAs draw attention to their omission of environmental impacts. For example Hazell (2008) in his broad ranging assessment of agricultural research in South Asia concludes that “there are few impact studies from South Asia that estimate a return to a research investment corrected for environmental benefits and costs” (p. xv). He also points to the use of indicators as a means of ranking research investments in terms of both their environmental and poverty impacts but is clear that there is no consensus as to which indicators should be used. Without such a consensus – as would be provided by a core of agreed theory – the use of indicators remains arbitrary and hence limited. Hazell therefore recommends empirical studies to link research investments to poverty and environmental outcomes in order to assess past investments and to design more effective future research initiatives.

Maredia and Raitzer (2006) draw similar conclusions with regard to the CGIAR experience in sub-Saharan Africa. For instance, the research effort into biological control programs is shown to be 'cost effective and sustainable' but that conclusion is based only on the 'conventional financial benefits of biological control of pests, while the benefits to ecological and human health have not been estimated' (p48). Indeed their meta analysis does not include research into integrated natural resource management (such as improved fallow, fertilizer trees, alley farming and no-till) because of a lack of benefit estimates, given their largely environmental nature. Maredia and Raitzer (2006) conclude that their focus on productivity impacts reflects 'the fact that the methodology for quantifying productivity impacts of research outputs or outcomes is much more advanced than the methodology for quantifying other types of research impacts'(p55). In this regard, they specifically mention social, equity, environmental and health impacts.

Even the assessment of impacts of CGIAR research investments in natural resource management (where environmental aspects would be expected to be prominent) carried out by the Science Council Secretariat (SCS) (2006) includes little by way of quantified environmental benefits. The SCS acknowledges that CGIAR investments in natural resource management (NRM) are 'in response to increased concerns about the environmental and NRM foundations of agriculture' (p3), and post-1987, 'managing and enhancing the quality of the environment and conserving natural resources' was a specifically stated goal. However, the predominant focus of the assessment of these investments remains on agricultural productivity. A barrier to the inclusion of environmental, social and livelihood security issues in epIA is seen to be the highly conceptual way in which these issues are defined. Hence 'specific and quantitative assessment (is) problematic' (p6). Despite these difficulties, the SCS initiated a sequence of seven impact assessments from across the CG Centres to consider NRM research investments. These are now outlined[3].

Natural Resource Management Impacts
The seven assessments are detailed in Waibel and Zilberman (2007) and will not be detailed here. What is striking about the sequence of assessments is that none of them attempted to estimate non-production based environmental benefits of the research undertaken.

1. CIAT: Cassava cropping systems in Vietnam.
Intercropping, manure and mineral fertilizer use and genetic improvement in cassava growing were assessed in terms of their impacts on yields.

2. CIFOR: Sustainable Forest Management criteria and indicators.
Impact pathways to forest certification and auditing practices were developed. No income changes or environmental benefits were estimated.

3. CIMMYT: Zero till in India's rice-wheat systems
The direct changes in consumer and producer surpluses in rice and wheat markets were estimated. A description of environmental benefits was provided without quantification.

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[3] Prior to this initiative some studies had specifically investigated CGIAR Centre NRM investments. For example, Franzel, Phiri and Kwesiga (1999) estimated the higher returns to land and labour that result from including fallow rotations in Eastern Zambian maize production and Listinger (1989) investigated insect damage in high yielding rice as a function of fallow length.

4. ICARDA: Crop-livestock production systems in Morocco and Tunisia
Productivity benefits of alley cropping (resulting from reduced soil erosion and improved soil fertility) were weighed up against the costs of incentives paid to farmers.

5. IWMI: Irrigation management transfer
The demand for the research outputs was documented through citations, downloads and distributions of papers, reports etc. No quantification of benefits, environmental or otherwise was attempted.

6. ICRAF: Fertilizer trees
Financial benefits relating to improved productivity were estimated and integrated into a CBA. Food security improvements and reduced deforestation were noted but not integrated.

7. WorldFish: integrated aquaculture-agriculture technologies in Malawi
The effects of the project on economic surpluses were estimated but no environmental or social impacts were integrated into the CBA.

Consistently, the lack of quantitative relationships between the research investments and environmental and social outcomes is noted, as is the absence of monetary estimates of those outcomes. As the Science Council (2006) concludes:

> "Development of effective monetary indicators of benefits and corresponding baseline data collection efforts before/without the project compared with after/without the project is a priority if a more comprehensive assessment of the value of NRM projects is to be developed" (p42).

Some progress in this regard has been made in the field of health impacts of CGIAR research.

Health impacts
A number of studies have documented the health benefits associated with CGIAR research results and have included estimates of their monetary values in epIA. Antle and Pingali (1994) investigated the effect of pesticide exposure amongst rice farmers in the Philippines and used the avoided costs of health treatment as well as the opportunity cost of labour to estimate the benefits of reduced use resulting from various policy initiatives. The same type of approach was also taken by Pingali and Gerpacio (1997), Rola and Pingali (1993) and Pingali, Marquez and Palis (1994) in other rice production contexts and by Crissman, Antle and Capalbo (1998) for potatoes in Ecuador. More recently, the Philippines rice production context was re-visited by Templeton and Jamora (2008).

While these studies provide useful insights into the benefits of farmer health improvements resulting from reductions in pesticide use, it must be noted that they are inaccurate as benefit estimates. Conceptually, this type of 'avoided cost' estimate of benefit relies on the expenditure being able to render the 'before and after' situations equivalent in terms of the individual's well-being. This is clearly not the case with the costs of medical treatment where the medical treatment is not a perfect substitute for good health. Hence, the avoided costs technique can only be regarded as a lower bound estimate of the benefits involved.

Resource use impacts
Another type of study to investigate the environmental benefits and costs associated with agricultural research involves the estimation of the amount of natural resources

(land and water) required to meet the food and fibre demands of the world. The basic premise underlying such studies is that without agricultural research, the productivity of land and water would be lower and, hence, that the area of land and volume of water required for production would be greater. This would mean that other land and water resources, otherwise devoted to the production of environmental goods and services – such as forests and native grasslands and the 'environmental flows' in rivers and streams – would be brought into production and their environmental outputs lost. These costs are therefore recognised as benefits of the productivity enhancing research investments.

This is the approach taken by Nelson and Maredia (1999) who estimate the amount of deforestation avoided due to CGIAR research. They then proceed to calculate the monetary value of the environmental benefits this area of forest produces in terms of biodiversity and carbon sequestration values. To do this they rely on benefit estimates drawn from other studies. Nelson and Maredia (1999) acknowledge the inadequacies of their study in terms of the broad level of assumptions required to provide such an overall valuation, given especially the localised and specific nature of the environmental impacts of deforestation. They also recognise that many of the benefits of avoiding deforestation are not incorporated, especially those relating to downstream effects where hillsides are cleared. They recommend further research effort be devoted to the establishment of 'cause-effect' relationships between research outputs and environmental outcomes that impact on people (the anthropocentric approach) and the estimation of monetary values for a wider range of environmental change. Nelson and Maredia also indicate an understanding of the general equilibrium impacts of agricultural research by suggesting that the demand and supply elasticities of food and fibre crops be better developed. This is in recognition that productivity enhancement can lower prices and hence cause an expansion of demand which in turn increases the amount produced. The overall impact on the resources used in production is therefore not entirely clear.

A further study of averted deforestation by Raitzer (2008) also makes an attempt to integrate non-marketed environmental benefits. The assessment is of CIFOR's research impact on the political economy of Indonesia's pulp and paper sector. A valuation framework centred on the concept of 'total economic value' – incorporating use and non-use environmental benefits – is set up and populated with estimates of values produced in other studies. This is known as the 'benefit transfer' approach and is used to supply values associated with the watershed services, carbon sequestration and biodiversity protection losses that have been avoided through CIFOR research's impact on the rate of deforestation. The Raitzer study represents the most significant attempt to incorporate environmental values into an epIA yet seen in the CGIAR.

The conclusions drawn by the Independent Review Panel (2009) of the CGIAR System in their chapter 3 that is focused on the impact of CGIAR research are insightful as a summary of the position. The Panel concludes:

> "Environmental benefits are largely ignored – presumably because of the methodological difficulties in quantifying them. Such quantification would presumably require non-market valuation techniques whose use is still relatively rare in developing country contexts"

They go on to recommend:

> “that future ex ante and ex post impact assessment make effort to accurately assess environmental, gender and other indirect consequences of agricultural research for development”.

In what follows, some strategies to comply with that recommendation are detailed, particularly in terms of overcoming the ‘methodological difficulties’ confronted when applying non-market valuation techniques in developing country contexts.

4. Alternative integrative methodologies

The primary tool use within the CGIAR for epIA has been cost benefit analysis (CBA). The criticisms levelled at past applications of CBA in terms of the failure to integrate social and environmental impacts have been based largely on the limitations associated with the estimation of these non-marketed effects in monetary terms. Hence the first integrative methodology considered here is the extension of CBA to incorporate non-marketed benefits and costs.

The key task involved is thus to engage with the techniques that economists have developed over the past 30 years that allow the estimation of non-marketed, environmental benefits and costs. The conceptual framework of welfare economics – based on the notions of anthropocentric utilitarianism – is maintained in this process as the integration of social and environmental impacts is merely an extension of the existing method.

Another feature of ‘extended cost benefit analysis’ (ECBA) is the integration of the economic models designed to provide estimations of benefits and costs with models that are developed to forecast the biophysical impacts of research outputs. This so-called bio-economic modelling ensures the linkage of elements of the epIA process. To date, parallel models linking social impacts with economic valuation models (potentially, socio-economic models) have not been developed, largely because most social modelling is more qualitative in nature and so less amenable to integration with the quantitative approach taken by economic models.

ECBA also involves time periods of assessment that extend well into the future and the incorporation of asset values recorded at the end of the ‘assessment life span’ into the analysis. This is to ensure that ‘sustainability’ issues are incorporated. Similarly, the geographic scope of impacts is broad to ensure that ‘off-site’ impacts are integrated. ECBA can also take into account equity issues (whereby the well being or utility of different groups in society are judged to make different contributions to the overall welfare of the society) through the application of ‘welfare weights’ to the estimates of costs and benefits derived from market and non-market information.

The use of ECBA offers epIA the strength of a widely accepted, rigorous conceptual framework. Its (conceptual) capacity to incorporate the impacts of research outcomes across the spectrum of the economic, social and environmental provide a vehicle for the delivery of policy recommendations that is consistent with established practice and sufficiently broad to allow complete integration.

The weaknesses of ECBA[4] relate to the availability of information. In order to integrate, it is first necessary to have the component parts in place. It is common for the bio-physical modelling, the social modelling and the economic modelling associated with non-market values to be lacking. This is a primary cause for the 'extensions' to be omitted from CBA.

Furthermore, where ECBA calls for the use of 'welfare weights' to recognise equity concerns, estimates of these weights have generally been unavailable.

Largely in response to these limitations facing ECBA, other integrative techniques have been developed. Foremost of these has been 'multi criteria analysis' (MCA).

MCA – otherwise known as multi attribute utility analysis, project planning budget sheets, etc – in its simplest form begins with the analyst determining the array of 'criteria' that will be impacted by a number of research projects' outputs[5]. These criteria, which can take on multiple dimensions, are then measured in the most convenient unit available (hectares, kilograms, kilometres, money etc). The raw measurements are then converted into 'scores' through a range of mathematical processes. For instance, scores may be set at the rank achieved in that criterion by each research project. They may be set at the difference from the mean score etc. Once all criteria for all research projects are scored, each criterion is assigned a weight to reflect its relative importance. The scores, multiplied by their respective weights are then summed to provide an aggregated score on which the 'best' research project can be selected.

While MCA has the advantage of not requiring the estimation of all research impacts in monetary terms and can be viewed as being 'inclusive' through its ability to integrate any number of impacts into one framework, it suffers from numerous, fatal weaknesses. First, it is without a conceptual framework. There is no theoretically rigorous structure to underpin the selection of criteria, the development of scores or the estimation of criteria weights. Hence, the analyst is at liberty to determine these processes as required. The immediate danger is that analysts (and decision makers) have the opportunity through MCA to develop the tool in ways that will ensure it delivers the policy prescription that suits their vested interests. In addition, this paucity of conceptual framework means that no two MCA applications are necessarily comparable. The application of the technique by one analyst will be different from another. Another key problem is that MCA does not require the incorporation of the 'status quo' counterfactual (no research project) as one of the possible outcomes. The

[4] The weaknesses of standard CBA – which are primarily weaknesses of ECBA as well – are widely reported and not repeated here.

[5] The strategic guidelines for epIA prepared by Walker et al (2008) make mention of multi-dimensional impact assessment whereby check lists of issues and 'indicators' are integrated to provide an assessment. This approach bears some strong similarities to MCA and therefore suffers from that approaches' conceptual frailties. Problems associated with double counting when 'livelihoods' are considered alongside indicators of 'poverty' as well as the financial benefits arising are apparent. So too are the issues arising from the weighting of all the indicators to present an overall assessment score, whether or not those weights are implicit or explicit.

implication is that an MCA need not be able to provide an assessment of the relative performance of the with and without scenarios that are so vital to the development of research policy.

Even the MCA 'strength' of not requiring monetary estimates of criterion impacts is fictitious. The weights that are applied to each of the criterion – given that at least one criterion is monetary – are 'de-facto' estimates of the 'prices' of each criterion.

Put simply, MCA is designed to avoid the most severe limitations of CBA but in doing so encounters problems that are even more severe.

Other, simpler, tools have been advanced as alternative mechanisms for decision making. These generally rely on the measurement of 'indicators' to represent broader social concerns. One example is the 'carbon footprint'. Alternatives under consideration are assessed in terms of the amount of carbon they emit into the atmosphere. The decision rule is that the option delivering the least carbon (and by inference, the one that is least likely to precipitate global climate change) should be selected. Another example is the 'food miles' criteria (choose the option that involves the consumption of food that is transported the fewest kilometres from source to table) or the 'ecological footprint' (choose the option that involves the use of as little land as possible around the place of consumption).

All of these methods fall short of requirements because they focus on the impacts of options in terms of a single resource. For example, making a choice on the basis of carbon output alone ignores costs to society through the use of resources other than the upper atmosphere as a carbon sink and ignores the creation of different streams of benefits entirely. Contradictions soon emerge across these various indicator rules. For instance, growing bananas in Moscow may provide Muscovites with low food miles food but the carbon footprint involved in operating the required greenhouses though the winter would no doubt be more significant than that associated with the airfreight from the tropics.

None of these alternatives are able to provide the conceptual rigour of ECBA. However, some other 'variants' of ECBA have been developed to cope with information inadequacies.

An example is the use of 'threshold value analysis' (TVA). Where non-market, environmental or social value estimates are not readily available, the gap that exists in an ECBA can be formatted to provide a decision rule. What is required is for the analyst to proceed through the phases of a CBA until all available monetised impacts are incorporated into a net present value (NPV) figure. For example, it may be found that the NPV of a research project, excluding its positive impacts on the survival of an endangered species, is -$4m. In other words, without the endangered species benefit incorporated, the research costs society $4m. This figure in the TVA is considered to be the 'threshold' the value of the endangered species benefit would need to exceed if the research was to provide a net benefit. Decision makers then have a value context in which to consider the endangered species benefit. They may be able to make a judgement call with that context or they may call on studies done on the values of endangered species protection in other contexts to provide more background information. TVA therefore provides a contextual framework for decision making rather than any further information per se.

Another technique takes this approach a step further. Known as the ‘safe minimum standard’ (SMS) approach, it looks at the un-estimated non-market values in a CBA and raises the prospect of them involving irreversible consequences. In other words, if a research project had the potential to drive an endangered species to a level of threat from which it could not survive, it would be considered to have the potential to breach a SMS. Hence, the SMS approach requires an assessment of the prospects of irreversible outcomes being precipitated. However, all the approach requires when such a ‘standard’ is approached is for a more considered analysis of the choice to be made. This is because the SMS rule requires these standards not to be breached unless the costs of doing so are unbearable. Put simply, the rule permits standards to be breached when avoiding them is ‘too costly’. What defines too costly has not been specified but the implication – ironically - is that a CBA of breaching the standard is required.

The chief implication of this review of alternatives is that ECBA is the preferred technique of integration. However, for it to perform the task adequately, the non-marketed environmental and social impacts of research outcomes must be estimated in ways that are robust and accurate. Furthermore, the use of ‘welfare weights’ to incorporate equity concerns must be facilitated through the application of sound methods to generate estimates. In the following sections, techniques to estimate non market values and welfare weights are described and applications in developing country contexts discussed.

5. Estimating Non-market Environmental and Social Values[6]

Economists have developed two types of non-market valuation tools. The first type rely on observations of peoples’ behaviour in the buying and selling of goods and services that are somehow related to the non-marketed good or service of interest. These techniques are called the ‘revealed preference (RP) techniques’. The second type involve asking people questions about their preferences for the non-marketed good or service of interest, usually through the construction of a hypothetical scenario. These are known as the ‘stated preference (SP) techniques’.

5.1 Revealed Preference techniques

There are three widely applied RP techniques. These are the Travel Cost Method (TCM), the Hedonic Pricing (HP) technique and the Production Function Method (PFM). Because they rely on observations of peoples’ behaviour when they have direct contact with a non-marketed good or service, their application is limited to the estimation of direct ‘use values’.

5.1.1 The Travel Cost Method

[6] Bolt, Ruta and Sarat (2005) is a handbook for environmental value estimation produced by the Environment department of the World Bank. It provides a useful outline of many of the techniques set out in this section. A source of case studies in environmental valuation from developing country contexts is Pearce, Pearce and Palmer (2002)

The TCM is used to estimate the values people place on the use of sites that for a range of reasons attract visitation. Such sites may be areas of environmental significance, providing scenic beauty or access to species, heritage significance, such as historical sites, or cultural significance, including pilgrimage destinations. It may therefore be of interest when a research project's outputs are predicted to cause impacts on the level of use of such a site. For instance, if the implementation of a catchment management research project's findings will result in improved downstream water quality such that recreational swimming becomes possible for the residents of nearby cities, the TCM may be implemented to estimate the value associated with the resultant recreational benefits.

At the heart of a TCM application is the estimation of a 'trip generation function'. This is the relationship between visitation frequency to a site and the distance people travel to the site. Hence, the expectation is that people living further from the site (with higher costs of travelling to the site) will visit less frequently. This function is estimated using data collected at the site. In order to develop a simple demand function for the site (in the absence of any market for entry to the site) a simulation exercise is performed. By assuming that people will react to an entry fee in the same way as they react to travel costs, it is possible to estimate the number of visitors to the site given different hypothetical entry fees. By simulating different fees and observing the resultant level of visitation, the demand curve can be estimated. The consumer surplus (the net benefit to the visitor) per visit to the site can then be derived. This figure can then be integrated into the ECBA of the research project, usually with an adjustment for the probability that the research project will generate the change in visitation rate.

The TCM is widely applied and accepted as standard practice in the developed world, particularly in the USA where a bank of 'standard values' for days of different recreational experiences is available. Its reliance on the observed behaviour of people gives it methodological rigour. It is not without application challenges. For instance, dealing with visitors who have multiple destinations within one journey and the treatment of time as a cost of travel are two complexities. However, there is widespread experience in dealing with these challenges.

Experience in the developing country context is not as wide spread although the number of applications is growing. Much of the developed country TCM literature focuses on hunting activities or the value of visits to recreational areas such as National Parks and forest reserves. In the developing country context, studies such as that of Gurluch and Rehber (2008) are beginning to feature in the international literature. They use the TCM to estimate the value enjoyed by visitors to a Ramsar listed wetland in Turkey, coming to the conclusion that the recreational benefit is greater than the investment and management costs of the site

5.1.2 The Hedonic Pricing Technique

HP can be applied to estimate the value of non-marketed characteristics of consumption activities where those activities involve marketed goods and services. Its most widespread use has been in the estimation of the non-marketed attributes of real estate purchases. For instance, proximity of urban areas to farmland may carry with it a price discount because of agriculturally sourced odours or exposure to toxic pesticides used on the adjacent crops. The HP technique uses the relationship between the extent of this type of exposure and the price of property to determine a monetary estimate of the costs to the urban people of the odours/chemical exposure. Hence, if a research project is able to produce outcomes involving reduced odours or use of chemicals, these costs so avoided would be become benefits of the research. Other applications have involved labour markets where wages are, in part, determined by non-marketed environmental factors. For instance, the cost to labourers of chemical exposure on the farm may be reflected by the wage premium they seek in order to be compensated for the risk they take. Saving such costs might be the outcome of research investigating chemical use strategies.

Central to the HP approach is the econometric estimation of the relationship between a product or service price (property, labour etc) and all of the factors that are causative. This involves an intensive data collection exercise given the wide array of factors that influence price determination. For instance, the price of houses may be affected by the size of the house, its distance from transport, its construction material etc, as well as numerous environmental, non-marketed characteristics such as noise levels, access to views, odour exposure etc. The estimated coefficient associated with the non-marketed environmental characteristic is the marginal contribution made by that characteristic to the overall price. It represents the marginal willingness to pay for more (or less) of that feature and as such can be used as a benefit estimate. Where the buyers are heterogeneous in their socio-economic characteristics, this estimate requires further refinement. However, for most applications, the initially estimated coefficient is sufficiently robust for integration into relevant ECBAs.

Data requirements for the application of HP limit its application. Markets must have sufficient numbers of transactions within periods of time to be able to estimate price models with very large numbers of independent variables. High quality transaction records must also be kept either by the private or the public sector for the technique to be practicable. Furthermore, price restrictions imposed by governments cannot be a feature of the market because of their distorting influence. Urban housing markets are typically the target of this type of analysis because of the volumes of trades but even they pose problems in developed country contexts because of factors such as rent control and low income housing support programmes. For instance, Mahan, Polasky and Adams estimated the value of wetlands in an urban setting using the technique

In the developing country context where consistently recorded data are scarce and market distortions are common, the use of HP has been restricted. However, Shanmugan (2000) used labour market data to estimate the values of injury risks, including death, in India.

5.1.3 The Production Function Method

The PFM is useful in the estimation of values associated with non-marketed environmental inputs into production processes where a marketed product is the result. For instance, if water is a ‘free’ resource input into a farming system, the PFM can be used to estimate its value to farmers in the absence of any price. Hence, the epIAs of research projects that have as a goal the improvement in the quality or quantity of a non-marketed input into a farming system, would be advantaged through the application of the PFM.

Applications of the PFM involve the econometric estimation of the relationship between the inputs into a production process and the outputs. Typically in a farming application, data on the level of land, labour, capital, seed, fertilizer, etc are collected along with production figures. Specific functional forms are fitted to the data sets and the contribution of each input to the output (the marginal physical product) is calculated. By multiplying this by the price received for the output the value of the marginal physical product can be calculated and this provides an estimate of the contribution the input provides to farm revenue. At a zero price for a non-marketed input, it also shows how much the farmer would be willing to pay for the input. As such, it provides an estimate of the value to the farmer of access to the input.

A research project may be focused on strategies that would increase the bird populations in a wetland. If these birds prey on insects that in turn create crop damage on nearby farms, the research project could claim as part of its epIA, the benefits of the birds as an input into the farmers production process (an 'ecosystem service'). A study of the relationship between the bird input and the crop output through to the estimation of the value of marginal physical product would provide the necessary information for the epIA.

Applications of the PFM require extensive data on the inputs and outputs of specific farming systems. These data are seldom available 'off the shelf' and so require in-the-field collection exercises. It is therefore important for this type of work to be integrated into the broader research effort rather than being left to the tail end of a project when there will inevitably be too little time or resources to achieve the benefit estimation goal.

A study of the value of water to coffee producers in the Central Highlands (*Tay Nguyen*) of Vietnam (Cheesman and Bennett 2008) is illustrative. Growing competition for the scarce groundwater resource between agriculture and urban demands has brought into question the current allocation processes. The study involved the collection of input (including irrigation regimes) data and coffee output information. It was found that at the current levels of irrigation water application, the marginal physical product of water is zero. That is, so much water is being applied that the additional output being achieved by the last unit of input is zero. The study also enables policy makers to look at the value of water to farmers when less in being applied. This assists the water supply authorities to judge the optimal allocation of water across the alternative users but also demonstrates the value of water to farmers where there is currently no market for groundwater. Research into water saving technologies or management practices can be better assessed in the light of such benefit estimates.

The Cheesman and Bennett study took over two years to complete given difficulties associated with a relatively complex and large scale data collection exercise in an undeveloped region of Vietnam. However it does illustrate the potential for the PFM to deliver estimates of non-market values that are directly applicable to epIA.

5.2 Stated Preference techniques

RP techniques are limited to the estimation of the values of environmental goods and services which involve people having direct contact. These are the so-called 'use values' of the environment. Where people enjoy a broader set of values from the environment, including passive use and non-use values, the RP techniques are inadequate. It is in these circumstances that stated preference (SP) techniques are of importance to the environmental valuation process and hence the extension of CBA to encompass such non-marketed benefits and costs. SP techniques rely on people as respondents to questionnaires stating what they would do under various hypothetical circumstances involving changes in the supply of environmental goods and services. The most widely used SP technique is the Contingent Valuation Method (CVM) whilst more recently emerging techniques include Choice Modelling (CM) – otherwise known as Choice Experiments (CE) – and Contingent Behaviour (CB).

5.2.1 The Contingent Valuation Method (CVM)
Early version of the CVM simply involved survey respondents being asked the amount of money they would be willing to pay for the provision of more of an environmental good or for reductions in the supply of an environmental bad. While this type of questioning is consistent with the concepts of benefits and costs that underpin ECBA, it was found wanting in terms of its 'incentive compatibility'. Put simply, the direct, open-ended CVM question did not give respondents the incentive to answer accurately. Subsequent research over the past three decades has been directed at improving the accuracy of the CVM in the light of this and a number of other potential biases in responses.

Most recent versions of the CVM involve binary choices in a referendum style format: survey respondents are asked if they are willing to pay a pre-assigned amount for the environmental change in question. Furthermore, a provision rule is applied (the environmental good will only be provided if more than 50 per cent of respondents agree to pay) and the (hypothetical) scenario is described as realistically as possible to ensure that respondents believe that their answers will have an impact on policy development. With these features in place, CVM applications are deemed to be incentive compatible.

In the research evaluation context, CVM is of significant potential because of its flexibility. It is able to generate estimates of benefits and costs falling outside the market across a wide spectrum of contexts. Hence, in the context of research epIAs it has the potential to fill a wide range of value estimate gaps.

The use of the CVM has become widespread through the developed world. Its flexibility in being able to deal with a wide range of contexts and to generate estimates of both use and non-use values has given it strong applicability. Countering this has been a suspicion amongst some economists that its capacity to avoid bias is limited. Furthermore, some environmentalists have been wary of its application for more philosophical reasons: the environment should not be valued in monetary terms. Economists working on the CVM have been at pains to test the validity of value estimates with considerable success. Furthermore, environmentalists concerns about monetary valuation can be readily assuaged through demonstration that even without explicit values, any choice involving trade-offs between environmental conservation and development is underpinned by an implicit valuation.

European Union and UK environmental policy now specifically mandate the use of the CVM. In the US where much of the development research into CVM has occurred, CVM was approved as a technique for estimating the value of environmental damages sought under court actions.

Experience in the developing country context is more limited but has been growing rapidly in the past decade particularly through numerous research initiatives including those of the Environmental Economics Program South East Asia (EEPSEA) and the South Asia Network of Development and Environmental Economists (SANDEE). The focus of these initiatives has been on a wide range of applications including forest protection, health impacts and air pollution. While little has been done to design CVM applications to research initiatives directly, the environmental – and social – values estimated have relevance to the outcomes of CGIAR Centre research investments.

An illustrative example of an application is found in Flatley and Bennett (1996) who used the CVM to estimate conservation values of forests in Vanuatu. The technique's versatility is demonstrated by Whittington, Pattanayak and Kuma (2002) who use it to investigate the benefits of a privatised water supply system in Kathmandu, Nepal. The latter paper is drawn from the EEPSEA data base of studies, many of which have utilised the CVM. The same is true of SANDEE studies.

5.2.2 Choice Modelling

While CVM applications involve respondents selecting between the 'status quo' alternative and another that proposes environmental change at some cost, CM applications provide respondents with more choice questions involving a greater variety of options. Fundamentally, a CM questionnaire asks respondents to make a sequence of choices between multiple future possible outcomes where one option is always the 'status quo'. The future outcomes are described by way of various 'attributes' taking on different levels across the multiple choices. One of these attributes is a monetary cost. By observing the choices respondents make across the multiple questions, it is possible (statistically) to observe the trade-offs they make between the attributes when making their choices. Because one of the attributes is money, these trade-offs can be translated into a willingness to pay for the attributes, even though they are non-marketed.

Hence, a CM application is capable of generating estimates of benefits and costs associated with a range of attributes associated with a resource use choice. These may be environmental (the value of an extra hectare of protected forest, the reintroduction of a species of bird, an additional kilometre of stream bank vegetation in good condition, etc) or social (the value of a reduction in the number of days sickness each year due to pollution, an extra health care centre, increased public transport services, etc).

CM applications have become numerous in the past decade. Its growing frequency of use is largely due to its ability to produce estimates of the benefits of multiple scenarios of resource use from one study. This is in comparison to the CVM which can only produce one value estimate from each application. CM has thus added greater flexibility. It also has the capacity to avoid some of the bias problems faced by the CVM. It is for instance able to provide a frame of reference for respondents within its own questioning structure and its complexity of combinations of multiple attributes makes strategic answering on the part of respondents much more difficult and so less attractive than 'truth-telling'.

The growth of popularity in the use of CM is notable particularly in the UK and Europe where it is now the valuation tool of preference in most environmental policy development applications. Birol[7] and Koundouri (2008) set out a number of European examples.

Developing country applications are also on the rise, as demonstrated by the forthcoming publication of Bennett and Birol (forthcoming), an edited volume that sets out numerous CM applications in developing country contexts including nature protection, public service provision and food safety.

The CM application detailed in Wang *et al* (2007) is illustrative. The context of the study was an evaluation of the Chinese Government's investment in the Conversion of Cropland to Forest and Grassland Program (CCFGP) where many of the goals involved (non-marketed) environmental improvements. The CM targeted the estimation of the benefits enjoyed by people resident in the Loess Plateau where the CCFGP has been targeted and people living in Beijing. The CM questions asked respondents to choose between options for the future of the CCFGP. Continuation of the Programme, and the continued provision of environmental goods such as diminished frequency of sand storms, increased water quality and greater biodiversity, was predicated on the financial contribution of the respondent.

The values so estimated, such as the willingness to pay for one less day of sandstorms, were then included into an ECBA of the overall CCFGP. Similar application of the estimates could be made in the evaluation of, for instance, research work on improvements in grazing management in Mongolia, or the introduction of new cultivars for stabilising fragile soils on the Plateau.

Other CM applications in developed nations have expanded the attributes included in natural resource management studies to include both environmental and social attributes. Bennett, Whitten and van Bueren (2004) detail two studies that estimated the wider Australian society's values for maintaining the viability of rural communities threatened due to agricultural land being converted to conservation purposes. Hence in the choice sets presented to CM survey respondents, the attributes included environmental features supported be land use conversion such as area of wetlands, remnant vegetation and length of rivers in good ecological health as well as the number of people leaving affected districts.

A similar approach was taken by Do and Bennett (forthcoming) in their study of wetland restoration in the Mekong River delta in Viet Nam. Hence, the technique has demonstrated its capacity to provide estimates of both environmental and social non-marketed benefits and costs.

5.2.3 Contingent Behaviour

Whereas Choice Modelling involves survey respondents choosing between alternative future management options which would involve them paying more, CB seeks a response in terms of future actions. Frequently, CB applications propose to respondents different potential prices for a good or service which is currently not marketed. They are asked to predict their behavioural response to the change: if the

[7] Ekin Birol is a staff member at IFPRI.

price was ‘x’ how much would you consume? If it was ‘y’ how much would you consume? etc.

In this way, an ordinary demand curve for an otherwise non-marketed good can be constructed and the normal processes of estimating benefits and costs employed.

With the focus of the questioning in CB taken away from a monetary response and placed on a behavioural response, there is less emphasis on the issue of strategic behaviour although the potential of bias still remains. The practicality of the CB approach also has some advantages in that there is a benchmark of behaviour that can be used to anchor responses. In other words, we can observe what people do currently. From that current behaviour, CB questions can be focused on change that would result from proposed circumstances.

Some applications of this style of valuation in the developed world have involved developments from the TCM. People are asked at a recreation site what they would do if the price was changed or the recreational good itself changed in character. However, the technique is yet to be widely applied in a broader range of contexts, possibly because again the technique is limited to applications where direct contact with the resource is involved.

Similarly, developing country applications are even more limited. The work of Cheesman, Bennett and Son (forthcoming), again in the context of water allocation in the Central Highlands of Vietnam is illustrative. People living in the regional capital city of Buon Ma Thout were asked questions about their current water use and their answers were verified against a current water bill. Subsequently, they were asked how their water use patterns would change if the price was changed to a specific level. Taking an inventory of their water use provided a real base for the hypothetical question. Across the whole sample, using a range of different water prices, an aggregate demand curve for water was constructed and benefits so estimated using the standard consumer surplus concept. This estimate was then used to provide the necessary information for water authorities to consider the trade-off between urban and rural water use. However, the value estimate is also suitable for inclusion in epIAs of research that was targeted at improving water use efficiency in agriculture: water freed from rural use due to the research innovation would be valued at the benefit enjoyed through its use by urban residents.

6. Incorporating equity issues into epIAs

The techniques outlined in the previous section are useful in the preparation of epIAs that extend beyond what has been the norm for inclusion. Specifically, they provide estimates of non-marketed environmental and social benefits and costs in a form that is consistent with the principles of welfare economics that underpin CBA. Including such estimates extends the scope of the analysis of the economic efficiency consequences of investments in research activities. Fundamentally, they allow more elements to be included in the aggregation of utility impacts created by research investments.

While this expansion of the scope of epIAs is useful to a more complete analysis of alternative investments, and to the checking that investments are delivering positive contribution to society's well being, it does not address concerns regarding the distribution of the utility impacts across society. Hence, it considers that one US dollar is of equal importance to the well-being of a tax payer in England where the funding for a research initiative may be sourced, as is to a farmer in Ethiopia who will enjoy the benefits of the research's outputs. Similarly, it considers the welfare contribution of one US dollar to be the same for people in the current generation (who fund the research) as it will be for people of our grandchildren's generation (who will benefit from the long term environmental improvements a research project may generate).

To make progress in considering how concerns arising from the omission of this type may be incorporated into epIAs of research investments, it is useful to make the distinction between the terms 'utility' and 'welfare' as they are used in the economics literature. First, utility is defined as the well being of the individual, as seen by that individual. The simple summation of estimates of changes in utility forms the crux of conventional CBA. Second, welfare refers to the well being of society as a whole as seen by society as a whole. Hence, the simple (unweighted) summation of the utilities of individuals as carried out in conventional CBA does not necessarily amount to a calculation of the change in society's welfare because the view that society takes of its well being may not be the same as that taken by its component individuals.

If society is structured around a Benthamite philosophy, the individual's view of welfare reigns supreme. Hence the summation of individual utility changes to create a measure of change in overall social welfare remains unweighted. However, at the other extreme – under the Rawlsian philosophy – only the utility of the least well-off person in society matters. Their utility is given a weighting of one and all other utility effects are weighted at zero in the summation of utilities to create a measure of welfare impact. This is because Rawls considered that the consideration of welfare impacts should be made from behind a 'veil of ignorance' as to who each individual will be once the resource re-allocation decision is made. The risk-avers position is for people to judge on the basis of their being the worst off person.

The reality of modern society is that the functional relationship between the utilities of the individuals (as represented by the estimates of benefits and costs in conventional CBAs) lies somewhere between the Benthamite and the Rawlsian views. The issue then is to determine the magnitudes of the weights that need to be applied to the individual utility changes making up the total change in social welfare. Ideally, all individuals affected by a research project would have an assigned weight indicating the relative importance of their utility to social welfare. However, the more likely approach is to estimate the weights associated with changes in the utilities of key groups of those impacted. For instance, developed country taxpayers, developing country farmers, urban dwellers in developing countries; both in the current generation and in future generations.

Generating such estimates has proven to be a difficult task for economists. They have resorted to the value judgements of decision maker, or even of themselves, or observed the implicit weightings inferred by past decisions. These methods are however fraught with dangers associated with rent seeking in the assessment task.

Preferable would be a method that would provide weighting estimates that come from society itself. To this end, some preliminary experimentation has been carried out with the use of Choice Modelling to estimate these 'welfare weights'.

Scarborough and Bennett (forthcoming) provided survey respondents with choices between environmental projects that differed only in so much as they were beneficial to three different groups of people within society: those over 50, those between 25 and 50 and the young. In providing their choices across a sequence of choice sets, respondents showed their willingness to trade off between the utilities of the three groups of people within society. This willingness represents the weights that the respondents, on average (as randomly selected representatives of the wider society), place on the utilities of the groups in making up aggregate social welfare. It was found that society did not hold Benthamite views – the weights were significantly different from each other – but nor did they adopt a Rawlsian philosophy as all the weights were significantly different from zero. Rather they held weights that favoured younger people over older.

The Scarborough and Bennett result is illustrative of the potential for CM to generate utility weights across different sections of society. The work was carried out as a trial of the technique in an application context quite different from previous contexts. Similar studies to estimate utility weights of greater policy significance have now been shown to be possible.

7. Potential applications

Many of the epIAs carried out for CGIAR Centre research projects have stated that their analyses have understated the benefits of research because of an inability to extend the conventional CBA approach to incorporate non-marketed environmental and social impacts. Extending those analyses to create more complete epIAs will require a number of extra steps.

Initially, it has to be recognised that all the challenges faced in conventional CBAs must also be faced in handling environmental impacts. In particular, the issues of defining the counterfactual, the determination of the uncertainties of implementing the research results and attributing changes to the results of the research work must be tackled. However, two additional key tasks are required[8].

First, the environmental consequences of the research must be predicted. This involves the bio-physical modelling of the environmental consequences. Frequently, this step has not been part of the initial research work and may not be a trivial exercise. It is a step that parallels the type of modelling that is required to forecast, for instance, the crop yield improvements that result from the development of a new crop cultivar.

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[8] These two tasks are consistent with the principles of strategic guidance for epIAs provided by Walker et al (2008) and act to fill a gap in those guidelines given that they do not provide any direction for the incorporation of non-market values.

However, it is usual for that type of forecasting to be a primary component of the research work itself. Environmental (and social) impacts tend to be 'externalities' of the research work and so do not command the primary interests of the researchers. It may also be the case that the researchers do not have the technical competence to devise the bio-physical models required. For example, those developing lower water using crops may not be skilled in the development of hydrological and ecological models needed to forecast the consequences for river health.

Hence the extension of conventional CBA to incorporate environmental and social impacts will require the development and application of this style of bio-physical modelling. Importantly, the type of bio-physical modelling involved is stochastic. Just as risk adjusted values for financial impacts are now standard practice in CBAs, so too must the accounting for risk (and uncertainty) become a part of the estimation of non-marketed environmental benefits. Increasingly, Bayesian techniques are being used within bio-physical models to account for imperfect information regarding the future outcomes of changes in natural resource management, yet their linking with economic valuation models is yet to become widespread even in developed nations.

The second key additional task is that of estimating the values of the predicted bio-physical impacts. This is the province of the techniques outlined in Section 5. Importantly, the bio-physical projection studies required for Stage 1 of the extension to CBA must be consistent with the valuation process undertaken in Stage 2. Essentially, this requires that the bio-physical impacts being observed or projected are impacts that are consistent with peoples' views as to what are benefits and costs. That is, it is no use for instance, projecting levels of dissolved oxygen in a water way. That is a parameter of change that carries no value to most people. However, levels of dissolved oxygen will in turn impact on fish populations, a parameter that does impact on peoples' well-being.

The logic of the CBA extension process therefore involves two stages:

1. What are the impacts on the environment of the research outcomes?
2. What values does society place on these impacts?

The review of CGIAR epIAs set out in Section 2 demonstrates that there is little by way of existing information that goes toward the taking of either of these two steps. Non-market valuation studies have not been performed, but nor have studies of past or projected environmental conditions been conducted.

Furthermore, to extend the CBA framework to incorporate equity as well as efficiency issues, an additional step would be required and that is the estimation of the utility weights held by society for the various groups within society that experience the utility changes.

It is clear that these additional steps are not trivial in terms of their intellectual requirements, the time required for them to be taken as well as the resources. Furthermore, there is little by way of past CGIAR experience to assist in avoiding either of them. As was detailed in Section 2, none of the existing epIAs carried out within the CG system have either predicted the environmental outcomes of research investments, nor have they estimated non-market values in a rigorous way. Indeed, because many of the environmental impacts of research activities are likely to involve long time lags before evidence of change will be available, *ex post* observation of change or even 'ground truthing' of environmental change modelling results are largely unavailable. So while the research investments under investigation may well be *ex post* their environmental consequences are mostly *ex ante.* Even in developed country applications, most projections of environmental impacts are either modelled *ex ante* or are based on 'expert opinion' (see Box1).

There are some potential approaches that could be taken to reduce some of the barriers to application. First, once a number of base case studies of non-market values have been established, the prospects for 'benefit transfer' will become more attractive. Benefit transfer (BT) involves the use of already estimated values from 'source studies' in the circumstances of the situation under current investigation – the 'target study'. Given appropriate caution with regard to similarities across the source and target studies, the BT approach can significantly reduce the costs of incorporating value estimates.

A growing portfolio of bio-physical models predicting environmental consequences may offer similar potential. The increased interest amongst the research community – donors and scientists – in the environmental 'side-effects' may bring a heightened interest in mainstreaming the carriage of these bio-physical models within the research projects themselves.

Box 1: Developed Country Applications

Most applications of non-marketed, environmental valuation techniques in developed country contexts have focused on providing information for resource use policy determination rather than research evaluation.

The investigation of future management options for the River Red Gum forests along the Murray River in Australia, undertaken by the Victorian Environmental Assessment Council (VEAC)[9]*, involved the incorporation of non-market benefits associated with environmental improvements and costs of foregone duck hunting opportunities into a CBA. A specifically commissioned Choice Modelling application provided the environmental values and the duck hunting costs were 'transferred' from a Travel Cost Method study previously conducted in South Australia. Projections of the environmental and hunting impacts of the various management strategies investigated by VEAC were generated through consultations with experts. Hence, no formal modelling of the bio-physical consequences of the strategies was conducted for the study.*

More sophisticated modelling of the biophysical impacts formed the basis of Kragt and Bennett's (2009) study of the management of the George River catchment in Tasmania, Australia. A formal Bayesian Network model was constructed using both established modelling results and expert opinion to generate probabilistic relationships between management strategy 'cause' and natural resource condition 'effect'. The values placed on these 'effects' by the residents of Tasmania were estimated using the Choice Modelling technique when they were not marketed. More conventional surplus estimation techniques were used for estimating the values

[9] See: http://www.veac.vic.gov.au/riverredgumfinal/BCA_Final_Report_2008_all.pdf

associated with marketed 'effects' such as changes in oyster production in the George Bay estuary.

Another modelling approach – called MOSAIC - was used by Mazur and Bennett (2009) to provide New South Wales, Australia Catchment Management Authorities with CBA of alternative natural resource management strategies. The approach combined a number of models used by the state government to predict the consequences of proposals for resource use change, particularly vegetation clearing, on key parameters of environmental condition. At a catchment wide scale, these aggregated models were supplemented with environmental benefit estimates from a Choice Modelling application and the financial and opportunity costs associated with resource use scenarios to create an objective function where the goal was to maximise the net present value of resource use. The model then used the simulated annealing process to develop the mixture of land uses that maximised the objective function.

[CG case studies removed]

8. Conclusions

By not including non-marketed environmental benefits and costs of its research investments into epIAs, component Centres and the whole CGIAR are ignoring potentially significant improvements in the net present values of returns on donor funds and possibly directing resources into areas of research that are less productive.

The 'technology' of non-market valuation has advanced considerably over the last decade and methods are now available to allow the integration of monetary based value estimates of environmental and social impacts into epIAs of research investments, at the project and/or programme level.

The implication of these developments is that extending conventional CBA to encompass non-market values is possible. There is no need to enter the conceptually dangerous waters of alternative integrative methods such as multi criteria analysis and other 'indicator-based' decision support tools. The problems of complexity in CBA that these techniques are often designed to overcome, have now been successfully tackled by the main stream of economic analysis.

Developments have also been made in estimating utility weights so that an equity adjusted social welfare function can form the heart of epIAs. This means that equity issues, both inter and intra generational can supplement the efficiency analysis of CBA.

Skill availability to undertake non-market valuation studies in developing countries is a limiting factor to implementing these techniques. Furthermore, their use is resource intensive due to the need for primary data collection. However, the prospects of 'benefit transfer' as a means of lowering application costs are good, but will require a bank of initial studies to be performed in order to generate a data base of source studies.

With such a wide array of 'conventional' or financially based epIAs already undertaken by the CGIAR and its Centres, there are many opportunities to develop supplementary studies that would convert them to ECBAs. The potential of adding the necessary steps to allow for environmental value estimation to scheduled epIAs is also real and gives the chance of starting to build a portfolio of value studies and hence the core of a benefit transfer data base. Integrating these steps into future epIAs and indeed into future research initiatives will also offer the potential for cost savings.

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