



Chapter 7

How do we deal with leakage?

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7.1 Introduction

Imagine you live on a mountain lakeside. Recently, glacier melting from global warming has repeatedly caused severe flooding of your lands. You therefore decide to build a dike to protect the lowest-lying, most flood-prone lands. But since the lake is small, doing so will further raise the lake's water level and lead to flooding of previously unaffected areas. If your overall objective was to protect lakeside land from flooding, the projected gains from the dike project need 'leakage' deduction, i.e. quantification of losses from shifting some flooding pressures elsewhere in space.

In principle, carbon leakage is a similar off-site effect. While the 37 developed countries in Kyoto Protocol's Annex I countries have agreed to cap their industrial emissions, increasing imports from non Annex I countries may cause emission 'leaks'. Greenhouse gas (GHG) net emission reductions in one area are affected by project-attributable emissions outside of targeted mitigation areas. Leakage can occur whenever the spatial scale of intervention is inferior to the full scale of the targeted problem. Carbon mitigation is a global goal, so leakage can occur at various scales—farm-level, local/regional,

national, or international/global - and in many sectors, including energy and forestry mitigation projects. Carbon leakage is fundamentally an economic process, although other anthropic and biophysical processes may interfere. Unlike in the dike example of exclusively ‘crowding out’ pressures, mitigation leakage may sometimes work in the opposite direction as well, i.e. a mitigation activity may be ‘crowding in’ further emission reductions from areas outside the defined mitigation area (called ‘reversed leakage’).

Taking a reducing emissions from deforestation and degradation (REDD) example, a farm-level payment for environmental services (PES) programme may reward the landowner for not deforesting the PES-enrolled forest plot A during five years. However, if the owner shifted all planned deforestation from plot A to another, non PES-enrolled plot B, mitigation would be entirely offset by leakage or ‘displacement of emissions’, as the phenomenon is called in the Bali Action Plan (Thirteenth Session of the Conference of the Parties - COP 13). If the landowner further used all PES funds to buy chainsaws to enable additional clearing and cattle to graze on the land, medium-run leakage may well exceed 100 percent of mitigation - implying leakage also has a time dimension, depending on how quickly economic and biophysical processes work. Conversely, if the landowner invested the money in ecotourism or agroforestry and stopped all clearing, leakage would be reversed, crowding in off-site mitigation gains beyond target plot A.

7.2 Dimensions of leakage

7.2.1 Leakage channels

Some analysts distinguish between primary (‘activity-shifting’) leakage caused by REDD stakeholders and secondary (‘market’ or ‘partial/general equilibrium’) leakage from third actors, e.g. in response to price changes (Aukland *et al.* 2003). Table 7.1 outlines broad differences in expected leakage across three mitigation project types. For REDD activities (last two columns), conservation set-asides are distinguished from sustainable forest management (SFM) projects.

Shifts in demand for land, whether through competitive land markets or other spatial substitution mechanisms, are the dominating leakage force for REDD (both conservation and SFM): since deforestation is primarily caused by land conversion to agriculture, closing the agricultural frontier will create land shortages, unless technologies allow for intensification, e.g. shortening fallows or intensifying pastures. Induced land shortages are more pronounced for REDD than for afforestation and reforestation (A/R), which is often carried out on degraded lands with low economic value.

Table 7.1. Likely leakage impacts of forestry mitigation actions and transmission forces

<i>Project types</i>	Afforestation and Reforestation	REDD – Set-aside Conservation	REDD – Sustainable Forest Management
<i>Leakage channels</i>			
<i>A. Land markets</i>	Substituting crops/livestock through plantations	Curbing planned agricultural land conversion	Curbing planned agricultural land conversion
<i>B. Labour markets</i>	Labour-using initially; variable later	Less employment may cause out-migration	Labour-saving, or Labour-using shift?
<i>C. Capital markets</i>	Returns may attract capital	Crowding out effects from lower returns	Impact on returns disputed
<i>D. Technological innovation</i>	Variable	None (unless combined with ecotourism, non-timber forest products)	Reduced impact logging, etc.
<i>E. Output markets</i>	Planted forest products (medium run) reduce extraction pressures	No agricultural or timber supply from set-asides	Less timber (short to medium run)
<i>F. Income generation</i>	Variable	Variable	Variable
<i>G. Ecological conditions</i>	Plantations increase or decrease ecological integrity (pests, wind, biodiversity, etc.)	Increase in landscape integrity and adaptation, avoided 'edge effects'	Increase in landscape integrity and adaptation, avoided 'edge effects'

Note: Light grey cells indicate leakage (extra-site decrease in net mitigation effect), dark grey cells indicate reversed leakage (extra-site increase in net mitigation effect), and plain cells indicate ambiguous/context-dependent impacts.

REDD conservation tends to be less labour-intensive per hectare than most converted land uses, which may lead to out-migration and possibly relocated GHG pressures; for A/R and SFM projects, employment impacts are time and context-specific. Capital markets are among the most fungible forces: like in the dike example where water flows smoothly into the remotest corners, financial capital normally flows smoothly towards high-return options. Capital may thus respond to all mitigation-induced constraints that lower returns by financing higher-return options elsewhere. SFM and A/R may sometimes offer attractive investment opportunities, thus 'crowding in' capital and causing reversed leakage.

Technological innovations in SFM (e.g. reduced-impact logging) may reduce forest degradation in neighbouring areas, but technological spread is usually negligible for conservation and A/R. For output markets, A/R will increase future timber supply (though likely reduce crop and livestock output).

In contrast, REDD conservation will reduce both (short-run) timber and agricultural supplies, raise commodity prices, and thus possibly stimulate production elsewhere. Note that reduced deforestation may induce higher forest degradation elsewhere through timber markets. SFM also curbs crop and livestock expansion, but sustains timber supply over time.

Income effects, backwards and forwards production linkages, and other changed development trajectories from mitigation projects are complex and difficult to determine *a priori*. But they can greatly influence leakage, and should thus be on the checklist. Finally, REDD may help keep landscapes ecologically healthy, including being more adaptable to climate change, avoiding ‘edge effects’ of forest degradation, and consequently reducing offsite GHG emissions. This reversed leakage under REDD is likely to be more important than for A/R projects, which are dominated by monocultures.

7.2.2 Size and importance

Table 7.1 indicated that leakage forces (shaded cells) could potentially be more significant for REDD than for A/R, principally because REDD unambiguously tends to curb local land-based development. SFM probably causes less leakage pressures than set-aside conservation, but its disappointing adoption tropics-wide indicates that it is also harder to implement. Does REDD generally leak more than energy and A/R projects? Energy-project leakage had in the Intergovernmental Panel on Climate Change (IPCC) 2nd Assessment Report been estimated at a wide 0-70% range, but was later reduced to 5-20%. There is little reason to believe that A/R projects should have higher leakage (Chomitz 2000). Recent case studies confirm this view, e.g. slight reversed leakage found in the 10-year-old Scolel Té community tree-planting project in Chiapas, Mexico (de Jong *et al.* 2007). Sathaye and Andrasko (2007: 966) conclude that ‘[a]voided deforestation has a much wider range of leakage in analyses up to date (0-92%), and appears to increase as the region of analyses is expanded’. Wu (2000) finds leakage effects in the U.S. Conservation Reserve Program’s land-retirement programme around 20%. Only one REDD project in the tropics has been analysed thoroughly: the Noel Kempff project in Bolivia (Box 7.1). The difficulties of setting REDD baselines, with two orders of magnitude of variation between three alternative model projections, illustrate the largest current problem: few real-life REDD projects and tentative quantification models leave enormous space for speculation. We thus do not really know how large REDD leakage is, let alone how it compares with other sectors (Schwarze *et al.* 2002).

Box 7.1. The Noel Kempff project: Carbon mitigation by curbing logging and deforestation

In 1997, three electricity companies interested in the voluntary carbon market joined forces with The Nature Conservancy and invested USD 9.5 million in the 634,000 ha extension of the Noel Kempff National Park in eastern Bolivia. The money was used mainly to buy out timber concessions and large landowners, and to initiate integrated conservation and development projects (ICDPs) with three local communities. Focus was initially on avoided logging (forest degradation), but shifted over time towards avoided conversion to agricultural uses (deforestation). Primary leakage prevention was key in the contractual design, preventing in particular logging concessionaires from simply setting up shop elsewhere in Bolivia. Leakage for the stop-logging component was thoroughly screened and found to be in the 2-42% range, wood decomposition rates and timber-demand elasticities being most influential. Deforestation among local communities actually increased initially, which was hoped to be transitory, related to the creation of new land use systems. Setting baselines for deforestation and logging proved to be tricky. Three models for baseline carbon emissions over 20 years reached dramatically variable results: FAC=11.54 TgC, GEOMOD=1.05 TgC, and LUCS=0.18 TgC. For timber leakage, a dynamic optimisation model was constructed. For the spatial modelling of deforestation leakage, GEOMOD would be most appropriate, but short-run project-internal deforestation had not been cut, and remoteness seemingly still limits dangers of increased land colonisation by squatters in buffer zones.

Sources: Winrock (2002), Sohngen and Brown (2004), Brown *et al.* (2007)

7.2.3 Determinants of leakage

Few REDD schemes are currently in operation, so asking for credible leakage estimates or leakage-proof design recipes is premature. It is helpful to play around with the numbers, but prediction ranges remain unacceptably wide.

Domestic leakage may significantly affect subnational REDD schemes. If a nation loses 1% of its forest cover annually, 99% is not currently threatened. Advocates of REDD's cost efficiency, e.g. the Stern Report, assume this 1% can be exactly identified, an obviously unrealistic position. Indeed, deforestation in forwards-moving agricultural frontiers is highly concentrated, e.g. in the Brazilian Arc of Deforestation. Spatial modelling in Mexico now allows prediction of two thirds of deforestation, using variables such as closeness to roads and markets, soil quality, slopes, population growth, etc. Yet, in areas where gradual clearing of forest islands in agricultural landscapes prevails, spatial prediction of deforestation is much more challenging, and addressing leakage will be more complex. Hence, errors in spatial prediction, and higher spatial fungibility of economic pressures, imply that additional reserves beyond the initially threatened ones will have to be simultaneously protected. Such multisite leakage threats may increase REDD costs significantly.

Some common-sense leakage pre-assessment for different sites and scenarios may, however, help (see Figure 7.1). First, if labour and capital are highly mobile, then REDD-displaced activities and emissions will easily flow elsewhere (a). If adjacent forest areas with suitable soil conditions and weak protection status or low land price are available, then leakage into those areas is more likely than if the alternatives are remote, well-protected, expensive, and/or less apt for conversion (b). If demand for REDD-constrained products (timber, crops, livestock, etc.) is price-inelastic, i.e. the REDD-induced reduction in supply will not result in much reduced demand, then the activity is more likely to leak (c). Flexible production technologies can help absorb land scarcity from REDD set-asides at the local level (d), e.g. when land-extensive Amazon cattle ranching is intensified through pasture renovation or when slash-and-burn cycles are reduced through improved fertilisation. Conversely, if mechanised soy production depends on a technology package with fixed input coefficients, land-saving local adaptations are precluded and leakage becomes more likely.

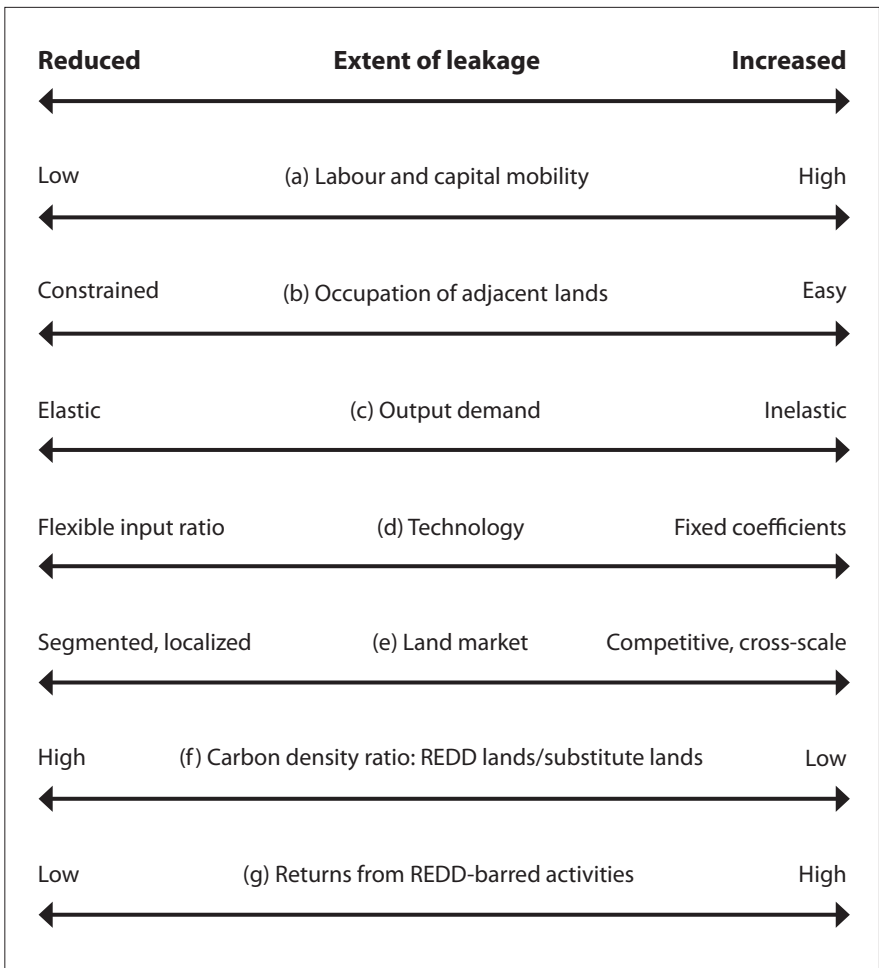


Figure 7.1. Main likely explanatory factors behind high vs. low leakage scenarios

If land markets are competitive and integrated across regions and scales, then leakage is more probable (e). For instance, when in the 1980s Brazilian soy farmers expanded, they bought out small farms in the drier parts of central Brazil, pushing cattle production farther north, including into the Amazon. Conversely, in Papua New Guinea practically all land is owned by local communities, and large-scale market-led land reallocations of the Brazilian type would be unlikely.

Leakage is also about how much carbon is stocked on the protected land, compared with the land REDD-restricted activities move to – including changes over time in comparative carbon stocks (f). High-value activities, such as oil palm, soybeans, perennials, logging, or mining will – if effectively barred by REDD – more easily overcome the incremental transport and relocation costs of moving elsewhere than low-value production such as firewood, slash-and-burn agriculture or land-extensive pastures (g). Pre-checking of considerations (a)–(g) may put in question some carbon-mitigation proposals from the outset, as in the Ecuadorian Yasuní case (Box 7.2): even without any measurement efforts, leakage problems appear overwhelming.

Box 7.2. The Yasuní proposal: Carbon mitigation by keeping oil underground

Yasuní National Park in Ecuador's Amazon region has forests with extraordinary biodiversity, but also large oil reserves. President Correa announced in June 2007 the intention to extract oil from the 982,000 ha park unless the international community came up with annual compensations of USD 350 million over 20 years, representing about half the estimated oil revenues. Notwithstanding biodiversity-conservation gains, carbon benefits alone are argued to more than justify such payments: 111 million tons of carbon otherwise exported would be kept underground and forest-degradation emissions from drilling and transport infrastructure avoided. Permanence after 20 years, and the moral hazard of threats to abolish a long-established park, may render the proposal controversial. Yet, selected criteria from Figure 7.1 also reveal that, while the proposal's REDD component may work, the leakage from keeping the oil underground would likely approach 100%: global energy demand is highly inelastic, while energy supply is elastic. Thus, barring Yasuní oil extraction would — through marginal price changes — move most oil production elsewhere (c). Little labour is required, oil-industry financial capital is highly mobile (a), and returns from extraction are very high (g), thus further facilitating spatial factor fungibility and high global leakage.

Source: Correa and Moreno (2002)

Wood harvesting activities (driving forest degradation) and agricultural conversion (driving deforestation) are sometimes lumped together in REDD leakage overviews (Murray 2008), yet represent substantially divergent economic processes. Logging of high-value species is typically a rent-seeking activity requiring little spatially fixed investment; deforestation is normally an immobile investment in future land uses, has more variable returns, and is on average less export-orientated. According to Figure 7.1, high-value logging would normally have higher leakage than deforestation.

Finally, different leakage scales are important for different purposes. On-farm leakage is key for PES scheme design, a vital on-the-ground REDD implementation tool. Project-level leakage is important for investors, though regional-level baselines are often more reliable (Sathaye and Andrasko 2007). Nested REDD approaches can help be a bridge to national-level goals (Chapter 9). International REDD leakage into high-forest-cover, low-deforestation countries (e.g. Gabon, Suriname) may occur if these countries do not receive moderate preventive incentives to protect their large forest stocks (da Fonseca *et al.* 2007), linking leakage to both crediting baseline and stock-flow issues (Chapters 6 and 9).

7.3 Options for dealing with leakage

7.3.1 Monitor

Leakage is doubtlessly a key ‘REDD flag’. Given its complexity, an overarching recommendation in many United Nations Framework Convention on Climate Change (UNFCCC) submissions (e.g. Colombia, European Union, United States of America – see Appendix) is to better monitor its extent. For primary leakage, historical deforestation figures (preferably sectorally disaggregated) are vital. Careful selection of control areas can help monitoring impacts within and outside project boundaries. Local socioeconomic surveys and trend indicators (demographics, prices for land, crops, livestock, and timber) can provide further understanding and measurement of offsite project impacts (Auckland *et al.* 2003). The Voluntary Carbon Standard for land use projects and the BioCarbon Fund now recommend leakage-belt monitoring, e.g. areas five to seven times the size of project areas greater than 100,000 ha and 20 to 40 times the size of smaller ones (<100,000 ha). Secondary and international-level leakages need monitoring through better economy-wide or global trade models using improved data, thus hopefully reducing the currently huge predictive ranges and modelling sensitivities (section 7.2).

7.3.2 Increase scale

Many UNFCCC submissions recommend higher accounting and crediting scales, i.e., moving from subnational to national levels, as the key to leakage control (see Chapter 4). International leakage through commodity markets is potentially high for REDD actions that significantly curb global commodity supply, as rising world market prices stimulate production elsewhere. Thus, the more deforesting countries participate in REDD, the less international deforestation leakage is likely to occur.

7.3.3 Discount

Some UNFCCC submissions (e.g. Colombia, World Bank – see Appendix) express doubts over how much increasing the REDD-scale will help leakage control in practice. As long as country participation remains below certain thresholds, one may need to discount REDD benefits not only for non-permanence, but also for their estimated international leakage (Murray 2008). The various UNFCCC-proposed mechanisms, such as banking non-credited conservation reserves, insurances, discounted credits, or leakage-adjusted baselines and targets (Murray 2008), essentially have similar purposes of more conservative credit accounting. Improved monitoring is required to know just how large discount factors should be. This can also be a useful focus for learning in REDD demonstration projects.

7.3.4 Redesign

Less often featured in UNFCCC submissions, yet equally important are national and project-level design questions (section 7.2.3): how large are leakage risks for different on-the-ground REDD actions? Do focus, location, boundaries, and incentives of the proposed action make sense in a leakage control perspective? Given quite different effects originating from REDD conservation, SFM, and A/R projects (Table 7.1), can careful national/regional balances among them help control leakage by better absorbing crowded-out labour and capital (Schwarze *et al.* 2002)? Getting these balances right may substantially reduce subnational leakage.

7.3.5 Neutralise

Some ‘decision-tree’ stylisations (Auckland 2003:129) recommend addressing all primary leakage through neutralising ‘alternative livelihoods’ components. However, as we know from decades of Integrated Conservation and Development Project (ICDP) investments, shifting people into alternative livelihoods can be a daunting challenge. If the productive shift, for instance, requires Brazilian cattle ranchers to adopt more land-intensive pasture

management, then adding a targeted intensification training and incentive package may be advisable. If it entails turning logging workers and shifting cultivators into ecotourism operators and non-timber forest entrepreneurs – as in the Noel Kempff case – the task may become overly difficult, costly, and risky. Conversely, some ICDPs become economically over-successful, creating ‘magnet effects’ that attract migrants and increase natural-resource pressures (Wittemyer *et al.* 2008). Some land-intensifying, high-yield technology diffusion, often recommended by leakage experts, can ultimately be adopted so widely that deforestation increases, causing so-called ‘super-acceptance effects’ (Auckland 2003).

7.4 Assessment of options

If you strike your fist into a down pillow, you will compress some feathers, but others will inevitably bulge at other ends. Similarly, REDD leakage is impossible to eliminate completely unless all global forests and woodlands were to be REDD-enrolled simultaneously. But given its importance, how can leakage be addressed in ways that balance effectiveness, efficiency, and equity?

Doubtlessly the most effective way is to increase REDD scales, both within and among countries. Under current climate policy, international leakage in particular is the rule, independent of the mitigation sector. Only broadened global participation can reduce it, and here REDD constitutes a strategic entry point. If leakage is safely quantifiable through monitoring (7.3.1), it is advisable to discount benefits or bank ‘reserve credits’ (7.3.3), ensuring that only net emission reductions are rewarded. Redesigning REDD interventions can effectively restrict in-country leakage (7.3.4). Leakage neutralisation (7.3.5) is only exceptionally recommendable; add-on ICDP projects risk becoming ‘REDD and white elephants’.

As to cost efficiency, there is probably an optimal monitoring level, beyond which measurement of particularly degradation leakage makes little sense. However, explicit monitoring boundaries have to be defined. Attempts at leakage neutralisation may often be more expensive than redesigning the scheme or discounting the credits. In spite of the complexities at hand, efficient and cost-effective leakage control seems an attainable goal; leakage risks should not lead us to abandon REDD.

In terms of equity and development concerns, leakage may actually indicate a healthy economy: in response to REDD-induced barriers, production factors float fluidly to new opportunities, keeping welfare losses minimal. For instance, if a REDD set-aside impedes forest conversion for high-return soybean production, preventing this conversion from leaking may not be socially desirable if high foreign-exchange and multiplier benefits are foregone.

Even explicit primary leakage contracts, e.g. the deals in Bolivia impeding loggers from moving elsewhere, may be undesirable from a welfare perspective. Additionally, in a world of mobile financial capital, they may ultimately have only short-run effects. Redesigning REDD towards factors that are less mobile and leakage-producing (e.g. labour, marginal lands) may also improve equity by creating pro-poor REDD investments. Balancing activity-reducing REDD conservation with activity-expanding A/R and SFM interventions in the mitigation portfolio may impede impoverishing labour expulsion. Recognising trade-offs between carbon mitigation and broader development goals may thus lead us to deliberately accept some leakage and to reprioritise mitigation actions.

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