A DECISION MATRIX APPROACH TO EVALUATING THE IMPACTS OF LAND-USE ACTIVITIES UNDERTAKEN TO MITIGATE CLIMATE CHANGE

An Editorial Essay

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Abstract. Land-use activities that affect the global balance of greenhouse gases have been a topic of intense discussion during ongoing climate change treaty negotiations. Policy mechanisms that reward countries for implementing climatically beneficial land-use practices have been included in the Bonn and Marrakech agreements on implementation of the Kyoto Protocol. However some still fear that land-use projects focused narrowly on carbon gain will result in socioeconomic and environmental harm, and thus conflict with the explicit sustainable development objectives of the agreement. We propose a policy tool, in the form of a multi-attribute decision matrix, which can be used to evaluate potential and completed land-use projects for their climate, environmental and socioeconomic impacts simultaneously. Project evaluation using this tool makes tradeoffs explicit and allows identification of projects with multiple co-benefits for promotion ahead of others. Combined with appropriate public participation, accounting, and verification policies, a land-use activity decision matrix can help ensure that progressive land management practices are an effective part of the solution to global climate change.

1. Introduction

Though there has been much contentious debate over whether and how land-use activities should be included as accredited greenhouse gas mitigation activities under the Kyoto Protocol, decisions at the last several meetings of the Conference of the Parties (COP) make it clear that greenhouse gas 'removals by sinks' will be pursued and accredited. In the first commitment period, Annex I countries with net domestic greenhouse gas emissions due to afforestation, reforestation and deforestation (ARD) in 1990 must report emissions and net changes in carbon stocks resulting from activities undertaken since 1990 (Article 3 in UNFCCC, 1998; Noble and Scholes, 2001). Annex I countries may also choose to account for human-induced sources and sinks from other domestic land-use activities including revegetation and forest, cropland or grazing-land management undertaken since 1990 (Decision 11 in UNFCCC, 2001). In addition, Annex I nations may acquire

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emission reduction credits from afforestation and reforestation projects through the Clean Development Mechanism (CDM) for projects in developing countries (Article 12 in UNFCCC, 1998; Decision 17 in UNFCCC, 2001), and through Joint Implementation (JI) for projects in other Annex I countries (Article 6 in UNFCCC, 1998). The door has been left open for additional land-use change and forestry activities to contribute to accredited emission reductions in future commitment periods.

A primary reason that land-use projects are a contentious element of the climate change accords is their potential for causing unintended environmental and socioeconomic harm. If terrestrial carbon accumulation is the sole metric by which projects are judged, land-use activities such as new monoculture plantation forestry, management strategies which increase the risk of catastrophic loss of forest land to fire or disease, and even the replacement of a native forest by faster growing species may become accredited, despite their obvious negative environmental impacts. Similarly, projects with negative socioeconomic impacts such as loss of local income generation, long-term soil fertility or food security, could potentially be funded through the climate change accords. On the other hand, sinks projects may provide new resources for community development and environmental improvement as well as for climate change mitigation (Brown, 1998). Local management of native forests can increase rural income and maintain biodiversity, while more sustainable management of agricultural soils can enhance soil fertility and promote carbon sequestration simultaneously (Klooster and Masera, 2000; Lal and Bruce, 1999). Positive and negative impacts are likely to be project specific, depending on the baseline land use and subsequent land management practices (IPCC, 2000).

In recognition of the serious potential risks and benefits of CDM land-use projects specifically, the seventh COP agreed that guidelines should be created to address the potential environmental and socioeconomic impacts of these projects (UNFCCC, 2001). The Parties have also stated more generally that climate change mitigation activities should 'promote sustainable development' and be designed specifically to minimize adverse social, environmental and economic impacts on other Parties, including developing countries (Articles 2, 3, 12 in UNFCCC, 1998; Decision 9, 17 in UNFCCC, 2001). In addition, land use, land-use change and forestry activities should contribute 'to the conservation of biodiversity and sustainable use of natural resources' (Decision 11 in UNFCCC, 2001). To ensure that no net harm is done to local ecosystems or communities, and that socioeconomic and environmental co-benefits are realized, a robust and enforceable framework for land-use project evaluation should be established.

Borrowing from the field of decision analysis, we propose such a framework for evaluating the full scope of climatic, environmental and socioeconomic impacts of domestic and international land-use projects: a multi-attribute land-use activity decision matrix. The primary advantages of a decision matrix approach are that (1) it allows a project's environmental, socioeconomic and global climate impacts to be quantified simultaneously, in a flexible, participatory and transparent manner; (2) it can be used to screen out projects that do not demonstrate net positive impacts, ensuring that only projects with net socioeconomic and environmental benefits receive emissions reduction credits; and (3) it can identify projects with numerous potential co-benefits so that they can be put on the 'fast-track' for review and approval. Developers will have no incentive to exaggerate projected benefits or minimize projected drawbacks of their proposed land-use projects if they are held to those projections, and are either required to perform mitigation or are awarded fewer credits if they do not meet them. This approach complements standards and criteria, which set minimum requirements, but which on their own do not allow an overall evaluation with tradeoffs among positive and negative impacts. It also avoids the pitfalls of 'positive lists', which do not take local conditions into account.

2. The Land-Use Activity Decision Matrix

The field of Decision Analysis develops tools that facilitate the resolution of multi-stakeholder, multi-criteria decisions. Over the last two decades, multi-attribute utility theory has been used in a variety of settings to help make environmental policy decisions where cost-benefit analysis is perceived to be inadequate (e.g., von Winterfeldt, 1987; McDaniels and Roessler, 1998). Whereas this kind of tool is commonly used to choose a single best alternative from among several (e.g., the best project for a given site), we propose a land-use activity decision matrix be used to determine whether a proposed CDM, JI or domestic land-use project meets a multi-criteria standard. Projects will meet the standard if the expected net climate, environmental and socioeconomic impacts are all positive and if the sum score of all categories is greater than a predetermined threshold.

The land-use activity decision matrix structure can be envisioned as a table with a list of potential project impacts as row labels, and the set of projects to be evaluated or compared as column labels. For every project, the intensity of each impact is estimated and assigned a score on a predetermined scale, filling in the cells of the matrix. In addition, a negotiated weight reflecting the relative importance of each impact (constant across projects) can be applied to allow explicit tradeoffs among project impacts within a single project. A cumulative score for each project can be calculated by summing the product of each impact score and its respective weight across all impacts. Of central importance in the theoretical framework is that the impacts can be scored in a way that may not translate easily into dollars, thus avoiding the drawbacks of more traditional cost-benefit analysis using contingent valuation (Gregory et al., 1993). The assigned weights make tradeoffs among different impacts explicit and consistent across all projects. We suggest the matrix format, as opposed to a simple list of impacts for any given project, to make it clear that if project evaluation is systematic and considers the full range of impacts in every case, comparisons among projects are simple and allow limited resources to be used for the greatest benefit.

2.1. THE IMPACTS LIST AND IMPACT SCORING

The most important part of the decision matrix is its list of impacts. In past practice, the only criteria for including an impact in a final list of impacts are that (1) one must be able to compare projects according to a single impact such that the project with a higher score for a single particular impact reflects an actual preference for that project over one with a lower score, all else being equal; and (2) as much as possible, each described impact should be independent of all others in the list to avoid double counting of impacts (Gregory et al., 1993). Impacts can also be aggregated into groups or classes of impacts at several levels. This aggregation step is useful for identifying collections of impacts that may not apply to a given project, focusing impact assessment on the most relevant ones. In the case of evaluating land-use activities, the impacts of projects fall into three broad categories: global climate impacts, environmental impacts, and socioeconomic impacts. Under each of these categories would fall specific impacts and impact groups such as net carbon flux, water quality, and local income generation. Our proposed list of impacts (Table I) reflects our primary concerns and expectations, and is an example of a comprehensive list of the potential positive and negative impacts of climate change driven land-use projects. Any eventual list of impacts should be developed in a participatory manner and should reflect the concerns of all stakeholders as well as information gleaned from experience with early projects.

When a proposed or completed project is evaluated, evaluators would assign a score to each impact indicating the expected or actual impact level from the project. A typical scoring scheme could be a range from +5 to –5, where +5 indicates a very positive impact, –5 indicates a very negative impact, and 0 indicates no discernable effect. For the matrix to work, it is essential that quantifiable metrics be defined for each score level of each impact so that project evaluation is based on consistent and objective measures. A simple approach to quantifying impact intensity is to assign an improvement of 20% or less over the baseline a score of 1, 20–40% improvement a 2 and so on.* A second approach would score each impact on its own natural scale, for example in tons C ha^{-1} yr^{-1} for carbon flux or hectares for wetland habitat (Gregory and Slovic, 1997). With the second approach, the weighting scheme must be carefully developed to allow explicit tradeoffs among impacts measured on different scales. For example, stakeholders must agree on the number of hectares of wetland loss that can be compensated by a gain in hectares

* Simple scoring for project impacts could be based on relative improvement or deterioration. Such a scheme could grant a score of 1 for $<$20% improvement in a given impact (–1 for $<$20% deterioration), $\pm$2 for 20–40%, $\pm$3 for 40–60, $\pm$4 for 60–80%, and $\pm$5 for $>$80% improvement or deterioration.

Table I

Potential impacts of land-use activity projects

Global climate impacts	Environmental impacts	Socioeconomic impacts
▶ *Greenhouse gas fluxes* • Short-term (1–5 years) ⋆ CO_2 – Net aboveground carbon flux – Net belowground carbon flux ⋆ Fossil fuel use ⋆ Net methane flux ⋆ N_2O production ⋆ Soot/particulates ⋆ Production of other aerosols† • Long-term (5–50 years) ⋆ CO_2 – Net aboveground carbon flux – Net belowground carbon flux ⋆ Fossil fuel use ⋆ Net methane flux ⋆ N_2O production ⋆ Soot/particulates production ⋆ Production of other aerosols† ▶ *Land surface parameters* • Latent heat flux (evaporation) • Sensible heat flux (air circulation) • Radiant heat flux (albedo)	▶ *Local climate* • Maintain/restore historic hydrologic regime • Ground surface temperature† ▶ *Air quality* • Carbon monoxide • NO_x • SO_x • Volatile organic compounds ▶ *Water quality* • Dissolved oxygen levels • Salinity† • pH† • Sediment load ▶ *Soil condition* • Erosion • Nutrient capital • Desertification • Salinity • Compaction ▶ *Water and soil contamination* • Agricultural and forestry-related ⋆ N, P, K ⋆ Pesticides ⋆ Herbicides • Industrial ⋆ Metals ⋆ Petro-chemicals ⋆ Phosphates • Human and animal waste ⋆ Bacteria ⋆ N ▶ *Biological diversity* • Preservation of endangered/threatened/rare species • Native plant diversity • Genetic diversity • Introduction of alien invasive species • Use of genetically modified organisms (GMOs) ▶ *Habitat* • Terrestrial • Aquatic • Wetlands ▶ *Resistance/resilience to stress* • Fire • Pests/pathogens • Hurricanes or storms • Floods • Climate change	▶ *Local revenue from market commodities* • Timber • Agriculture • Livestock • Non-timber forest products ▶ *Non-market commodities* • Food • Fiber • Fuel • Water ▶ *Net job opportunities* • Short-term (1–5 years) • Long-term (5–50 years) ▶ *Economic equality* ▶ *Community involvement* • Local capacity building • Use of local talent • Use of goods from local resources • Involvement of women/minority groups ▶ *Local culture* • Protection of religious/spiritual/historical significance of project area • Recreational importance of project area ▶ *Migration into project area*† ▶ *Human health and safety* • Ambient exposure ⋆ Chemicals ⋆ Particulate matter • Risk of disease • Risk of occupational injury/illness in existing or newly created jobs

At the coarsest scale of analysis, we are concerned with three kinds of impacts: global climate, environmental and socioeconomic. Each of these impact categories is comprised of sub-categories. Projects should be evaluated at the finest level of detail in the impacts list. Impacts marked † are those for which the sign (+ or –) of a given change is dependent on both location and context. For definitions of technical terms, see Botkin and Keller, 2000.

of riparian area or by a reduction in aquatic nutrient loads measured in kg ha^{-1} yr^{-1}.

Regardless of the adopted impact measurement approach, each land-use project should be evaluated for climate, environmental and socioeconomic impacts in relation to an explicitly agreed upon baseline. The most workable baseline for evaluating such a comprehensive suite of impacts is likely to be the existing land use. However, for assessing the greenhouse gas impacts of a project, it may be more suitable to employ the same baseline used for assigning carbon credits to ARD projects, if it is different. The decision matrix evaluation approach is flexible enough to allow different baselines for different sets of impacts. Independent of the chosen baseline(s), evaluating all impacts together within the proposed framework will allow the award of carbon credits to be tied directly to a project's estimated environmental and socioeconomic co-benefits.

2.2. THE WEIGHTING SCHEME AND MULTI-IMPACT EVALUATIONS

A decision matrix provides flexibility to project developers through its system of tradeoffs among the different impacts. Matrix developers assign numbers (e.g., from 1–10 or 1–100) to each impact that reflect relative weights, where impacts given the same weight are viewed as equally important. For example, an increase in belowground carbon accumulation may be preferred over the same increase in aboveground carbon accumulation because the former kind of carbon storage may be viewed as less susceptible to wildfire risks. This preference could be made explicit by assigning belowground carbon twice as much weight as aboveground carbon.

By summing the product of impact weights and scores for each category and in total, scores for a project's expected climate, environmental and socioeconomic impacts can be determined. By advocating a weighting scheme and calculation of cumulative project impacts we recognize that negative impacts may not always be avoidable and permit numerous or larger positive impacts to offset fewer or smaller negative ones. However, we believe there should be some restrictions on which impacts can balance one another. We recommend that impact scores be permitted to balance one another only *within* the broader categories of global climate, environmental, and socioeconomic impacts. For a project to be allowed to proceed, it should achieve a net score of zero or greater in each of these impact categories. This means that positive global climate impacts could not offset negative socioeconomic or environmental impacts. We propose this restriction in part because projects that improve or 'do no harm' to local environmental and socioeconomic conditions are more likely to gain local support, and as a result, are more likely to succeed over the long term. Projects expected to result in net harm may meet with resistance or even resentment toward not only the project itself, but toward the overall goal of climate change mitigation. In addition, if projects are to be consistent with the sustainable development objectives of the Kyoto Protocol, neither poor communities nor the environment should experience net harm from a project designed to mitigate greenhouse gas emissions.

While in practice it may be more difficult or expensive to design the ideal 'win-win-win' projects, this restriction does not preclude 'win-0–0' projects from being approved. However, should review boards choose, thresholds can be established at values greater than zero to require not only no net harm, but discernable net benefits as well. In practice, thresholds of any kind should inspire mitigation steps to be included as part of any project proposal.

2.3. UNCERTAINTY WITHIN THE DECISION MATRIX

The issue of uncertainty is of primary importance in all aspects of climate change science and policy. As a result, our proposed matrix approach incorporates explicit evaluation of uncertainty in the same structure as direct impacts. We recommend that a simple semi-quantitative estimate of uncertainty be associated with each estimate of an impact score using uncertainty ranges such as those used in the Third Assessment Report (IPCC, 2001a,b). Project developers should have to state that the estimated improvement or deterioration in each impact is, for example, virtually certain, very likely, likely, of medium likelihood, unlikely, very unlikely, or exceptionally unlikely.* While aggregating uncertainties across impacts can be problematic, we suggest combining individual uncertainty estimates into a weighted average using the same weighting scheme adopted for impacts. This weighted mean uncertainty is not equivalent to an overall estimate of project impact uncertainty, but can highlight projects with high overall uncertainty for closer scrutiny. Further, projects with more certain outcomes for a given positive impact score should be favored over less certain ones at all levels of the approval process. Thresholds for uncertainty may also be devised to filter out high-risk projects.

3. Implementation of a Land-Use Activity Decision Matrix

3.1. ESTABLISHING AN INTERNATIONAL FRAMEWORK

Internationally, the COP could develop a land-use activity decision matrix with the involvement of non-governmental organizations (NGOs) and business groups. For CDM projects, designated operational entities would carry out evaluations using this matrix framework during project validation, and later, project verification. Alternatively, a matrix could be developed and used by any national government

* Virtually certain is >99%, very likely is 90–99%, likely is 66–90%, of medium likelihood is 33–66%, unlikely is 10–33%, very unlikely is 1–10%, and exceptionally unlikely is <1% chance as used in Working Group I's Third Assessment Report (IPCC, 2001a). Working Group II (IPCC, 2001b) uses an alternate scheme proposed by Moss and Schneider (2000) for assessing and reporting uncertainty. For land-use project impact uncertainty assessment we recommend that a single scheme be agreed upon and guidance be given to the project developers and reviewers who will use it.

during the approval process for domestic, CDM and JI land-use projects. Additional decision matrices could also be designed and applied on regional or local scales, involving stakeholders for specific projects.

In any of these cases, we see important roles for the international community in developing and diffusing such an impact assessment tool. In particular, the effectiveness of any project evaluation process depends on trust in the objectivity and accuracy of the project assessment. The IPCC could be responsible for developing a comprehensive impact list that can be adopted or modified by the COP, by national governments, or by other matrix implementers. The IPCC would also be an ideal objective and qualified body to design clear quantitative metrics for the scores for each impact. Regardless of project locale, assessing the level of projected impacts in an internationally consistent manner will lend integrity to the project assessment process. A final important role for the international community is in developing local and national capacity for rigorous climate, environmental and socioeconomic impact assessment. Training and funding for the program administrators and natural and social scientists to evaluate project proposals will be important to the successful implementation of the decision matrix or any similar evaluation process.

3.2. MATRIX DEVELOPMENT AND APPLICATION

Impact weights and thresholds within the decision matrix could be agreed upon internationally, nationally or regionally, and would likely be the result of a complex and potentially contentious political process. The opinions of NGO and local community stakeholders should be incorporated at all levels in order to gain their confidence in the final evaluation process. The explicit trade-off weights and threshold values will also better reflect the land-use priorities of the entire national or international community if there is greater participation and democracy in decision-making. In addition, the very exercise of assigning the weights requires transparent discussion of the relative importance of individual impacts to each stakeholder group.

Whether implemented by the COP or by national governments, we see three stages where a decision matrix evaluation framework would be useful: first as a screening process where compliance with thresholds must be demonstrated, second as qualification for expedited treatment for superior projects, and finally as an enforcement tool in project certification for emission credits. The primary goal of any project impact evaluation process is to ensure that projects with net negative environmental and socioeconomic impacts are not pursued. Screening proposals is a critical first step toward preventing damaging projects from being undertaken in the first place. In addition, projects that can demonstrate net benefits in all categories could receive an expedited review, approval and registration process, or 'fast-tracking'. In the end, certification of emission credits should be made contingent not only on the ability to verify emissions reductions, but also on meeting environmental and socioeconomic requirements (Vine et al., 2000) including contractual agreements, land-use activity decision matrix thresholds, and other established standards and criteria. If actual impacts are more negative than those estimated at the time of project approval, project implementers should be required to perform mitigation, or credits received for the project should be reduced. Making the certification of emissions credits contingent on achieving initial estimates of matrix scores instead of minimum standards should prevent project implementers from exaggerating project benefits during the pre-implementation evaluation. Ultimately these kinds of incentives and accountability should result in a 'ratcheting up' of project quality over time.

3.3. LOCAL AND REGIONAL PARTICIPATION

At the regional or provincial level, decision matrices could be developed with impacts and weights that reflect priorities different from those at the national level. Delegation of regulatory authority below the national level is quite common and well-justified, as long as reasonable minimum criteria are maintained. At the local level, the decision matrix could be used in a more participatory fashion with local evaluations used as a supplement to those provided by project proponents or national agencies. Using the matrix at various stages and all levels of project implementation would encourage project developers to work toward a consensus among all project stakeholders during a project's conception and early development.

A concern that our decision matrix cannot adequately address is the problem of aggregation, particularly as it relates to cumulative impacts of multiple projects in the same region. Because the matrix accepts tradeoffs among impacts, new projects must be considered in light of other projects occurring in close proximity. If all neighboring projects accept the same negative tradeoffs for the same positive benefits, the actual cumulative effects in a region may differ from the additive effects of the individual projects. Benefits may be reduced or enhanced for a given project if many similar projects are implemented in the same area. Also, the implementation of multiple identical projects with the same possible vulnerabilities (e.g., to fire or pest outbreak) may increase the chances of large losses of accumulated and credited carbon (Breshears and Allen, 2002). For this reason, the CDM executive board and national governments should take into account the full range of approved and proposed projects during project review and registration, a process facilitated by the systematic matrix evaluation structure. Decision-making procedures can also take account of the need for a diverse portfolio of land-use projects by increasing the reward for projects that do not simply maximize carbon accumulation.

To be successful in promoting sustainable projects, the land-use activity decision matrix must be accompanied by other socioeconomic and environmental safeguard policies. Such policies should include information disclosure, local stakeholder consultations at early stages of project development, prior and informed stakeholder consent, compensation for adversely affected individuals, an independent appeals process, and transparent and participatory procedures for project evaluation using the matrix.

4. Conclusion

If applied consistently, the land-use activity decision matrix is a transparent and systematic framework for evaluating and comparing all proposed land-use projects, and for highlighting those that are expected to have significant net climatic, environmental, and socioeconomic benefits. We do not expect decision matrix evaluations to solve all of the problems of land-use and development projects, because wherever there are tradeoffs, there are inherently conflicts of interest. However, we believe that if conscientiously implemented, the decision matrix approach could lead to more honest and successful negotiations among stakeholders. In addition, land-use policy driven by climate objectives, if done well, has the potential to incur significant benefits to biodiversity, local economies, quality of life, and ecosystem services. Our proposed evaluation approach can help ensure that these co-benefits are considered early on in project design and are actually realized for local communities and ecosystems.

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