Environmental Valuation

Lecture Notes on Natural Resource Economics (AEC- 608)

Prepared by

Aditya K. S.
Scientist, Division of Agricultural Economics,
ICAR-Indian Agricultural Research Institute
https://adityaraoks.github.io/

May 27, 2025

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1 Introduction

The rational use of **natural capital** is now widely recognized as fundamental to sustainable development. Economic development, when not aligned with environmental conservation, can lead to resource depletion, ecosystem degradation, and a decline in human well-being. Environmental valuation provides a set of tools and concepts to measure the value of environmental goods and services, many of which are not traded in conventional markets but are essential for life and economic activity.

Why value the environment? Historically, the environment was treated as a free good, its services and resources assumed to be inexhaustible. However, with rising population, technological advances, and increased consumption, the pressure on natural resources has intensified, making it crucial to assign economic value to environmental goods and services to inform decision making. But, key question is can we really value the environment? Our objective in environmental valuation is not to measure the value in absolute terms; but to measure the change in flow of services and how it affects the human welfare. We can never be sure that we have arrived at the 'precise' and 'accurate' value. The objective is to propose a logically grounded, systematic estimation of value, and then invite others to come up with better valuation. For more clarity, read the paper on value of world ecosystem services by Costanza et al. 2014.

Key objectives of environmental valuation:

- To inform policy and investment decisions by quantifying the benefits and costs of environmental conservation or degradation.
- To integrate environmental considerations into cost-benefit analyses of development projects.
- To design compensation schemes for victims of environmental damage.
- To set appropriate user charges, taxes, and incentives for pollution control and resource use.
- To support efficient and equitable allocation of resources, especially where markets fail to reflect true social values.

2 Economic Value of Environmental Goods and Services

What is Environmental Value?

Environmental value refers to the monetary worth of environmental goods and services, as reflected in individuals' or society's preferences. According to Pearce and Turner, economic value is not intrinsic to any object; it arises from the interaction between

people and the environment. An environmental attribute has value only if it contributes to someone's utility (well-being) or a firm's production process.

Total Economic Value (TEV) Framework

The **Total Economic Value** framework is a comprehensive approach to classifying the values associated with environmental resources. It includes both use and non-use values:

- **Use Values:** Values derived from the actual use of the environment, either directly or indirectly.
  - *Direct Use Value:* Derived from direct consumption or enjoyment (e.g., timber harvesting, fishing, recreation, scenic beauty).
  - *Indirect Use Value:* Derived from ecosystem functions that support or protect economic activity (e.g., water purification, flood control, nutrient cycling).
- **Non-Use Values:** Values not associated with current or planned use.
  - *Existence Value:* Value derived from knowing that a resource or species exists, even if one never uses it (e.g., value of protecting endangered species).
  - *Bequest Value:* Value placed on preserving resources for future generations.
  - *Option Value:* Value of preserving the option to use a resource in the future, especially under uncertainty about future preferences or availability.

Example: Forests provide timber (direct use), regulate climate and water (indirect use), offer existence value (e.g., biodiversity), and bequest value for future generations.

3 Market Failure and the Need for Valuation

Market Failure in Environmental Context

Markets often fail to allocate resources efficiently when environmental goods and services are involved. This is due to:

- **Externalities:** Costs or benefits of economic activities not reflected in market prices. For example, pollution imposes health costs on society, but these are not paid by the polluter.
- **Public Goods:** Environmental goods like clean air and biodiversity are non-excludable and non-rivalrous, leading to free-riding and under-provision.
- **Lack of Property Rights:** Many environmental resources are open-access, leading to overuse and degradation (the "tragedy of the commons").

- **Space and time dimension:** Benefits cut across space and time

Result: Goods with negative externalities (e.g., pollution) are overproduced, and those with positive externalities (e.g., clean air) are underprovided. The market outcome is not socially optimal.

Role of Environmental Valuation

Valuation helps to:

- Make invisible values visible by assigning monetary values to non-market goods.
- Provide information for cost-benefit analysis, guiding policy and investment decisions.
- Design compensation and incentive mechanisms (e.g., payments for ecosystem services).
- Set user charges, taxes, or subsidies to correct market failures.
- Support sustainable resource management and intergenerational equity.

4 Classification of Environmental Values

Use Values

- **Direct Use Values:**
  - *Consumptive Use:* Harvesting timber, fishing, collecting non-timber forest products, drinking water extraction.
  - *Non-Consumptive Use:* Recreation (e.g., hiking, birdwatching), aesthetic enjoyment, vicarious consumption (e.g., viewing photos of natural sites).
- **Indirect Use Values:**
  - Ecosystem services such as flood control, water purification, climate regulation, pollination, and nutrient cycling.
  - Example: Wetlands filtering pollutants, forests regulating rainfall and soil fertility.

Non-Use Values

- **Existence Value:** Value derived from the mere knowledge that a resource or species exists, regardless of any intention to use it.

- **Bequest Value:** Value placed on preserving resources for the benefit of future generations.
- **Option Value:** Value of maintaining the option to use a resource in the future, under uncertainty about future demand or supply.

Example Table: Types of Environmental Values in Forests

Table 1: Types of Environmental Values in Forests

Value Type	**Examples in Forests**
Direct Use (Consumptive)	Timber, fuelwood, medicinal plants, food
Direct Use (Non-Consumptive)	Recreation, spiritual value, landscape beauty
Indirect Use	Carbon sequestration, water regulation, soil fertility
Existence Value	Value of rare/endangered species, old-growth forests
Bequest Value	Preserving forests for future generations
Option Value	Potential future use of genetic resources, medicines

5 Methods of Environmental Valuation

Environmental valuation methods are broadly categorized into **revealed preference** and **stated preference** approaches. Each method has its own strengths, limitations, and domains of applicability.

Revealed Preference Methods

These methods infer environmental values from observed behavior in related markets.

1. **Production Function Approach**
    - Measures the contribution of environmental inputs to production.
    - Example: Assessing how water quality influences crop yields or fish catch.
    - Limitation: Requires detailed data and may face issues of double-counting and static analysis.
2. **Cost-Based Methods**
    - *Averting Expenditure:* Costs incurred to avoid environmental harm (e.g., buying water filters, air purifiers).
    - *Cost of Illness/Human Capital:* Medical costs and lost productivity due to environmental degradation.

- *Restoration Cost:* Cost of restoring an asset to its original state after environmental damage.
- Limitation: May not reflect full value or welfare loss.

3. **Travel Cost Method (TCM)**
    - Estimates recreational site value based on travel expenses and time incurred by visitors.
    - Types: Zonal TCM (uses zone-based data), Individual TCM (uses individual survey data), Random Utility TCM (models site choice among alternatives).
    - Limitation: Difficult to model multi-site visits, assumes travel cost as entry fee.
4. **Hedonic Pricing Method (HPM)**
    - Uses differences in property prices to infer the value of environmental attributes (e.g., air quality, noise).
    - Steps: Estimate hedonic price function, include environmental variables, derive implicit prices.
    - Limitation: Only captures value reflected in market transactions, assumes perfect information.
5. **Wage Differential Approach**
    - Estimates value of environmental quality by examining wage differences for similar jobs in different locations.
    - Example: Higher wages in polluted or hazardous areas reflect a risk premium.

Stated Preference Methods

These methods use surveys to elicit values directly from individuals, suitable for valuing non-market goods and non-use values.

1. **Contingent Valuation Method (CVM)**
    - Constructs a hypothetical market and asks respondents their willingness to pay (WTP) or accept (WTA) for changes in environmental quality.
    - Elicitation formats: Bidding game, payment card, discrete choice (referendum), follow-up approach.
    - Steps: Define scenario, select payment vehicle, design survey, analyze data.
    - Limitations: Susceptible to biases (starting point, hypothetical, strategic, information).
2. **Choice Modelling/Discrete Choice Experiments**
    - Respondents choose between alternatives with different attributes and costs, allowing estimation of the value of specific changes.
    - Advantage: Can value multiple attributes simultaneously.

Benefit Transfer (Environmental Value Transfer)

- Uses values estimated in one context (study site) to inform decisions in another (policy site), with appropriate adjustments for context differences.
- Steps: Identify relevant studies, gather background info, adjust values, apply to new context, estimate total benefits/costs.
- Limitation: Accuracy depends on similarity of contexts and quality of original studies.

6 Welfare Measures: WTP and WTA

Compensating Variation (CV): The amount of income that compensates consumers for a price change, returning them to their original welfare level.

Equivalent Variation (EV): The amount of income change that yields the same utility change as a price change.

Willingness to Pay (WTP): The maximum amount an individual is willing to pay to secure a gain or prevent a loss.

Willingness to Accept (WTA): The minimum amount an individual is willing to accept to tolerate a loss or forego a gain.

Note: WTP and WTA often diverge due to income effects and loss aversion. Typically, WTA exceeds WTP for the same change.

7 Selected Valuation Techniques

Production Function Method

Concept: Values environmental inputs by measuring their effect on production output. For example, the impact of improved water quality on crop yields.

Application:

- Used in agriculture, fisheries, and forestry.
- Example: Estimating the value of coastal wetlands by their role in protecting against hurricane damage.

Limitations:

- Difficult to isolate environmental effects from other factors.

- May double-count benefits if multiple outputs are affected.
- Often static, not capturing dynamic changes.

Cost-Based Methods

- **Averting Expenditure:** The costs incurred to avoid negative environmental impacts (e.g., buying bottled water, installing air purifiers).
- **Cost of Illness/Human Capital:** Includes medical treatment costs, lost earnings, and reduced life expectancy due to environmental degradation.
- **Restoration Cost:** The cost of restoring an asset to its original state, used as a proxy for its value.

Limitations:

- May underestimate or overestimate true welfare cost.
- Restoration may not be technically feasible or may not fully restore original value.

Travel Cost Method (TCM)

Concept: Values recreational sites by analyzing travel expenses incurred by visitors.

Types:

- *Zonal TCM:* Uses aggregate data by geographic zones.
- *Individual TCM:* Uses survey data from individual visitors.
- *Random Utility TCM:* Models site choice among multiple alternatives.

Assumptions:

- Populations in zones are homogeneous.
- Travel cost is analogous to an entry fee.
- Difficult to model multi-site visits.

Steps:

1. Define zones around the site.

2. Collect data on number of visitors from each zone.
3. Calculate visitation rates and average travel cost per trip.
4. Regress visits per 1000 population against travel cost to estimate demand.
5. Calculate area under the demand curve to estimate total value.

Hedonic Pricing Method (HPM)

Concept: Uses differences in property prices to estimate the value of environmental attributes (e.g., air quality, noise).

Steps:

1. Estimate the hedonic price function (property price as a function of attributes).
2. Include environmental variables.
3. Derive implicit prices for environmental changes.
4. Estimate inverse demand function to account for heterogeneous preferences.

Limitations:

- Assumes zero transaction costs and perfect information.
- Only captures value reflected in market transactions.
- Complexities in separating environmental effects from other factors.

Contingent Valuation Method (CVM)

Concept: Constructs a hypothetical market to elicit WTP/WTA for non-market goods.

Elicitation Methods:

- *Bidding Game:* Iterative price offers.
- *Payment Card:* Respondents choose from a range of values.
- *Discrete Choice/Referendum:* Yes/no responses to specific price points.
- *Follow-up Approach:* Adjusts price based on initial response.

Survey Administration: Can be conducted via phone, mail, or interviews.

Biases and Limitations:

- Starting point bias
- Payment vehicle bias
- Hypothetical bias (WTP may exceed actual payment)
- Strategic bias
- Embedding effect
- Information bias
- Systematic divergence between WTP and WTA

Steps in CVM:

1. Define the market scenario and payment vehicle.
2. Choose the elicitation method.
3. Design and administer the survey.
4. Analyze data to derive WTP/WTA.
5. Interpret results and conduct scope/price tests.

Benefit Transfer

Concept: Uses values estimated in one context to inform decisions in another, with adjustments.

Steps:

1. Identify and select relevant original studies.
2. Gather background information.
3. Adjust values for context differences.
4. Apply transferred values to new context.
5. Estimate total costs and benefits.

Limitation: Accuracy depends on similarity between study and policy sites.

8 Environmental Impact Assessment (EIA)

Definition: EIA is an assessment of the impact of planned activities on the environment, including biodiversity, ecology, water, and air. It aims to identify, predict, and evaluate likely environmental effects of a project to define mitigation actions.

Objectives:

- Ensure environmental considerations are integrated into decision making.
- Anticipate and avoid adverse effects.
- Protect the productivity and capacity of natural systems.
- Promote sustainable development.

Basic Steps in EIA

1. **Screening:** Decide if EIA is needed, based on anticipated environmental impacts.
2. **Scoping:** Identify key issues and set boundaries for the assessment. Engage stakeholders and select relevant baselines and alternatives.
3. **Impact Assessment and Mitigation:** Assess impacts (qualitative and quantitative), suggest mitigation measures, and conduct economic analysis.
4. **Impact Management:** Plan and monitor mitigation measures and associated risks.

Methods Used in EIA

- **Expert Judgement:** Collect and prioritize expert opinions (e.g., Delphi approach).
- **Rapid Impact Assessment Matrix (RIAM):** Systematic approach using multidisciplinary teams and both qualitative and quantitative data.
- **Battelle Environmental Evaluation System:** Divides impacts into categories (ecology, pollution, aesthetics, human interests) and uses indicators and parameter importance units.
- **Benefit-Cost Analysis:** Compares monetary estimates of benefits and costs, including opportunity cost.
- **Cost-Effectiveness Analysis:** Compares costs of different options with similar outputs to identify the least-cost solution.
- **Threshold Value Analysis:** Used when development and conservation are mutually exclusive; estimates opportunity cost of conservation.

- **Trade-Off Analysis and Multi-Criteria Analysis:** Engages stakeholders to rank and evaluate management options using multiple criteria.

9 Summary Table: Key Environmental Valuation Methods

Table 2: Comparison of Environmental Valuation Methods

Method	**Type**	**Key Features / Applications**
Production Function	Revealed Preference	Values environmental inputs via effects on output; suitable for agriculture, fisheries
Averting Expenses	Cost-Based	Uses costs to avoid environmental harm as proxy for value
Cost of Illness	Cost-Based	Values health impacts via medical costs and lost productivity
Restoration Cost	Cost-Based	Uses cost of restoring asset as value proxy
Travel Cost Method	Revealed Preference	Values recreation via travel expenses; best for site-specific amenities
Hedonic Pricing	Revealed Preference	Infers value of environmental attributes from property prices
Contingent Valuation	Stated Preference	Elicits WTP/WTA for non-market goods via surveys
Benefit Transfer	Transfer	Applies values from past studies to new contexts

10 Assignments

1. List all the different types of environmental values offered by forests (e.g., timber as direct use value, scenic beauty as non-consumptive use value).

2. Prepare a list of research papers using one of the environmental valuation methods described in this section.

3. Design a research plan to estimate willingness to pay for pesticide residue-free grapes using the contingent valuation format.

4. Write a one-page summary of Costanza (1997), "The value of the world's ecosystem services and natural capital".