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GEF Documentation

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This paper represents the first steps in the development of a framework for measuring the incremental costs of climate change mitigation projects by the Global Environment Facility (GEF). The GEF is a financial mechanism that provides grants to developing countries for the incremental cost of projects aimed at protecting the global environment.

The paper develops a taxonomy of potential options to reduce the risk of climate change, and clarifies certain misconceptions related to incremental cost by presenting a clear methodology for estimating the difference or "increment" between the costs of five projects that a country might undertake, and the costs of possible GEF interventions to incorporate global environmental benefits.

The author demonstrates how incremental costs can be incurred even in an alternative that is economic, and how baseline project costs avoided by an intervention constitute a legitimate part of the calculation of costs. The paper stresses the need for a case-by-case approach in the evaluation of projects because of the different ways in which system boundaries and baselines can be constructed, and the influence of local factors on cost estimates.

This paper is the sixth in a series of GEF Working Papers to deal with the Program for Measuring Incremental Costs for the Environment (PRINCE). PRINCE was initiated in February 1993 at a workshop held at the Tata Energy Research Institute in New Delhi. It covers methodological studies, field tests, and dissemination related to the technical issues of measuring incremental cost. This is a concept central to the GEF; the two conventions to which it is linked—the Framework Convention on Climate Change and the Convention on Biological Diversity; and the Montreal Protocol dealing with ozone depletion.

Participating governments provided PRINCE with $2.6 million from the Core Fund for a three-year program. It builds on existing work concerning the phase-out of ozone-depleting substances and concentrates on the incremental costs of reducing the emissions of greenhouse gases. Parallel work will extend the concept of incremental cost to the conservation of biodiversity and the protection of international waters.

This paper has benefitted greatly from discussions with Ken King of the GEF Secretariat and with the author's colleagues at the Center for Global Change—Alan Miller, Irving Mintzer, Frank Muller, Harvey Sachs and Pamela Wexler. Parul Subramanian and Marybeth Shea helped with the editing.

Dilip Ahuja is an Associate Research Scholar at the Center for Global Change at the University of Maryland and a Consultant to the Global Environment Facility.

The other Working Papers currently in the PRINCE series are numbers 4, 5, 6, 7 and 8.

Contents

CFL	Compact fluorescent lamp
CO_2	Carbon dioxide
FCCC	Framework Convention on Climate Change
GHG	Greenhouse gas
ha	Hectare
IPCC	Intergovernmental Panel on Climate Change
LPG	Liquified petroleum gas
MTC	Million tons of carbon
pH	(measure of acidity or alkalinity)
STAP	Scientific Technical and Advisory Panel (of the Global Environment Facility)

Introduction

The three recent international environmental treaties—the Montreal Protocol, the Framework Convention on Climate Change (FCCC), and the Convention on Biological Diversity—include provisions to make available to developing countries financial resources for global environmental benefits. They specify that these resources shall be for the "incremental costs" of activities aimed at protecting the environment—costs that are "agreed" upon by the financial mechanism of the treaties and the country where the project or intervention is to be undertaken. The principles governing the Pilot Phase of the Global Environment Facility (GEF) contain similar language. The conventions on climate change and biodiversity also specify that these costs shall be "agreed full incremental" for certain categories of interventions, such as mitigation projects; and "agreed full costs" for other categories, such as national inventories and response plans.

King (1993) convincingly demonstrates that, irrespective of the allocation rule, incremental cost estimates are required whenever there is to be a distribution of costs between the global community and a country. The incremental cost estimates presented in this paper focus on interventions to mitigate the risk of climate change by reducing greenhouse gas (GHG) emissions or by increasing their sequestration. They represent the first steps toward the establishment of a framework for the assessment of incremental costs.

The paper presents a taxonomy of mitigation options based on the work of the Scientific and Technical Advisory Panel (STAP) of the GEF, introduces the definition of incremental costs, and applies it to five potential projects. The examples and calculations are intentionally kept simple to illustrate the concepts involved; possible complications in estimating costs and benefits are mentioned but not elaborated upon.

As the examples in this paper demonstrate, a case-by-case approach in the calculation of incremental costs seems inevitable. Factors unique to each situation greatly influence the calculation, underlining the need for "agreement" between the host country and the financial mechanism for projects involving both incremental costs and incremental global benefits.

1 A Taxonomy of Mitigation Actions

Several studies in the last three years describe options to respond to the risk of climate change. Most focus on mitigation options alone (Lashof and Tirpak 1990; National Academy of Science 1991), but a few have also considered adaptation options (IPCC 1991). More recently, the International Institute for Applied Systems Analysis has developed an inventory and database of over 500 mitigation measures (Schafer, Schrattenholzer and Messner 1992).

In a meeting at Princeton in June 1991, STAP's Ad Hoc Working Group on Global Warming and Energy recommended the initial priorities for mitigation options for GEF's Pilot Phase. STAP has periodically added other recommendations to this list through the Ad Hoc Working Group on Global Warming, the mid-term review of the first three tranches of the Pilot Phase, and the Draft Analytical Framework on Global Warming (GEF 1992, 1993).

Table 1.1 presents a taxonomy of options based on the work of STAP. The first part of the table (A) shows mitigation options in the energy sector; the second part (B) provides a listing of options in non-energy sectors. The choices in the energy sector represent four kinds of interventions:

- Reduction of energy consumption in existing processes through an increase in efficiency
- Reduction of emissions from existing processes
- A switch to more energy-efficient processes
- A switch to lower emission processes.

Interventions are also possible at various stages of the fuel cycle:

- At the production and/or generation stage
- During transmission and distribution
- At end-use.

This provides us with the 4 x 3 matrix of options shown in table 1.1 A.

Options for intervening in other sectors (forestry, agriculture, waste management and industries) are less well developed than in the energy sector. For example, we do not know whether changing rice cultivars, irrigation and fertilization practices would reduce methane and nitrous oxide emissions from paddy cultivation, and if so, by how much. As research on these topics continues, typologies akin to that for the energy sector can be created.

Table 1.1 B includes options for innovation in institutional and policy reform with the potential to reduce GHG emissions in the energy and non-energy sectors. Clearly, any such typology must be dynamic and constantly updated by dropping mature interventions that can compete in the market and including promising new ones.

The taxonomy presented here excludes global geoengineering interventions (such as introducing dust, soot or bubbles in the stratosphere, placing mirrors in space, or fertilizing the ocean phytoplankton with iron filings (National Aca-

Table 1.1 A A taxonomy of interventions in the energy sector

Option	Stage: Production/generation	Stage: Transmission & distribution	Stage: End-use
Reduce energy consumption of existing processes by increasing efficiency	. Refurbish old power plants . Repower old power plants	. Reduce T & D losses in electrical grids	o Reduce energy intensity of basic materials production o Efficient motors and drives o Irrigation pumpsets o Vehicular fuel efficiency . Process heating . Space heating and cooling . Energy conservation
Reduce emissions from existing processes	o Reduce associated gas flaring o Use coalbed methane . Collect CO_2 from fossil-fuel systems and store in depleted gas/oil fields or in deep ocean	. Reduce leaks in natural gas pipelines	. Install end-of-pipe emissions controls in wood-stoves, cars (e.g., catalytic convertors)
Switch to more energy-efficient processes	o Biomass gasifiers-gas turbines o Advanced efficient gas turbine cycles . Clean coal technologies	. HVDC transmission . Promote inter-regional flows of natural gas and hydro-electricity	o Lighting (CFLs) o Transport modal shifts (road to rail, personal to mass) . Innovative technologies for appliances, vehicles . Improved cookstoves . Land-use planning . Infrastructure efficiency
Switch to lower emission processes	o Photovoltaics o Biomass . Wind farms . Solar thermal . Small hydro . Geothermal . Fuel cells . H_2 from non-fossil electricity . Methanol from flared gas . Nuclear . MHD generators	. Hydrogen as an energy carrier	o Solar water heating . CNG transport . Electric vehicles . Natural gas-fired engine-driven cooling systems

Notes:

o	=	*STAP high priority options for GEF Pilot Phase*
.	=	*other options*
shaded	=	*examples considered in this report*
T & D	=	*transmission and distribution*
HVDC	=	*high-voltage direct current*
CFL	=	*compact fluorescent lamps*
CNG	=	*compressed natural gas*
H_2	=	*hydrogen*
MHD	=	*magneto-hydro dynamics.*

Table 1.1 B A taxonomy of interventions in non-energy sectors

I. Forestry sector

- o Combatting deforestation
  - -Biomass combustion
  - -Provide incentives for maintenance of forests
  - -Alternatives to shifting cultivation
- o Greenhouse gas sequestration
  - -Carbon sequestration in growing forests and on currently degraded lands
  - -Management of tropical forests

II. Agricultural sector

- . Reduce emissions from
  - -Cultivation of rice paddies
  - -Livestock management
  - -Application of nitrogenous fertilizers

III. Waste management sector

- o Urban and rural waste treatment
  - -Collect and use or flare landfill gas
  - -Biogas systems

IV. Industries sector

- . Reduce emissions from cement production
- . Halocarbons: CFCs, HFCs, HCFCs (reduce lifetimes and energy penalties of substitutes)

V. Institutional and policy reform (applicable to energy and non-energy sectors)

- . Improving performance through innovations
  - -Price and tax reform
  - -Least-cost planning
  - -Conversion of utilities to energy service companies
  - -Creation of new energy service companies
  - -Independent power companies
  - -Management of dispersed energy systems
- . Technology transfer
- . Manufacturing energy-efficient products in developing countries
- . Assessing technology import versus domestic manufacture
- . Training and institution building
- . Database development
  - -Energy consumption highly disaggregated by end-use
  - -Renewable energy resource mapping
- . Market aggregation

Notes: CFC = *chlorofluorocarbon*
HFC = *hydrofluorocarbon*
HCFC = *hydro-chlorofluorocarbon.*

demy of Science 1991)), as it is unlikely that individual countries would attempt these options unilaterally. If they were attempted at all, it would be as a consensual global response. Responses related to population stabilization are also excluded.

2 Incremental Cost Calculation: A Primer

An incremental cost calculation involves a comparison between two projects or programs that provide the same service. King (1993) provides a detailed description of the concepts involved in the calculation. This chapter provides a brief framework that will aid in understanding the examples that follow.

Assume that in the absence of global environmental considerations, a country would choose to undertake an economic project whose cost is C_b, and which provides a domestic benefit of DB_b. In general, the project will also have global consequences (GB_b, which could be positive if GHGs are sequestered, or negative if gases are emitted). Until now these considerations have been omitted from national decision-making and treated as externalities. Table 2.1 treats this situation as the baseline. The unit of domestic benefits is not necessarily monetary—it could also be in terms of services provided to the country. This simplifies the calculation: considerations such as price distortions and subsidies do not need to be taken into account.

Assume that there also exists an alternative intervention that costs C_a and provides the same domestic benefit in type and level of service as the baseline project, so that $DB_a \approx DB_b$. This alternative will be preferred from a global perspective if the global benefits GB_a are greater than those in the baseline, i.e., if $GB_a > GB_b$. This condition is necessary for the alternative to be preferred to the baseline. Similarly, positive incremental costs will be said to exist if $C_a > C_b$. Again, if this did not hold, the alternative project would be preferred on domestic grounds alone. Table 2.1 summarizes the situation.

The following conclusions emerge from this discussion:

- The baseline project must be economic, otherwise it would not be attempted, i.e.:

$$DB_b > C_b > 0.$$

- The maximum that a country would be willing to pay for the alternative intervention, while receiving the same level of domestic benefits, is C_b—the same that it would pay in the baseline case.
- Incremental costs are defined as the difference between the total costs of an alternative and the costs of a baseline project that yields the same benefits, i.e.:

$$IC_{ab} = C_a - C_b.$$

- Incremental global benefits are simply:

$$IGB_{ab} = GB_a - GB_b.$$

- Whether a project gets funded or not depends upon the funds available and on the cost of the intervention per unit global benefit obtained, i.e., upon the comparison of IC_{ab}/IGB_{ab}, with some value of cost-effectiveness determined outside the system.
- The country will be indifferent between the alternative and the baseline project because it

Table 2.1 Costs and benefits of a baseline project and an alternative

	Total costs (million \$)	*Domestic benefits (services provided)*	*Global benefits (tons CO_2-equivalent)*
Baseline (b)	C_b	DB_b	GB_b
Alternative intervention (a)	C_a	DB_a	GB_a
Incremental (ab)	$C_a - C_b$	0	$GB_a - GB_b$
Constraints	$C_a > C_b$	$DB_a \approx DB_b$	$GB_a > GB_b$

receives the same benefit and spends the same amount in each case.

- When $C_a < DB_a$ it is fallacious to conclude that the project does not incur incremental costs. It is equally incorrect to deduce from the inequality $C_a > DB_a$ that incremental costs are equal to $C_a - DB_a$. These errors stem from mistakenly defining incremental costs as the difference between the costs and benefits of a project without reference to a baseline situation.
- When $DB_a \neq DB_b$, two possibilities arise. If $DB_a > DB_b$, the incremental cost is incurred with respect to both incremental global benefits and incremental domestic benefits. However, if $DB_a < DB_b$, there are incremental domestic costs instead of incremental domestic benefits. In either case, the allocation of the incremental cost between domestic and international financiers is a matter for policy determination.

3 Examples of Incremental Cost Calculation

This chapter presents five examples of mitigation options representing four different sectors. These interventions, mentioned earlier in table 1.1, concern:

- Reduction in the emissions of associated gas at oil-wells
- Reduction in the emissions of landfill gas
- Carbon sequestration through reforestation
- Demand-side management for electricity involving compact fluorescent lamps
- Reduction of emissions in rice cultivation.

Several concepts are implicit in each example:

- System boundaries and baselines must be selected carefully
- The alternative project can be economic in its entirety and still incur incremental costs
- Costs incurred in the baseline but avoided in the alternative form a legitimate part of the calculation
- Uncertainty about achieving global benefits affects cost-effectiveness and project selection
- Incremental costs can sometimes be negative
- Additional domestic benefits (or costs) can occur.

It is possible to depict all these concepts with each intervention chosen, but we will emphasize only a few to clearly illustrate the concepts involved in each calculation of incremental costs. The numerical values chosen for costs and benefits, while being realistic, are not precise and do not pertain to any particular project. Each example follows an identical sequence: an introduction is followed by a national decision-making framework in which different alternatives are evaluated. The baseline and the alternative are described, followed by cost calculations. Each sub-section ends with a discussion of the possible complexities in estimating both costs and benefits.

Reduction of gas flaring

The extraction of oil is accompanied by the emission of large amounts of gas. The contribution of this gas to global warming is greatest when it is allowed to seep out and be vented to the atmosphere. However, most of this gas (approximately 95 percent worldwide) is captured and used. The oil production facilities themselves use a small fraction. In several instances though, this captured gas is flared, leading to carbon dioxide (CO_2) emissions. This usually happens when domestic markets are not developed to use the gas, political barriers exist to building cross-national pipelines to markets, marginal economics preclude liquefaction and export, or the geology of an area precludes reinjection. The prevention of gas flaring offers a very cost-effective means for reducing GHG emissions because the flared product has a market value, and because the sources of these emissions are concentrated.

This gas is a "wet" gas in that it is mixed with "natural gas liquids," which also get burned during flaring. In order to prevent flaring, the gas must be gathered and piped to separation facilities that remove the liquids from the "dry gas," which is essentially methane. The liquids yield liquified petroleum gas (LPG), as well as condensates that are also known as natural gasoline. Several applications exist for these by-products, and different technological routes may be followed for using any one of them. The dried associated gas can be used as a fuel for the production of electricity or steam for industry, or as a feedstock in the production of methanol, fertilizers, or other petrochemicals, including liquified natural gas. Similarly, LPG can be bottled and used for cooking, refrigerated and exported, or used in refineries as a fuel. Natural gasoline is mixed with the crude oil that is extracted.

The multiple technological options change cost (and therefore incremental cost) calculations. For example, the export of LPG would require the purchase or lease of a tanker, but its use in a local refinery would obviate the expense of the tanker but create the need for a longer pipeline, and so on. In discussing incremental costs in this context, we first focus on the simple case and then briefly consider some of the complications that could arise.

Decision-making framework

Since the calculation of incremental costs of a project designed to capture global benefits depends on the baseline situation, it is useful to consider certain possibilities. Assume that a country has just discovered an oil field. The first decision for the country will be whether to exploit the new resource or leave it intact and continue to import oil, if that is the currently cheaper option. If the decision to exploit the resource is made, the crude oil will need to be separated from the associated "wet" gas, which consists of natural gas liquids and methane. The next decision will concern the recovery of the resources in this associated gas versus the expedient option of flaring it. If the decision to recover this resource is made, the liquids will need separation from the dry gas portion. Some of this gas will be used to fuel operations in the separation plant. The third level of decision-making will be over whether to capture the dry gas or flare it. If the capture option is preferred, then one of several options available for the use of the gas will also need to be chosen. Figure 3.1. summarizes this decision tree.

Baseline situation

Let us assume there exists an offshore well that is currently flaring the associated wet gas it produces. Assume also that it is economic to build a plant for capturing the liquids, but that this plant will flare the dry gas. Since this project is economic by assumption, the incremental domestic benefits will exceed incremental domestic investment, and although there are global benefits (the liquids will displace an equivalent amount of oil and LPG), no incremental costs will be incurred in obtaining them. (This need not always be so; it would depend on the liquids content of the gas stream. If this project were uneconomic, it would incur incremental costs that could be financed by the financial mechanism of the FCCC if the expenses were judged to be cost-effective.) The liquids plant with dry gas flaring then becomes the baseline situation rather than the previous oil-well that flared the wet gas.

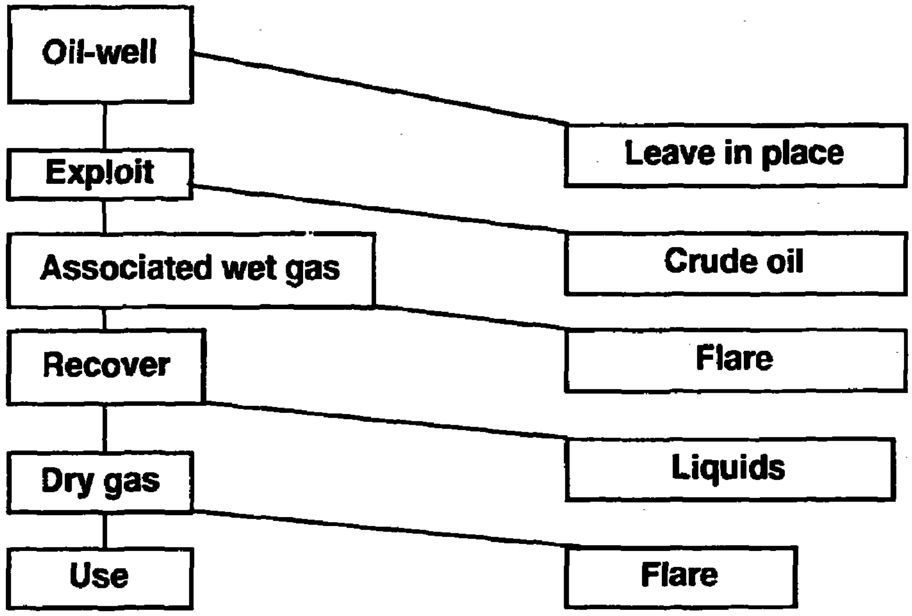
It is not enough merely to focus on the baseline situation as just defined. Since the alternative project, as described below, uses the dry gas for power generation, more fuels in current use will be displaced. In principle, therefore, the baseline also includes the electric power plant. If the avoided fuel is non-associated gas from another field, then the baseline will include that gas well.

Alternative project intervention

To realize further global benefits, the dry gas must not be flared. It can be compressed and piped to a facility that uses it, such as a power plant. (This is but one option.) Let us calculate the incremental costs of this option.

The technology for the baseline project requires the construction of an offshore platform for dehydrating and compressing the associated gas, and piping it via an underwater pipeline to a gas plant at the shore. The LPG recovered is to be pumped to an offshore LPG tanker, the condensate liquids to an oil storage facility, and the fuel gases to local installations for use.

Fig. 3.1 Decision-making framework for reduction of associated gas flaring



In the alternative project, the dry gas is compressed and piped to a power plant that currently operates on non-associated gas from a natural gas well. The liquids part of the project (the baseline) has large domestic economic benefits, but small global warming benefits; the dry gas part has large global benefits but small domestic benefits (in this example, this portion is in fact uneconomic).

Cost calculation

Let the present value of the total cost of the baseline project—the cost of the separation plant to extract the liquids from the gas stream—be CS. Let the cost of the fuel (non-associated gas) to run the power plant be CF. The benefit this baseline project yields to the national economy is the value of the liquids extracted and the power generated. Both the costs and the benefits accrue to the country. The baseline project also has certain global implications in terms of emissions (200 million tons of CO_2-equivalent from the liquids, the associated gas and the non-associated gas), but these are incidental and of little concern to the country. Table 3.1 shows this baseline situation.

The alternative project yields the same domestic benefits of power and natural gas liquids as the baseline. The alternative project costs now include the cost of the separation plant CS, and the costs of the compressor and pipeline for the natural gas, say \$30 million. The fuel costs for the power plant will now exclude the value of the non-associated gas, say \$10 million. The alternative project results in GHG emissions of say 155 million tons of CO_2-equivalent.

As table 3.1 shows, the incremental costs in this example amount to \$20 million. Whether the alternative project is also economic is irrelevant to the calculation of incremental costs. From a national perspective, there are no domestic benefits for an additional investment of \$20 million. The country would be indifferent between the baseline and the alternative if its expenditures were limited to CS + CF in each case. The global community must determine whether the incremental global benefits (a reduction of 45 million tons of CO_2-equivalent) are worth the incremental cost of \$20 million. The same argument holds irrespective of the size of domestic benefits of the baseline project.

Table 3.1 Incremental costs of a project to avoid gas flaring

	Total costs (million $)	*Domestic benefits (arbitrary units)*	*Global benefits (million tons CO_2-equivalent)*
Baseline (recover liquids)	CS + CF	Liquids + power	- 200
Alternative (recover liquids & gas)	CS + 30 + (CF - 10)	Liquids + power	- 155
Incremental	20	0	+ 45

Complications in cost calculation

Many project-specific factors affect the calculation of incremental costs, such as the associated gas-to-oil ratio and amounts, and the natural gas liquids-to-dry gas ratio. But the most significant factors relate to the various uses to which the liquids and gas might be put. The system boundary, therefore, must be expanded to include utilization of these two resources and of the fuels they displace.

When the dry gas is used for power generation, it is important to know if we need to re-engineer the power plant for multi-fuel capability. The reliability of demand for the gas also needs to be considered. If the power plant experiences frequent outages, periodic dry gas flaring will occur. Similarly, the reliability of oil production at the well will affect the reliability of dry gas supply and, therefore, its economic value, since the value of interrupted gas supply is less than that of constant supply. In general, all such projects being attempted for the first time will also require a training component.

Project costs will also be affected by the technological option chosen. For example, if a decision to extract the liquids is taken, will the flaring tower at the well still need to be constructed for possible safety reasons? If the dry gas is to be used, must the flaring tower at the separation plant still be erected in the eventuality of closure of the power plant?

Complications in benefits assessment

Since the utilization of flared gas will not itself reduce carbon dioxide emissions, the system boundary must be broad enough to include the fuels displaced by dry gas. If renewable energy sources are being displaced, there is no benefit through averted emissions. The emissions averted by liquids are ignored in this example because they form part of the baseline.

The amount of gas flaring increases with time because the gas-to-oil ratio increases in oil production. This increase must be predicted and discounted to the present while calculating the value of avoided costs of non-associated gases.

Implementation of the alternative project could affect capacity expansion plans in the natural gas sector. The investments required in the future, when the current capacity no longer meets demand, could thus be delayed or reduced or both. This is one quantifiable domestic benefit of the project; it is usually incorporated by taking the value of the natural gas production avoided at its long-run marginal cost, rather than the value reflected by current prices.

Capture of landfill gas

The increase in urbanization worldwide has made the disposal of municipal solid wastes a serious concern. In developed countries, the typical or preferred method of disposal has been sanitary landfills where the waste is spread, compacted, and covered with soil each day. When a particular cell is full, it is sealed. Because of anaerobic conditions, the organic component of the waste is broken down by bacteria into carbon dioxide and methane. The carbon dioxide, having been fixed by plant matter recently, is recycled back to the atmosphere. But the emissions of methane present both a safety hazard near the site and a net contribution to the greenhouse effect. Lately it has become economic to capture and use this methane as an energy source, especially in landfills receiving more than 200,000 tons of waste per year.

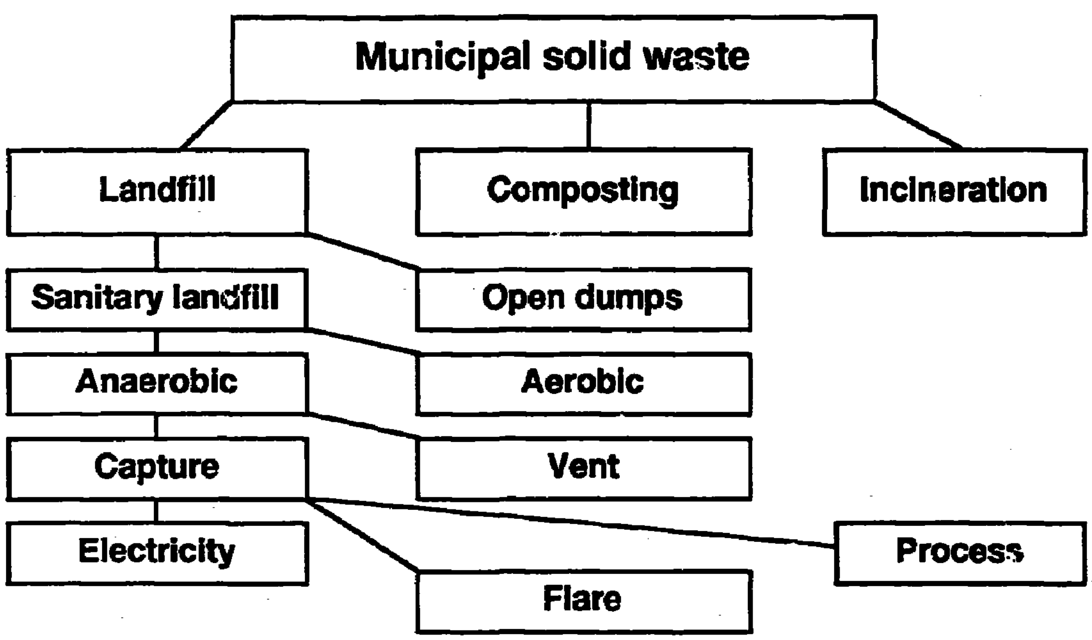
In developing countries, many disposal sites near urban areas are uncontrolled open dumps. While this could be considered preferable in terms of methane emissions (because conditions are more likely to be aerobic), several local health problems are exacerbated by unsanitary conditions (by flies, scavenging, and spontaneous smoldering fires). As larger cities in developing countries move toward more sanitary landfills, methane emissions will increase unless the landfills are accompanied by recovery systems.

Decision-making framework

The three main options for the disposal of urban municipal solid waste are, in order of increasing cost: landfills, composting and incineration (see figure 3.2). Composting plants have not worked well in large cities because of high costs, waste separation problems, and the inadequate marketing of compost. The incineration of wastes in developing countries is even less feasible because the moisture in the waste stream is too high for cost-effective operations.

If a landfill is the preferred method of disposal, a choice will need to be made between sanitary landfills and open dumps. For reasons already mentioned, let us assume that open dumps are not chosen. In sanitary landfills, a choice exists between anaerobic landfills, where the tops are sealed with an impermeable layer of soil and clay, and aerobic landfills. The aerobic option is less cost-effective because expenses are higher and global benefits lower, with smaller amounts of methane being produced and less fossil fuels displaced. In an anaerobic landfill, the cheapest option would be to vent the landfill gas (a mixture of carbon dioxide and methane) to the atmosphere. If this gas were

Fig. 3.2 Decision-making framework for capture and use of landfill gas



captured it could be flared, or its energy value used to displace other fuels. With minimal cleaning, the gas could be used directly to produce electricity using gas turbines, internal combustion engines or fuel cells. The landfill gas could also be enriched (by removing carbon dioxide), purified (by removing sulfuric gases), compressed and then fed into a pipeline for industrial use.

Baseline situation

The baseline case could be an open dump or a sanitary landfill. Since open dumps have significantly lower methane emissions than sanitary landfills, the benefits of replacing open dumps with sanitary landfills incorporating gas recovery and use are largely the avoided emissions from displaced fuels. The avoided methane emissions also provide a greater global benefit. Let us assume that the baseline proposal is to build a new sealed sanitary landfill capable of receiving 700,000 tons of waste per year, and that incremental financing would prevent the diffusion of methane into the atmosphere.

The baseline plan does not include the cost of the gas recovery system. But as described below, the alternative project includes recovery and uses a gas turbine for the production of electricity that is fed into an electricity grid. The baseline situation, therefore, must also include a provision for the generation of the same amount of electricity as will be produced by the landfill gas. This can be done in at least two ways: the most obvious way is to assume that the electricity is produced by internal combustion engines powered with diesel. But if a project of this size would not typically appear in a country's capacity expansion plans, then one must consider the electricity that now would not need to be generated at a nearby power station. The baseline costs of each of these two options will be different. For the sake of simplicity, we consider the first option.

Alternative project intervention

To achieve optimal gas capture in an anaerobic sanitary landfill, the waste must be spread in thin layers, compacted, covered daily with soil, and finally sealed with a thick layer of soil and clay. Wells are drilled into the landfill after it is capped. The gas is withdrawn under negative pressure and gathered at a central processing unit. The gas treatment system removes moisture and, if required, impurities like hydrogen sulfide. The gas is then compressed to the desired pressure. Since this recovered gas will be used for generating electricity, generators and the equipment for delivering the electricity to an existing grid will also be required.

Cost calculation

Let us assume that the cost of the land required for the sanitary landfill is $4 million, and the present value of lifetime operating costs for the landfill another $1 million. The baseline costs include the cost of fuel (CF) for generating electricity—fuel that would not be required under the alternative scenario. The benefits of this project are the power produced and the local benefits which are valued at say SL, which could be any number greater than $5 million. The sanitary landfill in the baseline case also results in methane emissions, the CO_2-equivalent of which, along with emissions from the power plant, is say 25 million tons.

In the alternative case, the landfill design needs to incorporate equipment to capture the landfill gas and generate electricity from it. Assume that this equipment costs $25 million. To generate electricity, less fuel is required now than in the baseline case. Let us assume that the value of the displaced fuel is determined from long-run marginal costing principles to be $5 million. The benefits here are the same as in the baseline: SL + the value of the power generated. Net GHG emissions will be reduced to say 10 million tons of CO_2-equivalent. As table 3.2 shows, the incremental costs of the project are $15 million, and the global benefits are 15 million tons of CO_2-equivalent. Incremental costs are therefore significant, being about three times the cost of the baseline project.

Complications in cost calculation

The costs of using landfill gas are highly dependent on the technologies used, especially the technologies for end-use of the captured gas. For example, carbon dioxide removal from the gas would be required for the production of electricity, but not for use as an industrial fuel. Flaring may be the most expedient option (for small landfills), but it does not capture the energy value of the methane. Anoth-

Table 3.2 Capture and use of landfill gas

	Total costs (million $)	*Domestic benefits (arbitrary units)*	*Global benefits (million tons CO_2-equivalent)*
Baseline (sanitary landfill)	5 + CF	SL + power	- 25
Alternative (capture + use)	25 + (CF - 5)	SL + power	- 10
Incremental	15	0	+ 15

er factor is the degree of leachate recycling in the soil. This recycling reduces local water pollution (a domestic benefit) and increases methane generation by increasing moisture content and creating more favorable pH conditions. Where methane is captured and used, additional methane provides a larger global benefit by the further displacement of fuels. Again, these incremental costs must be compared with incremental benefits.

Complications in benefits assessment

The rate of methane generation varies (by a factor of 35) in landfills, and depends upon many factors including waste composition, moisture content, acidity, temperature and landfill design. Systems generally perform best when waste streams have a high organic content and include paper. The amount of methane produced is even more uncertain than in the previous example of the oil-well.

Choosing the industrial use option instead of the electricity option could cause an intermittent demand for the gas, requiring occasional flaring and reducing global benefits.

Sanitary landfills with gas capturing systems have several local environmental benefits that have not been considered in the above estimation. These include the reduction of other malodorous and hazardous gases such as volatile organic compounds (VOCs), and a lowered risk of explosion.

It has been suggested that after the life of a landfill, the degraded wastes may have some economic value as compost, but it is difficult to estimate the value of this fertilizer or its future price and demand.

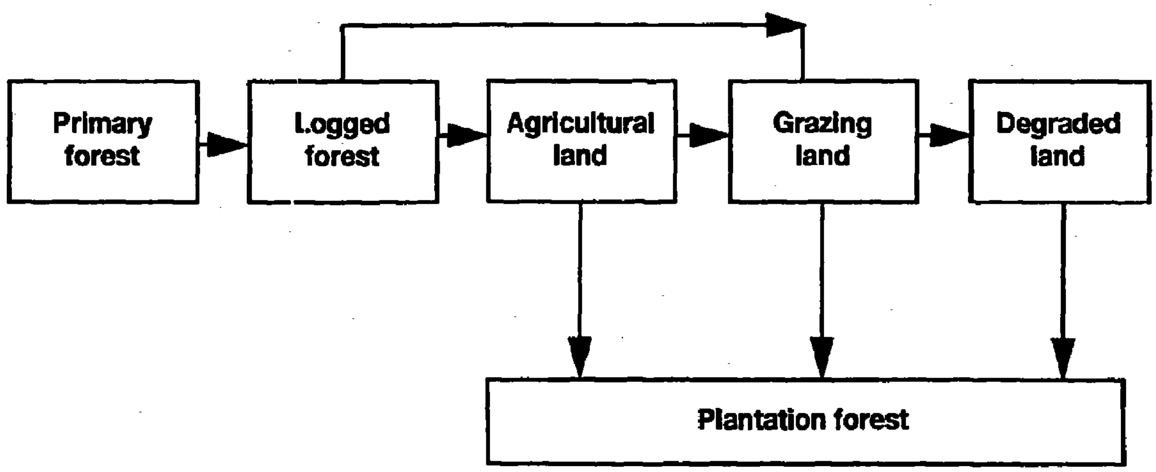
Reforestation

The restoration of tropical lands degraded by inappropriate anthropogenic practices in logging, grazing, and agriculture has the potential to sequester significant amounts of carbon at moderate costs. According to one estimate (Grainger 1988), there are more than 500 million hectares of tropical lands potentially suitable for afforestation projects, and another 200 million hectares of previously forested land suitable for reforestation projects. Because these lands are degraded, the productivity of plantations is often low. This drawback can be overcome through the application of natural mulch or commercial fertilizer to seedlings, and by choosing native species that are well adapted to local pest and environmental conditions. Let us consider an example of a reforestation project that is likely to incur incremental costs.

Decision-making framework

It is possible to conceive of at least five broad categories of land use with different carbon densities: undisturbed primary forests, logged forests, agricultural lands, grazing lands and degraded lands. Historically, progressive utilization changes primary forests to degraded lands and sometimes, if conditions are right for natural regeneration, back to primary forests (see figure 3.3). Since soil quality in forested regions often varies significantly over short distances, reforestation requires the preparation of land-use and forest management plans.

Fig. 3.3 Simplified land-use plan for reforestation project area



A land-use plan consists of mapping areas according to the suitability of soils for potential uses such as agriculture, forestry, and pasture, and comparing this with present land-use patterns. Areas can then be selected for reforestation and sustainable management, or for preservation as reserves. Inventories and biomass densities have to be conducted on samples of each land classification so that changes can be monitored and forest resources utilized rationally.

Baseline situation
Let us assume the following for the baseline case:

- Over the twenty-year project period, there exists a total national demand for hardwood (for internal consumption and exports) equivalent to 5 million tons of carbon (MTC)
- All this hardwood comes from forests that are unsustainably logged
- The efficiency of logging operations is 50 percent, resulting in a reduction of 10 MTC stored in logged forests
- The net present value of the cost of these logging operations is $1 million (old growth timber is undervalued in many countries)
- There is no change in carbon sequestration in any of the other land categories, and no plantation activities are carried out anywhere in the project region.

Alternative project interventions
The project calls for the purchase of 10,000 hectares of land that are either degraded or under agriculture or pasture from smallholders seeking to sell their land. Project authorities wish to plant native tropical hardwood species which will be sustainably logged at maturity. It is expected that the net sequestration of carbon on former agricultural lands will be 20 MTC, on former pasture lands 10 MTC, and on degraded lands 5 MTC.

For the calculation of incremental costs, one does not need to consider global benefits, and it might suffice to draw the system boundary narrowly around the project. But in order to judge whether a project results in the cost-effective sequestration of carbon, larger system boundaries need to be taken into account. It is therefore necessary to estimate the "carbon consumption" of the population that sells the land and moves.

Let us consider two alternative outcomes, A and B. In case A, the displaced population moves to an urban area and uses only hydro-electricity for its energy needs. We can assume that the pressure on logged forests is less than before (because the plantations will begin to yield some timber), and that there is no change in the primary climax forests. In alternative B, let us assume that the population is either encouraged by governmental regulations or forced by a lack of choice to colonize primary forests that are consequently significantly degraded. Because primary forests now become the source of timber, the pressure on logged forests is reduced and they recover somewhat. Table 3.3 summarizes these carbon emission and sequestration streams.

Cost calculation

Let us assume that the average price paid (reflecting the opportunity cost of land to the sellers) is $1000 per hectare. The total cost of the land is then $10 million. The price of establishing plantations on degraded grasslands in Indonesia has been around $400 per hectare. Let us assume that this figure includes the cost of seedlings/saplings, water, fertilizer, fencing, sustainable harvesting and administrative needs. Using this figure, the net present value of the total cost of the project is $14 million. Since the domestic benefit in all cases is the same (5 million tons of hardwood), the incremental costs are the difference between project costs and what would have been spent in the baseline, i.e., $13 million (see table 3.4). In this case too, the incremental costs are not insignificant.

Complications in cost calculation

Any standing stock of trees is subject to many natural risks such as drought, fire, pests, disease, and anthropogenic risks such as air pollution. If the financing mechanism will make only one-time payments, it could be argued that payments ought to cover these types of risks. Of course, if it is possible to make a stream of payments to the project, these risks need not be quantified in advance.

Complications in benefits assessment

A necessary starting point is to establish an appropriate baseline against which changes can be measured. Carbon inventories will need to be carried out early in the project cycle. A significant portion of the carbon stored in forests is to be found in the soil or in roots, and must be accounted for. The project's long-term storage depends upon how many trees are harvested, how much of the tree is harvested, and how efficiently the wood is processed. If trees or parts of trees that cannot be marketed are left to decay in the forest, they will release carbon dioxide back into the atmosphere as they decompose.

Other non-monetary local benefits like the prevention of soil erosion, increased precipitation, ecotourism, and non-timber forest products are included in the alternative case but not in the baseline. These are bonuses to the national economy and are not valued in the determination of incremental costs.

Even when a project is narrowly defined as a reforestation project, the system boundary cannot be limited to the plantation area alone. While that might suffice for the calculation of incremental cost, it does not help in determining whether the project should be undertaken. If a project has significant social and environmental consequences, they become relevant factors for consideration. In alternative outcome B, though the net carbon balance is positive, 30 MTC are lost in primary forests. From a greenhouse perspective, the project is desirable because the baseline situation results in a net loss of carbon, but those 30 MTC may represent

Table 3.3 Net changes in carbon sequestration over project life

	Land use					
	Primary forest	*Logged forest*	*Agricultural land*	*Grazing land*	*Degraded land*	*Total carbon sequestered (million tons)*
Baseline	0	-10	0	0	0	-10
Outcome A	0	-5	+20	+10	+5	+30
Outcome B	-30	+5	+20	+10	+5	+10

Table 3.4 Incremental costs of a reforestation project with two different outcomes

	Total costs (million $)	*Domestic benefits: hardwood (million tons carbon)*	*Global benefits (million tons carbon)*	
			Outcome A	*Outcome B*
Baseline (business-as-usual)	1	5	-10	
Alternative (reforest 10,000 ha)	14	5	+30	+10
Incremental changes	13	0	+40	+20

invaluable biodiversity loss or impinge on the dwindling rights of indigenous peoples, in which case the project ought not to be implemented.

Demand-side management for electricity

Let us assume that a utility has been asked by its government to extend the provision of lighting services by providing 700 lumens per household to a million new rural customers. Let us also assume that the utility is faced with a financial constraint in implementing its capacity expansion plans. In view of studies that show that investments in compact fluorescent lamps (CFLs) are cheaper by more than an order of magnitude than power plants to energize incandescent lamps, and compelled to consider least-cost planning, the utility decides to explore demand-side management (DSM) options in supply. Although CFLs are twenty times more expensive than incandescent lamps, they last ten times longer and consume only 20 to 25 percent as much electricity to produce comparable lighting levels. The utility would like to explore the possibility of applying for incremental financing to purchase a million CFLs, since a substantial reduction in GHGs is likely to result from their use.

Decision-making framework

Whenever the cost of conservation is less than the cost of the displaced electricity supplies, society is better off by investing in conservation than in supplying the equivalent amount of electricity (Joskow and Marron 1993). Typically, many promising DSM interventions will be available to a utility along with several supply options. The framework for evaluating them is provided by the least-cost planning methodology. Let us assume that the provision for more efficient lighting services finds a place in the least-cost plan. Then the utility must choose amongst the alternatives available, for example, between CFLs and lineal fluorescent lamps. The utility must also determine whether it wants to offer a one-time initial subsidy to consumers for the purchase of more efficient lamps, or institute a leasing program in which the monthly payments charged to consumers are less than the savings in the consumers' electricity bills.

The average cost of supplying an additional kilowatt-hour (kWh) of electricity is the long-run marginal cost of supplying electricity in any given area, and will vary for base-load and peak-load power, perhaps between $0.05 to $0.07 per kWh.

Baseline situation

In this example, it does not matter whether the electricity in the baseline case is provided by an extension of the grid or a stand-alone facility. Let us assume that the electricity is generated by oil-based generators. In a business-as-usual scenario, the utility would install sockets for 60 Watt (W) incandescent bulbs in each of the million households and increase the generating capacity by the new load (60 megawatt (MW), assuming for simplicity that lighting is the only load).

Alternative project intervention

Assume that the alternative project aims to introduce, instead of incandescent, 1 million CFLs in the area. The CFLs will be leased to customers at monthly charges that are less than their savings due to reduced consumption. Since the CFLs consume

16 W of electricity instead of 60 W, an installed capacity of 16 MW will now be required instead of 60 MW.

Cost calculation

As in the other examples, the figures used below are approximations and have been selected merely to illustrate the different situations that could arise in the calculation of incremental costs.

In the baseline case, the utility will arrange for an oil-fired generating capacity of 60 MW and provide connections to an additional 1 million rural customers. We assume that the net present value of total capital and operating costs for this option is $95 million. This would result in the emissions of say 80 million tons of CO_2-equivalent over seven years, which is the average lifetime of CFLs being used at an average of four hours per day. The relatively inexpensive incandescent bulbs are purchased by the customers. Since the technologies are well known, the utility does not incur any additional program costs (see table 3.5).

In the alternative situation, the utility must provide for a generating capacity of 16 MW instead of 60 MW. It must also purchase a million CFLs at approximately $10 per lamp. With program costs of $5 million, let us assume that the net present value of this option is $30 million. This cost includes the capital costs and the cost of fuel for the 16 MW generating capacity. This option results in emissions of say 20 million tons of CO_2-equivalent.

Although this project leads to a substantial reduction of carbon dioxide emissions (60 million tons in this example), it does not incur any incremental costs. These costs are in fact negative because of the avoided costs of installing new capacity, and the need for less fuel for what is now a smaller capacity. Even if program costs are here underestimated and in reality proved to be higher, the total expenses of the alternative would need to exceed $95 million before incremental costs could be positive.

Complications in cost calculation

Most energy-efficiency and DSM options in current energy literature are either negative cost or low-cost options; few expensive options have been considered. Because there are so many DSM options with unrealized technical potential that are cheaper than the cost of providing new supply, analysts have not focused on more expensive options that could involve positive incremental costs. It is easy to think of examples where incremental costs could be positive, such as the installation of triple-glazed windows filled with rare gases for houses that do not require much space conditioning. But this runs counter to the very essence of the philosophy of least-cost planning. It would therefore be difficult to justify funding DSM projects under a policy of strict adherence to existing incremental cost principle.

Demand-side management program costs should include costs for overheads, program monitoring, evaluation, marketing, administration, and so on. These costs are significant, averaging 30 percent of direct equipment and installation costs in the United States (Joskow and Marron 1993). However,

Table 3.5 Demand-side management for electricity

	Costs (million \$) *(Lamps+program+power supply)*	*National benefits* *(million lumens)*	*Global benefits* *(million tons CO_2-equivalent)*
Baseline (incandescent)	0 + 0 + 95	700	- 80
Alternative (CFLs)	10 + 5 + 20	900	- 20
Incremental	- 65	+ 200	+ 60

these costs are often underestimated by proponents of DSM projects. Some so-called negative cost projects may in fact be positive cost projects when realistic assumptions of program costs are made.

Similarly, arguments can be marshalled in support of including costs for stabilizing the line voltage that would make a CFL project more likely to succeed. As explained above, it does not suffice to show that costs are positive for a project to become eligible for incremental cost financing—total project costs must be more than those of the baseline project.

Since many DSM and energy-efficiency projects are extremely desirable from a global perspective and do require initial financing, the financial mechanism of the FCCC should be given the authority to make concessionary loans available in certain cases where incremental costs are negative.

Complications in benefits assessment

A 16 W CFL provides about 900 lumens of light compared to 700 lumens from the 60 W incandescent bulb it replaces. This extra benefit is entirely local but would usually be considered a bonus rather than an additional benefit that the country should finance from its own resources. We assume that the lighting service (amount and quality of illumination) provided by the two lamps is equivalent.

Fluctuations in line voltage are common in developing countries and can reduce the expected lifetimes of both the CFL and the incandescent. Both lamps have to incorporate technological fixes to operate in different project environments, and assumptions about operating efficiencies and lifetimes are not strictly transferable from developed country settings. This can affect the calculation of both costs and benefits.

If the electricity were to be generated at a centralized plant and supplied to the project area by grid extension, global benefits larger than those estimated for a decentralized plant would be obtained because of substantial losses in transmission and distribution.

Rice cultivation

A significant fraction of global anthropogenic emissions of methane is caused by the cultivation of rice in flooded fields. The most likely estimate for this fraction is one-sixth, although it could be as small as one-tenth or as large as one-third (Houghton, Callander and Varney 1992). The flooding creates anaerobic conditions in soils that in turn enable methanogenic bacteria to decompose organic matter and produce methane. Aerobic methanotrophic bacteria oxidize a large part of this methane before it reaches the soil-water surface. Some of the methane produced is leached away, being dissolved in the percolating water. The remaining methane is emitted to the atmosphere either through the plant or through diffusion and ebullition.

Scientists have identified some of the factors that affect methane emissions from rice cultivation: tillage practices, rice species, seeding and transplanting practices, soil type and temperature, the irrigation water regime, the type and method of application of fertilizer, and the pattern and number of croppings in a year. Current information is insufficient to determine the relative importance of these factors in influencing emissions. All other things being equal, the emissions of methane are higher in fields with warmer soil temperatures than in those with lower temperatures, in continuously flooded fields than in intermittently flooded fields, and with certain types of organic fertilizers than with chemical fertilizers (Khalil 1993). Years of careful and painstaking research will be required before we can be certain that our interventions in rice agriculture will be beneficial for the global environment.

Decision-making framework

For any set of interventions in rice agriculture to become widely acceptable, it must satisfy the following four conditions (Khalil 1993):

- The productivity or yield must not decrease
- The farmer should derive some additional benefit, such as the improved utilization of water or labor
- The rice variety should have attributes considered desirable by consumers
- Net GHG emissions must not increase.

Among the factors affecting methane emissions listed above, the ones that offer the earliest and most obvious opportunities for mitigation are the choices of a cultivar, water regime and fertilizer.

Cultivar selection
About 120,000 varieties of rice exist (Khalil 1993). It should therefore be possible to choose those that have lower emissions and satisfy the constraints listed above.

Water regime
Methane emissions are influenced by the inundation periods and drainage schedules used during cultivation (USEPA 1993). Experiments have shown that intermittent flooding can reduce methane emissions over the growing season (Khalil 1993). Thus flatland and lowland irrigated areas with secure and controllable water supplies might profit from shifting to a regime that more closely resembles natural conditions in rain-fed areas. But to avoid a decline in productivity, the soil moisture must be maintained at fairly high levels during the critical stages when the plant is most susceptible to drought (USEPA 1993), for example, during tillering, flowering, or during the second half of the vegetative state. Another concern is that intermittent flooding can increase nitrous oxide emissions while reducing methane emissions (Tirpak and Ahuja 1992). Only careful research over time will demonstrate whether such flooding leads to an increase or decrease in net emissions on a CO_2-equivalent basis. Similarly, changes in soil chemistry during different water regimes must be evaluated before changes are recommended.

Fertilizer application
The manipulation of the timing, mode, and location of application of fertilizer offers the third avenue for reducing methane emissions in rice cultivation. Fields using nitrogenous fertilizers or composted or digested/fermented fertilizers have lower emissions than fields that are either unfertilized or fertilized with raw organic matter, such as rice straw. The reduction in emissions with nitrogenous fertilizers is more pronounced when fertilizers are incorporated more deeply in the soil. Addition of nitrification inhibitors, such as encapsulated calcium carbide, seems to reduce emissions further. There is some concern that the increased use of nitrogen-based fertilizers may increase nitrous oxide emissions. Any recommendation to replace the use of organic matter with mineral or chemical fertilizers must be based on careful research, given that traditional systems have shown sustained productivity for thousands of years.

Baseline situation
Drawing the project boundaries in this example is simpler than in the cases of energy- or forestry-related projects. We assume that there is a flat, low-lying area in a developing country that grows a high-yielding modern variety of rice. Assume that the area cropped annually is 1 million hectares (thus a 1-hectare field cropped thrice a year counts as 3 hectares) and the average productivity is 3 metric tons per year. The annual rice production is therefore 3 million metric tons.

Let us also assume that in the baseline (which could describe either the current situation or the situation at the time that we are ready with cost-effective interventions), 1 million hectares of rice fields emit 20 million tons of CO_2-equivalent emissions per year of methane and nitrous oxide. Since modern agriculture comes as a package deal, the choice of a cultivar has predetermined requirements for water and fertilizer application rates.

Alternative project intervention
The farmers will be asked to grow a cultivar that has the potential to reduce net GHG emissions instead of their usual varieties of rice. The regimes for the application of water and fertilizers will be specified. It can reasonably be expected that larger amounts of water and fertilizer will be required. We assume initially that the productivity remains constant at 3 metric tons per hectare. (Cases where this assumption does not hold are discussed briefly later.) Assume that net emissions are reduced by 20 percent to 16 million tons of CO_2-equivalent per year.

Cost calculation
Costs are incurred for several inputs during rice production. The first category is the use of human and animal labor for various activities ranging from land preparation, raising, pulling, transplanting, fertilizing, irrigating, weeding and spraying, to

Table 3.6 Costs and benefits of alternative rice cultivation

	Total costs (million $) Seeds + water + fertilizer + extension + other	*Domestic benefits (million tons of rice)*	*Global benefits (million tons CO_2-equivalent)*
Baseline	100 + other	3	-20
Alternative	130 + other	3	-16
Incremental	+30	0	+4

finally harvesting, threshing, winnowing and hauling (Barker, Herdt and Rose 1985). There are also the costs of seeds, fertilizer, insecticides, herbicides, water and the energy required to pump it.

In this example, the only costs that we assume to be different between the baseline and the alternative are the costs for seeds, water, fertilizer and extension activities. For each of these, the costs can be expected to be higher in the alternative than in the baseline. All other costs identified above, and other post-harvest costs such as milling and transportation, are assumed to be the same for the baseline and the alternative. In the latter, the cost of pumping is included in the cost of water, and the extra cost of deeper application of fertilizer is included in the cost of fertilizer.

Among the inputs required for modern rice agriculture, fertilizer costs are highest, and can easily exceed 50 percent of total costs. Water costs are usually significantly smaller, followed by seed costs which are approximately 2 percent, followed by extension costs. We assume that the costs for four categories of inputs—seeds, water, fertilizer and extension services—incurred by the farmers (and the government, which incurs the costs for extension) are $100 million in the baseline and $130 million in the alternative. (The numbers are chosen for illustrative purposes only.) The incremental costs in this example then amount to $30 million. The calculation is summarized in table 3.6.

Complications in cost calculation

As in the other cases, several complications can arise. If the farms are small, with an average size on the order of a hectare, a million farmers will need to be compensated. The costs of administering such a large program will also form a legitimate part of incremental costs. The large number of units involved will increase the potential for error. Whereas the costs between the alternative and the baseline are chosen to be significantly different, in actuality the increment may only be a small difference between two large numbers. Finally, if the new cultivars are developed and tested within the country itself, some costs of research and development of the new cultivar will also be associated with the alternative intervention and thus become a part of the incremental costs.

Complications in benefits assessment

We have assumed in this example that the yield in the alternative is the same as that in the baseline case. It is just as likely that the yield might increase. Thus the same area might yield 4 million tons of rice per year instead of 3 million tons. Asking 25 percent of the farmers in the project area to shift to another crop to maintain the same yield is clearly infeasible. The market value of the additional million tons of rice could swamp the value of the incremental costs. As mentioned in chapter 2, it is then a matter of policy to determine how the incremental costs should be divided between the country and the financial mechanism.

On the other hand, it is also possible that productivity might decrease. In principle, it is conceivable that if the global benefits are cost-effective, the farmers could be compensated for both the incremental costs and the loss of yield. In practice, it would be very difficult to "sell" to a developing country an alternative project that would protect the global environment but reduce its food security. So the first condition mentioned on page 19 is likely to prove a binding constraint.

4 Summary

This paper demonstrates an initial application of incremental cost principles to five diverse projects designed to reduce the risk of climate change. A taxonomy of climate change mitigation projects is also presented, but the non-energy sectors are insufficiently developed and require further study.

The incremental cost of any alternative action is measured against a baseline representing the situation that would otherwise exist. It is therefore a reference value which indicates the additional burden that a country would bear if it were to obtain the services provided by the original activity (the baseline) in another way, for example, by taking into account global environmental concerns. This reference value is usually equal to the grant provided to the country, but the Conferences of the Parties to the conventions on climate change and biodiversity could, in some cases, be guided by policy considerations other than strict incremental cost financing to determine the financial incentive required to make a country implement the alternative in preference to the baseline.

In addition to estimating incremental costs, an application of the framework presented in this paper can help to define areas where technical studies or negotiations may be needed to improve estimates or resolve uncertainties, and to sharpen the debate about existing trends (baseline situations) and potential shifts in strategy as represented by alternative interventions.

The examples chosen in this paper highlight the following aspects of the application of incremental cost principles to climate change mitigation projects:

- National priorities are not subverted by an alternative project and there is no inherent conflict between the baseline project and the intervention. The intervention merely adopts an alternative, possibly more expensive, route to achieving the same domestic benefits in order to reduce potential damage to the global environment.
- Costs incurred in the baseline but avoided in the alternative form a legitimate part of the calculation and cannot be classified as "incidental" domestic benefits.
- Incremental costs need not be small, as suggested by the term. Their magnitude depends on the alternative proposal, and can sometimes be several times the cost of the baseline project.
- Incremental costs may be incurred even when the proposed alternative is economic as a whole. Even though the costs of an alternative are less than the domestic benefits that it provides, incremental costs will result whenever these costs exceed those in the baseline.
- Incremental costs are specific to each application and cannot be assigned generically to project types. The need for a case-by-case approach is inevitable because of the many ways in which baselines and system boundaries can be drawn, and because many local factors influence cost estimation.

This paper confines itself to the application of the incremental cost framework to projects. A clear need remains, however, to demonstrate the framework's application at the program, sectoral and country levels.

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*UNDP Field Offices**

P.O. Box 5
Kabul Afghanistan

Deshmoret 54
Shkurdit Street
Villa No. 35
Tirana, Albania

Boite postale 823
Alger Gare,
Algiers 16000,
Algeria

Caixa Postal 910
Luanda, People's
Republic of Angola

Casilla de Correo
2257
1000 Capital
Federal
Buenos Aires,
Argentina

United Nations
Unified Interim
Office
Hrazdan Hotel
2nd floor
Pionerskaia St. 2
Yerevan, Armenia

United Nations
Interim Office
3 Istiglaliyat Street
Baku 1, Azerbaijan

P. O. Box 26814
Manama, Bahrain

G.P.O. Box 224
Dhaka 1000
People's Republic
of Bangladesh

P.O. Box 625 C
Bridgetown,
Barbados

G.P.O Box 103
220000 Minsk
Belarus

Boite postale 506
Cotonou, Republic
of Benin

B P. 575
Ouagadougou 01
Ouagadougou,
Burkina Faso

G. P. O. Box 162
Thimphu, Bhutan

Casilla 9072
La Paz, Bolivia

P.O. Box 54
Gaborone,
Botswana

Caixa Postal 0285
70359-970 Brasilia,
DF
Brazil

P.O. Box 8
1184 Sofia
Bulgaria

Boite postale 1490
Bujumbura,
Burundi

Boite Postale 872
Bangui, Central
African Republic

P.O. Box 877
Phnom Penh
Cambodia

Boite postale 836
Yaounde, Republic
of Cameroon

P.O. Box 2077
Douala
Cameroon

Caixa Postal 62
Praia, Republica de
Cabo Verde

Boite postale 906
N'Djamena
Republique du
Tchad

Casilla 197-D
Santiago, Chile

2 Dongqijie
Sanlitun
Beijing, People's
Republic of China

Apartado Aereo,
No. 091369
Bogota, Colombia

Boite postale 648
Moroni, Federal
Islamic Republic
of Comoros

Boite postale 465
Brazzaville,
People's Republic
of
the Congo

Apartado Postal
4540
San Jose, Costa
Rica

01 Boite postale
1747
Abidjan 01,
Republique de Cote
d'Ivoire

UNDP Cuba
1 United Nations
Plaza
New York, N.Y.
10017, U.S.A.

P. O. Box 5605
Nicosia, Cyprus

P.O. Box 2530
DK-2100
Copenhagen
Denmark

Boite postale 2001
Djibouti,
République de
Djibouti

Apartado 1424
Santo Domingo,
DominicanRepublic

P.O. Box 27
Pyongyang,
Democratic
People's
Republic of Korea

P. O. Box
1703-4731
Quito, Ecuador

P. O. Box 982
Postal Code No.
11511
Cairo, Arab
Republic of Egypt

P. O. Box 1114
San Salvador, El
Salvador

P.O. Box 5366
Asmara
Eritrea

UNDP Malabo,
Equatorial Guinea
c/o UNDP, P.O.
Box 1608
Grand Central
Station
New York, N.Y.
10163-1608

P.O. Box 446
EE-0090 Tallinn
Estonia

P. O. Box 5580
Addis Ababa,
Ethiopia

Private Mail Bag
Suva, Fiji

Boite postale 2183
Libreville, Gabon

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Uzbekistan

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1889 F Street,
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The GEF Secretariat

1818 H Street, NW
Washington, DC 20433 USA
Telephone: (202) 473 1053
Fax: (202) 522 3240
(202) 522 3245

undp

United Nations Development Programme

GEF/Executive Coordinator
One United Nations Plaza
New York, NY 10017 USA
Telephone: (212) 906 5044
Fax: (212) 906 6998

UNEP

United Nations Environment Programme

GEF Unit/UNEP
PO Box 30552
Nairobi, Kenya
Telephone: (254 2) 621 234
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The World Bank

GEF/Operations Coordination Division
Environment Department
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Fax: (202) 522 3240
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United Nations Development Programme

GEF/Executive Coordinator
One United Nations Plaza
New York, NY 10017 USA
Telephone: (212) 906 5044
Fax: (212) 906 6998

UNEP

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GEF Unit/UNEP
PO Box 30552
Nairobi, Kenya
Telephone: (254 2) 621 234
Fax: (254 2) 520 825

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Environment Department
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