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The economic determinants of land degradation in developing countries

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SUMMARY

The following paper investigates the economic determinants of land degradation in developing countries. The main trends examined are rural households' decisions to degrade as opposed to conserve land resources, and the expansion of frontier agricultural activity that contributes to forest and marginal land conversion. These two phenomena appear often to be linked. In many developing areas, a poor rural household's decision whether to undertake long-term investment in improving existing agricultural land must be weighed against the decision to abandon this land and migrate to environmentally fragile areas. Economic factors play a critical role in determining these relationships. Poverty, imperfect capital markets and insecure land tenure may reinforce the tendency towards short-term time horizons in production decisions, and may bias land use decisions against long-term land management strategies. In periods of commodity booms and land speculation, wealthier households generally take advantage of their superior political and market power to ensure initial access to better quality resources, in order to capture a larger share of the resource rents. Poorer households are confined either to marginal environmental areas where resource rents are limited, or only have access to resources once they are degraded and rents dissipated.

Overall trends in land degradation and deforestation are examined, followed by an overview of rural households' resource management decisions with respect to land management, frontier agricultural expansion, and migration from existing agricultural land to frontiers. Finally, the discussion focuses on the scope for policy improvements to reduce economic constraints to effective land management.

1. INTRODUCTION

The world's population is expected to continue expanding well into the next century, with much of this population growth occurring in developing countries. An inevitable consequence will be the demand for new crop-land for commercial and subsistence agriculture. How much additional forest and other land needs to be converted to agriculture will depend to some extent on how well the productivity of existing arable land is maintained or even enhanced. Unfortunately, current evidence suggests that much existing as well as potentially productive agricultural land in developing countries is being lost through the processes of land degradation and abandonment. The key features of these processes are the failure of rural households to invest in long-term land improvements on existing agricultural land, abandonment of this land in favour of migration to forest and other marginal lands, and continual expansion of the agricultural frontier through more forest and marginal land conversion.

Far from being a purely technical problem of soil science or plant breeding, the core of the land degradation problem is economic. In developing countries, poor rural households are often found in marginal agricultural areas where land productivity, and therefore household income, are stagnant or declining. Consequently, a rational strategy for poor rural households with limited access to capital and alternative economic opportunities may be to extract short-term rents through resource conversion and degradation, so long as there are sufficient additional resources available in frontier areas that can be exploited relatively cheaply and the cost of access remains low. The result is both increased land degradation and the expansion of agricultural activity on frontier forest and other marginal lands, resulting in further processes of degradation. A brief review of deforestation and land degradation trends in developing countries provides some evidence of the linkage between these trends.

The 1990 global forest resource assessment indicated that the annual deforestation rate across tropical countries over 1981–1990 was approximately 0.8%, or 15.4 million hectares (ha) per annum (FAO 1993). Although the highest rate of deforestation occurs in Asia (1.2%), the area of tropical forests cleared, on average, each year in Latin America, 7.4 million ha, is almost as much as the combined area of forest cleared in Asia and Africa. The largest amount of deforestation is currently occurring in tropical South America (6.4

million ha), followed by insular South-East Asia (1.9 million ha), but the highest rates of deforestation are being experienced in continental South-East Asia (1.6% annually) and Central America and Mexico (1.5% annually).

A statistical analysis of 53 tropical countries has attempted to explain the aggregate economic determinants of tropical deforestation (Barbier & Burgess 1997). The results indicate that increased population density increases forest clearance, whereas rising income per capita and agricultural yields reduce the demand for forest conversion. The latter effects suggest that as countries develop economically and the productivity of their existing agricultural lands improves, there is less pressure for deforestation.

A recent study of global trends in human-induced soil erosion over the period 1945–1990 indicates that over 20% of the vegetated land in developing regions of the world is degraded, much of it suffering from moderate, severe or extreme degradation (Oldeman *et al*. 1990). Deforestation appears to be a major source of human-induced soil degradation in developing regions. In both Asia and South America, deforestation accounts for around 40% of erosion, in Central America and Mexico 22%, and in Africa 14%. Experiments on land clearing throughout the tropics have shown that deforestation leads directly to degradation of soil structure, changes in the chemical and biological properties of the soil, a decrease in the porosity of the surface layer, an increase in soil compaction, and decreases in infiltration rates (Lal 1995).

Lastly, an analysis by Leonard *et al*. (1989) found that the poorest 20% of the rural population in developing countries was mainly concentrated on 'low potential' lands. The latter are defined as resource-poor or marginal agricultural lands, where inadequate or unreliable rainfall, adverse soil conditions, fertility and topography limit agricultural productivity and increase the risk of chronic land degradation. Almost three-quarters of the poorest 20% of the rural population in Latin America, 57% in Asia and 51% in Africa, can be found on low potential lands.

As low potential lands are considered to be prone to chronic land degradation, then clearly the problems of resource management by poor rural households and human-induced soil degradation are linked in developing countries. Moreover, given that many marginal and resource-poor lands are also likely to have been previously forested lands, then a strong rural poverty–deforestation link may also exist. Finally, the evidence that deforestation may itself be an important cause of human-induced soil degradation across developing regions raises the possibility of a 'cumulative causation' link between rural poverty, deforestation and land degradation: poor rural households abandon degraded land for 'frontier' forested lands, deforestation and cropping of poor soils lead to further degradation, which in turn leads to land abandonment and additional forest land conversion, and so on.

2. MANAGING LAND DEGRADATION

The conventional approach to soil conservation in developing countries has been to encourage adoption by farmers of improved farming systems and crop production techniques and 'packages' that have been designed specifically for hilly and marginal lands. Often generous subsidies are made available to farmers to spur adoption. Although improvements in marginal land farming systems and soil conservation techniques are extremely important, there are, as this section will highlight, more fundamental economic considerations such as food, security, land, labour and capital constraints, tenure problems and risk perceptions which will determine farmers' willingness to adopt these improvements. Even the provision of subsidies does not necessarily improve adoption, and in many cases farmers revert to former practices once the subsidies eventually end. Moreover, investments in improved farming systems and soil conservation projects are generally expensive–especially if subsidies are required–and this usually limits the scale and geographical coverage of such investments. If adoption rates are poor, then even the demonstration value of such investment projects and programmes will be limited.

A recent review of different soil conservation projects in Central America and the Caribbean illustrate some of the problems, highlighting in particular the key role of profitability in adoption rates (Lutz *et al*. 1994; Current *et al*. 1995). On the whole, physical conservation measures such as diversion ditches, terraces, and rock walls yield lower financial returns than that of agroforestry. Many of the physical measures actually appear to be unprofitable, and would suggest that farmers are unlikely to adopt them. Even for the measures that are profitable, the length of time required for investments in conservation measures to break even may become a critical problem, particularly for farmers with insecure tenure (Lutz *et al*. 1994). All the agroforestry systems analysed proved to be profitable, although alley cropping, natural and/or planted fallow and green manure systems tend to generate lower returns than alley cropping and perennial intercropping. However, even some of the profitable systems have significant 'waiting costs', with payback periods ranging from 3–6 years.

In many of the agroforestry projects analysed, adoption rates by farmers are low, and where adoption was successful, the farmers often adapted the system to suit their requirements. Nevertheless, there are significant constraints on farmers' willingness to adopt agroforestry systems (Current *et al*. 1995). Systems such as alley cropping are generally very labour- intensive, whereas fallow and some perennial systems require large land holdings. Farmers without well-defined land rights do not have the incentive to invest in agroforestry systems, and in many countries tree-harvesting laws and regulations are also significant barriers to adoption. The riskiness of the returns is a particular problem for agroforestry systems, with fluctuations in tree product yield and prices especially influencing the profitability of perennial alley cropping or inter-

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cropping systems. Therefore, some of the more profitable systems also tend to be the riskiest. In general, the preferred agroforestry systems seem to offer short payback and intermittent benefits that allow farmers to self-finance their own investments in these systems.

Because many soil conservation projects in developing countries do not take into account the factors determining farmers' land management decisions, they tend to fail after the intensive technical assistance and the special incentives and subsidies provided by the projects are no longer are available. For example, a recent review of the extensive soil conservation programmes in El Salvador concluded that the main reasons for failure in many of these programmes were (i) that there was an inappropriate emphasis on prevention of soil loss for its own sake, rather than on cost–benefit grounds; and (ii) the establishment of conservation schemes was usually a response to pressure from the extension services and the provision of incentives and subsidies rather than from farmers considering that the conservation measures promoted were desirable (World Bank 1994). In contrast, successful programmes have tended to promote conservation measures that are appropriate to the existing farming and cropping systems. Thus, farmers have been willing to continue them with little or no additional incentives.

The above evidence on profitability and adoption of soil conservation suggests conservation decisions of farming households' in developing countries must be examined from the perspective of the effect of such decisions on the overall profitability of the farming system. Recent conceptual models have attempted to analyse this behaviour (Barbier 1990, 1996; Barrett 1991; Grepperud 1995). The results suggest that several key factors influence the decision of rural households to invest in improved land management.

First, both the upfront investment cost of soil conservation measures and any additional 'waiting cost' before future land productivity gains are realized are critical to the farmer's land management decision. If conservation measures are prohibitively expensive for farming households, in terms of either cash outlays or labour allocation, then the costs of conservation today to farmers may not be worth the future gains in productivity. As discussed above, the 'waiting cost' associated with soil conservation may also be a disincentive, particularly for small and poor farmers, and those without secure tenure. To the extent that farming households consider that having more crop income now is more valuable than waiting for future productivity and income gains, then these households are less likely to invest in control of soil erosion.

The upfront costs of soil conservation measures can be considerable for small farmers. For example, in the uplands of Java during the 1980s, it was estimated that the introduction of bench terracing on slopes of 50% or less would require an input of labour of around 750 to over 1800 person-days (PD) per ha, depending on the slope (Barbier 1989). Because the total labour requirements for terracing would generally exceed the dry-season availability of labour from within the farming household, constructing terraces inevitably means additional cash expenditures on hired labour. There would also be additional material and input costs of construction amounting to between US $420 and $2060 per ha (1979 prices). On top of this initial outlay would are the costs of periodic maintenance of terraces, waterways, and drop structures. Not surprisingly, a survey of farmers in the Citanduy watershed of West Java who did not adopt bench terracing revealed that 87% of the respondents cited lack of money as the primary reason for not constructing terraces.

Imperfect land and capital markets may also significantly influence the farmer's decision to control soil erosion. The most reliable indicator that a farming household will have of the effects of soil erosion on future land productivity is through land prices. However, in many developing countries, rural land markets are imperfect or distorted. Consequently, the costs of soil erosion, in terms of foregone future crop productivity and income, may not be reflected adequately or even bear any relation to the price of land in local markets. Similarly, the lack of effective rural credit markets may distort the farming household's decision as to whether it is worthwhile investing in protecting the soil because of its future productivity and income potential, as opposed to exploiting it for immediate gain today. In other words, the 'opportunity cost' of conserving the soil may be extremely high. If the farmer also has to borrow in the short-term to invest in conservation, then distorted or non-existent local capital markets may make the direct costs of conservation prohibitively expensive.

Other market, policy and institutional failures, such as insecure tenure or ownership of the land, distorted market prices for inputs and outputs, imperfect competition, incomplete markets, etc., can all affect the farmer's perception of the costs and benefits of controlling soil erosion. In particular, agricultural policies can affect production decisions, so that sub-optimal land management practices are encouraged, resulting in unnecessary land degradation. Other economic policies can also have profound effects on land use; virtually any policy that distorts the market prices of agricultural inputs and outputs can alter incentives for soil conservation. The impact of specific policies on farmers' decision-making and land degradation is often ambiguous, however, making generalization difficult. Impacts on households will vary to the extent that policies affect certain groups more than others.

Poverty clearly constrains farmers' ability to manage land degradation. Poor rural households in developing countries have generally only land and unskilled labour as their principal assets, and thus few human or physical capital endowments. These households are also highly dependent on agricultural production as their main source of income, but the importance of off-farm income increases as the size of holdings declines. The unfortunate consequence of this situation is that poor households with limited holdings often face important labour, land, and cash constraints on their ability to invest in land improvements. For example, in

discussing their review of the adoption by farmers of agroforestry systems in Central America and the Caribbean, Current *et al.* (1995) concluded that 'poorer farmers may find agroforestry profitable, but their rate and scale or adoption is often constrained by limited land, labour, and capital resources and their need to ensure food security and reduce risks'.

A recent analysis of sources of income of the rural poor in Mexico illustrates the formidable problems posed by poverty (Deininger & Heinegg 1995). In Mexico, the 1.3 million farm households (34% of all producers) with holdings of less than 2 ha display a high dependence on off-farm income coupled with extreme poverty. Their agricultural systems are highly unproductive and lack diversity. Almost two-thirds of the output value is derived from maize and beans, which occupy, on average, 84% of the land area available to these producers.

A recent study in Malawi highlights how the poorest rural households face unique incentives and constraints in combating serious problems of erosion and soil fertility decline (Barbier & Burgess 1992*b*). In Malawi, female-headed households make up a large percentage (42%) of the 'core-poor' households. They typically cultivate very small plots of land (< 0.5 ha) and are often marginalized onto the less fertile soils and steeper slopes ($> 12\%$). They are often unable to finance agricultural inputs such as fertilizer, to rotate annual crops, to use 'green manure' crops or to undertake soil and water conservation. As a result, poorer female-headed households generally face declining soil fertility and crop yields, further exacerbating their poverty and increasing their dependence upon the land.

Poor farming households may be able to overcome such constraints if they have access to credit, but usually such access is denied because of their low level of investment collateral. Often the only asset available for collateral is their land, and this may not always be allowed as the basis for acquiring loans. Throughout the developing world, the ability of poor farmers to obtain credit for land improvements is limited either by restrictions on the availability of rural credit for this purpose, or because insecure property rights mean that poor farmers are not eligible for credit programmes. For example, in Honduras, legal land titles prove to be significant in helping alleviate liquidity constraints affecting the purchase of working inputs, and the additional rate of return to holdings from acquiring land titles was estimated at about 12% per year (López 1997).

Of the rural producers surveyed across Mexico who received rural credit, only 9.6% had holdings of 0–2 ha (Deininger & Heinegg 1995). In Malawi, although approximately 45% of rural smallholders have holdings of less than 1 ha and over 21% are 'core-poor' households with less than 0.5 ha, only 17% of medium-term credit is allocated to households with less than 2 ha of land (Barbier & Burgess 1992*b*). In El Salvador, it was noted that the lack of an agricultural credit policy tailored to subsistence smallholders affects land management in two ways: (i) the Central Bank does not allot disbursements without proof of input purchases; this favours the use of credit for the buying of pesticides and fertilizers, rather than for obtaining additional labour for soil conservation investments; and (ii) there are no special incentives or provisions for smallholders to obtain credit to help diversify their cropping systems away from less erosive annual crops. As a result, less than 20% of small farmers use agricultural credit, and only 0.3% of total credit from the publicly funded Agricultural Development Bank is used for reforestation, soil conservation, irrigation and drainage, and on-farm improvement works. Instead, small farmers rely heavily on the use of suppliers of credit from agricultural products wholesalers, to whom they sell their products as collateral at below-market prices (World Bank 1994).

3. CONTROLLING FRONTIER AGRICULTURAL EXPANSION

In many developing countries, the problem of deforestation is clearly linked to the process of frontier agricultural expansion and development. There are two aspects of this problem. First, some rural households appear to forego improvements that would control degradation on their existing, often marginal, land so that productivity declines. Instead, they choose to migrate to new lands on the forest frontier. Many landless and near-landless households also migrate to the frontier as rural employment opportunities in existing agricultural areas become increasingly scarce. Second, there are also households that forego investments in sustainable farming systems on the land that they initially convert and occupy on the frontier, instead choosing to abandon this land as yields decline and migrate to new lands further into the forest frontier. Both problems involve essentially related processes, which can be referred to collectively as the incentives for rural households to abandon existing agricultural land in favour of converting and occupying new land on the forest frontier.

Many factors have been identified as having an influence on the expansion of frontier activities and deforestation in developing countries. These factors include activities such as (i) road building, that 'opens up' previously inaccessible frontier lands; (ii) the general open access conditions of the frontier; (iii) poor tenure or property rights, and (iv) policy failures that lead to price and other economic distortions.

Road building and insecure property rights in frontier forest areas make forest lands artificially cheap and readily available to farmers. Road building not only reduces the cost of access to these lands by farmers, but also ensures an abundant supply of new land to meet demand. This tends to prevent agricultural land prices from rising. The effect is compounded by insecure tenure arrangements. Although lack of property rights may mean that initial occupation is relatively cheap, frontier property rights and claims to the land can only be maintained if farmers occupy and appear to be 'using' the land. At the same time, because land cannot be used as collateral for loans, smallholders often have difficulty in obtaining the credit to purchase land that is already being cultivated. The result of these factors is that

frontier land becomes both accessible and underpriced, which encourages further extensive conversion of this forested land to agriculture, cattle ranching, and other activities.

Such processes have been observed on the agricultural frontier throughout Latin America (Mahar & Schneider 1994; Southgate 1994). A statistical analysis by Chomitz & Gray (1995) for Belize has shown that the distance to roads, and on-road travel time to markets, have a strong impact on land use and deforestation. Using these results to simulate the impacts of a road building strategy, the authors suggest that newly opened areas with good soils would experience some forest conversion to semi-subsistence cultivation, with low returns to labour and land. The agricultural frontier could expand dramatically, particularly as crop rotation would be likely to affect an area several times larger. If the roads were extended into remote frontier areas with poor soils, there would be less agricultural conversion, although extraction of mahogany and bird poaching may increase.

By contrast, in Bolivia, the lack of an extensive road network, and a consequently weak transportation system, has been cited as a key factor explaining its relatively low rate of deforestation compared to other Amazonian countries (Kaimowitz 1995). Due to its small domestic savings, Bolivia has had to finance almost all of its major road and railroad construction projects with foreign loans and aid. These resources have not always been forthcoming because of the country's limited credit-worthiness and political instability. Bolivia's rugged terrain has also contributed to its poor road and transport system.

The general open access conditions of unoccupied forest land is now recognized as a key condition underlying frontier agricultural expansion in developing countries (Pearce *et al*. 1990; Mahar & Schneider 1994; Southgate 1994). Land titling regulations which essentially acknowledge forest clearing as evidence of effective occupation for both agriculture and livestock raising have also been documented as a major factor in frontier agricultural conversion in Costa Rica, Ecuador, Honduras, Panama and other Latin American countries (Southgate *et al*. 1991; Peuker 1992; Mahar & Schneider 1994; Kaimowitz 1995; Sunderlin & Rodrígez 1996). For example, in Costa Rica, occupation of public lands has resulted in 60% of farms lacking land title, and often competing claims for land (Peuker 1992). This has provided an incentive to undertake activities on the land, such as clearing land of trees, which clearly demonstrate possession. Title to land can be obtained after ten years of possession, and a claimant can title up to 100 ha of land if the property is devoted to agriculture, and up to 300 ha if it is devoted to cattle raising. The process has proved to be highly susceptible to fraud with respect to time of occupation, the area of the land to be titled, and the actual use of the land.

Finally, throughout the developing world a number of policy-induced price distortions have further exacerbated the tendency for frontier agricultural expansion. These include (i) the use of fiscal incentives and tax breaks to promote projects and the purchase of frontier land; (ii) subsidized rural credit, particularly for cattle ranching, pasture formation and selective crops, which has encouraged frontier land conversion; and (iii) crop price supports, input subsidies and transport subsidies, which have artificially increased the returns to marginal farming in frontier areas.

In Brazil, income tax breaks, differential taxes, and other fiscal incentives have contributed substantially to deforestation in certain areas of the Amazon region, particularly in encouraging large-scale development projects, large-scale cattle raising and general land speculation (World Bank 1992; Mahar & Schneider 1994). Although the overall effects on deforestation may be small, such distortions contribute to a more rapid rate of forest conversion, increased demand for land among individuals with high income, and land appreciation and concentration of land ownership. In recent years, some of these perverse incentives have been curtailed—in particular the fiscal incentives for livestock development in the Amazon—but problems with tax evasion and avoidance now occur.

It is often short-term extractive operations, such as timber harvesting, mining, and large-scale commercial ranching and farming that are likely to be involved in initial frontier development. Usually it is fairly straightforward for governments to allocate large tracts of frontier land to commercial concerns and individual operators for extractive purposes, and as noted above, often their activities receive subsidies or other fiscal incentives of some kind. Short-term land speculators may also be encouraged in this way. Generally, the objective of these extractive and speculative operations is to maximize short-term resource rents; long-term investment in frontier economic development is not a major priority, particularly if it is difficult to acquire long-term property or use rights, or to control illegal occupation. Consequently, once sufficient rents are extracted, land abandonment and selling-off is common.

However, as noted above, once the frontier is 'opened' by large-scale activities, the lack of secure property rights and general open access conditions prevailing on the frontier inevitably encourage rapid expansion of frontier agricultural activities by small-scale farming and landless households in search of new land. Recent economic models have attempted to summarize conceptually the basic economic behaviour underlying frontier agricultural expansion by rural households (Mendelsohn 1994; Schneider 1994; Barbier 1997).

Faced with increased availability of new land in the form of abundant forest resources, farming households will continue to expand their agricultural activities into the forest frontier until rents are completely dissipated. This behaviour is influenced directly by some of the factors behind frontier expansion discussed above, such as lack of property rights or tenure arrangements, as well as the 'ease' of access and relocation of farming activities into forested regions. For example, the lack of effective property right or tenure arrangements for forested land would mean that farmers do not have to compensate those owning these resources if they are to be converted to farmland.

Equally, road building, timber operations and other activities that open up the frontier can reduce the costs of access and relocation, and thus increase the extent of frontier agricultural expansion. Policy-induced price distortions and institutional failures can further affect the incentives for farmers to convert frontier forest land.

4. EXISTING VERSUS FRONTIER AGRICULTURAL LAND

A key factor in frontier expansion and development is continual migration of new settlers to the frontier and further conversion of new areas of forest. This process involves both initial migration from existing agricultural areas to the forest frontier as well as the process of land abandonment for further conversion and exploitation of frontier forest land. The basic economic behaviour underlying the decision by farming households to abandon existing land for frontier forest land conversion has been analysed in a number of models (Southgate 1990; Larson 1991; Barbier 1997). A farmer could invest to make the existing farming system more 'sustainable' in the long-term, but would incur not only the direct costs of land improvement investments but also sacrifice some immediate income. In a land-abundant frontier with relatively low costs of access and relocation, the sacrifice in income includes the potential returns that could be earned from migrating to and converting new areas of forested land. Effectively, the farming household bases its decision to abandon existing land and migrate to (or further into) the frontier by assessing the perceived comparative returns from the existing and frontier land opportunities.

Many migrants to frontier areas in developing countries are landless or near-landless rural households that are also in search of new land and economic opportunities. As common with other poor migrants, these households have low levels of human capital and low overall opportunity costs of migrating to the frontier—particularly if employment opportunities in existing agricultural areas are scarce. For landless and near-landless households, the decision to migrate involves comparing the returns to rural employment opportunities and income in existing agricultural areas with the potential net returns of frontier land opportunities (Barbier 1997).

For example, Heath & Binswanger (1996) discuss the process of how poor rural households are increasingly migrating to both marginal upland areas and equally fragile land in the forested Amazon–Orinoco basin in Colombia. The result is continued unsustainable farming of both the Andean slopes and the Amazonian basin, with land abandonment as yields decline, and inevitably further extensions of frontier farming. The problem is exacerbated less by failures in rural labour markets or labour policies than by the failure of agricultural and land policies to provide adequate rural labour absorption, efficient land use patterns, and most importantly, higher returns to existing smallholder agricultural land.

In the Brazilian Amazon, the process of land abandonment for further conversion and exploitation of frontier forest land has long been recognized as a major problem. As argued by Schneider (1994), the returns to 'sustainable' farming on existing frontier land in the Brazilian Amazon rarely compare favourably with the returns from 'unsustainable' farming through abandoning existing land and converting additional frontier forest land. The problem has been made worse by the prevalence of high real interest rates over the past decade or so. They have ranged from 27–43% recently, although the rates faced by farmers undertaking relatively high-risk activities in the Amazon were surely much higher. Schneider has shown that such high interest rates force Amazonian farmers to seek immediate and thus unsustainable profits from frontier land. Unless investments in more sustainable farming systems can yield initial profits that are 50–70% higher than existing nutrient-mining farming practices, then farming households on the frontier will continue to engage in these practices, abandon their land when yields decline, and move to new frontier land. With the additional incentives to 'sell out' existing land for modest gains to higher income settlers, the pressure to abandon currently occupied land and migrate further into the frontier appears almost inevitable.

A study in Thailand highlights the complex linkages between agricultural crop prices, the relative returns from different crops and the demand for land (Panayotou & Sungsuwan 1994). In Thailand, approximately 40% of the increase in cultivated land in recent years has been met by conversion of forest land. The most important factors affecting the demand for cropland, and thus forest conversion, appear to be population growth, followed by non-agricultural returns, although agricultural pricing also has a significant influence. Higher aggregate real prices may have a slightly positive influence on the demand for cropland, and thus increase forest clearing; however, this direct effect may be counteracted by the indirect impact of higher agricultural prices, which encourage increases in the productivity of existing land and the cultivation of previously idle land, thus reducing the demand for new land. Changes in relative prices also influence the demand for new cropland by affecting the relative profitability of land-saving as opposed to land-extensive cropping systems.

Policy distortions, notably in land markets, may have a major impact on the comparative returns to existing as opposed to frontier land. There appears to be two dimensions to this problem. First, poorer households are often unable to compete with wealthier households in land markets for existing agricultural land. The result is two segmented land markets: the wealthier rural households dominate the markets for better quality arable land, whereas the poorer and landless households either trade in less productive land or migrate to marginal lands. Second, although poorer households may be the initial occupiers of converted forest land they are rarely able to sustain their ownership. As the frontier develops economically and property rights are established, the increase in economic opportunities and potential rents makes

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ownership of the land more attractive to wealthier households. Because of their better access to capital markets, they can easily bid current owners off the land, who, in turn, may migrate to other frontier forested regions or marginal lands.

For example, in Colombia, distortions in the land market prevent small farmers from attaining access to existing fertile land (Heath & Binswanger 1996). That is, as the market value of farmland is only partly based on its agricultural production potential, the market price of arable land in Colombia generally exceeds the capitalized value of farm profits. As a result, poorer smallholders and of course landless workers cannot afford to purchase land out of farm profits, nor do they have the non-farm collateral to finance such purchases in the credit market. In contrast, large land holdings serve as a hedge against inflation for wealthier households, and land is a preferred form of collateral in credit markets. Therefore, the speculative and non-farming benefits of large land holdings further bid up the price of land, thus ensuring that only wealthier households can afford to purchase land, even though much of the land may be unproductively farmed or even left idle.

Tax and credit policies in Brazil also generally reinforce the dominance of wealthier households in credit markets, and the speculative investment in land as a tax shelter (World Bank 1992; Mahar & Schneider 1994). Because poorer households on the frontier do not benefit from such policies, their ability to compete in formal land markets is further diminished. This reinforces the 'sell out' effect of transferring frontier land ownership from poorer initial settlers to wealthier and typically urban-based arrivals, forcing the poorer households to drift further into the frontier (Schneider 1994).

5. CONCLUSION: THE ROLE OF POLICY

As documented throughout this paper, a number of distortions in agricultural, land and tax policies encourage not only degradation of existing agricultural land and conversion of forestlands but also additional migration from existing to marginal and frontier lands. These policy distortions have two effects: the economic returns to farming and, therefore, real land values of existing agricultural land are repressed relative to the price of land in markets, so that this land is effectively 'overpriced'. In contrast, on frontier lands virtual open access and inappropriate polices make forest lands relatively cheap and available to exploit at even low rates of economic returns, leading to effectively 'underpriced' land.

Although many developing countries are undergoing major economic structural reforms, it is not always evident that the reforms will succeed in removing some of the critical distortions affecting land degradation and deforestation. Given the sector and economy-wide effects of such reforms, it is often difficult to determine the resulting production responses of households to changes in input and output prices, let alone the overall implications for land degradation and frontier and marginal land use (Barbier & Burgess 1992*a*).

Nevertheless, recent economic analyses are beginning to indicate what kind of policy reforms may be necessary to improve the incentives for better land management in developing countries. Very generally, it appears that policy reforms that reduce price distortions, promote efficient operation of rural financial markets, and make property rights enforceable should reinforce these incentives (Coxhead 1997). In some countries, there may be a 'win–win' situation between general macroeconomic and sectoral reforms and improved land management. In the Philippines, for example, it was found that reducing import tariffs and export taxes may also reduce the rate of upland degradation (Coxhead & Jayasuriya 1995). Similarly, in Indonesia, reducing fertilizer, pesticide and other subsidies for irrigated rice could be compatible with improved investment and credit strategies for the uplands of Java (Pearce *et al*. 1990).

However, other economy-wide and sectoral reforms may have unknown—and possibly negative—aggregate impacts on land and resource use strategies of rural households. It may therefore be necessary to complement these reforms with specific, targeted policies, to generate direct incentives for improved rural resource management. The main purpose of such policies should be to (i) increase the economic returns of existing as opposed to frontier lands; (ii) improve the access of poorer rural households to credit and land markets; and (iii) alleviate any remaining policy biases in these markets that favour relatively wealthy farmers and individuals. In some cases, specific non-price transfers in the form of targeted subsidies could reduce significantly the incentives for land degradation and forest conversion in developing countries. This is particularly true for expenditures that aimed to improve the access to credit for poor people in rural areas, research and extension investments to disseminate conservation, information and technologies to smallholders, and investments in small-scale irrigation and other productivity improvements on existing smallholder land. For example, in Mexico there is some evidence that a land improvement investment programme for existing rainfed farmers, particularly in states and regions prone to high deforestation rates, could provide direct and indirect incentives for controlling deforestation by increasing the comparative returns to farming existing smallholdings as well as the demand for rural labour (Levy & van Wijnbergen 1992; Barbier & Burgess 1996).

Targeting the agricultural sector with public investments and expenditures to provide effective credit markets and services to reach poor rural households, while continuing to eliminate subsidies and credit rationing that in the main benefit wealthier households, may be important in achieving a more efficient pattern of land use—and a less extensive one—in many developing countries. An important inducement for many poor smallholders to invest in improved land management is to establish proper land titling and ownership claims on the land that they currently occupy. To improve land tenure services in areas where frontier expansion is occurring, it may be necessary to develop more formal policies for small-

holder settlement, such as a policy to allocate preferentially public land with fully demarcated ownership and tenure rights to smallholders.

In addition, policies that have increased processes of land degradation and deforestation as an unintended side effect should be mitigated. For example, expansion of the road network in frontier areas has been identified as a major factor in opening up forest lands, thereby making these lands artificially cheap and abundantly available. Tax policies that encourage the holding of agricultural land as a speculative asset not only artificially inflate the price of existing arable land but promote much idling of potentially productive land.

Finally, in many developing countries policy reform will have to be complemented by investments in key infrastructural services. Several have been mentioned already—the availability of rural credit, conservation and general extension services, land tenure and titling services, and irrigation and other land improvement investments for existing smallholder land. However, other services may also be important. For example, in most rural areas there needs to be a general development of adequate post-harvest and marketing facilities targeted at smallholder production. In frontier areas, there is a need not only to increase credit and extension services to initial settlers, but also more basic services such as improved community, education and health care services.

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Discussion

P. Sanchez (*ICRAF, Nairobi, Kenya*). Although there is a fairly good geographically referenced database on land attributes across many developing countries, is there an equivalent data base on poverty (e.g. numbers of people below a per capita annual income of US$100)?

E. B. Barbier. Although there have been numerous regional and country-level studies of poverty, to my knowledge, there is not an adequate geographically referenced database on poverty across all developing countries. In my paper, I refer to a recent World Bank study of rural poverty in Latin America (see López & Valdes 1997). This study had great difficulty in finding comparable data on rural poverty across all Latin American countries, and the quality of the data varied considerably from country to country. Several separate household surveys in key Latin American countries had to be conducted in order to obtain adequate comparisons across these countries. Of course, one problem that has plagued many comparative studies of poverty is that there are different definitions of poverty used, and that such definitions tend to vary from study to study even within a developing country. You mention one possible definition of a poverty threshold—US$100 per capita income—but some studies prefer some notion of minimum subsistence level income to define a poverty threshold. Also, it is increasingly common to find poverty defined not per capita but per household. Finally, you quite rightly imply that for land degradation analysis, it would be extremely important to have a geographically referenced poverty database. Unfortunately, this kind of database for developing countries is still exceedingly rare. In my paper, I refer to a recent study in Mexico that has used such a database fairly successfully (see Deininger & Heinegg 1995). We clearly need more such databases and studies.

R. Thomas (*CIAT, Cali, Columbia*). Is it possible to obtain better estimates and projections of the expansion of cultivated land by linking land use with the expansion of roads and navigable waterways?

E. B. Barbier. As explained in my paper, recent economic studies of frontier agricultural expansion and deforestation clearly link these processes to road building and other activities that 'open up' previously inaccessible forest lands. Navigable waterways are also an important factor, but waterways are essentially 'fixed' in supply, whereas planned and unplanned expansion of road networks in unexploited regions of developing countries is a continuing process. From good regional or country-level statistical analyses of the factors influencing frontier agricultural expansion, including road building, it should be possible to obtain fairly reliable projections of what likely land use changes could occur as a result of future road building in the region or country.

A. Wagner (*London*). As you emphasise in your paper, the issue of land tenure and property rights is a major issue in developing countries. Often the rights of indigenous peoples are not officially recognized by governments, and often land is taken by military force rather than managed through an orderly legal or justice structure.

E. B. Barbier. There are of course many serious political and social issues underlying the existing distribution of land tenure and property rights in developing rights. Given the topic of my paper, I have not focused on the historical, political and social reasons behind problems of land tenure and property rights conflicts. Instead, I have examined how lack of property rights and insecure tenure can influence the land management decisions of small rural households in developing countries, in particular by reinforcing the incentives to extract short-term profits by erosive farming practices, abandoning existing agricultural land, and moving to marginal and frontier land areas.