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Leslie Lipper and Romina Cavatassi

ESA Working Paper No. 03-13

July 2003

Agricultural and Development Economics Division

The Food and Agriculture Organization
of the United Nations

www.fao.org/es/esa

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Leslie Lipper
Agricultural and Development Economics Division
Economic and Social Department
Food and Agriculture Organization
Italy
e-mail: leslie.lipper@fao.org

Romina Cavatassi
Agricultural and Development Economics Division
Economic and Social Department
Food and Agriculture Organization
Italy
e-mail romina.cavatassi@fao.org

Abstract

Land use change is a key requirement for improving rural incomes and making a significant reduction in poverty levels globally. Over 70% of the world's poor are located in rural areas, with land use as a major source of subsistence. Improving the productivity of their land use systems is essential for increasing incomes and food security among them. Land use change is also a relatively low cost and rapidly implementable means of climate change mitigation. To the extent that the land use changes required for poverty alleviation coincide with that required for carbon sequestration, significant synergies can be harnessed in meeting both objectives. Estimates of predicted supply costs and demand prices indicate that several types of land use change appropriate for small and low income landusers will be a competitive source of emission reduction credits, although again there is considerable uncertainty in the final form of the market. However, even where there is significant potential for sequestration payments to contribute to poverty alleviation, considerable effort will be required to move from the objectives to the reality. In some cases this may be made through the structure of carbon sequestration payment programs, to address the investment and insurance needs of poor producers and provide adequate incentives for participation. In other cases larger institutional and policy reforms may be necessary in order to create the conditions necessary for poor landusers to benefit from carbon sequestration payments.

Key Words: Carbon Sequestration, Land Use, Land Use Change, Poverty Alleviation, Technology Adoption

JEL: Q2, Q12, O0, O13

* The authors are deeply grateful to David Cooper for insightful comments and Irini Maltsoglou for research assistance. The usual disclaimers apply.

Land use change is a key requirement for improving rural incomes and making a significant reduction in poverty levels globally. Over 70% of the world's poor are located in rural areas, with land use as a major source of subsistence. Improving the productivity of their land use systems is essential for increasing incomes and food security among them. Land use change is also a relatively low cost and rapidly implementable means of climate change mitigation. To the extent that the land use changes required for poverty alleviation coincide with that required for carbon sequestration, significant synergies can be harnessed in meeting both objectives. Using payments for the adoption of land use systems which generate sequestration has been touted as a "win-win" solution where both environmental and poverty reduction goals can be attained. Most of the mechanisms being developed for exchanges of carbon emission offset credits with developing countries explicitly require the consideration of poverty alleviation and sustainable development goals, including the Clean Development Mechanism under the Kyoto Protocol, and the recently established Biocarbon Fund under the World Bank.

However, it is also the case the land use changes which lead to poverty reduction may conflict with carbon sequestration, or be much less efficient than other types of land use change as a source of climate change mitigation, just as carbon sequestering land use changes may actually exacerbate poverty. Clearly some categorization of landuse changes in terms of their impacts on poverty reduction and carbon sequestration will be useful for targetting efforts. Information on the conditions under which tradeoffs versus synergies are present between poverty alleviation and carbon sequestration is essential for designing projects which generate both, as well as indicating the need for compensation in tradeoff situations. With better information about where the opportunities and constraints lie in achieving poverty reduction through carbon sequestering land use change, a systematic assessment of their implications for project and institutional design and policy needs to enhance the potential for successful outcomes on both objectives can be made.

In this article we address the key issues which will determine the impact of landuse change on the joint reduction of poverty and carbon sequestration, describing the potential as well as the constraints. We begin with a brief discussion of the types of land use change that generate carbon sequestration, their relevance to low income landusers and their potential for generating sequestration. This is followed by a description of the major sources of payments or funding for the provision of joint sequestration and poverty alleviation through land use change in developing countries, and the types of activities funded under each, as well as an overall assessment of the market for carbon credits. In Section II we assess the incentives for poor landusers to participate in carbon sequestration programs and in Section III the relative competitiveness of poor landusers in supplying carbon credits is examined through an analysis of both abatement and transaction costs. Section IV concludes the paper with a discussion of the implications of the analysis for the design of carbon payment programs which also generate poverty alleviation and the policy and institutional reforms necessary to promote these.

I. Links Between Carbon Sequestering Land Use Change and Poverty Alleviation

A. The role of carbon sequestration through land use in mitigating climate change.

There are many land use activities which generate carbon sequestration and thus counteract the impact of emissions made elsewhere. Reducing deforestation, generating increased forest stocks through expansion of forestry plantations, adopting agro-forestry activities, reducing soil degradation and rehabilitating degraded forests are all examples of such measures (Tipper, 1997). With the exception of plantation establishment, any of these land use practices can be and have been adopted by low income land users, and have been shown to lead to increased incomes under certain circumstances. The mitigation potential from the adoption of these activities is quite substantial. Niles et al. (2001) estimated the total mitigation potential by geographic region from major classes of land use change occurring between 2003-2012 for developing countries, which is summarized in Table 1 below.

INSERT TABLE 1 HERE

In this study, avoided deforestation was defined relative to a baseline assuming constant deforestation rates. Sustainable agriculture was defined as the adoption of four different types of zero tillage systems (intensive cropping, mixed rotations, mixed rotations with cover crop, and agroforestry plus cover crops) which are associated with increasing levels of sequestration. Rehabilitation of forest lands estimates were based on data from Trexler and Haugen (1995). In all, they estimate that the atmospheric carbon could be reduced by a total of 2.2 billion tons by 2012 through these land use changes. Land use change obviously constitutes a major vehicle for attaining this goal, although the degree to which it may be applied to meet treaty requirements is limited, as is discussed in more detail below.

The categories of land use change used in the Niles study are made up of a wide range of different practices on the ground. There are also additional categories of land use change which were not considered in their study, such as the adoption of low-tillage systems and afforestation, which may generate mitigation. In the context of poverty alleviation it isimportant to that, within each of the broad categories, there are land use systems which are relevant to small-holders and which have in many cases already been the focus of sustainable development efforts. Community forest management programs and no-till agricultural systems have been promoted by development agencies for the benefits they are expected to provide to producers rather than mitigation benefits. It is for this reason that payments for sequestration through land use change appears to be such an attractive proposition: it can help to fund activities which will generate both income growth and environmental improvement. However before jumping to this happy conclusion, it is important to consider the experience that has been obtained with the adoption of these systems of land use among small-holders, which in many cases has been quite poor. It is also necessary to consider the degree to which a market or payment potential exists for the various types of activities, and the degree to which small-holders and low income landusers will be able to compete in supplying mitigation services.

B. Payment Programs with Joint Sequestration and Poverty Alleviation Objectives

One of the most important mechanisms for the joint promotion of carbon sequestration through land use change and sustainable development is the Clean Development Mechanism (CDM). The CDM is a system set up under Article 12 of the Kyoto Protocol that allows investors from Annex B countries (industrialized countries with legally binding emissions reduction commitments) whose greenhouse gas emissions surpass their commitment levels, to obtain a carbon credit from developing countries who, in return, cut their emissions or increase carbon sinks through actions such as conserving forests or investing in clean technologies (Olsson et al. 2002). In November 2001, the Marrakesh Accords were signed by 178 countries, which set the ground rules for CDM operation and confirmed the eligibility of reforestation and afforestation as legitimate activities, but excluded the conservation of standing forests (avoided deforestation) and farming-based soil carbon sequestration, at least for the first commitment period ending in 2012. The accords also set a cap upon the maximum limit of emission reduction credits which can be obtained from sequestration at approximately 175 million tonnes of CO^2 equivalent, which is based on an amount equal to 1% of the base year's emissions (1990) of the Annex B countries, multiplied by five (Black-Arbalaenz, 2002).

Referring back to Table 1., with these restrictions on the CDM, the only land use category which is eligible for CDM credits is forest restoration, for which the total estimated mitigation potential in developing countries was 315.8 million tons of carbon. Potential supply thus is greater than demand, which indicates that competitiveness will be an issue for suppliers. However, for the CDM supply of carbon credits are not defined as solely mitigation, but as mitigation within sustainable development. The intention of the CDM is to stimulate investment on the part of industrialized countries in projects that promote sustainable development as well as carbon sequestration in developing countries (Brown, K. and Pearce, D. W., 1994). The vision is that payments for emissions offsets to developing countries could be used to finance sustainable development, and a set of guidelines to direct this process is currently being developed. How exactly sustainable development will be defined will affect the competitive position of suppliers to the CDM as well as their efficiency in supplying sequestration. In addition, CDM guidelines on the tricky issues of baselines, leakage and permanence will have an impact on the degree of competitiveness of land use projects. There is still considerable uncertainty over the final form the CDM will take and how this will impact the attractiveness of land-use based sequestering changes in the market for mitigation.

Aside from the CDM, there are other potential sources of payments for the adoption of carbon sequestering land use change which may also include poverty alleviation goals. The Biocarbon Fund, recently established by the World Bank with a capitalization of $100 million for the first phase, is one important example. The fund is divided into two separate windows for financing: one which will be targeted to land use changes that qualify for credits under the CDM, and another which allows a broader menu of land uses to be considered, including avoided deforestation and soil carbon sequestration. The Fund explicitly requires that projects include rural development objectives as well as sequestration.

In addition to this source of funding, the U.S. may be a major source of bilateral payment programs even outside of the Kyoto and CDM, with the potential passage of legislation requiring emission reductions and allowing CDM type credit schemes, as is proposed in the "Brownback Bill" (http://brownback.senate.gov/LICarbonFarm.htm). Another example is the Chicago Climate Exchange which facilitates carbon credit transfers between US companies and Mexico, with the inclusion of land use activities for sequestration, comprising soil carbon sequestration from agriculture (http://www.chicagoclimatex.com/html/about.html).

The Global Environmental Facility is another source of funding for sequestration through land use change, which also has sustainable development as an objective. Although the activities eligible for funding under the GEF climate change operational area are limited to energy and technological efficiency issues, a relatively new funding window of integrated ecosystem management does allow for consideration of sequestration through land use change. This operational program is designed to fund activities which generate multiple environmental benefits including biodiversity conservation, conservation and sustainable use of water, prevention of pollution of terrestrial ecosystems, emissions reduction and increasing storage of greenhouse gasses in terrestrial and aquatic ecosystems (GEF 2000). GEF estimates a total of $200 million annually will be needed by 2010 to support this operational category.

Already there are several payment schemes for sequestration through land use change in operation. Over 30 carbon offsetting land use change projects have been developed on a bilateral payment basis although it is still unclear whether they will qualify for CDM based credits (Nasi, Wunder & Campos 2002; Bass and others 1999). These include some projects which specifically target small-holders and limited income producers. The Scolel Té Project in Chiapas Mexico is one such example (De Jong and others 2000). In this project carbon credits generated by forestry activities undertaken by groups and communities of small farmers are brokered through a Trust Fund which also provides technical and financial assistance to the participants. Other prominent examples include the Profafor project in Ecuador which also involves smallholder provision of forestry emission credits (Cacho et.al. 2002).

C. Demand and Supply for Sequestration Through Land Use Change

Any source of funds for carbon sequestration payments will be affected by the ultimate form of a global market for carbon offset credits, which is still being determined. On the demand side of the market, considerable uncertainty exists due to the U.S. withdrawal from the Kyoto Protocol, which is expected to reduce the demand by an estimated 40 to 55 percent although this figure does not take into account demand that may be generated through US national or state legislation or voluntary emission reductions in the country. On the supply side, uncertainty exists regarding when and how Russia will enter the market as a supplier. A full-scale and immediate entrance of Russia into the market could drive market prices down by a third (Black-Arbelaez, 2002). Under these conditions, prices for CERs could drop as low as $3.60 per ton of carbon (Black-Arbelaez, 2002).

A final factor affecting the market is the possibility of banking credits for future commitment periods which may end up in a reduction in supply in the first commitment period and thus higher prices for carbon emission reduction credits. At present, estimates of the most likely range of prices are between $15 to $20 per ton carbon (Smith and Scherr 2002).

II. The Impact of Poverty on Incentives to Participate in Sequestration Programs

A. A Model of Landuse Decision-making

The potential for carbon markets to achieve poverty alleviation depends on the degree to which the poor will be willing and competitive suppliers of credits. Opportunity costs faced by land users are a key determinant of who the willing sellers will be, and the prices they would supply at. The opportunity costs of adopting sequestration are simply the benefits that producers would have to give up in order to provide sequestration. However, this is not solely a matter of comparing profits from different farming systems; issues such as the degree of food security offered by a system, the timing and amount of labor required, and size and timing of investments and returns are also important determinants of the opportunity costs producers face. Since the poor are frequently operating in situations where markets are either inexistent or not well-functioning, it is especially important to consider non-market costs and benefits in assessing their potential adoption behavior.

The opportunity costs of land use change are dependent on the overall benefits that current land use systems provide, not only to the landusers themselves but also to national governments who will also be important decision-makers in the process of deciding to supply sequestration services. For the purposes of analyzing the incentives to adopt sequestration we divide landusers into the following categories:

1. those whose current landuse system yields a lower net private production benefit than carbon sequestering land use over a period of time which is relevant to the decision-maker (say 20 years), even in the absence of payments for carbon sequestration, but who are unable to move to systems with greater benefits due to some sort of barrier (e.g. institutional, financial, social)

2. those for whom the current landuse system yields higher private benefits than carbon sequestering land use change in the absence of carbon payments.

To further facilitate the discussion, a conceptual framework for land management decisions of land users and their implications for the generation of private and public benefits is presented below. In this framework – schematically presented in Figure 1 - the land-using household is taken as the key decision-making unit. Households operate under given socio-economic and environmental conditions which shape their ultimate decisions on land use. These include macro level factors such as the degree of market integration, the presence of infrastructure, agro-climatic conditions etc. These factors will affect the incentives and constraints land users face in making their decisions. In addition, they shape the endowment of resources, e.g. land, labor and capital which households control. These are allocated to various activities in the effort to maintain a livelihood which can be divided into those that are land-use versus non-land use based. The allocation of resources to activities generates outcomes, which in this framework include private production benefits from land use (e.g. income or subsistence), public environmental goods from land use (e.g. watershed functions, carbon sequestration or emissions) and private benefits from non-land use based income. The household decision on allocating resources among activities depends on the relative return or benefit each provides. The rate of transformation between allocated resources and outcomes, or the production functions of the household, are affected by conditioning factors as well as the technologies employed. For example, environmental conditions affect the productivity of agriculture as well as sequestration.

FIGURE 1 HERE

Payments for carbon offsets will affect the relative returns to the household of adopting land use based practices which generate sequestration, and thus affect the overall resource allocation and outcomes of the household. Prior to the possibility of receiving payment for sequestration, the landuser has no incentive to generate this public good. With payments, the amount that will be generated depends on the relative costs and benefits associated with adoption in relation to the "business as usual" case. Referring back to our typology of landusers, for those in the second category there will exist a tradeoff between private production benefits and sequestration: the household will lose some private benefits from land use production in order to generate sequestration. In these cases the level of payment required to encourage adoption is at least as much as the loss of private production benefits. However, the total returns to adopting carbon sequestering land use will not only depend on the payment for sequestration; it will also depend on the impact on the allocation of labor and capital across all activities and their relative returns. For example, if the adoption of carbon sequestering land use practices results in a reduction in labor requirement on the land, then the household could allocate the surplus labor to non-land use activities. Thus the returns to non-land use activities is also an important indicator of the incentives households will have to adopt carbon sequestering land use systems.

The landusers in category 1 are likely to be poor, as poverty is the source of several constraints to the adoption of new forms of production. Poor landusers face several barriers to the adoption of new technologies, even when adoption would mean higher profits for them in the long run. Lack of investment capacity, poorly defined property rights, high discount rates and risk aversion are all important factors which determine adoption behavior of the poor (Lipper 2001; Feder, Just & Zilberman 1985). In the case of this group, the adoption of carbon sequestering land use changes will lead to an increase in private production benefits, e.g. the elusive "win-win" scenario. Referring back to Figure 1, this situation would be represented by a strong positive effect from environmental outcomes to conditioning factors. An example here is improvements to soil fertility associated with the adoption of no till systems, which leads to increases in productivity. Or it may involve a shift from pastoral to agroforestry production. An important factor in determining the viability of these types of transitions is the length of time it takes to realize improvements in benefits associated with the new system, as well as the magnitude. The key issue with this group is overcoming the barriers to adoption which, in some cases, may result in a higher cost of sequestration supply. In section C below, we take a closer look at the barriers which poor producers face in adopting new land use systems based on an assessment of the economic literature, and draw conclusions about their implications for the design of payment programs.

B. The impact of permanence accounting on incentives to supply sequestration

Unlike reductions in emissions, mitigation of climate change through sequestration is reversible, therefore the relative value of credits from sequestration versus emission reductions have been a topic of some debate in the effort to set up markets for emission reduction credits. The implications of the reversibility of sequestration activities is likely to result in some sort of discount factor being applied to prices paid for such services, depending on the perceived risk of sequestration reversal. One method proposed, to deal with the non-permanence of land use, is the ton-year approach (Moura-Costa and Wilson 2000) and is based upon the decay path of CO2 in the atmosphere over 100 years. With this system a land use project would have to keep CO2 from being emitted for 46.4 years in order to receive the same credit as a permanent emission reduction. Annual payments would be adjusted by an equivalence factor of .0215, which will result in a significant reduction to landusers. While this approach is attractive due to lower transactions costs, it also may not generate payment levels sufficiently high to induce land use change (Cacho 2002). Other proposals for handling permanence have also been made such as the Columbian Proposal that calls for a repayment of all emission credits at the end of any sequestration/avoided release project, which could then be renewed for a new project if the sequestering activity is maintained (Kerr 2000). This proposal provides considerable flexibility to buyers and sellers although it also raises questions of sharing risk and liability and higher transaction costs. Whichever way the permanence issue is finally resolved, it will likely result in lower returns to suppliers of sequestration through land use change through higher transactions costs or discounted market prices. In most estimates of market prices for carbon emission reduction credits this factor is not taken into account, thus supply response may frequently be overestimated.

The issue of permanence could result in a reduction of payment levels for sequestration services provided by the poor, if they are perceived as being at higher risk of reversing sequestration practices. This may very well be the case, due to the higher need among the poor to insure against risk, as well as their more limited capacity to do so. Low income providers of carbon sequestration services may be more likely to reverse sequestration practices in the absence of any other mechanisms for insurance which could result in lower carbon payments.

However, permanence issues may also work to the benefit of poor land-users if they are perceived to be permanent adopters due to the overall productivity benefits they stand to gain. This would be the case for producers in Category 1, who have a private financial incentive to maintain the sequestering land use even in the absence of payments, provided that barriers to adoption are adequately addressed. As a consequence identifying in which category landusers fall is important not only for efficient targeting of projects, but also potentially for achieving a diminution in transactions costs through a reduction in the risk of reversal.

C. Barriers to the Adoption of Alternative Land Uses Associated with Poverty

The experience of recent decades has shown that poverty creates a wide array of barriers to the adoption of new technologies in general, and of those that involve a time lag between investment and returns, in particular. . The key issues identified are:i) risk, particularly to food security; ii) high costs of capital and lack of investment capacity; iii)poorly defined property rights and iv) labor usage. These barriers to adoption may be relevant to either Category 1 or 2 of landusers, in the former case they are sufficiently high to preclude adoption, while in the latter case they may result in lower returns to participation.

i. Risk

Livelihood activities generate more than just a stream of income or products, they also provide security by allowing households to cope with the risk of unexpected events, like crop or market failures, sickness in the family etc. One important example for many poor rural households is meeting subsistence food requirements from their own production as a critical means of insuring against food insecurity. Insecurity may arise from the household's lack of access or availability. Either food supplies are not available at an affordable and stable manner or the household is not able to access them due to limited resources. Consequently, the impact on food security of a change of land use system must be considered when assessing the opportunity costs facing the poor in adopting carbon sequestering land use change. This assessment must include consideration of local food markets and supply, as well as household capacity to access sufficient food.

Apart from food market failure, poor land users face other sources of risk which impact their access to food and other goods. In response, they adopt land use activities which allow them to respond to unexpected crises by maintaining a set of assets that they can rapidly liquidate in times of trouble. A standing forest represents a potential source of income, which can be accessed through logging in the case of a sudden need for income. Participation in a sequestration program reduces or removes the potential use of this source of income, and therefore creates a need for other means of insurance to deal with crisis situations. Carbon payments could present an important way of increasing security to poor households, depending on how they are structured and the degree of uncertainty they involve. If sequestration payments are designed to provide insurance benefits, then poor land-users may be much more responsive to the programs.

ii. Investment Capital

One important reason poor farmers do not adopt land use systems that offer higher productivity is their inability to make investments which require financial resources in the short run, in order to obtain benefits in the long run. Low income landusers are often required to obtain financial services in the informal sector, which generally involves higher costs than that of the formal sector. Investment capital is more expensive for the poor, therefore preventing them from making the investments they otherwise would like to undertake, and entailing that a higher rate of return to capital to make the investment attractive (Fafchamps 1999; Lipper 2001). An important issue in facilitating adoption of carbon sequestration among low income landusers is the degree to which programs are structured to allow producers to overcome investment constraints. Payment schemes could be designed to meet investment needs, or credit packages could be offered to participants in sequestration programs.

iii. Labor

Adopting carbon sequestering land use change will most likely result in a change of labor allocation to land use – either an increase as may be the case in moving to agro-forestry from pastoral systems or a decrease as may occur with forest establishment on agricultural land. In the latter case, the potential return to labor released from land use activities will be an important determinant of adoption. In areas where there is a fairly high wage for non-land use labor, sequestering activities that result in a decrease in labor requirements on the land will be more attractive. Alternatively, in areas where there are few non-land use opportunities for labor employment, labor-intensive sequestration activities may be the most attractive alternative. However there are some additional issues to be considered here. First, for people with low nutritional and health status, systems which require a low intensity of labor (e.g. less caloric expenditure) may be more attractive than high intensity systems, even if the overall return to labor is higher in the latter. In this situation the return to calories expenditure is a more important indicator than returns to labor of the opportunity cost of labor. In addition, average returns over the year are often used to calculate opportunity costs of labor, but this may be misleading as the cost of diverting labor from certain activities over the year (e.g. planting, harvesting) could be very high, precluding adopting activities with conflicting labor requirements even though average returns to labor over the season may be higher. The implications of this analysis for carbon sequestration programs is the need for a fairly sophisticated assessment of labor demand and supply in current and sequestering land use systems, including physical effort required and seasonal distribution of labor.

iv. Property Rights

Frequently, poor land users do not hold secure and clear title to their land assets, or operate under systems of common property management that require a capacity for group coordination in order to institute changes. In addition, more than one type of property right may exist for a given land area, such as rights to trees, water, post-harvest residue collection and so on. The poor may have access to only one type of property right affecting a given piece of land and often this is only on informal terms. Frequently land use is driven by the need to establish a property right, e.g. clearing of forestlands for agricultural use. Property rights are a key determinant of the incentives and constraints of land users in making land use decisions. Uncertain or complex property rights reduce the incentives of landusers to adopt sequestering land use as the rewards to do so will be uncertain. Sequestration payment programs, which include poverty alleviation objectives, will thus often be required to include some institutional support for clarifying and establishing property rights and forms of collective management.

v. Returns to Land

In general, low income land users can be expected to have a lower rate of return to their land than others, due to the series of issues related to investment and land use choice discussed above. The stream of income from more capital intensive commercial agriculture will be higher than that which can be obtained from low input subsistence oriented systems on marginal lands. Thus the payment necessary to entice a land-user to forego such income is likely to be lower for poor producers than those capable of engaging in more commercial systems. The implications are that low income land users could potentially be least cost providers of sequestration services, if programs are structured in such a way as to address the various issues which have been raised above including food security, risk management, property rights and returns to labor. However the costs of overcoming such barriers could be prohibitively high and the productivity of carbon supply from landuses associated with the poor will also be important determinants of least cost suppliers considered in the following section.

III. The Competitiveness of Poor Producers as Carbon Suppliers

The cost per unit of supplying sequestration is an important determinant of the returns producers will attain from adoption, as well as their competitiveness relative to other potential suppliers. The costs can be divided into two components: the actual cost of generating the sequestration (e.g. the abatement cost) and the cost of getting the sequestration to market (e.g. the transaction cost). The latter is more frequently focussed upon in discussions of the competitiveness of smallholders and low income landusers in participating in the market, but the former is an equally important issue. The abatement cost is essentially the opportunity cost of sequestering land use adoption divided by the amount of carbon which can be produced by the change. The amount of carbon that can be generated through land use change and hence the cost per unit of carbon sequestration varies considerably by the type of land use activity as well as the initial agro-ecological conditions and technologies employed. It is also important to distinguish between the total production potential of sequestration supply through land use change associated with a particular agro-ecological zone, versus the productivity or the cost effectiveness of sequestration supply from a zone. The former gives a physical estimate of what can be produced, the latter gives an estimate of the cost effectiveness of the production, and it is this measurement, which is most relevant in determining competitiveness in carbon sequestration supply, although the two are often confused.

The following section discusses how poverty might impact the productivity of carbon sequestration supply, and thus the competitiveness of poor producers in carbon markets.

A. Relative Abatement Costs

There is considerable spatial heterogeneity in the biophysical capacity of land and trees to sequester carbon and the cost of the technologies which will be required to accomplish this. The competitiveness of poor land-users in supplying carbon sequestration will be dependent on the biophysical conditions under which they operate, as well as the potential they have for adopting least cost technologies.

A sample of the estimates of abatement costs compiled from various studies and reported in the IPCC Third Assessment Report are presented in the table 2 below.

INSERT TABLE 2 HERE

As can be seen from the figures, these costs fall within the range of estimated carbon demand prices cited above, indicating sequestration through land use change will be competitive, always keeping in mind the caveat that prices may fall lower than expected, and the estimated costs given above do not generally include transactions costs, or even a complete assessment of opportunity costs. However, indications are that some land use changes will be competitive. Native forest regeneration, which is essentially reversing forest degradation, is the least cost method of sequestration for all countries, followed by plantations and then agro-forestry, although for Mexico and Venezuela the difference between the latter two is not very significant. In other countries such as India, agro-forestry is the cheapest means of achieving sequestration through land use. Relative costs are driven by the initial status of the ecosystem (e.g. with or without tree-cover) as well as the land use adopted. Thus countries and regions will vary in terms of their comparative advantage in supplying sequestration through land use change. Cacho et al. (2002) estimated the production costs per ton of carbon for four agroforestry systems on degraded lands in Sumatra and found that systems associated with smallholders were competitive with plantations in carbon productivity (Cacho and others 2002). Smith and Scherr (2002) note that data on the production costs of carbon associated with smallholder systems to date are quite variable, with the opportunity cost of the land and scarcity of tree products as a major determinant. They note that while the production costs of carbon of smallholder systems may be higher than industrial plantations in some cases, non-carbon benefits often offset this disadvantage (Smith and Scherr 2002). Tomich and others 2001 conducted a very detailed study of the opportunity and production costs associated with carbon sequestration in a variety of land use systems in Sumatra and concluded that smallholder systems were competitive in sequestration production, but the question of whether they are competitive with land uses associated with large scale operations (e.g. oil palm plantations) in terms of private profitability is still unresolved (Tomich and others 2001).

The ability of soils to sequester carbon through land management changes varies widely depending on the type of soil, the degree to which it is degraded, and climatic conditions. Antle and McCarl (2001) give comparisons of the productivity of sequestering carbon across varying sites and technologies in the U.S. and found considerable variation. Estimates indicate that highly degraded soils with a significant degree of sensitivity are those through which achieving increases in soil carbon are most costly. Thus, the lands which may have the greatest physical potential to supply soil carbon sequestration may very well be those from which it is most expensive to generate carbon sequestration. Olsson and Ardo also found quite variable levels of soil carbon sequestration productivity over varying ratios of cropping to fallowing and concluded that producers in degraded drylands areas could be viable low cost suppliers of sequestration (Olsson and Ärdo 2002).

Since most forms of payments for carbon sequestration in developing countries carry a dual objective of sustainable development, the competitiveness of land use practices must be judged according to both criteria, rather than sequestration productivity alone. As a consequence, land uses which generate least cost sequestration may not be those that generate least cost sequestration with sustainable development objectives included. The primary example here is plantation establishment which can be a very efficient means of sequestering carbon. However concerns have been raised that carbon markets will stimulate wide-scale plantation development that will crowd out small producers, reduce biodiversity and overall reduce sustainability. Again, the importance of how sustainable development is defined emerges as a critical determinant of which land uses will be promoted under carbon trading programs.

B. Transactions Costs

High transaction costs associated with poor suppliers of sequestration services represent a major barrier to their participation in carbon markets. These costs arise from the small scale and isolated conditions under which poor land-users operate, as well as a higher degree of uncertainty in their rights to land-based property. Transaction costs are defined as the costs of completing a contract, which includes the costs for buyers and sellers to find one another, the costs associated with bargaining and the costs associated with monitoring and enforcing the contract.

Clearly the costs associated with identifying, negotiating, contracting and enforcing sequestration payments are much higher when dealing with small and geographically scattered producers, operating under heterogeneous agro-ecological and institutional conditions. Cacho et al. (2002) found that project costs per hectare and costs of sequestration per ton were negatively correlated with project size, using data from five land use projects. They conclude that the size of the sample is too small to make any definitive conclusions, but project size is likely to be a determinant of competitiveness in carbon markets.

Coordinating and consolidating sequestration supply among groups of poor landholders is the primary means by which transaction costs can be reduced. Carbon projects which consist of coordinated group landuse activities such as community forestry, may be conducted through local level organizations which are already in place, such as local governments, farmers' associations or NGOs. The potential for coordination of smallholder landuse projects is illustrated by the FACE Foundation that has six sequestration projects through land use change located in Latin America, Europe, Asia and Africa. The largest of these is Profafor in Ecuador with 22,500 hectares reforested (Cacho and others 2002). Several other examples of projects involving smallholder coordination in the supply of carbon services are described in Cacho et. 2002, Smith and Scherr 2002 and Orlando etal. 2002. In these projects the costs to buyers of identifying, contracting, and enforcing viable carbon sequestration opportunities among smallholders are reduced through the activities of an intermediary, which most frequently is an NGO. It is important to note however, that the sellers also bear a cost in participating in such group schemes, and this cost must be lower than the benefits that can be derived from participation, in order to provide the incentives for sellers to participate. In some cases these costs are subsidized by the intermediary, particularly those that are interested in promoting overall development objectives, rather than pure carbon market transactions. It is also possible that future buyers may be willing to subsidize such costs by paying higher prices for sequestration credits that carry a "sustainable development" certification, although so far this type of marketing has not occurred.

It is more difficult to overcome the problem of complex and unclear property rights in designing carbon sequestration projects through land use change that involve smallholders. Some sort of institutional development will be required to address this problem, which may or may not require government intervention. In some cases assistance in managing a common property may be all that is required, in others cadastral surveys and titling could be involved. The costs associated with these vary considerably, but can be very substantial, certainly large enough to make sequestration supply very expensive and non-competitive. This is especially likely to be true in cases where property rights need to be established, as in the case of land reforms, resettlement projects or decollectivization programs in economies in transition. However, in these situations the main policy objective is not carbon sequestration, but rather rural development and economic growth. Payments for carbon sequestration may then be an additional source of finance, but not the main or sole source of finance. In contrast, where rights have already been established but assistance is needed in coordinating their use, as is frequently the case with common properties, sequestration payments may be sufficient to provide the incentives necessary for group coordination. Even in this case however, costs can be quite variable and the degree of social capital or capacity to cooperate within a community will be a major determinant of these levels. The Scolel Té Pilot Project in Chiapas Mexico provides clear evidence of this: communities which were found to have intractable internal conflicts were found to be economically infeasible for the supply of sequestration services, while those which had already achieved successful community management of resources were found to be competitive. The differences in costs for establishing community capacity for joint forest management ranged from $52/hectare, in the communities with high levels of social capital, to over $325/hectare in those were conflicts were prevalent (De Jong and others 2000).

IV. Conclusions

Land use changes which have already been identified as potential means of achieving sustainable rural development among small and poor landusers also have a significant potential to contribute to climate change mitigation through sequestration. Most of the facilities that will pay for carbon sequestration through land use change in developing countries also require they contribute to sustainable development objectives, although how these will be defined and their impact on the competitiveness of land use change in supplying mitigation has not yet been determined. Estimates of predicted supply costs and demand prices indicate that several types of land use change appropriate for small and low income landusers will be a competitive source of emission reduction credits, although again there is considerable uncertainty in the final form of the market. Lower levels of demand, higher levels of supply or significant price reductions for non-permanence may result in a very restricted opportunities for suppliers of carbon sequestration through land use change.

The analysis presented here indicates that there is a great deal of variation in the potential for sequestration through land use change to lead to poverty alleviation and that in some cases, the adoption of sequestration will lead to tradeoffs between sources of income for landusers rather than synergies. We've identified three types of information which are necessary in order to assess which category landuse changes will fall into: 1) the costs associated with generating sequestration by landuse change and ecosystem which must include a comprehensive accounting of the opportunity costs the suppliers will bear as well as the associated transactions costs, 2) the benefits which would accrue to landusers, including non sequestration related income from landuse, income to non landuse related labor and income from payments for sequestration, and the 3) costs associated with overcoming barriers to the adoption of carbon sequestering landuse changes. Overlaying these three strata of information will indicate where the greatest opportunities for achieving both poverty alleviation and carbon sequestration lie, as well as where there is potential to enhance sequestration benefits in projects which are primarily development oriented, and poverty alleviation in projects which are primarily oriented towards carbon sequestration.

In many cases the information necessary is already being collected as part of an ongoing assessment (e.g. the Forest Resource Assessment, the Millenium Ecosystem Assessment, Land Degradation Assessment, National Poverty Assessments etc.). In other cases the necessary data is available but the appropriate analyses have not yet been done. This is a task which will require collaboration among academics, international and national agencies and and NGOs to accomplish.

Our analysis has also indicated that even where there is significant potential for sequestration payments to contribute to poverty alleviation, considerable effort will be required to move from the objectives to the reality. In some cases this may be made through the structure of carbon sequestration payment programs, to address the investment and insurance needs of poor producers and provide adequate incentives for participation. Facilitating the capacity of communities and groups to coordinate landuse activities, through the establishment of new institutions or by working with ones already in operation is another important requirement for helping poor producers access benefits from carbon payments. These measures may be largely implemented through project developers and intermediaries operating in carbon markets. Taking measures to stablize food supplies and assigning or clarifying the property rights to land among poor landusers is likely to require a wider support base to accomplish, with government and international development aid as the most likely sources.

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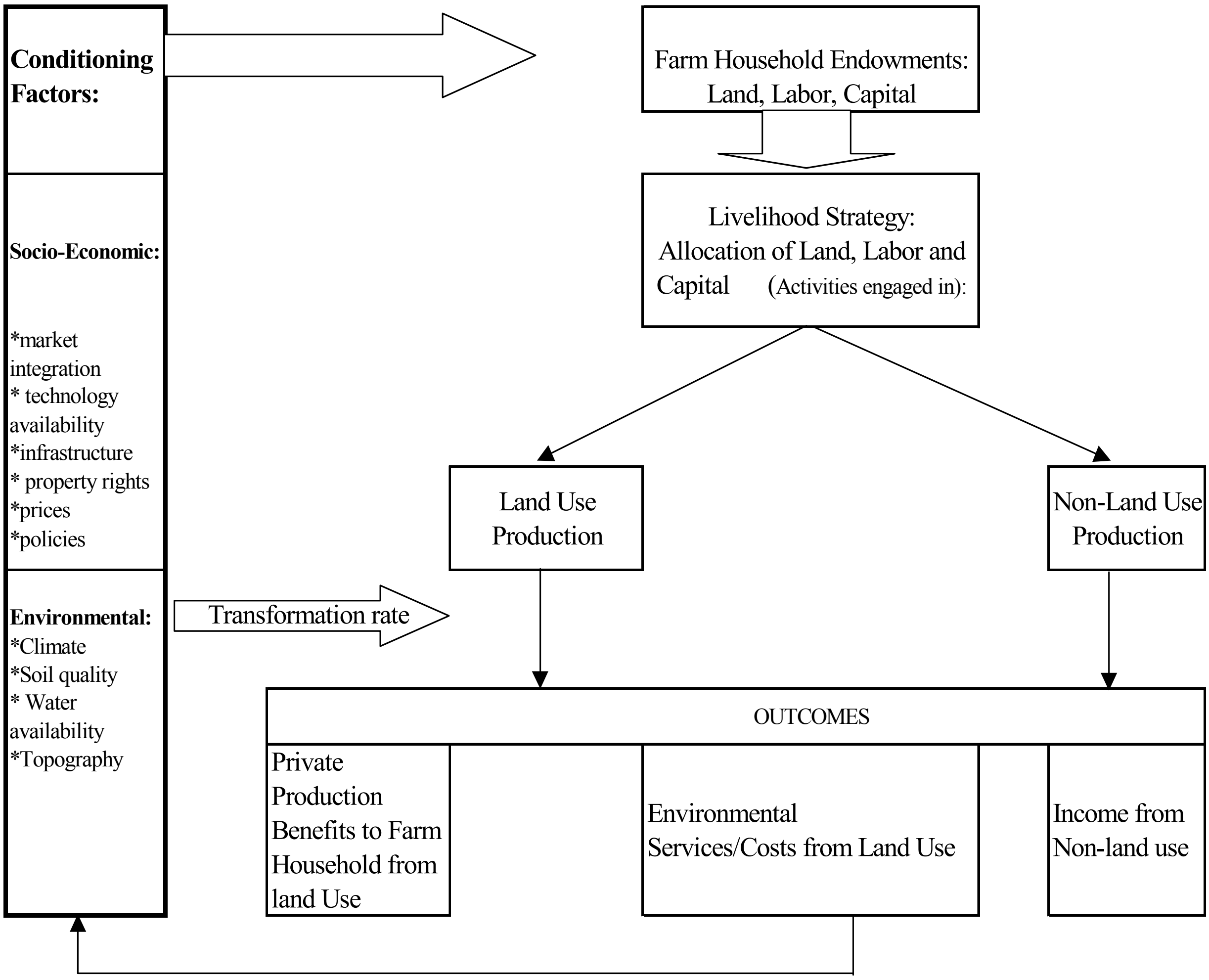
Table 1.
Potential Carbon Mitigation by Land Use Change Category and Region

(M Ton C)	Avoided Deforestation	Sustainable Agriculture	Forest Restoration	Total
Latin America	1097.3	73.9	177.9	1349.1
Africa	167.8	54.1	41.7	263.5
Asia	300.5	160.5	96.2	557.1
Total	1565.5	288.5	315.8	2,169.8

Source: Niles et al. 2001

Table 2. Selected Sample of Unit Costs for Sequestration by Land Use and Country Source: IPCC Third Assessment Report 2001 (Mitigation) Note: Estimates not comparable across countries due to variations in methods				
($/Cton)	Mexico	Venezuela	China (N & NW)	China (S, SW & NE)
Agro-forestry	2-11	20	16.3	9.8
Native Forest Regeneration	.1-4	9	1.3	3.5
Plantation	5-7	17	1.3	5

Figure 1: Conceptual framework for land management decisions.



Authors: L. Lipper, R. Cavatassi

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Agricultural and Development Economics Division (ESA)
The Food and Agriculture Organization
Viale delle Terme di Caracalla
00100 Rome
Italy

Contact:
Office of the Director
Telephone: +39 06 57054368
Facsimile: + 39 06 57055522
Website: www.fao.org/es/esa
e-mail: ESA@fao.org