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Methods for Valuation of Impacts of Disasters – A Critical Appraisal

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Introduction

Valuation is the heart of environmental economics and is emerging as a very active and rapidly expanding field. In general environmental Valuation is concerned with the analysis of methods for obtaining empirical estimates of environmental values, such as the benefits of improved river water quality, or the cost of losing an area of wilderness to development. The most commonly used approach is based on the concept of Total Economic Value (TEV). The Total Economic Value is generally decomposed into three categories of value: (1) direct use value; (2) indirect use value; and (3) non-use value. The former two categories are sometimes collectively referred to as "use value.

The Direct use value is derived from goods, which can be extracted, consumed or directly enjoyed. It is also therefore known as extractive or consumptive use value.

Indirect use value is referred to as non-extractive use value, derived from the services that an environmental resource provides. A wetland, for example, acts as a water filter, often improving water quality for downstream users. This service is valued by downstream users, but does not require any good to be extracted/consumed.

Non-use values are defined as those benefits or welfare gains/losses to individuals that arise from environmental changes independently of any direct or indirect use of the environment. This category can be further subdivided into (1) option value and (2) existence value.

Option value is the value derived from maintaining the option to use a good or service at some point in the future, it is sometimes treated as a special case of use value.

Existence value can be defined in various ways. Most definitions however contain two main components: (1) pure existence values and (2) bequest values.

Pure existence values are intrinsic in nature, i.e. they represent a value that resides in something. Some possible motivations or rationales for the presence of such values include the preservation of, concern for, sympathy with, respect for the rights of, any other altruistic motives with respect to non-human beings. A number of pure existence values are related to ecological attributes.

Bequest value derive from our desire to preserve the environment for relatives and friends, and also for all other people living today and future generations, so that they may benefit from conservation of the environment

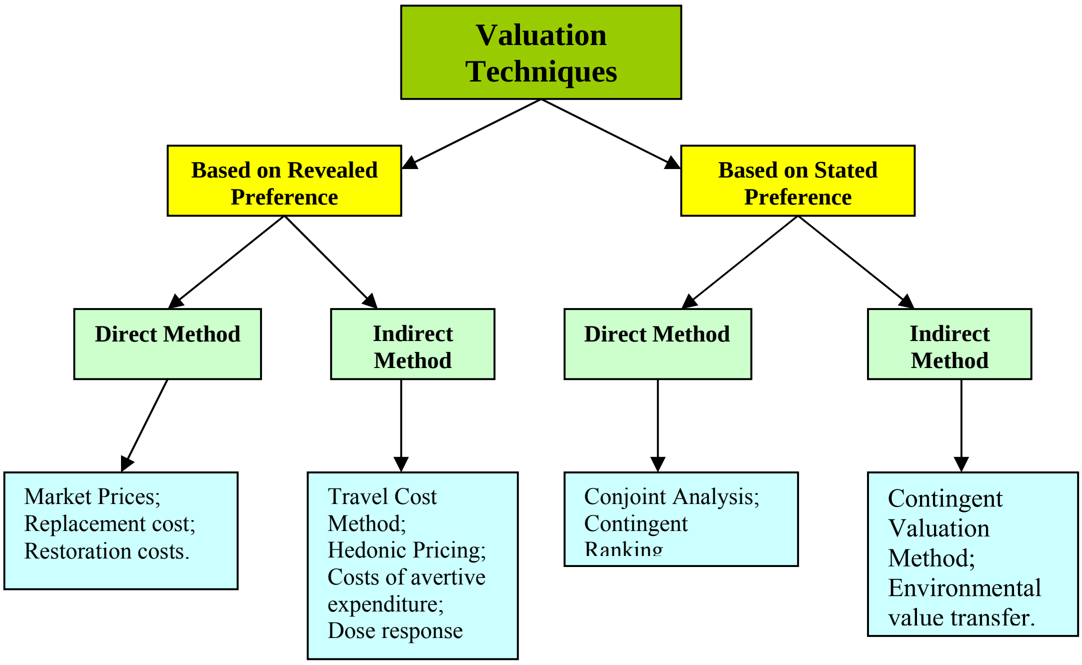
Total Economic Value = Direct and Indirect Use Values + Option Values + Existence Values

The methodologies applied to measure the total economic value associated with social, economic, health and environmental impacts can be classified essentially into market-based and non-market-based techniques. In general, environmental valuation techniques are of two types: (i) those based on revealed preferences or what human actually do in the markets; and (ii) those based on stated preferences or on humans behaviour in a hypothetical market. Both techniques evaluate human behaviour in economic terms but they differ in the sense that the former is based on actual or observed behaviour while the latter is based on potential or likely behaviour. All economic and environmental valuation techniques, whether market – based or non-market – based, measure the change in consumer/producer welfare (Banerjee, 1994).

On the other hand both revealed preference method and stated preference method can be divided into two major types of environmental valuation techniques: First monetary (Direct) valuation techniques - the techniques which directly determine the monetary values of individuals, place on receiving environmental amenities or avoiding environmental costs where survey methods are used to obtain valuation information directly from households. The direct methods seek to infer individual preferences for environmental quality directly through the questioning of individuals on their willing to pay (WTP) for a good or a service. These techniques include the Market Prices, Replacement/Restoration costs, Contingent ranking and conjoint analysis.

Secondly, non-monetary or physical valuation techniques (sometimes called indirect valuation techniques) measure physical environmental impacts themselves (e.g. tons of pollution emitted and the effects of such emissions on health), without directly placing a monetary value on those impacts. Indirect approaches rely on observed market behaviour to deduce values. They include the Travel Cost Method (TCM), Hedonic Pricing (HP) approach, Averting Behaviour method, Dose-response techniques, Contingent Valuation Method (CVM) and Environmental Value Transfer. This can be shown with the help of the following **Flow Chart 1**.

Flow Chart 1: Valuation Techniques



Objectives

There exists a wide range of above-mentioned environmental valuation techniques in theory some of which can be applied to measure the impacts of extreme events. The aim of the present paper is to provide a brief overview of different valuation techniques (Flow Chart 1) that can be used to assess disaster impacts comprehensively, systematically and consistently. **Section 1** gives a broad overview of the assessment procedure and the different steps involved. **Section 2** outlines the different types of impacts that disasters can have, including deaths and injuries, direct damage to physical assets, indirect losses in the flows of goods and services, intangible impacts, and repercussions for macroeconomic variables. **Section 3** will discuss how these impacts caused by natural disasters can be assessed. **Section 4** presents the critical analysis of different methodologies. **Section 5** will conclude the paper.

Section 1: Overview of Assessment Methodology

This section will briefly describe the different methodologies (Flow Chart 1) applied to measure environmental impacts.

Direct Approaches

Market Prices

The first and easiest valuation technique is to estimate the economic value of marketed goods and services as indicated by the market price adjusted for any distortion. Market prices are adjusted to allow for any subsidies, taxes and trade distortions, converting them to 'shadow prices' that reflect the true economic value to society. The use of market analysis techniques is outlined in Young and Haveman (1985). Studies of market transactions have been conducted in the South Western states of the United States of America (Saliba and Bush, 1987), and elsewhere in the world (Easter and Hearne,1995).

The impact of climate variation on US agricultural land values was assessed by Mendelsohn, Nordhaus, and Shaw (1999)[1] using a Ricardian approach. Market price of the output was used to estimate the actual expenditure. Aggregate farm value in each county was modeled as a function of climate, soil characteristics, and economic variables. Climate variations (inter-seasonal and diurnal) were included in addition to temperature and precipitation variables. Four empirical models, a cropland model and crop revenue model with and without climate variation terms, were estimated. Without climate variation, the results suggest that increased temperature is increasingly harmful to US farm values. The reduction in net annual income to US agriculture ranges from US$11.9 billion to US$39.8 billion (1982) with the cropland model, higher compared to the crop revenue model estimates. Increases in precipitation are mildly harmful based on the cropland model and inconsequential based on the crop revenue model. With climate variation, the results changed drastically suggesting that increased temperature and precipitation is beneficial except when temperature increase approaches 5 degrees Centigrade based on the cropland model. The benefits range from US$11.5 billion to US$28.4 billion based on the crop revenue model and from -US$3.7 billion to +US$3.9 billion with the cropland model. The study demonstrated the importance of changes in climatic variation to agriculture.

Replacement Cost/ Avoided Cost

The replacement cost estimates the benefits of an environmental asset based on the costs of replacement or restoration. The replaced or restored asset is assumed to provide a direct substitute for the original. The technique is used widely because the data required are usually readily available from actual expenditures or estimated costing. The underlying assumption is that the costs of replacement equal the benefits that society derives from the asset.

The avoided cost approach employs the notion of a household production function. Households can be viewed as 'producing' certain service flows or goods, such as drinking water, by combining various inputs, one of which is environmental quality. Thus a rural household might combine water taken from its well with purification equipment to produce water fit to drink. If water quality in the well declines then the household must increase its expenditure on other inputs to maintain constant the quality of its drinking water. Courant and Porter (1981) showed that under certain circumstances, this increase in 'averting expenditure' measured the welfare loss to the household of the decline in environmental quality. Other applications have been made to, for example, the value of reduced risks of car accidents (Blomquist 1979); the value of reduced risk of death as the

[1] Mendelsohn, R., W. Nordhaus, and D. Shaw (1999)

result of fitting smoke alarms (Dardin, 1980) and noise nuisance from airports (Layard, 1972).

Grigalunas, Opaluch, French and Reed (1988)[2] use the Natural Resource Damage Assessment Model by applying cost of replacement for Coastal and Marine Environments (NRDA/CME) to estimate the damages associated with spills of petroleum products and various chemicals in various quantities, times of the year, and locations. The model relies on a series of sub-models to estimate the physical impact on resources and the results of previous economic studies and market data to assign monetary values. Results generated in the study include the following:

For a 100 metric ton summertime estuarine oil spill in the Virginian province total damages to commercial and recreational fisheries of $41,737, damages to commercial invertebrates of $4,254, damages to birds and mammals of $1,058 for total damages of $47,051.

Additional estimates are for a range of spill sizes in the summer season in the Virginian province by location (marine or estuarine). These values range from $2,491 (estuarine) and $329 (marine) for a 5 metric ton spill to $426,668 (estuarine) and $312,377 (marine) for a 1,000 metric ton spill. Values for a 100 Metric ton spill vary by location and season from a low of $1,216 in the Arctic province in the winter to a high of $373,341 for a spill in the California province in the spring. Damages for the 100 metric ton baseline spill (summertime, estuarine in the Virginia province) would have varying associated damages depending on the shoreline type.

Contingent ranking and conjoint analysis

Contingent ranking is implemented in the same vein as contingent valuation except that the respondent has to rank order a large number of alternatives that comprise various combinations of environmental goods and prices. A random utility framework is used to analyse the data on complete ranking of all the alternatives. The statistical estimation is often performed using essentially a multinomial logit model of the rank order of the random utility level associated with each alternative. Implicit attribute prices or welfare change measures are then calculated from the parameter estimates of the logit model.

Instead of being asked to express a willingness to pay for or accept an environmental effect, respondents are asked to rank several alternatives in their order of preference. The alternatives include the environmental effect to be valued. The alternatives also include substitutes for the effect and some good with a money price ($P) to act as a threshold. The results from the ranking are interpreted as follows.

- If the environmental effect ranks below the threshold good, its value is less than $P.
- If the effect ranks above the threshold good, its value exceeds $P.

[2] Grigalunas, T.A., J.J. Opaluch, D. French, and M. Reed (1988)

In a simple extension to contingent rating, respondents are asked to rate the alternatives on a scale of say 1 to 100 according to their preferences. The rating of the environmental effect (RE), the rating of the threshold (RT) and $P are then used to value the effect.

Value = f(RE, RT, $P)

Applications of contingent ranking usually involve the ranking of large numbers of alternatives, which often appear similar to the respondent. The cognitive task of arriving at a complete ranking is very difficult. Furthermore, the estimated statistical models used are often poor representations and result in imprecise environmental values. Therefore, the contingent ranking method has met with a mixed response (Smith and Desvousges, 1986; Lareau and Rae, 1989).

Conjoint analysis is related closely to contingent ranking. Individuals participate in a conjoint analysis experiment to undertake a large number of ranking tasks. Each ranking task involves a small number of alternative options. Based on the collected data, a type of utility index model is estimated for each individual. Therefore, it differs from contingent valuation and ranking. Conjoint analysis has strong foundations in psychology and statistics, but has a rather less sound theoretical foundation in terms of individual choice theory. However, there is a trend for valuation studies to move away from reliance on purely statistical methods towards more behaviour-based models.

Phanikumar and Maitra (2006)[3] assessed the urban bus attributes in Kolkata using conjoint experiment method. The data were gathered through in-person interviews from sample intercepted at various locations in the city. Various specifications of the logit model, were estimated for commuting and non-commuting trips. The choice of an alternative was modeled as a function of attribute levels, socioeconomic characteristics of respondents and cost of various alternatives. The WTP for commuting trips ranged from 2.35 to 26.34 for multinomial logit model and 3.18 to 26.28 for random parameters logit models. For non-commuting trips, the multinomial logit model values ranged from 1.65 to 29.08 while the random parameter logit model values ranged from 1.30 to 25.75. Values reported in 2004 Indian Paise. This study found that the urban bus user's choice is influenced by quantitative and qualitative attributes with non-commuting trip's WTP value higher than commuting trip's value for qualitative attribute. The values obtained for some attributes such as vehicle travel time were found to be consistent with other existing studies in the developing countries. This study demonstrated the development of acceptable method that can help formulate strategies for improvement of urban bus transportation system in developing countries.

Indirect Approaches

Travel Cost Method (TCM)

[3] Phanikumar, C. V. and B. Maitra (2006)

Many natural resources, such as lakes and rivers, are used extensively for the purpose of recreation. It is often difficult to value these resources because no prices exist for them from which demand functions can be estimated. To enable valuation, the travel cost approach takes advantage of costs of travel that are incurred by individuals in visits made to recreational sites. The costs of travel (the costs of transport plus the value of time) are used as implicit prices to value the service provided and changes in its quality. Travel costs measure only the use value of sites and are usually limited to recreational use values; the option and existence value of the sites are measured using other techniques.

There are two variants of the simple travel cost visitation model. The first can be used to estimate (representative) individuals' recreation demand functions. The visitation rate of individuals who make trips to a recreational site are observed, as a function of the travel cost. The value of the recreation site to the person is measured from the area under the individual's demand curve: the total recreation (use) value of a site is the area under each demand curve summed over all individuals. This 'individual' travel cost model requires that there be variation in the number of trips that individuals make to the recreational site in order to estimate their demand functions. A particular problem associated with this model is that such variation is not always observed, especially as not all individuals make a positive number of trips to a recreational site. Indeed, some individuals do not make any. Where the data analysis makes use of standard statistical techniques such as ordinary least squares, non-participants are excluded from the data sets. This exaggerates participation rates and results in the loss of potentially useful information about the participation decision. However, inclusion of data on individuals in the sampling area requires use of more complex statistical methods - in particular, discrete choice models.

The second variant, known as the 'zonal' travel cost model, estimates aggregate or market demand for a site using standard statistical techniques. The unit of observation is the "zone" as opposed to the individual. Zones are specified as areas with similar travel costs; the region surrounding a site is divided into zones of increasing travel cost. The method entails observation of the number of visits to the recreational site per capita of population for each zone. Data are again collected through a survey of visitors to the site.

The individual travel cost model is generally preferred to the zonal variant. The latter is statistically inefficient as it aggregates data from a large number of observations into a few zonal observations. Moreover, it assumes that the cost of travel to the site for all individuals within each zone is equal, which is often not the case.

For both variants, the demand curve is estimated by the regression of the visit rate against socio-economic factors (such as income), the travel cost of visiting the site and some indicator of site quality.

The simplest version of TCM involves collecting data on the total number of visits to a site from zone I, that is, V_i, and the total visitor population P_i, of zone i. Then (V_i/P_i) is proposed to be a function of the average travel cost C_i and other socioeconomic characteristics, S_i. This C_i is the total travel cost which includes both direct expenditure during the trip and the imputed value of the time – cost.

$(V_i/P_i) = f(C_i, S_i) = \beta_0 + \beta_1 C_i + \beta_2 S_i + \omega_i$

Where, ω_I is the random error term and i= 1, ….,k, k being the number of zones.

The estimated β_1 coefficient would quantify the change in the visitation rate due to a change in the travel cost. So β_1 is the estimated slope of the implicit demand function for the recreational site. To estimate the intercept of this demand function, data upto that level of C_i where visitors stop visiting the site altogether due to exorbitantly high costs are required.

The travel cost method is a technically well-developed valuation approach, which has been employed widely in the past two decades. Its strength is that, in theory, it is based on observed behaviour. However, the technical and data requirements should not be underestimated. Travel cost is unlikely to be a low cost approach to valuation of non-marketed services. An early exploration of the technique was done by Clawson and Knetsch (1966). Duffield (1984) represents a "typical" TCM study. Duffield developed a TCM to estimate the recreational value associated with visiting Kootenai Falls, the site of a proposed hydroelectric facility in North - western Moutana.

Hedonic Pricing (HP)

Hedonic pricing employs differences in the prices of marketed goods to derive the value of environmental characteristics. Marketed goods can be viewed as comprising a bundle of characteristics; for some goods, these include environmental characteristics. The differential prices that individuals pay for such goods reflect their preferences for environmental quality. Statistical analysis of the prices and characteristics of the goods is employed to derive an implicit value for environmental quality.

The HP is based on a straight forward premise: the value of an asset, whether a price of land, a car, or a house, depends on the stream of benefits that are derived from the asset. These include the benefits of environmental amenities. One of the most common applications of the HP has been the use of differences in the values of real estate with different environmental amenities to estimate the value of those amenities. Houses may have different views or be located in areas with better schools or lower crime rates. Houses may also differ in their exposure to pollution. By using regression techniques, a HP model can, in theory, identify what portion of property value differences can be attributed solely to environmental differences and infer individuals' WTP for environmental amenities and therefore the overall social value of a given amenity. The HP can also be applied to estimate WTP to avoid dis-amenities.

For example, like any other market the transaction decisions in the housing market are also determined by the market demand and supply conditions (Banerjee, S. 1994). Let us assume a rational consumer has a utility function U and level of income Y. The consumer will buy any particular house if some environmental attributes (α) are available and the price of the house will obviously depend on those environmental attributes, i.e., $p = p(\alpha)$, where p is the price of the house. The consumer will allocate his income, Y between the consumption of the commodities, X and the housing. Now the problem of the consumer is to maximize the utility function subject to the budget constraint, i.e.,

Max U (X, α), subject to Y = X + p(α).

The consumer can bid for the house with the given quality, α and maintaining the utility at U_0, which is known as the bid function and can be expressed as:

$\Phi = \Phi (Y, \alpha, U_0)$

On the other hand supply side of the housing market can be observed as the offer function. The total cost of production of the house will depend not only on the non-land input prices (r) but also on the environmental qualities, α. Therefore the cost function is:

C = c (r, α).

If the price of the house offered by the producer is denoted by θ, then the profit (π) function can be written as:

Π = θ - c (r, α).

Keeping Π fixed at Π_0 at given r, the offer curve of the producer can be obtained as:

$\theta = \Pi_0 + c (r, \alpha) = \theta (r, \alpha, \Pi)$.

As more and more better quality of α would be purchased, there would also be larger and larger increment in the price of the house, θ.

The Market Equilibrium: The Hedonic Price Function

In the housing market there will be different combinations of bid-offer of different consumers and producers. The hedonic price function or the equilibrium in the market is obtained as the locus of the tangency points between bid and offer curves of different agent.

Brookshire and Colleagues (1982) applied HP to rent values and pollution levels in Los Angels. Consistent with the theory, the authors found that rents were directly correlated with reduced pollution levels and that surveyed WTP to avoid pollution was less than the observed rent differentials. Other examples of the application of HP to valuing the environment are O'Byrne et al (1985), Murdoch and Thayer (1988), and Graves et al (1988).

Gundimeda and Kathuria (2003)[4] estimate the willingness to pay for avoiding water shortages and improving the quality of water in India, using the hedonic price technique.

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[4] Gundimeda, H and V. Kathuria (2003)

The hedonic study uses data obtained through a survey of 1028 households within 5-6 kilometres of the city centre in Chennai, India. The estimated mean willingness to pay for improved water availability through piped water for a representative household is Rs. 2,918. Similarly the mean willingness to pay for improved quality from contaminated to unpolluted water is Rs. 1,155. The aggregate consumer surplus of the entire population of Chennai is estimated at around Rs2480 million for improved water supply and Rs. 981 million for improved water quality. The results show scope for implementing water projects with significant welfare impacts on the population of Chennai. The study was funded by the South Asian Network of Economic Initiatives.

Averting Behaviour and Defensive Expenditures

Perfect substitutability provides the basis for the averting behaviour and defensive expenditures technique. This technique focuses on averting inputs as substitutes for changes in environmental characteristics. For example, expenditures on sound insulation can be used to indicate householders' valuations of noise reduction; and expenditure on liming might reflect the value of reduced water acidification. The approach requires data on change in an environmental characteristic of interest and its associated substitution effects. Fairly crude approximations can be found by looking directly at changes in expenditure on a substitute good that arise as a result of some environmental change. Alternatively, the value per unit change in an environmental characteristic can be determined. This involves determining the marginal rate of substitution between the environmental characteristic and the substitute good, using known or observed technical consumption data. The marginal rate of substitution is multiplied by the price of the substitute good to give the value per unit change in the environmental characteristic.

Dose - response Functions

The dose-response function was used by Ellis and Fisher (1987) to estimate the contribution that wetlands protection makes to the production of shell fish. Another application is made in the study by Kahn and Kemp (reported in Kahn, 1991). The authors carried out a very detailed dose-response analysis of the impacts of atrazine run-off from farmland on recreational and commercial fishing in Chesapeake Bay, owing to the loss of submerged aquatic vegetation (SAV). A fuller discussion of dose-response studies is available in Hanley and Spash (1993). For instance, physical damages D are related to the level of the suspected pollutants P_i, as well as any other related variables. Thus a regression model of the following form can be estimated.

$D = \beta_0 + \beta_1 P_1 + \beta_2 P_2 + \beta_3 P_3;$

Where, coefficients β_1, β_2, and β_3 measure the change in damage because of a change in the level of the pollutants. There may also be cross-effects. In other worlds the damage caused by pollutant X may depend on the level of pollutant Y, & so on. If so, these effects will also need to be incorporated into the regression.

A dose-response model describes the probability of a specified response from exposure to a specified pathogen in a specified population, as a function of the dose. This function is based on empirical data, and will usually be given in the form of a mathematical relationship. The use of mathematical models is needed because:

- contamination of food and water usually occurs with low numbers or under exceptional circumstances; the occurrence of effects can not usually be measured by observational methods in the dose range needed, and hence models are needed to extrapolate from high doses or frequent events to actual exposure situations;
- pathogens in food and water are usually not randomly dispersed but appear in distinct clumps or clusters, which must be taken into account when estimating health risks; and
- experimental group sizes are limited, and models are needed, even in well controlled experiments, to distinguish random variation from true biological effects.

In certain instances, dose-response functions can be established between changes in environmental variables (the dose) and the resultant impact on marketed goods and services (the response). Where this is the case, a dose-response function can provide the basis for valuation of the environmental variable of interest; this is the main technique used to derive economic values for air pollution. Valuation is carried out by multiplying the physical dose-response function by the price or value per unit of the impact (usually some form of physical damage) to give a 'monetary damage function'. The latter is equivalent to the change in consumer surplus plus producer surplus caused by the impact.

Where the impact predicted by the dose-response function is marginal, it may be possible to value the impact using relevant market prices, adjusted for any government interventions and market imperfections. For larger impacts, a modeling approach is likely to be required, to predict the resultant changes in prices and behaviour on both the supply and demand sides of the relevant markets. For example, in the case of an impact on a production process, a producer might respond to an impact by changing the quantity of other inputs used, which would alter the costs of production and thereby change the producer surplus. A change in the output price will change consumers' consumption patterns, and thereby the consumer surplus. Prediction of such market responses is complicated. Individuals will often make complex changes in their behaviour to protect themselves against undesirable impacts. For example, farmers might switch to crop varieties that are resistant to pollution. A large number of markets might be involved, and modeling such an interrelated system can be extremely sophisticated. However, simple models can provide useful estimates, provided their shortcomings are recognized.

The specification of the dose-response function is crucial to the accuracy of the approach. The pollutant responsible for the damage needs to be identified as well as all possible variables affected. Large quantities of data can be required. It may be possible to record the impact of change in the environmental variable using variables that are easy to observe and measure (e.g. leaf drop and discoloration of vegetation). However, some impacts (e.g. reduced plant vigour and reduced pest resilience) are difficult to observe directly. In such cases, an 'instrumental variable', which is easily measurable and provides an indicator of the impact of interest, can be used as a measure of the impact. As an alternative to empirical data, dose-response functions can also be specified using suitably validated simulation models, such as fishery models, crop yield models, and biological growth models.

Contingent valuation method (CVM)

The contingent valuation method for the valuation of environmental goods was first used by Davis (1963) in a study of hunters in Maine. The development of the method began in earnest (Brookshire et al., 1976; Randall et al., 1974). Since then, the method has become the most widely used and most controversial of all environmental valuation techniques. Comprehensive accounts of the method may be found in Hanley and Spash (1993), Mitchell and Carson (1989), and Bateman and Willis (1995).

Any CVM exercise can be split into five stages:

1) Setting up the hypothetical market;
2) Obtaining bids;
3) Estimating mean willing to pay (WTP) and/or willing to accept (WTA);
4) Estimating bid curves; and
5) Aggregating the data.

Stage One: the hypothetical market

A hypothetical market will be set up for the environmental service in question for example the policy to restore old civic buildings in a city centre. This must explain a reason for payment for services. How funds will be raised (for eg. through property taxes, income taxes etc.) should also be specified. The survey instrument (questionnaire) should also describe whether all consumers will pay a fee and how this fee will be set.

Stage Two: obtaining bids

The questionnaire should be pre-tested before the main survey occurs. This can be done either by face-to-face interviewing, telephone interviewing or by mail.

The individuals are asked to state their maximum WTP and/or minimum WTA for the increase or decrease in environmental quality for which the survey is designed. This may be done in several ways:

(i) As a bidding game: higher and higher amounts are suggested to the respondents until their maximum WTP is reached.

(ii) As a payment card: A range of values is presented on a card. This helps respondents to calibrate their replies.

(iii) As an open-ended question: Individuals are asked for their maximum WTP with no value being suggested to them. It is relatively difficult for the respondents to answer such questions.

(iv) As a closed-ended referendum: A single payment is suggested, to which respondents either agree or disagree (yes/no reply). Such responses are often known as dichotomous choice (DC).

Stage Three: estimating average WTP/WTA

If open-ended bidding game is chosen, then the calculation of sample mean and/or median WTP or WTA is straightforward. In the DC framework, the random utility theory (Hanemann, 1984) may be used. In particular, it is assumed that the individual has the utility function, U = f(Q_j, y,x), where Q is the level of environmental quality, y is the level of income and x is a vector of socioeconomic characteristics. If now environmental quality improves from j = 0 to j = 1, and the individual is asked to pay an amount A for the improvement in environmental quality, the probability that they will accept this offer (i.e., say 'yes') is:

$$\mathrm{P}[yes] = \mathrm{P}\ [v(Q_1, y - A, x) + \varepsilon_1) \geq v(Q_0, y, x) + \varepsilon_0],$$

Where, ε_i is an identically and randomly distributed error with zero mean, and the probability of saying 'no' is $\{1-(P[yes])\}$. The above equation can be estimated statistically.

Stage Four: estimating bid curves

A bid curve can be estimated for open-ended CVM formats where WTP bids might be regressed against income y, education E and age A as well as against some variable measuring the 'quantity' of environmental quality being bid for Q, if this varies across respondents:

$WTP_i = f(y_i, E_i, A_i, Q_i)$.

In DC framework, bid curves are the logit functions which predict the probability of a 'yes' response to a particular offer price. The explanatory power of bid curves (measured by adjusted R^2 or its maximum likelihood equivalent) may be considered as a test of the success or failure of a CVM survey where poor explanatory power indicates a poor survey.

Stage Five: aggregating data

Aggregation refers to the process whereby the mean bid or bids are converted to a population total value figure. Aggregation involves following three issues:

First is the choice of the relevant population – (a) which includes all those, whose utility will be significantly affected by the action or (b) all those within a relevant political boundary who will be affected by the action.

Second is the estimation of population mean from the sample mean. This can be done in several ways for example sample mean could be multiplied by the number of households in the population, N.

Third is the choice of the time period over which benefits should be aggregated.

A good CV study will consider the following in its application:

- Before designing the survey, how people think about the good or service in question must be studied. People's familiarity with the good or service, as well as the importance of such factors as quality, quantity, accessibility, the availability of substitutes, and the reversibility of the change must be considered.

- Determine the extent of the affected populations or markets for the good or service in question, and choose the survey sample based on the appropriate population.
- The choice scenario must provide an accurate and clear description of the change in environmental services associated with the event, program, investment, or policy choice under consideration. If possible, convey this information using photographs, videos, or other multi-media techniques, as well as written and verbal descriptions.
- Unlike ordinary survey questions, which sometimes ask respondents whether they are willing to pay x dollars to improve "air quality," the nature of the good and the changes to be valued must be specified in detail in a CV survey. It is also important to make sure that respondents do not inadvertently assume that one or more related improvements are included. For example, if people are asked to value only air visibility, it would be important to make sure that they do not include their value for health-related improvements in their stated willingness to pay amount. Similarly, if people have a tendency to think of environmental improvements in general, even when asked about water quality alone, it would be necessary to point out specifically that environmental quality, other than water quality, would remain the same.
- Questions can be asked in a variety of ways, using both open-ended and closed-ended formats. In the open-ended format, respondents are asked to state their maximum willingness to pay for the environmental improvement. With the closed-ended format, also referred to as discrete choice, respondents are asked whether or not they would be willing to pay a particular amount for the environmental improvement, or whether they would vote yes or no for a specific

policy at a given cost. The discrete choice format is generally accepted as the preferred method.

- In addition to the hypothetical question that asks for willingness to pay, the survey must specify the mechanism by which the payment will be made, for example through increased taxes. In order for the question to be effective, the respondent must believe that if the money was paid, whoever was collecting it could effect the specified environmental change.
- Respondents should be reminded to consider their budget constraints.
- Specify whether comparable services are available from other sources, when the good is going to be provided, and whether the losses or gains are temporary or permanent.
- Respondents should understand the frequency of payments required, for example monthly or annually, and whether or not the payments will be required over a long period of time in order to maintain the quantity or quality change. They should also understand who would have access to the good and who else will pay for it, if it is provided.
- In the case of collectively held goods, respondents should understand that they are currently paying for a given level of supply. The scenario should clearly indicate whether the levels being valued are improvements over the status quo, or potential declines in the absence of sufficient payments.
- If the household is the unit of analysis, the reference income should be the household's, rather than the respondent's, income.
- Thoroughly pre-test the valuation questionnaire for potential biases. Pre-testing includes testing different ways of asking the same question, testing whether the question is sensitive to changes in the description of the good or resource being valued, and conducting post-survey interviews to determine whether respondents are stating their values as expected.
- Include validation questions in the survey, to verify comprehension and acceptance of the scenario, and to elicit socioeconomic and attitudinal characteristics of respondents, in order to better interpret variation in responses across respondents.

In general, a survey is conducted in which people are asked to state their maximum WTP (or, minimum WTA), amount of money they would be willing to pay for an improvement in an environmental good or service for a proposed change in environmental quality, α. This may be conducted through face-to-face interviews, telephone or mail surveys. In developing countries, face-to-face interviews are considered the most appropriate (because of high rates of illiteracy and defective telephone networks). The design of the questionnaire is important and typically comprises three components. First, the questionnaire provides an explanation of the environmental issue of interest together with information on the change in quality. Second, it includes questions regarding willingness to pay or willingness to accept. The third part of the questionnaire comprises questions about the socio-economic characteristics of the interviewee, which enable analysis and verification of the validity of responses on willingness to pay or willingness to accept given by respondents.

A respondent’s choice or preference can be elicited in a number of ways. The simplest is to ask a direct question about how much the respondent would be willing to pay for the good or service (known as continuous or open-ended Referendum). High rates of non-responses can be a problem with this approach. Alternatively, respondents can be asked whether they would want to purchase the service if it cost a specified amount. These are known as discrete or dichotomous choice (DC) questions or a close ended Referendum, and may be favoured because they do not give the respondent any incentive to answer untruthfully, i.e. the approach is 'incentive compatible'. A hybrid approach is the 'bidding game', where respondents are asked a series of questions to iterate towards a best estimate of their valuation. Alternatively, respondents may be shown a list of possible answers - a 'payment card' - and asked to indicate their choice, though this requires a careful determination of the range of possible answers. Each approach implies particular requirements in terms of statistical methods, and the appropriate choice for a specific problem is a matter of judgement on the part of the analyst.

The average WTP is estimated by using either arithmetic mean of median. The lower bids are more likely than higher bids in an open ended referendum, median WTP is generally less than mean WTP. On the other hand, for DC type closed ended referendum, partial observables involve a serious problem in the estimation process.

Kohlin (2001)[5] estimated the willingness to pay for forest resources obtained through the establishment and maintenance of village woodlots through open-ended contingent valuation study in Orissa, India. A 1995 survey consisting of 743 households was conducted. The survey solicited information on the use of village woodlots and natural forests, fuel use in different seasons specified by kind and source, as well as additional household data. The household's willingness to pay (WTP) was also elicited. Prior to the WTP solicitation, the benefits of the woodlots were described. The WTP solicitation consisted of two steps. First, the respondent was asked a yes/no question about whether they would be WTP for a woodlot. Second, the maximum amount that the respondent would be WTP to establish and keep the plantation. The average aggregate WTP for a village was estimated to be Rs. 111,000. Excluding enumerator outliers, the mean individual monthly WTP for proposed woodlots ranged from Rs. 9 to Rs. 21. This study showed the application of using contingent valuation method in international development projects and identified further design improvements in the method applicable to developing countries. This study was sponsored by the Swedish International Development Cooperation Agency.

Environmental value transfer

Environmental value transfer here refers to transfer of values for environmental costs as well as benefits (the latter is otherwise known as 'benefits transfer').

The costs of valuing impacts on the environment can be considerable. However, it is not always necessary to undertake a new valuation study. Where valuation has been

[5] Kohlin, G (2001)

undertaken for a similar case elsewhere, it may be possible to transfer the estimates and employ them as indicators of the economic welfare impacts in a new study. The original valuation may have utilized any of the valuation techniques outlined above. Environmental value transfer is undertaken largely for reasons of cost-effectiveness and scope to rapidly inform decision-making. It is a very attractive alternative to resource-intensive and time-consuming valuations based on original data. However, it is fraught with difficulties and subject to a number of caveats.

Boyle and Bergstrom (1992) suggest the following criteria be employed to determine which studies are suitable for use in value transfer:

- the goods or services that are being valued should be the same;
- the relevant populations should be very similar;
- the assignment of property rights for the resources under consideration should be the same.

As specified in NEEDS[6], Value Transfer Techniques can be or two types:

1) Unit transfer (eg. WTP/hh/yr) correcting for Income PPP and for income elasticity of WTP.
2) Function transfer where,

   WTP = f(characteristics of site and population) – Benefit function from similar type site and change in environmental quality; or

   WTP = f(characteristics of site and population) – Meta analysis of previous studies of same environmental commodity.

Desvousges *et al.* (1992) suggest that consideration should also be given to the sites in which the goods or services are located, and quality of the study.

Three broad approaches can be used for environmental value transfer (Pearce, Whittington and Georgiou, 1994).

One approach uses average value estimates. This approach assumes that the change in utility experienced by the individuals considered in the new study is equivalent to that experienced on average by individuals in the previous studies. For example, in the case of a change in resource management that affects recreation benefits, the change in recreation services would be valued in terms of individuals' average willingness to pay per day. This could be estimated using values presented in suitable previous studies. Multiplying the resultant figure by the predicted change in the number of person days of recreation in the new study would yield the total aggregate value of the anticipated impact on recreation. A drawback is that the situations examined by the two studies are unlikely to

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[6] Integrated Project, 6th Framework Programme, Supported by the European Commission; http://www.isis-it.com

be identical. Consequently, studies that are suitable for value transfer (according to the criteria listed above) are unlikely to be available.

A second approach uses adjusted average values. This entails the adjustment of mean values from previous studies for any biases in the data to better reflect conditions examined in the new study. For example, adjustments might be made to reflect the socio-economic characteristics of households, the environmental change in question, the policy setting, or the availability of substitute or complementary goods and services. Such adjustments can increase the suitability of values for transfer.

A third approach uses value functions. This entails transfer of the entire demand function for the good or service in question to the new study. It enables transfer of a greater amount of information than through use of average values alone. It is likely to result in better approximations of values, but is more involved than the other two approaches.

Eade, Jeremy and Moran (1996)[7] estimate the total economic value of the Rio Bravo Conservation Area in northwestern Belize. The benefits transfer is performed by constructing a spatial representation of total economic value of the conservation area. The study employs Geographical Information Systems (GIS) mapping techniques to develop strength characteristics of environmental assets. These maps are then used to recalibrate benefit estimates from study-sites being transferred. The result of this process is the creation of "economic value maps" that describe the benefit value of the natural capital assets in the Rio Bravo in two dimensions. The study suggests that the calibration of economic value in map form is most beneficial for predicting where vulnerable areas are likely to occur as a result of disturbance/development. Asset maps may also be useful in evaluating resource use scenarios to determine the most economic use of land and provide a systematic framework for determining necessary transfer payments as incentives for attaining efficient land use.

The above mentioned methodologies are summarized in the **Table 1.**

Table 1: Summary of different economic valuation techniques

Valuation methods	Description	Direct use values	Indirect use values[1]	Non-use values
Market analysis & market-based transactions	Used where market prices of outputs (and inputs) are available. Marginal productivity net of human effort/cost. Could also be approximated using market price of close substitute. May require shadow pricing.	Ö	Ö	
Derived demand functions	Derive value from the household's or firm's inverse demand function based on observations.	Ö	Ö	

[7] Eade, Jeremy D.O., and Dominic Moran (1996)

Hedonic price method	Derive an implicit price for an environmental good from analysis of goods for which markets exist and which incorporate particular environmental characteristics.	Ö	Ö	
Travel cost method	Costs incurred in reaching a recreation site as a proxy for the value of recreation. Expenses differ between sites (or for the same site over time) with different environmental attributes.	Ö	Ö	
Contingent valuation method	Construction of a hypothetical market by direct surveying of a sample of individuals and aggregation to encompass the relevant population. Problems of potential biases.	Ö	Ö	Ö
Contingent ranking	Individuals are asked to rank several alternatives rather than express a willingness to pay. Alternatives tend to differ according to some risk characteristic and price.	Ö	Ö	Ö
Damage costs avoided	The costs that would be incurred if the catchments function were not present, e.g. flood prevention.	Ö	Ö	
Avertive behaviour & defensive expenditures	Costs incurred in mitigating the effects of reduced environmental quality. Represents a minimum value for the environmental function.	Ö	Ö	
Replacement/cost savings	Potential expenditures incurred in replacing/ restoring the function that is lost; for instance by the use of substitute facilities or "shadow projects". A total value approach; important ecological, temporal and cultural dimensions.	Ö	Ö	Ö[1]
Dose-response	Dose-response: takes physical and ecological links between pollution ("dose") and impact ("response") and values the final impact at a market or shadow price.	Ö		

Source: United Nations(2004) Economic Valuation of Water Resources in Agriculture, FAO Corporate Document Repository, Rome.

Section 2: Types of Disaster Impacts

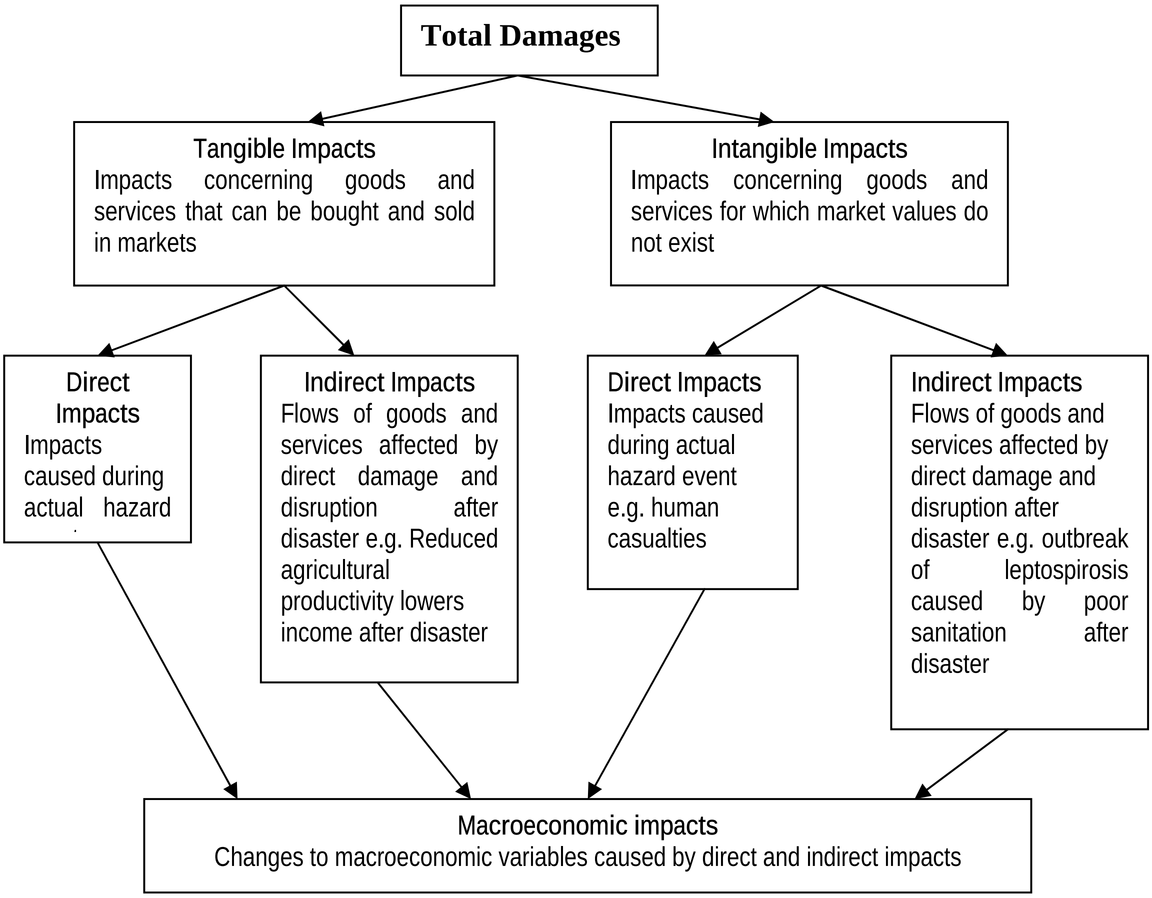
Disaster impacts include direct damage to physical assets, indirect losses in the production of goods and services, alterations to macroeconomic variables, and cross-sectoral effects, such as impacts on environmental and psychosocial conditions. In general, a natural disaster causes three main types of impact: 1) direct impacts caused by a natural hazard during the actual event, 2) indirect impacts in terms of flows of effects that occur over time after a hazard event, and 3) repercussions for macroeconomic variables.

International experience has shown that natural disasters caused by natural hazards of geophysical origin (such as earthquakes, volcanic eruptions and tsunamis) tend to lead to a high proportion of direct damage to assets and a low proportion of indirect losses in economic flows. Natural disasters caused by hydrological phenomena (such as droughts and floods) tend to cause a low proportion of direct damage, but a high proportion of indirect losses. Flow chart 2 shows the categories of direct, indirect, intangible and macroeconomic impacts of natural disasters.

Direct impacts

Direct impacts are caused by a natural hazard during the actual event. Direct impacts will occur over different periods of time depending on the type and magnitude of the disaster. During slowly evolving or long-duration events, such as droughts, direct damages may occur over an extended period of months or even years. In contrast, the direct damage of a short-duration disaster, such as an earthquake, may occur only in a matter of minutes. Natural disasters can cause direct damages involving the complete or partial destruction of physical assets in both the public and private sectors. Examples of physical assets that may be damaged by natural disasters include infrastructure, buildings, installations, machinery, final goods, raw materials, equipment, transportation, farmland, harvested crops and irrigation works. Deaths and injuries are also a type of direct impact if they occur during the natural disaster events.

Flow Chart 2: Direct, indirect, tangible, intangible and macroeconomic impacts of natural disasters



Intangible direct impacts

Some direct impacts, often called 'intangible impacts', are particularly challenging to value in monetary terms because their very nature is difficult to measure and quantify. Examples of intangible direct impacts include death and injury, environmental damage, damage to cultural artifacts, and losses of memorabilia, such as photographs, books, toys and personal original work.

Indirect impacts

Indirect impacts are flows of effects that occur over time after a hazard event and are caused by the direct impacts of a disaster. Examples of indirect impacts might include a decline in agricultural harvests after flooding or prolonged droughts, or losses in industrial production due to damage to factories caused by a cyclone or earthquake. Disasters may also generate positive indirect effects that generate benefits to society. For example, large-scale disasters often generate a construction boom as aid funds flow into the country for rebuilding damaged properties, which can boost production and income in the construction sector and supporting industries. Positive indirect impacts must also be estimated and included in a disaster impact assessment. Indirect impacts are dynamic flows that occur over time. It is therefore particularly important when estimating indirect impacts to compare the situation that develops after the disaster with the situation that would have occurred without the disaster. The indirect impact is calculated as the difference between the 'with disaster' situation and the 'without disaster' situation.

Intangible indirect impacts

Some indirect impacts, often called 'intangible impacts', are particularly challenging to value in monetary terms because their very nature is difficult to measure and quantify. Intangible indirect impacts of natural disasters include negative psychological effects, such as fear, stress and depression, and health problems that arise after the disaster, such as leptospirosis outbreaks or respiratory illnesses. Intangible indirect impacts can also be positive, such as development of community solidarity and trust.

Macroeconomic effects

Macroeconomic effects are any changes to the main economic variables that are caused by the direct and indirect impacts resulting from a natural disaster. Macroeconomic indicators illustrate changes to economic activity. The most important macroeconomic effects of a disaster are usually on Gross Domestic Product (GDP), gross investment, the balance of payments, and public finances. Depending on the type and scale of the disaster, an estimate of the effects on inflation and employment may also be relevant. Quantification of macroeconomic effects is usually done for the national economy as a whole, although in principle, if the information is available, it can be done for disasters affecting smaller areas, islands or regions.

Section 3: Natural Disaster Impact Assessment

Natural disaster impact assessment involves identification and where possible measurement in monetary terms, all the impacts of a disaster on the society, economy and environment of the affected country or region. This section will describe briefly the different methodologies that can be applied to measure the damages caused by the extreme events.

Valuing direct physical damage

A monetary value needs to be placed on direct impacts once they have been identified and quantified. There are a number of alternative methods for valuing direct impacts, which vary in how accurately they represent the real value of the damage. In theory, shadow prices (Brandon and Hommann, 1995) rather than market prices (Table 2) should be used to obtain a close approximation of the value of damage to society. A shadow price is a "price" used in economic analysis to represent a cost or benefit from a good when the market price is a poor indicator of economic value or there is no market at all for that good. Shadow prices correct for distortions such as subsidies and taxes, which affect market prices so that they do not reflect the true social value of a resource.

It may be desirable to use more than one alternative for valuation of disaster impacts to allow assessment results to be used in different ways. Using the replacement cost of the original equipment will give a more accurate picture of the real damage caused, whereas the replacement cost of technically more advanced equipment may provide a more accurate cost of the financial resources required for reconstruction. The two valuation methods give different information, which can be useful for different purposes.

Valuing intangible direct damage

The value of intangible direct damage is difficult to assess, as it is not reflected in market prices. Frequently intangible losses are not included in estimates of natural disaster impacts because they are considered too difficult to estimate meaningfully. However, some methods do exist for valuing intangible impacts (Table 2).

A variety of non-market valuation methods can be applied to assess the value of intangible direct damages:

1) **Revealed Preference Method**: (i) Replacement cost method; (ii) Production method; (iii) Hedonic pricing; and (iv) Travel cost method;

2) **Stated Preference Method**: Contingent valuation is one of the best stated preference methods.

Placing a monetary value on deaths and injuries is a particularly difficult task. Setting aside the suffering sustained by victims and their families, fatalities are a direct loss of productive human assets, and injuries entail the expense of health treatment. The value of injuries may be roughly approximated as the cost of treatment and, if the appropriate data is available, as the average loss of income of the injured person while recovering. There are two main approaches – 'human capital' and 'willingness to pay', that can be applied to estimate the monetary value of a human life, but these techniques are controversial.

Valuing indirect impacts

Indirect impacts are dynamic flows that occur over time. As indirect impacts occur over time, they should be measured in present value terms. Surveying is often the most appropriate methods for estimating indirect losses caused by a natural disaster. Many indirect losses can only be ascertained months or years after a natural disaster making it difficult or impossible to assess these losses in the immediate initial damage assessment. It is therefore important to do subsequent follow up assessments to evaluate indirect impacts. The appropriate time period for estimating indirect losses is the length of time required for the country or region to achieve a situation equal to the one prevailing before the disaster. For many disasters, a two-year time frame is appropriate, although it may be necessary to assess indirect impacts over a shorter or longer time period depending on the type and scale of disaster.

A comprehensive evaluation should at least identify and where possible quantify intangible indirect impacts, so that they are less likely to be ignored in decision-making. Some methods do exist for valuing intangible impacts, which are revealed preference methods and stated preference methods.

Valuing macroeconomic indicators
Estimating macroeconomic effects is a complementary way to assess direct damages and indirect losses from a different perspective, so they should not be added to direct and indirect impact estimates because this will involve double counting.

Like indirect impacts, macroeconomic variables are dynamic flows that occur over time. It is therefore important to compare how the macroeconomic variable develops after the disaster with how that variable was expected to behave if the disaster had not occurred. Background information on how macroeconomic indicators were expected to evolve without the disaster can help to make these forecasts. These forecasts provide the baseline for ascertaining the degree to which the disaster disrupted macroeconomic aggregates from the levels that would have been achieved otherwise. Forecasts can be based on different likely scenarios and these estimates are compared. The time frame for estimating macroeconomic effects is a couple of years, or in the case of a major disaster, five years, after a natural disaster.

The macroeconomic assessment begins by collecting information on pre-disaster economic trends, and features of economic policy. Central banks, economic, tax, finance and planning ministries, statistics offices, universities, regional and international organisations may have the macroeconomic information needed. On the basis of information and interviews, a projection should be prepared of how economic growth (GDP growth) was expected to develop before the disaster occurred and how this would have been reflected in inflation, exports, imports, debt etc. Estimates of the impact of the disaster on GDP should be made in real / constant terms, rather than nominal or current GDP figures.

Section 4: Assessment of Different Valuation Techniques

Basically environmental valuation techniques are of two types: (1) those based on revealed preferences or actual or observed behaviour of humans in the markets and (2) those based on stated preferences or potential or likely behaviour in a hypothetical market context. As the revealed preferences are based on actual observations, they may involve data difficulties and statistical problems and can affect the quality of results.

However, the valuation techniques used to quantify the health, economic and social impacts may be classified into market-based and non-market-based techniques. All economic valuation techniques whether market-based or non-market-based, measure the change in consumer/producer welfare. The following table describes the different valuation techniques according to: (i) the type of market they rely upon; and (ii) how they make use of actual or potential behaviour of economic agents (Table 2).

Table 2: Taxonomy of economic valuation techniques.

Conventional Market	Implicit Market	Constructed Market
Based on Revealed Preferences		
Private goods sold in the market (conventional price and quality analysis) ・The Productivity Approach ・Effects on Health or Earnings ・Defensive Expenditures ・Averting Expenditure	Public goods/Government services (collective choice analysis) ・Hedonic Pricing ・Travel Cost Analysis ・Hedonic Property Values Approach ・Proxy Marketed Goods or Supply and Demand Analysis of Related Goods	Artificial Market
Based on Stated Preferences		
Potential Market Goods (experimental economics, conjoint analysis) ・Repair/Replacement Cost ・Shadow Project Analysis	Indirect or Passive Use of Environmental Resources ・Contingent Valuation Method Conjoint Analysis ・Habitat Equivalency Analysis Direct Use of Environmental Resources ・Contingent Valuation Method, Conjoint Analysis ・Habitat Equivalency Analysis	・Contingent Valuation Method, Bidding Games Trade off Games

Source: Intizar Hussain, Liqa Raschid, Munir A. Hanjra, Fuard Marikar and Wim van der Hoek, *Wastewater Use in Agriculture: Review of Impactsand Methodological Issues in Valuing Impacts,* Working Paper 37, IWMI, 2002.

The valuation techniques have been described in terms of the data that each needs and illustrated in terms of the kind of environmental effects that each can value. It shows that some techniques are better suited to particular kinds of effects. As the Table 3 illustrates, few techniques are suitable to value non-use benefits. Many are available to value pollution effects and some techniques have wide applications. All the environmental effects can be valued by at least three techniques. Some environmental valuation techniques are generally applicable while some others have potential and still are applied in some selective environmental and resource issues (Table 3).

Table 3: Applicability of Valuation Techniques to Environmental Impacts

Valuation Method	Health Impacts		Aesthetic Impacts	Ecosystem Impacts	Recreational Impacts	Production Impacts
	Illness	Mortality				
Productivity Approach	Yes		Yes	Yes	Yes	Yes
Opportunity cost	Yes		Yes	Yes		Yes
Preventive Expenditure/ Replacement cost	Yes	Yes	Yes	Yes		Yes
Hedonic Pricing		Yes	Yes		Yes	
Travel Cost			Yes		Yes	
Contingent Valuation	Yes	Yes	Yes	Yes	Yes	Yes

Source: Based on EPA, New South Wales State of the Environment, 1993

Evaluations of different Valuation Techniques

Each of the environmental valuation techniques has advantages and limitations related to reliability, data requirements, application and the amount of experience gathered. Next section will discuss the limitation of different techniques.

Travel Cost Method (TCM)

A rational individual will weigh up the costs of a recreational visit against the benefits of the visit and then display the answer in actual behaviour. In this way, the willingness to pay for use of an environment is inferred from travel expenditures of those who visit it. Data on actual travel costs (including food costs, accommodation costs and any forgone income) can be collected by a survey and willingness to pay to visit the site can be derived from them. The benefits to a given individual are the cost savings relative to the other individuals who visit the same recreational environment.

Applications of the travel-cost technique

The technique has been applied to value the benefits of recreation in:

- the Grampians forests of Victoria (Ferguson and Greig 1973)
- the Warrumbungles National Park of New South Wales (Ulph and Reynolds 1978)
- the Great Barrier Reef (Hundloe *et al*. 1987)
- Kakadu National Park in the Northern Territory (Knapman and Stanley 1991)
- the state forests of southeastern New South Wales and East Gippsland in Victoria (Resource Assessment Commission 1992b).

The results obtained from TCMs have generally been positive. However, there are some disadvantages to the technique. **First** it requires a large amount of data to estimate regressions. Collecting that much data is both time consuming and expensive. **Second**, the methodology also assumes that travel to a given site is for the sole purpose of visiting the site. There is no way that the methodology can allocate costs between multipurpose trips other than in an arbitrary manner (Randall, 1994). Despite these limitations, the methodology should be considered when adequate data are available.

The individual travel cost method is one of the most commonly applied approaches to estimating the recreational value (or ‘consumer surplus’) of open-access sites where the visitor does not have to pay an entrance charge for using the area. It indicates the amount of value that visitors have for the site in excess of the direct purchase cost (say an entrance fee) which they have to pay for its use (in the case of an open-access site this entrance fee is zero). However, a GIS can be used to measure distances and travel times to recreation sites to calculate overall travel cost (Bateman, Brainard, Lovett, Garrod, 1999).

Hedonic Pricing (HP)

The price paid for a property directly reflects the benefits of the characteristics of the property. In this way, environmental characteristics such as clean air, peace, quiet and beauty are traded in the property market. The property-value technique derives the value for a particular characteristic from the price paid for the property. Data are collected on prices paid and characteristics of the property. The amount of the price attributable to the characteristics is then identified through statistical analysis. In essence, if two houses differ in only one characteristic, the difference in price is the value of that characteristic.

Applications of the Hedonic Pricing

Increase in soil conservation were found to be associated with increase in the value of farms in Manilla Shire, New South Wales (King and Sinden 1988). The increase in value were attributed to conservation's role in improving aesthetics, maintaining farm access and improving long-term sustainability of output.

Retention of woodland on farms may enhance the naturalness of the environment, aesthetic quality and biodiversity but it may also lower farm land value. Reynolds (1978) estimated the loss in property value for increase in area retained and for increments in naturalness, aesthetic and biodiversity for a region of northern New South Wales. These losses are one measure of the cost of preservation of woodland.

Extension of a water supply pipeline to farms in Western Australia would benefit farm households as well as farm production activities. Coelli *et al*.(1991) valued these benefits as the increase in property value.

Identification of property price effects due to a change in environmental quality usually employs a multiple regression analysis of data from a representative number of properties over a period of many years (time series), or from a large number of diverse properties at a point in time (cross section), or from both (pooled data). In practice, because of the difficulty of controlling for other influences over time, most studies have used cross section data.

Estimation of the relationship between property price and level of an environmental attribute using this procedure will generally lead to an overestimation of the benefits of an improvement or an underestimation of the cost of deterioration (Markandya 1992; Brookshire *et al.* 1982). Experimental tests suggest that the overestimation can be as much as two- to three-times the true willingness to pay for the benefit (Bishop and Heberlein, 1979).

Other difficulties may also arise. The methodology is applicable only in situations where households are fully aware of the costs or benefits produced by an environmental attribute and where they are able to adjust their residential location to secure their desired combination of environmental attributes. There is also a question about whether rental or property prices should be used to estimate implicit prices. Rental prices are theoretically considered to be better since they relate only to benefits or costs arising from the current levels of the attributes. Property prices, on the other hand, are likely to reflect expected future levels of the attribute as well as current levels. (Markandya 1992).

Overall, the general conclusion appears to be hedonic pricing techniques can generate useful knowledge in areas where little directly-related information is available. The value and reliability of the information, of course, will depend on the availability and quality of the available data. Data availability will also determine the extent to which the technique is capable of being applied practically. While a review of the literature suggests that hedonic pricing valuations are typically approximations and can be subject to large errors, the results are no less accurate than those obtained from other techniques. The applicability and usefulness of the technique in any one case will depend on data availability and on the particular circumstances of the case in question.

Averting Behaviour and Defensive Expenditures

Households are sometimes willing to pay to prevent damage to their environment and so defend their existing level of enjoyment from it. They will only make such expenditures when they believe that the benefits from the damage that is avoided exceed the payments to prevent it. The willingness to incur these expenses indicates the benefit from protection. The technique applies wherever households spend money to prevent damage to their environment. Examples include spending to prevent floods, noise, fire and reductions in water quality.

Where observed averting behaviour is not between two perfect substitutes, the value of the environmental characteristic is underestimated. For example, if there is an increase in environmental quality, the benefit of this change is given by the reduction in spending on the substitute market good required to keep the individual at their original level of welfare. However, when the change in quality takes place, the individual does not reduce spending (in order to stay at the original level of welfare). Income effects cause reallocation of expenditure between all goods with a positive income elasticity of demand. Consequently, the reduction in spending on the substitute for environmental quality does not capture all of the benefits of the increase in quality.

Further problems with the approach are that individuals may undertake more than one form of averting behaviour in response to an environmental change, and that the averting behaviour may have other beneficial effects that are not considered explicitly (for example, the purchase of bottled water to avoid the risk of consuming polluted supplies may also provide added taste benefits). Furthermore, averting behaviour is often not a continuous decision but a discrete one, e.g. a water filter is either purchased or not. In this case, the technique again gives an underestimate of benefits unless discrete choice models for averting behaviour are used.

Therefore, simple averting behaviour models can give incorrect estimates of value where they fail to incorporate the technical and behavioural alternatives to individuals' responses to change in environmental quality. Nevertheless, although the technique has rarely been used, it is a potentially important source of valuation estimates as it gives theoretically correct estimates that are gained from actual expenditures and which thus have high criterion validity.

Replacement cost/avoided cost

The technique identifies the expenditure necessary to replace an environmental resource or a human made good, service or asset. Expenditure actually incurred on replacement is a measure of the minimum willingness to pay to continue to receive a particular benefit. It gives only a minimum estimate because more may have been spent had it been seen to be necessary to do so.

Application of the replacement-cost technique

The costs of replacing access to houses lost by re-routing a highway were taken as a measure of the benefits of maintaining access in the assessment of the Noarlunga Freeway in Adelaide (Nairn1971).

The cost of replacing parkland lost in construction of the Sydney Harbour tunnel are a measure of the benefit from maintaining the flow of parkland amenities (Beder undated).

Expenditure to restore strip-mining sites to their original condition can be used to estimate the benefits of maintaining the land environment. This provides information for decisions on mining (Thampapillai 1988).

However, the benefits derived from the asset could substantially outweigh the costs of renovation or restoration, in which case the technique will underestimate the value of the asset. Thus, the replacement cost/avoided cost is a valid measure of economic value only in situations where the remedial work is required to comply with an economically determined environmental standard. Use of such technique assumes that complete replacement or restoration is feasible. In the case of environmental assets, this often is not the case. There are also temporal issues as replacement or restoration of an alternative water resource, e.g. a wetland, may not coincide directly with the damage or loss of the original resource. Because of the potential for confusion between costs and benefits, the replacement cost/avoided cost technique should be used with care, and only where benefits cannot be estimated easily.

Contingent Valuation Method

There is great appeal in asking the following question:

- How much one is willing to pay for a particular environmental effect or how much are you willing to accept in compensation for a reduction in environmental amenity?

When the respondent understands the question and answers truthfully the benefit of the environmental effect is valued directly. The simplicity of the technique has led to widespread application, widespread testing of its forms and assumptions and widespread comment on its perceived adequacy. There are many practical applications of direct survey questions.

Applications of contingent valuation

Clean air, cars and lead pollution: In an effort to gain some knowledge of the magnitude of the benefits of pollution control on automobiles, the Australian Environment Council (1982) asked vehicle owners the following question: How much are you prepared to increase your annual car cost to help reduce air pollution?

Non-use benefits: The non-use benefits of existence value, vicarious value, option value, quasi-option value and bequest value can often only be assessed with contingent valuation and the survey of the non-use benefits of the Kakadu Conservation Zone is an attempt to do so (Imber, Stevenson and Wilks 1991).

Quality of recreational environments: Walpole (1991) assessed the recreational benefits of 25 sites along the Ovens and King Valleys in northeastern Victoria with contingent valuation. The value of a recreation visit per group ranged from $7 to $30 across the sites and higher values consistently occurred at sites with higher environmental quality ratings. A one unit increase in the environmental rating, on 1 to 10 scale, was associated with an $8 per visit increase in recreation benefit.

There are many problems that have been identified with CVM:

1. A primary criticism is that the values elicited in contingent valuation surveys are not based on real income decisions - they are hypothetical. There is no budget constraint in a hypothetical survey and without a budget constraint choices are meaningless. This bias is identified as hypothetical bias.
2. There may also be strategic bias in response. If the respondent presumes that the amount of money would actually be collected from him at some future date, then with the intention of free-riding he would understate his preference. On the other hand, if he is convinced that this question is totally unrelated to his ability to pay then to enjoy higher moral satisfaction he would overstate his preference.
3. Another problem with CVM is called embedding. The response is sensitive with respect to quality and not quantity. People may place the same value on cleaning up one lake or ten lakes (Banerjee, 1994).

To reduce all these biases a number of improvements have been suggested towards more careful survey designing. Some cross questions may be included in the questionnaire to eliminate hypothetical bias. For example, in the questionnaire the questions are incorporated to identify the income constraint of the respondent. To handle the possibility of strategic bias a closed ended DC model is recommended. The National Oceanic and Atmospheric Administration (NOAA) panel has offered a set of guidelines that it believes should be followed to cover all contingent valuation studies. Contingent valuation is likely to be most reliable for valuing environmental gains, particularly where familiar goods are considered, such as local recreational amenities.

The use of contingent valuation to determine value has stimulated an extensive debate. It has been criticized for its theoretical background, the isolation from contextual issues, and for imposing a market construct and context on respondents. Contingent valuation studies are costly and entail an inevitable comprise between expense and quality.

Standard practice in stated preference typically blurs the distinction between household and individual response valuation exercises (Bateman, Munro). However, there is some theoretical debate regarding the appropriate approach and to date there have been no empirical tests of whether values for say a two adult household elicited by interviewing one randomly selected adult are the same as the values generated by interviewing both adults simultaneously. While throwing light on the theoretical debate, the more immediate consequence of such findings are to question the assumption, implicit in common practice, that differences between individually and jointly elicited estimates of household values can effectively be ignored.

The environmental valuation techniques place monetary values on both marketed and non-marketed goods and services and environmental resources. The Contingent Valuation Method has lead to two non-monetary approached to valuation: Conjoint Analysis; and Habitat equivalency analysis (Braden 2000)[8]. The habitat equivalency analysis attempts to identify which bundle of natural resources is equivalent to the other damaged resources for example, by the public. So far no attempt is made to determine their relative importance to the humans, even in physical terms. On the other hand, Conjoint Analysis attempts: (1) quantify the equivalence in terms of physical units; and (2) assign relative importance in terms of human preference structure. However, both habitat equivalency analysis and conjoint analysis do not attempt to translate physical units into monetary terms.

Apart from the above mentioned valuation techniques there are some more advanced valuation techniques: Dose Response and Environmental Value Transfer. The dose-response function was first used by Ellis and Fisher (1987) to estimate the contribution that wetlands protection makes to the production of shell fish. In certain instances, dose-response functions can be established between changes in environmental variables (the dose) and the resultant impact on marketed goods and services (the response). Where this is the case, a dose-response function can provide the basis for valuation of the environmental variable of interest; this is the main technique used to derive economic values for air pollution. Valuation is carried out by multiplying the physical dose-response function by the price or value per unit of the impact (usually some form of physical damage) to give a 'monetary damage function'. The latter is equivalent to the change in consumer surplus plus producer surplus caused by the impact.

[8] Braden, John B. (2000)

Environmental value transfer here refers to transfer of values for environmental costs as well as benefits (the latter is otherwise known as 'benefits transfer').

The costs of valuing impacts on the environment can be considerable. However, it is not always necessary to undertake a new valuation study. Where valuation has been undertaken for a similar case elsewhere, it may be possible to transfer the estimates and employ them as indicators of the economic welfare impacts in a new study. The original valuation may have utilized any of the valuation techniques outlined above. Environmental value transfer is undertaken largely for reasons of cost-effectiveness and scope to rapidly inform decision-making. It is a very attractive alternative to resource-intensive and time-consuming valuations based on original data. However, it is fraught with difficulties and subject to a number of caveats.

Dose-response functions

The use of dose-response functions is theoretically sound. Any uncertainty surrounding their use resides in the specification of the function itself and in predicting any behavioural responses that might occur. Dose-response functions are suitable for use in instances where the relationship between change in an environmental variable and the resultant impact on a good or service can be established (it cannot be used to estimate non-use values). It can be a costly technique to use where manipulation of large databases for physical and economic modeling is required. However, where the necessary dose-response functions already exist and impacts are marginal, the method can be very inexpensive to use with low demands on time, providing reasonable first approximations of true economic value.

Environmental value transfer

Several limitations are common to all the approaches for value transfer: a requirement for good-quality studies of similar situations; the potential for characteristics to change between different time periods; and inapplicability to the valuation of novel impacts. The quality of studies carried out using transferred values can be no better than the quality of the data in its original context (Green *et al.*, 1994). Garrod and Willis (1994) found that for applications in the United Kingdom, even careful modification of available benefits estimates did not yield transfer estimates 'which were reliable and robust enough to be used with confidence in policy applications.' There is little published evidence that tests the validity of environmental value transfer. In the few studies conducted, transfer errors have been found to be substantial (Brouwer 1998). It may be possible to make value transfer more robust if, as well as socio-economic variables, essential physical variables, e.g. ecosystem characteristics and processes are considered at the different sites. As more information about factors that influence environmental values becomes available, e.g. through meta-analysis, the transfer of values across populations and sites will become more practicable, using either only existing data or supplementing this with new original data.

Environmental value transfer is still in its infancy, partly because only a limited number of high-quality valuation studies have been completed for many environmental impacts. However, it does offer a potentially important and useful means for valuation, and could feasibly provide accurate and robust benefit estimates at a fraction of the cost of original valuation studies.

Table 4: Comparisons of different Valuation Techniques

Valuation Method	Reliability of results	Data requirement	Ease of application	Technical development	Accumulated experience
Special features: based on market transactions –assumes no distortions in market prices					
Productivity approach	High	Medium	High	High	High
Opportunity cost	High	Medium	High	High	High
Preventive expenditure/ Replacement cost	High	Medium	High	High	High
Special features: assumes mobility and perfect information					
Hedonic Pricing	High	High	Medium	High	Medium
Special features: use limited to recreation benefits					
Travel Cost	Medium	Medium	High	High	High
Special features: the only technique that measures existence values can suffer from a lot of biases					
Contingent Valuation	High	Medium	Low	High	High

Source: Intizar Hussain, Liqa Raschid, Munir A. Hanjra, Fuard Marikar and Wim van der Hoek, *Wastewater Use in Agriculture: Review of Impactsand Methodological Issues in Valuing Impacts*, Working Paper 37, IWMI, 2002.

Table 4 presents a comparative overview of advantages and limitations of various valuation techniques.

A detailed description of the valuation techniques, their application, and problems can be found in James (1994)[9], Hanley and Spash (1993)[10], and Pearce and Turner (1990)[11].

Selection of a technique

There are a wide range of techniques available to value environmental effects which have been reviewed and illustrated in the first part of this study.This section offers suggestions on how to choose between the techniques on the basis of:

- suitability to value specific kinds of effect
- the need to use a range of techniques for any given project
- validity
- requirements for data and skill.

[9] James, D. 1994
[10] Hanley, N.; and C. L. Spash. 1993
[11] Pearce, D.; and K. Turner. 1990

The validity of each technique can be summarised as high, mid or low validity. The data requirements are reviewed in the Table 4 in terms of the overall data requirements (high, mid or low) and whether an extensive survey is needed to collect the data (yes or no). As the table indicates, data requirements tend to be high when surveys are needed but are low when market prices or costs can be applied. The requirements for skill are assessed in terms of the need for specialist statisticians to analyse and interpret the results (yes or no) and the availability of experience and expertise (high, mid, low).

Where several techniques are suitable, the choice between them can be made in terms of:

- theoretical validity
- market validity
- data requirements
- skill requirements.

Where several techniques appear suitable to value a given effect, the preferred method would normally be that with higher validity and lower data and skill requirements.

Until now different authors have often focused on contingent valuation. Hence, there is a need to use more of the techniques and to gain experience with more applications.

In cases where there are limited time and resources, the use of a benefits transfer approach may be applicable. In essence, this approach draws on existing valuation studies. Benefits obtained in past studies of similar sites are transferred to the site in question. These estimated benefits can be adjusted for assumed biases in the original studies, differences in socio-economic characteristics, extent of substitute goods and services and differences in the policy or project (OECD 1994). In applying this approach, the New South Wales Environment Protection Authority's database on valuation studies could prove extremely useful.

Section 5: Conclusion

Natural disasters can cause temporary or permanent loss of economic opportunities from damaged ecosystems, such as agriculture and forests, and loss of environmental services, such as water purification, floodwater retention, coastal protection, biodiversity protection, carbon sequestration, soil retention, and recreation potential.

In many cases, it may not be possible to conduct a quantitative assessment due to the restrictions on time, resources and accurate quantitative information. In these cases, it is best to describe the impacts qualitatively (in terms of the type of natural resource affected, and severity and extent of impact) and wherever possible economic impacts can be assessed. Satellite images and geographic maps can be useful for this. Examples of direct damage caused by natural disasters in Pacific Island Countries include soil erosion and beach damage caused by cyclones. Lahiri, Sen, Rao and Jena (2001) discussed the economic consequences - extensive losses of lives, injuries and material losses of Gujarat earthquake in India, January 26, 2001.

The presence of non-use values and the lack of markets for many environmental goods and services pose theoretical and practical obstacles to valuing environmental damage. Because many environmental resources are not traded in markets, they do not have a clearly defined price. Only a few environmental goods or assets can be measured directly in terms of their market value. Consequently, indirect procedures are commonly used to estimate them. Thus it is important to decide whether to conduct an economic evaluation of environmental losses and benefits due to disasters or whether just to conduct a quantitative assessment in non-monetary units.

However, different studies have compared the different methodologies but disagreement remains there regarding the most appropriate technique in different situations. There may be cases where one or more methodologies may be inappropriate. It is difficult, for example to use HP to a study on the value of visibility at the Grand Canyon. Similarly TCM is more appropriate for determining user values of recreational facilities. On the other hand CVM studies are most appropriate where well-defined markets do not exist.

From the existing literatures (Smith 1993a; Cropper and Oates 1992; Cummings, Brookshire, and Schultz 1986), it seems reasonable to apply CVM in spite of some strategic biases. Much improvement has been made in designing CVM studies so that the various biases can be ruled out.

One severe problem with CVM studies, which is rarely mentioned, is its cost in policy applications. Undertaking large surveys can be time consuming and also expensive. A quick and inexpensive survey may not yield robust and reliable estimates. This same criticism can be applied to TCM which also requires survey data. An advantage of HP is that much of the data can be readily collected from the market transactions.

Moreover, the use of market prices to estimate damages may not give the clear picture. Changes in the value of outputs may occur and in that case changes in producers' and consumers' surplus must be examined not only in the directly affected market but in indirectly affected markets as well.

However, some techniques have been regularly used for many years. For example, the change-in-productivity and property-value methods have long been used to value the unpriced effects of agricultural use of the land. The property-value method is used routinely to work out the cost of noise in the assessment of highway projects in New South Wales.

This critical assessment of valuation methods suggests that there is great potential for further applications on the economic assessment of disasters such as floods, cyclones and earthquakes.

End notes:

Further details of the underlying theory and practical implementation of the techniques is provided in general texts including Braden and Kolstad (1991), Freeman (1993), Pearce, Whittington and Georgiou (1994), Georgiou et al., (1997) and ECLAC (2003), K.G.Willis and J.T.Corkindale (1995) and Karl Goran Maler and Jeffry Vincent (ed.), (2003), Nick Hanley, F. Shogren and Ben White (2007).

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