Land Use and Forests, Carbon Monitoring, and Global Change

Cooperative Agreement between Winrock International and the EPA
ID# CR 827293-01-0

Product 9

Draft manuscript on leakage analysis (since published in Climate Policy 3:123-136)

Sandra Brown
Winrock International
1621 N Kent St, Suite 1200
Arlington, VA 22209

May 2002

A conceptual framework and its application for addressing leakage on avoided deforestation projects

Louise Aukland[1], Pedro Moura Costa[1] and Sandra Brown[2]

1. EcoSecurities Ltd, 45 Raleigh Park Road, Oxford OX2 9AZ, UK

2. Winrock International, 1621 N Kent St., Suite 1200, Arlington, VA 22209, USA

Abstract

One of the most challenging technical issues associated with project-based mechanisms to mitigate the effects of climate change is that of leakage. A conceptual framework is proposed for the identification and analysis of leakage potentially generated by a project. The categorization of leakage based on the actors responsible for their manifestation is proposed, which divides sources of leakage into primary and secondary types. Primary leakage occurs when the greenhouse gas benefits of a project are entirely or partially negated by increased emissions from similar processes in another area. Secondary leakage occurs when a project's outputs create incentives to increase greenhouse gas emissions elsewhere. The extent and type of leakage will vary depending on the project typology. Using a decision tree approach, the process of identifying potential sources of leakage is demonstrated for avoided deforestation projects. Primary leakage analysis is intrinsically linked to an understanding of the project baseline. If the main elements determining a baseline are properly identified and understood, in particular the 'baseline agents', a combination of the decision tree approach and apportioning responsibility, can assist in the minimization, quantification and monitoring of possible leakage. Econometric methods may prove more useful in analyzing secondary leakage and market effects.

Key words: carbon offsets, leakage, baselines, greenhouse gas mitigation, avoided deforestation, sinks, forest conservation.

1. Introduction

The inclusion of project-based mechanisms in climate change policy as a means of achieving emission reduction targets has generated a number of key technical questions on the validity of such activities. This is particularly evident within the land use, land-use change and forestry sector, where criticism relating to the environmental integrity of carbon dioxide sequestration or avoided greenhouse gas emissions through averted deforestation activities are widespread. This has led to the exclusion of avoided deforestation activities from the Clean Development Mechanism (CDM) of the Kyoto Protocol, at least for the first commitment period.

Among the various technical issues in question, the most challenging are the methodologies for baseline establishment and identification and monitoring of leakage. The mere presence of the potential for leakage does not necessarily make a project unattractive, instead strategies need to be developed to either mitigate it and/or account for it. A methodology for analyzing leakage is the issue addressed in this paper.

Over the past 10 years a number of conservation projects have been established around the world to prevent the release of greenhouse gases into the atmosphere that would otherwise occur as a result of deforestation (Table 1). Most of these projects have only been implemented for periods of less than five years and have, most likely, not run long enough to detect much in the way of leakage. It is expected that, after they have been implemented for a long enough period, these will provide enough experience and data to be able to draw some conclusions about the occurrence of leakage. To date, however, the treatment of leakage still has to resort to conceptual analysis.

The goal of this paper is to present a conceptual framework on the issue of leakage for avoided deforestation or conservation projects. It also aims at indicating how this could be used to identify sources of leakage and proposes ways in which leakage could be monitored if there is the potential for it to occur. The focus in this paper is on CDM-type projects. For countries with national assigned amounts of emissions (developed countries), leakage is considered to be of lesser importance because its effect will be captured in the required national inventory of GHG emissions (Brown *et al*., 2000b).

Table 1: Examples of existing avoided deforestation carbon projects.

2. Definitions of leakage

The term 'leakage' is commonly used to refer to an unanticipated loss of net carbon benefits of a project as a consequence of the implementation of project activities (Brown *et al.*, 1997). For this reason, leakage is also referred to as a greenhouse gas externality (Moura Costa *et al.*, 2000). Because leakage usually occurs outside of the project's immediate boundaries, it is also referred to as an 'offsite effect'.

While leakage often refers to the negative externalities of a project, i.e. those that result in additional greenhouse gas (GHG) emissions, it is possible that it is manifested as a positive GHG externality. This has been referred to as 'positive leakage' or 'spillover'. Because of its negative impact on the environment, the former requires a great deal more attention than the latter, and is therefore the focus of this paper.

Existing literature also refers to a number of other terms related to sub-categories of leakage, such as slippage, activity shifting, outsourcing, market effects, life-cycle emission reductions, etc. (Watson *et al*., 2000; Moura Costa *et al.*, 2000; Schlamadinger and Marland, 2000; Sedjo and Sohngen, 1999; SGS 1998; Brown *et al.*, 1997; Carter 1997; Moura Costa *et al.*, 1997;

Trines, 1998; USIJI, 1994). This variety of terms, often unaccompanied by proper defintions and overlapping with each other, have led to additional confusion with regards to leakage analysis.

To be able to analyse leakage, it is necessary to understand their different causes and sources and to adopt a standard terminology to refer to them. This paper proposes a way to categorize the various types of leakage based on the actors responsible for their manifestation, to which we refer to as the 'baseline agents' (see Section 3 below). Following this logic, we divided leakage into the primary and secondary categories, as defined below.

Primary leakage, previously referred to as slippage in other publications (e.g., SGS, 1998; Moura Costa *et al*., 1997), occurs when the GHG benefits of a project are entirely or partially negated by increased GHG emissions from similar processes in another area. Primary leakage essentially results in the displacement of the negative activity tackled by the project (the 'baseline driver', see Section 3), rather than its avoidance. It is, therefore, directly related to the activities or threats that are modeled in the baseline and the actors responsible for causing them ('baseline agents'). Primary leakage can be divided into the following sub-types:

- *Activity Shifting* – means that the activities that cause emissions are not permanently avoided, but simply displaced to another area. In forestry, an example is when one discrete area is demarcated for preservation, causing cattle farmers who were converting the area into pasture to simply move into another area outside of the immediate project boundaries to convert forests there.

- *Outsourcing* – is the purchase or contracting out of the services or commodities that were previously produced or provided on-site. Thus, the responsibility for the activity (deforestation) is shifted to another party, possibly not seen to be directly associated with the project.

Secondary leakage occurs when a project's outputs create incentives to increase GHG emissions elsewhere. Unlike primary leakage, secondary leakage activities are not directly linked to, and carried out by, the original 'baseline agents'. Secondary leakage can be subdivided into:

- *Market Effects* - Market effects occur when emissions reductions are countered by emissions created by shifts in supply and demand of the products and services affected by the project. For example, a reforestation project may result in over-supply of timber in a region, causing a reduction in timber prices and consequently an increase in consumption and associated waste. It could also lead to a reduction in planting activities by third parties. This type of leakage is most likely to be associated with projects that affect market-based activities, such as commercial logging, reforestation and afforestation. It is less likely to occur in projects whose baselines are driven primarily by subsistence activities (for example projects based on the avoidance of land conversion conducted by subsistence farmers) since these activities do not affect markets for the forest products involved.

- *'Super-acceptance' of alternative livelihood options* – this is a particular type of leakage that may result from the alternative activities provided by a project. For example, as part of a conservation project, alternative livelihood options may be promoted to reduce the need for conversion of the forest to agricultural land. As a result, there may be an influx of people attracted into the area from regions outside of the original ‘project boundaries’ or target group, who may adopt the activities promoted by the project. This may result in either positive or negative leakage:

– *Positive* – when people move in from other areas where they were previously undertaking activities with high carbon emissions e.g. forest clearing. As a result of joining in or adopting the project livelihood options (based on sustainable low GHG emitting activities), there may be an overall reduction in GHG emissions (i.e., positive leakage).

– *Negative* – when there is an influx of people with lower GHG emitting lifestyles e.g. coming from urban environments or farming. The move to the project area may result in an increase in their GHG emissions (e.g., by gaining access to new forest land), thus resulting in negative leakage.

Another source of unexpected carbon emissions occurs in the event of incomplete or inaccurate project or baseline determinations (e.g., emissions from fertilizer production, or transport of wood products). This should be seen more as a fault of the project-baseline calculations rather than an issue of leakage.

3. Leakage, baselines and causes of deforestation

As defined above, leakage is a source of emission not anticipated in the baseline and, consequently, leakage analysis is intrinsically linked with an understanding of the project baseline. If the main elements determining a baseline are properly identified and understood at the onset of a project, a large extent of the potential leakage can be prevented/addressed at the project design phase.

The main elements determining a baseline can be categorized according to the following criteria: 'baseline drivers', 'baseline agents', 'causes and motivations', and 'indicators' (Table 2). 'Baseline drivers' are defined as the activity predominantly taking place in the absence of the project, and that the project will replace. For conservation projects, for instance, the main drivers are deforestation, logging, or mining/oil extraction. These activities are actually conducted by the 'baseline agents'. In the case of deforestation, the baseline agents may include a whole cross-section of local, regional, national and international people as shifting cultivators, subsistence farmers, forest concessionaires, cattle ranchers, private and government logging companies, mining and oil corporations. Different baseline agents may be motivated by different factors to engage in the baseline driving activities, such as the (perceived or real) opportunity cost of land, the need to secure land tenure through 'land use', food supply, etc. These, in turn, could be affected by other conditioning factors enhancing or reducing the intensity of the main motivation.

Many attempts have been made to try to understand the underlying causes of deforestation, resulting in a wealth of information from across the world (e.g., Rudel *et al.,* 2000; Kaimowitz, 1997; Angelsen and Kaimowitz, 1999). One of the prime factors assumed to affect deforestation is thought to be population growth, although the exact way in which it influences deforestation can be misleading or complex (Palo *et al.*, 1996; Kaimowitz and Angelsen, 1998). Perhaps more importantly, population distribution is likely to influence the pattern and rate of deforestation (Pfaff, 1999). Numerous other factors have been proposed as having an influence on deforestation, including transporatation corridors and road construction (Liu *et al*., 1993; Chomitz and Gray, 1996); distance to market (Pfaff, 1999); biophysical characteristics of the land, such as soil quality, slope, and vegetation density (Pfaff, 1999); agricultural suitability of the land (Munroe *et al*., 2001; Faminow, 1998);

income levels (Wunder, 2001a and b); policy and institutional factors (Contreras-Hermosilla, 2000); and land use and fiscal policies (Ruzicka and Moura Costa, 1997).

In effect, deforestation is rarely the result of one factor but is caused by a chain of events, with the key factor varying depending on local pressures. Contreras-Hermosilla (2000) refers to this sequence of events as a “causation chain”. It is unlikely that any definite cause-effect linkages are going to be applicable universally and each situation will need to consider locally dependent variables.

Estimation of the degree and intensity of baseline drivers can be done through the use of indicators. In the case of deforestation, for instance, the main indicator used is forest cover, or the reduction in forest cover taking place in a region. In many cases, secondary indicators may need to be used in order to infer what the primary indicator is. For example, because of data availability constraints, it may be easier to analyze the volumes of timber extracted from a region, instead of trying to determine the area actually logged.

Table 2: Main baseline drivers, agents, causes and indicators, for different types of projects.

4. Leakage in relation to project typology

The combination of the categories of leakage with the elements determining a baseline provide us with a process to determine the types of leakage likely to be associated with different projects. Because different projects involve different baseline drivers, agents and motivations, certain types of projects are inherently more prone to certain types of leakage. Table 3 shows a typology of land use projects and the type of leakage most likely to occur.

Conservation projects (particularly avoided deforestation) are generally most susceptible to primary leakage of the activity shifting type because the project is based on the discontinuation or avoidance of an economic activity (agriculture, logging) taking place in a site. If no alternative livelihood option is provided to the agents of deforestation, it may simply lead to a direct displacement of activities to another location.

Table 3: Types of leakage likely to be associated with baseline drivers and project activities, for different types of projects.

Reforestation and afforestation projects, on the other hand, are based on the development of an economic activity where it was previously not taking place. If the baseline agents get directly involved in the project, they may, consequently, engage in an economic activity directly provided by the project and not need to move elsewhere. Occurrence of primary leakage, therefore, is confined to situations where the baseline agents previously using the project site are displaced by the project, but this can be considered a project design flaw. Secondary leakage caused by market effects, however, is the most likely type expected from this kind of project. This can happen, for instance, if the additional supply of forest products generated by the project drive their prices down. This in turn may lead to an increase in demand (over consumption) or to a feedback effect on supply (i.e., a reduction in planting rates).

Alternative technology projects (such as the introduction of reduced impact logging practices or intensification of agricultural activities), if properly managed, may be able to avoid both types of leakage mentioned above. By not discontinuing, but changing land-use practices, there is no displacement of the original baseline agents, and because the project is based on the maintenance of the same economic activity occurring previously, there should be no market effects. This type of activity may only lead to leakage if: a) there is resistance to the adoption of the new technology for whatever reason (difficulty, lack of capacity and/or training, higher costs, etc.), creating a source of primary leakage due to activity shifting to areas outside the project area; or b) if the new technology results in a reduction of forest products output (as for instance, reduction in logging outputs, because of operational constraints caused by the new logging guidelines), resulting in secondary leakage due to market effects.

5. Assessing leakage – a conceptual framework

Using the elements described above, a step-wise approach can be devised to guide the process of identification and analysis of leakage potentially generated by a project. A decision tree approach was adopted to facilitate this process (Figure 1) and its use will be illustrated through the example of a forest conservation project to avoid deforestation activities caused by subsistence agriculturalists. This approach can be used at the project design phase to identify possible future sources of leakage and therefore adjust the project design to minimize leakage effects. It can also be used during the implementation phase to assess and monitor the effectiveness of leakage prevention activities, or to identify possible new sources of leakage.

As discussed above, a first step in the identification of leakage is to determine the main drivers of the project baseline, and whether the chosen project interventions can tackle these baseline drivers. A separate analysis needs to be conducted for each baseline driver identified, following the decision tree in Figure 1. In the case of this fictitious project, the baseline driver is deforestation, and the establishment of an area of effective forest conservation could prevent deforestation within this area.

After defining what the project activities are, the next step is to consider whether or not alternative livelihood options have been provided by the project for each of the groups of baseline agents involved. This should be done for each driver that is considered in the establishment of the baseline over the project lifetime. In the case of the subsistence agriculture example, the main type of alternative livelihood option promoted by projects in the past revolve around sustainable agriculture and agroforestry activities in buffer zones surrounding the conservation area (e.g., Noel Kempff Mercado, Brown *et al.*, 2000a; Costa Rican Protected Areas Project, Stuart and Moura-Costa, 1998; Care-Guatemala, Brown *et al.*, 1997). If no alternative livelihood options are provided, primary leakage will certainly occur through the shift of the activities currently conducted by baseline agents to another area.

Figure 1: Decision tree for identification of types of leakage likely to impact land use projects.

If alternative options have been provided then the analysis needs to determine whether or not the baseline agents are actually engaging in these options. Those that do not engage fully in these alternative options may well be a source of primary leakage, and the reasons for them not engaging must be analyzed by the project developers. Thus a key to monitoring the likelihood of leakage for the example project here is to measure the rate of adoption of the alternative practices, and then to determine what level of adoption is likely to result in little to no leakage. This offers the opportunity for adopting a threshold, below which projects do not need to quantify and account for this type of leakage (Section 6).

If the baseline agents do engage in alternative options, on the other hand, two other potential forms of secondary leakage may still occur. In the case where these buffer zones are very successful, they may attract the participation of people previously not involved with the original baseline, leading to the 'super-acceptance' of the alternative livelihoods program. Depending on what activities these groups were engaged in previously, this may have a positive or negative effect in terms of GHG emissions. For example, if these were shifting cultivators, their adoption of the alternative activities may lead to an expansion of the project's benefits beyond the expected area of project influence. If, on the other hand, farmers from other regions are attracted to the area by the prospects of securing land tenure by joining the agricultural activities promoted by the project, this could lead to the deforestation of additional land than was previously anticipated at the onset of the project. Another cause of leakage may be derived from the market effects of additional agricultural production generated by this alternative livelihoods program, but in the case of subsistence agriculturalists, this is likely to be of limited scale.

It is important that the leakage analysis takes into consideration the whole timeframe of a project because the baseline agents involved in the project may be expected to change over time (see Section 6 for a discussion on this).

6. From classification to quantification

The framework described above addresses the identification and classification of different types of leakage likely to be occurring as a consequence of a project. It is necessary, then, to link the analysis to a methodology for the estimation of the extent of potential leakage or leakage that may have already occurred. In some cases, however, it may be deemed unnecessary to continue with further analyses if no leakage is expected to occur (Figure 1).

The first step in this process is to apportion the primary leakage to the different baseline drivers and agents, as they may change with time. For example, if the baseline driver is deforestation, but there are two key baseline agents, subsistence farmers and commercial cattle ranchers, the extent to which each contributes to potential leakage may differ over the project lifetime (Table 4). The information for this first step should be based on the relative contributions of different agents to the baseline emissions, therefore stressing the importance of the link between baseline and leakage analyses. The complexity of this analysis, number of drivers and agents, and relative timeframes will depend on the project and associated baseline analyses.

Table 4: Example of apportioning potential primary leakage to baseline agents.

This allocation between groups of agents may become particularly important if a socially based monitoring approach is used (see below). A spatial modeling approach may facilitate this analysis, especially if baseline agents of deforestation are composed of, for example, a development front emanating from a large urban center and from subsistence farmers. The development front can be modeled and the time it takes to get to the project area of interest and the magnitude of its impact estimated; this can be differentiated from the more local clearing due to subsistence farmers.

The issue of time becomes an important one at this stage, particularly when a baseline agent only becomes an actor in the medium or long term. Whether or not the project should be responsible for trying to quantify and account for such leakage is a valid question, particularly when the assumed causes and motivations driving the agents may no longer be applicable at that stage.

Different methods have been proposed to quantify leakage in avoided deforestation projects (Brown *et al*., 2000b). Given the different nature of the causes of deforestation and the agents involved, it is useful to devise methods that focus on specific types of leakage, i.e., primary and secondary. Methods proposed for quantification of primary leakage in deforestation projects include:

a) Tracking historical series of deforestation surrounding projects, before and after the beginning of the project. This requires extending the area for leakage analysis well beyond the project's original boundaries. The idea is that, if leakage occurs, the rates of deforestation taking place after the project may increase as a result of leakage. It remains challenging how to determine whether or not such changes can be attributed to the project or to other factors affecting deforestation in a region as a whole.

b) To address the weakness of the method above, it has been suggested that control areas independent from the project area can be used to ascertain if increases in deforestation can be attributed to the project or to other factors affecting the underlying causes of deforestation as a whole (e.g., a change in forest law, enforcement policies, etc.). However, identifying "matching" control areas is likely to be difficult, taking into consideration the need to match both biophysical and socioeconomic factors.

c) Another possible way to correct for these external factors could be to run correlation analysis with other factors, such as rate of population, agricultural prices, road density, etc., but lack of data availability at the right definition limits the use of this approach.

d) The use of leakage indicators, such as demand for timber, firewood, and agricultural land, has been proposed as a surrogate for the activities directly impacting the forest (Brown *et al.*, 1997).

e) Socio-economic surveys, tracking the agents involved in the baseline throughout the project timeframe and the activities they engage, may be a possible method to determine primary leakage effects. This could be linked to tools such as the LUCS Model (Faeth *et al.*, 1994).

Most of the methods described above are predominantly based on determining the area of forest loss that can be attributed to leakage from a project (except for methods (d) and (e)), i.e., ‘spatial’ approaches. In most cases, satellite imagery has been proposed (or used) as a tool to facilitate such analyses (*e.g.*, Hall *et al.*, 1995; Chomitz and Gray, 1996). An issue that is key to this approach relates to the selection of boundaries for analysis. Given that leakage is, usually, an offsite effect, it may be necessary for the area covered by the analysis to be extended well beyond the project’s boundaries. This has led to the idea of using regional baselines in order to try to detect whether leakage may be occuring outside a project’s boundaries (Brown, 1997; Brown et al., 2000b). This ‘regional baseline’ approach has been used by the Scolel Té project in Mexico (Tipper and de Jong, 1998).

Given that most projects have not run for a long enough timeframe (Table 1), it is unlikely that significant changes in previous land-use trends can already be detected through spatial analysis. Lack of data, or data of the right scale of definition, is another hindrance making this type of analysis difficult. This has indeed been the experience of this research project. Given these constraints, socially related analysis may provide a more feasible method to track possible sources of leakage in these avoided deforestation projects, whereby the combination of the framework analysis and leakage apportioning provides a simple methodology for estimating primary leakage. However, it does assume that the baseline analysis is able to provide assumptions relating to the agents and their relative contributions to predicted baseline emissions. The Noel Kempff project in Bolivia is used as a case study to demonstrate how this framework can be applied to a real project (Box 1).

Box 1: The Noel Kempff Mercado Climate Action Project, Bolivia

Methods for determination of secondary leakage, of the market effect type, are more concerned with volumes of forest products produced, their prices and levels of demand elasticity. The theory is to try to detect any possible effect that a change in the levels of forest output may have on price and demand for these products (e.g., Sedjo et al. 2000; Sohngen and Mendelsohn, 2001; Sedjo and Sohngen, 1999 and 2000). While econometric models exist for this type of analysis, it remains to be seen whether the land-use change data sets required for analysis exist, and whether the scale of these projects is large enough to generate detectable results. Testing of these assumptions is underway (Sohngen, pers. comm.), and it may lead to guidelines and thresholds for dealing with market-effect leakage.

Leakage from super-acceptance of alternative livelihood programs, on the other hand, would most likely be easier to quantify through socio-economic surveys, as described above.

Irrespective of which method is used to quantify, leakage then needs to be incorporated into the carbon acccounting of the project. It has been proposed that the leakage estimated for a project is simply deducted from the project's claims (Brown *et al.*, 2000b). An alternative approach has been proposed, whereby 'leakage coefficients' are defined based on the perceived risk of leakage of a project, and is used to reduce the project's claims accordingly (Trexler and Kosloff, 1998). The scheme proposed in this paper could assist with both these approaches, since it involves the apportioning of potential leakage according to different baseline drivers and agents, and can use the framework (Figure 1) to assess the extent of leakage for each driver. It could therefore assist in estimating the amount of leakage to be deducted from the project's claims, or help preventing certain types of leakage from occurring.

7. Conclusions

Identification and quantification of leakage remains one of the most challeging technical issuess related to the development of GHG mitigation projects. This has been the subject of many studies, and it appears to be equally problematic for both land use and energy projects (Chomitz 2000, Schlamadinger and Marland, 2000).

Experience to date has been limited to a few projects, and hindered by the lack of data, and short timeframes since project inception. Qualitative methods may need to be further developed, together with efforts to generate more accurate data at the right level of definition.

In the meantime, the approach described above may enable developers to identify possible sources of leakage that could occur as a consequence of the project. This, in turn, may be used in the project design phase, so that modifications can be made to try and avoid the occurrence of leakage. This should be particularly effective in the case of sources of primary leakage, where well-structured alternative livelihood option programs may be the most appropriate way to prevent leakage from occurring, and avoiding the need for more complex quantification analyses. Combined with the use of socio-economic surveys and monitoring linked to specific 'baseline agents', this may prove an effective strategy.

With relation to secondary leakage and market effects, econometric methods may prove useful, but is likely that they their application will remain limited due to the lack of data and the complexity of the analyses required. A more pragmatic approach may be to determine threshold values below which market effects can be considered negligible.

A more philosophical question relates to whether this should be the subject of concern or not. The objective of carbon finance is to provide financial incentives to promote a new paradigm, in this case related to a better utilization of forests by valuing them as carbon pools and carbon sinks. In an initial phase, while availability of carbon finance remains limited to a few, isolated projects, their impact could be questioned because of the possibilities of leakage. As carbon funding becomes available to a wider population, this opportunity cost will become integrated in the decision-making process of the agents of deforestation, altering their behavior. Perhaps this phase of uncertainty is a necessary step towards this desirable output.

8. Acknowledgements

Funding for this work was provided by a Cooperative Agreement between Winrock International (WI) and the US Environmental Protection Agency (US EPA) (ID No. CR 827293-01-0; Sandra Brown, Principal Investigator). The authors would like to thank all those that provide inputs, comments and suggestions to this work, including Brent Sohngen, Myrna Hall, Bill Stanley, Mark Trexler, Richard Tipper, Ben De Jong, Paige Brown, Ken Andrasko, Rodel Lasco, Richard Vaca, and the participants of The Nature Conservancy's Leakage Workshop held in Brazil, May 2001.

References

Angelsen, A. and Kaimowitz, D. (1999) Rethinking the Causes of Deforestation: Lessons from Economic Models. *The World Bank Research Observer.* **14 (1)**: 73-98

Brown, P.; Cabarle, B. and Livernash, R. (1997) Carbon Counts: Estimating Climate Change mitigation in Forestry Projects. *World Resources Institute*, Washington DC.

Brown, S.; Burnham, M.; Delany, M., Vaca; R., Powell, M. and Moreno, A. (2000a) Issues and Challenges for Forest-Based Carbon-Offset Projects: A Case Study of the Noel Kempff Climate Action Project in Bolivia. *Mitigation and Adaptation Strategies for Global Change.* **5 (1)**: 99-121.

Brown, S.; Masera, O. and Sathaye J. (2000b) Project-based activities. In Watson, R.T., I. R. Noble, B. Bolin, N. H. Ravindranath, D. J. Verardo, and D. J. Dokken (eds.), *Land use, Land-use change, and forestry; Special Report to the Intergovernmental Panel on Climate Change*, Cambridge University Press, **Ch. 5:** 283-338.

Carter, L. (1997) Modalities for the Operationalization of Additionality. *Paper presented at the UNEP/German Federal Ministry of Environment Workshop on AIJ*, Leipzig.

Chomitz, K. (2000) Evaluating carbon offsets from forestry and energy projects: how do they compare? *World Bank Policy Research Working Paper 2315*. World Bank Development Research Group, Washington, 25 p.

Chomitz, K and Gray, DA. (1996) Roads, land use and deforestation: a spatial model applied to Belize. *World Bank Economic Review*. **10 (3)**: 487-512.

Contreras-Hermosilla, A. (2000) The Underlying Causes of Forest Decline. *CIFOR Occasional Paper* **No. 30**.

Faeth, P., Cort, C., and Livernah, R. (1994) Evaluating the Carbon Sequestration Benefits of Forestry Projects in Developing Countries. *World Resources Institute,* Washington DC.

Faminow, M.D. (1998) Cattle, Deforestation and development in the Amazon: An Economic, Agronomic and Environmental Perspective.

Hall, C.S.; Tian, H.; Qi, Y; Pontius, G., and Cornell, J. (1995) Modelling spatial and temporal patterns of tropical land use change. *Journal of Biogeography.* **22**: 753-757.

Kaimowitz, D. (1997). Factors determining low deforestation: The Bolivian Amazon. *Ambio.* **26 (8)**: 537-540

Kaimowitz, D. and Angelsen, A. (1998) Economic Models of Tropical Deforestation – A Review. *Center for International Forestry Research.*

Liu, S.; Iverson, L. and Brown. S. (1993) Rates and patterns of deforestation in the Philippines: application of geographic information system analysis. *Forest Ecology and Management* **57**:1-16.

Moura Costa, P. and Stuart, M. (1998) Forestry based greenhouse gas mitigation: a short story of market evolution. *Commonwealth Forestry Review.* **77 (3):** 191-202

Moura Costa, P., Stuart, M.D., and Trines, E. (1997) SGS Forestry's Carbon Offset Verification Service. In Riermer, P.W.F., Smith, A.Y., and Thambimuthu, K.V. (eds.), *Greenhouse gas mitigation. Technologies for activities implemented jointly. Proceedings of Technologies for AIJ Conference, Vancouver,* Oxford, Elsevier, pp. 409-414.

Moura Costa, P., Stuart, M., Pinard, M., and Phillips, G. (2000) Elements of a certification system for forestry-based carbon offset projects. *Mitigation and Adaptation Strategies for Global Change*. **5 (1):** 39-50

Munroe, D., Southworth, J. and Tucker, C.M. (2001) The Dynamics of Land-Cover Change in Western Honduras: Spatial Autocorrelation and Temporal Variation. *Prepared for the 2001 AAEA Annual Meetings.*

Palo, M.; Mery, G. and Lehto, E. (1996) Latin American Deforestation and Sustainability Prospects. In: *Sustainable Forestry Challenges for Developing Countries*, eds M. Palo and G. Mery. *Kluwer Academic Publishers*. 199-228.

Pfaff, A. (1999) What drives deforestation in the Brazilian Amazon: Evidence from satellite and socio-economic data. *Journal of Environmental Economics and Management*. **37(2)**: 26-43

Rudel, T.K.; Flesher, K.; Bates, D.; Baptista, S. and Holmgren, P. (2000) Tropical Deforestation Literature: Geographical and Historical Patterns. *Unasylva* **203**, **Vol. 51**: 11-18.

Ruzicka, I. and Moura Costa, P. (1997) Sustainable Forest Management: Allocation of resources and responsibilities. *Final report for ODA funded research*. Department for International Development, London, 60 pp.

Schlamadinger, B. and Marland, G. (2000) Land Use and Global Climate Change – Forests, Land Management and the Kyoto Protocol. *Pew Center on global Climate Change,* Washington, DC.

SGS (Société Générale de Surveillance) (1998) Final Report of the Assessment of Project Design and Schedule of Emission Reduction Units for the Protected Areas Project of the Costa Rican Office for Joint Implementation, Oxford, *SGS,* 133 pp.

Sedjo, R., and Sohngen, B. (1999) Carbon Sequestration By Forestry -- Effects of Timber Markets. Report Number PH3/10, June 1999. London, England*: International Energy Agency, Greenhouse Gas Research and Development Program*.

Sedjo, R., and Sohngen, B. (2000) Forestry Sequestration of CO_2 and Markets for Timber. *Resources for the Future.* Discussion paper **00-35**

Sedjo, R.; Sohngen, B., and Mendelsohn, R. (2000) Estimating Carbon Supply curves for Global Forests and Other Land Uses. *Resources for the Future*. Discussion paper **01-19**

Sohngen, B., and Mendelsohn, R., (2001) Optimal Forest Carbon Sequestration. *Department of Agricultural, Environmental, and Development Economics, Ohio State University.* Working Paper: **AEDE-WP-0009-01**.

Stuart, M.D., and Moura Costa, P. (1998) Greenhouse gas mitigation: A review of international policies and initiatives. In: *Policies that Work for People*, International Institute of Environment and Development, London.

Tipper, R. and de Jong, B.H. (1998) Quantification and regulation of carbon offsets from forestry: comparison of alternative methodologies, with special reference to Chiapas, Mexico. *Commonwealth Forestry Review* **77**: 219-228.

Trines, E. (1998) SGS's Carbon Offset Verification Service. *Commonwealth Forestry Review* **77**:209-213.

Trexler, M.C. and Kosloff, L.H. (1998) The 1997 Kyoto Protocol: What does it mean for project-based climate change mitigation? *Mitigation and Adaptation Strategies for Global Change* **3**: 1-58.

USIJI (1994). The United States Initiative on Joint Implementation, Internal Document, *US Department of Energy*, Washington DC. US Department of Energy.

Watson, R.T.; I. R. Noble; B. Bolin; N. H. Ravindranath; D. J. Verardo, and D. J. Dokken (eds.). (2000) Land use, Land-use change, and Forestry; Special Report to the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.

Wunder, S. (2001a) Deforestation and economics in Ecuador: A synthesis. Forestry Discussion Paper **35**, *Royal Veterinary and Agricultural University*, Copenhagen.

Wunder, S. (2001b) Poverty Alleviation and Tropical Forests - What Scope for Synergies? *World Development,* **vol. 29 (11)**: 1817-1834.

Box 1: The Noel Kempff Mercado Climate Action Project, Bolivia

The Noel Kempff Mercado Climate Action Project was initiated in 1997 and involved the expansion of the original nature reserve. The baseline drivers for this project are the conversion of forest (deforestation) and conventional logging. The agents that are driving the deforestation baseline are likely to be:

1) local communities surrounding the park;
2) possible isolated colonisations from people moving into the area (already occurring);
3) the imminent arrival of the 'agricultural frontier'.

The project has been implementing community development projects in the region surrounding the park, in order to prevent leakage from the averted deforestation activities. These activities focus on the agents likely to cause leakage in the short term but do not address the implications of the longer-term threats to the area. However, given the timescale of the project and the difficulty in predicting longer term land use patterns (and therefore in estimating the potential impact of other agents) it would seem appropriate to focus on the immediate threat, as is being done in the Noel Kempff.

The following table illustrates how a project can think about the issues of time and sizes of threat for the different baseline agents, and therefore apportion responsibilities for potential leakage. These numbers are estimates, to illustrate the method, and not the result of an actual analysis:

Table 5: Apportioning potential leakage to baseline agents – a hypothetical example for the Noel Kempff project.

This methodology can be applied at the project design stage to identify which type of project activities and leakage prevention measures should be priority. It can also be used during the implementation phase in combination with the decision tree for identifying the types of leakage likely to impact the project (Figure 1). The results of this analysis for the avoided deforestation part of the Noel Kempff project are shown below (Figure 2).

Figure 2. Decision tree applied to the Noel Kempff Project.

Table 1: Examples of existing avoided deforestation carbon projects.

Project Name	Date initiated	Carbon offset (1000 tC)	Area (ha)	Host Country	Investor Country
AES – Oxfam – Coica	1992	15,000	1,500,000	South America	USA
Rio Bravo	1994	2,400	60,000	Belize	USA
Carfix	1994	2,000	91,000	Costa Rica	USA
Ecoland / Tenaska	1995	350	2,500	Costa Rica	USA
Noel Kempff Mercado	1996	6,000	634,000	Bolivia	USA
PAP OCIC	1997	18,000	570,000	Costa Rica	Norway, USA
Scolel Te	1997	15	13,000	Mexico	UK, France
Virilla Basin project	1997	230	52,000	Costa Rica	Norway
AES/Ecologica – Ilha Bananal	1998	n.a.	260,800	Brazil	USA
TNC Guaraquecaba	1999	≈1000	7,000	Brazil	USA

n.a. = not available.
Source: adapted from Moura Costa and Stuart (1998) and Brown et al. *(2000b).*

Table 2: Main baseline drivers, agents, causes and indicators, for different types of projects.

Project type	Baseline drivers	Baseline agents	Causes or motivation	Main indicator
Conservation	Deforestation *(loss of carbon)*	Subsistence farmers, commercial farmers, cattle ranchers, urban developers, mining companies	Opportunity cost of land, (securing land tenure, food supply, financial returns), land use policy, fiscal policy	Forest cover
	Logging (loss of carbon)	Logging companies, small scale extraction by individuals	Financial returns, need for forest products, land use policy	Area logged
Large scale plantation forestry	No economic activity, fallow, agriculture, ranching. *(low carbon land uses)*	Small or large scale farmers, cattle ranchers, absent land owners	Financial returns, policy	Current use of land, area under plantations versus other land uses in a larger landscape, rate of planting at landscape level
Small scale plantings or agroforestry	No economic activity, fallow, agriculture, ranching. *(low carbon land uses)*	Small or large scale farmers, cattle ranchers, absent land owners	Financial returns, supply of agricultural products, policy	Current use of land. area under plantations versus other land uses in a larger landscape, rate of planting at landscape level
Reduced impact logging (alternative technologies)	Conventional logging *(loss of carbon)*	Logging companies	Financial returns, lack of technology and knowledge	Damage levels and area logged
	Deforestation (commercial) *(loss of carbon)*	Logging companies, cattle ranchers, commercial and subsistence farmers	Opportunity cost of land, need for land	Forest cover

Table 3: Types of leakage likely to be associated with baseline drivers and project activities, for different types of projects.

Project activity	Baseline driver to be neutralized	Type of Leakage	Causes of leakage
Conservation	Deforestation	Primary: activity shifting due to lack or inappropriate alternative livelihood options provided by the project	Opportunity cost of land (to secure land tenure, food supply, or financial returns)
		Primary – refusal of the alternative livelihood options, leading to activity shifting	
		Secondary – 'super-acceptance' of the alternative livelihood options	
		Secondary – market effects: limited to cases when deforestation is driven by market forces, rather than subsistence	Financial returns caused by market effects
	Logging	Primary – shifting of logging to elsewhere, or intensification elsewhere, conducted by same baseline agents	Demand for logs, and no livelihood options provided
		Primary – non-adoption of livelihood options (or partial adoption), leading to activity shifting	Livelihood option provided is inadequate
		Secondary – market effects	Reduction in production leads to changes in supply and demand equilibrium
		Secondary – 'super-acceptance' of the livelihood options	Livelihood option attracts other actors previously not involved with the baseline
Afforestation and Reforestation	No land use or agricultural use	Primary – afforestation on productive agricultural land or land demarcated for development.	Competition for land leading to deforestation elsewhere
		Secondary leakage – market effects	Over supply leads to reduction in prices, leading to increased demand or causing a reduction in supply elsewhere
Alternative technologies (e.g. RIL)	Logging	Primary – activity shifting, if new technologies are imposed on baseline agents, and loggers move elsewhere	E.g., intensification of extraction rates elsewhere, by baseline agents, because of failures in the project
		Leakage – market effects, if the technologies lead to changes in the volume of forest outputs	E.g., intensification of extraction rates elsewhere, by other actors, as a response to reduction in supply caused by the project

Table 4: Example of apportioning potential leakage to baseline agents.

Baseline driver	Baseline agent	Timeframe		
		Short term	Medium term	Long term
Deforestation	Subsistence farmers	25 %	15 %	5%
	Cattle ranchers	0 %	35 %	45 %
Logging	Logging companies	50 %	50 %	50 %

Table 5: Apportioning potential leakage to baseline agents – a hypothetical example for the Noel Kempff project.

	Short term (0-10 yrs)	**Medium term (10-20 yrs)**	**Long term (20-30 yrs)**
Local communities	2%	3%	5%
Migration 'sporadic colonisation'	0%	25%	0%
Agricultural frontier	0%	5%	60%

Figure 1: Decision tree for identification of types of leakage likely to impact land use projects.

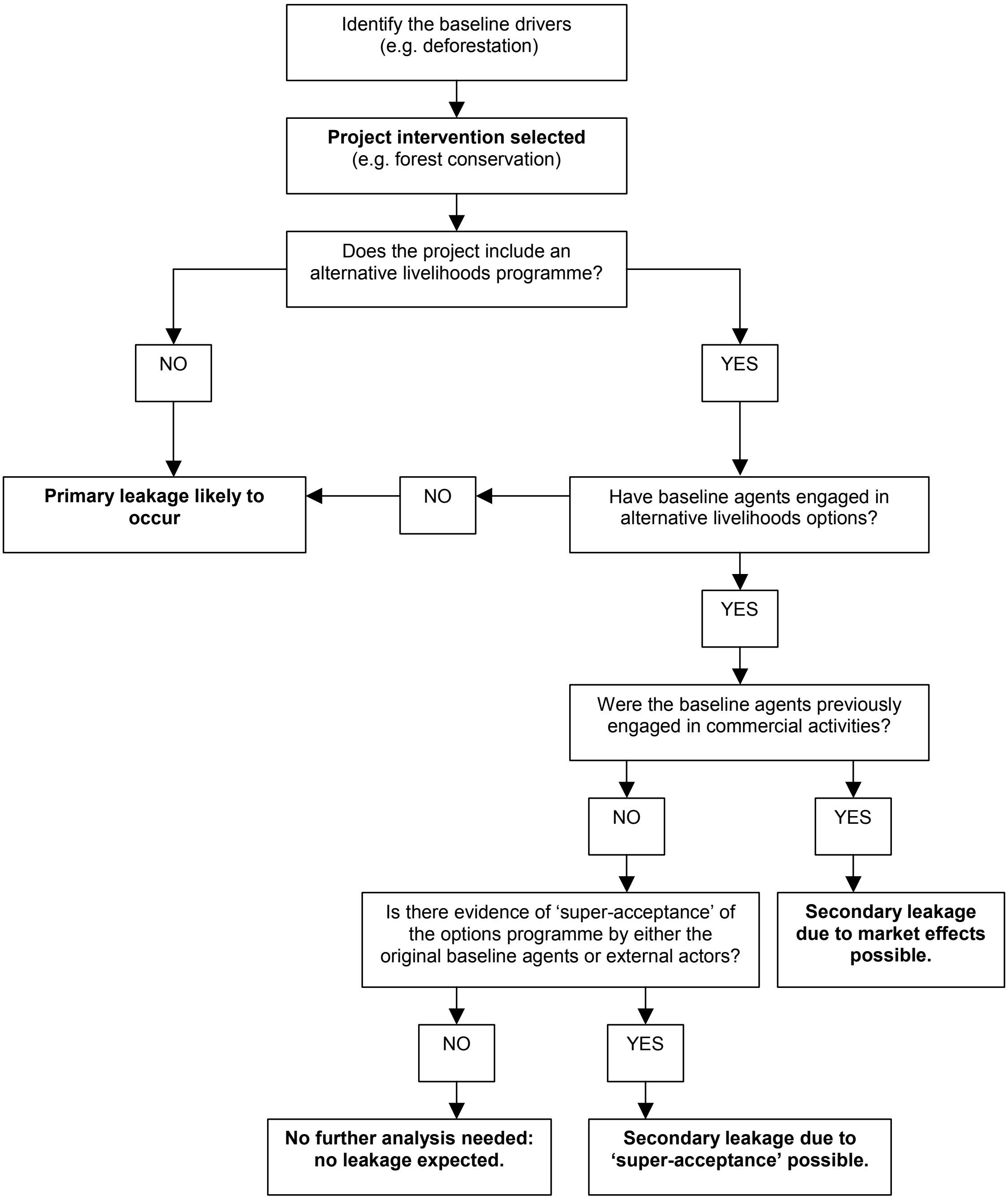

Figure 2. Decision tree applied to the Noel Kempff Project.