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INTRODUCTION TO ENVIRONMENTAL AND ECOSYSTEM VALUATION

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"Regional Training Programme on the SEEA Experimental Ecosystem Accounting for Countries in Africa"

October 2019

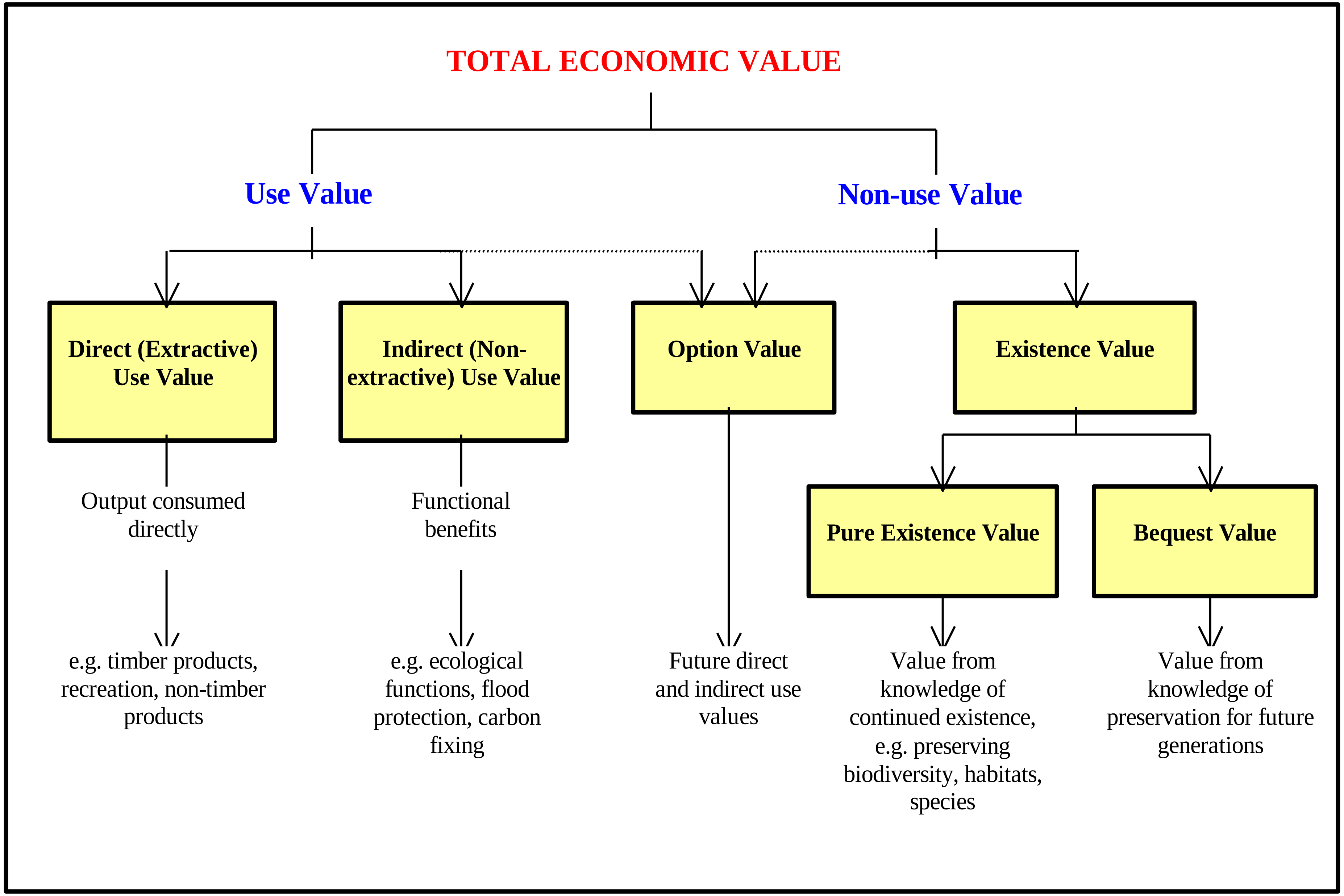
The Need for the Valuation of Environmental Functions

Valuation of environmental functions important to help correct economic decisions which treat the environment as if it were a free input, in turn resulting in its misuse.

Monetary evaluation of environmental functions serves two main purposes:

- ⇒ to illustrate the kinds of economic damage done to the society by resource depletion and pollution
- ⇒ to integrate the unpriced, but valuable functions of natural environments into project or policy appraisal (e.g. Cost Benefit Analysis) ("Polluter Pays Principle") (Setting of standards)

The monetary valuation of environmental impacts is also know as "benefit assessment", or its converse "damage cost assessment".



TEV is concerned with the valuation of preferences **held by people**; it does not encompass any value which may intrinsically reside "in" environmental assets.

Methods of Valuation

1. Based on physical linkages between environment and good, services, health.
2. Methods based on revealed preference
   Investigating expenditures made to protect against a bad environment or take advantage of a good one
3. Methods based on stated preference.
   Asking people affected by environmental change how much they value that change.

Methods Based on Physical Linkages

Valuation Techniques Based on Physical Linkages

These techniques exhibit technical (physical) linkage between change in the state of the environment and change in a good/service traded in a market (has an observable price).

STEP ONE: The physical linkage is described by cause-effect (or dose-response) function

- Example - links the level of water pollution (cause) to a change in fish harvest rates (effect).

STEP TWO: Expected change in the quantity fish harvested are converted to money using price.

They are also called collectively known as damage function methods. Main methods include:

- Replacement cost.
- Change in the output (or input) of marketable goods;
- Costs of illness and premature mortality

Replacement Cost Technique

When the benefits of a given environmental impact cannot be measured directly, cost data can be used to yield valuable information. Estimates of the potential costs (or savings) to households and producers, for example, can be obtained by using:

- ➡ the cost of replacing the services provided by the affected environmental resource <u>after</u> the impact has occurred (RC); or
- ➡ the cost of reducing or avoiding the impact <u>before</u> it occurs (AE or PE).

Example:

A rangeland area of 2,600 ha currently produces 4,771 tons of forage for sheep and cattle. As a result of expected degradation this will decline by 50%. What is the damage caused?

Application of the RC approach:

METHOD 1

The estimated damage first requires loss of forage. This is estimated by modelling the link between forage production and state of rangeland.

The replacement cost after the damage is estimated by calculating the cost of substitute. In this case a substitute was considered as sorghum. One ton sorghum replaces 1.62 tons forage and to buy one ton of sorghum costs US$201/ton. So value of the loss = 0.5*201*4,771/1.62 = US$296,000 per year. If this loss is permanent and discount rate is 10%, the value of lost forage = 592,000/0.1 = US$2.96 million.

METHOD 2

A program to protect the rangeland from degradation would take 10 years and would cost US$2 million in present value terms.

ALTERNATIVE APPROACH (NOT REPLACEMENT COST)

The loss of forage can also be valued in terms of loss of meat from animals. The current forage support 2,074 LSU, which produce US$360,000 of milk and meat per year. A 50% decline in forage would mean a 50% decline in output, worth US$180,000 per year or if permanent then the loss is US$1.8 million.

Replacement Cost Technique

- The method provides useful information but we cannot decide whether the replacement costs are justified. Ideally we need to compare the replacement cost with:
  - The costs based on replacing damaged losses before the event with costs of prevention before the damage has happened (if that is possible)
  - The costs of doing nothing and letting the damage remain.

Replacement Cost Technique: Advantages and Disadvantages

Positive Side	Negative Side
Measured by engineering/agricultural estimates of the costs of replacement or restoration, if damage from pollution or degradation were to arise. Hence, the required economic data for site-specific assessments is typically accessible.	Obscures the distinction between costs and benefits. E.g. there is no guarantee that you are willing to pay the estimated cost - No necessary relationship with ‘true’ social values: individuals’ WTP for the replacement/restoration of a damaged asset may be more or less than the costs incurred in doing so.

RC is best suited to assessing the costs arising from damage to tangible assets, since the repair or replacement costs are easily measurable. Conversely, the technique is less well suited to valuing damage to unique assets, which cannot be replaced or restored, and for which restoration costs are uncertain.

Changes in Output or Input of Goods that are Priced

The economic value (*V*) of a decrease (increase) in output can be determined by first estimating the gross margin for each unit of affected output. For one unit of product *k* the gross margin *(gm)* is given by:

$$gm_k = P_k^0 - VC_k^0$$

P_k^0 the market price for a unit of product (the subscript '0' refers to the without environmental impact), and

VC_k^0 the variable costs of producing a unit of product .

Consider the case where an environmental shock affects the activity.

Then we multiply the projected change in output by the gross margin per unit – i.e.:

$$V_k = \Delta Q_k * gm_k = \left(Q_k^1 - Q_k^0\right) * gm_k$$

Q_k^0 the projected output of product in without environmental impact case, and

Q_k^1 the projected output of product in the with environmental impact case.

NB must be able to predict Q_k^1

Changes in Outputs of Goods that are Priced: Example

- Due to overfishing the coastal water of a country are threatened with a collapse of fisheries in a few years.
- One proposed solution is to restrict fishing of threatened species for two years to allow the stocks to recover.
- The loss of output during this period would be 6,000 tons per year and the average gross margin is USD2/Kg.
- The cost of the overfishing can then be estimated as: 6000*2000 for year one and year two. With a discount rate of 10% the present value of the loss comes (in USD millions to: 12+12/(1.1) = USD22.91 million.

Changes in Input of Goods that are Priced

The economic value *(V)* of a decrease (increase) in input or production costs can be determined by multiplying the unit cost of a particular resource input (e.g. raw/potable water, agrochemicals, etc.) by the projected change in its use – i.e.:

$$V_i = \Delta R_i * MC_i = (R_i^1 - R_i^0) * MC_i$$

MC_i the unit cost of resource input ,

R_i^0 the projected use of resource input in the without environmental impact ,

R_i^1 the projected use of resource input in the with environmental impact.

Example:

As a result of increased annual mean temperature, suppose that the annual application of fungicide to 1,000 ha of beans is increased from 1kg to 2kg. (NB must be able to predict R_i^1). The annual economic cost of environmentally induced reduction in fungicide is:

$$V_{fungicide} = (2{,}000\text{ha - apl./yr} - 1{,}000\text{ha - apl./yr}) * \$31.25\text{/ha - apl.} = \$3{,}125$$

Changes in Inputs and Outputs: Complexities

- In reality, when there is an environmental shock both inputs and outputs can change.
- A full analysis taking account of both changes can be complex, requiring a modelling of the behaviour of the producers who are responsible for the decisions on input and output.
- In addition prices may also change, requiring a full supply/demand analysis of the markets for the goods.
- It can get complicated but a first approximation for small effects can be obtained by looking at the changes in inputs and outputs individually.

Cost-of-illness & Human Capital

Health impacts of pollution are divided into sickness (or morbidity), and premature deaths (or mortality). Once the physical health impacts have been estimated, a monetary value can be placed on them, to give the economic benefits of a reduction (or increase) in the pollution.

Two main approaches economists use to value health outcomes:

- Individual preferences (WTP or WTA compensation) - preferred measure of economic value.
  - Derived through averting expenditure, wage-risk or contingent valuation studies.
- Resource or opportunity costs.
  - More 'direct' measures are commonly used - the cost of illness approach for morbidity, and the human capital approach for mortality.

Cost of Illness and Human Capital: Example

- The effects of water borne diseases from unsafe water and lack of sanitation are valued as follows:

Impact	Method of valuation
Loss of time at work	Loss of wages or if not waged then value of time lost at cost of labour
Medicines and visits to doctor	Costs of these items per episode of illness
Cases of years of life lost	Value of a statistical life or
Pain and suffering	Valued at the willingness to pay to avoid this

- Pain and suffering valuation requires the use of stated preferences
- Premature death value depend on stated and revealed preference type studies
- WHO and some others calculate the impacts of exposure to unsafe water in terms of **disability adjusted life years (DALYS),** which combine the above. Estimates are 0.01017 DALYs per person per year for lack of sanitation and 0.02288 for lack of safe water.
- Value of a DALY is taken as between GDP per capita and 2.5 times GDP per capita.

Methods Based on Revealed Preferences: Travel Cost and Hedonic Pricing

Basic assumptions of Travel Cost

1. The cost of the travel and of the time spent to reach and stay at the site are a proxi for the value of the recreational experience
2. Use value is assessed taking into account the number of visits to the sites among the group being valued.
3. There are a number of models to estimate the demand for visits to the site and from that the value of the visits

The single site model

- The single site model describes the demand for recreation of a different people who each make one visit during a season
- The quantity demanded is the number of visits
- The number of visits (r) is a function of the cost per visit (tcr), the cost of a visit of a substitute site (tcs), income (y) and other factors (z)

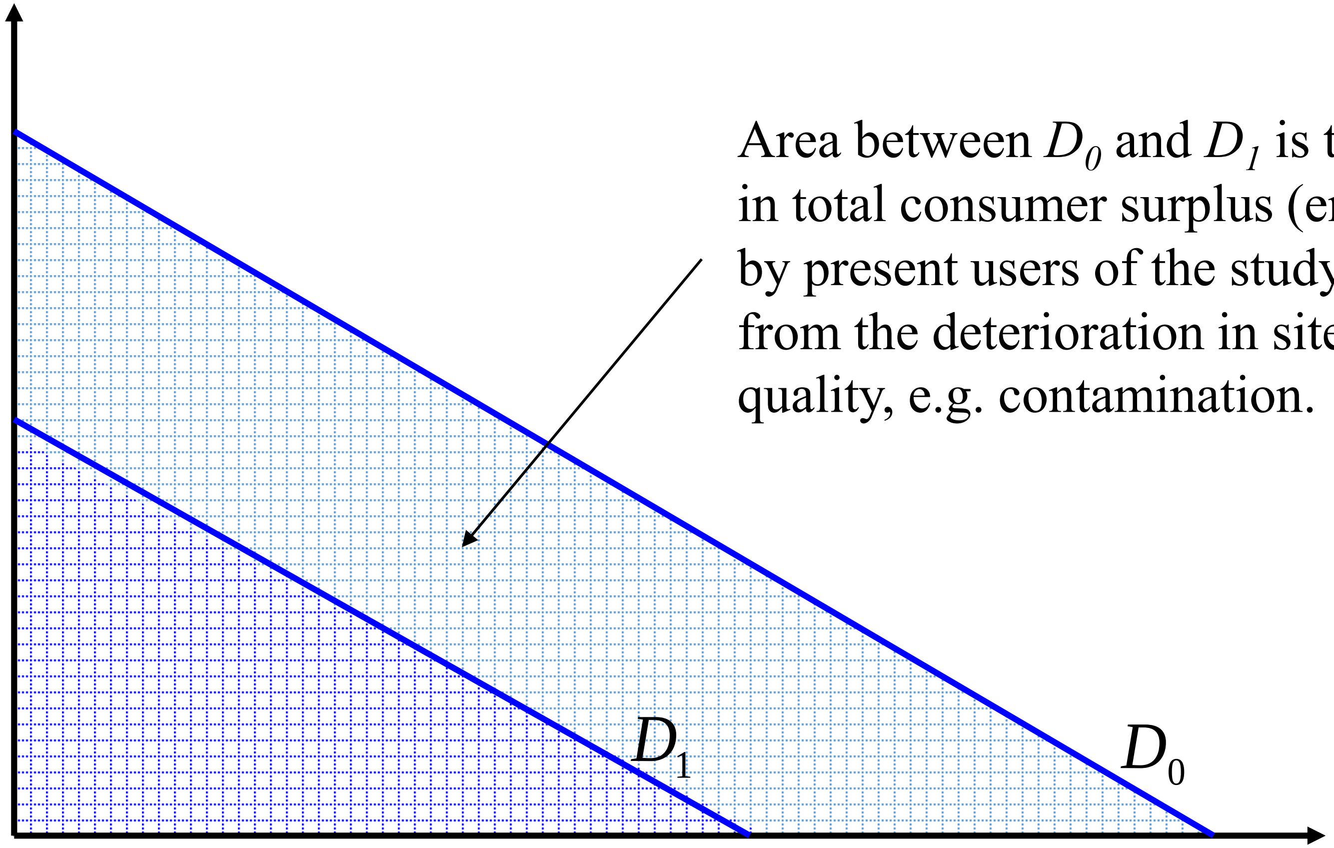
- In linear form we may write it as

$$r = \beta_{tc_r} tc_r + \beta_{tc_s} tc_s + \beta_y y + \beta_z \mathbf{z}$$

The value of the visits is then the area under the demand curve linking *r to* $tc_{s.}$ This is called the consumer surplus.

ESTIMATING THE VALUE OF VISITS TO A SITE USING TRAVEL COST AND CHANGE IN VALUE DUE TO A DETERIORATION

Travel cost plus admission fee *(tc_s)*



Area between D_0 and D_1 is the loss in total consumer surplus (enjoyed by present users of the study site) from the deterioration in site quality, e.g. contamination.

Total Number of Visits *(r)*

Steps in estimating a single site model

1. Define the site to be valued
2. Define the recreation uses and seasons
3. Develop a sampling strategy
4. Specify the model
5. Design and implement the survey
6. Measure trip cost
7. Estimate the model
8. Calculate access value

Estimate the model

- Using regression methods we can estimate the demand for visits to a site
- The total value of visits to the visitors is the area under the demand curve less the costs incurred to make the visits
- Part of the travel cost is a benefit to the park (i.e. the fee)
- When some parameter changes (such as the quality of the site) the demand curve shifts so the area changes
- The value of the change is then the change in area due to the change in quality.

Example of Travel Cost: Change in River Quality in Kruger National Park (KNP)

- A survey was carried out of S. Africans and International visitors to KNP.
- A visitation rate (VR) was calculated for each group, which is the number of visitors from a region (for S. Africa) or country (international) divided by the population of that region/country.
- The cost of a visit to the park was estimated from the entrance fee, costs inside the park plus travel to the park (for international visitors only a share of cost to travel to S. Africa was taken). (TC)
- Two demand curves were estimated: $Ln(VR) = \alpha + \beta\, TC$. One for S. African and the other for international visitors.

J. Turpie and A. Joubert: (2001) Estimating potential impacts of a change in river quality on the tourism value of KNP: An application of travel cost, contingent and conjoint valuation methods. *Water SA* 27, № 3. 2001.

Example of Travel Cost: Change in River Quality in Kruger National Park (KNP)

- The consumer surplus was estimated for each group as area under demand curve multiplied by the population of the sending area.
- To this was added the expenditures inside and outside the park.
- The component benefits were divided into values for visits to Komati Basin and the Crocodile Catchment based on % of time & money spent in these areas.
- The results showed a total value of R384 million for visit to KNP, R236 million for Komati Basin and R85 million for Crocodile Catchment. About 78% was consumer surplus, 10% each was onsite and offsite spending.
- The authors then went on to consider how values would change if Crocodile catchment was degraded if water flows were reduced by using CV methods (discussed next).

Hedonic Pricing

Hedonic pricing method

- Based on revealed preferences
- No questionnaire!
- We gather data that come from the market
- No need to build a hypothetical market

- Where do we decide to live?
- Why do we choose a specific location?
- Which factors push companies to choose one location rather than another?
- Which characteristics of an area affect housing prices?
- Which are the important elements of a house that determine its price?

The choice of localization

- The choice of housing is a composite good
- Distance from work, availability of public services, distance from schools, availability of green areas, availability of sport facilities, characteristics of housing (# of bedrooms, # of bathrooms, flat, detached, etc.) etc.
- We assume that buyers choose houses that maximize their utility
- The constraints in the maximization problem are given by income, the price of the houses and the level of taxes
- => therefore, the housing market give us some information on buyers preferences for housing and for their localization

Composite goods

- The hedonic pricing method uses the idea that goods are composed by a set of characteristics
- Consider the characteristics of a house:
- Number of floors, presence of a garden, central heating, number of bedrooms, number of bathrooms, square footage of the house, type of house, age, materials, etc.
- And also:
- Distance from public transport, distance from the city centre, distance from main roads, distance from shops, distance from sport facilities, crime rate, average income of inhabitants, presence of a university, etc.
- The composite good has a price, but there is no explicit price for each characteristic that compose the good.

The Hedonic Pricing Method

- Hedonic prices are identified through a comparison of similar goods that differ for the quality of one characteristic
- The basic idea is to use the systematic variation in the price of a good that can be explained by an environmental characteristic of the good. This is the starting point to assess the WTP for the environmental characteristic.
- We look at market data!
- Real transactions!

- The hedonic pricing method applies this simple concept to the environmental characteristics of residential properties or land
- The price difference between houses that have different levels of environmental quality, keeping constant all other characteristics, reflects the WTP for the different level of environmental quality
- => we can assess the value of an environmental quality, according to market prices of residential properties
- => variation in environmental quality affects the price of housing

Model estimate

- Now we need to specify a functional form for the price of a property p.
- A common functional form is the semi-log:

$$\ln p_i = \alpha + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots + \beta_k x_{ki} + \varepsilon_i$$

- The coefficients of the regression function give the implicit price, in natural logarithm terms, of the characteristics of the house
- The implicit price can be estimated for specific value of the characteristics of houses (for example, the average value)
- For the semi-log function, the implicit price of x_1 is given by:

$$\frac{\partial p}{\partial x_1} = p\beta_1$$

- β_1 gives the percentage change in the price of housing given a unit change in x_1
- We usually estimate the implicit price at the average value of housing

Some limitations and assumptions

- Perfect information:
  - Buyers observe the characteristics of houses and are able to perfectly describe the hedonic price function
- Buyers can purchase whatever combination of characteristics they desire.
  - They can always find the combination of bedrooms, bathrooms, location of the house that they want
- Implicit prices allow us only to assess **marginal** variations in the characteristics of houses)
  - Example: if the average house has 3 bedrooms and costs X, I cannot say that buyers are willing to pay Y for a house that has 7 bedrooms. We can’t say that an increase of 4 bedrooms is a marginal change
- The estimate of non-marginal variations requires the estimate of individual demand parameters, which is very difficult

Example: Water quality

- Leggett and Bockstael (2000) *Journal of Environmental Economics and Management*
- 741 observations
- Effects of Chesapeake Bay water quality on prices of houses located along the bay
- Leggett and Bockstael use the appraised value of houses for size, no of baths etc.
- Water quality is measured using information on the level of pollution of the bay publicly given by the Department of Health of Maryland (fecal coliform concentrations in the water).

Descriptive Statistics

Variable	Description	Media N=741
Price ($1000)	Sale price	335.91
VSTRU	Appraised value of the house	125.84
ACRES	House acreage	0.90
ACSQ	$acreage^2$	2.42
DISBA	Distance from Baltimore	26.40
DISAN	Distance from Annapolis	13.30
ANBA	DISBA*DISAN	352.50
BDUM	DISBA*(% commuters)	8.04
PLOD	% of land not intensively developed	0.18
PWAT	% of land with water or humid areas	0.32
DBAL	Minimum distance from a polluting source	3.18
F.COL	Median concentration of fecal coliform	109.70

Results

Dependent variable = sale price; Linear model		
	Coefficient	Standard Error
Intercept	238.69	47.44
VSTRU	1.37	0.040
ACRES	116.9	7.62
ACSQ	-7.33	0.79
DISBA	-3.96	1.74
DISAN	-11.80	2.50
ANBA	0.36	0.09
BDUM	-10.2	-0.03
PLOD	71.69	0.27
PWAT	119.97	0.35
DBAL	2.78	2.50
F.COL	-0.052	0.025

‘Welfare’ change

- The presence of fecal coliform is equal to -0.052 dollars per 1,000 dollars of the value of the house

- Suppose fecal coliform increase from 109 (average value) to 159:
- The welfare change is equal to:
- (159-109)*(-0.052) = -2.6

- This means that a person that is buying a house is willing to pay $2,600 more to avoid the increase in the concentration of fecal coliform.

Measuring Welfare Via Hedonic Methods

- The above calculations give the change in the house price due to fecal coliform changes but do not really give the changes in welfare, in the sense of the addtional consumer surplus you get from the change.
- Possible applications in Africa:
  - Loss of value of agricultural land due to degradation
  - Loss of value of housing due to problems of contaminated land
  - Gain in value of housing due to improved waste disposal

AVERTING OR PREVENTIVE EXPENDITURES

Averting or Preventative Expenditures

These approaches assess the value of non-marketed goods such as clean water or air, through the amounts households/producers are WTP for market goods:

- to prevent the environmental impact, or
- to prevent a utility loss from environmental degradation, or
- to change their behaviour to acquire greater environmental quality.

The preventative or averting expenditures are intended to eliminate or mitigate the environmental impact of the pollution before it occurs.

Assuming your water supply is sourced from a groundwater well - if the groundwater were to become polluted, what actions might you take to avoid potential adverse health impacts?

You could avoid the potential adverse impacts of groundwater pollution in any one of three ways:

- buying durable goods (e.g. point-of-use treatment systems);
- buying non-durable goods (e.g. bottled water); and
- changing daily routines to avoid exposure (e.g. boiling water for cooking and drinking, or reducing the frequency or length of showers/baths).

The implicit value of the groundwater pollution is revealed in your willingness to incur these preventative expenditures.

AE or PE rarely eliminate pollution impacts <u>completely</u>.

↳ where AE or PE are considered a reasonable measure of the pollution costs avoided, the total costs of pollution are the <u>sum</u> of AE or PE and residual pollution costs.

Methods Based on Stated Preferences

Techniques Based on Behavioural Linkages: Stated Preference

Seeks to measure consumer preferences for environmental goods by asking individuals to directly state their preferences:

ONE: The value of an environmental improvement can be measured either by:

- The individual's maximum WTP to obtain the improvement; or
- The individual's minimum WTA compensation to forgo the improvement.

TWO: The value of environmental damage can be measured either by:

- The individual's maximum WTP to avoid the damage; or
- The individual's minimum WTA compensation to consent the damage.

The main type of stated preference approach is the contingent valuation method.

The Contingent Valuation Method

- Stated preference technique
- Questionnaire based
- Direct method
- Valuation of a hypothetical scenario

\- It is called “contingent valuation” because the valuation is contingent on the hypothetical scenario put to respondents

- Non Use Values + Use Values
- Willingness To Pay (WTP) question

Format of WTP question

- **Open Ended**:
  - “How much are you willing to pay for public good A?”

- **Bidding Game**:
  - 1) “Are you willing to pay X for public good A?”
  - 2a) If Yes to (1), “Are you willing to pay Y for public good A?” (Y>X)
  - 3a) If Yes (2a), “Are you willing to pay Z for public good A?” (Z>Y).
  - 4a) if Yes to (3a) …
  - If No to (Na), WTP questions stop.
  - 2b) If No to (1), “Are you willing to pay T for public good A?” (T<X)
  - …

- **Payment Cards**:
  - choose a WTP point estimate from a list of values

- **Dichotomous or Discrete Choice** CV (Referendum format):
  - "Are you willing to pay X for public good A?" => STOP

- **Dichotomous or Discrete Choice CV with follow-up**:

  1) "Are you willing to pay X for public good A?"

  2a) If Yes to 1, "Are you willing to pay Y for public good A?" (Y>X)

  => STOP

  2b) If No to 1, "Are you willing to pay Z for public good A?" (Z<X)

  => STOP

NOAA Panel Guidelines

- Conservative design => better to underestimate WTP
- WTP, rather than Willingness to Accept (WTA)
- Referendum format (i.e. Yes/No Questions)
- Accurate description of the good/scenario => use of **focus groups** and **pretest** of the survey instrument
- Reminder of substitute commodities
- Yes/No follow ups
- Checks on understanding and acceptance
- Cross tabulations
- Sample size circa 500 is a minimum.

Other important aspects for questionnaire development (1)

- Mail / In Person / On the Phone interview
- In person => costly, interviewer bias, time consuming, more accurate, better option if it is difficult to explain the scenario (need pictures), only users if on site
- Mail => low response rate, sampling bias => who takes the survey? Those who are interested in the topic?, limited information, relatively inexpensive
- Telephone => relatively inexpensive, limited information, not accurate, response rate, developing countries?
- Mail + Telephone
- Internet
- Computer based instruments

Other important aspects for questionnaire development (2)

- Introduction
- Warm-up questions
- Questions on the knowledge of the problem / experience with the environmental good => USE values, etc
- Description of the scenario
- WTP question(s)
- Debriefing questions => why did you vote in favour or against the program

  - Use and Non-Use values investigation => did you vote yes, because (a) you will visit the national park, (b) even if you will never visit the national park, you want future generations to visit the park, etc.
- Attitudinal questions
- Socio – demographic questions. Ask questions on Income at the end of the questionnaire!!! => we don’t want to irritate the respondent

Other important aspects for questionnaire development (3)

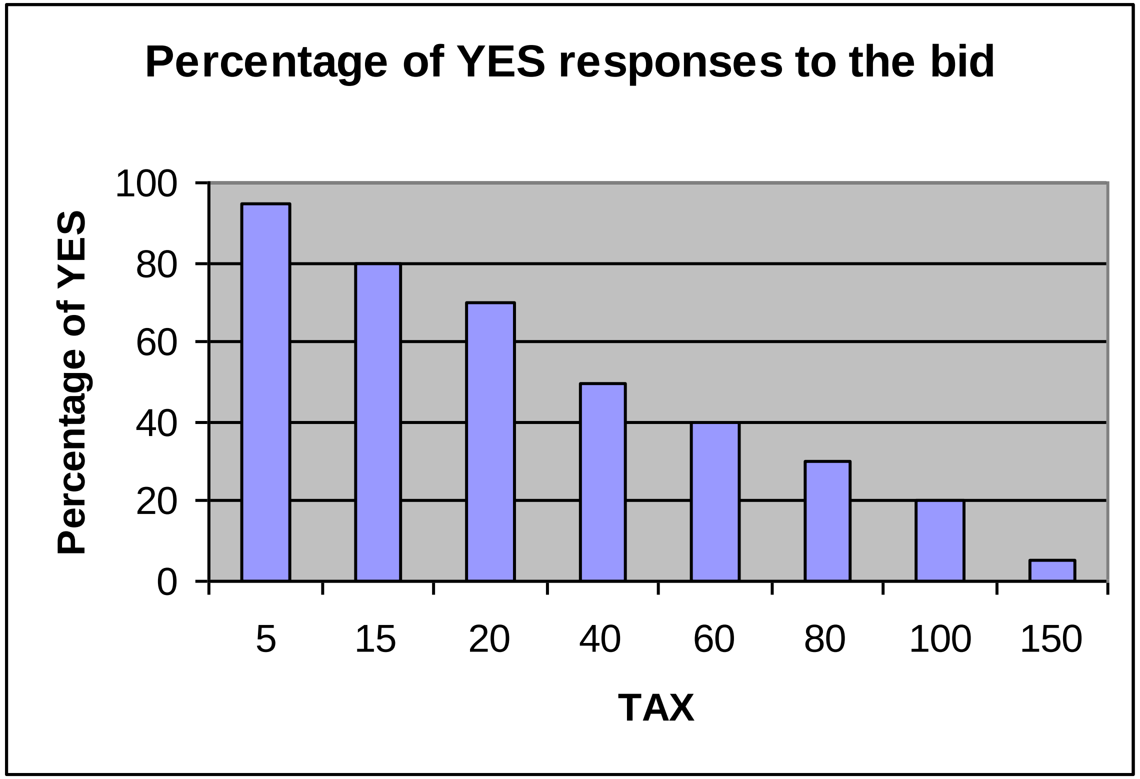
- Identify protest respondents after the WTP questions (ask why the respondent voted YY, NN, NY, YN)
- Analyze the data for the full sample of respondents, then delete those respondents that show protest behaviours
- Income. Try to get an answer to the income question. In developing countries, sometimes researchers (ask a list of expenditures. If you have no information on income from some respondents, don’t lose those observations. Add a dummy equal to 1 for those that did not answer the income question, and 0 otherwise. Set equal to 0 the income of those respondents that did not answer the income question. In your regression the coefficient of the dummy for those that did not answer the income question tells if they are statistically different from those that reported income. In this way you don’t lose the observations!
- Clearly define the population of interest
- Consider your budget constraint
- Make sure that your referendum question avoids free rider behaviours!

Payment vehicle

- Whose welfare are we interested in?

  => Important for sampling plan

- TAX => One time Tax is incentive compatible
- How do we choose the tax level? Focus groups, previous research, pre-test, optimal bidding design literature, cost of the public program



WTP and WTA

- Formally the value of a good or service can be measured in terms of the amount someone is **willing to pay** for it (WTP) or the amount someone is **willing to accept** (WTA) if it is taken away from them.

- In principal we can ask either question to value the good in a CV study.

- In practice the WTA question results in a wide range of answers, including some that are not credible.

- People when asked WTA do not limit themselves to their current situation and may think of it as a chance to gain a benefit, which is not what we want.

- So in general we tend to ask a WTP question but now WTA questions are being accepted as long as the framing is clear.

Dichotomous-Choice Contingent Valuation

- When dichotomous choice questions are used, the researcher does not observe WTP directly: at best, she can infer that the respondent's WTP amount is greater than the bid value (if the respondent is in favor of the program) or less than the bid amount (if the respondent votes against the plan), and form broad intervals around the respondent's WTP. To estimate the usual welfare statistics, it is necessary to fit binary data models.

- Median WTP is generally regarded as a robust, and conservative, welfare statistic associated with the good or proposed policy. It is usually estimated more precisely than mean WTP, and is interpreted as the value at which 50% of the respondents would vote in support of the program, and hence the cost at which the majority of the population would be in support of it.

SOME ESS VALUATION STUDIES FROM AFRICA

Valuing Wetland Services: SW Cape in S. Africa

Problem	Wetlands remove pollutants such as nitrogen from the water, which mean less treatment cost for using it for drinking
Method	Removal rates for nitrites+ nitrate nitrogen (NO3+NO2), ammonium nitrogen (NH4-N) at sampling points were regressed against the % area of land that was wetland for each sub catchment. Coefficients for wetland was significant.
Valuation	The removal of N per unit area per year was estimated from the regressions at 1,594 +/- 1,375 kg N per ha per year. This was valued at the cost of removing it using water treatment.
Result	The value of the wetland comes out at USD1,913+/- 1,651 per ha. per year.
Question	It would be nice to know what was the opportunity cost of keeping the wetland – i.e. was it more or less than the value of this service?

See: Turpie, J. et al. Wetland ecosystem services and their valuation: a review of current understanding and practice WRC Report No. TT 440/09 2010.

Valuing Mangrove Services: Gazi in Kenya

Problem	**A mangrove was replanted with r*hizophora mucronata* at Ghazi Bay in Kenya. The question is, what was the value of the plantation?**
Method	Area of 700 ha, with population of 1,000 was assessed for services in 2006 from a planation made in 1994
Valuation	Wood and firewood were valued at market prices less cost of collection. Fisheries were valued at total catch less cost of catch Carbon sequestration was valued at the amount of carbon in the biomass valued at international prices per ton Shoreline protection was valued at replacement cost, which was cost of constructing a sea wall 55km from Gazi Education & research valued at cost of research budget
Result	Values came out USD2,903 /ha/yr. 55% was shoreline protection, education was 29%. Cost of establishing mangrove was USD70/ha.yr.
Questions	Values for education and shoreline may be questioned. Values for wood and fish need to be sustainable.

See: Kairo J, Wanjiru C and Ochiewo J, Net Pay: Economic Analysis of a Replanted Mangrove Plantation in Kenya May 2009 Journal of Sustainable Forestry 28(3-5):395-414

Valuing Floodplain Re-indundation in Cameroon

Problem	**The Waza Logone floodplain was degraded as a result of a dam which created a reservoir (Lake Maga). The question was whether engineering work to release water to the floodplain was justified in terms of ESS provided.**
Method	Different options for flood release were evaluated in terms of fisheries, dry season pasture, crop production in dry season, transport on water, recovery of wildlife. Also flooding created some losses, which had to be deducted.
Valuation	Techniques for valuation are detailed on the next slides.
Result	Benefits per Km^2 were calculated for 3 engineering flooding options Maximum (X), Middle (Y) and Minimum (Z). The costs of each were compared with the additional benefits from pasture, crops and fisheries. Benefits come over time so a net NPV was calculated showing X to be the best up to 12% discount rate. At higher rates Y and Z may be better.
Questions	Real CBA (rare!). Timing of benefits are uncertain as are costs so sensitivity analysis needed.

See: Emerton L., 2002, The return of the water: Restoring the Waza Logone Floodplain in Cameroon, IUCN Wetlands and Water Resources Programme

Economic Benefit/Cost	Coverage of study
Pasture	Valued using effect on production techniques for sedentary and nomadic pastoralists using flooded pasture
Fishing	Valued using effect on production techniques for fishing households using re-flooded areas
Fish trading	Valued at market prices for traders selling fish from re-flooded areas
Rice cultivation	Valued using effect on production techniques for rice cultivators using re-flooded areas
Rice trading	Valued at market prices for traders selling rice from re-flooded areas
Thatching grass	Valued at replacement cost for house thatch harvested from re-flooded grassland areas
Grass used for fish baskets	Valued at market prices for construction of fishing baskets from grass harvested from re-flooded grassland areas
Beekeeping	Valued at market prices of honey producers using re-flooded areas
Surface water supply within Waza National Park	Valued using mitigative expenditure techniques for waterholes depending on re-flooding
Surface water supply for domestic use	Valued using mitigative expenditure techniques for domestic water supplies in re-flooded areas
Surface water supply for water transport	Valued at market prices for boat operators using newly opened/deepened channels and watercourses
Surface water supply for livestock	Reflected in effect on production of pasture (to avoid double counting)
Fish breeding and habitat	Reflected in effect on production of fisheries (to avoid double counting)
Wildlife breeding and habitat	Partially reflected in mitigative cost of waterholes in Waza NP
Land productivity	Reflected in the valuation of agriculture and pasture (to avoid double counting)
Option values	Not valued due to lack of time and data
Non-use values	Not valued due to lack of time and data
Infrastructure investment and maintenance costs	Valued using direct costs figures prepared for reinundation proposal (IUCN 1999b)
Crop losses	Valued using effect on production techniques for households losing red millet to re-flooding
Arabic gum losses	Valued using effect on production techniques for Arabic gum production lost to re-flooding
Wildlife crop damage costs	Valued using avertive expenditures for households suffering increased wildlife crop damage after re-flooding

<table>
<tr><th>Parameter</th><th>Option X</th><th>Option Y</th><th>Option Z</th><th>Flood loss (costs)</th></tr>
<tr><td rowspan="2">Flood coverage and frequency</td><td>Good year 916 km^2, average year 867 km^2, bad year 646 km^2</td><td>Good year 839 km^2, average year 687 km^2, bad year 532 km^2</td><td>Good year 645 km^2, average year 479 km^2, bad year 291 km^2</td><td rowspan="2">Based on actual figures: a decline of 964 km^2 to an annual flooded area of 2,418 km^2</td></tr>
<tr><td colspan="3">Include pilot release areas. All good bad and average years flood areas from IUCN 1999b. Good year occurs 1 year in 6, bad year occurs 1 year in 10. Flooding commences at 50% area in Year 5, and then stabilises.</td></tr>
<tr><td>Pasture benefits</td><td colspan="3">Increases steadily over 5 years and then stabilises, based on area of previous year's floods.</td><td>Decreases evenly until stabilises at minimum after 8 years</td></tr>
<tr><td>Fisheries benefits</td><td colspan="3">Increases steadily over 5 years and then stabilises. No adjustment of value in good and bad years, as price fluctuations compensate for variation in catch</td><td>Decreases based on figures extrapolated from data collected before and after pilot release</td></tr>
<tr><td>Agriculture benefits</td><td colspan="3">Increases steadily over 3 years and then stabilises. No adjustment of value in good and bad years, as price fluctuations compensate for variation in yield</td><td>Decreases evenly until stabilises after 5 years</td></tr>
<tr><td>Water transport benefits</td><td colspan="3">Returns after 1 year and then stabilises, does not depend on flooded area</td><td>Immediate loss after 1 year</td></tr>
<tr><td>Grass benefits</td><td colspan="3">Returns after 1 year, based on area of previous year's floods</td><td>Immediate loss after 1 year</td></tr>
<tr><td>Beekeeping benefits</td><td colspan="3">Increases evenly over 3 years and then stabilises, does not depend on flooded area</td><td>Full loss after 2 years</td></tr>
<tr><td>Surface water supply benefits</td><td colspan="3">Returns after 1 year, does not depend on flooded area</td><td>Immediate loss after 1 year</td></tr>
<tr><td>Crop losses</td><td colspan="3">Incurred after 1 year, does not depend on flooded area</td><td>Immediate decrease in cost (benefit realised) after 1 year</td></tr>
<tr><td>Gum arabic losses</td><td colspan="3">Incurred after 1 year, does not depend on flooded area</td><td>Cost decreases (benefit increases) evenly until stabilises after 8 years</td></tr>
<tr><td>Wildlife crop damages</td><td colspan="3">Incurred after 1 year, does not depend on flooded area</td><td>Cost decreases (benefit increases) evenly until stabilises after 5 years</td></tr>
<tr><td>Physical costs of flood release measures</td><td colspan="3">All expenditures from IUCN 1999b. Preparation and design costs incurred Years 1-2, construction costs incurred Years 3-4, modification costs incurred Year 6, maintenance costs incurred Year 7 and every 5 years onwards</td><td></td></tr>
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