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INCLUSION OF ENVIRONMENTAL AND HUMAN HEALTH IMPACTS IN AGRICULTURAL RESEARCH EVALUATION: REVIEW AND SOME RECENT EVALUATIONS

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This is a summary of a paper presented at a workshop on Integration of research evaluation efforts of ICRISAT with National Agricultural Research Systems and other International Research Institutions: 14–16 December 1994 at ICRISAT, Hyderabad, India. The full version of the paper can be obtained by writing to the following address: Economic Evaluation Unit, Australian Centre for International Agricultural Research (ACIAR), GPO Box 1571, Canberra, ACT 2601, Australia.

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CONTENTS

ABBREVIATIONS

ACIAR: Australian Centre for International Agricultural Research
ICRISAT: International Crop Research Institute for Semi-Arid Tropics

1. BACKGROUND

1.1 Motivation for including environmental and human health impacts

The motivation for writing this paper is well expressed in the following words of Pearce and Warford (1993, p. 3):

> 'Most people are now painfully aware that pursuing economic growth without paying adequate attention to the environment—both built and natural—is unlikely to be sustainable: it cannot last. The issue though is how not whether to grow. Many disagree even at this level. They argue that limits to growth are set by the carrying capacity of the earth, particularly its capacity to receive more and more waste from the world's economic system. We share their belief in potential limits, even if humanity continues to discover new technologies. We differ from the anti growth school, however, in our belief that the limits can be avoided—that the world will not necessarily come to an end—if imaginative policies are devised and implemented.'

Inclusion of environmental and human health impacts in economic analysis is necessary to ensure that appropriate imaginative policies are devised and implemented at the global, national, sector and project levels. This paper focuses on including these impacts when evaluating projects and thus making more effective allocative decisions at the micro-economics level.

The starting point of this paper is an empirical application of welfare theory based on the economic surplus concept for use in *ex ante* and *ex post* evaluations of agricultural research projects. An example of such an application can be found in the monograph by Davis, Oram and Ryan (1987) and (Alston et al. 1995). Underlying this empirical application of welfare theory are the postulates by Harberger (1971), namely:

- that the competitive demand-price for a given unit measures the value of that unit to the demander;
- that the competitive supply-price for a given unit measures the value of that unit to the supplier; and
- that when evaluating the net benefits or costs of a given action (project, program, or policy), the costs and benefits accruing to each member of a relevant group (e.g. a nation) should be added without regard to the individual to whom they accrue.

The aim of the paper is to explore and discuss ways to include environmental and human health impacts in the research evaluation of agricultural projects.

1.2 Other methods for including environmental and human health impacts

It is important to note that there are many possible ways to tackle the problem of including environmental and human health impacts in research evaluation. Other approaches include (Graaff, 1993):

- approaches that do not require an explicit evaluation of costs and benefits;
- approaches requiring explicit evaluation of costs and benefits and the setting of certain standards;
- cost–effectiveness analysis;
- Lichfield's planning balance sheet;

- shadow project approach; and
- multi-criteria analysis and multi-goal programming.

Multi-criteria analysis is sometimes regarded as an attractive approach (e.g. Pelt 1993) because it can handle both qualitative and quantitative variables. However, it is a scoring model-based approach and as such has a number of problems because:

- it is too subjective and thus it is difficult to resolve conflicts between decision-makers with different philosophies and thus differing weights;
- some of the methods of assigning weights are difficult to explain and comprehend;
- in processes involving more than one decision maker, it is not possible to standardise the process of weight assignment;
- a different set of decision-makers may assign different weights to the same impacts;`
- sometimes the government, private sector agents or both are not willing to express their views on the relative priority of environmental and other objectives in terms of qualitative or quantitative weights (Pelt, 1993, p 259); and
- the rankings and other results derived from using scoring models can be wrong, unreliable and misleading.

Of course some of the variables that are of interest to decision-makers cannot be monetised. However, the long term aim is to have a system where most, if not all, of the impacts that are important to decision makers are monetised. In the short term, the second best strategy is recommended, that is monetise those impacts that are amenable to quantification and monetisation and describe those that are difficult to quantify, for example because of gaps in scientific knowledge.

For those impacts that are difficult to monetise, it is preferable to ask scientists and other experts to describe them in detail and use those descriptions to estimate the costs and benefits associated with various environmental and human health effects. This approach is preferable to asking for ranking of variables based on expert opinion.

1.3 Outline of the paper

This paper is about extending the empirical application of welfare theory to problems and projects with environmental and human health impacts. The rest of the paper is organised as follows. In section 2 the types of impacts that are often left out of cost–benefit analysis, but which need to be included in project evaluation are categorised and discussed in the context of ACIAR’s research programs. In section 3 the empirical methods available for valuation of environmental and human health impacts are discussed. In section 4 literature on project evaluations that have included environmental and human health effects is reviewed. Section 5 contains some concluding remarks.

2. Environmental and human health impacts in agricultural research

2.1 Types of environmental and human health impacts

The impacts that this paper is interested in fall in four main categories as summarised below.

	ON-SITE	**OFF-SITE**
Market	On-site, $E_{1,\ market}$	Off-site, $E_{3,\ market}$
Non-market	On-site, $E_{2,\ non\ market}$	Off-site, $E_{4,\ non\ market}$

- *on-site, market impacts (E_1)*

The on-site, market impacts are those that affect only one site, do not have downstream effects and can be evaluated using conventional markets. An example is soil mining, that is the loss of nutrients like carbon, nitrogen, phosphorous when farming systems that do not adequately replenish the nutrients are used. Soil degradation leads to impacts that include reduced soil depth, poorer soil structure, decreased aeration, and increased salinity. These effects are specific to the site that is affected, but they have intra-temporal as well as inter-temporal effects on the productivity of the soil. These impacts are reflected in declining yields of crops and can be valued using markets for the relevant crops.

- *on-site, non-market impacts (E_2)*

On-site, non-market impacts are those that affect only one site, but are not reflected in the market place. An example of such an impact would be the effect of slash-and-burn in some farming systems. Among other impacts, this practice affects biological diversity on the slash and burn site. However, this loss of biological diversity cannot be valued using conventional markets. Contingency-valuation techniques would be needed to evaluate such an impact.

- *off-site, market impacts (E_3)*

Off-site effects concern individuals and communities downstream from where the activity generating the impact is undertaken. In the soil degradation example, downstream effects include silting of reservoirs, rivers and irrigation canals; reduction in water storage capacity of reservoirs and irrigation capacity; rendering water more costly and/or increasing dredging costs for rivers and harbours.

- *off-site, non-market impacts (E_4)*

These are effects that affect downstream communities on sites different from where the impact originated and they will affect individuals of generations that succeed the one that undertook the polluting activity. The most important example of these impacts is atmospheric pollution. For example, the use of methyl bromide for soil fumigation may lead to the depletion of the ozone layer which, in turn, may have human health impacts on future generations.

2.2 Why include environmental and human health effects in project evaluation

The following are some of the reasons for including environmental and human health impacts in project evaluations:

- It is a reminder that the environment is not free, even though there may not be a conventional market for its services (Winpenny, 1991). The environment or natural capital encompasses stocks of non-renewable resources, such as oil, gas, mineral deposits, and renewable resources such as forests, fisheries and soil fertility. It also includes the biosphere's capacity to sustain human life and economic activities through, for example, provision of clean air, water and a limited capacity to absorb waste products (Amsberg, 1993).

- It helps redress the balance between quantifiable and non-quantifiable impacts.
- In the context of decisions based on cost–benefit analyses, valuing as many effects as possible and plausible narrows the field remaining for pure judgement (Winpenny, 1991).
- Quantification and valuation of these impacts can provide a more secure basis for policies to induce more careful use of the environment.

3 THE METHODS FOR THE QUANTIFICATION AND VALUATION OF ENVIRONMENTAL AND HUMAN HEALTH IMPACTS

Before environmental and human health impacts can be included in project evaluation they have to be quantified and valued in monetary terms. This section thus summarises the methods available for quantifying and valuing, in monetary terms, these impacts.

3.1 Methods for the quantification of environmental and human health impacts

There is no unique equation that can be used to quantify, in physical terms, the effect on output or human health of an environmental or human health impact. It is important to understand the source of the impact, the nature of an impact and the relationship between the impact and those variables that can affect current, potential or future producers and consumers. The best known attempts at quantifying the environmental impacts are concerned with soil erosion. This requires:

- the Universal Soil Loss Equation, which makes soil loss a function of rainfall erosiveness, soil, erodibility, topography and erosion control (Winpenny, 1991);
- erosion–fertility and fertility–yield equations;
- a fertility–yield equation that would link the changes in fertility to changes in crop yields; and
- the estimation of sedimentation rates, and the identification of sources of sediment to determine the downstream impacts of soil erosion.

However, each impact may need a different set of equations for quantification and may require a different set of equations depending on the agricultural problem.

3.2 Methods for valuing, in monetary terms, the environmental and human health impacts

This subsection briefly describes some of the methods available for valuing environmental and human health effects. These methods are described in detail elsewhere (see Winpenny (1991), Pearce and Warford (1993), Pelt (1993) and Bojo et al. (1992). Bojo et al. (1992) groups the methods as follows:

Methods that value impacts using conventional markets, namely:

- the effect on production approach or the production function approach;

- replacement approach;
- the preventive expenditure;
- human capital approach; and
- the Amsberg approach.

Methods which value impacts using implicit markets, namely:

- hedonic method—surrogate markets techniques; and
- travel cost method

Methods that value impacts using artificial markets, namely:

- the contingency valuation method—market creation techniques: and
- the shadow project approach and irreversibility.

3.3 Concluding remarks about evaluation methods

This section has summarised a number of methods available for the inclusion of environmental and human health impacts in project evaluation. The choice of valuation method is dependent on the type of impact.

In concluding this section the issue of selecting the discount rate is discussed. The issue has been extensively explored by Pearce and Warford (1993) and Pearce et al. (1990). The debate in the literature has been on: whether to use zero discounting; a market discount rate; a social discount rate, which is less than the market rate; or some other discount rate. Pearce and Warford (1993) correctly argue against zero or lower discounting rates because:

- there is no unique relationship between high discount rates and environmental deterioration;
- high discount rates may have favourable environmental benefits because high discount rates are likely to slow down growth and reduce the demand for natural resources; and
- it is unreasonable to require that all ethical and environmental concerns be accounted for by adjusting the discount rate.

The next section reviews literature that has included environmental and human health effects in project appraisal.

4 REVIEW OF PROJECT EVALUATIONS INCORPORATING ENVIRONMENTAL AND HUMAN HEALTH IMPACTS

4.1 An overview of studies

Lubulwa and Davis (1994b) summarises 35 studies that have included environmental and human health effects. The studies are listed by author, environmental and human health impact in project, country, commodity, and method used in the evaluation. Where they are available the net present value and internal rates of return are reported. The studies are obviously not exhaustive. Emphasis has been placed on studies involving those countries that collaborate on ACIAR projects or whose agro-climatic zones are similar to those of ACIAR's collaborators. A recent review of Australian studies can be found in Young (1991).

There has been extensive attempts to include environmental and human health effects in project evaluation. The most difficult are those attempts to include values of biodiversity-related environmental benefits, and other benefits and costs requiring the use of contingency valuation. The cost of establishing these values for inclusion in project evaluation may be prohibitive. For projects that need evaluating quickly, the time will not always be available to enable one to do a proper contingency evaluation study.

There are too many studies to discuss individually. However two studies are discussed in more detail in the ensuing two sub-sections.

4.2 Recent experiences with inclusion of human health impacts of fungi and aflatoxins in evaluations of ACIAR projects.

This subsection is based on Lubulwa and Davis (1994a) and describes the estimation of the social costs of five important potential impacts of fungi and aflatoxins in maize and peanuts, namely:

- quality deterioration in the agricultural products;
- spoilage of the agricultural products;
- mutagenic and carcinogenic effects on humans who consume aflatoxin-contaminated food over a long period;
- livestock health and productivity effects arising from the use of aflatoxin-contaminated feedstuffs; the emphasis is on increases in mortality rates and reductions in feed-to-weight conversion ratios for chickens, ducks, egg layers, and pigs; and
- the loss of export markets due to aflatoxin regulations restricting international trade in aflatoxin-contaminated grains.

The subsection describes the approach for estimating the social costs of these impacts and then estimates the social costs of aflatoxins in Indonesia, Philippines and Thailand. The social cost of the spoilage effects of fungi and aflatoxins is estimated using a product wastage economic model, and is equal to the surplus lost by producers and consumers as a result of fungal attack and aflatoxin contamination of maize and peanuts. The social cost of human health effects of aflatoxins is estimated as the value of lost productive capacity due to premature death and morbidity from aflatoxin-related primary liver cancer. The social costs to the livestock sector of aflatoxins are estimated as the change in producer and consumer surplus from the increase in costs to livestock producers as a result of using aflatoxin contaminated feed.

These social costs are summarised in A. The total annual social cost, in Indonesia, Philippines and Thailand, due to aflatoxins in maize in 1991 was about $A319 million. Indonesia incurred 62% of this cost, Philippines 27% and Thailand incurred 11% of the cost. The total annual social cost of aflatoxins in peanuts in 1991 was about $A158 million—Indonesia incurred 84% of this cost, Thailand incurred 13% and Philippines 3% of the cost. These estimates do not include the cost from loss of foreign markets which for these commodities in these countries are not expected to be substantial at this time.

Table A. Estimates of the 1991 annual social costs of aflatoxins in Indonesia, Philippines and Thailand (Mill. $A).

Sector	Impact of aflatoxins considered	Parameter used in social cost estimation	Maize
Grains sector	Product spoilage effects	Change in wastage rates and postharvest costs	$70.9
Households	Human health effects	The cost of premature death due to aflatoxin-related primary liver cancer	$112.7
	Human health effects	The cost of disability due to aflatoxin-related primary liver cancer	$63.8
Poultry	Increased mortality rates and reduced feed to weight conversion	Reduction in the unit cost of production when the aflatoxin content of feed is reduced	$28.9
Hen eggs	Increased mortality rates and reduced feed to weight conversion	Reduction in the unit cost of production when the aflatoxin content of feed is reduced	$6.6
Pig meat	Increased mortality rates and reduced feed to weight conversion	Reduction in the unit cost of production when the aflatoxin content of feed is reduced	$36.2
Total			$319.1

Source: Lubulwa and Davis (1994a)

4.3 Human health effects associated with the use of methyl bromide

This subsection discusses an evaluation of a project reported in Lubulwa et al. (1994). The human health effects associated with the use of methyl bromide arise from the fact that methyl bromide is a catalyst in the ozone depletion process. Ozone depletion leads to an increase in the amount of ultraviolet radiation reaching the earth. The medical literature indicates that there are three main human health effects of a chlorine- and bromide-related reduction in ozone. These are:

- sunburn (erythema), which is the most commonly encountered effect of ultraviolet radiation;
- skin cancer and accelerated aging—there are three major types of skin cancer: basal cell carcinomas (BCC), squamous cell carcinomas (SCC) and malignant melanomas;
- eye disease—the most common eye diseases caused by ultraviolet radiation are conjunctivitis, pterygium and senile cataracts; and
- immunological effects—an increase in exposure to ultraviolet radiation may reduce the skin's immune responses.

Lubulwa et al. (1994) used results from Barton and Paltridge (1992), evidence from the medical literature and unit costs of cancer related disease from Bryant et al. (1992) to estimate the human health impacts of methyl bromide and to include these effects in the cost benefit analysis of a research project on the replacement of methyl bromide. Table B and Table C show the results. These two tables indicate that where a project has impact on environment and or human health, then excluding those impacts in project evaluation may lead to socially sub optimal decisions with respect to funding of a project or not funding it.

Table B. The base case results without human health effects[a].
A project development assessment of PN 9046.
The replacement of methyl bromide in timber for quarantine fumigation.

Quarantine treatment	Description of option	Internal rate of return (%)	Net present value ($A, Thousands, 1994)
Thermal disinfestation (PN9406)	To kill insects, heat wood and maintain at 55°C for 5 minutes	23	19 378
Phosphine in cylinders	To kill insects use phosphine	Negative	–101 181
Phosphine with a pellets generator	Fumigant	Negative	–8 198
Sulfuryl flouride	Fumigant	b	b
Carbon bisulphide	Fumigant	Negative	–41 324
Carbonyl bisulphide	Fumigant	b	b
Methyl isothiocyanate	Fumigant	Negative	–18 501
Hydrogen cyanide	Fumigant	4	–2 110

a: The discounted human health benefits are equal to $A 41 370 and is the same for each of the potential replacement technologies because each one of the options under consideration is non-ozone depleting.
b: Not estimated—key data missing.
Source: Lubulwa et al. (1994).

Table C. The base case results with human health effects[a].
A project development assessment of PN 9046.
The replacement of methyl bromide in timber for quarantine fumigation.

Quarantine treatment	Description of option	Internal rate of return (%)	Net present value ($A, Thousands, 1994)
Thermal disinfestation (PN9406)	To kill insects, heat wood and maintain at 55 °C for 5 minutes	34	60 756
Phosphine in cylinders	To kill insects use phosphine	Negative	59 803
Phosphine with a pellets generator	Fumigant	28	33 179
Sulfuryl flouride	Fumigant	b	b
Carbon bisulphide	Fumigant	8	52
Carbonyl bisulphide	Fumigant	b	b
Methyl isothiocyanate	Fumigant	24	22 875
Hydrogen cyanide	Fumigant	29	39 267

a: The discounted human health benefits are equal to $A 41 370 and is the same for each of the potential replacement technologies because each one of the options under consideration is non-ozone depleting.
b: Not estimated—key data missing.
Source: Lubulwa et al. (1994).

5. Concluding remarks

In this paper we have reviewed the literature on including environmental and human health impacts in project evaluations. While there is a multiplicity of qualitative methods that rely on scoring and subjective judgements, we have argued that it is preferable to cost as many of these impacts as possible. This paper has suggested that while those modifications are non-trivial they are feasible for a number of projects which involve environmental and human health effects. The inclusion of these impacts can make significant changes to the net present values and the rates of return estimated for agricultural projects.

For example, Davis et al. (1987, p. 47) give a low priority ranking to groundnuts in Southeast Asia and globally. This ranking is due partly to the low levels of production of groundnuts in this region and the world compared to commodities like rice. The analysis above indicates that the importance of groundnuts and its ranking for research funding may be different when the human health impacts of aflatoxin-contaminated peanuts are included in the analysis. Thus, ignoring the human health impacts of consuming aflatoxin contaminated peanuts may distort the ranking of priorities between groundnuts and other commodities and may mean a socially suboptimal allocation of research funds.

Similarly, Tables 9 and 10 indicate that, if the project on replacing methyl bromide is assessed without considering the human health benefits of replacing the fumigant, the project may have negative returns to the research funds invested in a search for replacement technologies.

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