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POPULATION, LAND TENURE, AND NATURAL RESOURCE MANAGEMENT: THE CASE OF CUSTOMARY LAND AREA IN MALAWI

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ABSTRACT

This paper uses cross section-time series data on 57 communities in Malawi to determine statistically the factors determining changes in land use, tree cover, and crop yield. The econometric model is developed from a theoretical model which also endogenizes population growth and prevailing land tenure institutions within the customary sector of Malawi. The analysis reflects changes between 1971 and 1995, utilizing aerial photos taken at these dates and complementing these with field surveys. The data show a deterioration of Malawi's natural resource base: declining yields, loss of tree cover, and near exhaustion of land for agricultural expansion. Key findings are that population pressure induces land conversion but not yield or tree cover change; the matrilocal system of household residence is negatively associated with tree cover but induces agricultural conversion; and there is some improvement in management of resources as their scarcity increases. Policy recommendations include greater focus on agroforestry to increase tree cover as woodland areas are poorly managed, and increased effort to improve market integration since this benefits crop yields without adverse effects on tree cover.

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by Frank Place and Keijiro Otsuka[*]

1. INTRODUCTION

Malawi, as elsewhere in sub-Saharan Africa, has experienced a significant change in its landscape cover. Although reliable figures are hard to come by, the Forestry Department estimates the annual deforestation rate to be 1.3 percent per year in the 1980s (World Resources Institute, 1994). This has raised concern about the future supply of fuelwood and other tree products and environmental services (French, 1986; Hyde and Seve, 1993; Dewees, 1995). Much of the deforestation is believed to be linked to conversion of miombo woodlands into agricultural land. This involves expansion onto steep slopes and other fragile lands in many cases. Bojo (1994) presents data suggesting that the consequent effects on soil erosion create serious costs to the Malawian economy.

Attaining sustainable use of woodland resources and sustainable growth of agriculture are important for Malawi because the economy is agricultural-based and of its approximately 12 million people, nearly 87 percent live in rural areas (World Bank, 1995). The population density is about 100 persons per square kilometer which is high among southern African countries and places a great pressure on agriculture which benefits from only a single rainy

season. Primary commodities still account for 94 percent of all export revenues in Malawi, though agriculture's share in GDP is about 40 percent. Growth of agriculture, recorded to be 4.4 percent in the 1970s, has fallen to 2.1 percent between 1980 and 1993 resulting in declining food production per capita.

Malawi policy makers, having few resources at their disposal, must make critical choices concerning the type of land use patterns that will prevail in the future. Unfortunately, while much information has been generated about current land use, there is little understanding of the dynamic process leading up to the current land utilization pattern nor to related effects on productivity and the stock of natural resources. This study will provide new evidence as to how communities have managed their land and tree resources and what factors seemed to be most important in their decisions. This information is valuable to policy makers who continue to struggle with the twin objectives of alleviating poverty in the short run and in preserving the natural resource base in the long run so that future generations may have access to high quality income generating assets.

Evidence from other countries in sub-Saharan Africa is scanty. A study in Nigeria shows that deforestation is neither inevitable nor linearly related to population growth (Cline-Cole et al. 1990). In a study of 64 sites in Uganda, Place and Otsuka (1996) found large differences in land use change and tree cover on-farm and off-farm between 1960 and 1990. These differences were largely attributed to differences in population growth and density, but also to access to roads, land tenure regime, and to the responses of communities and individuals to initial tree density levels and hence their scarcity value.

In this study we are concerned with the influence of population pressure and land tenure on land use and tree resource management in Malawi. Regarding land tenure, a few

points unique to this country need to be mentioned. There are several tenure regimes governing the use and management of land and trees in Malawi, including customary or indigenous lands and the estate sector. While the estate sector has generated a great deal of policy debate in Malawi (Kydd and Christiansen, 1982; Dickerman and Bloch, 1989; Sahn and Arulpragasam, 1991), our study focuses on the customary sector which occupies about 70 percent of land area in Malawi. In this sector, cultivators are small peasants with few exceptions and many of them suffer from severe poverty. Uncultivated land is usually owned by the community and the permission from the village headman is required to clear the land for agricultural production (Nothale, 1982; Mkandawire, 1983/84; Hirschman and Vaughan, 1984). While the use rights over agricultural land are well established, the rights to transfer are limited, as in the case of other areas in Africa (Ault and Rutman, 1979). Hence, no land market exists and transfer of agricultural land is primarily through inheritance. Traditionally, matrilineal inheritance was practiced by the majority of the rural population, but the patrilineal system has increasingly been adopted in many areas. The objective of this study is to identify statistically how the customary land tenure institutions and their changes affect land use and management of woodland resources in the context of the customary sector of Malawi.

The remainder of the paper is organized as follows. We begin with a description of customary land tenure in our study sites which leads into our major hypotheses. This is followed by the presentation of the theoretical and econometric model used to test the hypotheses and then a brief description of data collection methods. The remaining sections describe and discuss the results of our analysis first at a descriptive level and then based on our econometric analyses. Finally, the conclusions and policy implications are presented to end the paper.

2. CUSTOMARY LAND TENURE SYSTEMS IN MALAWI

The customary sector consists mainly of smallholders and a key distinction here is between matrilineal and patrilineal ethnic groups. When land was abundant both systems vested land in chiefs and village headmen. The village headmen in turn would cede rights over specific tracts of land to families and family leaders. New lands could be opened through requests to family leaders and village headmen.

In a matrilocal system (practiced by the Chewa and Yao in our study sites), where husbands move to live in the wife's village, land had traditionally been passed from mother to daughter or from family leader to female family members (Mkandawire, 1983/84). The couple often resided permanently in the wife's village. This system is akin to matrilineal systems observed in some parts of Asia, such as Sumatra (Otsuka et al., 1997). In matrilineal systems where the couple moves to or otherwise resides in the husband's village, the husband traditionally acquired land from a village headman or family leader in his village. This land would then pass from uncle to nephew or niece (perhaps through the family leader). Inheritance of land from uncle to nephew is common in other areas of Africa, such as western Ghana. These traditions appear to have changed over time and new couples search for land from several sources and locations. Precious little evidence is available on this process and this paper hopes to document the extent of this change.

A patrilineal system, common in the north of Malawi, is similar to those elsewhere in sub-Saharan Africa in that men claim land ownership and can pass on all land developments to his children. It has been customary among the Ngoni and Tumbuka at our sites to favor

sons over daughters in inheritance practices.

The various modes of transfer and tenure arrangements might have different incentives on farm and tree management due to differences in tenure security (Besley, 1995). Land that passes from parents to children or merely from mother to daughter seemingly offer the appropriate incentives to households to make long-term investments (labour and capital) on the land. While these appear to be the majority of cases in matrilineal systems, three types of situations are of concern. The first is where husbands reside in the wife's village (uxorilocal marriage) only on a temporary basis. In some of these cases, the husband will have rights to land in his own village (and may have more than one wife). This situation can reduce the incentives for a man to work in his wife's village. A second situation is where land passes from uncles to nephews or nieces, bypassing the children. In such cases, couples may neglect the long-term quality of the land especially as they grow older. This case, however, is seldom observed in our sample. A third case concerns rights to land following death or divorce of a spouse. In the case where the widow or widower resides in the deceased's village, continued rights to land are not at all guaranteed. Where either a death or divorce becomes more likely, the non-resident spouse may likely increase activities which enhance short-term returns at the expense of long-term returns.

Although most farms in Malawi are small, constrained by the inability of household to cultivate much land with low levels of technology, some individual customary holdings in the northern half are quite large. These are farms in villages where 'communal' lands had been partitioned to families. The resulting large farms contain both cultivated and uncultivated areas. The latter are primarily miombo woodlands and are largely open-access land for village members (Lowore et al., 1995).

There are also communally held lands, held by the clan or village headman. Informal interviews during recognizant work found that these are virtual open-access resources, with few rules on user group membership or use rates (see also Coote et al., 1993a, 1993b). One notable exception is the Village Forest Area system initiated in the 1920s, rekindled recently by the Forestry Department, in which communities demarcate woodland areas to be placed under special management rules (which are always conservation oriented).

A first area of investigation will be the impact of population growth on changes in tenure systems. One of the hypothesized effects is that population growth will lead to a conversion from matrilineal systems of land acquisition to more non-traditional sources such as inheritance through the male's family (Mkandawire, 1983/84). This is likely to occur when sufficient land is unavailable in the wife's village due to the exhaustion of village land.

Secondly, we hypothesize that increased population pressure will lead to conversion of woodlands to privately held lands resulting in loss of tree cover. However, the relationship may not be linear and some woodland area may be maintained even at very high population densities. The speed of conversion may be conditioned by other factors such as the value of woodlands (e.g., values might be higher where livestock holdings are large) or the possibilities and incentives for intensification on existing agricultural land.

A third area of examination involves the effect of land acquisition mechanism and associated incentives on land use, tree planting and other natural resource investments. Greater investment in tree planting or preserving woodland resources may be associated with improved tenure security for males if they have greater power over natural resource management decisions. If this is the case, better management of woodlands and tree resources is expected in patrilineal rather than in matrilineal systems and in non-matrilocal

rather than in matrilocal systems. The opposite could be the case, however, if women have greater decision-making power.[1]

3. THE THEORETICAL AND ECONOMETRIC MODEL

In this section, we construct a simple model of land use change in order to identify key variables affecting the farmer's decision to convert woodland to farm land. Conversion of land is one strategy households can pursue to increase production and income. We focus initially on the decision to convert because it is a good entry point into addressing related issues of deforestation and productivity. Specifically, we consider a farming household which faces the choice of preserving woodland or converting it to farm land. If it is preserved, it generates a net benefit of π_{Nt} at time t for a given area. For simplicity, we assume that the net benefit grows at a constant rate of β. Then, the following relation holds:

$$\pi_{Nt} = \pi_{N0} e^{\beta t}, \tag{1}$$

where π_{N0} is the net benefit in the current period. If woodland is managed sustainably, β is likely to be positive, because the value of those resources will increase over time. If woodland resources deplete sufficiently rapidly, however, β will be negative.

If woodland is converted to farmland, it accrues a net benefit of π_{At} at time t. Again assuming a constant growth rate, π_{At} can be expressed as

$$\pi_{At} = \pi_{A0} e^{\alpha t}, \tag{2}$$

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[1] Mkandwire (1983/84) considers that males are heads of households in the matrilineal communities of the Chewa ethnic group.

where π_{A0} is the net benefit in the current period and α is its expected growth rate. The net

benefit is likely to decline if crop farming is unsustainable and, hence, crop yield is declining.

On the other hand, if production methods improve, α will be positive.[2]

Future benefits are discounted due to time preference and the risk of losing rights over

future benefits from land. Under the matrilineal cum matrilocal system, if a wife dies or a

marriage breaks down, the husband loses rights to use land and must return to his original

village. Similarly, under the patrilineal cum patrilocal system, if a husband dies or a marriage

breaks down, the wife often loses the right to receive benefits from land and must leave the

husband's village. For simplicity, we assume that the discount rate combines the rate of time

preference, r, and the expected rate of change in the probability of retaining land rights, ρ,

both of which are constant. The magnitude of ρ will depend on the instability of marriage,

mortality, and the bargaining positions of husband and wife. This rate may be small under the

patrilocal system, if the husband has sole decision making power and disregards his wife's

concern about the loss of her land rights in the assessment of his future benefits. In contrast,

this discount factor may be positive and large if the husband is a major decision maker under

the matrilocal system and is concerned with the chance of losing his land rights upon death

of his wife or divorce in the future.

Under the assumptions made above coupled with the assumption of an infinite time

horizon, the net present values of farm land and woodland can be shown, respectively, as

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[2] Note that we have assumed away any positive externalities from woodlands which would affect profits from agriculture. In the absence of steep slopes and irrigation, this seems reasonable.

$\pi_{A0}/(r + \rho - \alpha)$ and $\pi_{N0}/(r + \rho - \beta)$.[3] Then, the benefit of converting woodland to farm land (V) can be expressed as the product of the converted area (ΔX) and the difference in the net future benefits between farm land and woodland:

$$V = \Delta X \left[\pi_{A0}/(r + \rho - \alpha) - \pi_{N0}/(r + \rho - \beta) \right] . \qquad (3)$$

If V is negative, no woodland is converted to farm land. If V is positive, some woodland area may be converted to farm land, depending on any conversion costs incurred. As in the model of Ehui et al. (1990), an increase in farm productivity, which will increase π_{At}, leads to larger conversion of woodland to farm land in the model.

The major cost of investment in land conversion is labor cost and, hence, investment cost (C) depends on the scarcity of labor, which will decline with increases in population density (N_0/X), and access to urban labor markets, but will worsen with increases in distance to urban centers (D). The investment cost also depends on the difficulty of land conversion, which is assumed to be reflected in the proportion of land area already converted to farm land (X_{A0}/X). Thus, the cost function for investment may be expressed as:

$$C = C(\Delta X, N_0/X, D, X_{A0}/X) , \qquad (4)$$

where both the first and the second partial derivatives with respect to ΔX are assumed to be positive.

Woodland area is usually owned by the community and its use is controlled by the village headman. Thus, a community member who wants to clear woodland needs to obtain

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[3] A similar specification of net future benefit is adopted by Mendelsohn (1994) in his model of land use by squatters who possess insecure land rights.

permission from the headman. In reality, however, permission is easily granted and woodland area is essentially open access to the community members. We implicitly assume that woodland is an open-access area.

The household will determine the optimum amount of land conversion so as to maximize the net benefit of investment, V - C. Assuming the existence of unique interior maximum, the investment function can be derived as:

$$\Delta X = \Delta X \ (\pi_{A0}/(r + \rho - \alpha) - \pi_{N0}/(r + \rho - \beta), \ N_0/X, \ D, \ X_{A0}/X) \ . \qquad (5)$$

This function is not directly estimable, as we do not possess data on π_{A0}, π_{N0}, ρ, α, and β. Therefore, in actual estimation, we use proxies and variables which are expected to affect those key variables. Firstly, we assume that the profitability of farming per unit of land in the base period (π_{A0}) is positively and closely correlated with yield of maize, which was estimated to occupy over 72 percent of smallholder cultivated area (in purestands and mixes) in Malawi in 1980 (Malawi Government 1984). Secondly, we assume that the net benefit from woodland in the base period (π_{N0}) can be captured by the average woodland tree cover. Thirdly, we assume that α and β are proportional to the rates of change in yield and tree cover, respectively. We note that population pressure on land may affect α and β by changing the scarcity of foods and woodland products, even if population pressure does not affect the physical farm output and the amount of woodland resource extraction. Finally we assume that ρ is conditioned by the land tenure system, which is reflected in the prevalence of the matrilineal cum matrilocal system or the proportion of land received from wife's family and the village headman of the wife's village (M). It is, however, difficult to determine the effect

of M on ρ or ΔX on an *a priori* ground. Our own observation, as well as the observation of Ng'ong'ola et al. (1996), is that husbands are often the major decision makers with respect to land use change and, hence, the risk of losing their land use rights is a major concern under the matrilocal system. Thus, we may hypothesize that ρ is a positive function of M. Even so, the effect of M on the relative profitability of land conversion is unclear, as it is conditioned by the relative magnitudes of α and β (see equation (3) or (5)). If crop farming is less sustainable than woodland resource extraction, so that $\alpha < \beta$ holds, an increase in ρ will increase the relative profitability of crop farming, and vice versa. In other words, an increase in ρ favors the choice of less sustainable land use system.

Assuming that each household maximizes the net benefit of investment and that all households in the community have common expectations about α and β, the aggregate area converted from woodland to agricultural land at the community level is the sum of the converted areas by households. Thus, we postulate that the land conversion at the community level is affected by the following set of explanatory variables:

$$\Delta X/X = F(Y_0, G_Y, T_0, G_T, M, N_0/X, G_N, D, X_{A0}/X) \ , \tag{6}$$

where the dependent variable is normalized by total area of community (X) to adjust for differences in the total size of communities; Y_0 and T_0 denote yield and woodland tree cover in the initial period, respectively; G_Y and G_T represent their expected growth rates; and G_N stands for the population growth rate. While Y_0, T_0, N_0/X, D, and X_{A0}/X are either predetermined or exogenous, G_Y, G_T, M, and G_N should legitimately be considered as endogenous variables. For simplicity, we do not change notation for the converted area (ΔX)

at the individual level (equation (5)) and at the aggregate level (equation (6)).

If the Boserupian hypothesis of intensification of the farming system takes place in response to population pressure (Boserup 1965), or if the Hayami-Ruttan thesis of induced technological innovation takes place in response to changing factor scarcities (Hayami and Ruttan 1985), G_Y will depend on population density and on access to output and input markets. Although maize yield had been stagnant or even declining in Malawi until the late 1980s (Kydd 1989), delayed green revolution in maize has taken place in some areas (Smale 1995). If induced farming intensification took place, we may expect that the green revolution was particularly successful in land scarce areas close to urban markets. Farmers may also adopt soil conservation practices to prevent declining yield in such areas by investing in land improvements including tree planting (Ndiaye and Sofranko 1994). Land tenure may matter in the growth rate of maize yield, to the extent that yield-enhancing investment plays a significant role. Thus, we assume the following functional relationship in the determination of yield growth:

$$G_Y = G_Y (Y_0, T_0, M, N_0/X, D, X_{A0}/X, E) \ , \tag{7}$$

where E is a vector of exogenous environmental factors, such as rainfall, which would affect yield growth.

As was pointed out earlier, woodland resources have been depleted in Malawi, because no explicit management rules have been adopted (Coote et al. 1993a, 1993b; Lowore 1995). Even so, management efficiency may depend on the homogeneity of community members, since this affects the cost of organizing community actions and enforcing agreements (Clarke et al., 1996; Matose and Wily, 1996), and on the prevailing land tenure,

as this affects the extent of myopic behavior. Aside from the cost of mobilizing collective action, the rate of resource extraction will depend on the demand for woodland resources, which is affected by population density and access to markets, and the supply, which is governed by the initial endowment of woodland and the ability to regenerate woodland. It is also important to note that the Malawi government has attempted to promote tree cover by designating village forest areas and by implementing tree planting projects. These considerations lead to the formulation of the following functional relationship:

$$G_T = G_T (Y_0, T_0, M, N_0/X, D, X_{A0}/X, H, A, GP) \; , \tag{8}$$

where H represents the degree of homogeneity of community members, which may be measured by the proportion of the major ethnic group and the proportion of cattle-owning households using woodland for grazing; A represents an ability for woodland regeneration, which may be measured by the incidence of tree species with coppicing ability; and GP corresponds to government policies, such as protection of village forest areas and implementation of tree planting projects. In the estimation, we use the woodland tree cover in the initial period for T_0 and percentage changes in tree cover for G_T.

We do not have clear-cut theory to explain secular changes in matrilineage cum matrilocal system towards patrilineal cum patrilocal system. In Malawi, ethnic groups under the patrilineal tradition reside mainly in northern and north-central regions, whereas other areas are occupied by ethnic groups practicing matrilineal descent traditions. Needless to say, such traditions affect the prevalence of the matrilineal system at present. Hirschmann and Vaughan (1983, 1984) argue that when land becomes scarce husbands in matrilineal societies work off farm and often migrate to other areas to find jobs. This suggests that ample

opportunities for off-farm employment help preserve the matrilocal system. If sufficient land is unavailable in the wife's village and off-farm employment opportunities are limited, a couple may seek land from the husband's family and reside in his village if land is available, thereby transforming a matrilineal system to a patrilineal system (Mkknadwire 1992). Therefore, we postulate that the tradition of ethnic groups, scarcity of land, and off-farm employment opportunities, among other things, affect the prevailing land tenure institutions measured by M, i.e.,

$$M = M \ (Y_0, \ T_0, \ N_0/X, \ G_N, \ D, \ X_{A0}/X, \ EH) \ , \tag{9}$$

where EH indicates dummies for ethnic groups distinguished by matrilineal and patrilineal traditions.

The population growth rate reflects both natural growth and net migration. We assume that population growth will be affected by the following set of variables: (1) ethnic traditions, (2) population density in the initial period, (3) access to markets, (4) productivity of farming, (5) proportion of already cultivated land, and (6) the prevalence of polygamy. The last variable is included as the degree of polygamy is expected to be a positive indicator of out-migration (of males) from the area and may also be related to lower birthrates per woman. Thus, we specify the following function to explain the population growth rate:

$$G_N = G_N \ (Y_0, \ T_0, \ N_0/X, \ D, \ X_{A0}/X, \ EH, \ PO) \ , \tag{10}$$

where PO denotes the proportion of households under the polygamy system.

4. DATA COLLECTION METHODS AND DESCRIPTION

SAMPLING STRATEGY

The data for this study come from 57 enumeration areas throughout Malawi.[4] There are about 6,500 enumeration areas in Malawi which were created for census purposes. This is the smallest unit for which boundaries are known and can thus be transferred onto maps with relative ease. The boundaries often follow physical land features and they do not run through villages. The next largest well defined area, an extension planning area, was often too large to ensure collection of accurate information about communities. Enumeration areas are designed to have roughly the same population and thus are different in size depending on the density of population. Our sample had a range of size from 180 to 5,580 hectares, with the mean being 1,271 hectares (or about 4km by 3km). Excluded from the sample were enumeration areas in the extreme north and south (Karonga and Shire Valley), and those corresponding to towns and gazetted state land. The remaining enumeration areas were selected by a stratified random process in which 15 each from the north, north-central, south-central, and south of Malawi were selected. This stratification was made to ensure a variation in population density and tenure type, both of which are known to vary from north to south in Malawi.

The data are reflective of the customary areas in the study sites as estates were found in only six of the enumeration areas and represented a small proportion of land area. Because

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[4] Aerial photographs for 60 sites were analyzed for land use and tree cover change, but three were not visited for field surveys due to logistical difficulties.

of the small influence of estates and the fact that smallholders have only recently been granted

access to quotas of tobacco, the most important commercial crop in Malawi, we do not

believe that demand for fuelwood for curing tobacco played any significant role in land use

and tree cover change in our study.

NATURAL RESOURCE MANAGEMENT INDICATORS

Land Use and its Change

For each enumeration area, aerial photographs were obtained for 1971-3 and 1995.

The 1970s aerial photos are from a countrywide coverage at a scale of 1:25,000. The 1995

aerial photos, kindly made available by the British Overseas Development Agency, were at

the same 1:25,000 scale which greatly facilitated the land use and tree cover interpretation.

The photos were all taken during the dry season in Malawi and there were no problems with

cloud cover in the study sites. At such a scale, the minimum mapping unit (i.e., area which

can be effectively differentiated and given boundaries) is about one hectare.

Interpreters differentiated as many as 27 classifications for land use and tree cover (see

Appendix 1). The broad land use classifications were agriculture, wetland, grassland, forests,

plantations, woodlands, woody regrowth (i.e., bushland), rocky areas, marshes, built-up

areas, and surface water. Within agriculture, there were several sub-categories, including

upland rainfed, irrigated, and wetland cultivation. Within upland agriculture (which comprises

99 percent of all agricultural land), further differentiation was made according to tree cover

with separate classes identified for under 2 percent cover, 2-5 percent cover, 5-10 percent

cover, 10-20 percent cover, and 20-40 percent cover. Forests were differentiated by normally

stocked (averaging of 80-100 percent) and depleted (average of 50-60 percent). Woodlands

and regrowth were each differentiated into five tree cover classes: 2-20 percent, 20-40 percent, 40-60 percent, and 60-80 percent cover. Other land use categories were largely devoid of trees by definition.[5]

Natural forests and plantations were easily distinguished from each other by the pattern found in plantations. The two were also distinguished from woodlands by the density of stand and type of species. The difference between woodland and bushland is less obvious. An area is classified as woodland if the average height of woody vegetation exceeds four meters in height; it is bushland otherwise. In our analyses, the two are always grouped together. Where a tree cover estimate was difficult to discern, a grid with square sampling areas was overlayed on the area in question and the tree cover from the sampled squares was measured by hand or with the aid of available cover guides. Areas were measured with the use of a planimeter or circle grid.

Table 1 displays some statistics on broad land use categories in the 1970s and in the 1990s using simple averages across the 57 enumeration areas.[6] Agriculture had the largest share of the enumerated land area in both years, averaging .52 in 1972 and .68 in 1995.[7] Roughly 20 percent of enumeration areas had an agricultural land share of over .80 in 1972 but as many as 48.0 percent achieved the same proportion by 1995. Despite this, a few enumeration areas from the north of Malawi maintained relatively little agricultural activity during the period. The lowest share of land in agriculture among enumeration areas was .03

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[5] If there was significant tree cover, then the area would have been reclassified (e.g., from grassland to woodland).

[6] It is worthy to note that the 1995 land use estimates from our enumeration areas correlate very closely to those from a larger study designed to be representative of Malawi (Green and Mkandawire, 1996).

[7] Note that agriculture is a small proportion of land in the larger enumeration areas (in northern Malawi). Thus, the weighted share of land in agriculture is much lower, .50 in 1995, for example.

in both 1972 and 1995. Moreover, 10 of the 57 enumeration areas experienced a decrease or no change in aggregate agricultural land area over the study period. The change in share of agricultural land per enumeration area ranged from -.32 to +.73 across the study sites.

Table 1 Land use and land use change across study sites

Land use category	Average share across sites in 1971	Average share across sites in 1995	Share change interval which includes 80 percent of sites	Most positive absolute change in share	Most negative absolute change in share
Agriculture	.515	.677	-.02 to .41	.73	-.32
Woodland & Bushland	.330	.185	-.38 to .00	.10	-.66
Forest & Plantations	.013	.002	.00 to .00	.07	-.63
Other	.142	.136	-.12 to .08	.35	-.18

Most of the increase in land under agriculture was accommodated by a reduction in woodland and bushland. This broad category of land use had a mean share land area of .33 in 1972 which dwindled down to .19 in 1995. About one-fourth of all enumeration areas had less than a .10 share of woodland in 1972, but the percentage of enumeration areas in the same category jumped to 60.0 percent by 1995. Nonetheless, about one-fifth of all enumeration areas retained a woodland area comprising at least a .40 share of land area in 1995 (mainly areas in the north). There were very few natural forests or plantations in the study sites. The number of enumeration areas with at least 1.0 percent forest cover was only five in both 1972 and 1995 and the share of land in this category remained negligible over the entire period. The 'other' category remained more or less constant at 13.6-14.2 percent. Most of this area is comprised of village settlement areas while in some, the low-lying grasslands (or dambos) are significant.

Tree Cover and its Change

Table 2 displays some summary statistics pertaining to tree canopy cover across the enumeration areas. In 1972, the average canopy cover was estimated to be 17.3 percent, but the median was much lower, at 9.0 percent. Over half of the enumeration areas had a tree cover of under 10.0 percent and four enumeration areas were virtually devoid of tree cover (under 1.0 percent cover). At the other extreme, about one-fourth of enumeration areas had a canopy cover of over 30.0 percent, with the highest recorded being 61.0 percent. By 1995, tree cover had fallen to an estimated cover of 10.1 percent (the median being only 3.3 percent). Some 14 enumeration areas had tree canopy covers of 1.0 percent or less. A nearly equal number (12), however, remained with relatively high tree canopy cover of over 20.0 percent.

Table 2 Tree cover pattern across study sites

Broad land use category	Average tree cover across sites in 1971	Average tree cover across sites in 1995	Cover change interval which includes 80 percent of sites	Most positive absolute change in cover	Most negative absolute change in cover
Agriculture	.023	.020	-.02 to +.01	.05	-.07
Non-agriculture	.243	.167	-.18 to .03	.14	-.61
Average	.173	.101	-.20 to .00	.06	-.57

There are significant differences in tree cover according to whether the primary land use is agriculture or not. Table 2 shows that tree canopy cover in agriculture land is very low in the sites, estimated to be only around 2 percent in both years. This level of cover has remained constant across most enumeration areas as noted by the fact that the change in absolute tree cover was between -.02 and +.01 for 80 percent of the sites. Perhaps the one

encouraging note is that tree cover density on agricultural land did increase in nine sites, though it is not known whether this occurred on land already under agriculture in 1971 or whether it is was largely on newly converted lands. Tree cover in non-agricultural areas is much higher, but has shown a more marked decline. From a level of about 24.3 percent in 1971, tree cover in non-agricultural areas has dropped to 16.7 percent, on average, across the study sites.[8] Some 44 sites experienced a decrease in non-agricultural land tree cover, while nine showed an increase. By 1995, 31 percent of enumeration areas still maintained a tree cover in non-agricultural land of over 20 percent. Our data do not seem to support the contention of Hyde and Seve (1993, p.286) that "the level of deforestation still exceeds the level of reforestation, but the rate of reforestation is rapid."

Crop Yield and its Change

Data on average yields of important crops in 1971 and 1996 were collected through group interviews. Maize is the most important crop grown by smallholders in Malawi and we received data on maize yields for 52 of 57 sites.[9] Reported yields for 1996 are considered to be fairly accurate, while those for some 25 years back may be less so. Nonetheless, we feel that the relative changes in yields across sites are not systematically biased in any significant way and therefore provide at the minimum a useful ordinal ranking (see Table 3). The mean maize yield in 1996 was 1.1 tons per hectare and only seven sites reported means of above two tons per hectare. All but three enumeration areas saw maize yields decline over the study

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[8] Again, note that because the northern enumeration areas are larger and have a greater tree density, the weighted average tree cover for Malawi would be much higher than indicated by our simple averages across sites.

[9] Maize yield estimates were not obtained for five enumeration areas. For these, averages calculated from nearby enumeration areas were used.

period. Some of the yield decline may be due to crop expansion onto more marginal land. In many cases the declines were substantial and the mean decline in yield was as large as 54.5 percent. The agricultural development strategy based on large-scale estate agriculture miserably failed, as it neglected the development of smallholder agriculture (Kydd and Christiansen 1982; Kydd 1989; Dickerman and Bloch 1991; Sahn and Arulpragasam 1991).

DRIVING FACTORS

Data for the explanatory variables in our model come mainly from group and household surveys conducted in each of the enumeration areas. Our field surveys consisted of interviews with a group of well-informed elders and local leaders at each site. They provided information on location variables, ethnic group variables, cropping patterns and yields, livestock holding patterns, types of trees on the landscape and external interventions, and information on resource tenure rights and rules. Surveys of 10 randomly selected households in each site provided additional information on household type, location of residence and method of plot acquisition. Secondary data sources were used for information on population, climate, and soils.

Table 3 displays information on many of the factors we hypothesize lead to changes in the management of natural resources. They are presented as averages by three zones. The north includes the 12 sites from Mzuzu Agricultural Development Division (ADD). This is distinguished by its relatively low population density and predominance of patrilineal ethnic groups, as can be seen from the low percentage of plots acquired under the matrilocal system. The north-central includes sites in Kasungu and Salima ADDs and are grouped together because these two areas have witnessed the greatest expansion of the estate sector and

associated population increase through migration (Christiansen, 1984). The south is generally more heavily populated by matrilineal groups.

Table 3 Description of important explanatory variables

Variable	North region	North-central region	South region	Average
1971 maize yield (ton/ha)	2.3	5.2	2.7	3.4
Average percentage change in maize yield, 1971-95	-44.4	-65.5	-51.5	-54.5
1971 population density	25.4	48.7	93.8	65.2
Annual population growth rate, 1971-95 (%)	3.9	5.2	3.4	4.1
Percentage of plots acquired through matrilocal system	13.4	33.5	68.9	46.0
Average year of plot acquisition	1984	1984	1981	1982
Distance to tarmac (km)	33.8	13.9	28.1	24.8
Distance to a major city (km)	110.6	129.1	117.8	119.8
Percentage of households with cattle in 1971	11.3	13.2	9.9	11.3
Percentage of households using fertilizer in 1971	30.0	35.5	24.9	29.3
Average annual rainfall (mm)	1,004.0	867.0	907.0	915.0
Average distance to plots (km)	1.3	1.1	1.1	1.1

Table 3 confirms that our regional groupings are quite important. Population density in 1971 ranges from 25.4 per square kilometer in the north to 93.8 in the south. Growth of population is found to be significantly higher in the frontier zone where estates had been formed and many families resettled. The higher growth rates of population are also reflected

in the average date of acquisition of land plots, which is about three years earlier in the more populated southern region.[10]

The prevalence of matrilocal inheritance systems is strongest in the matrilineal south, weakest in the patrilineal north, and is moderate in the transitional north-central zone. Overall, about half of all plots were acquired through the wife's family. In our sample, 22.8 percent of sites reported that the Tumbuka or Ngoni, patrilineal groups, were the most prevalent groups. The Chewa, a matrilineal group, was clearly the most commonly found group, being the most prevalent in 47.4 percent of enumeration areas. The remaining 29.8 percent of sites reported other traditionally matrilineal groups as being the most common.

Two locational factors were measured to approximate access to markets and off-farm employment opportunities: distance to a tarmac road and distance to a major city (Mzuzu, Lilongwe, or Blantyre). There was significant variation in the responses for both. The mean distance to tarmac was 24.8 kilometers and this was notably higher (33.8) in the north and less in the north-central (13.9). The latter is explained by the fact that a major tarmac route forms a loop through the north-central region. Mean distance to a major city was much longer, 119.8 kilometers, and was quite similar across regions.

Cattle holding is not as common in Malawi as it is in some other countries as shown by the relatively low percentage of households with cattle in 1971 (11.3 percent). Few cows are milked and cattle raising is a means of saving in Malawi (Blanc et al., 1996). The percentage has more or less stayed the same over time and herd sizes are not large either. Goats are more prevalent, with about one-third of households reporting to have at least one

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[10] Population growth and density were based on 1977 and 1991 figures, the two most appropriate census years. The values were used to extrapolate forward or backwards to 1971 and 1995.

goat in 1996. The ratio of households using chemical fertilizer in the early 1970s was fairly similar across regions, ranging from 24.9-35.5 percent. Following liberalization of fertilizer marketing and pricing, this has dropped off considerably in 1995-6 in our study sites, but other reports indicate that fertilizer use remained quite high through the early 1990s (Smale, 1995).

Three variables were obtained which are directly related to tree cover and its change. Information on external tree planting projects was obtained including the approximate number of trees planted. The average across all sites was about 630 trees but the average across the 13 sites which had projects was 2,762. Just over one-third of sites reported to have had Village Forest Areas in the early 1970s. These may not have actually corresponded to the Village Forest Areas as laid forth in the Forest Act in Malawi, but they nonetheless represent areas identified by respondents as different from ordinary miombo woodlands and managed, at least during some period, by the community. For those sites with such areas, about 40 percent of the area on average was under such schemes. The final variable was the coppicing ability (or ability to regrow after cutting) of trees, which is defined as the percentage of all trees on the landscape in 1971 having a high coppicing ability (calculated by weighting and scaling up from individual species). The average for the entire sample was 25.4 percent, though 20 parishes registered a zero.

Average annual rainfall across all sites was 915 millimeters. Rainfall was somewhat higher in the north (1,004mm) than in other regions (867mm to 907mm). Soil texture and soil type were obtained only at a large scale; consequently the degree of precision is relatively low. In our sample, about 63 percent of the sites were considered to be sandy or sandy mixtures, 43 percent were clays or clay mixtures (there are some sandy-clays reported), and

47 percent were identified as having a fine texture as opposed to coarse. Data on slopes is not available.[11]

5. ECONOMETRIC ANALYSIS

ESTIMATION METHOD

The model expressed in equations (6) through (10) contains five endogenous variables: land use change, woodland tree density change, yield change, population growth, and indigenous land tenure regime. Land use change is reflected by the absolute change in the share of agricultural land (of total enumeration area land). As indicated above, this change is nearly equal to the change (in the opposite direction) of woodland and bushland, so that the inclusion of one land use change in the model is sufficient. Theoretically, tree density change on agricultural land and non-agricultural land ought to be considered in the model. However, in practice, our data indicate very little change in tree cover density on agricultural land; in both the early 1970s and mid 1990s, a very low tree density is found. Due to the limited number of sample observations and the difficulties in identifying each of the equations, it was decided to exclude tree cover on agricultural land from the formal analysis. A third natural resource management variable is the change in yield. Since maize is the most commonly grown crop in Malawi, the change in yield of maize is used as the measure of yield change. Population growth is the annual rate of change between 1971 and 1995. Lastly, the tenure variable is the percentage of plots (within each of the enumeration

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[11] At the time of this draft, data on elevation is being verified and will be included in the final analysis if it exhibits sufficient variation.

areas) coming from the wife's side of the family, which indicates the strength of female control and consequently weak male control over land resources.

Although there may well be unidirectional and/or lagged relationships among the variables, we cannot *a priori* rule out a simultaneous equations structure. Consequently a three-stage least squares (3SLS) estimation procedure is employed. In a five equation model, especially one in which endogenous variables are clearly linked, satisfying the rank condition for identification can be difficult. Nonetheless, we feel that our choice of 'identifying variables' is sound: average year of plot acquisition and dummies for major ethnic groups for the tenure equation; degree of polygamous marriage for population growth; coppicing ability of trees, presence of external tree planting and management projects for tree cover change; and initial period use of fertilizer and average distance to plots for yield change.

RESULTS

The results from two models are presented in Tables 4 and 5. They differ as to the degree to which the population growth, tenure, and land use change impact on the endogenous variables. In model 1, we assume that endogenous variables affect only land use change. This is relaxed in model 2 where feedbacks are tested in each of the regression equations. The R-squares in most of the equations were very encouraging (ranging from .45 to .69 for all but the land use change equations). The results discussed below are robust across the two models (Tables 4 and 5) except where noted.

Table 4 3SLS model with no feedbacks from population growth

Variable	Population Growth	Percentage of plots acquired by women	Tree cover change on nonagricultural land	Maize yield change	Change in share of agricultural land
Constant	7.2298	-12.619	.2843	2.5401	-.8437
	(1.74)	(-0.66)	(1.81)	(3.10)	(-1.76)
North-central zone	3.8685**	.0652	-.2868**	.1297	-.0236
	(3.91)	(0.59)	(-5.36)	(0.79)	(0.17)
Southern zone	3.9023**	.3864**	-.1591	-.1257	-.4391**
	(3.63)	(3.05)	(-1.85)	(-0.48)	(-3.05)
Chewa ethnic group	-.1419	-.1490*			
	(-0.20)	(-2.05)			
Patrilineal ethnic groups	-.6306	-.2389**			
	(-0.95)	(-3.05)			
Proportion of population of main ethnic group	-.0148	.0003	.0002		
	(-1.11)	(0.17)	(0.22)		
1970 population density	-.1500**	.0026	.0007	.0028	.0184**
	(-2.91)	(0.43)	(0.24)	(0.26)	(3.25)
1970 population density squared	.00075**	-.00001	-.000005	-.00002	-.0001**
	(2.63)	(-0.28)	(-0.32)	(-0.36)	(-3.04)
Log of distance to tarmac	.3194	-.0785**	-.0208	.0870*	.0302
	(1.34)	(-3.12)	(-1.44)	(2.05)	(1.05)
Log of distance to major city	.4576	.1074*	.0216	-.1844*	-.0583
	(1.01)	(2.07)	(0.78)	(-2.03)	(-1.15)
1970 log of yield	.2218	-.0306		-.3031**	.0351
	(0.57)	(-0.76)		(-4.40)	(0.59)
1970 share of land in agriculture	-5.2917**	-.0421	.0138	-.0680	-.3285*
	(-3.80)	(-0.26)	(0.18)	(-0.27)	(-2.05)
1970 woodland tree cover	-2.6057		-.6479**		.4272
	(-1.38)		(-6.86)		(1.28)
Percentage of polygamous households	-.0555**				
	(-4.20)				
Average year of acquisition of plots		.0065			
		(0.67)			
Proportion of trees that coppice well			.0479		
			(1.33)		
1970 percentage of Village Forest Area to total area			.0016**		
			(3.70)		

Table 4 (continued)

Variable	Population Growth	Percentage of plots acquired by women	Tree cover change on nonagricultural land	Maize yield change	Change in share of agricultural land
Number of trees planted by external projects			-.000005 (-1.25)		
1970 percentage of households with cattle			-.0001 (-0.11)	.0008 (0.32)	.0009 (0.71)
1970 percentage of households using fertilizer				-.0022 (-1.75)	
Average annual rainfall				-.00005 (-0.32)	
Average distance to plots				.0065 (0.11)	
Whether sandy soils prevail				-.0888 (-1.13)	
1970 agricultural land tree cover				-.4927 (-0.10)	
Population growth					.0366* (1.74)
Percentage of plots acquired by women			-.2612* (-2.38)	.1915 (0.50)	.6455** (3.71)
Change in woodland tree cover					-.1590 (-0.37)
Change in yield					-.1923 (-1.58)
R-squared	.536	.691	.594	.454	-.089

Note: Figures in brackets are t-values. ** indicates 1% significance level, and * 5% level.

Table 5 3SLS model with feedbacks from population growth

Variable	Population Growth	Percentage of plots acquired by women	Tree cover change on nonagricultural land	Maize yield change	Change in share of agricultural land
Constant	7.2708 (1.78)	-19.375 (-0.94)	.3423 (1.82)	2.5192 (3.07)	-.8489 (-1.77)
North-central zone	3.8929** (3.96)	.0283 (0.21)	-.2534** (-3.16)	.0818 (0.43)	-.0105 (-0.08)
Southern zone	3.7718** (3.51)	.3662* (2.55)	-.1289 (-1.29)	-.1465 (-0.56)	-.4316** (-2.95)
Chewa ethnic group	-.3535 (-0.52)	-.1245 (-1.61)			
Patrilineal ethnic groups	-.7644 (-1.16)	-.2040* (-2.34)			
Proportion of population of main ethnic group	-.0130 (-0.98)	.00006 (0.03)	.00009 (0.11)		
1970 population density	-.1423** (-2.77)	.0029 (0.45)	-.0018 (-0.58)	.0045 (0.40)	.0184** (3.19)
1970 population density squared	.00071* (2.49)	-.00001 (-0.29)	.00001 (0.58)	-.00003 (-0.49)	-.00010** (-2.99)
Log of distance to tarmac	.3020 (1.27)	-.0790** (-3.10)	-.0180 (-1.19)	.0816 (1.87)	.0309 (1.07)
Log of distance to major city	.4188 (0.93)	.1028 (1.92)	.0232 (0.82)	-.1869* (-2.05)	-.0586 (-1.15)
1970 log of yield	.2022 (0.54)	-.0387 (-0.91)		-.3092** (-4.36)	.0344 (0.58)
1970 share of land in agriculture	-5.1752** (-3.73)	.0437 (0.21)	-.0226 (-0.24)	-.0072 (-0.03)	-.3327* (-2.04)
1970 woodland tree cover	-2.4621 (-1.31)		-.6626** (-6.59)		.4549 (1.37)
Percentage of polygamous households	-.0532** (-3.97)				
Average year of acquisition of plots		.0099 (0.94)			
Proportion of trees that coppice well			.0522 (1.39)		
1970 percentage of Village Forest Area to total area			.0016** (3.02)		

Table 5 (continued)

Variable	Population Growth	Percentage of plots acquired by women	Tree cover change on nonagricultural land	Maize yield change	Change in share of agricultural land
Number of trees planted by external projects			-.000005 (-1.23)		
1970 percentage of households with cattle			-.000001 (-0.00)	.0011 (0.42)	.0008 (0.64)
1970 percentage of households using fertilizer				-.0023 (-1.78)	
Average annual rainfall				-.00006 (-0.37)	
Average distance to plots				.0052 (0.09)	
Whether sandy soils prevail				-.0839 (-1.05)	
1970 agricultural land tree cover				-.5807 (-0.12)	
Population growth		.0134 (0.56)	-.0078 (0.59)	.0177 (0.50)	.0351 (1.52)
Percentage of plots acquired by women			-.2600* (-2.33)	.1199 (0.29)	.6566** (3.76)
Change in woodland tree cover					-.1191 (-0.28)
Change in yield					-.1986 (-1.63)
R-squared	.548	.685	.581	.441	-.104

Note: Figures in parentheses are t-values. ** indicates 1% significance level, and * 5% level.

Population Growth

Several variables were found to be related to the rate of population change. The initial population density was found to have a non-linear impact on the population growth rate which is negative but decreasing (i.e., less negative) with increases in population density. This implies that population growth is highest in areas with lower densities and that growth rates decrease more slowly and eventually may increase again as population densities increase to high levels. Our models predict that population growth rates are minimized at a 1970 population density of 99 (this is exceeded in about 23 percent cases). Related to population density, we also found that the 1970 share of agricultural land is negatively related to population growth. This is sensible since a higher share implies less new land for expansion and accommodation of new families. Population growth was lower in sites where polygamous households were more common. Possible explanations for this include smaller nuclear family wealth or farm sizes per household in polygamous marriages (i.e., the wealth of the husband is shared across many households). However, we did not find any literature providing evidence to support these explanations. Lastly, the regional dummies were significant, with growth higher in the north central region (where in-migration has been highest) and in the southern region.

Transmission of Land Through Women

Ethnic and location variables are the prominent variables explaining the choice of land transfer practice. Variables significantly associated with greater emphasis on transmission through the women's side of the family include patrilineal ethnic group (-), the Chewa ethnic group (-) as opposed to the base and omitted matrilineal ethnic groups, distance to a major

city (+), distance to a tarmac road (-), and to the southern region (compared to the north). While the results for the ethnic groups are reasonable (that for the Chewa loses statistical significance in model 2), those for the location variables are more difficult to explain. Longer distance to a tarmac road may indicate the lack of off-farm opportunities for labor (e.g., trade) which may lead to a greater desire of men to concentrate on farming and to acquire land from their side of the family. The result on distance to city may indicate that inheritance systems are becoming more patrilineal-like following exposure to urban culture. Since ethnic group is already controlled for the positive significance of the southern region dummy implies that the traditional system has had greater resiliency in this region. Contrary to our hypothesis, transition to more patrilineal cum patrilocal land transfers was not hastened by population density or population growth.

Change in Non-agricultural Land Tree Density

The change in woodland tree density is found to be negatively related to more matrilineal cum matrilocal systems as opposed to patrilineal cum patrilocal systems. This finding supports the general observation that the miombo woodlands have largely disappeared in the central and southern areas of Malawi where the matrilineal system is prevalent. One reason for this finding could be that husbands have reduced incentives for long-term natural resource management when living in their wives' villages. They will exploit resources, including trees in the woodlands, if they lack long-term secure rights to resources outside of their home village. We found that tree cover change was higher (mainly smaller decreases) where Village Forest Areas occupied a larger share of the area. These were identified by respondents as specially managed areas, implemented with the assistance of the Forest

Department.[12] The change in tree density was negatively related to the initial period level, suggesting that change is more rapid when the scarcity value was lower. Finally, tree cover change is related to region; there has been greater tree density loss in the north-central region, characterized by estate development and high demands for tobacco curing, and less so in the southern regions, though the latter effect disappears in model 2.

Change in Crop Yields

Few of the included variables were significant determinants of changes in maize yields. The strongest relationship appears to be the initial period yield which shows a negative relationship. This may simply reflect the fact that respondents were much more aware of current day yields (which were relatively similar across enumeration areas) than they were of past yields (which varied much more). Surprisingly, yields declined more rapidly where 1970s fertilizer use was more prevalent. This is possible if initial period fertilizer use is not a good predictor of fertilizer use over the period (so that farmers who later used fertilizer realized large gains in yield). It may also be that farmers who did not use fertilizer in the early 1970s chose not to because they had already adopted alternative sustainable practices such as intercropping or rotations with nitrogen fixing legumes. Yield decline was steeper the closer to a tarmac road and further away from a major city. The former result may perhaps be due to greater mining of the land for short-term returns in areas nearer a tarmac road which would have been developed earlier and the latter result may capture the higher ratio of input costs to output prices leading to lower use of inorganic nutrient inputs in areas far away from major

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[12] It should be noted, however, that many of the Village Forest Areas had been depleted by 1996.

cities, especially in recent years where liberalization has led to significant reductions in fertilizer use.[13]

Change in Share of Agricultural Land

Both tenure and population growth had statistically significant impacts on land use change. Conversion of woodlands into agricultural land was accelerated in matrilocal areas relative to patrilocal areas. Consistent with the results on tree density, this could be a reflection of men's lack of long-term incentives for management which in turn leads to increased demand for land conversion and consequent receipt of short-term benefits. Population density has the expected positive effect on the rate of conversion of woodlands to agricultural land. The negative sign on the squared term indicates that this positive effect declines with population density and is maximized at a population density of 94 per square kilometer (exceeded by 23 percent of sites). Thus, very high levels of population pressure reduce the rate of conversion of woodland to farmland. Similarly, the 1970 share of agricultural land was negatively related to conversion reflecting the higher costs of land conversion associated with the diminution of the land frontier. Population growth also has the expected positive effect in model 1, although it disappears in model 2. The final significant result was that conversion of woodlands was lowest in the southern region. Given the results in other equations, it appears that the high population growth in the southern region has mainly resulted in smaller farm sizes rather than expanded agricultural area.

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[13] Suspecting possible negative yield effects of expanding crop cultivation into more marginal areas, we also ran the model with land use change entered into the yield regression. The sign of the coefficient is negative but not statistically significant.

6. SUMMARY AND CONCLUSIONS

First of all, it should be made clear that it is difficult to generalize our findings for all of Malawi, because of the considerable variation from north to south. In our discussions below, we have in mind the situation facing the central and southern regions, which are home to the majority of the population and which are facing more critical natural resource management choices. The north, with its relatively low population density, cannot be lumped in with the others in the following discussion, although it may face similar issues in the near future.

We found several trends in natural resource management which portend hard times ahead for rural households in Malawi. First, we found that in nearly all sites, yields of maize, the staple food crop, were reported to have declined over the past 25 years. Second, while families and communities have hitherto been able to compensate for this by expanding agricultural areas, new uncultivated areas are becoming scant. In nine enumeration areas land once under woodlands has completely disappeared and in virtually all others, the area under woodland has decreased markedly. Third, the conversion of land has had a dramatic and negative impact on aggregate tree density since tree cover is many times greater on non-agricultural land than on agricultural land (16.7-2.0 percent in 1995). At the same time, we found little evidence of significant tree planting, though in some of the sites, tree density on agricultural land inched upwards. Fifth, exacerbating the effect of land conversion on tree cover is the decrease in tree density on remaining woodlands (by about 33 percent).

In sum, the increasing scarcity of woodlands and their products have not yet manifested itself in sufficiently attractive incentives for their sustainable management. Given

the high degree of poverty among rural households and the poor remuneration from maize production, it is unlikely to be high profits from agricultural production that have driven the conversion process. Instead, one must look at weaknesses in the management of woodlands themselves as contributing towards the seemingly low valuation attributed to their preservation and management.

It is difficult to assess the degree to which this apparent natural resource degradation is undesirable. However, considering negative environmental externalities arising from degradation of woodland resources and the lack of woodland resource management, the pace of natural resource degradation almost certainly exceeds the socially optimal level. The rather likely possibility that resources have been degraded beyond the sub-optimal rate implores us to then ponder how these trends can be reversed.

For this, we turn to our econometric analyses for some insights. Population density was found to have its anticipated positive effect on the conversion of land into agriculture. However, interestingly, neither population density nor growth necessarily led to decreased yields or tree cover. This is encouraging and suggests that to some extent, there are some induced responses occurring within communities. It is also encouraging to see that tree cover change is negatively (and strongly) related to initial tree cover. This again points to some locally recognized increase in the scarcity value of tree resources (Hyde et al., 1996).

Connectivity to markets could play a role in raising long-term benefits from resources and improving household incentives to manage them. We found that proximity to major urban areas was positively associated with yield change and at the same time did not lead to degradation of tree resources or woodlands over the study period. Such a finding is similar to that found for Uganda (Place and Otsuka, 1996) where market integration was linked to

significant tree planting activities by households. The fear that infrastructure development will have deleterious effects on the environment is unwarranted. This is notably different than evidence pertaining to virgin forest areas in the Amazon (Fujisaka et al., 1996) suggesting that property rights systems in more settled areas such as Malawi are sufficient to forestall wanton resource depletion. There is clearly a role for governments to play here and increased market connection can be a strategy to reduce poverty while simultaneously promoting natural resource management.

While tree planting on farms has shown little movement in the aggregate, there seems to be better scope for increasing tree density on farms than on woodlands, where areas and tree densities have displayed a rapid decline. Aside from improved incentives to plant and manage trees on individual farms, the simple fact that the most of the landscape (the north excepted) is already under agriculture leads us to this conclusion.

But growing trees on farms in Malawi does not seem to be straightforward as noted by Dewees (1995). This is no doubt linked to institutional constraints on the supply side, such as lack of a seed production and distribution system. However, our study has found evidence to suggest that tenure factors play an important role on the demand side of the equation. We found that woodland conversion and tree density in remaining woodlands are lower the more matrilineal cum matrilocal land tenure systems dominate. We believe this is an indication of poor incentives for males to manage natural resources on a sustainable basis in such tenure systems. We are not, however, recommending that the systems be changed and are not sure that they could be in any case. Our results indicate that continued integration with markets and urbanization will lead to changes in tenure systems, albeit slowly and non-linearly. In the meantime, projects which aim to improve natural resource management must

take these tenure considerations very seriously and devise strategies to ensure that proper incentives are in place for both males and females who will be expected to invest in the management of the natural resource base.

APPENDIX: DEFINITIONS OF LAND USE CATEGORIES
AND VEGETATION COVER

(1) Cultivated Land

- Rainfed:

    -- rainfed with less than 2 percent tree canopy cover

    -- rainfed with 2 - 5 percent tree canopy cover

    -- rainfed with 5 - 10 percent tree canopy cover

    -- rainfed with 10 - 20 percent tree canopy cover

    -- rainfed with 20 - 40 percent tree canopy cover

- Wetland cultivation

- Dimba cultivation

- Irrigated cultivation

(2) Grassland

- High or low montane grassland

- Dry grassland/scrub

- Seasonally wet grassland of floodplains

- Seasonally wet grassland of upland drainage systems

(3) Plantation Forests

(4) Natural Forests and Woodland

- Evergreen forest:

    -- normally stocked

    -- depleted

- Woodlands (trees over 4m in height):

    -- open, 2 - 20 percent tree canopy cover

    -- medium, 20 - 40 percent tree canopy cover

    -- dense, 40 - 60 percent tree canopy cover

--   very dense, 60 - 80 percent tree canopy cover

•   Recent regrowth of woody vegetation (under 4m in height):

              open, 2 - 20 percent tree canopy cover

              medium, 20 - 40 percent tree canopy cover

              dense, 40 - 60 percent tree canopy cover

              very dense, 60 - 80 percent tree canopy cover

(5) Marshes

(6) Rock

(7) Water

(8) Built-up areas

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