Valuing Environmental Goods and Services

An Economic Perspective

Choices

- Choice is fundamental to human existence, ranging from daily individual decisions to major collective choices that shape society
- Individual choices encompass:
    - Routine decisions about time and money management
    - Major life decisions regarding housing, family, and career paths

- Collective choices involve:
    - Creation of laws and regulations
    - Management of public resources
    - Decision-making through voting or representatives
- All choices involve trade-offs:
    - Selecting one option means foregoing others
    - Both individual and collective choices require evaluating alternatives based on preferences

- People’s choices reveal their preferences:
    - Choosing an activity shows it was “worth” its cost
    - Observed choices help understand what people value
- Nonmarket valuation focuses on choices not captured by traditional markets:
    - Environmental goods and services (clean air, wilderness)
    - Natural amenities that aren’t directly purchased
    - Public resources requiring collective decision-making

- Understanding preferences helps inform policy decisions:
  - Guides allocation of public funds
  - Assists in evaluating environmental preservation
  - Supports cost-benefit analysis of public projects

Market failure and choices

- The "invisible hand" principle has limitations:
  - While individual choices can benefit society, this doesn't always work for environmental goods
  - The principle assumes markets exist for all goods and services people value

- Market failures in environmental goods lead to undersupply:
  - Without markets, providers can’t receive payment for environmental benefits
  - Private landowners lack incentives to protect habitat when they can’t monetize the benefits
  - The true social value of environmental goods isn’t reflected in market transactions

- Environmental externalities create economic inefficiencies:
  - Negative externalities occur when actions harm others without compensation
  - Companies don’t pay for environmental damage, leading to excessive pollution
  - Private costs don’t include environmental impacts, distorting decision-making
- Two solutions exist for market failures:
  - Create new markets for environmental goods where possible
  - Implement government interventions through regulations or direct provision

- Nonmarket valuation serves crucial roles:
  - Helps quantify environmental benefits that markets don’t capture
  - Provides information to address market failures
  - Supports policy decisions about environmental protection

Non-market Valuation

- The evolution of nonmarket valuation spans several decades:
  - Originated in 1950s U.S. for water resource project analysis
  - Gained momentum in 1980s through key federal actions
  - Executive Order 12291 mandated benefit-cost analyses
  - Environmental legislation required damage assessments

- Applications expanded to include:
  - Environmental regulation benefit assessment
  - Natural resource damage compensation
  - Land and water management decisions
  - Ecosystem services valuation

- Growing recognition of ecosystem services drove wider adoption:
  - Non-economists began showing interest
  - Environmental degradation raised awareness
  - Policy decisions often overlooked ecosystem value
  - Need emerged to quantify natural benefits
- Landmark ecosystem valuation studies emerged:
  - 1997 study estimated global ecosystem value at $33 trillion
  - Generated controversy and critique from economists
  - Sparked important discussions about valuation methods
  - Highlighted need for proper methodology

- Current state of nonmarket valuation:
    - Serves critical role in environmental decision-making
    - Helps quantify previously ignored natural benefits
    - Requires careful understanding of proper techniques
    - Continues to evolve with new applications and methods

Values vs valuation

- Economic valuation differentiates between two types of values:
  - Held values: Core principles like loyalty, freedom, or environmental stewardship
  - Assigned values: Specific valuations, such as how much someone would pay to preserve a local forest or clean up a polluted lake

- Assigned values are influenced by multiple factors:
  - Individual perceptions: A hiker might value wilderness differently than a developer
  - Personal held values: Someone who believes in environmental protection might assign higher value to endangered species preservation
  - Context: The value assigned to clean air might be higher in a heavily polluted city versus a rural area
  - External circumstances: Income levels affect how much people can pay for environmental improvements

- Nonmarket valuation specifically focuses on:
  - Measuring assigned values: Quantifying how much people value improving air quality from level A to B
  - Relative changes: Comparing outcomes like having a protected wetland versus developing it
  - Practical examples: Determining the value of preserving a national park or reducing water pollution in a river
  - Trade-off decisions: Whether to spend $20 million on forest preservation or a new museum

- Key principles of environmental valuation:
  - Values are relative: Clean air is valued against current pollution levels
  - Specific outcomes: Preserving 1,000 acres of wetland versus abstract environmental protection
  - Practical applications: Assessing damages from oil spills or benefits of emissions regulations
  - Real-world choices: Deciding between expanding a highway or protecting adjacent wildlife habitat

- Economic approach to valuation:
    - Real-world applications: Evaluating compensation for environmental damage from chemical spills
    - Policy decisions: Determining appropriate pollution control standards
    - Project assessment: Analyzing costs and benefits of dam construction
    - Resource management: Deciding optimal harvest levels for fisheries or forests

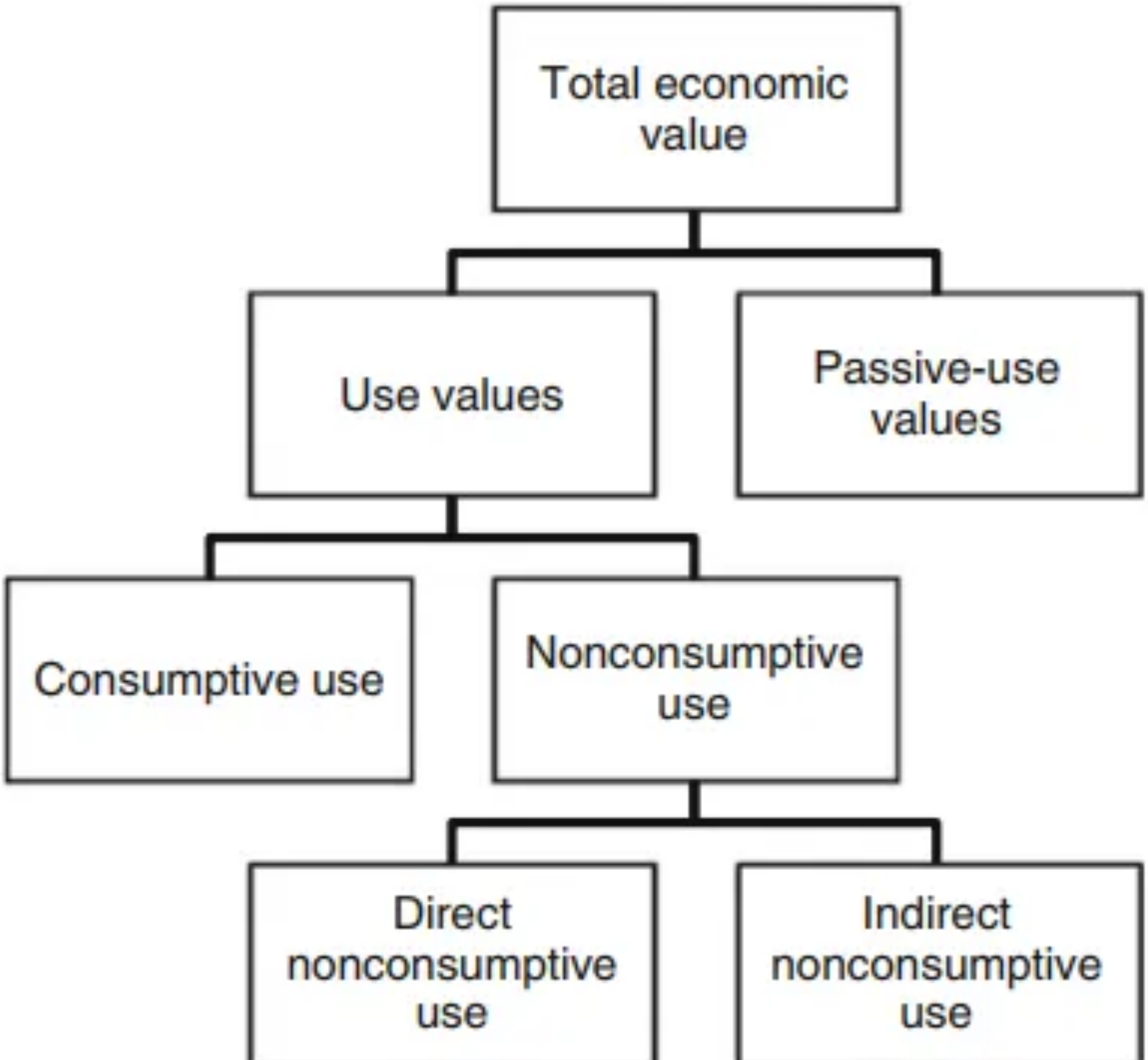
Concept of value

- Economic theory defines value through trade-offs:
  - Value = Maximum amount one would give up to gain something
  - Example: How much money someone would sacrifice to preserve a local park
  - Negative values exist too: Compensation required to accept pollution

- Two key principles of economic value:
  - Higher willingness to sacrifice indicates higher value
  - Example: If someone would pay ₹100 to save forest A but only ₹50 for forest B, they value A more
  - Values can be compared by measuring sacrifice amounts
  - Example: Choosing between ₹20M for air quality improvement or water cleanup

- Trade-offs can be measured in different ways:
  - Monetary terms (most common): Rupees willing to pay
  - Risk trade-offs: Accepting one risk to reduce another
  - Example: Accepting slightly higher traffic risk to reduce flood risk
  - Time trade-offs: Hours willing to volunteer for environmental cleanup
- Key economic value concepts:
  - Willingness to Pay (WTP): Amount someone would pay for improvement
  - Example: ₹50 monthly for cleaner air
  - Willingness to Accept (WTA): Compensation required to give up something
  - Example: ₹1000 to accept loss of neighborhood green space

- Benefits in economic valuation:
  - Specifically means monetary value assigned
  - Allows comparison across different projects
  - Enables cost-benefit analysis
  - Example: ₹5M benefit from wetland preservation versus ₹3M cost


Total economic value
Use values
Passive-use values
Consumptive use
Nonconsumptive use
Direct nonconsumptive use
Indirect nonconsumptive use

The Valuation Process

- Six Key Steps in Environmental Valuation:
  - Step 1: Problem Formulation
  - Example: Evaluating dam removal options for river restoration
  - Identify alternatives like full removal, partial removal, fish ladders
  - Step 2: Identify Environmental Changes
  - Example: Changes in water flow, fish population, habitat quality
  - Map out all potential biophysical impacts

- Step 3: Link to Human Well-being
- Example: Improved fishing opportunities (₹5000 annual value)
- Consider both use and passive-use values
- Include cultural and ecological benefits
- Step 4: Quantify Changes
- Example: 40% increase in fish population
- Measure impacts in concrete, measurable terms
- Focus on changes relevant to human welfare

- Step 5: Estimate Economic Values
- Example: Calculate willingness to pay for improvements
- Use appropriate valuation methods
- Consider both direct and indirect benefits
- Step 6: Communicate Results
- Present findings to decision-makers
- Clearly explain methodology and assumptions
- Support informed policy choices

- Important Process Characteristics:
  - Iterative rather than linear
  - Requires interdisciplinary collaboration
  - Must link scientific measures to human values
  - Example: Can’t just measure phytoplankton changes without connecting to human benefits
- In moving from conceptualizing the valuation process described above to actually estimating values (benefits) using nonmarket valuation, a number of issues can arise.

Issue 1: Whose value to include

- Defining the Relevant Population:
  - Cannot simply include everyone who values a change
  - Must consider specific context and purpose
  - Population scope affects total valuation significantly
- Compensation Scenarios:
  - Legal entitlement determines relevant population
  - Example: Oil spill compensation
  - Local impacts: Affected fishermen claiming ₹50,000 each
  - Broader impacts: Public claims for wildlife damage
  - Must define “public” - local, national, or global

- Policy Evaluation Contexts:
  - Greenhouse gas emission reduction example:
  - National benefits: ₹500M in reduced climate impacts
  - Global benefits: ₹10B in worldwide impact reduction
  - Choice depends on policy objectives
- Key Decision Factors:
  - Policy objectives: Local vs global benefits
  - Cost bearing: Who pays for implementation
  - Example: If country bears ₹1B cost:
    - Local benefits only: May not justify cost
    - Global benefits included: May justify cost

- Important Considerations:
  - Decision-maker perspective matters
  - Geographic scope affects benefit calculations
  - Need clear criteria for population inclusion
  - Balance between costs and beneficiary scope

Issue 2: Aggregating values accross individuals

- Aggregating Individual Values:
  - Standard method: Simple addition across population
  - Example: If 1000 people value a park at ₹500 each = ₹500,000 total
  - Typically uses unweighted summation
  - Alternative: Voting-based preference aggregation
    - Drawback: do not reflect the intensity of individual preferences for one option over another.
    - For example, in a three-person vote, an option that is only slightly preferred by two individuals would win over an option that is strongly preferred by the third individual.

- Maximizing **aggregate net benefits** (or **total income**) is **not always** the same as maximizing **total utility**.
- The two are equivalent **only if** income is redistributed to equalize **marginal utility of income (MUY)** across individuals.

- Let $Y_i(x)$ be income of **Person i**, where $i = 1, 2$.
- Let $u_i(Y_i(x))$ be the **utility function** of Person i.
- If **Person 1 gains** while **Person 2 loses**, then:
  $$\frac{\partial Y_1}{\partial x} + \frac{\partial Y_2}{\partial x} > 0$$
  → **Total income increases (benefit > cost).**
- However, if **marginal utility of income** differs:
  $$\frac{\partial u_1}{\partial Y_1} < \frac{\partial u_2}{\partial Y_2}$$

Then:
$$\frac{\partial u_1}{\partial Y_1}\frac{\partial Y_1}{\partial x}+\frac{\partial u_2}{\partial Y_2}\frac{\partial Y_2}{\partial x}<0$$

→ **Total utility decreases, despite net income gain.**

- Suppose **Policy X** increases **Person 1's** income by **₹1000** but decreases **Person 2's** income by **₹800**.
- **Net income gain**:
  $1000 - 800 = ₹200 > 0$
- However, if **Person 1** is **wealthy** and **Person 2** is **poor**, then:
  $MU_{Y_1} < MU_{Y_2}$
- **Loss in utility** for **Person 2** may exceed the **gain** for **Person 1**, leading to an overall **reduction in aggregate utility**.

- **Within a generation**, taxes and subsidies can correct disparities.
- **Across generations**, redistribution is harder, affecting long-term **cost-benefit analysis**.
- Hence, **ignoring marginal utility differences** across individuals is common in static analysis but **crucial** in **intergenerational welfare analysis**.

- Income Effect Challenges:
  - Higher income leads to higher willingness to pay
  - Example:
    - Wealthy person values clean air at ₹10,000
    - Low-income person values same at ₹2,000
    - Same preferences but different ability to pay

- Equal Weighting Issues:
  - Appears fair but has implications
  - Benefits skew toward wealthy populations
  - Example:
    - Two identical parks
    - Wealthy area shows ₹10M total benefit
    - Poor area shows ₹2M total benefit
    - May lead to biased decision-making

- Key Considerations:
  - Need to understand wealth bias in results
  - Consider distributional impacts
  - Provide decision-makers with:
    - Total unweighted benefits
    - Distribution across income groups
    - Social equity implications
- Alternative Approaches:
  - Weighted aggregation possible
  - Can incorporate distributional concerns
  - Must be transparent about methodology
  - Consider generational equity issues

Issue 3:Aggregating Benefits Across Time

- **Importance of Time in Benefit Calculation**
- Policies (e.g., **climate change mitigation**) generate benefits over **multiple time periods**.
- **Total benefit** = sum of **current and future benefits.**
- Future benefits must be appropriately **weighted** when compared to present benefits.

- Standard approach: **Discounting** using a **discount factor**.
- Total **discounted benefit** over time:

  $$B = \sum_{t=0}^{T} \frac{B_t}{(1+r)^t}$$

  where:
  -B_t = Benefit in period t
  -r = Discount rate
  -T = Total time horizon

- **Why Discount Future Benefits?**

1. **Investment-based rationale:**
    - Money today can be **invested** to earn returns.
    - Example:
        - ₹100 today at **5% interest** → ₹105 next year.
        - **Hence, ₹105 next year is worth ₹100 today.**
        - Future payments should be **discounted** to reflect this.
2. **Consumption-based rationale:**
    - **Diminishing Marginal Utility of Consumption** (MUY)
    - **Example:** If future generations are richer, an extra ₹1000 will be **less valuable** to them than to us today.

- **Intergenerational Equity & Discounting**
- Should future generations be valued **equally**?
- If yes: **Equal utility weights** across generations.
- If future generations are **richer**, their benefits may be discounted:
  $\text{Higher consumption} \Rightarrow \text{Lower marginal utility} \Rightarrow \text{Discounting justified}$
- Policy decisions should **balance** equity and economic growth.

- **Practical Approach to Discounting**
- **Uncertainty in discount rates** → Use a **declining discount rate** over time.
- Standard practice: **Compute benefits for multiple discount rates** (e.g., **2%, 4%, 6%**) to capture variations.

Issue 4: Uncertainty in Valuing Environmental Changes

- **Sources of Uncertainty**
- **Uncertainty in predicting environmental changes** (e.g., climate change impact).
- **Uncertainty in assigning values** to environmental changes.
- Example: Policy to **reduce greenhouse gas emissions** → uncertainty in:
  - **Emissions reduction effectiveness**
  - **Climate impact of emission reductions**
  - **Effects on health, agriculture, and ecosystems**

- **Role of Models in Predicting Outcomes**
- Use of models introduces **structural and parameter uncertainty**.
- Uncertainty exists in:
  - **Future economic conditions** (income, preferences).
  - **Preferences of future generations**.
- Values assigned to outcomes reflect these uncertainties.

- **Incorporating Uncertainty in Economic Valuation**
- Economic value under uncertainty is based on **expected utility**:
  $$EV = \sum P_i U(Y_i)$$
  where:
  - P_i = Probability of outcome i
  - $U(Y_i)$ = Utility from income level Y_i.
- Individuals' **risk preferences** influence valuation:
  - **Risk-averse:** Higher value on certainty.
  - **Risk-neutral:** Value based purely on expected return.

- **Techniques to Address Uncertainty**
- **Sensitivity analysis:** Examining how variations in key parameters affect results.
    - Example: Evaluating a Carbon Tax Policy Suppose the government implements a carbon tax to reduce emissions.
        - Key uncertain factors:
            - Elasticity of demand for fossil fuels (How much will consumption decrease as price increases?).
            - Cost of renewable energy alternatives (How competitive are they?).
            - Economic growth rate (Affects future emissions and policy impact).
        - Method:
            - Run the cost-benefit analysis with different values for each variable.
            - Identify how sensitive the net benefits are to changes in

assumptions.

- If small changes in a parameter (e.g., renewable energy cost) drastically alter the policy's net benefits, the policy outcome is highly sensitive to that factor.

- **Monte Carlo simulation**: Running multiple simulations to estimate probability distributions of outcomes.
  - Example: Predicting Future Economic Losses from Flooding A city wants to estimate economic damages from future floods due to climate change.
    - Key uncertain variables:
      - Future sea level rise (Varies due to climate uncertainty).
      - Storm intensity (More extreme weather events are likely).
      - Property values (Higher values mean greater damages).
    - Method:
      - Assign probability distributions to these variables (e.g., sea level rise follows a normal distribution).
      - Run 10,000 simulations, each time drawing random values for variables.
      - Analyze the distribution of projected damages.
    - Instead of predicting one single damage estimate, the city gets a

probability range (e.g., ₹500 crore to ₹2000 crore, with a 70% chance of exceeding ₹1000 crore).

- **Surveys**: Eliciting public values for uncertain environmental outcomes.

- **Valuing Risk Reduction**
- Some policies **explicitly aim to reduce risk** (e.g., air pollution policies).
- Example: Reducing **PM2.5 pollution** lowers risk of:
  - **Asthma**
  - **Infant mortality**
- Economic value of risk reduction estimated via **willingness to pay (WTP)**:
  $WTP = \sum P_i(U(Y_i^*) - U(Y_i))$
  where Y_i^* is improved health outcome due to policy.

- **Challenges in Nonmarket Valuation of Uncertainty**
- **Health risks** are easier to value than broad environmental risks.
- Long-term, geographically broad, or **catastrophic risks** (e.g., climate disasters) remain difficult to quantify.
- Need for **advanced valuation methods** to incorporate uncertainty effectively.

Valuation Methods

- **Revealed Preference vs. Stated Preference Methods**
- **Revealed Preference Methods**: Infer values from actual market behavior.
- **Stated Preference Methods**: Rely on survey responses to hypothetical scenarios.

Revealed Preference Methods	Stated Preference Methods
Travel Cost Method	Contingent Valuation
Hedonic Pricing	Attribute-Based Methods
Defensive Behavior	Hypothetical Substitution

- **Revealed Preference Methods**

  1. Travel Cost Method (TCM)
  - Used for valuing **recreational sites** by analyzing how much people spend to visit.
  - **Example**: Estimating the value of a national park by considering travel costs (fuel, time, entry fees).
  2. Hedonic Pricing Method (HPM)
  - Estimates the value of environmental attributes based on their impact on **market prices** (e.g., real estate).
  - **Example**: Comparing property prices in areas with different air pollution levels to measure the implicit value of clean air.
  3. Defensive Behavior Method
  - Measures how much people spend to **avoid environmental harm**.
  - **Example**: The cost of water filters in areas with polluted drinking water helps estimate the value of clean water.

- **Stated Preference Methods**

  1. Contingent Valuation Method (CVM)
  - Uses surveys to directly ask individuals about their **willingness to pay (WTP)** for an environmental good.
  - **Example**: Asking citizens how much they would pay for a program to reduce air pollution in Delhi.
  2. Attribute-Based Methods
  - Uses hypothetical choices between different scenarios to estimate preferences.
  - **Example**: Presenting people with different combinations of **fuel types, vehicle prices, and emission levels** to estimate the value of reduced pollution.

- **Choosing the Right Method**
- **Regulatory Needs**: Major policies may require more **rigorous** valuation methods.
- **Cost vs. Accuracy**: Stated preference methods may be **cheaper**, but revealed preference methods are often **more reliable**.
- **Combinations of Methods**: Sometimes multiple methods are used to get a **more complete valuation**.