

## Contributing Paper

# Best Practice Methods for Valuing Energy Benefits

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*For further information see <http://www.dams.org/>*

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# 1. Methods for Valuation of Impacts of Hydropower Projects

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This section reviews the different methods used to value the impacts of hydropower. We divide these impacts into two: the direct benefits in the form of electric energy, irrigation and flood control; and indirect benefits and costs such as losses of forestry, biodiversity, increases in disease vectors, etc. The second group also includes the valuation of social impacts, such as resettlement.

Given the limited space available, the coverage here is necessarily brief. Further details of the valuation methods are methods can be found in Markandya et al. (2000), ADB (1997), OECD (1995). For a rigorous application of direct methods see Ray (1984) and of indirect methods see, Braden and Kolstad (1991).

## 1.1 Direct Benefit Estimation

### 1.1.1 Private Costs and Social Costs

The key concepts in the assessment of all benefits and costs are social costs, private costs and externalities. Underlying these are the notions of opportunity cost, and willingness to pay/willingness to accept. This section provides a non-technical review of these concepts, and a discussion of their relevance to the ancillary cost/benefit debate.

The conceptual foundation of all cost estimation is the value of the scarce resources to individuals. Thus values are based on individual preferences, and the total value of any resource is the sum of the values of the different individuals involved in the use of the resource. This distinguishes this system of values from one based on 'expert' preferences, or on the preferences of political leaders. These values are measured in terms of the willingness to pay (WTP) by individuals to receive the resource or by the willingness of individuals to accept payment (WTA) to part with the resource. The costs of WTP and WTA therefore play a critical part in the whole cost methodology. A frequent criticism of this basis of costing is that it is inequitable, as they give greater weight to the 'well off'. While acknowledging the validity of this criticism it is important to note that there is no coherent and consistent method of valuation that can replace the existing one in its entirety. Where there is a concern about equity that should be addressed separately from that of cost estimation.

In parallel with this, a second foundation of all valuation is the notion of opportunity cost. The opportunity cost of providing a commodity or service (call it X) is defined in terms of the value of the scarce resources that have been used in producing X. Those in turn are measured in terms of the value of the next best thing, which could have been produced with the same resources. This notion of cost may differ greatly from the common notion of cost. For example, take the cost of developing a reservoir by inundating an area of land. In estimating the costs of such a program, what do we take as the cost of the land? In some cases a zero 'cost' is attached, because the land is not rented out and no money actually flows from the project implementor to the owner. This, however, is incorrect in terms of opportunity cost. The cost of the land is to be measured in terms of the value of the output that would have been received from that land had it not been used for the dam. Such output may be a market good or service (e.g. agricultural output), and/or a non-market good or service (e.g. recreational use),<sup>1</sup> which is dealt with in Section 1.2.

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<sup>1</sup> In some cases recreation benefits may be marketed. Other examples of non-marketed services include soil erosion control and biodiversity conservation.

The two concepts of WTP/WTA and opportunity cost come together because opportunity cost is measured in terms of WTP/WTA. To make the example concrete, consider the example of one day of labour hired by a construction company as part of the program of building a dyke. The WTA payment for that day of work will be equal to the value the worker attaches to the best alternative use of the time, which is the opportunity cost of that time to the worker. As for the payment offered by the employer, the WTP will be no greater than the value of the alternative use to which the payment could be put. Hence both the WTA and WTP concepts are related to the concept of opportunity cost.<sup>2</sup>

### **1.1.2 Shadow Prices for Goods and Services**

The relevance of the above analysis for direct cost and benefit estimation relates to the adjustments we need to make to the costs of inputs such as labour and capital, and outputs, such as electricity, water etc. Where market prices exist for these inputs and outputs the process of adjustment is based on shadow prices and shadow price factors. The standard assumption for social cost pricing of all such goods and services is to take the international prices for all tradable commodities.<sup>3</sup> Where goods are not tradable, shadow prices are estimated using the costs of production with inputs priced at international prices. This assumes that international prices are indeed free market prices. If that is not the case, a further adjustment must be made to the international price to reflect any divergence from social cost. Note that such adjustments will mean that all inputs and outputs will be valued net of any taxes or subsidies. The most important adjustments that are made in dam analysis relate to the valuation of (a) labour, (b) capital, and (c) exchange rate and (d) energy. If the domestic prices are distorted we must use a shadow price. Box 1 provides a detailed calculation of the shadow price for labour using the shadow price method. The details of how such premia can be calculated are discussed in standard treatments of the subject, eg Ray (1984).

#### **Box 1: The Shadow Wage Rate and Shadow Price of Capital**

If the wage paid to a worker is \$30/day and the opportunity cost of his or her time is only \$15 a day, the shadow wage is \$15 and a shadow wage factor of 0.5 is applied to the actual wage to get the social cost of that input. The underlying imperfection in this case may be union power which keeps the wage artificially high, or macroeconomic failure, which prevents the labour market from clearing. The opportunity cost is based on the value of the time in 'non-formal work' activities. The person may spend time doing home duties, or working in the informal sector. The total value of all these activities gives the opportunity cost of labour. Likewise, where capital markets are distorted, the market price of capital may not reflect its true scarcity. This would imply the need to apply a shadow price factor to capital of greater than one; something which is routinely done in project appraisal by public sector investors.

## **1.2 Indirect Benefit Estimation**

There are many indirect impacts from hydropower, from the construction, operations and transmission activities associated with large dams. Table 1 summarises these impacts, giving the stage at which they occur, the 'receptor' i.e. the persons or resources affected, the priority attached to the valuation and the method of valuation to be used in valuing the impacts. The methods of valuation and main indirect impacts to which they apply are given in Table 1 below.

<sup>2</sup> In a competitive market the WTA and WTP values are equal for the last worker hired. Where the WTA and WTP values differ, we need to choose between them. This issue is discussed further below.

<sup>3</sup> The relevant prices are the international price f.o.b. from the country concerned for goods that are exports or potential exports, and c.i.f. to the country for goods that are imports or import substitutes.

**Table 1. Methods of Valuation Impacts to be Valued and Priority**

Method	Impact	Priority
Productivity Methods	Accidents to workers and public	H
	Health impacts on general public	H
	Loss of forest production	H
	Loss/gain of fishery production	H
	Loss of agriculture when market prices are inadequate	M/H
	Changes in water supply	L
	Replacement costs of damages to roads, buildings etc.	L
	Resettlement	H
CVM Methods	Accidents to workers and public	H
	Health impacts on general public	H
	Changes in recreational use of land	L/M
	Disturbance to and loss of wildlife	L/M
	Changes in recreational use of water, including angling	L/M
	Losses of cultural and archaeological objects	M/H
	Loss of endangered species	L/M/H
	Visual intrusion of operations	L
CVM and Travel Cost Methods	Resettlement	H
	Changes in recreational use of land	H
	Changes in recreational use of water, including angling	L/M
Hedonic Methods	Noise from construction/operations	L
	Accidents to workers	H

Note: H = high, M = medium, L = low

Note that many impacts can be evaluated using more than one method of assessment. In the discussion below we provide some guidance as to which method is preferable and when. Before we start, however, we should note that underlying information on which to base the valuation is not always available for every site and every country. It is necessary therefore to use data from other sites and possibly other countries. This process is known as 'benefit transfer'. Studies of benefits, particularly in developing countries will need such transfers. The basis for making them, however, needs to be made clear and adjustments for differences between the original country/site and the one where the data are being applied need to be made. This section provides some guidance on how this can be done.

### 1.2.1 Productivity Methods

Productivity methods essentially look to value changes in output using market prices if these are available, or using unit values for the output derived from other methods. The process of quantifying the output changes can, however, be quite complicated. In the examples given below we review some of the key issues.

#### *Accidents to workers and the public*

Hydropower related activities are known to cause significant accidents, resulting in serious injury and loss of life. The values attached to worker injuries are often taken at the compensation that has to be paid by law. This is almost certain to be inadequate. Another approach is to value the loss of earnings, plus of any medical expenditure of those affected. This too is an underestimate but is defensible when estimates based on WTP/WTA are not available. The latter are always higher than the former and methods using them are discussed below. Furthermore earnings approaches cannot be used to value old people or those who are unable to work due to injuries, or those not in paid employment. For the latter some value of work based on opportunity cost of time is required. Since the losses will take place over time, a discount rate has to be applied. The choice of the rate is a matter for public policy but typical rates in developing countries are around 10-12 percent in real terms, i.e. after allowing for inflation. This implies that all earnings calculations have to be done in constant

prices. Box 2 shows how the calculations might be made for (a) a child, (b) a working man, and (c) a housewife who is injured permanently so they cannot work. For injuries that cause death or that partially reduce earnings the same model applies.

### Box 2: Valuing Accidents and Injuries by the Productivity Method

The dam construction causes permanent injury to a male child aged 5, and to a working man and a housewife aged 30. The net value of net earnings is given by E, where

$$E = \frac{1}{(1+r)^T} \sum_{t=1}^{t=Tu} e_t \cdot (1+r)^{-t} - \sum_{t=1}^{t=T} c_t \cdot (1+r)^{-t}$$

Where r is the discount rate, T is number of years before the person starts work, TU is the number of years the person works,  $e_i$  are earnings after deduction of medical expenditures in year I and  $c_i$  are medical expenditures in year 'i'. We assume the working life is from 18-65 and we take a real discount rate of 10 percent. The value of T for the child is 13 (number of years to starting work) and for the man and woman it is 0. Earnings are fixed at \$3300 per year for a male. The woman's 'earnings' are valued at the opportunity cost of the time, or what she could earn if she worked. This is taken as \$2300 per year. The costs of medical treatment is estimated at \$300 per year giving net earnings of \$3000 for a male and \$2000 for a female. The net losses then work out at \$6,500 for the child working man: \$28,900 and non-working woman: \$19,300. More complex calculations can allow for earnings growth but the principle is the same. Note, however, that the method will generate a negative value for a retired person!

### Health Impacts on the General Public

The same issues apply to health impacts on the general public. These can arise from, for example, increased disease vectors as water is impounded. Loss of earnings can be valued in the same way but the key problem is to identify a link between increased incidence of the disease and (a) loss of earnings and (b) increased cost of medical treatment. The latter include costs borne by the individuals and their families but also costs borne by the government that are not recovered from the individual.

### Loss of forestry or fisheries or agriculture

The productivity method is best suited to valuing changes in outputs such as forestry, fisheries and agriculture. The dam may take land away from these uses for impoundment, road construction etc., in which case the loss of output has to be valued. The following steps explain how this can be done:

1. If the asset that is lost is traded on the market and if the market prices are based on reasonable competitive conditions, the value of the land on the market can be used to value the private benefit lost.
2. If the asset is not traded, the discounted net present value of the output can be used. This is the value of the output, less the costs of extraction. The key problem is valuing the output. If it is sold in well-function markets the sale price can be used, but if it is not, a value has to be imputed based on value in use. Furthermore the issue of whether the resource is being used sustainability comes into question. Box 3 shows show the valuation can be made and how it will vary according to sustainability.
3. The above will not pick up indirect values such as biodiversity, recreational use etc. These have to be obtained from other methods, such as CVM or travel cost (see below).

### Box 3: Valuing Losses of Forestry, Fisheries, Agriculture

Suppose the dam construction clear fells 1,000ha of forested land. The timber is removed and sold at a net value of \$30 per cubic meter, and each ha generates 100 cubic meters of useful timber. If the dam had not been constructed, timber would have been extracted at a rate of 15 cubic meters per ha for the indefinite future. Furthermore the net value is expected to grow at 3 percent per annum. The discount rate is 10 percent. Since forest land is not sold, the net cost of the clearance NC has to be calculated as follows:

$$NC = V_0 - \sum_{t=0}^{T-1} \frac{v_t (1+g)^t}{(1+r)^t}$$

Where  $V_0$  is the value of the initial clearance,  $v_0$  is the net value of the clearance that would have taken place in year 0,  $t$  is the year in which the present use comes to an end,  $g$  is the growth in net values per annum and  $r$  is the discount rate. For the case of sustainable future extraction  $T$  is infinity the net cost becomes

$$NC = V_0 - \frac{v_0}{(r-g)}$$

In the above example the values then are:

$$NC = 30 \times 100 \times 1000 - (15 \times 30 \times 1000) / (1 + 0.03 - 0.1) = 3.4 \text{ million}$$

Similar calculations can be made for other outputs, such as fisheries, agriculture etc. If the output is not sold, the net value has to be based on (a) the market value of equivalent output which is sold, or (b) the value of a substitute which the user would use if this product was not available.

#### ***Changes in water supply and other factors where a net back calculation is needed.***

There are some inputs into production or use that are not marketed, and which have a value that can be derived from the value of the final output. The processing of doing that is called net backing. The final output is taken and costs of distribution, processing etc. are deducted from it. The net value is then attributable to the product. The details of such a calculation for surface water in one province in Russia are given in Box 4. Note that a number of assumption have to be made about future values. In the case of Russia present values are very low, but we firmly expect them to increase when the transition period comes to an end.

#### **Box 4: Net Back Method for Valuing Surface Water in Yaroslavl Province in Russia**

The value of surface water stocks at the beginning of a year (PV) is determined by capitalisation method of user income:

$$PV = \sum_{T=1}^n V_{T_i} \times d_{T_i} ,$$

$V_{T_i}$  – income from Volga water use in Yaroslavl in the year  $T_i$ , thousands rubles/year;

$n$  – period of resource extraction, 102 years;

$d_{T_i}$  – discount factor for the year  $T_i$ .

The income from extraction and use of the resource in the year  $T_i$  is calculated as:

$$V_{T_i} = p_{T_i} \times Q_{T_i} ,$$

$p_{T_i}$  – net value of 1 cubic meter of water in the year  $T_i$ , thous.roubles/cub.m.;

$Q_{T_i}$  – annual volume of water extraction in the year  $T_i$ , thous.cub.m./year.

The value of 1 cubic meter of water is calculated under the formula:

$$p_{T_i} = WTP - COST$$

$WTP$  – willingness of households to pay for water, thousands rubles/ cubic meter;

This has been estimated at a rate of 0.65 thousands rubles/ cubic meter from the research carried out in Danilov (Yaroslavl province).

$Costs$  – costs of extraction and delivery of water to the consumer, thousands rubles/ cubic meter;

The discount factor for the year  $T_i$  is calculated under the formula:

$$d_{T_i} = \frac{d_{T_i-1}}{(1+r)} ,$$

$d_{T_i-1}$  – the discount factor for the previous year;

$r$  – annual discount rate, 3 % per year.

### Assumptions

- For the valuation of the stocks of surface water the WTP was based on CVM studies at 0.65 thousands rubles/ cubic meter. This value is expected to increase over time, to reach the value in other countries with similar *per capita* incomes.
- The value of 0.65 was taken to hold to 2011. From 2012 onwards, the assumption was made that the WTP level in Yaroslavl province will become equal to 6.5 thousands rubles/cubic meter in 2012. This value is taken from the WTP in the Philippines. Hence from 1997 to 2012 the WTP for Yaroslavl province is increased annually by 0.39 thousands rubles/cubic meter. From 2013 onwards, to the end of the calculated period of the resource use the WTP grows annually by 1 % *per annum*.
- The costs of water extraction and delivery to consumers are accepted taken as constant during the whole period of the resource operation — 3.5 thousand rubles/cubic meter.
- Total annual volume of water from Volga extraction in 1996 was 151,330 thousand cubic meters. This is assumed to remain constant during the period of the resource operation.

According to the listed assumptions and the annual parameters of income from the resource use, the discount factor and PV change, the total value of surface water stocks in Yaroslavl province is estimated as 16,406.6 billion roubles.

Source: Fomenko, G. Fomenko, M. and A. Markandya. 1997. Natural Resource Accounting In Russia: A Case Study for the Region of Yaroslavl; DFID Report, London.

### Resettlement

Resettlement is a major issue in almost all dam projects. The cost attached to this is difficult to ascertain, but it is clear that taking the value of assets lost at market prices is often not enough. Some allowance must be made for individual WTP over and above that. WTP measures are discussed in the next section. Here we note that direct resettlement costs include compensation for lost income for a specific period, compensation for the loss of assets or the reconstruction costs of housing and workshops, compensation for temporary production losses during relocation and the cost of removal and the cost of managing the resettlement process. Compensation for lost income should not be included as an economic cost if the economic price of land has already been estimated and included.

As discussed in Section 7.1, all costs all financial resource costs should be converted using shadow prices. Table 2 illustrates the calculation of the economic costs of resettlement from their financial costs. The economic cost at shadow prices should be included in the project resource flow in addition to the economic price of land. Note that as the cost of acquiring land has already been taken into account, it would be double counting to include the compensation paid to the owners as an economic cost. It reflects a transfer payment. For the economic costs we are interested use of resources by the project. Note that the financial costs will generally exceed the economic costs. Note also that these figures will underestimate the costs of resettlement to the extent that: (a) individuals without land lose their livelihood and their loss is not accounted for, (b) those who lose land have a higher WTA than the value of the land, which is certain to be the case. These points are taken up in the following section.

**Table 2. Economic cost of resettlement for a typical resettlement project**

Item	Financial cost (\$ m)	Resource Cost (RC) or Transfer (T)	Conversion Factor/ (1)	Economic cost
Land compensation /(2)	3.500	T/(4)	0.00	0.000
Reconstruction of buildings	10.788	RC	0.90	9.709
Temporary production losses/(3)	0.300	RC	0.85	0.285
Removal costs	0.750	RC	0.90	0.675
Management costs	0.782	RC	1.30	1.017
Total financial cost	16.120			
Total economic cost				11.686

Source: ADB (1997).

Notes:

- (1) Using world price, standard conversion factor = 0.90.
- (2) Seven years lost average production per hectare.
- (3) Net income from one harvest/three months net income. Shadow price is based on world prices.
- (4) Economic cost of land calculated separately.

## 1.2.2 Contingent Valuation Methods (CVM)

The contingent valuation method (CVM) asks people what they are willing to pay for a benefit, and/or what they are willing to receive by way of compensation to tolerate a cost. What is sought are the personal valuations of the respondent for increases or decreases in the quantity of some good, contingent upon an hypothetical market. Respondents say what is the maximum they would be willing to pay (WTP) for an environmental improvement or the minimum they would be willing to accept (WTA) for a decline in environmental quality if a market existed for the good in question. Alternatively, they might be asked whether they are willing to pay or willing to accept a particular figure. A contingent market is taken to include not just the good itself (an improved view, better water quality etc.), but also the institutional context in which it would be provided, and the way in which it would be financed.

The aim of the CVM is to elicit "bids" which are close to those that would be revealed if an actual market existed. The hypothetical market -- the questioner, questionnaire and respondent -- must therefore be as close as possible to a real market. The respondent must, for example, be familiar with the good in question. This might be achieved through photographs, videos, direct conversation, etc.

There are several issues that have to be addressed in such studies. The first is what form the survey should take. It can be a personal interview, a mail survey or a telephone interview. For most dam related programmes, a personal interview will be required. The second issue is the way in which the environmental change will be carried out. Will it be the responsibility of a particular agency, and how will it be paid for? These factors could influence the answers received. Third is the method by which the WTP or WTA is measured. There are essentially four elicitation methods: the direct open-ended question method, the bidding game, payment cards, and a take-it-or-leave-it (TIOLI) question. Details of the methods are available Mitchell and Carson (1989), Arrow et al. (1993) and Markandya et al. (2000).

Given the growth of interest in CVM methods, a comprehensive review of the method was carried out by Arrow et al (1993). The conclusions of that review provide a protocol for a good CVM study. They state:

- A. For a single dichotomous question (yes-no type) format, a total sample size of at least 1000 respondents is required. Clustering and stratification issues should be accounted for and random sub-sampling will be required to obtain a bid curve and to test for interviewer and wording biases.
- B. High non-response rates would render the survey unreliable.
- C. Face-to-face interviewing is likely to yield the most reliable results.
- D. Full reporting of data and questionnaires is required for good practice.
- E. Pilot surveying and pre-testing are essential elements in any CVM study.
- F. Underestimation of WTP/WTA is to be preferred to overestimation of WTP/WTA. A WTP format is preferred.
- G. Accurate information on the valuation situation must be presented to respondents, particular care is required over the use of photographs.
- H. Respondents must be reminded of the status of any undamaged possible substitute commodities.
- I. Time dependent measurement noise should be reduced by averaging across independently drawn samples taken at different points in time.
- J. A "no-answer" option should be explicitly allowed in addition to the "yes" and "no" vote options on the main valuation question.
- K. Yes and no responses should be followed up by the open-ended question: "why did you vote yes/no?".
- L. Cross-tabulations: the survey should include a variety of other questions that help to interpret the responses to the valuation question, i.e. income, distance to the site, prior knowledge of the site etc.
- M. Respondents must be reminded of alternative expenditure possibilities, especially when "warm-glow" effects can be prevalent (i.e. purchase of moral satisfaction through the act of charitable giving).

The panel concluded that CVM studies when adhering to the above mentioned guidelines “can provide estimates reliable enough to be a starting point for a judicial or administrative determination of natural resources damages”, assigning therefore to best practice CVM an important place among valuation methods.

Examples of the application of CVM methods are numerous although not specifically in the context of hydropower projects. This does not mean that they cannot be used for such impacts and there are some examples, such as the study by Navrud for hydropower Norway (ExternE 1995). In Box 5 we give one example of a study that valued water pollution benefits, which illustrates the method as applied in a developing country. We also discuss other applications that will be relevant for hydro power projects

### **Box 5: Application of CVM Method**

The workings of a CVM can be seen by looking at one the WTP for surface water quality improvements in Davao City, the second city in the Philippines. Surface water pollution arises mainly from the discharge of household effluent into the Davao River, which in turn pollutes the beaches near the city, used by local and foreign visitors.

The CV survey was carried out by 30 individuals from universities and government agencies, trained to administer household questionnaires. The questionnaire took two weeks to develop, including collaboration with enumerators and field supervisors. Numerous focus groups were held to discuss water pollution problems and pre-tests were carried out with 200 households before the questionnaire was finalised.

The survey included questions about the households demographic characteristics, followed by four major sections. The first dealt with the households’ existing water and sanitation situation and level of satisfaction with the services. The second sought information on the respondents’ priorities for environmental improvements, use of beaches, and knowledge and concern about water pollution issues. The third elicited the WTP for improvements in surface water. The final section asked about household socio-economic characteristics, including income.

The WTP issue was posed as a citywide plan to clean up the river and sea, and make the most popular beach safe for swimming. Households were told that if the plan was adopted, they would have to pay a monthly fee, and were then asked, on a TIOLI basis if they would be willing to pay a specified amount. A total of 581 interviews were completed, representing a 65 percent response rate.

The results are presented as a probability of a household being WTP a certain amount for water quality improvements, as a function of the amount. From this, the average and total WTP was estimated. The WTP was related to income and other socio-economic characteristics. In general, the study revealed a very low WTP for such water quality improvements.

Source: Choe, K.A., Whittington, D. and Lauria, D.T. 1996. "The Economic Benefits of Surface Water Quality Improvements in Developing Countries: A Case Study of Davao, Philippines," *Land Economics*, Vol.72, No.4, pp.519-537.

### ***CVM Applications for Hydro Projects: Value of Mortality and Morbidity***

One of the key areas where valuation of hydropower impacts can make use of CVM and related methods is the valuation of mortality and morbidity impacts. In the previous section we noted that when workers or the general public suffer health impacts or premature death, it has been the practice to value these effects using loss of earnings plus costs of medical treatment. We also noted that this results in an under valuation as most people have a higher WTP/WTA than this method would yield. Estimates are available for mortality effects through the Value of Statistical Life (VOSL). This can be described as follows. Suppose individuals are asked their WTP for a reduction in the risk of death of 1:100,000 and they answer \$5. This implies that a group of 100,000 persons would pay \$500,000 for such a reduction and the result would be one less death. Hence that life saved has a value of \$500,000. This is not the value of a particular person, but that of a statistical life. Values of

statistical life have been estimated using CVM methods and also using hedonic methods (see below). Almost all studies are in developed countries, but there are now some for countries such as India, Chile etc. (Markandya et al. 2000). The values for VOSL come out considerably higher than the productivity approach and also do not face the problem of the latter approach that non-earners have no value.

If estimates are available, it is recommended they be used to value mortality effects of dam activities. If they are not, benefit transfer may be applied. If the VOSL has been estimated in country 0 at  $VOSL_0$  and we are interested in the value for country 'i', then we would expect the WTP to vary with real income differences between the countries. The value of VOSL in country 'i' is given by:

$$VSL_i = VSL_0 \cdot \left( \frac{Y_i}{Y_0} \right)^\mu$$

Where  $Y_i$  is real per capita income in country 'i' and  $Y_0$  is the same in country 0.  $\mu$  is the elasticity of WTP for risk of death with respect to income. Estimates from studies suggest values between 0.3 and 1. Data on real per capita income are available from the World Bank's series on purchasing power parity adjust per capita GDP. Hence the above calculation can be made for most countries.

On morbidity the problem is more difficult to handle. Studies of WTP for reduced risk of health impacts such as hospital visits, reduced activity days etc exist but they are mainly for developing countries. Few studies are available for developing countries, although the situation is changing fast (Krupnick, Davis and Thurston 2000). Where such studies exist they should of course be used. Where data are not available, however, benefit transfer is difficult as the perceptions of health impact is cultural as are institutions for health care. Hence it is likely that a productivity approach will have to be used, knowing that it underestimates morbidity costs. Some work in the US suggests that WTP estimates are 2-3 times the productivity based ones (ExternE 1995).

### ***Resettlement***

We noted in the previous section that resettlement costs are underestimated using data on the direct costs of land and losses of output etc. There is a lot of evidence to indicate that individuals feel worse off if they are forced to move and compensated according to the market value of the assets they have lost. Much of this is because some assets, such as social capital are not valued.

The CVM approach could elicit the WTA for loss of livelihood but there are serious problems with using this method. The main one is that, as Arrow et al (1993) point out, WTA estimates are unreliable; individuals give answers that are unrealistic and not set in the context of their personal circumstances. WTP values, on the other hand, answering the question, what are you WTP not to have to relocate, give very low answers, often because the issue is highly charged and because many affected parties have little access to money income. For these reasons CVM methods have not been applied with much success to relocation decisions.

One alternative, based on the actual practice of many governments, is to provide oustees with financial compensation for loss of assets, plus assets of equivalent value on which they can base a sustainable livelihood similar to the one they have lost. This may look like double compensation but in fact it is not. The double payment makes up the loss of welfare resulting from the forced move.

### ***Recreational Activities***

Damns can both provide and remove recreational activities, such as angling, walking, bird watching etc. Estimates of the value of these are best obtained from travel cost methods (see below), but CVM methods can also provide relevant information. The protocol described here can be used for this purpose. Typical payment vehicles are entrance fees to the area, or charges payable through local taxes. Benefit transfer is difficult for such impacts as the services being valued are very site specific.

### ***Cultural Losses***

Ideally dam projects will be designed to avoid serious loss of cultural and religious assets. If this cannot be avoided, then the loss has to be valued and there is no alternative to the use of CVM methods. Studies have to be site-specific as the issues are very much site-specific. Examples of studies of cultural monuments can be found in ExternE (1995).

### ***Loss of Wildlife and Impacts on Endangered Species***

Many dam projects are criticised because of their effects on rare species and on wildlife in general. Where the loss is a 'use value' – i.e. related to photo tourism or hunting, values based on CVM or travel cost methods can be applied as indicated above. If, however, the loss is in non-use values, arising from people who never visit the area but who have a WTP to preserve the ecosystem and the species. CVM methods are generally considered unreliable for non-use values, although some recent studies have produced plausible estimates (see OECD 1995). If such a study is to be undertaken, it has to have an international dimension; much of the WTP lies outside the borders of the country where the impacts occur.

### **1.2.3 Travel Cost Methods**

Travel cost models are based on an extension of the theory of consumer demand in which special attention is paid to the value of time and the choice of site visits. They are used to value the benefits of improvements in recreational facilities in parks, or the values of cultural sites that are visited by people from many different locations. Numerous applications exist for the US, and some for Europe and Australia. In developing countries, some models are being used to estimate benefits from tourism development in countries with game parks and wildlife such as Kenya, Costa Rica and Madagascar, coastal improvement in Barbados, protected areas in Thailand and recreational facilities in Malaysia.

In travel cost models one assumes that there is a demand for the services of a particular site, which are contingent on the attributes of that site, and of other sites offering similar services. The alternatives will depend on who is making the visits. For local residents the alternatives are other sites in the vicinity. For foreign tourists they will be other sites in the country, and conceivably in other countries offering similar packages of facilities. In all these cases the objective is to estimate the relevant demand curves or the maximum price that each person would pay, plotted along with the number of people willing to pay more than that. From this we value the increase in welfare as a result of the project, which is expected to result in a shift in the demand curve and perhaps in a change in the price. The 'price' referred to here is not something that can be measured just in terms of what one has to pay to enter the site. There may be no such payment, and in any case that payment is only a small part of the total cost. The other items that make up the price are the time taken to get to the site, and the costs of getting there. An important part of the travel cost method is the estimation of that price. The benefits of a visit are the difference between the WTP and the cost of a visit, with the WTP measured as the area under the demand curve.

In developing countries one could also use this method to estimate points on a demand curve for a commodity such as water or fuel wood. Such commodities are often delivered, and the consumer pays for the delivery as well as the commodity. But others have to collect the commodity, in which case there may be no money charged for collection. The collection time can be quite a significant part of the person's total time available, and has an opportunity cost that can be measured. That opportunity cost gives the implicit price of the commodity and can be used to value the cost of delivery systems.

A number of issues have to be addressed in such studies. These include:

- What value should be attached to time?
- What statistical model should be used to estimate recreational benefits?
- How do we treat different lengths of visit?
- How do we take account of the preferences of those who do not visit the site but have some WTP for it?
- How do we estimate the shift in demand when the quality of a site improves or deteriorates?

An example of a study is given in Box 6. Careful studies of travel cost have to take account of all these factors. Doing so involves addressing some quite technical estimation issues and cannot easily be done for each dam project. One possibility is to have some benefit estimation from travel cost studies in the relevant country, which gives values of visits to similar sites and apply them to the number of visitors to the affected site. In cases where this is not possible a primary study will have to be carried out and this will be expensive. One guide as to whether it is worth spending this money is, however, to take benefits based on similar studies elsewhere and see if they make a difference to the overall net benefits from the project. If they do not, one can justify taking rough benefit transfer values. Likely areas where travel cost models could be important are

benefits from recreational use of reservoirs, losses from reduced use of rivers for angling and possibly, increased cost of time to collect water for those whose source has been diverted.

**Box 6: Example of a study using the travel cost approach**

As noted above, there are a few studies valuing the benefits of recreational areas and parks etc., using this approach. Among them is the one by Tobias and Mendelsohn (1993). The authors looked at a 10,000 hectare private rainforest reserve. Domestic visitors were divided according to their region of origin and an average visitation rate calculated for each zone by dividing the number of visitors from that region by its population. A zonal cost of visitation was calculated based on the travel cost, plus a value of the time of travel. The latter is normally taken at around one-third to one-half of the gross wage, but the paper does not specify what value was taken.

A regression was then run, using the data on visitation rates and costs per visit, as well as other demographic and socio-economic variables for the zones. The regression showed a downward sloping demand curve for the visitation rate against the cost per visit. From this a measure of the net benefit was estimated. This came to between \$97,500 and \$116,200, according to which specification was taken for the regression. These values are only the annual values at the time of the study (1988); one would expect the surplus to increase over time as per capita income rises, and as reserves such as this one become more rare. The authors allowed for these factors by opting for a lower rate of discount than normal -- of 4 percent. With this rate the present recreational value of the park comes out at between \$2.4 and \$2.9 million.

The above figure does not include the surplus from foreign visitors. The authors add an amount for such visitors, taking the domestic surplus as a lower bound for the foreign visitor's surplus. On this basis the total value is estimated at between \$2.5 million and \$10 million, with a 'central' value of \$8 million or \$1250 per hectare. With the current price of agricultural land at between \$30 and \$100 per hectare, this would suggest that conservation is justified on economic grounds. Of course, to implement the project the parties with control of the park would have to be able to 'capture' enough of the surplus to make conservation more attractive than conversion of the land to agriculture.

Source: Tobias, D. and Mendelsohn, R. 1993. 'Valuing Eco-tourism in a Tropical Forest Reserve', *Ambio*, Vol. 20, No. 2.

### 1.2.4 Hedonic Methods

The hedonic price approach looks for a market in which goods or factors of production (such as land and labour services) are bought and sold, and observes that environmental factors are frequently attributes of those goods or factors. Given that different locations or jobs have varied environmental attributes, such variations will result in differences in property values or wages. Focussing on property values the hedonic approach attempts through the use of appropriate statistical techniques to (a) identify how much of a property differential is due to a particular environmental difference between properties and (b) infer how much people are willing to pay for an improvement in the environmental quality that they face and what the social value of the improvement is.

The identification of a property price effect due to a difference in environmental attributes is usually done by means of a multiple regression technique in which data are taken either on a small number of similar residential properties over a period of years (time series), or on a larger number of diverse properties at a point in time (cross section), or on both (pooled data). In practice almost all property value studies have used cross section data, as controlling for other influences over time is much more difficult. In doing the exercise one is seeking to identify the relationship between the level of the environmental attribute, and the price of the related market property. It reflects the results of a market equilibrium between households who wish to purchase a property with a certain level of the environmental attribute and property developers and owners who supply dwellings at different attribute levels. This 'equilibrium' is represented in terms of a balance between the individuals' bid curves and the suppliers supply, or offer, curves for housing with different levels of the environmental attribute.

Applications of this method have been successfully carried out in developed countries, to estimate the costs of air and noise pollution, and of changes in amenities, but their use in developing countries has been more limited;

valuation of the benefits of municipal sites and services, are among the main applications to be found. Recently there have been a few studies of the costs of air pollution using hedonic methods in Brazil, Korea, Thailand and Mexico. Other applications in developing countries include urban land values in Ghana and Ivory Coast; self-help housing in Manila and piped water in the Bicol region of the Philippines; and sites and services in several countries in Latin America.

The use of hedonic studies in dam projects is not likely to be of great importance, unless the project has an impact on water supply to communities. If it does have such an effect the value of the water supply can be derived as indicated in the box below, and the value of the project that provided it calculated using the net back method discussed in section 8.2.1. Another use could be to value the noise nuisance or visual impacts of a dam. Such values are typically obtained from hedonic studies, but this is one area where benefit transfer is more feasible. Values of losses in property values per unit of noise or loss of a scenic asset are well established in a number of countries, in which case they can be taken in the project.

**Box 7: Example of a study using the travel cost approach**

As an example of the kind of data required for a hedonic study, consider the North and Griffin study of the value of piped water in the Bicol region of the Philippines. To estimate this, data were collected from 1903 households in the region using a stratified sample frame. The survey included questions about ownership of the dwelling (rented or owner occupied), value of the dwelling, income of the household and several household characteristics, including seven types of water supply (private connection of piped water from a community system, private well, tap in the yard, public tap, shallow well, natural sources such a river and purchased water). The authors also estimated the distance to the water source. From an econometric analysis carried out separately for different income groups they estimated that the willingness to pay for piped water was \$1.95 per month for high income households, \$2.25 for middle income households and \$1.41 for low income households. These values were affected by the presence of a well (in this case there was no additional WTP for piped water for the poorest households and the WTP of other households dropped). The researchers also found that the distance to the source had little effect on the WTP.

Source: North, J. and Griffin, C. 1993. "Water Source as a Housing Characteristic: Hedonic Property Valuation and Willingness-to-Pay for Water," *Water Resources Research*, July.

### 1.3 Hydropower: Identification of Burdens and Priority Impact Pathways

<i>ELECTRICITY GENERATION</i>				
<i>Construction</i>				
<b>Burden</b>	<b>Receptor</b>	<b>Impact</b>	<b>Priority</b>	<b>Valuation Method</b>
Construction roads/road traffic	General public	Noise	Low	Hedonic methods. BT possible
		Accidents	Low	CVMM methods desirable but productivity often used. Gives underestimate.
		Health effects from air emissions	Low	WTP estimates based on impact pathway approach. Data limitations may make BT only option.
	Air quality	Emissions from motor vehicles	Low	BT. Take standard estimates of marginal damages from GHGs
	CO <sub>2</sub> and climate change	Emissions from motor vehicles	Low	
	Wildlife	Disturbed by noise	Low	Loss of use value via CVM methods. BT unlikely.
	Forestry	Improved access to forest areas	Medium	CVM or TC methods to value recreational use.
		Loss of future production	Medium	Value of timber and non-timber materials. Sustainability, discounting and non-marketed goods issues have to be addressed.
Helicopter transport	General public	Noise	Low	Hedonic methods. BT possible
		Health effects from air emissions	No data	As other health effects
	Wildlife	Disturbances from noise	No data	Loss of use value via CVM methods. BT unlikely.
Accidents	Workers	Minor injuries	Medium	Hedonic studies on wages or CVM methods or compensation paid by law. Compensation gives an underestimate.
		Major injuries	High	
		Death	High	VSL or productivity methods
Jobs created and increased local income	General public	Local and national employment benefits and local economic effects	High	Shadow wage used to value benefits.

<i>Operation</i>					
<b>Burden</b>	<b>Receptor</b>	<b>Impact</b>	<b>Priority</b>	<b>Valuation Method</b>	
Flow alteration	Fish	Loss of habitat	High	For commercial fishery: loss of net value. For recreational fishery: CVM For endangered species: non-use CVM	
	Plants	Loss of habitat	Medium	Impact pathway to loss of fish then value of fish. Net value of plants for human consumption For endangered species: non-use CVM	
	Birds	Loss of habitat	Medium	CVM methods for use and non-use losses.	
	Wildlife	Loss of habitat	Medium	CVM methods for use and non-use losses.	
	Water quality	Eutrophication/ acidification	Low	Impact pathway to loss of fish and then value of fish; OR cost of liming to neutralise acidity.	
	Agriculture	Loss of grazing area (due to loss of “natural fence” effect)	Loss of source for irrigation	Low	Value of grazing. Sustainability, discounting and non-marketed goods issues have to be addressed.
			Loss of source for irrigation	High	Value of water in irrigation. Netback method used.
	General public	Aesthetic effects-cultural and archaeological objects	Waterfalls	High	CVM methods, but BT may be possible.
			Loss of areas for recreational activities: <ul style="list-style-type: none"> <li>• Fishing</li> <li>• Bathing</li> <li>• Hiking</li> <li>• Skiing</li> <li>• Hunting</li> </ul>	High	Values of lost areas have to be valued using TC or CVM methods. Some BT may be possible.
				High	
				High	
				High	
Loss/changes of water supply	High	Value of water in final use, net backed to source water. Water transport may be affected. Value is cost of increased alternative less present system.			
Changes in local climate	Negligible				
Impoundment/Dams	Agriculture	Loss of land	High	Value of land or discounted present net value of output.	
	Forestry	Loss of future production	High	Value of timber and non-timber materials. Sustainability, discounting and non-marketed goods issues have to be addressed.	

<i>Operation (continued)</i>				
<b>Burden</b>	<b>Receptor</b>	<b>Impact</b>	<b>Priority</b>	<b>Valuation Method</b>
Impoundment/Dams	Aquatic ecosystem	Loss of habitat	High	Impact pathway to fish and plants, which are then valued.
		Changes in recreation	Medium	Impounded areas may provide new facilities, which can be valued using CVM or TC methods.
	General public	Local climate	Negligible	
		Global warming impact-methane	Not proven	Use standard table of values for GHG gases.
		Health impacts from increased disease vectors	High	CVM or productivity methods.
		Resettlement	High	WTA payment for dislocation. Very difficult to measure using CVM methods. Common practice is to take economic loss and also compensate for loss of assets with alternative sources of livelihood.
	Cultural and archaeological objects	Loss of objects	High	CVM methods are only ones possible. BT not feasible.
Release of water from power station	General public	Changed local climate	Negligible	Quantification very difficult.
	Agriculture	Changed production due to changed local climate	Not proven	Very difficult to quantify.
	Aquaculture	Loss of fish due to a possible increase in concentration of toxic algae	Not proven	If quantified, valuation proceeds using impact pathway.
	Marine ecosystems	Small increase in algae production	Negligible	
		Possible release of PAH and heavy metals from sediments	Not proven	Very difficult to quantify.
Rock waste disposal sites	General public	Temporary reduced recreational value due to reduced aesthetic quality of area	Low	Loss of recreation use, using TC or CVM methods. BT possible.
Rock waste disposal sites	Agriculture	Temporary loss of grazing land	High	Value of land or discounted present net value of output.

	Forestry	Temporary loss of forest growth	Low	Change in discounted net value of timber and non-timber products.
Rock waste disposal sites	Terrestrial ecosystems	Loss of habitat	No data	Very difficult to quantify.
Accidents by operation of the hydro power plant	Workers	Minor injuries	Medium	Hedonic studies on wages or CVM methods or compensation paid by law. Compensation gives an underestimate.
		Major injuries	High	
		Death	High	VSL or productivity methods.
Dam failure	General public	Minor injuries	Low	CVM methods desirable but productivity often used. Gives underestimate.
		Major injuries	Low	
		Death	Low	VSL methods best but productivity often used.
	Infrastructure	Damages to roads, buildings, etc.	Low	Costs of increased frequency of replacement
Jobs created and increased local income	General public	Regional and national employment benefits and local economic effects	High	Shadow wage used to value benefits.

<i>TRANSMISSION</i>				
<i>Construction</i>				
<b>Burden</b>	<b>Receptor</b>	<b>Impact</b>	<b>Priority</b>	<b>Valuation Method</b>
Helicopter transport	General public	Noise	Low	Hedonic methods. BT possible
		Health effects from air emissions	No data	WTP estimates based on impact pathway approach. Data limitations may make BT only option.
	Wildlife and domestic animals	Disturbances from noise	No data	Not important.
Accidents	Workers	Minor injuries	Medium	Hedonic studies on wages or CVM methods or compensation paid by law. Compensation gives an underestimate.
		Major injuries	High	
		Death	High	VSL or productivity methods
Jobs created and increased local income	General public	Local and national employment benefits and local economic effects	High	Shadow wage used to value benefits.
<i>Operation</i>				
Physical presence	Forestry	Lost future production	Medium	Value of timber and non-timber materials. Sustainability, discounting and non-marketed goods issues have to be addressed.
	General public	Visual intrusion	Medium	CVM methods, but BT may be possible.
	Birds	Injury, death	Medium	CVM methods for use and non-use losses.
Electromagnetic fields	General public	Cancers	Not proven	VSL methods most appropriate.
Accidents	General public	Minor injuries	Negligible	CVM methods desirable but productivity often used. Gives underestimate.
		Major injuries	Negligible	
		Death	Negligible	VSL methods best but productivity often used.
Accidents of maintenance of transmission lines	Workers	Minor injuries	Negligible	Hedonic studies on wages or CVM methods or compensation paid by law. Compensation gives an underestimate.
		Major injuries	Negligible	
		Death	Negligible	VSL or productivity methods
Physical stress	Workers	Musculoskeletal injury	No data	As for other worker injuries
Jobs created and increased local income	General public	Local and national employment benefits and local effects	Negligible	Shadow wage used to value benefits.

### List of acronyms

BT	benefit transfer
CVM	contingency valuation method
TC	travel cost
VSL	value of statistical life
WTA	willingness to accept payment
WTP	willingness to pay

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