Links between economic liberalization and rural resource degradation in the developing regions

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Abstract

This paper examines evidence of the effects of economic liberalization and globalization on rural resource degradation in developing countries. The principal resource effects of concern are processes of land use change leading to forestland conversion, degradation and deforestation. The main trends in globalization of interest are trade liberalization and economy-wide reforms in developing countries that have 'opened up' the agroindustrial sectors, thus increasing their export-orientation. Such reforms have clearly spurred agroindustrialization, rural development and economic growth, but there is also concern that there may be direct and indirect impacts on rural resource degradation. The direct impacts may occur as increased agricultural activity leads to conversion of forests and increased land degradation from 'unsustainable' production methods. However, there may also be indirect effects if agroindustrial development displaces landless, near-landless and rural poor generally, who then migrate to marginal agricultural lands and forest frontier regions. This paper explores these direct and indirect effects of globalization and agroindustrialization on rural resource degradation both generally, plus through examining case study evidence. The paper focuses in particular on the examples of structural adjustment, trade liberalization and agricultural development in Ghana, and maize sector liberalization in Mexico under North American Free Trade Agreement (NAFTA). © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

Since their initial implementation in the early 1980s, an important long-term objective of economy-wide and trade liberalization reforms in developing countries has been to reallocate resources to key sector, such as agriculture and manufacturing, to make them more productive and export-oriented (Kahn, 1987; Lal

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and Rajapatirana, 1987). A critical element of this reform strategy has been the elimination of policy distortions that constrain productive investment and technological change as sources of long-term agricultural growth and agroindustrialization (Stiglitz, 1987; Jaeger, 1992). Increasing 'globalization' of agriculture in developing countries has also occurred.

Such economic liberalization reforms have clearly benefited many developing countries through promoting rural development, agricultural exports and economic growth. However, many developing regions also suffer from a 'cumulative causation' link between rural poverty, land degradation and deforestation: poor rural households abandoning 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 forestland conversion, and so on (Barbier, 1997).[2] An important issue is whether the economic liberalization reforms implemented in developing countries have further increased such processes of rural resource degradation. On the one hand, there is evidence that unintended environmental damage, including land degradation and forest conversion, can occur when economy-wide reforms in developing countries are undertaken while other policy, market and institutional failures that in particular affect poor rural smallholders are ignored (Reed, 1992; Munasinghe and Cruz, 1995). On the other hand, a statistical analysis of 53 tropical countries has indicated that forest clearing increases with population, but declines with income per capita and agricultural yields, suggesting that improved agricultural performance and development may help reduce rural resource degradation (Barbier and Burgess, 1997). This would suggests that a more productive and competitive agricultural sector, as well as better economic growth performance generally, should reduce pressures for greater forest conversion for agricultural expansion.

If the increased agricultural activity arising through economic liberalization reforms in developing countries has led to increased rural resource degradation, particularly additional forest conversion, it may have done so both directly and indirectly. The direct impacts may have occurred as increased agricultural activity results in the expansion of cultivated area, thus leading to further deforestation. That is, the effects of greater globalization and agroindustrialization on the agricultural sector make it increasingly profitable for farming households to convert more forestland to cultivation. However, there may also be indirect effects on deforestation if agroindustrial development dis-

places rural households dependent on farm labour and unskilled workers in redundant agroindustries. If these displaced households migrate to marginal agricultural lands and forest frontier regions to seek new land to cultivate, then the result is greater deforestation.

This paper aims to explore these possible direct and indirect effects of economic liberalization and globalization on rural resource degradation. Although the main focus will be on the price effects arising from the macroeconomic and sectoral policy reforms generally characterized as 'economic liberalization', the findings could be generalized to other 'price shocks' that arise through processes of globalization and agroindustrialization. These would include the emergence or reorganization of processing industries, loss of traditional export markets, competition from imported substitutes and greater exposure to global market fluctuations.

The outline of the paper is as follows. The first half develops a basic model of aggregate agricultural smallholder production that is dependent either on land expansion or yield improvement. The purpose of the model is to demonstrate how input and output price changes may influence the rate of land use change, as well as the demand for land in agricultural production. Such relationships are important, as economic liberalization reforms inevitably influence prices in the agricultural sector, thus impacting on the incentives for agricultural land expansion. By drawing on previously published material on two case studies, the remainder of the paper focuses on empirical evidence of the way in which economic reforms and price changes impact on the demand for agricultural land. The two examples are structural adjustment, trade liberalization and agricultural development in Ghana, and maize sector liberalization in Mexico under the North American Free Trade Agreement (NAFTA). Finally, Section 6 summarizes the principal findings and discusses their implications for the wider issues of agroindustrialization, globalization and development in developing countries.

2. A model of land use decisions in a rural economy

The purpose of the following model is to illustrate how changing input and output prices can influence the land use decisions of rural households in the

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[2] In Africa, this poverty–degradation linkage appears to be directly related to the low productivity and input use of African smallholder agriculture generally, which in turn leads to land degradation, stagnant or declining yields and extensive use of land (Reardon et al., 1999). In Latin America, land abandonment and frontier agricultural expansion are characteristic of the 'nutrient mining' process, whereby road building and insecure property rights make land in frontier forests artificially cheap and available to landless and near-landless migrants to the frontier (Schneider, 1994; Southgate, 1994). Proximity to cities and roads may also be factors explaining rapid land use changes (Mamingi et al., 1996).

agricultural sector of a developing country. To focus on these price effects, the model of land use choice is highly stylized, and some aspects of the impacts of price shocks on the extensification of agricultural systems in developing countries have been ignored.

The model developed here is broadly similar to recent approaches that model the agricultural production behaviour of a representative rural household with access to a stock of non-agricultural land (e.g. a forested area) to determine the derived demand by the household for converted land (Panayotou and Sungsuwan, 1994; López, 1997, 1998; Cropper et al., 1999). However, in this literature, varying assumptions have been employed about the 'supply' of converted land available to the rural household. For example, both Cropper et al. (1999) and Panayotou and Sungsuwan (1994) employ a similar agricultural household model, but whereas the former assume that a marketed supply of converted land is available to households, the latter assume that rural households convert land under open access conditions. In contrast, López (1997) develops a model of bush-fallow (or shifting) cultivation, in which the household converts land from the commonly managed pool of forested land available to a village. Such a model has been extended to examine the competing uses of land and labour by the household for agricultural production as opposed to products (e.g. fuelwood, poles and fodder) derived from the common forested land (López, 1998). The model developed here follows Panayotou and Sungsuwan (1994) and López (1997) in assuming that the 'pool' of non-agricultural land available to the household is non-marketed and freely accessible, but other uses of labour and the common land are ignored (e.g. as in López, 1998). Although this is clearly a simplification of household land and labour decisions, it does allow the focus to be on the influence of input and output price changes on land conversion, in common with other household land use models developed for this purpose (López, 1997).

Assume a representative rural household that is a price taker in all markets for the commodities that it both consumes and produces. Thus the profit and utility maximizing decisions of the household are determined recursively, and thus optimal household production is determined first and independently of consumption and leisure choices (Singh et al., 1986). It will be convenient to decompose the agricultural

production, Y, of this household into the stock of arable land (e.g. measured in hectares, ha), N, multiplied by agricultural productivity or yield per hectare, q. The latter is assumed to be determined by the amount of purchased inputs, X, and household labour allocated to agriculture, L^A. Thus the basic agricultural production technology is

$$Y = Nq(X, L^A),$$
$$q_X > 0, \; q_{XX} < 0, \; q_L > 0, \; q_{LL} < 0. \qquad (1)$$

However, the stock of agricultural land is not constant but grows by the amount of new land brought into production, i.e. $n(L)$, through allocating some household labour, L, to convert forest and other available non-agricultural land. It is also assumed that a proportion of agricultural land is taken out of production, or 'fallowed', each time period at a constant rate, a. The net expansion in agricultural land is therefore

$$\frac{\mathrm{d}N}{\mathrm{d}t} = \dot{N} = n(L) - aN,$$
$$n_L > 0, \; n_{LL} < 0, \; N(0) = N_0. \qquad (2)$$

Thus, the total endowment of (household and hired) labour, T, is used either for agricultural production, L^A, or land conversion, L. Given an aggregate output price, p, input price, w, and cost of converting land, $c(L)$, aggregate profits, Π, for the household are

$$\Pi = pY - wX - c(L), \quad c_L > 0, \; c_{LL} > 0. \qquad (3)$$

Denoting r as the rate of discount, the objective function of maximizing aggregate profits of the agricultural sector can be written as

$$\text{Max } J = \int_0^\infty \Pi \, \mathrm{e}^{-rt}\mathrm{d}t \qquad (4)$$

subject to Eqs. (1)–(3). The Hamiltonian for the above intertemporal maximization problem is

$$H = pNq(X, T - L) - wX - c(L)$$
$$+ \lambda[n(L) - aN]. \qquad (5)$$

The controls of the problem are X and L. The state variable is N, with the corresponding co-state variable

λ, which also represents the shadow value of land in terms of additional agricultural profits.[3]

The above problem can be easily solved for the optimal path to a steady-state equilibrium. However, the objective here is not to portray this solution but to show how prices and other factors influence both the rate of rural land use change (i.e. dN/dt) and the demand for land (i.e. N) along the optimal path. For example, substituting the first-order condition for optimal purchased input allocation, $pNq_X = w$, into (2) yields

$$\dot{N} = n(L) - \frac{aw}{pq_X}, \qquad \frac{d\dot{N}}{dw} = -\frac{a}{pq_X} < 0,$$

$$\frac{d\dot{N}}{dp} = \frac{aw}{p^2 q_X} > 0, \qquad \frac{d\dot{N}}{d(w/p)} = -\frac{a}{q_X} < 0. \qquad (6)$$

Thus Eq. (6) indicates that the rate of land use change will increase as a result of higher agricultural returns (i.e. an increase in p/w or p). The optimal path for agricultural land use, $N(t)$, could be increasing or declining towards its long run steady-state level. If optimal rural land use is falling over time ($dN/dt < 0$), then an increase in relative returns to agriculture will flatten the curve, and the rate of decline in rural land use is slowed down over time. If optimal land use is rising ($dN/dt > 0$), then an increase in p/w or p will steepen this path, and land expansion will therefore be more rapid over time.

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[3] Assuming an interior solution, the first-order conditions of (5) are

$$pNq_X = w, \qquad \lambda n_L = c_L + pNq_L,$$

$$\dot{\lambda} = (r + a)\lambda - pq(X), \qquad \lim_{t \to \infty} e^{-rt}\lambda(t)N(t) = 0,$$

as well as Eq. (2). The first equation is the standard condition indicating that purchased inputs are applied up to the point where their value marginal product equals their cost. The second equation governs the optimal allocation of household labour, which occurs where the marginal benefits of bringing additional land into cultivation, λn_L, equals the marginal costs of conversion, $c_L + pNq_L$. These costs consist of the direct conversion costs plus the opportunity costs of allocating any labour from agricultural production. The third equation determines the rate of bringing new land into production (i.e. the amount of hectare converted per time period), as reflected in changes in the shadow value of the land over time, $d\lambda/dt$. This rate of conversion is influenced by the relative cost and benefit of holding on to an additional unit of (converted) land today. The final equation is the standard transversality condition.

An equation for the optimal level of land use in each period, $N(t)$, can be derived by differentiating the first-order condition $pNq_X = w$ with respect to time, and assuming $dL/dt = 0$.[4] Substituting this expression for dN/dt in (2) and rearranging

$$N(t) = \frac{1}{a}\left[n(L) + \frac{wq_{XX}}{p(q_X)^2}\dot{X}\right],$$

$$\frac{dN}{d(w/p)} = \frac{q_{XX}}{(q_X)^2}\dot{X} \lessgtr 0 \text{ if } \dot{X} \gtrless 0. \qquad (7)$$

Expression (7) indicates that the current amount of land used in agriculture, i.e. the 'demand' for land, depends not just on the rate of land conversion, $n(L)$, and fallowing, a, but also on the level of agricultural returns, p/w, the rate of change in the marginal productivity of purchased inputs, q_{XX}/q_X, and the rate of input use over time, dX/dt. The latter is also important in determining the impacts of an increase in agricultural returns on land use, $dN/d(p/w)$. That is, if the application of inputs is growing over time, i.e. $dX/dt > 0$, then agricultural land use will increase with a rise in agricultural returns, $dN/d(p/w) > 0$. If input use is falling, then $dN/d(p/w) < 0$.

The above result suggests that the level of input use may therefore have important implications for the incentive effects of increasing agricultural returns on the demand for land. For instance, if farming is currently characterized by low input use, then one would expect future levels of input application to be higher than current levels, i.e. $dX/dt > 0$. Under such conditions, the incentive effects of an increase in agricultural returns would be to increase land use, i.e. agricultural production is more *land extensive*. In contrast, if cultivation already involves a high level of input application, then

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[4] The latter assumption that the amount of labour allocated to land conversion does not grow over time helps to simplify the subsequent analysis and resulting conditions. It is not essential to the overall outcome. However, the assumption is not unrealistic. As T is fixed, then it follows that $dL/dt = -dL^A/dt$. Thus if the labour used for land conversion is not growing over time, then the labour allocated to agricultural production is not falling. This is equivalent to assuming that, from time period to time period, the household allocates essentially the same amount of labour for routine production tasks, such as weeding, planting, harvesting, etc., and also has roughly the same amount of remaining labour 'left over' to bring new land into cultivation. Of course, the optimal allocation of labour requires that, at any time t, the household allocates labour at the margin between the two tasks, according to the first-order conditions indicated in the previous note.

future levels of input use are unlikely to grow significantly or may even decline, and consequently, land use will tend not to increase with rising returns to agriculture, i.e. agricultural production is more *land intensive*. Thus whether price incentive effects lead to more land conversion to agriculture will in turn be influenced by whether rural households depend mainly on land or purchased inputs to expand production.

This outcome illustrates a common problem identified in the rural poverty and resource degradation literature. Namely, poor rural households often have limited access to credit and purchased inputs, and such constraints may exacerbate rural resource degradation. For example, Reardon et al. (1999) use the term 'capital-deficient intensification' to describe the process whereby a farmer depends inordinately on labour — unassisted by improved technologies — to increase productivity. This involves cropping more densely, weeding and harvesting assiduously, and so forth. Over time, this type of intensification is 'unsustainable' as it depletes soil nutrients and cannot be sustained without shifting toward 'capital-led' investments such as inorganic fertilizers. Of course, the alternative to such investments is to bring new land into cultivation, which is the link to forest and marginal land conversion described in this paper. Although Reardon et al. (1999) suggest that 'capital-deficient intensification' is widespread particularly in Africa, it is clear that such low input agricultural production is characteristic of many poor rural smallholders throughout the developing world (Barbier, 1997).

3. Implications for economic liberalization and land expansion

The above insights into the relationships between changing agricultural returns, price incentive effects and land use suggest that economic liberalization policies, through influencing both agricultural input and output prices, may have important implications for the rural resource impacts of agricultural development. If such reforms increase the agricultural returns faced by farmers, the consequences in terms of greater land use may be more pronounced for low input as opposed to high input agriculture.

However, such a stylized model of land use choice is necessarily very simplistic, and will undoubtedly fail to capture some of the key transmission processes through which economic liberalization and other price shocks may affect the intensification and extensification decisions of poor farmers. For example, an important aspect missing from the model is the allocation of household labour to off-farm work. As Reardon and Barrett (1999) have argued, labour freed from agricultural production on existing lands will generally not be allocated to bringing more land into cultivation if off-farm work pays more than farm work at the margin, or if non-agricultural income is weakly covariate with farm income, making labour diversification across sectors an appealing strategy for smoothing income in a highly stochastic environment. Second, the model assumes a representative household, yet there may be instances where structural heterogeneity across households may be great and significantly influence the impact of policy reforms. For example, De Janvry et al. (1995) concluded that the agricultural households most at risk from the impacts of the NAFTA reforms in Mexico are non-diversified maize sellers who depend heavily on the price of maize for their welfare. In addition, the exogenous effects of price shocks are not as self-evident as implied by the above model. Evidence from Ghana of the effects of economy-wide reforms on the price-adjustment process in local markets suggests that price responsiveness and volatility in outlying markets will depend on their degree of interdependence with the main central markets in which the price reforms are initiated (Badiane and Shively, 1998). Finally, the model abstracts from the choice of product mixes and technology available to the farming household. As Reardon et al. (1999) have pointed out, this choice set available to the household is one of the key factors influencing its abilities to respond to the economic incentives arising out of policy reforms.

Incorporating all these possible influences on would of course require a much broader conceptual model of rural resource household behaviour than the one adopted here (see, e.g., Reardon and Vosti, 1995; Reardon et al., 1999). Nevertheless, by focussing on how input use and price incentive effects may affect land conversion by households, the above model does illustrate an important transmission process identified in the literature. To demonstrate further the importance of this process, the remainder of the paper discusses

recent empirical evidence of the influence of price shocks on the land expansion decisions of agricultural households.

Although Eq. (7) provides useful insights into how input use and price impacts influence the demand for land, this equation cannot itself be estimated empirically. However, solution of the first-order conditions of the above model should also yield the derived demand for agricultural land use as a function of input and output prices and the other parameters of the model.[5] For example, if the model was extended to, say, two competing land-using activities, then the derived demand for land by one activity would now be influenced by the agricultural returns of that activity, by the returns of the competing activity and by any exogenous factors affecting this demand. Specifically, the demand for land for use in agricultural activity i would be

$$N^i = N^i(P^i, W^i, P^j, W^j, Z) \quad \text{or}$$
$$N^i = N^i\left(\frac{P^i}{W^i}, \frac{P^j}{W^j}, Z\right), \tag{8}$$

where N^i is the demand for land by agricultural activity i, P^i the price of output produced by that activity and W^i the price of inputs used by that activity, P^j the price of output of the competing agricultural activity j and W^j the price of inputs used by that activity. The variable Z represents exogenous factors that may also influence the demand for land, such as population, income per capita, roads and specific government programmes and subsidies. The latter factors are important to include in any demand for land estimation. For example, as noted in Section 1, it is through these effects that the 'indirect' impacts of trade liberalization and economy-wide reforms on labour 'displacement', economic growth and targeted public investments may influence land expansion in agriculture.

The remainder of this paper is concerned with specific applications of Eq. (8) to estimate land expansion in developing countries, to illustrate the potential direct and indirect impacts of economic liberalization on this expansion. The first case study is for Mexico,

and is based on the analysis by Barbier and Burgess (1996), who estimate the demand for planted agricultural area for the period 1970–1985 leading up to the economy-wide and maize sector liberalization reforms implemented as part of the NAFTA. The estimated results for agricultural land expansion serve as the basis of discussing how the NAFTA reforms may influence this relationship, through the 'direct' impacts on prices and returns and the 'indirect' impacts of population displacement and other economic factors. The second case study is for Ghana, and is based largely on the analysis by Benhin and Barbier (1998), who employ a piecewise linear regression to capture the effects of structural adjustment policies on the demand for maize and cocoa land over the 1965–1995 period.

4. A case study of Mexico

Current estimates of the rate of deforestation in Mexico range from 0.4 to 1.5 million ha per year. However, all estimates suggest that deforestation is much higher in the tropical than temperate areas (Masera et al., 1992). A major cause of this deforestation has been the increase in land under rainfed agricultural production. Road building and timber extraction may also have contributed through 'opening up' new areas of forest for encroachment by other activities (Barbier et al., 1993).[6] Rural poverty also appears to be a significant factor in explaining land use change across Mexico (Deininger and Minten, 1999). Approximately 70% of the land in Mexico is owned by *ejidos* (communal landowners), 25% is owned by individuals and 5% by Amerindian communities (World Bank, 1989).

Barbier and Burgess (1996) have employed panel analysis to estimate a relationship similar to Eq. (8) above for agricultural planted area at the state level in Mexico over 1970–1985 to determine the main factors affecting forestland conversion in the pre-NAFTA period in Mexico. The estimated relationship was

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[5] Benhin and Barbier (1998) show how this is done with a similar model involving competing land using activities, and then estimate specific forms of the resulting demand relationships to determine the influence of prices and other exogenous factors. A similar approach can be applied to the model of this paper.

[6] Rapid expansion of livestock production and the demand for pastureland have contributed substantially to tropical forest loss. In some areas, poorly managed timber extraction and forest fires have led to degradation and loss of forests (Barbier et al., 1993). The study by Barbier and Burgess (1996) also includes an analysis of the expansion in livestock numbers. However, due to space considerations, the latter analysis is not discussed here. The interested reader is referred to the original study.

then used by Barbier and Burgess to examine the effects on deforestation of economy-wide reforms implemented during the post-NAFTA period. The results of the analysis showed that maize and fertilizer prices appear to have been the main influences on the expansion of planted area. For example, a 10% increase in the maize–fertilizer price ratio would cause a 3.2% increase in agricultural area planted. Population growth also affected agricultural activities. Thus the estimated relationship indicated that, prior to the NAFTA reforms, the comparative returns to agricultural production in Mexico had a major impact on agricultural land expansion activities, and thus on overall forest conversion. Following the insights of the theoretical model, this suggests that the majority of agricultural production in Mexico was essentially low input and extensive in land use, which conforms to the general impression of *ejido*-based crop cultivation by the majority of rural smallholders in Mexico (World Bank, 1989; Masera et al., 1992; Barbier et al., 1993).

These estimated relationships were used by Barbier and Burgess (1996) to examine the price incentive effects on land expansion of economic liberalization reforms in Mexico resulting from NAFTA. Of particular interest to this paper are the maize sector reforms that affect the maize–fertilizer price ratio faced by farmers. It was estimated that, due to the Government of Mexico's policy of supporting the rural producer price well above the world price of maize, complete liberalization of the maize market would cause the price to fall considerably, possibly as much as 50% (Levy and van Wijnbergen, 1992a). The price elasticities estimated by Barbier and Burgess indicate that a 10–50% drop in real maize prices should cause a 3–16% decrease in agricultural planted area. Over the period 1989–1991 Mexico also reduced substantially its subsidies in fertilizer. For example, country-level real prices for urea, ammonium nitrate and ammonium sulphate increased by 58, 74 and 60%, respectively. As a result, the price of fertilizer to farmers rose sharply. The elasticities estimated by Barbier and Burgess suggest that fertilizer price increases of around 50–70% should cause agricultural planted area to decrease by around 10–13%.

The potential impacts of these maize sector reforms on the expansion of planted area and livestock num-

bers are good examples of the 'first-order', or direct, effects of changes in pricing on the incentives for frontier expansion and forest conversion by rural households. However, there are also likely to be some 'second-order', or indirect, effects resulting from economy-wide and sectoral reforms that may produce opposite incentive effects, potentially even outweighing the first-order impacts. In particular, rural migration to forested areas may increase as a result of the impacts of economic reform on the returns and value of existing agricultural land.

For example, as a result of all of the liberalization reforms and structural changes undertaken recently, Mexico is expected to undergo a long transition to sustained economic growth accompanied by substantial return migration to rural areas (Levy and van Wijnbergen, 1992b). The positive inducement to convert forestland, based on increases in the rural labour force and falling rural wages, may outweigh the incentives to reduce agricultural expansion due to increasing real GDP per capita or a falling maize–fertilizer price ratio (Barbier and Burgess, 1996). The author's overall findings are that the pursuit of an open development strategy combining high economic growth and liberalization appears to mitigate agricultural area expansion more than reliance on liberalization alone. However, if Mexico is subject to substantial return migration to rural areas and undergoes a long transition to sustained economic growth, then increases in the labour force and falling rural wages may more significantly induce greater deforestation. Thus the ability of the Mexican economy and rural labour market to adapt to an open development strategy may also be a key determinant of the overall impacts on deforestation of trade liberalization and agroindustrialization.

The maize sector reforms are also likely to impact on land conversion indirectly through affecting the supply of labour, the value of land holdings, and the distributional impacts of welfare changes on different income groups. For example, as noted above, the effect of the substantial reduction in the producer price of maize in Mexico as a result of market liberalization is expected to lead to a reduction in output and thus planted area. This may also provoke a large fall in land values for rainfed land to nearly one-quarter that of irrigated land, thereby making subsistence farmers, rainfed farmers who are net sellers of maize, and landless rural workers worse off (Levy and van Wijn-

bergen, 1992a).[7] Although subsistence farmers will benefit from lower consumer prices, they will be doubly affected by the loss in value of their rainfed land and in employment opportunities as day labourers. The overall lack of employment and income opportunities could induce rural workers and subsistence farmers to migrate towards frontier forest areas, or to convert remaining forestland that is available to them locally. These 'second-order' effects of trade liberalization on deforestation could outweigh the initial impacts of the reduction in the maize–fertilizer price ratio on planted agricultural area (Barbier and Burgess, 1996).

An investment programme in land improvements to increase the productivity of rainfed land could potentially mitigate the negative distributional implications of NAFTA on the maize subsector (Levy and van Wijnbergen, 1992b; Barbier and Burgess, 1996). Such a programme could involve investments not only in irrigation infrastructure for 1.1 million ha of rainfed land but also in drainage, land levelling, ditch clearing and soil conservation. The distributional impacts of maize liberalization in Mexico are particularly reduced if the land improvement programme is combined with greater access by Mexican farmers to the US fruit and vegetable market (Levy and van Wijnbergen, 1992b). Consequently, expansion of rural farm employment opportunities on existing agricultural land, or off-farm employment opportunities generally, could be an important mitigating factor in reducing deforestation. This suggests that a land improvement investment programme for existing rainfed farmers, particularly in States and regions prone to high deforestation rates, could provide indirect incentives for controlling deforestation by increasing the demand for rural labour.

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[7] The evidence presented by De Janvry et al. (1995) suggests that the agricultural households most at risk from the impacts of the NAFTA reforms in Mexico are nondiversified maize sellers who depend heavily on the price of maize for their welfare. At the time of the reforms, maize accounted for over half the crop area harvested in Mexico and employs approximately one-third of rural workers (World Bank, 1989). In 1989, out of a total production of 12.8 million t, 8.8 million t were produced by rainfed farmers, and rural own consumption accounted for 3.6 million t. At most only 15% of all producers were net sellers, consisting of 250 000 large-scale producers on irrigated land and 80 000 rainfed farmers. The remaining 1.92 million producers were subsistence maize farmers located on rainfed lands (Levy and van Wijnbergen, 1992a).

5. A case study of Ghana

The annual rate of deforestation in Ghana has remained fairly constant in recent years, around 1.3% over 1990–1995 (FAO, 1997).[8] The most important causes of forest loss have been unrestricted logging and land conversion for farming (ITTO, 1993). The main problem has been the opening up and conversion of marginal forested lands for crop cultivation. Expansion of agricultural land is currently estimated at a rate of 2.5% annually (Benhin and Barbier, 1998). The productivity of land and labour in agriculture is very low due largely to the extensive use of traditional technology and methods of cultivation, and in the absence of intensive production methods, increasing cultivated area is the main driving force in boosting the production of tree crops, such as cocoa, and food crops, such as maize.

Since 1983, Ghana has undertaken a series of comprehensive macroeconomic and structural adjustment reforms aimed at reversing the economic decline of previous decades. Under the Structural Adjustment Programme (SAP), improved prices for cocoa and maize and improved credit facilities have been an incentive to expand production (ISSER, 1992). In addition, subsidies have been removed on inputs to cocoa production such as insecticides, and on key fertilizers in maize farming such as ammonium sulphates. A critical issue is how these price impacts of the SAP have affected the expansion of agricultural land and thus deforestation. To examine these effects, Benhin and Barbier (1998) have analysed the influence of the economy-wide reforms on the demand for cocoa and maize land over the 1965–1995 period. By using piecewise linear regressions, the authors were also able to differentiate the price effects in the pre-adjustment versus the post-adjustment period, through estimating equations similar to Eq. (8) above.

The analysis indicated that the price of maize was not an important factor in maize farmers' demand for land during the pre-adjustment period, and any

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[8] The forest reserves of Ghana now contain most of the country's remaining tropical moist forest, most of which exist in isolated fragments. The total area of forest reserves is 2.6 million ha, which comprise 11% of total land area. In contrast, unreserved forests comprise only 500 000 ha. Annual crops and tree crops account for 1.2 and 1.7 million ha, respectively.

increases in the price of ammonium sulphate fertilizers actually led to greater land expansion.[9] However, for the post-adjustment period, a 1% increase in the lagged price of maize led to a 0.23% increase in the demand for maize land in the current year. With the removal of guaranteed or controlled prices under the adjustment programme, the price of maize became more market-determined, and thus a significant consideration in maize land decision making in this era. Even though input prices have increased in the post-adjustment period with the removal of subsidies on farm inputs such as ammonium sulphate, the increased availability of the fertilizer to farmers and the relative higher returns to maize production, as compared to the pre-adjustment period, has meant that maize farmers have started to increase their fertilizer use. Thus fertilizer and land have become complements in the post-adjustment period, and a 1% increase in the price of ammonium sulphate was estimated to cause a 0.05% fall in the demand for maize land. Nevertheless, input use is still relatively low for most maize subsistence farmers in Ghana, and so increased production is still largely low input and dependent on land expansion. Finally, a 1% increase in population density led to a 1.2% increase in harvested maize land in both the pre- and post-adjustment periods. This suggests that population increases in Ghana lead to increasing demand for maize and therefore maize land. This is not surprising given the importance of maize as a food crop in Ghana. It also provides some evidence that any 'displacement' of labour due to globalization and agroindustrialization in Ghana could lead to greater maize land expansion, if this displaced labour is absorbed through increased subsistence maize production.

Overall, and returning to the insights of the theoretical model of this paper, the above price effects suggest that maize production in Ghana is essentially still low input and extensive in land use. This is expected, as Reardon et al. (1999) suggest that 'capital-deficient intensification' is widespread, particularly for food crop production, across Africa. Thus there is evidence that the increasing returns to maize production accompanying the economy-wide reforms in Ghana may have resulted in greater land expansion and deforestation. Also, the reforms may lead to an 'indirect' deforestation impact if they lead to a larger rural population dependent on subsistence maize production.

Because their analysis of forest loss indicated that maize land expansion was not significantly correlated with deforestation in Ghana over the 1965–1995 period, Benhin and Barbier were unable to estimate explicitly the impacts of the above maize price changes on forest loss.[10] However, their deforestation analysis did indicate that forest loss was highly correlated with cocoa land expansion. Because of the latter result, the authors were therefore able to estimate the effects of price changes over the 1965–1995 period on cocoa land expansion, and then calculate how these price changes in turn affected deforestation. The resulting elasticity estimates indicate strongly that either a rise in the producer price of cocoa or a fall in input prices (represented by the price of insecticide) leads to greater forest loss. Thus, cocoa production in Ghana has also tended to be low input and extensive in land use. The results also conform to the theoretical insights of Eq. (6). That is, over the 1965–1995 period, cocoa land expansion was generally increas-

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[9] Benhin and Barbier (1998) argue that the lack of a price effect on land expansion was expected, as the relatively low and stagnant guaranteed price paid to farmers in the pre-adjustment era offered little incentive for farmers to expand production. Moreover, the poor storage facilities and the government's inability to purchase all maize produce at the guaranteed price meant that any excess supply of maize was a cost to the farmer, who had to dispose of it at a relatively lower price in the open market. The results also indicate that land and fertilizers were substitute inputs in the pre-adjustment period. Given the poor returns to maize during this era, maize farmers could not afford higher prices for fertilizer and therefore tended to substitute land for fertilizer in production as the price of this input rose.

[10] The lack of evidence of a direct causal relationship between maize land expansion and deforestation in Ghana over 1965–1995 was somewhat surprising. However, one possible explanation is that the industrial roundwood explanatory variable in the deforestation analysis might have captured much of the effects of changes in maize land on forest loss. There is substantial evidence that logging increases the expansion of agricultural activity in the tropical forest area by providing access to previously inaccessible areas. Amelung and Diehl (1992) found that more than 70% of the primary forest areas brought under cultivation are first degraded by commercial logging. Deforestation rates due to agricultural conversion are reported to be eight times greater in logged-over forests than undisturbed forests (Benhin and Barbier, 1998). Barbier (1994) also reports that in many African countries, around half of the area that is initially logged is subsequently deforested, while there is little if any deforestation of previously unlogged forestlands.

ing, and thus forest loss occurring (i.e. $dN/dt > 0$), and any increase in the returns to cocoa led to a more rapid rates of land expansion and forest loss.

However, there is considerable difference in the magnitude of the price effects in the pre- and post-adjustment periods. Before the SAP, a 10% rise in the rate of change in the producer price of cocoa led to about 0.03% increase in forest loss, whereas the same level of an increase in the post-adjustment period would yield a 0.12% rise in forest loss. It is possible that, because of the rapid rise in producer prices in the post-adjustment period, the rate of impact was less strong than in the pre-adjustment period, when producer prices were kept artificially low. Also, there is evidence that during the SAP farmers have tended to invest in existing cocoa lands because of expectations of higher prices, suggesting that cocoa farmers have at least shifted partially from converting forests to investing in existing cocoa land in response to rising output prices. Similarly, in the pre-adjustment period a 10% increase in the price of insecticides led to a 0.4% fall in the rate of forest loss, whereas during the SAP era, the same level of increase in the price of insecticides produces a 0.004% fall in the rate of forest loss. The high level of subsidies for insecticide use in the pre-SAP era may have encouraged more insecticide use for cocoa production, including facilitating bringing new land into cultivation, and any increase in the price of insecticide would have had a large impact on overall returns, thus reducing the rates of cocoa land expansion and deforestation. Because of the removal of subsidies and the rise in input prices, cocoa farmers may have been using much less insecticide for most of the SAP era, and an increase in the price of insecticide might have had much less of an impact on overall cocoa farm returns and deforestation.

Finally, the above impacts of the SAP on the demand for agricultural land in Ghana are aggregated. As agriculture in Ghana is highly regionalized and very diverse, economic liberalization may have different impacts on the traditional, regional agricultural sectors of Ghana. One such sector is the predominantly shifting cultivation agricultural systems of Western Ghana. López (1997) has been able to estimate the key determinants of both agricultural output and the demand for cultivated land by individual farming households in this region. First, it was estimated that biomass, measured in terms of the proportion of land under forest

cover, contributes 15–20% of the value of agricultural output in the bush-fallow systems. Second, a decrease in the wage rate or an increase in agricultural prices faced by farmers in Western Ghana will lead to an increase in the area of land that they will cultivate. Through a general equilibrium model, López (1997) is able to confirm that the overall price impacts of trade liberalization will on an average cause a 2.5–4.4% decline in biomass in Western Ghana as a result of farmers increasing cultivated area. Thus although reducing trade distortions may increase overall income in the national economy, in Western Ghana poor smallholders dependent on low input and extensive bush-fallow cropping systems could lose through greater land conversion and degradation. [11]

6. Conclusion

This paper has explored the likely effects of economy-wide reforms leading to greater globalization in developing countries on rural resource degradation. The principal issue of concern has been the expansion of agricultural land and forest conversion. Two potential impacts of economic liberalization on this process have been identified. First, if such reforms aim to improve the productivity and export-orientation of agriculture, they will do so through influencing both agricultural input and output prices, thus affecting the returns faced by farmers. Any resulting increase in these returns may therefore induce rural households to convert more forestland to agricultural production. Second, economy-wide reforms and accompanying agroindustrialization may also affect

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[11] One caveat to the analysis by López is that it is often very difficult to predict how economy-wide price reforms in Ghana, which are targeted mainly on centralized agricultural markets, will affect more localized, outlying markets such as those in Western Ghana. A recent study in Ghana of the effects of economy-wide reforms on the price-adjustment process in local markets suggests that price responsiveness and volatility in outlying markets will depend on their degree of interdependence with the main central markets in which the price reforms are initiated (Badiane and Shively, 1998). The implication is that the price transmission process from central to outlying markets that occurs after, e.g., trade liberalization may not lead to the anticipated changes in local prices, thus making it difficult to predict the impacts of an economy-wide reform on the land management decisions of poor smallholders in remote and marginal farming areas.

land conversion indirectly through affecting the supply of rural labour and the welfare of different income groups. If this leads to increased 'displacement' of households, who are then absorbed in subsistence agricultural sectors, then greater land degradation and conversion may also result. Most importantly, if agricultural production is characterized by low input and extensive land use, then higher returns are likely to increase the demand for more land to be brought under cultivation. As this type of production typifies much of rural smallholder farming in the developing world (Barbier, 1997; Reardon et al., 1999), then it is possible that any improved agricultural returns from increased globalization and agroindustrialization may result in greater, rather than less, pressures on rural resource degradation — at least over the short and medium term while agricultural development makes the transition from low input and extensive to more high input and intensive use of land production.

Evidence of the direct and indirect impacts of economic liberalization on land use and forest conversion were also explored through examining case study evidence from Mexico and Ghana. Up to the implementation of the reforms, agriculture in both Mexico and Ghana was largely low input and extensive in its use of land. Consequently, both case studies indicate that both direct and indirect rural resource degradation effects can unintentionally result from structural adjustment and trade liberalization policies. However, the empirical evidence also suggests that any increased pressures on land degradation and conversion arising from liberalizing reforms can be mitigated somewhat, provided that greater investments and efforts are targeted at improving the input use and productivity of existing agricultural areas. The key is again ensuring a transition in these areas to greater input and land-intensive production. Once such a transition is made, farmers may begin responding to increased agricultural returns not by expanding cultivated area but by investing in greater land improvements and more sustainable production. Moreover, as the Mexico case study in particular has shown, increased public and private investments in existing farming areas can create employment opportunities and improve the welfare of various rural income groups, including the landless and near-landless. The result may be to reduce any 'second-order' impacts of globalization and agroindustrialization on rural resource degradation.

Although the analysis of the paper has focussed on the price shocks arising from economic liberalization and policy reforms, the results should hold generally for any widespread changes in the agricultural sector of developing economies. That is, other rapid processes of change associated with globalization and agroindustrialization, such as the emergence or reorganization of processing industries, loss of traditional export markets, competition from imported substitutes and greater exposure to global market fluctuations, may also influence significantly the returns faced by rural producers, thus affecting their land use decisions. As this paper has pointed out, the direct or 'first-order' impacts on land degradation are likely to depend on whether production by agricultural households is characterized by low input and extensive land use, or whether the agricultural sector has already made the transition to more high input and intensive use. However, equally important are the 'second-order' effects, which usually occur through affecting the supply of labour, the value of land holdings, and the distributional impacts of welfare changes on different income groups.

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