Prioritization of Climate Change Adaptation Options

The Role of Cost-Benefit Analysis

Session 5: Conducting CBA Step 4
(Introduction to economic valuation)

Accra (or nearby), Ghana
October 25 to 28, 2016
8 steps

Step 1: Define the scope of analysis.

Step 2: Identify all potential physical impacts of the project.

Step 3: Quantify the predicted impacts: With and without project

Step 4: Monetize impacts.

Step 5: Discount to find present value of costs and benefits.

Step 6: Calculate net present value.

Step 7: Perform expected value and/or sensitivity analysis.

Step 8: Make recommendations.
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Outline of presentation

1) When market prices are known
   Calculating the cost of input
   Calculating the benefit of an output

2) When market prices are not known

3) Benefit transfer methodology
Outline of presentation

1) When market prices are known
   - Calculating the cost of input
   - Calculating the benefit of an output

2) When market prices are not known

3) Benefit transfer methodology
Consider the following situation.

As a result of the large number of road accidents along a winding road in Ghana, the Government of Ghana considers improving the road.

Or:

As a result of the projected increased electricity demand, the Government of Ghana considers increasing supply capacity by adding a new coal-fired power plant to the power supply system.

Each of these projects will require 1,000 tons of steel and 1,000,000 hours of labor.

We know the market price of steel and the market price of labor.

But what’s the *economic* cost of these inputs?
Consider the following situation:
There is a tax on each unit of input going into the project.

Suppose the following:

QG is the quantity (tons) of steel procured by the project
P1 is the market price of steel
T is the tax on each ton of steel

Financial cost (to project developer): $(P_1 + T) \times QG$

Economic cost to society: $(P_1 + T) \times QG - T \times QG = P_1 \times QG$

Economic cost $< \text{ Financial cost}$

Taxes are called transfer payments.

Transfer payments are not included in the economic analysis.
In [economic] analysis, we count resources that are created or used up. Resources that are simply transferred from one pocket to another are not counted as costs or benefits.

Canada (1998):

Payments which redistribute income but which do not reflect either the value of a good to a consumer or the costs of its supply (...) are excluded from a cost-benefit analysis.

Australia (2007):

Payments which redistribute income but which do not reflect either the value of a good to a consumer or the costs of its supply (...) are excluded from a cost-benefit analysis.

New Zealand (1998):

A transfer payment is a payment for which no good or service is obtained in return e.g., a social welfare benefit. Transfer payments may change the distribution of wealth, but do not of themselves give rise to direct economic costs or benefits for the economy as a whole. They should therefore be excluded from CBA.
Suppose there is a negative externality with steel

Consider the following situation:
The production of steel generates water pollution.

Suppose the following:

QG is the quantity (tons) of steel procured by the project
P1 is the market price of steel.
EC is the external cost of each ton of steel produced. Suppose this external cost is not internalized in the market price of steel.

Financial cost (to project developer): \[ P1 \times QG \]

Economic cost to society: \[ (P1 + EC) \times QG \]

Economic cost > Financial cost
It is common (and wrong) in the economic analysis of development projects to use *multipliers* to account for multiplier effects (especially in analyses prepared by project developers or by those who stand to gain the most from project approval). These multiplier effects are occasionally referred to as *secondary* effects, *indirect* effects, or *spill-over* effects.

3 fundamental problems with using multipliers
Problem 1

• When a project hires labor, it is a cost for society, not a benefit.

• Suppose a project is going to hire skilled labor of which there is currently a shortage.

• Is the project going to create net jobs for this type of labor?

• No. It will simply displace some workers from existing job to work for the project. And the project will be able to do that by offering a higher salary to attract that labor. Hence, wages for this type of labor will go up, but no job is created.
Problem 1

The use of multipliers implicitly assumes that the economy is at less than full employment (and therefore that there is sufficient room in the economy to realize secondary or spill-over effects).

If the economy is at or close to full employment, it is not possible to increase net national income since no additional factor inputs can be allocated to production.
Problem 2

• Suppose now that a project is going to hire unskilled labor of which there is currently significant unemployment.

• It does not mean that this job creation is a benefit of the project. It is still a cost for society. However, the cost for society is less than the cost (wage) paid by the project to this labor (shadow price is less than market price).

• We use the shadow wage of labor.
Problem 3

Perhaps more importantly, the use of multipliers implicitly assumes that if the project is not implemented, there is no other project that can be undertaken. Put slightly differently, all development projects will have so-called multiplier effects (in an economy less than fully employed). Hence, upon choosing a project among many projects (or an option among many options), applying a multiplier to all projects (or to all options) provides the same result as applying no multipliers. But in fact, when examining a project in isolation of all other projects or options, the use of multipliers implicitly assumes that only the project under examination could yield multiplier effects, whereas other projects or options would not.
1) When market prices are known
   Calculating the cost of input
     Calculating the benefit of an output

2) When market prices are not known

3) Benefit transfer methodology
Let’s go back to our fisheries example where there may be an adaptation measure which could offset (partially or totally) the impact of climate change.

We have already identified and quantified the impact of this measure.

How would you monetize this impact?
1) When market prices are known
   Calculating the cost of input
   Calculating the benefit of an output

2) When market prices are not known
   Change of productivity methodology
   Revealed preferences methodologies
   Stated preferences methodologies

3) Benefit transfer methodology
1) When market prices are known
   Calculating the cost of input
   Calculating the benefit of an output

2) When market prices are not known
   Change of productivity methodology
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3) Benefit transfer methodology
This methodology is generally applied in the specific case where the environmental impact represents a change in a component of the environment (or ecosystem) which has a direct consumptive value.

This impact will be measured by a change in the production of a good for which there is already a market, and therefore market prices.

Market prices or shadow prices will be used to assess the economic impact of this change in productivity.
Examples where appropriate to use this methodology:

- Water pollution may impact fisheries yield;
- Reservoir sedimentation may impact power production;
- Floods may impact agriculture production;
- Sickness (from air pollution for example) impacts labor force productivity.
Proceeds in two steps:

**Step 1:** Establish the link or the relationship that exists between a change in environmental quality and the resulting impact on production.

This is generally called a **dose-response function**.

Examples of dose-response functions:

- Relationship between fisheries yield and water pollution;
- Relationship between reservoir sedimentation and power production;
- Relationship between floods and agricultural production.
Step 2: Once the change in production is established, market prices (or shadow prices which are market prices corrected for the presence of subsidies, taxes or for any other market imperfections) are then used to estimate the economic value of the estimated change in production.
Consider this example.

As a result of a projected increase in the number of days without rain, maize production could be adversely impacted.

Agricultural experts tell us that as a result, maize yield could fall from the existing 1 ton per ha, to approximately 0.5 ton her ha over the next 20 years (fictitious numbers).

However, agricultural experts also tell us that 50% of this impact could be offset if farmers were to switch from maize only to a compost maize-soya intercrop with bunding.

Net benefits of maize have been estimated to be GHS300 per ton.

How would you estimate the potential benefits of this adaptation measure?
Outline of presentation

1) When market prices are known
   Calculating the cost of input
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2) When market prices are not known
   Change of productivity methodology
   Revealed preferences methodologies
   Stated preferences methodologies

3) Benefit transfer methodology
These methodologies aim to provide an economic assessment of environmental impacts by observing actual behavior of individuals, and what this behavior reveals about their preferences for changes in environmental quality.
### Revealed preferences methodologies

<table>
<thead>
<tr>
<th>Methodologies</th>
<th>Revealed behavior</th>
<th>Types of application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of illness</td>
<td>Expenditures to treat illness</td>
<td>Health; morbidity</td>
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This methodology is generally applied in the specific case where the change in environmental quality has an impact on human health.

Examples:

- Reduction in air quality may increase the number of asthma attacks;
- More water pollution may increase the number of cases of gastro-intestinal diseases.
Proceeds in two steps:

**Step 1:** Establish the link or the relationship that exists between a change in environmental quality and the resulting impact on health.

This is also called a dose-response function.

**Examples of dose-response functions:**

- Link between air pollution and asthma attacks (e.g. for every increase of 1 microgram/m3 of PM-10, how many more cases of asthma attacks can we expect?);

- Link between water pollution and gastro-intestinal diseases.
Proceeds in two steps:

Step 2: Once the health impact has been established, market prices (corrected for the presence of subsidies, taxes or for any other market imperfections) are then used to estimate the economic costs of providing medical services to address these health impacts.

Types of medical costs:

- Cost of hospital stay per day; and
- Cost of medicine.

If working days are lost because of sickness, we would add the costs of these lost working days.
Cost of illness

Direct cost

- Cost of seeking treatment, diagnosis of illness, and treating illness.

Direct medical costs

- Hospital inpatient;
- Physician inpatient;
- Physician outpatient;
- Emergency outpatient;
- Diagnostic tests;
- Prescription drugs;
- Medical supplies.

Direct non medical costs

- Transportation to health care services.

Indirect cost

- Cost of resource lost because of disease.

- Time lost while treating illness.
## Revealed preferences methodologies

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However, individuals may undertake expenditures to avoid being ill (i.e. preventing illness instead of treating illness).

Examples of avertive behavior:

- People buy bottled water to avoid the risk of falling sick drinking contaminated water;
- People buy air purifiers;
- Motorcyclists wear a mask to protect themselves from car exhaust fumes.
When to use it

Difference between defensive expenditure and cost of illness methodologies:

Pollution → Exposure → Illness

Defensive expenditure methodology

Cost of illness methodology
Proceeds in three steps:

**Step 1:** Establish the link or the relationship that exists between a change in environmental quality and the resulting impact on health.

**Step 2:** Once the health impact has been established, observe what individuals do (behavior) to avoid the potentially adverse health impact.

**Step 3:** Use the estimated expenditures associated with this behavior (defensive expenditure) as an estimate (or a proxy) of the benefits of avoiding the adverse change in environmental quality.
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Significant river sedimentation may increase the cost of water supply company because of the need to use additional inputs to control (or remove) sediments from the raw water; this methodology is generally applied in the specific case where individuals aim to offset the adverse change in environmental quality using additional or complementary inputs in the production of the goods or services.

Examples:

- Significant river sedimentation may increase the cost of water supply company because of the need to use additional inputs to control (or remove) sediments from the raw water;

- Farmers may increase the use of fertilizers in order to offset the impact of soil erosion on the productivity of their land.
Proceeds in three steps:

**Step 1**: Establish the link or the relationship that exists between input and output, including a change in environmental quality.

**Step 2**: Use this relationship to assess the quantity of other inputs that must be used to offset the change in environmental quality.

**Step 3**: Estimate the economic value of those additional inputs. The market price of those inputs (corrected for the presence of subsidies or taxes or for any other market imperfections) can be used to assess this economic cost.
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Hedonic pricing

This approach recognizes that the price that consumers are willing to pay for some traded commodities (such as houses, or land) depends on a large number of variables, including environmental quality.

Examples:

- Consumers are willing to pay less for a house that is located near a landfill than for the same house away from a landfill;
- Consumers are willing to pay more for a house located near to a nice beach than a dirty beach.
## Revealed preferences methodologies

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This methodology attempts to assess the value of changes in ecosystem services by using the travel costs and opportunity cost of time that an individual incurs to visit a recreation site.

It may be inferred that the recreational value of a site (for example a beach) must at least exceed that the travel and time costs incurred by individuals to reach the site.
1) When market prices are known
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3) Benefit transfer methodology
These methodologies aim to provide an economic assessment of environmental impacts using data on hypothetical choices made by individuals responding to a survey and **stating** their preferences.

**Different methodologies:**

- Contingent valuation;
- Choice experiment.
This approach, implemented by means of surveys, aims to assess how individuals would hypothetically react to changes in environmental quality.

In particular, it elicits from respondents how much they would be willing to pay to access improved environmental quality or avoid a hypothetical reduction in environmental quality.
5 key issues

1. How to select the population of respondents to the contingent valuation survey?

2. What type of interview format should be used in the survey: in person, telephone or mail?

3. What type of questions should be used to elicit respondents’ valuation of the change in environmental quality (elicitation procedure)?

4. What change in the environmental quality is being valued?

5. Which vehicle would be used to extract payment for the change in environmental quality (payment vehicle)?
It will take some time, resources and expertise to implement these methodologies.

What to do if we don’t have enough time or resources to implement one or some of these methodologies?

One possible approach is the benefit-transfer methodology. This methodology is discussed in the next presentation.
1) When market prices are known
   - Calculating the cost of input
   - Calculating the benefit of an output

2) When market prices are not known

3) Benefit transfer methodology
   - What is benefit transfer?
   - Justification for the use of benefit-transfer
   - Typical applications
   - How accurate is benefit-transfer?
Outline of presentation

1) When market prices are known
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2) When market prices are not known

3) Benefit transfer methodology
   What is benefit transfer?
   Justification for the use of benefit-transfer
   Typical applications
   How accurate is benefit-transfer?
What is benefit transfer?

“The transfer of existing estimates of non-market values to a new study which is different from the study for which the values were originally estimated.” (Boyle and Bergstrom, 1992)

“Transfer economic value of a public good from study site (primary valuation study) to policy site (where you are doing analysis).” (Rosenberger and Loomis, 2003)
What is benefit transfer?

"Study site"
Take estimated values from the study site

"Policy site"
Obtain values for the policy site

Site where there has been an economic assessment

Site of interest

Transfer
What is benefit transfer?

Site where there has been an economic assessment  

Site of interest

“Study site”  

“Policy site”

Note:

• Transfer in space: From study site to policy site.

• Transfer in time: From past studies to current study.
  
  ➢ Adjustments for changes in values over time.
  
  ➢ Accounting for possible changes in preferences (and therefore WTP) over time.
Outline of presentation

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   What is benefit transfer?
   Justification for the use of benefit-transfer
   Typical applications
   How accurate is benefit-transfer?
Justification for the use of benefit transfer

• When there is not enough time or resources to undertake primary data collection to support original study.

• To generate preliminary (plausible?) or ‘back-of-the-envelope’ estimates of economic values.

• When the expected magnitude of the economic values does not appear to be an important determinant of the overall outcome of the economic analysis.
Outline of presentation

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   Typical applications
   How accurate is benefit-transfer?
Typical application 1:

Valuation of ecosystem services

A project or policy aims at protecting wetlands of Ghana which would otherwise disappear. What is the benefit of protecting X hectares of wetlands?
## Economic value of wetlands

<table>
<thead>
<tr>
<th></th>
<th>Mangrove Sediment</th>
<th>Unvegetated Marsh</th>
<th>Salt / Brackish Marsh</th>
<th>Freshwater Woodland</th>
<th>Freshwater</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>North America</strong></td>
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<td></td>
<td></td>
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<td>29,810</td>
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<td>33</td>
<td>12</td>
<td>9</td>
<td>20</td>
<td>30</td>
</tr>
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<td><strong>Latin America</strong></td>
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<td></td>
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<tr>
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<tr>
<td>Value per ha</td>
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<td>2</td>
<td>2</td>
<td>6</td>
<td>10</td>
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<td>15</td>
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<td>5</td>
<td>7</td>
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<td>47</td>
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<td>2,120</td>
<td>960</td>
<td>83,907</td>
<td>269,462</td>
</tr>
<tr>
<td>Value per ha</td>
<td>15</td>
<td>32</td>
<td>5</td>
<td>6</td>
<td>21</td>
<td>29</td>
</tr>
<tr>
<td><strong>World</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity</td>
<td>12,112</td>
<td>45,788</td>
<td>6,758</td>
<td>765</td>
<td>9,657</td>
<td>62,967</td>
</tr>
<tr>
<td>Value</td>
<td>185,667</td>
<td>2,848,575</td>
<td>73,382</td>
<td>3,836</td>
<td>333,223</td>
<td>3,444,682</td>
</tr>
<tr>
<td>Value per ha</td>
<td>15</td>
<td>62</td>
<td>11</td>
<td>5</td>
<td>35</td>
<td>55</td>
</tr>
</tbody>
</table>
Valuation of ecosystem services

A project or policy aims at protecting wetlands which would otherwise disappear. What is the benefit of protecting $X$ hectares of wetlands?

Key issue: How similar is the wetland of the policy site to the wetlands of the study sites? “Similar” here means not in terms of their physical characteristics (location, size, age, etc.) but in terms of the *goods and services* they provide.

Typical application 1:
Value of statistical life (VSL)

A flood control project will reduce annual mortality risk in a given area of Ghana from $1/100,000$ to $1/1,000,000$. What is the benefit per statistical life saved?
Kochi et al. (2006) conducted a meta-analysis of VSL studies from high income countries drawing on 18 contingent valuation studies and 42 hedonic wage studies. The authors report an average VSL of $5.4 million (2000 USD).

If risk preferences, discount rates, and survival probabilities were the same in all countries, then the VSL should simply be proportional to income:

\[
\text{VSL}_{\text{Ghana}} = \text{VSL}_{\text{USA}} \times \left( \frac{Y_{\text{Ghana}}}{Y_{\text{USA}}} \right)^\varepsilon
\]

Where \( Y \) is GDP per capita in PPP terms and \( \varepsilon \) is income elasticity.
Step 1: It is noted that the reported $5.4 million is measured in dollars of 2000. Using US GDP deflator available in the *World Development Indicators Database*, this figure amounts to approximately $7.1 million in 2015.

Step 2: One must obtain GDP per capita measured in PPP. The IMF’s *World Economic Outlook Database 2015* reports a GDP per capita of $56,084 and $4,291 for the USA and Ghana respectively. This provides a GDP per capita ratio of 0.0765.

Step 3: Income elasticity. Analyses suggest income elasticity between 1.0 and 1.5.
Remember: If risk preferences, discount rates, and survival probabilities were the same in all countries, then the VSL should simply be proportional to income.

Typical application 2:

<table>
<thead>
<tr>
<th>( VSL_{\text{Ghana}} ) millions</th>
<th>( \varepsilon = 1 )</th>
<th>( \varepsilon = 1.5 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>543,222</td>
<td>150,258</td>
<td></td>
</tr>
</tbody>
</table>
Outline of presentation

1) When market prices are known
   Calculating the cost of input
   Calculating the benefit of an output

2) When market prices are not known

3) Benefit transfer methodology
   What is benefit transfer?
   Justification for the use of benefit-transfer
   Typical applications
   How accurate is benefit-transfer?
Two key issues:

How similar are the characteristics of the study site(s) and policy site?

What is the quality of the research from the study site?
How similar?

How does the affected good or service compare to the resource referenced in existing studies?

What population group(s) was considered in the original study (e.g. was is a specific user group or all the resident of a given area)?

How similar are the demographic and socio-economic characteristics of the study site and policy site?

Were baseline conditions in the study site relatively similar as in the policy site?

Are attitudes, perceptions, level of knowledge the same at the policy and study site? Could these have changed over time since the research at the study site has been completed?
1. Good news: In all likelihood, we typically don’t know.

   The actual value for a policy site is unknown (otherwise there would be no need for benefit-transfer).

   Hence, it is very rare that original values for a policy site can be compared with values obtained from a benefit transfer exercise for that same policy site and for that same good and/or service.

2. How much is accuracy needed for our level of confidence to be sufficient enough to proceed with recommendation?
Database of interest

EVRI: Environmental Valuation Reference Inventory

ENVALUE

EUROFOREX Database

NOAA’s databases on Marine and Coastal resources

UK Defra Environmental Valuation Source List

USDA NRCS (Natural Resource Conservation Service)

US Recreational Value Database

American Economic Association EconLit database
Prioritization of Climate Change Adaptation Options

The Role of Cost-Benefit Analysis

Session 5: Conducting CBA Step 4 (Introduction to economic valuation)

Accra (or nearby), Ghana
October 25 to 28, 2016