Environmental Economics Programme

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THE ROLE OF SMALLHOLDER PRODUCER PRICES IN LAND DEGRADATION; THE CASE OF MALAWI

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LEEC Discussion Paper

DP 91-05

July 1991

The London Environmental Economics Centre is sponsored by the governments of Sweden, Norway and the Netherlands and is grateful for this assistance.

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The Role of Smallholder Producer Prices in Land Degradation
The Case of Malawi[1]

Paper presented at the
European Association of Environmental and Resource Economics
Annual Meeting, Stockholm, 11-14 June 1991

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Introduction

The role of agricultural producer prices in influencing land degradation has been debated in recent years. One argument is that depressing agricultural prices reduces farm profitability and the incentives to improve land productivity through investments in soil conservation. On the other hand, increasing farm prices and land values is also thought to drive extensive cultivation of more 'fragile' lands (for reviews see Repetto, 1988 and Southgate, 1988). Empirically measuring these effects is extremely difficult.

Measurement of the *supply response* to agriculture producer price changes in developing countries has been frequently conducted over the years. Early studies in the 1950s and 1960s, first in developed economies and then extended to developing economies, indicated that on typical farms small changes in the relative prices of crops may make large changes in the cropping practices more profitable (Heady, 1955; Krishna 1963 and 1967; Nerlove, 1956). These studies focused on changes in single-crop acreage as a proxy for supply responsiveness, and provided direct evidence of individual farmers' substituting among crops and *adapting* farming systems in response to relative price changes. The early analyses also noted that developing country farmers may respond to relative *price changes by switching* land *and* other resources between different individual crops but yet may be unable to increase (or decrease) aggregate output in response to overall rises in producer prices (Krishna, 1967).

More recent studies in sub-Saharan Africa confirm that the effect of changes in output prices on the aggregate level of production tends not to be substantial in many countries, but the responsiveness of *individual crops* to changes in *relative prices is highly significant.* Although individual crop supply elasticities vary between countries and between crops, elasticities of 0.5 or more were common (Bond, 1983; Fones-Sundell, 1983). The evidence again suggests that, as relative producer prices change, the increase in individual crop production is achieved at the expense of a reduction in substitute crops. However, in a critical review of agricultural supply response models in Sub-Saharan Africa, Ogbu and Gbetibouo (1990) argue that most models are deficient in the choice of *relevant explanatory* variables because either the structure of agricultural production in these countries is not properly modelled or the issues and constraints facing farmers is not known or over-simplified. Understanding the factors that explain the elasticities derived from empirical models is as important as the elasticities themselves.

Determining price and non-price supply responses for specific commodities is beyond the scope of this paper. The concern here is less with measuring *the actual magnitude* of small farmer response to price incentives than in determining *how well* they respond. A crucial issue for land degradation is the extent to which price-induced substitution encourages farmers to move away from less erosive crops and cropping systems to more erosive crops and systems. If changes in relative prices do influence farmers' choice of crops and land husbandry decisions - and this is an empirical question that still needs to be verified - how well do farmers respond to these price changes in making these investment decisions?

Evidence from Indonesia and Malawi suggests that under certain conditions, changes in relative producer prices can affect choice of crops and farming system, thus impacting on degradation (Barbier, 1988, 1989 and 1990; Barbier and Burgess, 1990; Becker, 1990; Carson, 1987). The relationships governing farmer responses to relative crop prices are very complex, and depend on various factors such as household wealth and income, tenure security, attitudes to risk, access to off-farm employment, labour and capital constraints and intra-household allocation of labour. Nevertheless, the limited evidence does indicate that farmers will respond to higher relative prices for erosive crops by seeking short run economic rents from erosive crop cultivation at the expense of long-term land degradation. This result holds mainly for sedentary farmers cultivating rainfed plots in areas with predominantly 'closed' agricultural frontiers (i.e. areas where agricultural extensification is reaching or has already reached its limits). In frontier agriculture, farmers will open up new areas to cultivation when the returns from the new land exceed those from existing land under cultivation (Southgate, 1990; Southgate and Pearce, 1988). Higher relative prices and returns to erosive crops will not only accelerate degradation on existing land but, as a consequence, will also induce a more rapid expansion into new areas and increased land clearance.

At the same time, fluctuations in relative prices can increase the uncertainty and risk borne by, in particular, small producers. Switching to and investing in new cropping systems and methods of cultivating involve high upfront costs and long payback periods for small farmers. Unless they can be assured that the relative prices and returns from the non-erosive systems will be sustained, these farmers may be less willing to invest in new, less-erosive cropping patterns and systems or in improvements to these systems where they already exist. Similarly, small producers may be less willing to invest some of the short-run profits from *erosive* cropping into expensive physical erosion control measures, such as bunds, contour ridging, bench terracing and so on, unless they can be sure that the high relative prices they receive for their crops today will also prevail in the future. Thus the *price risk* imposed by fluctuating relative prices may deter farmers from investing in land husbandry.

Insufficient attention has been given to date on the incentive effects of fluctuating relative prices for controlling land degradation. The following paper explicitly examines this problem with the example of smallholder producer prices in Malawi. The paper first develops a simple model illustrating the role of price fluctuations in land degradation, discusses its relevance to Malawi and analyzes the available empirical evidence on relative price fluctuations of non-erosive and erosive crops.

Analytical Framework

In analyzing fluctuations in producer prices it is important to distinguish between that part of the variation that is predictable by producers and that which is not (Hazell, Jaramillo and Williamson, 1990). To the extent that producers can predict movements in prices, they will be able to adjust resources and cropping practices accordingly and perhaps avoid any sizable investment losses. In contrast, unpredictable price changes represent a risk, especially to small producers in developing countries, who must essentially rely on self-insurance mechanisms and their own capital resources in the absence of futures, options or other insurance markets and little or no access to formal credit, especially for conservation investments. Thus a distinction should be made between *price risk*, the part of the total fluctuation in prices that could not have been predicted *ex ante* by small producers, and *price variability*, the simple variation of prices around a trend that is observed in a time series (Hazell, Jaramillo and Williamson, 1990). It is the effect of price risk arising from fluctuations in relative erosive to non-erosive crop prices in Malawi on smallholders' decisions to control land degradation that is the main focus of this paper.

The importance of relative crop prices, and thus price risk, to the land management decisions of small producers can be reflected in a simple model.[2] It is assumed that the objective of the farmers is to maximize the net returns from production over time. Holding input prices and quantities constant over time, net returns are determined by the prices and quantities of erosive and non-erosive crop cultivation and the costs of controlling land degradation.

Formally, the control problem, over an infinite horizon, is:

$$\begin{aligned} \max \Pi &= f(x,y,z,t) \\ &= \int_0^{\infty} e^{-\delta t}\{p^x x(z) + p^y y(z) - cg(z)\}dt, \end{aligned} \quad (1)$$

subject to

$$\begin{gathered} \dot{z} = g(z) - h(x,y), \\ \text{with } h_x > h_y > 0,\ g'(z) > 0,\ g''(z) < 0, \end{gathered} \quad (2)$$

$$x(t),\ y(t),\ z(t) \geq 0, \quad (3)$$

$$z(0) = z_0. \quad (4)$$

It is assumed that a small farmer maximizes the present value of his or her net returns from cultivation, Π, where δ is the farmer's rate of discount, x(t) is the quantity of erosive crops and y(t) non-erosive crops and p^x and p^y their respective prices.[3]

In (1), both crops are assumed to be increasing, concave functions of topsoil depth, z(t). The function q(z) represents *erosion control effort*, which also depends on topsoil depth and is subject to constant costs, c.

Constraint (2) indicates that changes in topsoil depth, $\dot{z} = \partial z/\partial t$, depends on erosion control effort, g(z), less the relative impacts of the erosive and non-erosive crops, h(x,y). Topsoil depth is either rising, stabilizing or falling depending upon whether degradation control effort is less than, equal to or greater than the erosion impacts of erosive and non-erosive crops. Increased cultivation of both erosive and non-erosive crops can increase land degradation, but non-erosive crops have less of an impact, $h_x > h_y$.[4] At higher levels of topsoil depth, greater effort is required to control erosion, g'(z), albeit at a declining rate, g"(z) < 0.[5] Constraint (3) is the standard set of non-negativity conditions. Constraint (4) defines the initial level of topsoil depth.

The current value Hamiltonian for the control problem (1)-(4) is:

$$H = (p^x x(z) + p^y y(z) - cg(z)) + \lambda(h(x,y) - g(y), \tag{5}$$

where λ is the current value costate variable associated with the state equation (2). Assuming an interior solution, the first order conditions for maximizing (5) are:

$$H_x = p^x - \lambda h_x = 0, \tag{6}$$

$$H_y = p^y - \lambda h_y = 0, \tag{7}$$

$$-H_z = \dot{\lambda} = [\delta\lambda + cg'(z)] - [\lambda g'(z) + p^x x'(z) + p^y y'(z)], \tag{8}$$

$$\lim t\to\infty,\ e^{-\delta t}\lambda(t)z(t) = 0. \tag{9}$$

$$H_\lambda = \dot{z} = g(z) - h(x,y), \tag{10}$$

The costate variable, λ, can be interpreted as the implicit value, or shadow price, of the soil. If topsoil is depleted, λ represents the user *cost* of soil erosion, i.e. the future returns forgone by a decision to deplete the soil faster today. Conditions (6) and (7) indicate that, along the optimal path, farmers should choose to cultivate each erosive and non-erosive crop to the point where the marginal returns from cultivation equal the marginal user costs of soil erosion, as determined by the kind of crop.

Equation (8) indicates that the 'value' of holding on to soil today must rise at a rate equal to the total opportunity cost of conserving soil less the increased current and future returns from the soil. The cost of conserving soil includes an 'interest charge', $\delta\lambda$, as well as the cost of current soil conservation efforts, $cg'(z)$.[6] These costs essentially represent the 'depletion motive' for increasing soil erosion today. The current returns from topsoil are represented by $p^x x'(z) + p^y y'(z)$ and the future returns by $\lambda g'(z)$. These current and future returns are the 'conservation' motive for maintaining topsoil.[7] Finally, equation (9) is the transversality condition, and equation (10) repeats the state equation constraint (2).

To simplify notation, assume that the incremental increase in the rate of soil erosion from cultivating additional erosive and non-erosive crops is constant; i.e., $h_x = a$ and $h_y = b$. Equations (6), (7) and (8) defining the optimal path can be re-written as:

$$\frac{p^x}{p^y} = \frac{h_x}{h_y} = \frac{a}{b} > 1, \tag{11}$$

$$\frac{p^x}{a} = [\delta \frac{p^y}{b} + cg'(z)] - [\frac{p^y}{b})g'(z) + p^x x'(z) + p^y y'(z)], \tag{12}$$

$$\frac{p^x}{p^y} = a\{[\frac{p^x}{p^y}\delta + \frac{c}{p^y}g'(z)] - [\frac{p^x}{p^y}g'(z) + \frac{p^x}{p^y}x'(z) + y'(z)]\}.$$

Small farmers are essentially price takers. Equation (11) shows that farmers should adjust cultivation of erosive and non-erosive crops, and hence their relative impacts on the soil, in response to changes in their relative prices. However, erosive crops will have a greater impact on the soil, thus reducing its asset value in terms of future productive potential. From the farmer's perspective, it is always optimal that the price of erosive crops be higher than that of non-erosive crops.

Equation (12) indicates how the 'depletion' and 'conservation' motive of farmers will change in response to price rises over time. If the price of erosive crops is increasing relative to non-erosive crops, then the depletion motive will outweigh the conservation motive; i.e., the costs of conserving soil exceed the returns. The farmer would be expected to change cultivation of erosive and non-erosive crops, their impact on soil erosion and erosion control effort accordingly.[8] If the relative price is falling, then the returns to conservation will exceed the costs. The farmer will have more incentive to conserve rather than deplete, and will change his farming system and practices to reflect this. Clearly, then, depending on the change in motives brought about by relative price movements, the farmer will adjust choice of crops, the rate of soil erosion and soil conservation effort.

The above model is obviously a simplification of the complex factors and choices determining a small farmer's decision to invest in soil conservation and non-erosive versus erosive crops. As argued by Ogbu and Gbetibouo (1990), both non-price and price factors must be taken into account in any modelling of agricultural supply responses of farmers in Sub-Saharan Africa. This certainly the case when such responses are extended to take into account their impacts on land degradation, as a recent study in Malawi has shown (Barbier and Burgess, 1990).

However, the model does show that, to the extent that the general conditions suggested by the model hold, then the relative price of crops can have an important influence on land management decisions by small farmers. More importantly, farmers must be able to predict changes in relative prices in order to know what investment crop and land husbandry decisions to make. Clearly, relative crop prices are not the only factors affecting these decisions. Input prices, capital, labour and input constraints, access to information and technology, agroecological conditions among others will also be influential. By abstracting from these factors, the model is not trying to demonstrate the all-pervasive influence of prices; rather, it focuses on the role of relative prices to show the extent to which *price risk* can be an important factor in land management decisions. The following sections examine this influence empirically with the example of smallholder producers in Malawi.

Agriculture and Smallholders in Malawi[9]

Although 4.3 million hectares (ha) of land in Malawi is classified as arable, only around 2.4 million ha is probably suitable for agriculture, most of which is already under cultivation. The 'dualism' of the agricultural sector is characterized by two distinct farming systems: the smallholder sub-sector, which accounts for about 80% of food production and comprises around 90% of the population, and the estate sub-sector, which accounts for 90% of export earnings.

Approximately 1.6 million smallholder families cultivate up to 1.8 million ha under customary tenure. The principal crop is the staple food, maize, which is grown on 75% of the cropped area, with other important crops being groundnuts, fire-cured tobacco, cassava, cotton, rice and various pulses, roots and tubers. Rapid population growth in Malawi of 3-4% per annum has meant that approximately 30,000 new families must be absorbed on customary land each year. Given that less than 30% of smallholders have access to fertilizer and the adoption rate for high yielding maize varieties is less than 10%, average yields are very low - about 900 kg/ha for maize. This combination of population pressure on scarce land and low yields has led to depressed farm incomes, declining per capita smallholder food production, widespread household food insecurity and land degradation.[10]

Moreover, an important distinction in the smallholder sub-sector is between those households cultivating less than 1.0 ha - the minimum required for attaining sufficient household calorie requirements from their land - and those with larger holdings. Approximately 715,000 households fall into the former category, of which over 338,000 are 'core poor' households with less than 0.5 ha. Consequently, the majority of smallholders are food-deficit, low-income households, that spend almost half of their cash income on food and depend heavily on off-farm labour employment. These constraints are extremely binding on these poor households, particularly the poor female-headed households, and can severely hinder economic opportunities and improved land management.[11] It is only the households with relatively larger holdings that are self-sufficient in food production. Thus only about 20% of smallholders in Malawi have access to credit and produce a marketable surplus - and these are generally farmers with holdings over 1.0 ha.[12]

Since 1979 Malawian agricultural has gone through a period of rapid macroeconomic adjustment, including extensive agricultural pricing and marketing reform for the smallholder sub-sector.[13] The objectives of the new pricing policy were to:

- o stimulate increased smallholder export production by paying farmers prices closer to export parity;

- o set a maize price that would achieve national maize self-sufficiency;

- o leave only tobacco and cotton prices controlled, i.e. as the government's Agricultural Development and Marketing Corporation (ADMARC) retains its legal monopsony over these two crops, the official prices paid by ADMARC are also the effective prices paid to smallholders; and

- o ensure that for all other smallholder crops, including maize, the prices set by ADMARC represent a guaranteed minimum price as ADMARC is obliged to buy all quantities offered at that price.

To improve pricing policy, the Government of Malawi (GoM) has instituted an annual producer price analysis and review. As prices have to be announced before the planting season to be effective as incentives, they can often fail to match the eventual border prices prevailing at the end of the season given the frequent fluctuations in export prices. Nevertheless, since 1981 smallholder producer prices have generally been approaching border-price equivalents. In recent years, groundnut and cotton prices have even exceeded export-parity values. The exception is smallholder tobacco, which is being sold to ADMARC at prices significantly below local auction floor prices that are essentially equivalent to border values. In addition, some crops such as beans and pulses have been banned for export because of the uncertainty over sufficient supplies to meet domestic requirements and because market prices continue to exceed the floor prices set by ADMARC (Lele, 1989 and Christiansen and Southworth, 1988).

Although farmers may have been responding to changes in relative prices by shifting their cropping pattern, the impact of pricing policy on their aggregate response is less certain.[14] After growing at an annual average of approximately 4.9% in real terms during the 1970s, agricultural growth slowed down to an average of 1.0% in 1980-84, recovering only to an average of 2.5% in 1985-88, still failing to keep pace with the population growth. In 1988/89 the total area sown to maize at 1.27 ha and production of 1.52 million tonnes - the highest levels on record - represented increases on the previous year of 4.9% and 6.6% respectively. Due to a drought in early 1990, maize production during 1989/90 was not expected to differ significantly from the previous year's production (Government of Malawi, 1990 and World Bank, 1989a).

However, what is of particular significance for land management and soil conservation is that the recent increases in agricultural output have been achieved by extensification of agriculture into marginal lands, rather than by improving the yields on existing cultivated land. The reasons for this are predominantly structural:

- o rapid population growth and the corresponding fast decline in the land-man ratio has led to increased land pressure and the opening up of more marginal areas for cultivation;

- o the pricing and marketing reforms have achieved little for the majority of smallholders cultivating less that 1.0 ha, mainly because the severity of the land constraint and low yields preclude production of net marketable services, thus limiting the main income benefits of these reforms to the relatively better-off producers;

- o in fact, the food security of many food-deficit households may actually deteriorate as the price of maize and other food crops increases, thus limiting the ability of these households to diversify out of own-food production and to take risks;

- o consequently, over the past five years there has been little change in the average yield for any of the main varietal maize groups - local, composite or hybrid - despite markedly higher rates of hybrid adoption and fertilizer use, and the low productivity of maize has in turn exacerbated the land constraint.[15]

The aggregate impacts of land degradation in Malawi may be highly significant. A recent study has shown that a conservative estimate of the on-site (user) costs of soil erosion in Malawi is around 4.8% of national GDP (Bishop, 1990).

Analysis of Price Impacts on Land Degradation

Of particular concern is how smallholder producer pricing policy may have influenced these trends by changing the pattern of smallholder crop production and the relative returns to various crops, thus affecting the incentives for long-term land management. One concern is that recent swings in relative prices in Malawi may be making it difficult for smallholders to plan and develop viable land management and cropping systems to counteract erosion. This is particularly the case for the poorer smallholders who appear to rely on intercropping and relay cropping maize, groundnuts and pulses as a means to meeting nutritional needs, maintaining soil fertility and conserving soil. Alternatively, some 'progressive' farmers may abandon these mixed-cropping systems to plant the more erosive crops, such as maize, cotton and tobacco, in pure stands if there appear to be higher relative prices for these crops, but the uncertainty arising from the fluctuations in prices might prevent them from making land management investments (Barbier and Burgess, 1990).

Figure 1 shows the long-run price trends for pulses, groundnuts and maize in Malawi. Until the early 1980s, prices did not

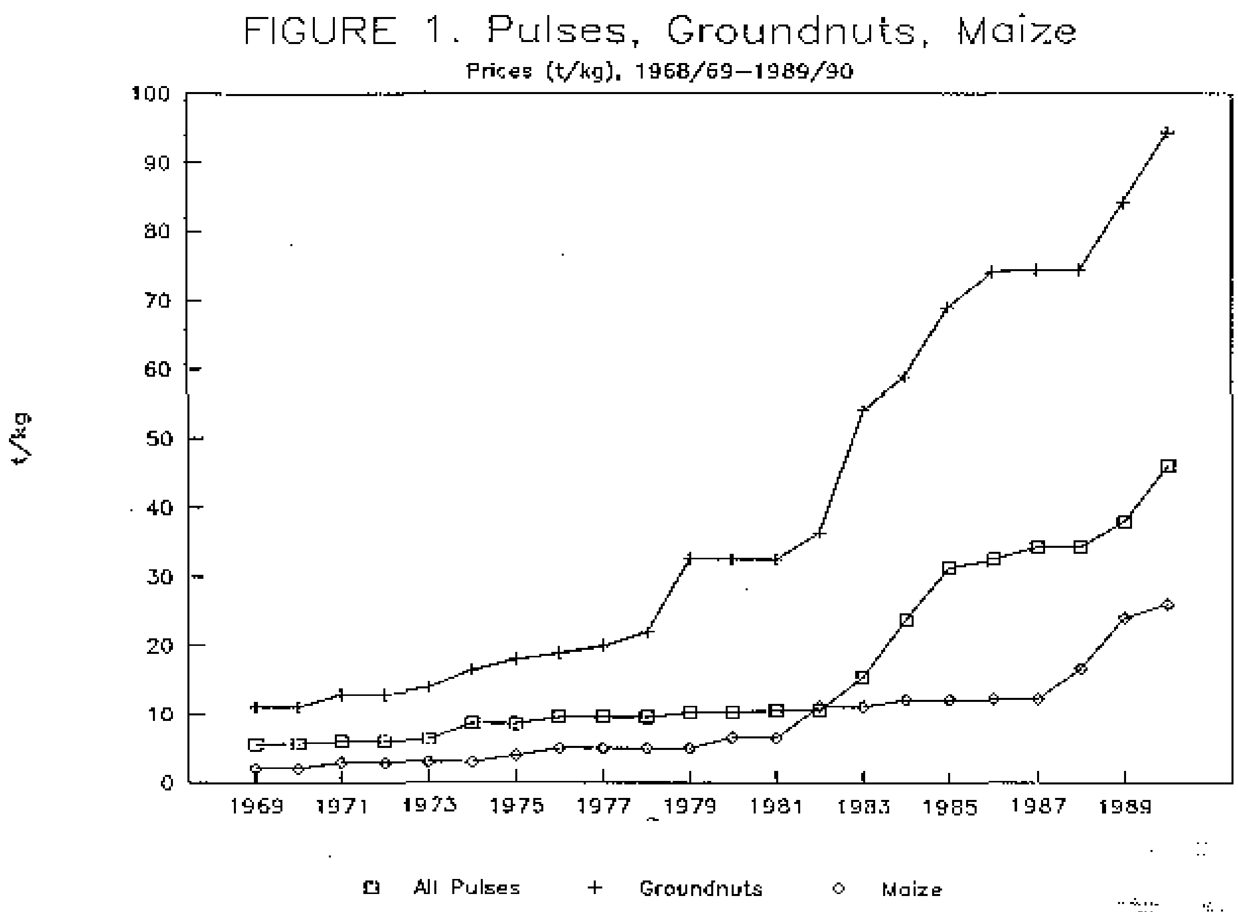


FIGURE 1. Pulses, Groundnuts, Maize
Prices (t/kg), 1968/69–1989/90
t/kg
100
90
80
70
60
50
40
30
20
10
0
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
All Pulses
Groundnuts
Maize

increase substantially. Prices for pulses and groundnuts began increasing in the early 1980s, and have risen rapidly. Maize prices were not increased significantly until after the 1986/87 season. Other key smallholder crops in Malawi are tobacco, cotton and cassava. Again, the prices of the cash crops cotton and tobacco did not increase substantially until the early 1980s, with tobacco prices rising dramatically in recent years (see Figure 2). Cassava prices have continued to remain low.

These trends in individual crop prices can be aggregated to derive price trends for the '*non-erosive*' as opposed to the '*erosive*' crops.[16] As indicated in Figure 3, prices for both the major non-erosive crops - pulses and groundnuts and the major erosive crops - maize, cassava, cotton and tobacco - have been rising steadily at approximately the same rate of increase. Consequently, as shown in Figure 4, the non-erosive/erosive crop price index has not risen significantly from 1968/69 to 1989/90 or from 1979/80 to 1989/90. However, Figure 4 does indicate that this index has fluctuated considerably over both the longer and shorter time periods. Smallholders intending to invest in new cropping patterns and systems could therefore face substantial uncertainty and thus be less willing to undertake such investments. The implications for land management are:

- farmers who are not incorporating non-erosive crops in their cropping systems may be less willing to do so since the price fluctuations indicate a high risk of investment from crop season to season and small long-term gains; and

FIGURE 2. Tobacco, Cotton, Cassava

Prices (t/kg), 1968/69-1989/90

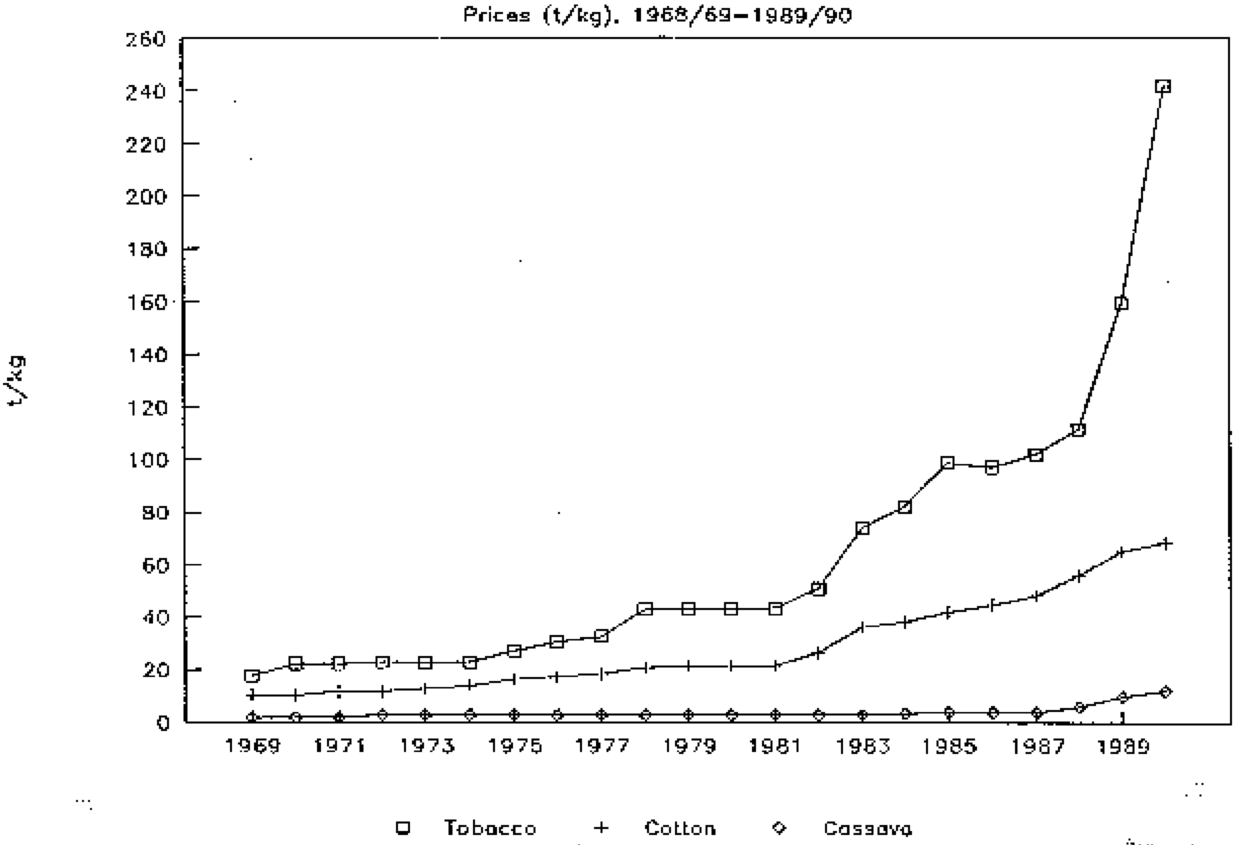


FIGURE 3. Non-Erosive & Erosive Crops

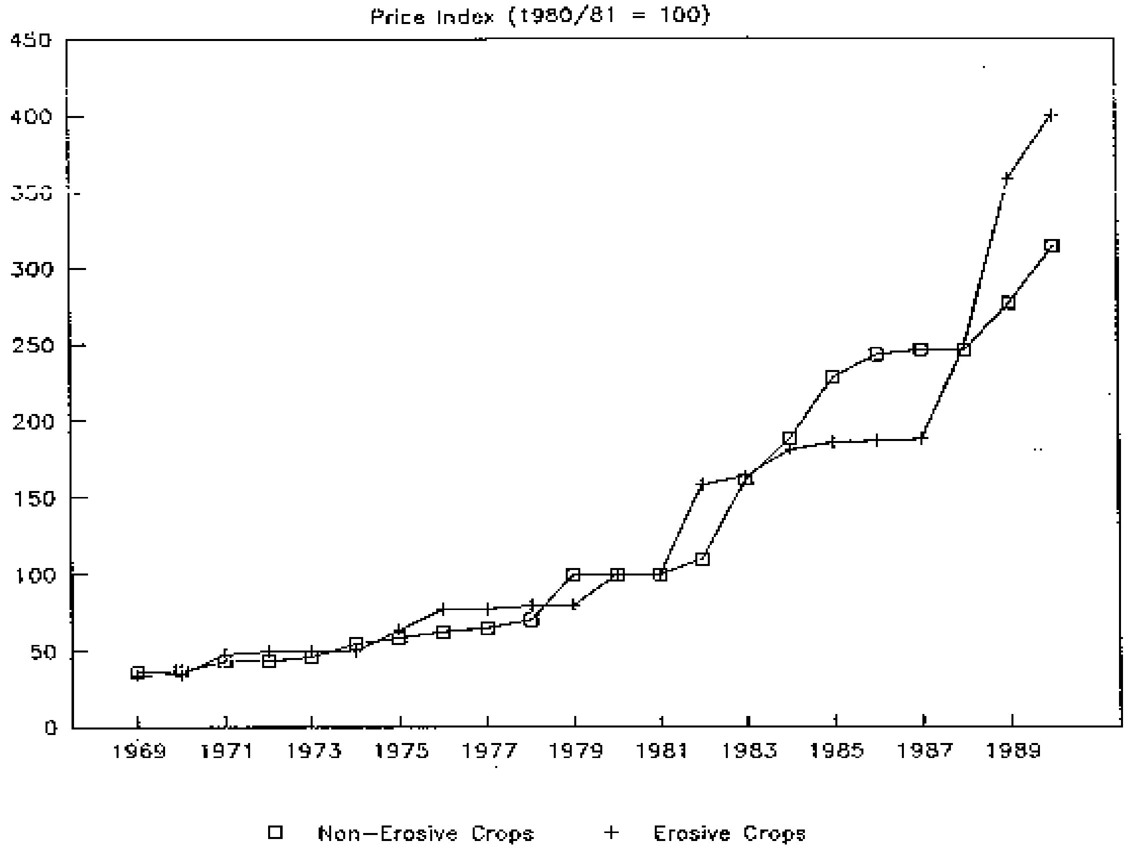
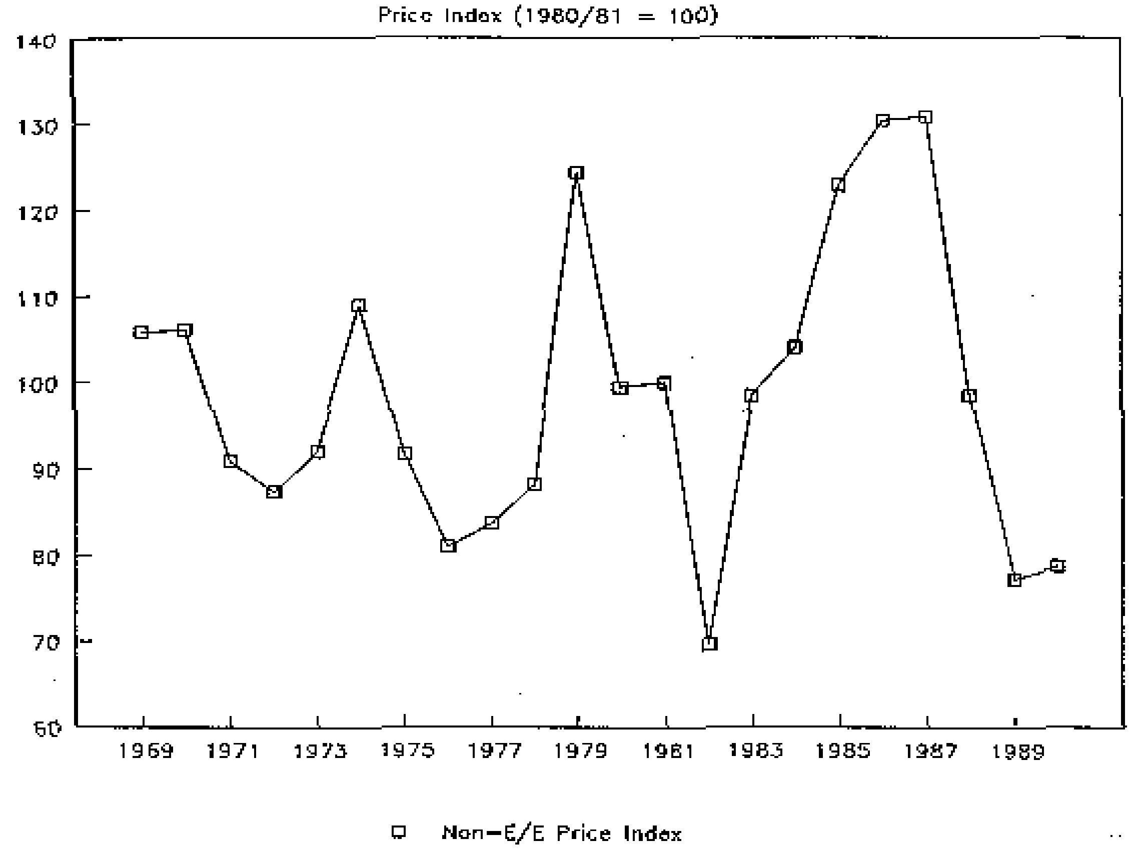


FIGURE 4. Non-Erosive/Erosive Crops



- o farmers who already incorporate non-erosive crops may have less incentive to invest in improvements to these mixed cropping systems - again because of the investment risks from seasonal fluctuations in relative prices and apparently insignificant long-term gains.

The extent to which smallholders in Malawi can anticipate or 'predict' the relative price of non-erosive to erosive crops is based on past price levels and trends.[17] If farmers are to make significant land management investments in cropping patterns and systems, such as switching between erosive and non-erosive crops or substantially improving non-erosive cropping systems, then they would be interested in anticipating future relative price trends of non-erosive to erosive crops. Of particular interest is the extent to which past relative prices and trends are an indicator of future prices, given that the past price levels and trends are probably all the information available to farmers for predicting future prices. If the relative price is highly unstable, then past prices will not be a good guide to the future, and the uncertainty surrounding farmers' investments is high; on the other hand, if the relative price is stable, then past prices could be highly predictive of future trends, and farmers would be less uncertain about the outcome of their investments.

Given that farmers are most likely to base their expectations over future prices on a simple extrapolation of past price levels and trends, fitting an <u>autoregressive trend model</u> to the time series of relative non-erosive/erosive crop prices is the most straightforward method of testing the accuracy of such extrapolations. In short, a basic Nerlovian process is assumed, where the change in price expectations by farmers in the current year is some proportion β of the error made in formulating expectations in the previous year (Nerlove, 1956).

The basic model is:

$$P^*_t = a + \beta P_{t-1}, \qquad (13)$$

where P^*_t = expected relative price of non-erosive to erosive crops in period t (the current year).

P_{t-1} = relative price of non-erosive to erosive crops in period t-1 (the previous year).

Additional past values of P (e.g. for years t-2, t-3, etc.) may also be added. Unfortunately, doing this may also add to problems of *multicollinearity* in any regression analysis, i.e. high correlation between two or more independent variables. However, as the major use of the estimated relationship is to predict future levels of P and not to precisely estimate parameters *per se*, then the presence of any high multicollinearity is less serious a problem.

Several versions of the basic model (13) were estimated, including adding additional past values and incorporating changes in past values in semi-log versions of the basic model. The following were the best results:

$$P_t = \underset{(3.96)}{4.119} + \underset{(2.35)}{0.441P_{t-1}} - \underset{(-2.85)}{0.556P_{t-3}} \qquad (14)$$

period: 1972–90 $\quad R^2 = .475 \quad$ adj $R^2 = .409$

S.E. = 0.524 $\quad$ D-W = 1.77 $\quad F_{2,16} = 7.23$

$$LP_t = \underset{(38.64)}{1.289} + \underset{(2.78)}{0.134DP_{t-1}} + \underset{(2.48)}{0.138DP_{t-2}} \qquad (15)$$

period: 1972–90 $\quad R^2 = .483 \quad$ adj $R^2 = .418$

S.E. = 0.140 $\quad$ D-W = 1.98 $\quad F_{2,16} = 7.48$

where LP_t = natural log of P_t

DP_{t-1} = $P_{t-1} - P_{t-2}$, i.e. difference between last year's price and the price prevailing the year before

DP_{t-2} = $P_{t-2} - P_{t-3}$, i.e. difference between the price two years ago and the price prevailing the year before

All estimated coefficients are significant at the 95% confidence level or higher, with their t-statistics included in parentheses underneath. The more basic model (14) indicates that present relative non-erosive/erosive crop prices can be positively extrapolated from prices the year before, and given the price fluctuations, can be negatively extrapolated from prices three years ago. For example, on average the current relative price will be around 44% of last year's price minus 56% of the price three years ago. The semi-log model (15) shows how this year's prices might change in response to changes in price differentials in the past; i.e., the coefficients indicate how a one unit change in past price differentials might be used to predict the percentage change in this year's prices. In this regression, the response is very low - only 0.13% to a marginal change in past price differentials.

Unfortunately, however, the explanatory power of both models (14) and (15) is not very good, as indicated by their respective R^2 and adjusted R^2 values. This suggests that it is difficult to extrapolate future prices from past price levels alone. Moreover, even if equation (15) is accurate, it indicates that past price differentials are not a very good guide to future price changes.

Models (14) and (15) can also be modified to include a long-run price trend for non-erosive and erosive crops. The assumption would be that smallholders take into account not only more recent prices but also the long-run relative price trend for non-erosive and erosive crops. The long-run trend rates of growth for non-erosive crop prices, erosive crop prices and relative non-erosive/erosive crop prices were estimated directly from the price series data for 1968/69 to 1989/90 using an exponential growth function:

Non-erosive crops:	11.04% per annum
Erosive crops:	11.18% per annum
Non-erosive/erosive:	0.21% per annum.

However, the estimated regressions for deriving trend rate of growth for the non-erosive/erosive price ratio was a very poor fit. This is not surprising, given the extreme fluctuation in this ratio as illustrated in Figure 4. Thus the trend rate of growth in the relative prices was derived indirectly from the difference between the rate of growth of non-erosive crop and erosive crop prices, i.e 0.14%. Using this rate of growth, a long-run constant trend in the relative price was estimated, which was employed in the following regressions:

$$P_t = \underset{(-1.75)}{-29.531} + \underset{(1.51)}{0.285P_{t-1}} - \underset{(-3.69)}{0.757P_{t-3}} + \underset{(1.998)}{8.818T} \quad (16)$$

period: 1972-90 $R^2 = .585$ adj $R^2 = .502$

S.E. = 0.481 D-W = 1.84 $F_{3,15} = 7.05$

$$LP_t = \underset{(2.94)}{0.135DP_{t-1}} + \underset{(2.90)}{0.138DP_{t-2}} + \underset{(40.73)}{0.325T} \quad (17)$$

period: 1972-90 $R^2 = .502$ adj $R^2 = .439$

S.E. = 0.138 D-W = 2.07 $F_{2,16} = 8.05$

The interpretations of regressions (16) and (17) are similar to that of (14) and (15), although adding in the trend variable has changed the coefficients in regression (16) and a 33% change in current prices in regression (17) is related to the long-run change in trend. However, the explanatory power of the regressions has improved only slightly, as indicated by the R^2 and adjusted R^2 values. Thus, even if smallholders were aware of both long-run relative price changes for non-erosive and erosive crops as well as past price levels, it would be difficult to extrapolate future prices with much accuracy. A large degree of uncertainty over future relative prices would remain. Thus, a great deal of *price risk* has existed with regard to relative erosive and non-erosive crop prices, which could have an important influence on the incentives for improved land management.

Gross Margins and Cropping Pattern Changes

Any significant impact of long-run price changes of erosive to non-erosive crops in Malawi should be reflected in changes in the returns and cropping patterns associated with each type of crop. The relative returns to different crops, in terms of gross margins and gross margins per standard man day (SMD), are given in Table 1. The relative returns of non-erosive to all erosive crops and of non-erosive to the high-value erosive crops (hybrid maize, cotton and tobacco) are displayed in Figures 5 and 6. Both the relative gross margins and the relative gross margins per SMD of non-erosive crops have clearly fluctuated over the 1980s, peaking in the mid-1980s and falling sharply in recent years. The fluctuation was mainly the result of rapid changes in the returns of groundnuts relative to maize, which has been influenced by policy reversals on the relative pricing of these two crops.[18] However, even when the relative returns to groundnuts were high, the gross margins of all non-erosive crops in aggregate remained below the aggregate returns to the high-

TABLE 1. MALAWI - ESTIMATED RETURNS OF CROP PRODUCTION MK/ha, 1981/82-1989/90

A. BEANS AND GROUNDNUTS

	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
BEANS									
Gross Margin (GM) 1/	33.91	-4.45	30.18	60.21	66.18	67.98	66.96	77.56	90.69
Gross Margin/SMD 2/	0.20	-0.03	0.18	0.35	0.39	0.40	0.39	0.45	0.53
ALL PULSES									
Gross Margin (GM) 1/	30.86	-5.15	32.28	61.51	65.43	67.43	66.86	80.11	105.64
Gross Margin/SMD 2/	0.18	-0.03	0.19	0.36	0.38	0.39	0.39	0.47	0.62
GROUNDNUTS (Chalimbana)									
Gross Margin (GM) 1/	90.79	171.31	202.62	236.20	250.11	251.22	238.42	230.96	222.35
Gross Margin/SMD 2/	0.80	1.50	1.78	2.07	2.19	2.20	2.09	2.03	1.95
GROUNDNUTS (Manipintar)									
Gross Margin (GM) 1/	NA	NA	151.64	203.73	220.62	260.22	256.43	285.32	351.01
Gross Margin/SMD 2/	NA	NA	1.33	1.79	1.94	2.28	2.25	2.50	3.08
NON-EROSIVE CROPS									
Gross Margin (GM) 1/	70.41	111.31	143.39	175.97	186.56	188.96	180.55	181.07	185.98
Gross Margin/SMD 2/	0.59	0.98	1.23	1.48	1.57	1.59	1.52	1.51	1.53

B. MAIZE

	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
HYBRID MAIZE 3/									
Gross Margin (GM) 1/	211.87	193.15	214.78	196.46	174.02	166.83	253.15	414.45	350.89
Gross Margin/SMD 2/	2.12	1.93	2.15	1.96	1.74	1.67	2.53	4.14	3.51
LOCAL MAIZE 3/									
Gross Margin (GM) 1/	140.98	130.83	143.86	137.06	125.70	123.78	174.70	278.66	284.06
Gross Margin/SMD 2/	1.81	1.68	1.84	1.76	1.61	1.59	2.24	3.57	3.64
LOCAL MAIZE 4/									
Gross Margin (GM) 1/	86.10	86.10	94.70	94.70	94.70	94.70	128.65	187.00	201.50
Gross Margin/SMD 2/	1.65	1.65	1.81	1.81	1.81	1.81	2.46	3.58	3.86
ALL MAIZE									
Gross Margin (GM) 1/	108.28	104.81	115.61	112.46	108.37	107.19	149.92	226.49	229.10
Gross Margin/SMD 2/	1.73	1.69	1.86	1.83	1.78	1.77	2.45	3.66	3.79

TABLE 1. MALAWI - ESTIMATED RETURNS OF CROP PRODUCTION MK/ha, 1981/82-1989/90

C. TOBACCO, COTTON AND WHEAT

	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
TOBACCO (NDDF) 5/									
Gross Margin (GM) 1/	264.54	390.92	491.72	530.50	511.16	533.16	542.36	798.61	1325.28
Gross Margin/SMD 2/	0.87	1.29	1.62	1.75	1.69	1.76	1.79	2.63	4.37
TOBACCO (Sun/Air) 6/									
Gross Margin (GM) 1/	174.84	258.19	281.20	391.64	306.37	318.39	392.54	595.01	894.51
Gross Margin/SMD 2/	0.58	0.85	0.93	1.29	1.01	1.05	1.29	1.96	2.95
COTTON									
Gross Margin (GM) 1/	206.84	292.42	310.81	342.40	287.84	316.49	356.52	358.83	395.96
Gross Margin/SMD 2/	0.84	1.18	1.26	1.38	1.16	1.28	1.44	1.45	1.60
WHEAT									
Gross Margin (GM) 1/	126.71	120.24	110.02	193.40	225.76	248.27	259.56	312.24	344.02
Gross Margin/SMD 2/	0.77	0.73	0.67	1.18	1.38	1.52	1.59	1.91	2.10
EROSIVE CROPS 7/									
Gross Margin (GM) 1/	112.29	112.34	124.22	122.52	117.02	116.82	159.15	235.84	244.85
Gross Margin/SMD 2/	1.69	1.67	1.84	1.82	1.77	1.76	2.42	3.59	3.74
HIGH VALUE EROSIVE CROPS 8/									
Gross Margin (GM) 1/	213.72	218.82	244.48	237.34	210.13	209.85	285.00	429.06	415.79
Gross Margin/SMD 2/	1.85	1.78	1.98	1.86	1.65	1.61	2.32	3.66	3.28
NON-EROSIVE/EROSIVE CROPS									
Gross Margin (GM) 1/	0.63	0.99	1.15	1.44	1.59	1.62	1.13	0.77	0.76
Gross Margin/SMD 2/	0.35	0.59	0.67	0.82	0.89	0.90	0.63	0.42	0.41
NON-EROSIVE/HV EROSIVE CROPS									
Gross Margin (GM) 1/	0.33	0.51	0.59	0.74	0.89	0.90	0.63	0.42	0.45
Gross Margin/SMD 2/	0.32	0.55	0.62	0.80	0.95	0.99	0.65	0.41	0.47

Notes: 1/ Gross margin equals gross return minus total variable costs excluding labor.

2/ SMD = Standard Man Days per ha. These are calculated from the total man equivalent hours, divided by four. Man equivalent hours are used to account for the differences in age and sex composition of labour. The efficiency coefficients used are:

1 hour worked by a man = 1 man equivalent

1 hour worked by a woman = 0.7 man equivalent

1 hour worked by a child = 0.3 man equivalent

3/ With conventional fertilizer.

4/ Without any fertilizer.

5/ NDDF stands for Northern Division Dark-fired tobacco.

6/ Sun/air refers to sun or air cured varieties of tobacco from the Southern Division.

7/ Erosive crops include all maize, NDDF and sun-air tobacco, cotton and wheat.

8/ High value erosive crops include hybrid maize, NDDF and sun-air tobacco and cotton.

Source: Barbier and Burgess (1990)

FIGURE 5. Non-Erosive/Erosive Crops

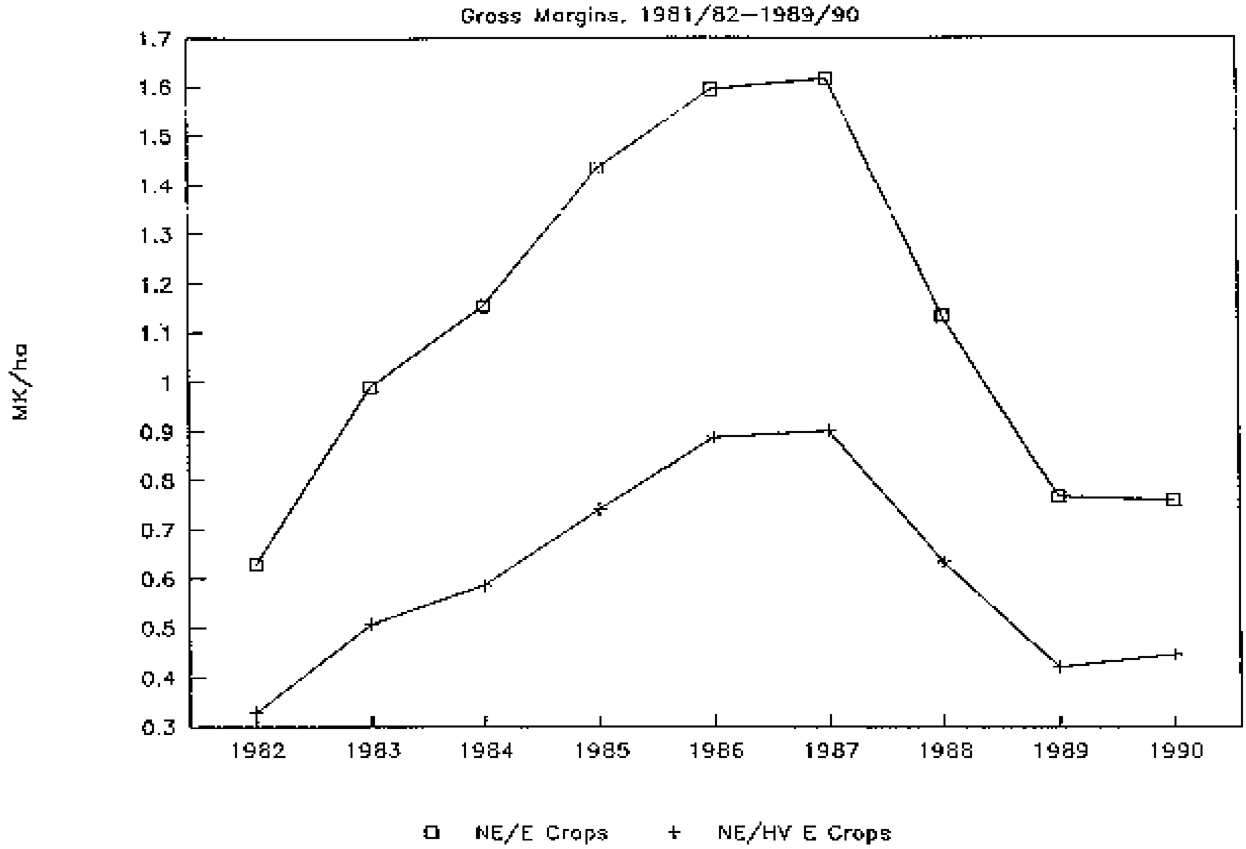
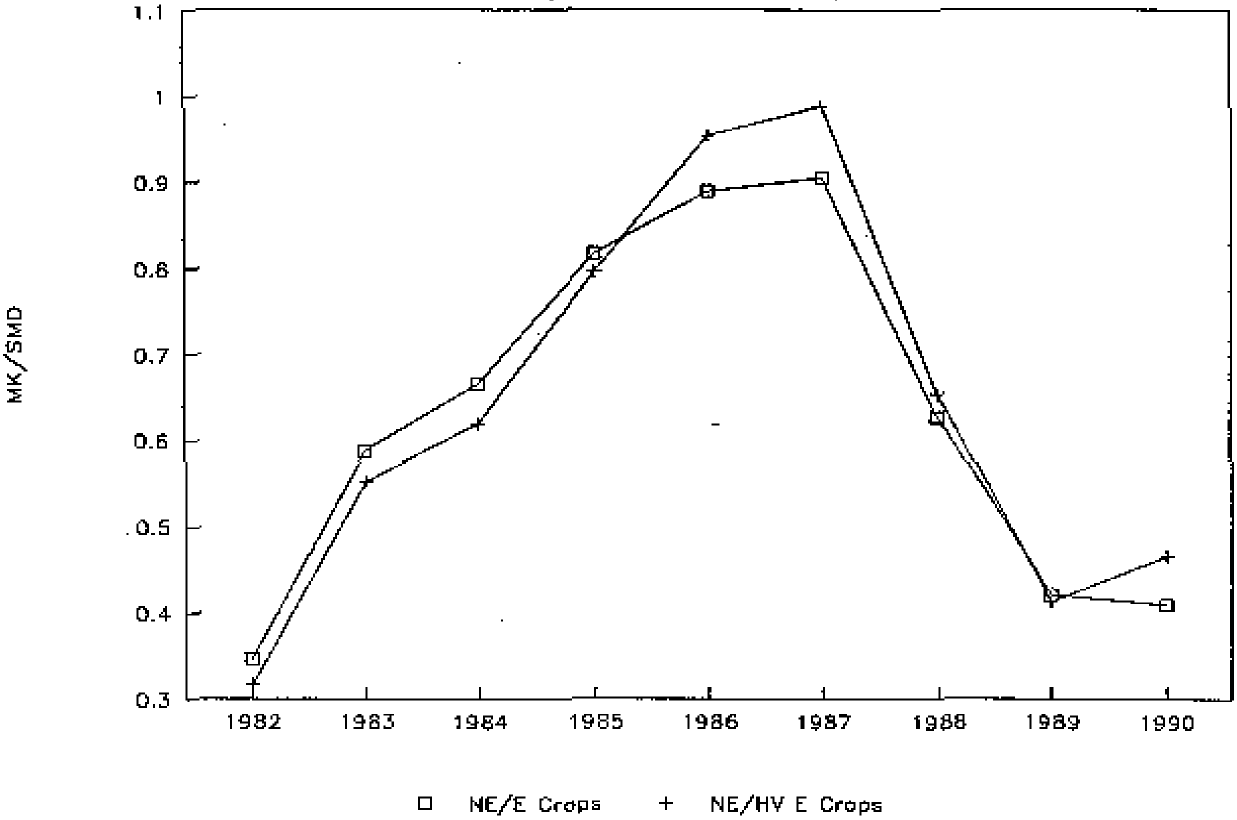


FIGURE 6. Non-Erosive/Erosive Crops

Gross Margin/SMD, 1981/82–1989/90



value erosive crops. In terms of returns to labour, the gross margins per SMD of the non-erosive crops have always remained below those of the erosive crops.

Evidence on the change in cropping patterns in Malawi is sparse. Table 2 includes some trends, although the data must be treated with caution because of the possible inconsistencies relating to mixed stand and pure stand cropping as well as reliability of data and comparability across different surveys and national estimates. On the whole, although maize - particularly local varieties - continues to be the dominant crop, the hectarage under maize appears to have been generally lower in the late 1980s. However, there seems to be little change in the proportion of inter-cropped and pure stand maize cultivation. The survey results in Table 2.A indicate that the area planted to pulses and groundnuts has increased in the 1980s, whilst the area planted to grains have remained fairly stable. Pure stand cultivation of groundnuts and some pulses are thought particularly to have increased (Kydd, 1989). This is not surprising, given the rapid rises in the prices of these crops since 1980/81 (see Figure 1). However the national estimates of crop hectarage indicate very little increase in the area planted to pulses and groundnuts (see Table 2.B).

TABLE 2. MALAWI - CHANGES IN SMALLHOLDER CROPPING PATTERNS

A. Malawi - Surveys of Cropping Patterns in the Smallholder Sector, 1969/70-1987/88

Crops	Percentage of Cultivated Area 1/			
	1969/70 2/	1980/81 3/	1986/87 4/	1987/88 5/
Maize (pure stand)		57.7		55.4
Maize (interplanted)		15.1		14.6
Total Maize	78.4	72.8	66.7	70.0
Groundnuts	4.6	10.2	11.8	15.5
Pulses	4.8	0.5	7.9	8.6
Cassava	2.0	2.7	3.6	2.3
Potatoes	1.4	1.1	1.4	0.9
Sorghum	3.5	1.5	1.7	1.6
Millet		1.6	1.0	2.3
Rice		1.7	1.1	2.2
Cotton	2.9	2.9		6.4
Tobacco	5.3	2.9	2.2	3.1
Others		1.4	0.7	

Notes: 1/ Hecterages under mixed stands are included for each crop in the mixture, therefore the % totals for each crop are not additive. Not all crops grown are listed.
2/ National Sample Survey of Agriculture, 1968/69, (NSSA) a large scale sample survey.
3/ National Sample Survey of Agriculture, 1980/81, (NSSA).
4/ Taken from J. Kydd, "Maize Research in Malawi: Lessons from Failure", Journal of International Development, Vol. 1, No. 1, January 1989, pp. 112-144, based on estimates made by the management of the Agricultural Development Divisions, informed by local sample surveys with uneven coverage.
5/ Annual Sample Survey of Agriculture, 1987/88.

TABLE 2. MALAWI - CHANGES IN SMALLHOLDER CROPPING PATTERNS

B. Malawi - National Smallholder Hectarage Estimates, 1982/83-1987/88

	1982/83		1983/84		1984/85		1985/86		1986/87		1987/88	
	('000 ha)	(%)	('000 ha)	(%)	('000 ha)	(%)	('000 ha)	(%)	('000 ha)	(%)	('000 ha)	(%)
Maize	1169.40	73.99	1182.60	70.21	1144.85	69.36	1193.28	67.96	1182.42	64.94	1215.23	[illegible]
- local			1067.53	63.38	1048.44	63.52	1104.58	62.91	1131.54	62.14	1137.64	[illegible]
- composite			26.07	1.55	21.48	1.30	20.10	1.14	13.78	0.76	18.70	[illegible]
- hybrid			89.01	5.28	74.94	4.54	68.59	3.91	37.10	2.04	58.89	[illegible]
Rice	20.31	1.28	21.92	1.30	20.81	1.26	22.87	1.30	19.08	1.05	21.24	[illegible]
Groundnuts	146.31	9.26	144.94	8.60	135.97	8.24	176.29	10.04	209.94	11.53	176.09	[illegible]
Tobacco	27.59	1.75	45.00	2.67	46.94	2.84	38.05	2.17	33.17	1.82	24.10	[illegible]
Cotton	32.60	2.06	51.06	3.03	60.82	3.68	51.91	2.96	34.50	1.89	43.65	[illegible]
Wheat	2.10	0.13	1.98	0.12	1.13	0.07	1.51	0.09	2.53	0.14	2.55	[illegible]
Sorghum	22.65	1.43	21.30	1.26	32.73	1.98	32.06	1.83	30.63	1.68	30.10	[illegible]
Millet	10.87	0.69	15.34	0.91	17.41	1.05	17.42	0.99	18.16	1.00	19.26	[illegible]
Pulses	82.93	5.25	91.32	5.42	79.97	4.85	113.66	6.47	152.08	8.35	157.40	[illegible]
Oil Beans 1/	3.30	0.21	3.00	0.18	3.00	0.18	2.30	0.13	2.00	0.11	4.45	[illegible]
Sunflower	3.06	0.19	3.07	0.18	3.51	0.21	4.08	0.23	2.55	0.14	2.96	[illegible]
Cassava	59.35	3.76	81.50	4.84	80.26	4.86	72.90	4.15	64.88	3.56	61.39	[illegible]
Potatoes			21.34	1.27	22.72	1.38	22.45	1.28	32.18	1.77	31.80	[illegible]
Cashew	0.05	0.00	0.01	0.00	0.01	0.00	6.55	0.37	24.03	1.32	27.30	[illegible]
Others 2/	0.03	0.00	0.05	0.00	0.46	0.03	0.48	0.03	12.75	0.70	1.05	[illegible]
TOTAL	1580.55		1684.43		1650.59		1755.81		1820.88		1818.58	

Notes: 1/ Oil beans include soya beans, ground beans and guar beans.
2/ Others include sesame, castor, coffee and chillies.

Source: Barbier and Burgess (1990)

Conclusion

This paper has explored the role of relative producer prices in influencing soil conservation and land management decisions by small farmers in developing countries. The theoretical model developed has shown the potential of this problem, especially the susceptibility of farmers' land management decisions to price risk. An empirical analysis of the problem was conducted for the smallholder sector of Malawi, where price fluctuations have occurred in recent years.

The analysis shows that fluctuations in relative crop prices and returns may be exerting a significant impact on the incentives for smallholders to invest in improved cropping systems and land management by increasing the degree of price risk. The dynamics of price risk may produce the following effects:

- given the very small margins for risk among most smallholders and the wide-spread prevalence of household food insecurity, the uncertainty arising from fluctuating prices and returns is not conducive to improving farming systems, incorporating new crops or investing in substantial improvements in existing cropping patterns, cultivation practices and conservation efforts;

- the relative poor returns of the non-erosive crops - groundnuts and pulses - to the more erosive crops, particularly in terms of returns per labour, may be further constraining the income of those poorer households who continue to rely on intercropped systems, with consequences for both their food security and land management; and

o the asymmetrical impacts of pricing for most households - i.e. that food-deficit households are likely to feel the impact of higher food prices as consumers rather than respond as producers to increase production - may have reinforced both the disincentive effect of price fluctuations on investment in improved farming systems and land management and the income constraints faced by poorer households.

Further, detailed analysis of these effects is required both in Malawi and other developing countries to improve understanding of the economic incentives, especially from relative price changes, on smallholder soil conservation and investment.

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Notes

1. This paper is based on work conducted for the World Bank's Southern Africa Department (Barbier and Burgess, 1990). I am grateful to Joanne Burgess, William Hyde and Richard Scobey for help and suggestions. The views expressed in this paper are those of the author alone, and cannot be attributed to the World Bank or to the above mentioned individuals.

2. The model used is adapted from Barbier (1990) and McConnell (1983).

3. In the model, time as a determinant of variables and functions has been omitted to simplify notation.

4. Technically speaking, therefore, there is no such thing as a 'non-erosive' crop. The distinction is really between 'erosive' and 'less-erosive' crops.

5. As in fishery models, *effort* can be thought of as some combination or *index* of the factor inputs required for soil conservation - capital, labour, materials, etc. The assumption is that greater topsoil depth means more soil to protect from erosion.

6. If the private rate of discount reflects the opportunity cost of capital to the farmer, then the interest charge is essentially the income the farmer forgoes by not depleting the soil today and re-investing in some other asset at the rate δ. The farmer's discount rate may also reflect his or her rate of time preference, which will be influenced by such factors as perceptions of risk and uncertainty, tenure insecurity and poverty. However, the social rate of discount will generally be lower than the private rate. For more on the factors influencing discounting in developing countries see Markandya and Pearce (1988), and for specific examples, Barbier (1990) and Pearce, Barbier and Markandya (1990).

7. See Vousden (1973). Ehui and Hertel (1989) develop a similar model for optimal deforestation and agricultural productivity in Cote d'Ivoire.

8. To simplify the model, erosion control effort is not a decision variable that the farmer controls directly. Rather, the farmer influences soil conservation effort indirectly by affecting the level of erosion. In practice one would expect the farmer to exercise more direct control over the soil conservation decision.

9. This section is based on Barbier and Burgess (1990) and the references cited therein.

10. For example, in 1986-87 average smallholder household income was only MK 382 (US$173), of which over 90% was from on-farm

activities, and over 55% of households produced insufficient food for their needs (Government of Malawi, 1987).

11. Becker (1990) has developed a household model for analyzing these constraints, especially for female labour, in Malawi. Barbier and Burgess (1990) provide more detail on how these constraints affect land management decisions, and the special implications for female-headed households, who comprise around 42% of the 'core poor' households in Malawi.

12. For an excellent overview see Lele (1989), who aptly describes this condition as Malawi's "dualism within dualism". See also World Bank (1989b) on the food security and poverty conditions in Malawi.

13. For reviews, see (Christiansen and Southworth, 1988 and Lele, 1989).

14. For example, using a microeconomic model of household choice to analyze supply response, Weaver (1989) found positive and significant own-price responses for rice, cassava and sorghum for smallholders in Malawi. For seed cotton and coffee, negative and significant own-price responses were found. Moreover, the model also estimated highly significant cross-price (relative) price effects. For example, an increase in the relative price of groundnut reduced sorghum production, while an increase in the relative price of cassava increased sorghum production. Similarly, groundnut and maize were found to be substitutes for cotton, whereas rice appeared to be a complement. However, Ogbu and Gbetibouo (1990) criticize Weaver's model for failing to distinguish between subsistence and commercial smallholders, as the authors believe that consumption, production and labour market decisions for these two classes of smallholders are different.

15. For more details, see (Barbier and Burgess, 1990; Christiansen and Southworth, 1988; and World Bank, 1989a).

16. The terms 'non-erosive' and 'erosive' are somewhat misleading. All annual crop cultivation will produce some soil erosion, runoff and fertility declines. However, the relevant point is that some annual crops - e.g., pulses and groundnuts - offer better ground cover, soil fertility maintenance and soil structure cohesion than do others - e.g., maize, tobacco, cassava and cotton, thus reducing land degradation. Also, as noted above, it is not the crop *per se* which causes soil erosion but the method of cultivation and cropping pattern.

17. As very little information exists on actual market prices in Malawi, the price series used in Figures 1-4 and in the following analysis are official prices. However, as the official prices are revised every year in light of market trends, these prices are thought to be sufficiently representative of prevailing price trends.

18. See (Christiansen and Kydd, 1990).

The London Environmental Economics Centre (LEEC) is now known as the Environmental Economics Programme, at the International Institute for Environment and Development. The former name dates from 1987 when the Centre was established by IIED and the Economics Department of University College, London.

Today, all environmental economics staff and research projects are based at IIED where the Programme has become a core area of Institute activity.

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