

GLOBAL TRADE FOR LOCAL BENEFIT: FINANCING ENERGY FOR ALL IN COSTA RICA

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First movers often have an advantage. But when it comes to the environment, latecomers sometimes enjoy an advantage as well. To illustrate this counterintuitive proposition, this chapter examines one of Costa Rica's policy goals—clean, sustainable electricity for all its citizens—through the lens of global public goods.¹

The global public goods perspective is logical for people and policymakers in Costa Rica. Like other Central American countries, Costa Rica is acutely aware of the risks that global warming would entail for the region. Many viewed recent experiences with El Niño as serious warning signs. Costa Rica is rich in natural resources, such as forests, that are sought-after commodities around the world. But Costa Rica, again like many other countries, does not want to pursue economic growth and development at the expense of the atmosphere. Thus economic growth and poverty reduction—and with them, electricity for all—must be achieved through a comprehensive strategy that relies on renewable, nonpolluting energy sources.

Climate stability is important for the lives of Costa Ricans and is a major national policy concern—but one with global dimensions. In a way Costa Rica's people and policymakers are fortunate to face the dual challenge of providing electricity for all in an environmentally sound way. The reason is that this challenge provides incentives to engage with other countries both to secure financing and to pursue an approach that is globally sustainable. Costa Rica also benefits from being a latecomer in fossil fuel consumption, because its “lagging” position will allow it to be among the first movers in carbon emissions trading. Carbon trading is not yet a reality, however, because global climate stability and a clean atmosphere are global public goods that follow a summation production process: all actors, public and private, will have to cooperate for these goods to emerge—creating demand for the natural resources and environmental services that Costa Rica has to offer.

THE DUAL CHALLENGE: PROVIDING CLEAN ELECTRICITY FOR ALL IN A GLOBALLY SUSTAINABLE WAY

Poverty and lack of electricity are often closely correlated. Access to energy increases and diversifies poor people's choices and economic opportunities (UNDP 2000; UNDP, UNDESA, and World Energy Council 2000). In Costa Rica, as in many other developing countries, providing electricity to every household is a policy priority. Policymakers usually have a choice of energy sources: traditional fossil fuels (oil, natural gas, coal) or renewable energy sources (biomass, geothermal, hydropower, solar, wind). Fossil fuels produce energy services with air pollutants that can damage the health of local communities and with greenhouse gases that affect global climate stability. Renewable sources produce energy services free of air pollutants and greenhouse gases. The choice between sources must reflect the area being served and depends on natural endowments, access to technology, and economic and political considerations.

Since the 1970s fossil fuels have generated less than 10 percent of Costa Rica's electricity, reflecting a preference for hydropower and a limited endowment of fossil fuels. Hydropower now generates 85 percent of the country's electricity (ECLAC 2001, p. 700).

About 6 percent of Costa Ricans—fewer than 50,000 households—lack access to the electricity grid. Most of these households have limited energy needs and live in isolated, dispersed rural settlements. Extending the grid in these areas is seven times more costly than in urban areas (World Bank 1996). Thus an appropriate solution would be to provide decentralized, clean power systems.

Renewable energy technologies have reached a stage where their application in developing countries is increasingly feasible, at least technically (UNDP, UNDESA, and World Energy Council 2001, pp. 219–72; World Bank 2000). For example, photovoltaic solar power systems, which convert sunlight into electricity, have been adapted for situations of low and varying demand. Moreover, for low and moderate energy loads in areas with good solar exposure—such as most of Costa Rica's rural areas—photovoltaic systems with short-term battery storage might even be cheaper than grid supplies (Anderson 1997).

Hence photovoltaic power seems like a promising energy option for Costa Rica. Moreover, Costa Rica has gained experience with solar energy through various pilot projects. These projects suggest that a 120-kilowatt photovoltaic panel can meet the basic needs of one rural family.² With each unit costing \$1,200, about \$60 million would need to be invested to provide solar electricity to Costa Rica's 50,000 off-grid households.

But how much are these households able and willing to pay for solar power? Surveys have found that off-grid rural residents could afford to pay \$2–16 a month for photovoltaic equipment and installation costs.³ But only 1 in 6 respondents was

willing to pay up to \$14, and just half were willing to pay \$3 (Castro and Cordero 2002; figure 1). Though these findings are only rough indications, they indicate that few off-grid households could afford solar technology that cost \$1,200.

So, what other financing mechanisms are possible? Complementary finance could include subsidizing capital costs nationally, extending credit to potential users, and mobilizing external financial and technical assistance. But Costa Rica has not had much success with indirect subsidies to industries generating power from renewable resources. In addition, rural Costa Ricans have limited access to sources of credit. External assistance is already being used, however, through support that the Global Environment Facility (GEF) provides for the Plantas Eólicas project in Tejona.

The Global Environment Facility was created to help developing countries cover the incremental costs of projects with global environmental benefits—that is, the costs of transforming a project with national benefits into one with global benefits.⁴ This financing enables developing countries to afford the often considerable upfront investment costs involved in switching to more environmentally sound economic activities. But the Global Environment Facility is not appropriate for providing longer-term incentives such as the subsidies that would be required to bring photovoltaic energy to poor Costa Ricans. The facility works on an ad hoc, project-by-project basis with limited, unpredictable resources that depend on voluntary contributions. This is not a sound basis on which to build a long-term energy and electricity policy.

SELLING ENVIRONMENTAL SERVICES AS A CONTRIBUTION TO CLIMATE STABILITY

A more reliable financing option may emerge as a result of growing global concern about climate change. This concern has generated new demand for environmental services, which Costa Rica is well endowed to supply efficiently.

International efforts to curb global warming

For two decades scientists have been alerting the international community to the risk of global warming. The most recent findings of the Intergovernmental Panel on Climate Change confirm that emissions of greenhouse gases generated by human activities “continue to alter the atmosphere in ways that are expected to affect the climate” (IPCC 2001, p. 3). Three-quarters of emissions of carbon dioxide—the main greenhouse gas—are due to the burning of fossil fuels and one-quarter to deforestation (IPCC 2001, p. 4).

In 1992 the international community adopted the United Nations Framework Convention on Climate Change, which urges countries to cut their greenhouse gas emissions. This goal was turned into a binding commitment with the adoption of the Kyoto Protocol in 1997. The protocol requires annex 1 countries

(defined as industrial countries and most transition economies) to cut greenhouse gas emissions by an average of 5.2 percent from their levels in 1990. These targets are to be reached by 2008–12 and sustained through 2012. Developing countries did not have to commit to specific reduction targets under the protocol; annex 1 countries took the lead because they were responsible for most past emissions.

Many annex 1 countries are heavy polluters but also achieve high levels of energy efficiency. Thus for many it will be costly to reduce emissions at home. Many developing countries, including Costa Rica, have lower energy consumption, lower energy efficiency, or both. The Kyoto Protocol provides an incentive to cut greenhouse gas emissions but also offers an advantage to some developing countries, as latecomers in energy consumption. By offering corrective, offsetting arrangements to industrial countries, developing countries can reap financial or development benefits.

The protocol foresees three “flexibility mechanisms” that will allow industrial countries to meet their abatement targets by using the lower emission limitation costs of other countries: joint implementation, international emissions trading, and the Clean Development Mechanism. Under joint implementation an industrial country can receive “emissions reduction units” when it helps finance projects that reduce net emissions in other industrial countries (including transition economies). International emissions trading allows industrial countries to trade their emission allowances with other countries. The Clean Development Mechanism is designed to help non-annex 1 countries achieve sustainable development and contribute to the protocol’s ultimate objective—global climate stability—while helping annex 1 countries achieve their targeted emission reductions. The mechanism enables industrial countries to earn emission credits when they invest in emission reduction projects in developing countries.

To enter into force, the Kyoto Protocol must be ratified by 55 countries, including annex 1 countries representing at least 55 percent of global greenhouse gas emissions in 1990. By May 2002, 84 countries had signed the protocol and 54—including just one annex 1 country—had ratified it. Even though the protocol is not yet effective, mounting global concern about climate stability and the prospect of a treaty have led to many pilot initiatives for trading in carbon emissions. Costa Rica hosts one of them.

Costa Rica’s carbon trading system

As noted, the Kyoto Protocol does not commit developing countries to cutting greenhouse gas emissions. But it does encourage them to limit the growth of their emissions. Such efforts to contain emissions reflect the summation process that drives the provision of the global public good at stake. In other words, every effort to cut greenhouse gas emissions is a step—even if a modest one—toward curbing global warming. Such efforts also reflect the equitable nature of the protocol. That

is, countries have common but differentiated responsibilities for the provision of the global public bad; thus there are not yet binding targets for developing countries.

In this context some developing countries have started to explore the value of their assets and the services they could offer. Three types of services matter for climate change: increasing energy efficiency (by using less fuel to produce the same amount of power), switching to less carbon-intensive fuels (by developing clean energy), and sequestering carbon released in the atmosphere (by promoting forests and controlling land uses and changes). Costa Rica's pilot project was originally aimed at promoting reforestation.

Costa Rica was one of the first developing countries to create a carbon emissions trading program through bilateral contracts selling carbon sequestration services to industrial countries. The development of its emissions credit program has gone through three stages. In the first stage (1994–95) the government tried to facilitate trades between individual domestic landowners and foreign governments or corporations. This phase was intended to compensate farmers and landowners for any income loss resulting from the adoption of land use programs that cut greenhouse gas emissions or logging methods that better preserve the carbon sequestration potential of forest covers. The authorities soon realized that it would be more efficient to consolidate emission reduction initiatives: negotiating one deal for a small reforestation initiative cost almost as much—for translators, lawyers, airline tickets, and the like—as for several consolidated initiatives. The first stage revealed the need to cut transaction costs to make carbon emissions trading viable and profitable.

In the second stage (1995–97) the Ministry of Environment and Energy assumed responsibility for consolidating and selling small projects. This effort resulted in the first-ever sale of an emission credit based on reforestation. A total of 238 reforestation initiatives, many bordering wildlife conservation areas, were consolidated to offer a credit to sequester 200,000 tons of carbon equivalents⁵ over 20 years (the usual timeframe for this type of contract in Costa Rica). This credit was sold to the Norwegian government in 1996 for \$10 a ton. This price reflected expected payments to cattle ranchers to induce them to convert their ranches into plantation forests. Despite the success of the transaction, Costa Rica's inspector general (the head of a government watchdog agency) criticized the ministry for having sold the credit at cost rather than seeking a higher price. Thus the second phase raised the complex issue of how to determine the price of a commodity not yet valued in a proper market.

In the third phase (1997–98) the Ministry of Environment and Energy addressed the inspector general's concerns by auctioning credits. It assembled enough projects to sequester 1 million tons of carbon equivalents over 20 years and offered them at a floor price of \$20 a ton. Although several governments and multinational firms expressed interest, in the end there were no bidders. When

asked why, some bidders privately told the minister that the floor price was too high. In March 1998, to help address bidders' concerns about additionality,⁶ the ministry hired a French technical certification firm to audit the project and attest that reforestation would take place as promised.⁷ Nevertheless, the ministry delayed auctioning the credits again until after national elections scheduled for later that year. Hence the third phase generated another lesson: it highlighted buyers' concerns about sellers' post-sale compliance with pre-sale commitments.

After the elections the new president, Miguel Angel Rodriguez, identified emissions trading as one of the few of his predecessor's programs that he intended to retain. One reason may be that President Rodriguez holds a doctorate in economics, which may have made him sympathetic to the rationale for and potential of such a scheme. In addition, environmental protection has always been popular in Costa Rica, and the president had won partly by appealing to rural voters who stood to benefit from emissions trading.

Thus the pilot project generated several lessons typical of a new market. It pointed to the challenge of defining precisely the commodity being offered, clarifying and allocating property rights, and instituting mechanisms for monitoring and compliance. The next section shows how these issues have been addressed and could be dealt with even more systematically in the future.

CREATING A NEW MARKET FOR ENVIRONMENTAL AND DEVELOPMENT SERVICES

After the pilot emissions trading project, several bilateral agreements were developed for clean energy offsetting arrangements. In April 2001 Costa Rica sold 260,000 tons of carbon emission reductions for \$20.80 a ton; the reductions were made possible by building a wind power plant to reduce the use of fossil fuels. Decentralized photovoltaic systems for poor rural residents could be financed by selling similar emission credits to industrial countries. But would carbon emissions trading be sufficient to finance the provision of electricity for the 6 percent of Costa Ricans who lack it? What rules of the game need to be defined at the local, national, and international levels to create a win-win situation where emissions are cut and poor people have access to electricity over the long run?

How much should carbon emission reductions cost?

In July 1999 the World Bank Prototype Carbon Fund announced that carbon emission reductions should cost \$20–30 a ton. However, there is still a lack of consensus on pricing, which calls for additional research on the valuation of sequestration and other environmental services offered by developing countries.

To fill this gap, Castro (1999) analyzed the implications of different price scenarios for forest conservation and agriculture in Costa Rica. The study confirmed

two things. First, higher carbon prices would encourage landowners to supply more land for sequestration services. Second, Costa Rica could supply these services more efficiently than industrial countries. Thus the study showed that Costa Rica has a comparative advantage in selling carbon sequestration services and that, if there is solvable demand, trading these services internationally would make all countries better off. The study also suggested that carbon emissions trading would benefit biodiversity and fragile ecosystem protection. For example, if emission reductions cost about \$100 a ton of carbon, 25 percent of Costa Rica's national territory could be maintained as a protected area.

If Costa Rican landowners were adequately paid for carbon sequestration, many might switch from planting crops to forests. Forest projects would most likely replace traditional activities such as raising beef cattle and growing rice, which require a lot of land. Forests would be less likely to replace more profitable export crops such as coffee, bananas, and pineapples. Castro (1999) found that if the carbon price were \$83 a ton, a farmer producing—or having the potential to produce—the average agricultural mix for Costa Rica might switch to forest plantations such as pine (*Pinus patula*).

Carbon sequestration payments could also induce landowners to preserve natural forests outside protected areas. For example, preservation is more profitable than raising beef cattle or growing rice if emission reductions cost \$20 a ton of carbon (table 1). But if a landowner had natural forest land suitable for export crops, the carbon price would have to exceed \$100 a ton for preservation to be competitive.

Thus the Castro study suggests a need to reassess Costa Rica's natural endowments through the lens of climate stability—a global public good of growing concern—and against the backdrop of many heavy polluters' interest in emissions trading. Such a reassessment would have to objectively consider all benefits and drawbacks. If forest projects replace subsistence agriculture, there may be a trade-off between food security and environmental services such as climate change mitigation. In this case environmental considerations might interfere with poverty alleviation. The issue of balancing local and global benefits and public and private benefits, discussed by Perrings and Gadgil (in this volume), also applies here.

Sales of emission credits could subsidize poor people's access to photovoltaic systems. If the carbon dioxide emissions avoided by installing 1,900 photovoltaic systems were traded for \$28 a ton of carbon, the revenue could finance about 20 percent (\$3) of the systems' monthly cost (see figure 1).⁸ As in the pilot forest project, these credits could be sold through bilateral arrangements with industrial countries or in an international market for carbon emissions.

Making the carbon market global

Previous sections have shown how creating new markets for environmental services—carbon sequestration and clean energy—could help pay for electricity

TABLE 1

Carbon indifference prices between forest protection and competing agricultural activities in various regions and private natural forests in Costa Rica

(U.S. dollars a ton)

Crop or activity	La Amistad	Rincón de la Vieja	Palo Verde	Piedras Blancas	Barra Honda	Guanacaste	Carara	Barbilla
Coffee	386	219	275	168	228	226	211	227
Pineapples	372	458	522	524	502	469	549	487
Watermelons	309	378	432	431	415	389	455	403
Yams	251	305	350	346	335	314	368	327
Avocados	245	298	342	338	327	307	360	320
Plantains	244	297	341	337	326	306	359	319
Tiquisque ^a	198	240	277	270	263	248	291	258
Passion fruit	189	228	263	256	250	235	276	245
Tomatoes	170	204	236	228	224	211	248	221
Forest plantations	124	35	71	14	51	50	54	62
Bananas	102	118	140	129	130	124	147	131
Palm hearts	98	114	135	124	125	119	142	126
Yucca ^a	91	106	126	114	116	111	132	118
Coconuts	73	82	99	87	91	87	104	93
Dairy cattle	66	74	90	77	81	79	94	84
African palms	63	70	85	72	77	74	89	80
Oranges	63	71	86	74	78	76	90	81

TABLE 1 CONTINUED

Carbon indifference prices between forest protection and competing agricultural activities in various regions and private natural forests in Costa Rica

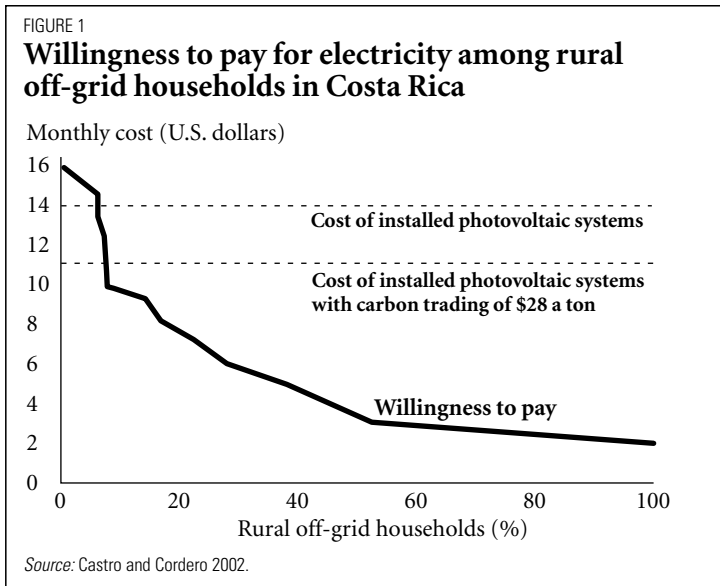
(U.S. dollars a ton)

Crop or activity	La Amistad	Rincón de la Vieja	Palo Verde	Piedras Blancas	Barra Honda	Guanacaste	Carara	Barbilla
Sugar cane	61	68	83	70	75	73	87	78
Beef and dairy cattle	51	55	68	55	61	59	71	64
Lemons	35	35	46	32	39	39	48	44
Beans	27	25	35	20	28	29	36	33
Melons	23	20	30	15	23	24	31	28
Potatoes	22	19	29	14	22	23	30	27
Rice	12	6	14	<0	8	10	14	14
Beef cattle	11	6	13	<0	7	9	13	13
Mangoes	3	<0	1	<0	<0	<0	<0	1
Managed forestry	3	<0	2	<0	<0	<0	1	2

a. Tiquisque and yucca are root crops similar to cassava.

Note: The carbon indifference price is the price at which a producer is indifferent between selling carbon and selling an alternative product being produced using the same land.

Source: Castro 1999.



access for poor, off-grid Costa Ricans. A variety of market-based instruments can be used to achieve this win-win situation. But how can the bilateral arrangements of the emissions trading pilot project be integrated with an international market?

As discussed, the Kyoto Protocol created three flexible, market-based mechanisms to reduce global greenhouse gas emissions. Estimates show that the larger is the global market, the cheaper it is to meet the protocol's objectives and so to pay for carbon emission reductions. If emissions abatement is undertaken domestically only for annex 1 countries, a ton of carbon costs an estimated \$77. If emission reductions can be achieved through joint implementation or a tradable permit market among annex 1 countries, the price falls to \$37 a ton. If developing countries participate in a global permit market, the average price falls to \$30 a ton (Morozova and Stuart 2001, p. 39). These prices are higher than those in the bilateral offsetting arrangements between Costa Rica and industrial countries and higher than the \$28 estimated by Castro (1999) to improve access to solar electricity in rural Costa Rica.

At the same time, the larger is the market, the lower are the costs of providing the final global public good, climate stability. Based on the "G-cubed" model cited by Baron (1999), without emissions trading the costs of abatement under the Kyoto Protocol would be 0.3 percent of GNP in the United States, 0.8 percent in Japan, and 1.4 percent in the other industrial countries that belong to the Organisation for Economic Co-operation and Development (OECD). With trading, emission controls would absorb just 0.2–0.5 percent of GNP in these countries.

But some researchers suspect that these estimates are optimistic, for two reasons (see Baron 1999). First, the models assume that every country would choose the most cost-effective strategy for controlling domestic emissions. But if policy-makers protect politically sensitive industries and regions from adopting even low-cost measures, the costs of abatement without trading might be much higher.

Second, the models assume fully fluid markets for emissions trading with no significant barriers or transaction costs. But in practice, developing countries' lack of commitment to specific emission targets is a cause of concern for annex 1 countries. Annex 1 countries are especially concerned about leakage and slippage. The net benefits of a carbon sequestration project could be reduced if a landowner takes money earmarked for forest conservation and uses it to convert a forest to cropland in another area (leakage) or increases carbon emissions by, for example, buying more vehicles (slippage).

Such outcomes would be a major impediment to carbon emissions trading and at the very least would require some neutral party to ensure that the additionality requirement was met—that is, that the emissions reduction would not have occurred anyway under business as usual. Germany has emerged as the leader of a number of industrial countries opposed to significant emissions trading with developing countries until they commit to emission targets. Germany has argued that without emission commitments, additionality would be hard to determine and easily evaded.

Despite these theoretical concerns and without a clear definition of how the additionality test would be met for the Clean Development Mechanism, some countries and large multinational businesses with high emission control costs are interested in buying credits. For example, British Petroleum recently set up a system to trade emission credits among its plants in industrial and developing countries, and discovered that its marginal costs of abatement were likely to be almost \$70 a ton of carbon. Thus it was interested in buying low-cost credits from other sources as a way to hedge its bets. Moreover, buying credits generated favorable publicity.

Most of the emission trades proposed at the global level are for electricity projects and so are compatible with Costa Rica's desire to develop clean electricity for poor people. There is also growing interest in including reforestation in the Clean Development Mechanism. Reforestation credits are usually offered for a limited period—say, 20 years—with the idea that at the end the forest will be logged and replanted. Some environmental groups oppose reforestation credits because the credits would have to be replaced if the forests were logged. Greenpeace, the international environmental group, has called reforestation credits a “time bomb” that will cause serious problems when they expire. But advocates of reforestation point out that other credits are also for limited periods—for example, a wind turbine can only be expected to last 20 years. Moreover, hopefully in 20 years technological progress will have cut the costs of emissions abatement.

Additional steps toward the global market

International negotiations on climate change proceed slowly. During negotiations between the parties to the United Nations Framework Convention on Climate Change in Bonn, Germany (July 2001) and Marrakech, Morocco (October–November 2001), the United States reaffirmed that it would not ratify the Kyoto Protocol. Nonparticipation in the global emissions trading system by the biggest emitter of greenhouse gases (24 percent of the world total) will have important economic consequences for all parties: it will lower compliance costs and the international price of carbon (to \$25 a ton) and reduce the level of resources flowing through the protocol's flexibility mechanisms (Grubb, Hourcade, and Oberthur 2001).

Still, the Marrakech agreement moved forward on procedures for the Clean Development Mechanism by easing a prompt start of it (with \$6.5 million in financial support in the 2002–03 budget) and by authorizing the mechanism's executive board to approve methodologies for baselines, accredit operational entities, and develop and maintain a registry for the mechanism.⁹ The Marrakech agreement also authorizes unilateral use of the Clean Development Mechanism, meaning that a developing country can undertake a project under the mechanism without an annex 1 country and market the resulting emission credits. In addition, afforestation and reforestation are eligible under the mechanism but cannot be used to control more than 1 percent of the concerned party's base-year emissions.

One of the most important and complex future steps is to scientifically determine the precise amount of carbon saved from a Clean Development Mechanism project. Many models have been used to estimate sequestration and mitigation potential. Early models calculated that at the global level about 500 million hectares were needed (Sedjo and Solomon 1989) or available (Nordhaus 1991) for carbon sequestration. Early models indicated that Latin America and Africa could provide at least half the required land, with low preparation costs and high forest-growing rates. More recent studies—such as a Harvard University study for Central America (Panayotou 2001) and a University of Mexico study (Masera 2000)—have compared carbon and fossil fuel options. The study for Central America calculates 54 millions tons a year in carbon reductions from forests (through conservation, forest management, and reforestation), compared with 6 million tons from fossil fuel emission reductions. The Mexico study calculates that forests accounted for 87 percent of the 40 million tons in carbon reductions available in Mexico in 2000.

Economists agree that carbon sequestration through afforestation and reduced deforestation may be a cost-effective way to cut global atmospheric concentrations of greenhouse gases (Castro and Cordero 1999; Masera 2000; Stavins and Newel 2000). Now that afforestation and reforestation are included in the international regime, it is essential to gather scientific evidence to value the envi-

ronmental services that developing countries can offer in the global market for emissions.

Plan B: reducing carbon emissions and debt

Because of the uncertainties surrounding the Kyoto Protocol, even developing countries such as Costa Rica—that is, pioneers in developing trade arrangements to market carbon credits—are considering alternative resource mobilization options for global emissions trading.

In 1995 the Costa Rican government promoted a mechanism that links debt reduction in developing countries to carbon reduction in industrial countries (*The Washington Times*, 1 August 2001). This “trees for debt” initiative is a variation of what Taylor (2001) calls a “world fund that would be financed with debt claims of the developed country parties upon developing country parties of the Kyoto Protocol.” These claims would be used to generate instruments that would be sold to carbon-producing companies in industrial countries as part of their carbon reduction programs (Costa Rican Office of Joint Implementation 1997). Taylor (2001) adds, “The depositing country would participate in the proceeds of the sales to rescue part of the debt value and cancel the liabilities of the debtor countries. In exchange for the debt cancellations, the developing and debtor country parties, by entering into agreements with the fund, would commit domestic resources equivalent or proportional to the annual service alleviation, toward the development of national carbon fixation programs in their territories.”

The “trees for debt” proposal, however, follows a different rationale than emissions trading. It looks at developing countries as aid recipients rather than as equal partners in a global bargain. The financial agreement proposed between the debtor and the developing country is based on poverty considerations. Creating adequate rules of the game for developing countries in new markets, in contrast, is based on recognizing the services that these countries offer to the international community—that is, their contribution to global welfare. This should be the criterion guiding their participation in the global production of a stable climate.

CONCLUSION

This case study has explored how developing countries’ scarcity of resources can sometimes be exchanged for richer actors’ scarcity of greenhouse gas emission rights. Local initiatives to enhance development by providing electricity or paying local farmers to protect forests can also contribute to the provision of global public goods such as climate stability. Indeed, over the long term combining the two objectives is probably the most efficient self-sustaining strategy.

Creating a market for carbon emissions trading will not be easy. It took 10 years to create another new market, the sulfur emissions market in the United States, just at the national level. But the challenge will be worthwhile.

At the same time, developing countries must be fully engaged in international negotiations on climate change. After 2012 these countries are expected to have differentiated binding commitments to cut their greenhouse gas emissions. As Blanchard and others (in this volume) stress, the rules of the game for the next stage should combine efficiency and equity. Whether and to what extent they do so depends, in no small measure, on developing countries' involvement in the debate.

NOTES

1. This chapter is based on Castro and Cordero (2002), which provides a more detailed examination of the issues raised here.

2. Each day this system supplies four hours of lighting (with two high-efficiency 15-watt bulbs), three hours of a 10-watt radio, and one hour of an 80-watt black and white television (World Bank 2000, p. 87). It produces an average of 0.35 kilowatt-hour a day, or 10.5 kilowatt-hours a month (with 3.5 hours of effective daily use).

3. The surveys were conducted between November 2000 and February 2001 by CID Gallup, a Costa Rican company that conducts public opinion surveys and market research. The surveyors interviewed a stratified random sample of 405 off-grid residents, with a standard error of ± 4.8 percent.

4. See http://www.gefweb.org/Operational_Policies/Eligibility_Criteria/Incremental_Costs/incremental_costs.html.

5. Tons of carbon equivalent are the present value of the annual flows of carbon dioxide.

6. Here additionality means that the emission reductions would not have occurred under business as usual—that is, the emission reductions produced by the project are additional to any that would have occurred in its absence.

7. The firm, Société Générale de Surveillance Group, had established a forestry offset carbon verification service.

8. The Costa Rican commission in charge of rural electrification estimates that 1,900 of the 50,000 off-grid households can be efficiently supplied solely by photovoltaic systems.

9. For an advance, unedited version of the Marrakech accords and declaration, see http://unfccc.org/cop7/documents/accords_draft.pdf.

REFERENCES

- Anderson, Dennis. 1997. "Renewable Energy Technology and Policy for Development." *Annual Review of Energy and the Environment* 22: 187–215.
- Baron, Richard. 1999. "The Kyoto Mechanisms: How Much Flexibility Do They Provide?" In Richard Baron, Maratina Bosi, and Alessandro Lanza, eds., *Emis-*

- sions Trading and the Clean Development Mechanism: Resource Transfers, Project Costs and Investment Incentives.* Bonn: International Energy Agency.
- Bartels, Carlton. 2001. "Carlton Bartels of CO2e.com Answers Questions Regarding the Greenhouse Gas (GHG) Emissions Trading Market Place." *FOW Derivatives Intelligence for the Risk Professional* 365: 42–43.
- Castro, René S. 1999. "Valuing the Environmental Service of Permanent Forest Stands to the Global Climate: The Case of Costa Rica." Ph.D. diss. Harvard University, Cambridge, Mass.
- Castro, René S., and Sarah Cordero. 2002. "The Supply of Clean Energy to the Rural Poor in Central America as a Response to Global Climate Change." ODS Working Paper 11. United Nations Development Programme, Office of Development Studies, New York.
- Castro, René S., Sarah Cordero, and Jose A. Gómez-Ibañez. 2000. "Potential Impact of the Emerging CO2 Market: Building on the Costa Rican Experience." In Luis Gómez-Echeverri, ed., *Climate Change and Development*. United Nations Development Programme, Regional Bureau for Latin America and the Caribbean, and Yale School of Forestry and Environmental Studies. New Haven, Conn.: Yale School of Forestry and Environmental Studies.
- Costa Rican Office of Joint Implementation. 1997. "Costa Rican Certifiable, Tradable Greenhouse Gas Offset." Ministry of Energy, San Jose.
- ECLAC (Economic Commission for Latin America and the Caribbean). 2001. *Statistical Yearbook for Latin America and the Caribbean 2000*. New York: United Nations Publications.
- Field, Martha A., and William W. Fisher III. 2001. *Legal Reforms in Central America: Dispute Resolution and Property Systems*. Cambridge, Mass.: Harvard University Press.
- Grubb, Michael, Jean-Charles Hourcade, and Sebastian Oberthür. 2001. *Keeping Kyoto*. London: Climate Strategies.
- IPCC (Intergovernmental Panel on Climate Change). 2001. *Summary for Policy Makers: A Report of Working Group I*. [<http://www.ipcc.ch/pub/spm22-01.pdf>]
- Larraín B., Felipe . *Economic Development in Central America*. 2 vols. Cambridge, Mass.. Harvard University Press.
- Masera, Omar. 2000. "Promotion of Reduction Strategies for Greenhouse Gas Emissions in Latin America: The Mexican Experience." Presented at the annual meeting of the board of governors of the Inter-American Development Bank, Tulane University, March, New Orleans, La.
- Morozova, Svetlana, and Marc Stuart. 2001. "The Size of the Carbon Market Study." In *United Nations Conference on Trade and Development, Greenhouse Gas Market Perspectives: Trade and Investment Implications of the Climate Change Regime*. New York and Geneva: UNCTAD.

- Nordhaus, William. 1991. "The Cost of Slowing Climate Change: A Survey." *Energy Journal* 12 (1): 37–65.
- Panayotou, Theodore, ed. 2001. *Environment for Growth in Latin America: Environmental Management for Sustainability and Competitiveness*. Cambridge, Mass.: Harvard University Press.
- Sedjo, Roger A., and Allen M. Solomon. 1989. "Climate and Forests." In Norman J. Rosenberg, William E. Easterling, Pierre Crosson, and Joel Darmstadter, eds., *Greenhouse Warming: Abatement and Adaptation*. Washington, D.C.: Resources for the Future.
- Stavins, Robert N. 1999. "The Costs of Carbon Sequestration: A Revealed Preference Approach." *American Economic Review* 89 (4): 994–1009.
- Stavins, Robert N., and Richard Newell. 2000. "Climate Change and Forest Sinks: Factors Affecting the Costs of Carbon Sequestration." *Journal of Environmental Economics and Management* 40 (3): 211–35.
- Taylor-Dormond, Marvin. 2001. Personal communication. Controller of the Central American Bank for Economic Integration. 24 August.
- UNDP (United Nations Development Programme). 2000. *Human Development Report 2000*. New York: Oxford University Press.
- UNDP, UNDESA (United Nations Department of Economic and Social Affairs), and World Energy Council. 2000. *World Energy Assessment*. New York: United Nations Development Programme.
- World Bank. 1996. *Rural Energy and Development: Improving Energy Supplies for Two Billion People*. Washington, D.C.
- . 2000. *Energy Services for the World's Poor*. Washington, D.C.