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Agricultural Policy and Technology Options in Malawi: Modeling Responses and Outcomes in the Smallholder Subsector

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CORNELL FOOD AND NUTRITION POLICY PROGRAM

AGRICULTURAL POLICY AND TECHNOLOGY OPTIONS IN MALAWI: MODELING RESPONSES AND OUTCOMES IN THE SMALLHOLDER SUBSECTOR*

Kenneth Simler

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ABBREVIATIONS

ADD	Agricultural Development Division
ASA	Annual Survey of Agriculture
ASAC	Agricultural Sector Adjustment Credit
HYV	High Yielding Varieties
LP	Linear Programming
SFFRFM	Smallholder Farmer Fertilizer Revolving Fund of Malawi

EXECUTIVE SUMMARY

For more than a decade, Malawi has experienced slow economic growth. The smallholder agriculture subsector, which employs the vast majority of the population, has been stagnant, while the population of the country has grown at a rate of over 3 percent per year. Poverty is pervasive in Malawi, with low incomes, high infant and child mortality, high rates of malnutrition, low life expectancy, and low literacy levels. A strategy is needed to restore growth to the Malawian economy and ensure that the benefits of the growth are distributed in a way that will address the severe poverty which characterizes Malawi.

There have recently been questions from some quarters about the appropriateness of an agriculture-led development strategy for Malawi. High population pressure on arable land and a weak record in promoting agricultural intensification in the smallholder subsector are cited as the main reasons for looking for alternative sources of economic growth. However, the industrial and service sectors of the Malawian economy, both formal and informal, are very small, especially in rural areas where the bulk of the population lives. Even if the rural informal economy doubled in size every year — a growth rate far in excess of any experienced previously in Malawi — the contribution to overall economic growth would barely keep pace with population growth. Thus, in the short term Malawi has little choice but to follow an agriculture-led development strategy. As between 80 and 90 percent of the population are smallholder farmers, it is only sensible that a growth strategy be oriented toward them. This should be complemented by policies to reinforce linkages between farm and nonfarm sectors and promote nonagricultural employment to help absorb the rapid growth in the labor force that accompanies rapid population growth.

Smallholders are not a homogenous group. They have different needs, and, more importantl,y they have different constraints and different capacities to respond to opportunities. Hybrid maize is an example — it has been a successful cropping option for those who can undertake it, but adoption has been extremely limited because of various constraints on smallholder farmers. There is a need to alleviate those constraints that can be eased, such as credit, and design policies to take account of constraints that will inevitably persist, such as labor shortages in female-headed households and land shortages for most households. In this paper the diversity that exists among smallholder households is recognized, and a typology of smallholder households is developed based upon the size of the area cultivated and the region of the country. This typology is used in the subsequent analysis to analyze the effects of different policies on different types of smallholders.

This paper examines the farm-level and national-level effects of a smallholder-based growth strategy that has four major components: flint hybrid maize, burley tobacco, agroforestry, and self-inoculating soybeans. All can contribute to smallholder incomes and economic growth, but the first two have the

advantage of being attainable in the very near term. The latter two, on the other hand, will require longer gestation periods, but have the advantage of being geared especially toward the needs of resource-poor households.

The development of flint hybrid maize varieties MH17 and MH18 overcomes one of the critical obstacles that has hindered adoption of hybrid maize to date: the poor processing and storage characteristics of the older dent hybrids. The flintier varieties have consumption characteristics that are closer to the preferred local varieties, but are capable of yields on a level with the dent hybrids. While the potential appeal of these seeds is obvious, it is not possible for most households to acquire the seeds and recommended fertilizer without a substantial infusion of funds to purchase the inputs. Thus, credit would have to be expanded. Furthermore, extension efforts would have to be expanded to reach the majority of smallholder farmers who have had little or no contact with the extension system. In addition to expanded outreach, adaptive research and extension will need to develop and deliver more site-specific recommendations than has been the case in the past.

Even if adequate input supplies, credit, and extension are provided and flint hybrids are adopted, smallholders operating on one-half hectare or less will still not be able both to repay input loans and retain sufficient maize supplies to meet household food requirements until the next harvest. For these households the need to improve land and labor productivity goes beyond the opportunities presented by flint hybrid maize. These smallholders, and smallholders in general, require greater opportunities to grow high value cash crops, which offer the highest returns to land and labor inputs. The strong growth in the estate agriculture subsector during the past decade has largely been built on expanding production and exports of burley tobacco. Until 1990 the growing of burley tobacco was the exclusive privilege of estates, and since then smallholders have only been granted burley licenses on an extremely limited basis. Although the inputs are expensive, burley tobacco has at least four major advantages over other cash crops. First, Malawi's exports of the crop have been growing rapidly, so increased allocations of burley tobacco quotas to smallholders can come from a growing "pie"; estate production levels can continue to grow alongside a growing smallholder share. Second, the payoff is quick relative to crops such as tea and coffee. Third, there are relatively few areas in the country that are not suitable for burley tobacco production. Fourth, burley requires a much lower capital outlay for production infrastructure than flue-cured tobacco.

It is this last feature that makes it easy to scale down burley tobacco production to levels appropriate for smallholder conditions. With a quota allocation of only 150 kilograms of burley leaf, a smallholder household could grow burley on a one-tenth hectare microplot. The household would still be able to practice the recommended one-in-four rotation to avoid pest infestation, would probably be able to meet all or most of the crop's labor requirements from family labor, and grow the usual food crops on the remainder of the available land. In fact, the potential profits from burley tobacco are such that a household should be able to repay loans for burley inputs and have funds available to help finance the adoption of flint hybrid maize.

Malawi has one of the highest nitrogen:maize price ratios in the world, which has inhibited the adoption of fertilizer and hybrid maize. This has led in turn to low productivity of land and labor, and declining soil fertility throughout the country. Research in Malawi, and elsewhere, has demonstrated the beneficial effects of including leguminous trees or hedge crops in the smallholder farming system, providing a source of cheap nitrogen for crops such as maize, as well as producing useful fuel and fodder by-products. Besides nitrogen, the trees and hedges add organic matter to the soil, thus improving soil structure and inhibiting soil erosion, a problem that has accelerated in Malawi along with expansion onto marginal lands due to pressure from population growth and estate expansion. With vigorous research and extension, the use of agroforestry practices can be increased, providing inexpensive nitrogen to resource-poor farmers and helping to preserve Malawi's most important natural resource: the fertility of its soil.

An important recent technological breakthrough is the development of soybeans that do not require the application of inoculant at planting. The Magoye variety is self-inoculating, making it useful to a wider range of farmers. Like all legumes, soybeans fix free nitrogen from the air in the soil, so that it is available for the next crop grown on that plot. Soybeans are also one of the few crops in Malawi that can produce as many calories per hectare as maize or cassava. Additionally, soybeans can be added to maize porridge to make an excellent weaning food, because soybeans are calorie-dense. Thus, it is easier for infants and children to receive sufficient calories from soybean enriched porridge, or Likuni *phala*, than it is from a simple bulky starchy staple such as regular maize porridge.

A set of linear programming (LP) models was developed to explore the effects that active promotion of this four-component smallholder strategy would have on smallholder households, and more generally on the smallholder agriculture subsector. The models are designed to maximize total income from farming and casual off-farm employment, with an adjustment for purchases of maize to meet household food requirements. The model includes all of the major smallholder crops, and disaggregates maize production by variety (local, dent hybrid, and flint hybrid) and fertilizer application (no fertilizer, inorganic fertilizer only, organic fertilizer only, inorganic and organic together). The model incorporates risk by including a "safety-first" constraint, which requires households to meet food consumption requirements, either from own production or from market purchases of maize. The model also explicitly includes on-farm and off-farm labor allocation, a feature neglected in most earlier linear programming models for Malawi, capturing the effects of household members' allocation of their labor time between work in their gardens and limited wage employment. Credit use is permitted up to a level specified for each simulation, although households may choose not to borrow the full amount available.

The LP models were calibrated by comparing results with actual outcomes for the 1990/91 season, and then used to simulate the effects of three different policy scenarios for the 2002/03 agricultural season. The ten-year time horizon was used in light of the time lag for investments to be made, new policies to take effect, and extension messages to be developed and adopted. The realism of the projections was enhanced by including projected changes in population and average landholding sizes in the simulations.

Three policy scenarios were considered. The first was a continuation of present policies, or essentially an extrapolation of recent trends in the smallholder subsector. This included continued growth in hybrid adoption, fertilizer use, and credit, along with continued slow growth in the allocation of burley tobacco licenses to smallholders. In this scenario it was assumed that the four components discussed above would play a minor role, their adoption restricted by limited investments in the necessary research and institutional development to support them. For example, in this scenario adoption of flint hybrid maize is assumed to be limited by insufficient multiplication of the seed, while smallholder burley tobacco production is constrained by meager quota allocations to the subsector.

The second policy scenario in the simulations describes an environment of policy reform. In this scenario smallholder burley tobacco production is allowed to increase to 25 million kilograms, supply of flint hybrid seeds is sufficient to meet demand, and agroforestry practices and maize-soybean rotations may be used on up to one-tenth of all cultivated area. Financial support for these farming activities is provided by a substantial increase in agricultural credit, at a total level of 2.5 times that presently available. Furthermore, the credit is assumed to be allocated on a more or less uniform basis regardless of landholding size, with smallholders operating one-half hectare receiving the same amount as farmers operating two hectares. This is because intensification is more urgent for severely land-constrained farmers, and intensification is expensive. To some extent, credit can substitute for land when that credit can be used to intensify food crop production, and the availability of the flintier hybrids facilitates this.

The third policy scenario considered is similar to the second, except that smallholder burley production is allowed to rise to 50 million kilograms, produced by some 333,000 producers. Credit is also allowed to increase by an additional MK 40 million above that in the second scenario to finance the additional growth in smallholder burley tobacco production.

Results of the LP model simulations indicated smallholder subsector annual per capita growth rates of 0.6 percent under a continuation of present policies. Thus, a smallholder population growth rate of 3 percent, implies an annual growth rate of 3.6 percent for the smallholder subsector. Despite this modest growth, average households in the small landholding category of the typology, who will comprise 70 percent of smallholder households by 2002/03, would not be able to meet minimum household food requirements from their own production or from purchases using income from wages or sales of cash crops. The problem of insufficient food intake due to limited effective demand (i.e., low incomes) would become worse than it is already. The model predicts a decline in per capita maize production in this scenario, as population growth outstrips increases in hybrid maize and fertilizer adoption.

Linear programming simulations for the two policy reform scenarios indicated much more favorable outcomes for smallholder households and the subsector, with annual per capita growth rates of 2.3 and 3.1 percent. With population increases, these per capita growth rates translate into annual growth rates of 5.3 and 6.1 percent for the subsector. This growth is driven by rapid income growth among smallholders on small landholdings. Per capita maize production is projected to increase, and due to increased incomes so is effective demand for maize. The households represented in each of the 12 models are all able to meet minimum food requirements from their own production or from market purchases. However, those on small landholdings remain net consumers of maize, so at the margin they still depend on the market for their food supplies. Increased access to credit and licenses to grow burley tobacco help finance intensification in maize production, with hybrids accounting for almost 40 percent of the total area planted to maize.

The results from the linear programming models show that this four component strategy can revitalize the smallholder subsector, by raising incomes for a majority of the population while increasing food production and consumption. The analysis identified several areas that are critical to the success of this program.

First, a concerted effort must be made to expand smallholder burley tobacco licensing, as burley production can operate both as an income generator and as a source of finance for intensification of food crop production, increasing the productivity of labor and land. Early results of the smallholder burley program have shown that smallholders are capable of producing high-quality burley, so the constraints to be overcome in this area are more institutional than technical.

Second, sufficient attention must be given to multiplication of flint hybrid seed so that supply can meet demand, which is not the case at present. Adaptive research needs to be undertaken to develop site-specific recommendations for these varieties, and extension must be able to deliver these messages.

Third, the availability of agricultural credit needs to be rapidly expanded, as burley proceeds cannot finance all of the intensification needed to generate growth in the subsector. Linear programming model estimates show that total smallholder credit availability would have to more than double, in real terms, during the next ten years to support the economic growth rates indicated above. Even under the more ambitious of the two policy reform scenarios, only one in seven smallholders would have a burley license; under the more conservative policy reform scenario the ratio would be one in fourteen.

Fourth, it is imperative that credit reach the smallest smallholders, and that the amount of credit per farmer be substantial. This is due in part to the advent of flint hybrids, which makes it easier for credit and input packages to contribute directly to household food security. Widespread availability of flint hybrid maize, with its favorable consumption attributes, means that a Kwacha of credit is often more efficiently used by a farmer with small landholdings than by a farmer with larger holdings. This is because the need for increased land productivity is so much greater for those on small landholdings, and to some degree credit can substitute for land. As small land holders also tend to have smaller pools of household labor, the same is true for labor productivity. Therefore, from an economic efficiency standpoint — as well as an equity standpoint — it may be argued that small landholders should receive at least as much, if not more, credit than those with larger holdings. When dent varieties were the only available maize hybrids, it made some sense that more land required more credit, as only large landholders had land remaining for planting after planting local maize for household food needs. This is no longer the case.

Fifth, burley tobacco and credit are not solutions for large numbers of resource-poor households. The multitudinous constraints they face produce a hostile environment for the high-risk, high-input agriculture described above. While leguminous trees, hedges, and crops cannot generally fix nitrogen at levels recommended for maximum maize output, they do provide limited but significant amounts of soil nutrients that can increase yields and arrest depletion of soil fertility at low cost, and therefore at low risk to the farmer. For all farmers, especially resource-poor farmers, these technologies can play an important role in the farming systems.

Lastly, implementation of the technological, institutional, and policy innovations described here needs to be pursued with the utmost urgency. The past decade of stagnant growth in the smallholder subsector has meant increased poverty and hardship for the typical Malawian. Adoption of a coherent, consistent set of policies to promote smallholder agriculture, especially for smallholders on very small landholdings, is necessary to prevent stagnation from becoming disastrous decline.

1. INTRODUCTION

Malawi is largely an agricultural country. Almost 90 percent of the population live in rural areas, and the vast majority are smallholder farmers. They produce subsistence crops and some cash crops, typically using labor-intensive hand hoe technology on small plots with few improved inputs such as high yielding varieties or fertilizer. Soil fertility is in decline due to insufficient fertilization coupled with inadequate fallow and crop rotations caused by high population pressure. Alongside the smallholder subsector is an estate subsector which produces export crops dominated by tobacco, tea, and sugar; the estate subsector, also produces limited quantities of maize, groundnuts, and other food crops.

Malawi is also an intensely poor country, with low incomes, high rates of malnutrition and infant mortality, and short life expectancies. Malawi recorded impressive aggregate economic growth, led by estate agriculture, from independence in 1964 through 1979. For the past 13 years, however, smallholder agriculture has stagnated while population has increased rapidly, and the number of Malawians in poverty is probably higher today than it was at independence.

There have recently been questions from some quarters about the appropriateness of an agriculture-led development strategy for Malawi. High population pressure on arable land and a weak record in promoting agricultural intensification in the smallholder subsector are cited as the main reasons for looking for alternative sources of economic growth (UNICEF et al 1992). However, the industrial and service sectors of the Malawian economy, both formal and informal, are very small, especially in rural areas where the bulk of the people live. Even if the rural informal economy were to double in size every year — a growth rate far in excess of any experienced in Malawi — the contribution to overall economic growth would barely keep pace with population growth. Thus in the short term Malawi has little choice but to follow an agriculture-led development strategy. This should be complemented by policies to reinforce linkages between farm and nonfarm sectors and promote nonagricultural employment to help absorb the rapid growth in the labor force accompanying the rapid population growth.

In this paper a limited set of appropriate and attainable agricultural policy options, and their projected effects on agricultural incomes, are examined. Included among the policy sets considered is a continuation of existing policies, which implies a continuation of recent trends. Most, but not all, of the policy innovations are related to technological innovations. Probably more important than the technologies, however, are the accompanying policy and institutional changes needed to support them. The effects of the different policy sets are modeled using farm budget and linear programming (LP) analysis. These are based on a typology of smallholder households, which takes into consideration the diversity that exists among smallholder households.

2. TYPOLOGY OF SMALLHOLDER HOUSEHOLDS

THE TYPOLOGY APPROACH

The present analysis is based on a typology of smallholder farming households. This approach takes explicit account of the fact that the estimated 1.8 million households who cultivate customary land are a heterogenous group. There is considerable variation in their farming systems due to different agroclimatic conditions, availability of land and labor, access to improved agricultural technology, and demands on time from nonfarm activities. Similarly, there are considerable differences across households in the relative importance of agricultural and nonagricultural activities because of varying endowments of human and physical capital and access to markets. Although poverty is pervasive among smallholder households, it is also true that a small proportion of these households are better off and would not be termed absolutely poor by sub-Saharan Africa standards. Resource endowments are a critical determinant of the incomes and welfare of these households.[1] Equally important, these differences indicate that poor households as a group are constrained by a wide range of factors, and the relative importance of each varies considerably. The unmistakable conclusion is that there is no universal solution for all smallholder households, and a comprehensive and consistent set of policies is required to reach all households. While it may not be possible to tailor specific policies for each type of household, it is necessary to understand which constraints are most important for each type of household and how that type of household will respond to changes in policy.

In the Malawian context, a useful starting point for classifying households for policy analysis is to take account of a household's capacity to respond to opportunities, such as changes in policies and prices. An example of smallholder response to promotion of improved maize technology is appropriate and illustrative. Only a limited number of farmers, typically those with above-average resources at their disposal, have been able to take advantage of high yielding varieties (HYV) of maize and fertilizer packages, which have been at the core of the government's efforts to develop smallholder agriculture and raise incomes. There are many explanations for this, each having a different degree of importance for different households. Most households do not have the financial capital to purchase hybrid maize seed or fertilizer, and access to credit has been severely limited by the membership practices of farmers' clubs. Prior club default on input loans has also impeded farmers' access to credit, and farmers with adequate capital to buy inputs on a cash basis have at times been unable to buy subsidized inputs because of ADMARC's credit-customers-first policy. Extension service has also been biased toward credit farmers.

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[1] In addition to resource availability, the efficiency (or effectiveness) with which resources are used may be an important source of variation in incomes and welfare of smallholder households. It is possible to examine this, at least in part, through the linear programming models presented in this paper.

Adoption of improved maize technology packages has also been constrained by a combination of small landholdings and inferior processing and storage qualities of the dent hybrid maize varieties that have been available to date. Even those households who have adopted HYVs have generally attempted to meet household maize consumption requirements through local maize production. Given the low yields of local maize, especially when grown on depleted soils with little or no application of fertilizer, households with less than one hectare of cultivable land — the majority of households in Malawi — typically have no land left for HYV maize after planting the household's requirement of local maize. Labor availability is another potential constraint, as households with acute labor shortages, including most female headed households, cannot provide the additional labor inputs associated with fertilizing and weeding fertilized maize. Labor shortages also increase the riskiness of HYV adoption, where timeliness of operations is an important determinant of yield levels, which in turn determine the profit or loss on purchased inputs. Low levels of assets and off-farm[2] income sources further restrict the household's risk-bearing capacity.

The preceding example of HYV maize gives some idea of the constraints, singly or in combination, which smallholder farmers face. This example also highlights a distinction that must be drawn between participation in the market and the capacity to respond to opportunities, whether they occur through market forces, technological innovation, policy, or institutions. Lack of capacity to respond to opportunities does not imply that these are strictly subsistence farmers who are untouched by the market. Rather, they either do not have the "prerequisites" to participate in certain arenas, or they are in such vulnerable positions that they cannot afford to take many risks, or both. Although access to markets varies, there is no household in Malawi that does not participate at some level, and the poorest households — the core poor — participate in the market a great deal, perhaps even more than those who are less poor. This is especially true of labor and food markets. The poor participate, but the range of feasible or viable options available to them is more limited.

Capacity to respond to opportunities is the conceptual foundation of the typology of smallholder households used in this analysis. At a general level, three types of household can be identified.

- Households that have existing capacity to respond to a wide range of opportunities through a combination of own production, farm and off-farm income, assets, and social networks. These households have secure access to basic food and nonfood requirements and the physical, financial, and human capital assets to take advantage of changes in markets, policies, technologies, and institutions.

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[2] As used here and elsewhere in this paper, "off-farm" refers to activities other than agricultural and livestock production on the farmer's own holdings, including agricultural labor for other smallholders or estates. The term "off-own-farm" would be more precise, but it is awkward; and off-farm is used instead.

- Households that have the potential to respond to a wide range of opportunities, but whose capacity to do so is limited by constraints that could conceivably be relieved in the near term. At present they are typically able to meet most of their basic needs for survival, but only by devoting almost all available resources to meeting those needs. The concentration of energies required to meet basic needs leaves little room for other activities, and capacity to bear risk is consequently limited.

- Households that have extremely restricted choices due to constraints which are numerous and sometimes severe. The potential for relieving at least some of these constraints, such as the ability to produce food requirements from land available to them is limited in the near term, and even in the long term for some.[3] These households are not meeting their basic needs at present, which suggests that even if constraints are relaxed one could expect very little qualitative change in household behavior in the near term, at least until basic needs are met. An examination of economic and social indicators reveals that this category comprises most households in Malawi. The range of agricultural opportunities feasibly open to them can be expanded, but not as widely as for the other two types of households, as only opportunities with a direct positive impact on basic needs, including food security, are viable for these households.

This brings us back to the conclusion that there is no simple solution for all smallholders, and that a range of policy and technology options is necessary if there is to be any possibility of reaching all households. Although formal and informal off-farm employment, transfers, and remittances form an important part of smallholder household income, the present analysis is restricted to policies which bear directly on smallholder agricultural production.

OPERATIONALIZING THE TYPOLOGY

While it is not difficult to describe the general characteristics of different types of households it is another matter to identify observable characteristics to allow classification of smallholder households into these three types. This is difficult because the three discrete household types described above are a stylized representation of what is, in fact, a continuum. More troublesome still is the complex set of variables involved and the manner in which they interact to determine a household's place on the continuum.

The question of smallholder classification is not new. Sophisticated statistical approaches, such as cluster analysis and discriminant analysis, have been applied to smallholders in specific areas of Malawi, notably by Dorward (1984) and Kydd (1982). These approaches are useful, but the data requirements

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[3] Note that land availability per se is a more or less universal constraint in Malawi. Land productivity is more flexible, however, incorporating technological aspects of seed, fertilizer, cultivation, irrigation, etc.

are great and the technical aspects would tend to blur the broad policy relevance that is at the heart of the present analysis.

The classification task is made somewhat easier by focusing on *potential*, as opposed to *achieved*, status vis-a-vis the three categories listed above. This is appropriate for the policy analysis at hand, which is a projection of the outcomes from policy and technology choices for the immediate future. The constraints that prevent households from realizing the potential benefits of previous policies can provide lessons to help guide policy design and avoid future shortfalls in policy goals.

As indicated above, a variable that is central to smallholder agricultural production is the availability of cultivable land. The size, or area, of land available is one important aspect, but quality is also important. Soil quality (e.g., fertility, structure, pH), temperature and the amount and distribution of rainfall are critical factors in determining the suitability of particular crops to particular environments. Another important variable is the degree of food security a household enjoys, which is determined by a number of factors. Prominent among these is the proportion of food requirements that can be met from the household's own production. Although it is possible in principle to meet basic food needs from market purchases, low wages and limited off-farm employment opportunities imply that own-production is usually the least-cost method of acquiring staple foods. Thus, land availability is related to household food security, which is in turn related to the household's ability to take advantage of available opportunities.

A useful typology which combines some of these elements is shown in Table 1. The three categories of households described earlier form the rows of the table, with the third category further subdivided into households that are sporadically food deficit and those that are chronically food deficit. The columns of the matrix are defined by the Agricultural Development Division (ADD); this is a measure (albeit crude) of the potential productivity of agricultural land in different parts of the country. Within each cell are ranges of land areas, in hectares, corresponding to the four household categories for each ADD. The choice of ranges for the area cultivated in each cell was guided by analysis of data from the Annual Survey of Agriculture (ASA), reviews of other recent surveys in Malawi, personal observations, and extensive discussions with persons involved in agriculture in Malawi. At this point it bears repeating that the household categories are defined by potential outcomes and not by actual existing outcomes. For example, there are undoubtedly households with more than 1.5 hectares who are not meeting their basic needs, perhaps because they are still growing low yielding varieties of maize and not applying fertilizer. Nevertheless, they could meet these needs, and then commercialize or diversify their agricultural enterprises if the constraints which limit their production to levels *below existing potential* could be relaxed.

Even within the framework of agricultural potential, there is a great deal of variation in potential due to factors not accounted for in Table 1. First, there is considerable agroclimatic variation within all ADDs, and tremendous variation in some. Differences in crops grown, yields, and calorie production are not captured by the typology in Table 1, except for that which is already accounted for by the area cultivated dimension.

Second, household size is not considered explicitly. The number of persons in a household is accounted for to the extent that household size is correlated with area cultivated. Overall, larger households in Malawi cultivate larger areas, as shown in Table 2. Although average household size shows a clear positive relationship with area cultivated, high variances in household size suggest that there are many households cultivating land areas that are disproportionately large relative to household size, and many households where the opposite is true.

Third, household composition is not taken into account in the typology above. The number of economically productive members of a household relative to the number of members who are too young, too old, or too infirm to contribute fully to household production is an important element in determining smallholder household welfare.

Fourth, the typology in Table 1 does not take account of off-farm earnings opportunities. These can be an important supplement to agricultural incomes, especially for households whose access to cultivable land is very limited. Off-farm income sources also enable households with more land to diversify their agricultural activities to a greater extent than would be possible if they did not have a source of cash with which to buy food requirements. Off-farm employment also reduces risk, especially when that employment is not strongly influenced by shocks to the agricultural economy.

Despite the inherent compromises and shortcomings of the typology shown in Table 1, the number of household types, 32, is still rather unwieldy for the budget and linear programming analysis used in this paper. By combining the two groups of food-deficit households, and combining ADDs with roughly similar agroclimatic conditions, it is possible to reduce the number of household types to be considered to 12. These are shown in Table 3. This categorization of household types will be used in the following analysis. General characteristics of these groups, including mean household size, mean area cultivated, and proportion of all households in each group are shown in Table 4. As a convenient shorthand these groups are termed Small, Medium, and Large according to mean area cultivated within the ADD grouping.

The deficiencies mentioned above are inherent in any analysis that isbased on representative, or average, farms or households. Disaggregation according to the typology provides more detailed information and realism than most analyses. The areas where the typology falls short, both those listed above and those not specifically mentioned, need to be kept in mind when using a typological approach.

Table 1 — Typology of Smallholder Households Using Area Cultivated and ADD

	Area cultivated (Ha) per household, by ADD							
Household Characteristics	**Karonga**	**Mzuzu**	**Kasungu**	**Salima**	**Lilongwe**	**Liwonde**	**Blantyre**	**Ngabu**
1. Emerging/surplus smallholders with enough land to produce a surplus	> 1.50	> 1.50	> 1.50	> 1.50	> 1.50	> 1.50	> 1.50	> 2.50
2. Smallholders with enough land to produce food requirements	0.75-1.50	1.00-1.50	1.00-1.50	1.00-1.50	1.00-1.50	1.25-2.00	0.75-1.50	1.75-2.50
3. Food Deficit Households								
Sporadically Deficit	0.50-0.75	0.50-1.00	0.50-1.00	0.50-1.00	0.50-1.00	0.50-1.25	0.50-0.75	1.00-1.75
Chronically Deficit	< 0.50	< .50	< .50	< .50	< 0.50	< 0.50	< 0.50	< 1.00

Table 2 — Average Household Size by Area Cultivated Group

Less than 0.5 hectares	4.00
0.5 to 1.0 hectares	4.60
1.0 to 1.5 hectares	5.01
1.5 to 2.0 hectares	5.65
Over 2.0 hectares	5.97

Source: Ministry of Agriculture, FSNM survey November 1991

Table 3 — Revised Typology of Smallholder Households Used for Policy Simulations

Household characteristics	Area cultivated (ha) per household, by ADD			
	Karonga Salima	Mzuzu Kasungu	Lilongwe Liwonde Blantyre	Ngabu
1. Emerging/surplus smallholders with enough land to produce a surplus	> 1.50	> 1.50	> 1.50	> 2.50
2. Smallholders with enough land to produce food requirements	1.00-1.50	1.00-1.50	1.00-1.50	1.75-2.50
3. Food deficit households	< 1.00	< 1.00	< 1.00	< 1.75

Table 4 — Selected Descriptive Statistics for Household Typology Used in Analysis

	Agricultural Development Divisions (ADD)			
	Karonga Salima	**Mzuzu Kasungu**	**Lilongwe Liwonde Blantyre**	**Ngabu**
Mean household size (persons)				
Small	4.3	4.1	4.1	5.0
Medium	5.0	4.4	5.1	6.9
Large	6.0	6.0	5.7	7.8
Mean area cultivated (hectares)				
Small	0.45	0.49	0.48	1.20
Medium	1.11	1.12	1.09	1.92
Large	2.13	2.16	2.02	3.70
Proportion of all smallholder households (percent)				
Small	4.3	9.2	43.8	5.7
Medium	2.1	5.1	14.0	0.5
Large	1.0	6.6	7.2	0.4

Source: Annual Survey of Agriculture, various years

3. COMPONENTS OF POLICY REFORM OPPORTUNITIES

This section discusses the various components of the smallholder-based agricultural strategy in some detail. Specific components to be considered include flint HYV maize, expansion of smallholder access to production of burley tobacco, addition of promiscuous or self-inoculating soybeans to cropping patterns, and promotion of agroforestry practices.

The qualitative aspects of each of these components will be outlined, followed by a partial budget for the new enterprise to be considered. The information in these partial budgets is used later in the linear programming model that is used to analyze the impact of these components on key variables at the national level and for different types of households. The budgets used here are based on average, or representative, smallholder farm households. This is also the framework used in the linear programming models. It should be kept in mind that the distribution on either side of these household averages is usually quite wide. Of particular concern are the 50 percent of households in each of the 12 types that fall below the average for their group, especially for the households in the Small group.

A NOTE ON PRICES USED IN THE MODELS

It would be difficult to overstate the importance of relative input and output prices to effective agricultural policy. While the policy analysis presented here does not focus at all on the merits or means of "getting prices right", it is important that the prices used in the analysis and the related underlying assumptions are articulated clearly at the outset. This is especially so because planned changes in policy on input subsidies in the near future make it impossible to simply take the official price series from the 1992/93 season and work from there.

At present the government, through the Smallholder Farmer Fertilizer Revolving Fund of Malawi (SFFRFM), subsidizes fertilizer for smallholders at an average rate of between 15 and 20 percent. The government is committed to removing all fertilizer subsidies over the next few years, and plans to take other measures to liberalize the fertilizer market more generally. At present, hybrid maize seed sold through ADMARC is also subsidized, at a rate of about 25 percent. It is planned that this subsidy will also be eliminated. As the government is already committed to removing these subsidies, it seems prudent to take account of them in the present analysis. It should be emphasized that the analysis treats subsidy removal as a given and does not attempt to evaluate the impact of the removal of subsidies per se.

The first step in developing a set of prices to use for the partial budgets and linear programming analysis was to estimate prices of fertilizer in the absence of the subsidy. This was done by taking the average of the SFFRFM break-even price in 1992/93 and the prices charged by private suppliers Optichem and Norsk Hydro in the same season. These are shown in Table 5.

A similar procedure was used to estimate the price of unsubsidized hybrid maize seed, using ADMARC's break-even price for the seeds and the price charged by NSCM. For the sake of simplicity, only one price is used for hybrid maize seed in the budgets and the linear programming models, that being the unweighted average price across all hybrid varieties. These prices are shown in Table 6.

The issue of input prices settled, it is now necessary to turn to projected changes in the producer and consumer prices of maize. Here the future policy of government is not as clear as it is with input prices, so a simple assumption was made. For the purposes of the analysis presented in this paper it was assumed that following the removal of fertilizer and seed subsidies, maize producer prices would be set to maintain the same relative prices between inputs and outputs as prevailed in the 1992/93 season (including subsidies). To put it another way, it is assumed that after removal of input subsidies, prices will adjust (or be adjusted) so that producers will have the same price incentives as they did in the 1992/93 season. The percentage increase in input costs over 1992/93 prices after subsidy removal is 30.7 percent, using the recommended application rates for seed and high analysis fertilizer.[4] This would imply an increase in the producer price of maize from the 1992/93 level of 43.0 tambala per kilogram to 56.2 tambala per kilogram, or MK50.58 per 90-kilogram bag. That this increase in producer price maintains current producer incentives was confirmed using VCR analysis.

The maize consumer price does not appear anywhere in the budgets that follow, but it is an important part of the economics of smallholder households in Malawi, most of whom purchase maize at some point during the year. The consumer price also plays a role in the production decisions of households, who must base their planting and input decisions on the cost of producing maize relative to buying it. This aspect of household and farm decision making is captured in the linear programming models. Reportedly, the official maize producer and consumer prices in 1992/93 eliminate the implicit consumer subsidy that ADMARC supported for a number of years. To project the consumer price that would prevail alongside a producer price of 56.2 tambala per kilogram it was assumed that ADMARC would maintain the same sales margin *in percentage terms* as in 1992/93. This implies a maize consumer price of 84.7 tambala per kilogram, or MK76.23 per 90-kilogram bag.

It is assumed that ADMARC's margin would stay constant in percentage terms, rather than in absolute Kwacha terms, for the following three reasons. One, many of ADMARC's (or any other maize trader's) costs are more closely associated with the price of the good than with the weight of the good. An example of this is the cost of working capital: if the producer price increases, a trader (including ADMARC) needs more working capital to buy the same amount of maize as before. This working capital comes at a cost, either the direct cost of borrowing or the

[4] The recommended rates are 25 kilograms of seed, 175 kilograms of urea, and 80 kilograms of DAP per hectare.

Table 5 — 1992/93 Fertilizer Prices Used for Estimates of Fertilizer Prices Without Subsidies

Fertilizer	SFFRFM with subsidy	SFFRFM break-even	Optichem	Norsk Hydro	Unweighted average of unsubsidized prices
	Price per kilogram of fertilizer (1992/93)				
Urea	1.22	1.44	1.68	1.54	1.55
DAP	1.32	1.59	1.80	na	1.70
CAN	1.39	1.39	1.36	1.36	1.37
D compound	1.86	1.86	1.82	na	1.84

Source: MOA Prices Section

Notes:
1. SFFRFM break-even price is unsubsidized with no profit margin.
2. Norsk Hydro prices vary by MK1.50 to 2.10 per 50 kg bag, depending on distance from import point to market.
3. SFFRFM puchased tobacco compounds from Optichem for resale in 1992/93.
4. Norsk Hydro urea has an additional 2 percent boron.
5. SFFRFM pricing based on new imports for 1992/93, not on pre-devaluation stocks.

Table 6 — 1992/93 Hybrid Maize Seed Prices Used for Estimate of Unsubsidized Maize Seed Prices

Variety	**ADMARC** actual	**ADMARC break-even**	**NSCM**	**Unweighted average of unsubsidized prices**
	Price per kilogram of seed (1992/93)			
MH12/16	3.65	5.58	5.36	5.47
MH17/18	3.27	4.19	3.73	3.96
NSCM41	3.35	4.71	4.22	4.46
Average for all varieties		4.82	4.44	4.63

Source: MOA Prices Section

Notes:
1. ADMARC purchased hybrid seed from NSCM for resale in 1992/93.
2. ADMARC break-even prices are unsubsidized with no profit margin.

opportunity cost of alternative uses of the capital. Two, a 30-percent increase in the price of maize is certain to exert upward pressure on prices and wages throughout the economy. These wage and price increases will affect maize traders, too, so it will cost more — at least in nominal terms — to handle the same volume of maize as before. Three, even a cursory examination of the historical trends in producer and consumer prices in Malawi shows that an assumption of a constant percentage margin is much closer to reality than an assumption of a constant Kwacha value margin. This is no doubt due to factors noted in the first two reasons.

FLINT HYBRID MAIZE (MH17 and MH18)

Although adoption of flint hybrid maize is neither a policy nor a strategy in its own right, the relevant policy or strategy is undertaking the commitment to make the investments necessary for effective promotion of the new varieties. This requires taking account of some of the lessons learned from the difficulties experienced in promoting hybrid packages in the past, and adaptation of the promotion message to reflect the fact that the flint hybrid varieties have more favorable consumption characteristics than the dent varieties. Field trials have shown that the flintier hybrids can yield as much as dent hybrids. The partial budget for this component of the strategy, shown in Table 7, shows input costs, production values, and gross margins for hybrid flint maize with and without fertilizer.[5] For the purposes of this analysis it is assumed that the recommended levels of high analysis fertilizer application are used, namely 80 kilograms of DAP and 175 kilograms of urea per hectare. The prices assumed are as described above. No allowance is made for credit in the budget because not all hybrid and fertilizer users obtain their inputs on credit; credit is treated as a separate issue here and in the linear programming models. Yields are allowed to vary by region, largely reflecting agroclimatic differences. The yields used are a synthesis of reported yields from a number of surveys, and are intended to represent average yields attainable by smallholder farmers, the average taking into account good years and bad years, above-average management and below-average management. The potential maximum yields are certainly much higher than those used here, but it would not be realistic to base estimates for average households on these potential yields. Although it is unlikely that many farmers would grow the flint hybrid without fertilizer, the inclusion of the budget without fertilizer serves several useful purposes. For one, it permits convenient comparison of the financial costs and benefits of fertilizer use on hybrid maize. Second, it makes clear the assumed nitrogen:yield response rates underlying the analysis. In this case the rates range from 7 to 18 units of grain per unit of nitrogen. Response rates of 21 (Conroy 1992) and 26 (FAO 1991) have been estimated for hybrid maize in Malawi, so those used here may be considered to be slightly conservative. The use of constant response rates for a relationship that is clearly nonlinear presents a problem, but it is a

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[5] The same budgets are used for hybrid dent maize varieties in the linear programming models.

Table 7 — Partial Budgets for Flint Hybrid Maize with and without Fertilizer, by ADD Grouping

	Agricultural Development Divisions (ADD)			
	Karonga Salima	Mzuzu Kasungu	Lilongwe Liwonde Blantyre	Ngabu
	Without fertilizer			
Seed cost (MK)	115.79	115.79	115.79	115.79
Total inputs cost	115.79	115.79	115.79	115.79
Assumed yield (tons/ha)	0.80	1.02	0.80	0.62
Value of production (MK)	449.60	576.05	449.60	351.25
Gross margin (MK)	333.81	460.26	333.81	235.46
	With fertilizer (high level HAF)			
Seed cost (MK)	115.79	115.79	115.79	115.79
Urea cost (MK)	271.80	271.80	271.80	271.80
DAP cost (MK)	135.73	135.73	135.73	135.73
Total inputs cost	523.32	523.32	523.32	523.32
Assumed yield (tons/ha)	2.40	2.80	2.20	1.30
Value of production (MK)	1348.80	1573.60	1236.40	730.60
Gross margin (MK)	825.48	1050.28	713.08	207.28

simplification which will have to be tolerated here for lack of adequate nitrogen:yield response data. In fact, this simplification of constant returns to scale in fertilizer use is required by the linear programming models. A third reason for including the budget without fertilizer is due to operational concerns of the linear programming models. Fertilization at levels below the high recommended levels is probably the most profitable, and feasible, option for smallholders adopting the new varieties. Including both fertilized and unfertilized options permits the linear programming models to choose from an infinite number of fertilization levels, all lying within the full range from zero to full recommended rates, to determine maximum farm profits given the relevant constraints. The linear programming models would represent this as a linear combination of the unfertilized and highly fertilized options, with application rates, costs, yields, and gross margins a weighted average of the two.

It has been observed that while the official recommended fertilizer application level will produce the highest yields, lower levels of fertilizer use are generally more profitable for the farmer (Byerlee 1992). Byerlee has also noted that lower levels of fertilizer application may lead to more efficient use of scarce cash, inputs, and labor during bottleneck periods. The recommendations in Malawi are probably unrealistically high, with nutrient levels equal to those "only just achieved by farmers in the irrigated Punjab of Pakistan, 25 years after the introduction of improved wheat and rice varieties" (Byerlee 1992, p. 41).

No attempt has been made to include labor costs in the partial budget. This is because of the problems inherent in placing a value on the labor of family members who are underemployed during much, but certainly not all, of the year. A strength of the linear programming models is the ability to calculate shadow wage rates, which take into account all of the opportunity costs of labor.

EXPANSION OF SMALLHOLDER BURLEY TOBACCO PRODUCTION

The next component of policy reform to be considered is the expansion of the smallholder burley tobacco program that was begun under the Agricultural Sector Adjustment Credit (ASAC). Smallholders have been growing burley officially on a very limited basis for three seasons. Many of the organizational issues of input supply and output marketing have been resolved during this period, and initial indications are that the program has been proceeding well (Phiri and Cameron 1992).

A one hectare budget for burley tobacco is shown in Table 8. It is proposed that the smallholder burley tobacco program be expanded on the basis of microplots of burley, with each grower growing only 0.1 hectare, on which they might produce 150 kilograms of leaf. An important technical reason for this is that it would allow smallholders on very small landholdings to observe the one-in-four crop rotation requirement for burley to avoid nematode infestations. By keeping the size of each individual's quota small, it is possible to spread the benefits of the program among the maximum number of smallholders, while still

Table 8 — One Hectare Budget for Smallholder Burley Tobacco

Seed/Seedbeds	124.80
Fertilizer	
D compound (600 Kg)	1,105.20
CAN (400 Kg)	547.73
Other cost	629.70
Cost (MK per Ha)	2,407.43
Yield (kg per ha)	1500
Output value (MK)	10,125.00
Gross margin	7,717.57

Sources: Agmmark (1990), Table 8.06 and Conroy (personal communication).

Note: Fertilizer and output prices adjusted to reflect 1992/93 levels (without input subsidies).

permitting program participants to earn sufficient returns from their burley production to help finance hybrid maize and fertilizer adoption as well as pay off any credit taken for burley production. By limiting production to such a small scale, it is also possible to eliminate some capital costs such as tobacco barns: many smallholders dry their burley crop in houses or kitchens and do not build structures specifically for this purpose.

The operative assumptions for this budget are as follows. The average yield is assumed to be 1,500 kilograms per hectare, and it is assumed that the farmer will receive an average of MK6.75 per kilogram after costs for marketing, but not inputs, have been deducted.[6] For lack of data indicating otherwise, averages yields are assumed to be identical in all ADDs. The fertilizer application rates are assumed to be 600 kilograms of D compound and 400 kilograms of CAN per hectare.

The rationale for expanding smallholder burley tobacco production is based upon several interrelated goals. One is to spread the benefits of the favorable world market conditions beyond the few thousand estates that have until very recently enjoyed exclusive permission to grow burley. A second is that, even with the advent of the flintier hybrids, it will be exceedingly difficult for resource-poor smallholders to adopt hybrid maize and fertilizer packages due to the high cost of fertilizer in Malawi. Many of those with very small landholdings would find it difficult to both repay any credits and retain sufficient quantities of maize for home consumption. Another source of income is clearly needed to help subsidize adoption and continued use of flint hybrid maize packages, and burley tobacco is an excellent candidate. Many smallholders have some experience with burley production, either as estate tenants, early participants in the smallholder burley program, or illegal growers of leaf for sale through licensed estates. Burley makes very profitable use of land, as may be seen from the budget, and the labor demand peaks for burley have only small overlap with those for the main smallholder crops. The additional infusion of income to smallholder burley growers would also boost the local nonfarm economy, as households would have more disposable income to spend on clothing and household durables, two categories of goods which have been shown to have high expenditure elasticities among smallholder farmers. This would generate extra income for rural traders and craftspeople and increase employment opportunities in the informal service and manufacturing sectors, thus diversifying the rural economy.

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[6] Average real burley tobacco prices were lower for leaf harvested in 1993. Lower burley tobacco prices would lower the revenues and gross margin for the crop, which would nonetheless remain the most profitable crop for smallholders. As long as the crop remains more profitable than the next best alternative (usually hybrid maize with fertilizer), lower burley prices would not have a major impact on the optimal cropping patterns in the LP models. The main effect of lower burley prices on the model predictions would be lower farm incomes, and some switching away from purchased inputs due to lower cash availability.

It may be seen in the budget that, while burley can generate a substantial amount of profit from a small area of land, it does require a considerable cash outlay to do so. Thus, funding for inputs becomes a critical issue, including consideration of alternative uses for those funds. As land availability and credit are two of the most severe constraints for smallholders, the interaction between the two is important. Fortunately, linear programming analysis is an excellent medium for evaluating these different constraints, and the implications of burley tobacco's relative efficiencies in credit and land use will be discussed in greater detail in a later section of this paper.

AGROFORESTRY: INTERCROPPING MAIZE WITH *ACACIA ALBIDA*

Short-to-nonexistent fallow periods between maize crops, coupled with the inability of the majority of smallholders in Malawi to apply significant amounts of fertilizer, has caused a decline in soil fertility and a reduction in yields. There are a variety of agroforestry practices that hold promise for arresting and possibly reversing this trend; all are based on the growing of leguminous crops, which fix nitrogen in the soil. This nitrogen substitutes for or supplements inorganic fertilizer and manure, which may also be applied on the garden. An advantage of agroforestry is the low cost relative to inorganic fertilizer, making it potentially attractive for resource-poor farmers. Another advantage is the production of fuel and fodder as by-products. The disadvantages are the time and numerous difficulties often encountered in establishing a tree or hedge crop, and potential conflicts in labor demands. In some cases the tree or hedge crop displaces other crops on the field. The agroforestry practices presently under consideration for introduction to smallholder farming systems in Malawi cannot fix enough nitrogen to meet recommended levels of nutrient application. Nevertheless, agroforestry can make it possible to increase soil nutrient levels and crop yields significantly at very low cost in a low-input cropping system, and reduce overall input costs as part of a high-input system.

Agroforestry research and farmer adoption are still at an early stage in Malawi. A number of trials have been conducted at Chitedze Research Station and on smallholder farms throughout the country. These have provided some preliminary results on the costs and benefits of agroforestry practices and recommendations for implementation. Research is continuing in order to determine the practices that are best suited to Malawian conditions, including the smallholder resource constraints (such as cultivable areas and labor availability) and agroclimatic conditions. The two practices that have received the most attention are alley cropping and intercropping trees with food crops in the same plot. The practice considered in this analysis is intercropping maize and *Acacia albida*, a leguminous tree indigenous to Malawi and found in many parts of the country. Management of *Acacia albida* intercropped with maize requires little additional labor. Thus, while alley cropping with *Leucaena leucocephala* or *Cassia spectabilis* might produce greater yield increases, and positive financial returns, within a shorter time horizon, intercropping maize and *Acacia albida* is appropriate for a wider range of agroecological conditions and household types.

The agroforestry budgets shown in Table 9 are estimated from a synthesis of data drawn from Bunderson et al. (1990), Selenje et al. (1990), and Hayes (nd). Selenje et al. report that data collected over two seasons in the Ntcheu Rural Development Project (RDP) show average yields of maize planted under *Acacia albida* to be more than twice that of maize planted in the open on the same field. The averages for the two seasons (1988/89 and 1989/90) were 1,532 and 1,265 kilograms per hectare under the *Acacia albida* canopy, compared with 688 and 614 kilograms per hectare in the open. Soil analysis revealed significantly higher levels of nitrogen, potassium, and organic matter in the soils underneath the trees.

Using data from trials in Mzuzu, Kasungu, and Salima ADDs, Bunderson et al. (1990) have also shown the beneficial effects of *Acacia albida* on maize yields, and the general (but not monotonic) reduction in these effects as distance from the tree increases. Mean increases in maize yields under *Acacia albida* ranged from 42 to 272 percent across different sites. The data presents some preliminary evidence that the response of hybrid maize is greater than that of local maize.

Hayes's analysis of the trials in Salima and Mzuzu ADDs showed gross margins for maize grown with *Acacia albida* 9 to 250 percent higher than those grown without the tree crop. Increases in gross margins were even greater if the value of wood and fodder produced by *Acacia albida* are taken into account. Hayes's analysis also demonstrates that intercropping with *Acacia albida* can generate returns comparable with those of hybrid maize and inorganic fertilizer packages, but at a much lower financial risk to the farmer.

The budgets reflect the estimated costs and returns of intercropped maize and *Acacia albida* after the trees have been established. Although it depends on input and output prices and the yield response function, as well as constraints on funds for inputs, it is usually desirable to supplement the nitrogen fixed by the trees with inorganic fertilizer. The limited empirical evidence available about this combination in Malawi supports the view that fertilizer application can further increase maize yields. In the budgets presented here it is assumed that additional inorganic fertilizer at the rate of 80 percent of recommended levels would bring total soil nutrient availability and crop yields up to a level equivalent to the full recommended fertilization level without organic nitrogen fixation.

SOYBEANS

A promising crop in Malawi is soybeans. It and cassava are the only crops suitable for many areas in Malawi that can produce as many calories per hectare as maize. Soybeans also fix nitrogen in the soil, thus improving soil fertility, or at least slowing depletion. Most varieties of soybean require inoculation with bacteria to start the nodulation process. This requires labor and considerable crop management skill. A soybean variety has been developed in Zambia that is promiscuous, or self-inoculating. This variety, Magoye, has been

Table 9 — Agroforestry: One Hectare Budgets for Acacia albida Intercropped with local and hybrid maize, with and without Additional Inorganic Fertilizer

	Appl. rate (kg/ha)	Agricultural Development Divisions (ADD) Karonga Salima	Mzuzu Kasungu	Lilongwe Liwonde Blantyre	Ngabu
Local maize with Acacia albida (no additional fertilizer)					
Seed cost (MK)	25	14.05	14.05	14.05	14.05
Urea cost (MK)	0	0.00	0.00	0.00	0.00
DAP cost (MK)	0	0.00	0.00	0.00	0.00
Total inputs cost		14.05	14.05	14.05	14.05
Assumed yield (tons/ha)		0.83	0.94	0.83	0.67
Value of production (MK)		468.15	529.40	468.15	374.85
Gross margin (MK)		454.10	515.35	454.10	360.80
Local maize with Acacia albida plus 80% of recommended fertilizer level					
Seed cost (MK)	25	14.05	14.05	14.05	14.05
Urea cost (MK)	64	99.40	99.40	99.40	99.40
DAP cost (MK)	16	27.15	27.15	27.15	27.15
Total inputs cost		140.60	140.60	140.60	140.60
Assumed yield (tons/ha)		1.10	1.40	1.10	0.90
Value of production (MK)		618.20	786.80	618.20	505.80
Gross margin (MK)		477.60	646.20	477.60	365.20
Hybrid maize with Acacia albida (no additional fertilizer)					
Seed cost (MK)	25	115.79	115.79	115.79	115.79
Urea cost (MK)	0	0.00	0.00	0.00	0.00
DAP cost (MK)	0	0.00	0.00	0.00	0.00
Total inputs cost		115.79	115.79	115.79	115.79
Assumed yield (tons/ha)		1.33	1.62	1.27	0.85
Value of production (MK)		749.15	908.75	712.05	477.70
Gross margin (MK)		633.35	792.96	596.26	361.91
Hybrid maize with Acacia albida plus 80% of recommended fertilizer level					
Seed cost (MK)	25	115.79	115.79	115.79	115.79
Urea cost (MK)	140	217.44	217.44	217.44	217.44
DAP cost (MK)	64	108.58	108.58	108.58	108.58
Total inputs cost		441.81	441.81	441.81	441.81
Assumed yield (tons/ha)		2.40	2.80	2.20	1.30
Value of production (MK)		1348.80	1573.60	1236.40	730.60
Gross margin (MK)		906.99	1131.79	794.59	288.79

grown in a number of areas of Malawi, especially near the border with Zambia, for the past few years. Farmer adoption has been brisk, and Magoye was officially cleared for distribution in Malawi in July 1992.

Soybeans may be intercropped with other crops, such as maize, or grown in pure stands. Perhaps the best strategy for many households is a rotation of soybeans with maize on a portion of their landholdings. Pure stands of Magoye soybeans fix an average of 60-70 kilograms of nitrogen per hectare, with beneficial effects of the nitrogen reflected in the following year's maize crop. One hectare budgets for maize-soybean rotation are shown in Table 10. In the budgets it is assumed that the price of Magoye soybean seed is MK1.05 per kilogram, equal to the 1992/93 official price for regular soybean seed; the seed is applied at a rate of 60 kilograms per hectare. The producer price of soybeans is assumed to be equal to the 1992/93 official price of MK0.65 per kilogram. The incremental maize output due to the nitrogen fixed by the soybeans is assumed to be 30 percent of the difference between maize yields with no fertilization and those with fertilizer applied at the recommended rate. This is the same yield assumption that was used for the maize and *Acacia albida* intercrop without inorganic fertilizer. This is a conservative estimate, as a good soybean crop can fix more than half of the recommended nitrogen required for the maize crop the following year. The budgets show one-half hectare planted to maize and one-half hectare planted to soybeans, and are set up to reflect the situation in the second year or later of such a rotation, when the nitrogen-fixing benefits of the soybeans have begun to be realized.

Table 10 – One Hectare Budgets for Rotations of Soybeans with Local and Hybrid Maize, by ADD Grouping

		Agricultural Development Divisions (ADD)			
		Karonga Salima	Mzuzu Kasungu	Lilongwe Liwonde Blantyre	Ngabu
	Soybeans	**Local Maize**			
Area (ha)	0.5	0.5	0.5	0.5	0.5
Seed application rate (kg/ha)	60.0	25.0	25.0	25.0	25.0
Seed cost (MK)	31.50	7.02	7.02	7.02	7.02
Total inputs cost	31.50	7.02	7.02	7.02	7.02
Assumed yield (tons/ha)	0.80	0.83	0.94	0.83	0.67
Value of production (MK)	260.00	234.07	264.70	234.07	187.43
Gross margin (MK)	228.50	227.05	257.68	227.05	180.40
	Soybeans	**Hybrid Maize**			
Area (ha)	0.5	0.5	0.5	0.5	0.5
Seed application rate (kg/ha)	60.0	25.0	25.0	25.0	25.0
Seed cost (MK)	31.50	57.90	57.90	57.90	57.90
Total inputs cost	31.50	57.90	57.90	57.90	57.90
Assumed yield (tons/ha)	0.80	1.33	1.62	1.27	0.85
Value of production (MK)	260.00	374.57	454.38	356.03	238.85
Gross margin (MK)	228.50	316.68	396.48	298.13	180.95

4. LINEAR PROGRAMMING MODEL FOR POLICY SIMULATIONS

In this section a simple linear programming model is developed for use in simulating the effects of three different policy scenarios on smallholder agricultural production, resource use, and incomes. The model is kept as simple as possible in an attempt to reach a wide audience. To simplify the exposition further, a single general model is developed. This model is then made more specific to different types of households by appropriate alteration of objective function values (e.g., crop gross margins), technical coefficients (e.g., average maize yield per hectare in different regions), and resource availability (e.g., cultivable land). Where a particular crop enterprise is completely inapplicable for a household type or region the activity is effectively excluded by setting coefficients for that activity to zero.

ACTIVITIES

The LP model is set up to maximize net monetary returns to selected cropping and noncropping activities, subject to a set of constraints on resource availability and subsistence needs. The general LP model has 37 activities, including major smallholder crops: local maize, hybrid maize, groundnuts, cotton, cassava, rice, sorghum, millet, intercropped maize, beans, and groundnuts. For pure stands of maize, further distinctions are made between fertilized and unfertilized local maize, and between fertilized and unfertilized dent and flint hybrid maize. Additional crops relevant to the simulations are burley tobacco, soybeans in a rotation with maize, and maize intercropped with *Acacia albida*. For the soybean and *Acacia albida*, enterprises separate activities are specified for local and hybrid maize. For the *Acacia albida* and maize intercrop activities a further distinction is made between land on which supplemental inorganic fertilizer is applied and land that only receives nitrogen from the *Acacia* trees.

Other activities entering the objective function are purchase of maize for home consumption, payment of interest for inputs acquired on credit, allocation of household labor to off-farm employment, and hiring of agricultural labor for crop production. Off-farm and hired farm labor activities are each disaggregated into six time periods, each period spanning from one to four months. The objective function coefficients for cropping activities are the gross margins per hectare indicated by the budgets that were described earlier. Thus, separate activities are not specified for seed and fertilizer purchase; these are already embodied in the gross margins from the budgets and do not need to be repeated in the LP model. Using the method described earlier to estimate input and output prices after removal of all subsidies, the cost for purchasing maize is 84.7 tambala per kilogram. The assumed interest rate on input credit is 12 percent. Wage rates for hired labor and off-farm family labor are estimated wages per day, assuming that most employment is as *ganyu* labor. The estimated daily wage used in the models is MK3.30; this is set higher than present prevailing *ganyu* wages because wages will have to rise to some extent in the face of large projected increases in producer and consumer prices of maize discussed earlier. A list of the variable names used in the LP model appears with brief variable descriptions in Table 11, and the full set of models for all 12 household types identified earlier appear in Appendix 2.

To take more complete account of the role of risk in smallholder farmers' decisions, development of a quadratic programming model that maximized expected returns was considered, but not undertaken. On the one hand, use of a quadratic programming model would limit the audience for the analysis. More important, sufficient data do not exist to build the variance-covariance matrix for crop yields or returns that would be central to a quadratic model. Instead, risk is accounted for in this model by a safety-first constraint — as described by Low (1974) — which explicitly includes meeting food consumption requirements as one of the household's objectives. The role of risk is also incorporated in the model by a constraint that requires the household to plant at least one-sixth of its total cultivated area to maize intercropped with secondary crops. This reflects the reality for most smallholders in Malawi, who grow a wide range of crops in addition to maize, often intercropped with maize (Shaxson 1990).

CONSTRAINTS

There are 22 constraints in the general model which represent a range of constraints applicable to smallholder farmers.[7] The first row of the constraint matrix, labeled Land, is a land constraint that simply specifies that the sum of the areas allocated to each crop or crop mix cannot exceed the total amount of land available to the household. The second constraint, labeled FoodSec, is the safety-first constraint that requires the household to have enough grain or cassava available to meet household requirements, estimated here as 200 kilograms per capita. This food can either come from maize purchases or household production of local or flint hybrid maize, rice, sorghum, millet, or cassava. Because of its undesirable consumption attributes it is assumed that dent hybrid maize would not be retained by the household for consumption.

The third constraint, labeled Budget, is a budget constraint which requires that the household's expenditures on maize, hired labor, and interest payments do not exceed the total value of earnings from crop production and off-farm employment. The fourth constraint, InputBuy, restricts the amount that can be spent on crop inputs such as seed, fertilizer, and chemicals to the amount of cash available at the beginning of the season plus any credit made available. The fifth constraint, CashAvl, is a simple identity used to capture the timing of expenditure using any cash held at the beginning of the season. The sixth constraint, SeasCons, limits the amount that can be spent on maize and hired labor to the amount of savings remaining after purchasing nonlabor inputs plus

[7] In addition to these 22 constraints, there are 37 non-negativity constraints restricting each of the 37 activities to values that are greater than or equal to zero.

Table 11 – Variable Names and Descriptions for Linear Programming Model

Variable name	Description
LMNF	Local maize, no fertilizer
LMF	Local maize, fertilized
HDMNF	Hybrid dent maize, no fertilizer
HFMNF	Hybrid flint maize, no fertilizer
HDMF	Hybrid dent maize, fertilized
HFMF	Hybrid flint maize, fertilized
LMSOY	Local maize (in soybean rotation)
HMSOY	Hybrid maize (in soybean rotation)
SOYMZ	Soybean (in maize rotation)
LMAA	Local maize & *Acacia albida* intercrop, no additional fertilizer
LMAAF	Local maize & *Acacia albida* plus fertilizer
HMAA	Hybrid maize & *Acacia albida* intercrop, no additional fertilizer
HMAAF	Hybrid maize & *Acacia albida* plus fertilizer
BURLEY	Burley tobacco
MMIX	Maize & pulse and/or groundnuts intercrop
RICE	Rice
COTTON	Cotton
CASSAVA	Cassava
SORGHUM	Sorghum
GNUT	Groundnuts
MILLET	Millet
BUYM	Maize purchases for household consumption
CREDIT	Interest payments on input credit
CASHSAV	Initial cash balance not spent on nonlabor inputs
CASHSPD	Initial cash balance spend on nonlabor inputs
LOFFJS	Off-farm labor, June-September
LOFFON	Off-farm labor, October-November
LOFFDEC	Off-farm labor, December
LOFFJAN	Off-farm labor, January
LOFFFM	Off-farm labor, February-March
LOFFAM	Off-farm labor, April-May
HLJNSP	Hired labor, June-September
HLOCNV	Hired labor, October-November
HLDEC	Hired labor, December
HLJAN	Hired labor, January
HLFBMR	Hired labor, February-March
HLAPMY	Hired labor, April-May

any earnings from off-farm employment.[8] The next constraint, labeled CredMax, restricts the amount of credit available to some predetermined value. (For most smallholders at present this predetermined value is zero.) Taken together, these four constraints add considerable realism to the model by preventing the household from financing operations by dissaving, which is not a realistic option for most households, and not a sustainable option for any household. The set of four constraints also captures some of the liquidity crunch that leads many smallholders to seek off-farm employment to earn food, or wages with which to buy food, during the growing season.

The constraint labeled BurMax restricts the area allocated to burley tobacco production to a specified level, set here at 0.10 hectare per participating household. The actual levels for the right hand sides of the credit and burley quota constraints were derived as follows. For credit in the base year, the total amount of credit available was divided by the number of hectares under cultivation to give an average credit per hectare amount. The implicit assumption is that, other things being equal, the amount of credit received is proportional to area cultivated (actual reliable data on credit use by area cultivated were not available). This amount was then multiplied by the average area cultivated in each landholding group to arrive at the coefficient for the right hand side of the constraint. The issue of credit versus noncredit farmers is taken care of by using the weighted average of credit available per household on the right hand side. The same procedure was repeated for other model runs using projections on the total availability of smallholder credit under different scenarios. A similar approach was used for the burley tobacco quota constraint, the main difference being that the right hand side values are the same for all landholding size groups, as the program is based on microplots that do not have to vary in size with total area cultivated.

The next constraint, labeled MzSoyR is a simple rotational constraint that restricts the amount of maize grown in the rotation to an area no greater than that planted to soybeans in the two-year rotation. It is still possible for more area to be allocated to maize under the other activities; likewise, it is possible to allocate more land to soybeans than to maize. The constraint labeled MaxSoy places an upper limit on the proportion of the area that can be planted to soybeans, the limit set at a maximum of one-tenth of total cultivated area. Trial runs of the model indicated large areas of soybeans grown in rotation with maize, because of the present profitability of soybeans combined with the beneficial effects of the residual nitrogen on the following maize crop. However, a more realistic assessment of the situation indicates that the total area allocated to soybean production would be constrained by a number of factors.

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[8] Households would only use off-farm earnings to finance hired labor if a member of the household can earn an off-farm wage above that paid to farm laborers. Otherwise, households would typically use family labor instead of hired labor, as long as family labor is sufficient. This is taken care of in the LP model by setting hired farm labor wages slightly higher than off-farm wages (by MK0.05 per day). The difference may be interpreted as the supervisory cost to the household of managing hired labor.

Among these are: possibility of decreased yields due to rust disease if soybeans occupy large expanses of cultivated land, difficulties harvesting large areas of soybeans in a timely manner to avoid shattering of the pods, and the limited market for soybeans in Malawi.

The constraint labeled MaxAA restricts the maximum proportion of land planted to a maize and *Acacia albida* intercrop to no more than one-tenth of the total cultivated area. As was the case with the maize and soybean rotation, agroforestry practices appeared at unreasonably large levels in the optimal solutions to the trial LP models. In practice the profitability of these practices will be constrained in the short term by difficulties in getting new tree plantings off to a good start and the long time it takes for the trees to get established and start fixing significant amounts of nitrogen (8 to 12 years in most areas of the country). Over the longer term adoption of this practice will be constrained by the unsuitability of some local conditions. The MinMix constraint is a crude attempt to account for risk and improve the realism of the LP model by requiring the optimal solution to include some of the cropping diversity that is shown in most smallholder cropping patterns in Malawi. Specifically, the constraint requires that at least one-sixth of the total area under cultivation be allocated to maize intercropped with pulses, groundnuts, or other crops. Without this constraint these secondary crops would usually not appear in optimal solutions because the returns are relatively lower than those of other activities. Nevertheless, such crop mixes are usually found in smallholder gardens, as these crops are important as relish ingredients and risk spreaders. These crops also permit scarce land to be used more intensively through relay cropping. Some of these crops are also useful for spreading labor demand and for providing food before the main staple crop is harvested (Shaxson 1990). The next six constraints limit labor input for crop production in each of six periods to available family labor plus any hired labor, less any time that family members work off-farm. The six periods are June-September, October-November, December, January, February-March, and April-May. The number of family members available for agricultural labor is estimated at 40 percent of the household size, and each member is assumed to be available to work an average of 19 days per month, except for December and January, when illness (and possibly food shortages) reduces this number to 15. These numbers might appear to be low, but that is because they take account of other demands on time, including gathering of wood, fetching water, food preparation, and community social and ceremonial obligations. The last four constraints limit the number of person-days a household can allocate labor to work off-farm between October and March to a maximum of ten person-days per month. This is done to account for the limited demand for labor, and thus limited opportunities for off-farm employment. The data on labor requirements for each cropping activity were taken from data gathered by UNDP/FAO for their agricultural mechanization project in Malawi.

USE OF MODEL FOR POLICY SIMULATIONS

The model was calibrated by comparing the results with both farm- and aggregate-level statistics on recent cropping patterns, production levels, and demand for credit and inputs. Where necessary, the model coefficients and constraints were adjusted to make model results more closely correspond with reality in the base year. The season 1990/91 was used to calibrate the model, as the disastrous 1991/92 drought year would be inappropriate for obvious reasons. Similarly, 1992/93 was not used as a base year because it was characterized by unusually good weather and abnormalities in input distribution. The latter includes a critical shortage of local maize seed following the drought and the free distribution of about 1,000 metric tons of hybrid maize seed, neither of which are likely to occur on a regular basis. As 1990/91 was also a good season (although not as productive as 1992/93), going back a couple years for a base year comparison does not underestimate the positive trends that have taken place in smallholder agriculture in recent years. Next a number of coefficients in the base year models were modified to simulate the effects of three different policy scenarios. The time horizon for each is ten years, so that the models are used to simulate outcomes in the year 2002/03.

Scenario One: Continuation of Present Policies

The first scenario may be termed Continue Present Policies. In this scenario it is assumed that recent trends will continue; note that it is definitely not assumed that no changes will occur over the next 10 years. Availability, but not necessarily use, of fertilizer is assumed to grow in line with the ten percent annual increases of recent years. Growth in the number of smallholder burley tobacco producers is assumed to be modest, with the total burley quota allocated to smallholders equal to 11 million kilograms and approximately 34,000 smallholders participating. Availability and distribution of credit is expected to grow at 3.2 percent per year, approximately in line with population growth. It is assumed that progress on new technological fronts, namely flint hybrid maize, agroforestry, and soybeans, would be modest. This assumption is operationalized by an additional constraint (MaxTech), which restricts the area allocated to these improved technologies to no more than one-fifth of the total cropped area. (In practice this constraint turned out to be not binding for all but two of the twelve household types, as other constraints, most notably credit, proved to be binding before the MaxTech limit was reached.)

Scenario Two: Policy Reforms

The second policy scenario in the simulations is labeled Policy Reforms. In this scenario it is assumed that the smallholder burley program will be accelerated, so that by the 2002/03 season the burley quota for smallholders would be 25 million kilograms. This would be grown by 166,000 participating farmers on microplots of 0.1 hectare each. It is assumed that due to encouragement given to NSCM and other seed suppliers the supply of flint hybrid maize seed would not be constraining. Availability of credit would increase to at least MK 250 million per year, more than double the base year levels, compared to a 33 percent increase in population. Only a portion of this additional credit, approximately MK 27 million, would be required by the smallholder burley program, with the balance going to support production of other crops, especially maize. It is assumed that investments and improvements made in agricultural research and extension would permit adoption of agroforestry practices and soybean production to proceed rapidly, subject to the overall constraints already outlined. It is also assumed that yields of local maize fertilized at a high rate would increase by 100 kilograms per hectare, and with increases of 200 kilograms per hectare for highly fertilized hybrid maize, due to improvements in cultural practices brought about by increased location-specific extension advice. Note that it is assumed that these yield increases will occur after controlling for the rate of fertilizer application. Increases in fertilizer application rates will cause overall yield increases to be greater.

Scenario Three: Rapid Policy Reforms

This scenario is almost the same as the Policy Reform scenario described above. The differences are larger increases in smallholder burley quotas and credit availability. Under the Rapid Policy Reforms scenario it is assumed that 333,000 smallholder farmers would be licensed to grow burley tobacco, with a total smallholder burley quota allocation of almost 50 million kilograms. Credit availability would be increased to at least MK 285 million, with a large share of the additional credit going to service these additional growers.

Table 12 shows projected burley tobacco export prospects for Malawi under two export growth rates, one at 2.5 percent per year and the other at 5.0 percent per year. It also shows the distribution of production between the estate and smallholder subsectors for the three policy scenarios outlined above. Note that in only one case, that of slow export growth combined with rapid growth in smallholder quota allocations, would estate quota allocations drop below 1991/92 levels of approximately 100 million tons. Thus, while increased burley tobacco production would mean a declining share of the total for the estate subsector, the estates could still enjoy significant growth in burley tobacco output, especially if the outlook for exports is strong.

At least three assumptions are constant across all of the three scenarios investigated. One, smallholder population growth is assumed to be 3 percent per year in all cases. This estimate is based on an assumption of total population growth continuing to be well in excess of 3 percent per annum, but allowing for rural-to-urban migration to continue at the present low rate, as well as an allowance for continued shifting of households from the smallholder subsector to the estate subsector. Two, the total area of land cultivated by smallholders is assumed to increase at about 1 percent per year, as has been the case over the past decade, with prospects for opening up new land becoming increasingly limited (Eschweiler 1993). As land availability is known to be an important constraint in Malawi and shows up as highly constraining for all farm types under all scenarios, this is a critical assumption. However, it is a realistic assumption, barring any unforeseen return of land from leasehold or freehold status to

Table 12 — Level and Distribution of Burley Production Between Estates and Smallholders under Three Policy Scenarios and Two Export Growth Scenarios

	Policy scenario					
	Slow growth in smallholder burley quotas (Continue Present Policies)		Modest growth in smallholder burley quotas (Policy Reform)		Rapid growth in smallholder burley quotas (Rapid Policy Reform)	
	Production ('000 kgs)	Share of total	Production ('000 kgs)	Share of total	Production ('000 kgs)	Share of total
	Slow export growth (2.5 percent per year)					
Estate	119,190	91.6	105,190	80.8	80,190	61.6
Smallholder	11,000	8.4	25,000	19.2	50,000	38.4
Total	130,190	100.0	130,190	100.0	130,190	100.0
	Fast export growth (5 percent per year)					
Estate	158,707	93.5	144,707	85.3	119,707	70.5
Smallholder	11,000	6.5	25,000	14.7	50,000	29.5
Total	169,707	100.0	169,707	100.0	169,707	100.0

Note: Total burley tobacco exports based upon 1991/92 exports of 99.2 million kilograms (World Bank, Commodities department) customary status. Three, all prices are assumed to be the same in all cases. The actual prices used in the model are those described in section 3. As these prices are substantially higher than those currently prevailing, it is to be expected that there will be increases in all variables measured in nominal Kwacha, e.g., net farm incomes. It is therefore variables measured in *real* units, such as tons of maize or hectares of land, which will be most telling when comparing the results for the different policy scenarios. When comparing Kwacha values it is the growth rates, as compared to the base year, that are emphasized.

5. RESULTS OF MODEL SIMULATIONS

To get a picture of the overall impact of these policy reforms on smallholders and on Malawian agriculture in general, the results from the linear programming models for the 12 representative farm types were aggregated using the distributions of households by area cultivated category shown in Table 13. The population distributions are based on the 1987 census, with adjustments made to take account of the fact that the arable land base is more or less fixed while the number of people occupying that land would be increasing. The adjustments are based on recent trends, including limited growth in the proportion of the population living in urban areas. The total number of smallholder households in 1992 is 1.8 million, and the number for 2002/03 is projected to be 2.4 million, which implies an average annual growth rate of three percent in the number of smallholder households.

The aggregation is a convenient means of both confirming the validity of the farm-level linear programming models, which form the basis for this analysis, and evaluating the impact of different policy sets on key national-level variables. As many of the reforms could only occur over the span of a few years, during which the population and number of smallholder households will undoubtedly grow, it is appropriate to use estimates of future population size in the projections. It is not only the increase in numbers of smallholders that is important, but the continued shift toward smaller areas cultivated that accompanies such growth, that is important to the results.

MODEL RESULTS — BASE YEAR

Some important aggregate results from the base year model runs are shown in Table 14, under the column headed Base Year. Grain production of 1.72 million metric tons (MMT) estimated from the linear programming models is close to the actual 1990/91 production level of 1.65 million metric tons. This figure includes maize, rice, and millet, as rice appears in the optimal solutions for the representative farms in Karonga and Salima ADDs, and millet appears in the solutions for Ngabu ADD.

Consumption of 1.55 MMT of grain is also close to the actual 1990/91 levels, and reflects the small surplus of smallholder maize production compared to *effective* demand for maize. One must be careful not to interpret this balance of supply and demand, or apparent maize self-sufficiency, with true food security, a mistake that is commonly made in discussions of Malawi's food situation. As this 1.55 MMT is not distributed equally, many fall below the per capita consumption level of 194 kilograms per year, which is already below the minimum nutritional requirement of 200 kilograms per year that is often suggested for Malawi. Quite sensibly, the government has not focused on equalizing distribution, but has long advocated increasing maize production so that all Malawians can receive their nutritional requirements whatever the distribution

Table 13 — Malaŵi: Population Distribution in 1992/93 and Projected distribution in 2002/03, by Area Cultivated Group and ADD Group

Area cultivated group	Agricultural Development Divisions (ADD)				
	Karonga Salima	Mzuzu Kasungu	Lilongwe Liwonde Blantyre	Ngabu	Total
	1992/93 population distribution ('000 households)				
Small	75.21	156.05	766.68	100.97	1,098.91
Medium	37.28	82.34	252.42	8.23	380.27
Large	20.53	139.79	152.52	8.35	321.19
Total	133.02	378.18	1,171.62	117.55	1,800
	2002/03 projected population distribution ('000 households)				
Small	111.61	242.29	1,117.43	142.22	1,613.55
Medium	44.04	92.67	288.97	7.17	432.85
Large	21.71	169.28	155.76	7.33	354.08
Total	177.36	504.24	1,562.16	156.72	2,400

Source: 1987 Census and author's calculations

Note: Small, Medium, and Large area cultivated groups as defined in Table 3.

Table 14 – Selected Variables from Aggregation of Linear Programming Models for Base Year and Three Future Policy Scenarios

	Actual 1990/91	Base Year	Continue Present Policies 2002/03	Policy Reforms 2002/03	Rapid Reforms 2002/03
Average farm returns (MK per HH per year)	328	421	449	531	570
Small size farms (63% of all HHs in base year, 70% in 2002)	na	153	253	343	384
Medium size farms (22% of all HHs in base year, 18% in 2002)	na	718	763	820	853
Large size farms (15% of all HHs in base year, 12% in 2002)	na	1,106	1,116	1,189	1,222
Maize production (1000 tons)	1,653	1,723	2,040	2,381	2,413
Total production per capita (kg)	207	215	191	223	226
Minimum maize consumption (1000 tons)	1,475	1,550	2,001	2,175	2,175
Minimum consumption per capita (kg)	185	194	188	204	204
Effective maize demand (1000 tons)	1,475	1,550	2,147	2,373	2,481
Effective demand per capita (kg)	185	194	201	223	233
Grain balance (Production - effective demand) (1000 tons)	178	173	(107)	8	(68)
Maize area (1000 Ha)	1,363	1,527	1,718	1,713	1,696
Local (including intercrops)	1,184	1,395	1,343	1,097	1,059
Hybrid	179	132	374	616	638
Fertilizer nutrient demand (tons) (includes maize only)					
Nitrogen	34,000	33,400	35,329	53,548	56,315
Phosphate	14,000	9,329	12,969	19,407	20,405
Additional Nitrogen fixed organically (tons)	na	na	3,245	3,386	3,386
Number of smallholder burley growers (1000)	11	11	41	166	332
Smallholder burley production (tons)	3,000	3,000	6,224	24,905	49,810
Credit demand (MK 1000)	75,000	112,288	144,046	243,384	283,842

of output. This objective has not been fulfilled, however, because of the failure to increase incomes of smallholders so that they would have the purchasing power to retain sufficient quantities of their own harvests or buy the maize necessary to meet their nutritional requirements. We shall return to maize consumption levels later in our discussion of the projected results under a range of policy reforms.

It is well-documented that a large proportion of Malawians, especially those with small landholdings, do not get sufficient food to lead active and healthy lives. High infant and child mortality rates, child malnutrition rates of over 50 percent, and widespread evidence of families eating only one meal per day, or less, during the hungry season are only three of the more obvious examples. The linear programming models successfully captured this disturbing aspect of smallholder household economics in Malawi. With food requirements in the safety-first food security constraint set at 200 kilograms per year, feasible solutions could not be reached for households in the Small landholding groups in Lilongwe, Liwonde, Blantyre, and Ngabu ADDs. Even after carefully rechecking other model coefficients, it was necessary to reduce food intake to 170 kilograms per person per year, only 85 percent of the recommended minimum, to reach feasible solutions. This is in fact what many households in Malawi do to survive. It is important to recall that the models are designed to model *average* households in each group, so the true amount of hunger is greater when one remembers the roughly one half of households who are below average — in incomes, food production, food intake, etc. — in each group. This is also true for the households in the other ADDs: the average household in the Small landholding group may be able to achieve 200 kilograms of staple food consumption per person per year, but many of those below average cannot.

Other model results shown in the Base Year column in Table 14 also correspond closely to the actual 1990/91 levels. These include area (on customary land) planted to maize, the proportion of that total devoted to hybrid varieties, fertilizer use, and the net returns to farming. The distribution of farm returns by area cultivated corresponds well with results reported elsewhere. Base year model simulation results for cropping patterns and production by landholding size class are also in line with known actual figures for 1990/91; these model estimates are shown in Table 15. The models also show the pervasive excess supply of labor, along with some of the seasonal fluctuations in labor supply and demand, in Table 16.

The model results on credit demand shown in Table 14 for the Base Year scenario are lower than expected, as SACA loaned approximately MK120 million in the 1992/93 season. One would expect the estimate in the models to be higher than this given the increases in input prices that are assumed (see section 3). The low estimates for credit are most likely due to two factors, both artifacts of the LP models. First, the models do not provide for leakage of fertilizer to the estate subsector, which occurs when smallholders sell the subsidized fertilizer they receive to estates, which normally pay the full market price. The price paid by the estates to smallholders for fertilizer presumably lies somewhere between the subsidized price and the market price. It has been estimated that as much as 30 percent of smallholder fertilizer finds its way to

Table 15 — Crop Production (aggregated totals) by Area Cultivated Group under Different Policy Scenarios

	Area planted (1000 Ha)				Production (tons)			
	Small	Medium	Large	Total	Small	Medium	Large	Total
Base Year								
Local maize-no fertilizer	151	4	5	160	96,563	2,271	2,827	101,660
Local maize-fertilizer	326	156	4	486	368,261	176,076	3,989	548,326
Hybrid dent maize-fertilizer	6	24	102	132	14,552	67,128	253,120	334,800
Maize & pulse intercrop	102	216	430	749	69,793	173,182	357,891	600,866
Millet	0	0	7	7	0	0	2,856	2,856
Rice	29	23	31	84	46,908	37,521	49,941	134,370
Cotton	0	12	5	16	na	na	na	na
TOTAL AREA	615	435	585	1,635				
	Small	Medium	Large	Total	Small	Medium	Large	Total
Continuation of status quo - 2002/03								
Local maize-no fertilizer	86	3	7	96	47,479	1,575	3,775	52,829
Local maize-fertilizer	28	6	3	37	28,649	6,270	3,063	37,982
Hybrid dent maize-fertilizer	0	52	78	130	0	136,398	213,256	349,654
Hybrid flint maize-fertilizer	62	26	0	88	154,397	62,948	0	217,345
Local maize & acacia albida-no fert	15	1	2	19	11,839	1,012	1,601	14,452
Hybrid maize & acacia albida & fert	66	42	49	157	165,007	107,550	135,305	407,862
Maize & pulse intercrop	518	304	369	1,191	405,474	245,146	309,417	960,037
Millet	0	0	2	2	0	0	751	751
Rice	33	26	29	88	53,066	40,815	46,528	140,408
Cotton	0	13	3	17	na	na	na	na
Burley tobacco	2	1	1	4	2,888	2,040	1,296	6,224
TOTAL AREA	810	475	544	1,828				
	Small	Medium	Large	Total	Small	Medium	Large	Total
Policy reform - 2002/03								
Local maize-no fertilizer	16	3	0	19	8,890	1,485	48	10,423
Local maize-fertilizer	85	6	5	95	84,752	5,602	4,839	95,193
Hybrid dent maize-fertilizer	1	52	92	146	3,398	139,212	256,821	399,432
Hybrid flint maize-fertilizer	286	20	0	306	717,464	49,316	0	766,780
Local maize & acacia albida-no fert	15	1	2	19	11,839	1,012	1,601	14,452
Hybrid maize & acacia albida-no fert	61	11	27	99	93,287	20,430	49,003	162,721
Hybrid maize & acacia albida & fert	5	35	25	65	12,084	84,673	62,219	158,976
Maize & pulse intercrop	302	308	354	964	229,400	247,921	295,754	773,074
Millet	0	0	6	6	0	0	2,187	2,187
Rice	16	22	26	63	25,879	34,852	40,862	101,594
Cotton	11	14	5	30	na	na	na	na
Burley tobacco	12	3	2	17	17,353	4,618	2,933	24,905
TOTAL AREA	810	475	544	1,828				
	Small	Medium	Large	Total	Small	Medium	Large	Total
Rapid policy reform - 2002/03								
Local maize-no fertilizer	7	3	0	10	3,771	1,388	132	5,291
Local maize-fertilizer	90	6	5	101	90,142	5,848	4,827	100,817
Hybrid dent maize-fertilizer	3	54	92	149	7,915	144,716	255,784	408,415
Hybrid flint maize-fertilizer	302	23	0	324	757,281	55,243	0	812,524
Local maize & acacia albida-no fert	15	1	2	19	11,839	1,012	1,601	14,452
Hybrid maize & acacia albida-no fert	61	11	22	94	93,287	20,430	40,552	154,269
Hybrid maize & acacia albida & fert	5	35	30	70	12,084	84,673	76,173	172,930
Maize & pulse intercrop	277	301	352	929	208,321	241,995	294,432	744,748
Millet	0	0	5	5	0	0	2,115	2,115
Rice	14	22	26	61	22,074	34,829	40,853	97,756
Cotton	14	13	5	32	na	na	na	na
Burley tobacco	23	6	4	33	34,707	9,236	5,867	49,810
TOTAL AREA	810	475	544	1,828				

Table 16 — Employment Supply and Demand by Region and Time Period, in Person-days

	Agricultural Development Divisions (ADD)			
	Karonga Salima	Mzuzu Kasungu	Lilongwe Liwonde Blantyre	Ngabu
Base Year				
Labor Supply				
Oct-Nov	5,376	9,950	45,103	2,490
Dec	3,902	11,321	35,149	2,351
Jan	1,440	3,782	16,608	0
Feb-Mar	6,481	22,691	70,297	6,341
Labor Demand				
Oct-Nov	0	11,390	30,557	3,847
Dec	0	0	0	2,336
Jan	3,818	5,544	14,243	1,739
Feb-Mar	0	0	0	0
Continue present policies - 2002/03				
Labor Supply				
Oct-Nov	8,683	13,762	61,470	4,698
Dec	5,321	15,127	46,865	3,134
Jan	2,164	5,489	25,125	1,413
Feb-Mar	9,793	30,254	93,730	9,403
Labor Demand				
Oct-Nov	0	8,660	21,803	6,751
Dec	0	0	0	1,198
Jan	3,916	4,710	12,788	2,207
Feb-Mar	0	0	0	0
Policy reform - 2002/03				
Labor Supply				
Oct-Nov	8,295	13,872	60,945	4,558
Dec	5,321	15,127	46,865	3,134
Jan	2,210	5,377	25,318	852
Feb-Mar	10,121	30,254	93,730	9,403
Labor Demand				
Oct-Nov	0	8,263	22,080	3,350
Dec	0	0	0	3,057
Jan	3,707	5,002	12,750	1,397
Feb-Mar	0	0	0	0
Rapid policy reform - 2002/03				
Labor Supply				
Oct-Nov	8,268	13,848	60,871	4,545
Dec	5,321	15,127	46,865	3,134
Jan	2,193	5,313	25,121	706
Feb-Mar	10,030	30,254	93,730	9,403
Labor Demand				
Oct-Nov	0	8,371	22,155	3,564
Dec	0	0	0	3,047
Jan	3,724	5,013	12,947	1,471
Feb-Mar	0	0	0	0

the estate subsector, but this is not included in the models. In the LP models all fertilizer purchased, whether with cash or credit, is used on the smallholders' plots. Second, since crop harvests and returns are already known in the model, farmers will only take credit if it is certain that they will be able to repay the loan plus interest. The model leaves no room for default, which has been a growing problem for SACA and smallholders alike. These two reasons explain a large part of the poor calibration of the model with respect to smallholder credit demand.

The model also tends to underestimate fertilizer nutrient demand slightly, indicating 33,400 tons of nitrogen and 9,329 tons of phosphate per year in the base year run of the model, compared with approximately 34,000 and 14,000 tons, respectively, in 1990/91. Fertilizer demand in 1991/92 was higher than in 1990/91. This underestimate is smaller than that for credit, and a large part of the underestimate may be explained by the same reasons given above for credit: the model does not allow for fertilizer leakage from the smallholder sector, and the model "knows" whether or not fertilizer will be profitable in advance.

MODEL RESULTS — CONTINUATION OF PRESENT POLICIES SCENARIO

Turning to the next column in the table, under the heading "Continue Present Policies - 2002/03" we see increases in levels of average farm returns, total maize production, consumption, and area planted. Because of population increases, however, maize production per capita declines from 215 kilograms in the base year to 191 in 2002/03. Even though average farm returns have increased in the Small category, in none of the ADDs could households operating smallholdings afford to consume the recommended minimum 200 kilograms of staple food. The four ADDs that were previously below the minimum could not rise above consumption of 85 percent of minimum, while small landholders in Karonga and Salima ADDs were able to meet only 95 percent of requirements. The corresponding level among small landholders in Kasungu and Mzuzu ADDs is 97 percent. This drop in household food security is due to the reduction in average holding size within each group that occurs because of population pressure; this is in addition to the shift of more households into the Small category. The simulation shows that with credit remaining extremely limited, smallholders working small plots of land have to meet more of their consumption requirements from purchased maize, and maize is generally much more expensive to buy in Malawi than it is to produce.

The decline in per capita maize production and consumption occurs despite a projected increase in the proportion of maize area under hybrids from 8.6 percent to 21.8 percent. This is a level just below the 24 percent recorded in the 1992/93 season. It has been noted above that 1992/93 was an unusual season in that there was not much local seed available for planting following the 1991/92 drought; the 1991/92 harvest was small, and most of the local maize harvested was consumed as food before planting for the 1992/93 season. The government and NGOs also provided 1,000 metric tons of hybrid maize seed to smallholders on a grant basis, and these two factors combined to push the proportion of area planted to hybrid maize to previously unanticipated high levels. The impact of this anomalous year on future hybrid maize usage is still unclear. On the one hand, it may cause a one-time ratcheting upward of hybrid adoption patterns, as farmers would most likely be pleased with a good harvest that came from hybrid maize and good weather. On the other hand, the financial constraints remain formidable for most smallholder households, and the inferior consumption attributes of the dent hybrids are unchanged. As it was mostly dent hybrids that were distributed (total supply of flint hybrids continues to be a binding constraint), it is possible that storage losses or low grain-to-flour extraction rates will discourage farmers from continuing with hybrids despite the good harvest. It must also be remembered that most of the growth in maize hybrid area to date has been by surplus producers who grow it as a cash crop, while continuing to grow local maize for home consumption. This growth potential for the dent hybrids will diminish in the future as households have less land left over after allocating land for household food consumption needs.

The projected increase in fertilizer use is small, with nitrogen use growing by only 6 percent, and phosphate use growing by 39 percent (from a low base) over the ten-year period. These figures show that much of the increase in fertilized hybrid maize area comes about as a shift from fertilized local maize, as farmers are able to take some advantage of the flint hybrid varieties MH17 and MH18, although in this scenario it is assumed that use of the new seeds is still constrained by insufficient seed supplies. In this scenario the models showed that adoption of the new varieties is also constrained by insufficient cash and credit, as well as extremely limited opportunities to grow high-value cash crops.

With respect to fertilizer use, the model predicts a dramatic slowing in the rate of increase in fertilizer use. From 1987/88 to 1991/92 smallholder fertilizer purchases increased at a rate of about 18 percent per year in terms of nutrients. It was noted above that some of this increase is probably due to leakages to the estate subsector. A more important observation about trends in fertilizer use is that these increases in fertilizer purchases were due more to a shifting out of the supply curve than a shifting out of the demand curve for fertilizer. As noted by Sahn and Arulpragasam (1991), the rapid increase in smallholder fertilizer sales took place in a context of static or increasing nitrogen:maize price ratios. In the mid-1980s there was excess effective fertilizer demand from the smallholder subsector, and during the following years SFFRFM increased its procurement levels, in steps, to meet this pent-up demand. Further evidence of this excess demand is the observation that fertilizer supplies at ADMARC depots were usually insufficient to meet demand by noncredit farmers. It would appear that SFFRFM and ADMARC finally caught up to the effective demand in 1991/92, based on the large carryover stocks of fertilizer held at the end of that season. Thus, future increases in fertilizer use will have to come from increases in fertilizer demand, which is a function of production technology, prices of inputs and outputs, availability of funds, and other factors. While there there is good reason to expect some increase in fertilizer demand, there is no evidence to suggest that the demand curve will shift out fast enough for smallholder fertilizer sales to continue increasing at the rate of 18 percent per year, especially under the assumptions of the Continuation of Present Policies scenario.

While these explanations of trends in hybrid maize and fertilizer use are most directly related to the Continuation of Present Policies scenario, they also have a bearing on the model predictions (and should have a bearing on less quantitative expectations) for the two policy reform scenarios. For example, even under ambitious policy reforms it is unlikely that smallholder fertilizer use will increase at the 18 percent per year that occurred in the late 1980s as rapid increases in supply were tried to eliminate the excess demand that had prevailed up to that point.

MODEL RESULTS — POLICY REFORM SCENARIO

The column in Table 14 headed "Policy Reforms - 2002/03" shows the projected outcomes indicated by the LP models which incorporate the full complement of policy reforms discussed in this paper, allowing ten years for these innovations to be implemented. This includes establishment and development of institutions for efficient handling of an expanded smallholder burley tobacco program, time to multiply large quantities of flint hybrid maize seed and get farmers to adopt these varieties, and time for farmers to adopt agroforestry practices and the leguminous trees to become established and have a positive effect on maize yields. Of course, the same growth in population and shift in distribution of landholdings that was described for the Continue Present Policies - 2002/03 case is also incorporated here.

One dramatic result is the 38 percent increase (about 3.3 percent per year) in maize production compared to the base year case. Increased productivity in food crop production coupled with the increased smallholder production of cash crops — the latter made possible by easing the land constraint effects of the former as well as changes in government policy — increases average returns to farming by 26 percent over the ten years. This is equal to an annual rate of growth of 2.3 percent per capita, or 5.3 percent overall. Projected growth rates for under the three policy scenarios are summarized in Table 17. While the total area under maize increases only slightly over that in the base year case (about one percent per year), the proportion of maize area planted to hybrids increases to almost 40 percent. This is made possible by the tremendous expansion in credit demand and supply, with credit use projected at a level two and one-half times that in the base year case. An important result of the model simulations is that for this level of credit to generate the growth indicated here, fully 70 percent of credit funds must go to the 70 percent of smallholders who are in the Small area cultivated category. Experimentation with the models showed that this is the most efficient use of credit. If the additional credit does not get distributed with this emphasis on smallholders working small landholdings, the total increase in available funds will need to be greater, or the increase in farm incomes will be less. Credit expansion comes about partly through increased supply of credit due to improvements in rural credit markets as a result of the Rural Financial Services Project, and partly because the attractiveness of flint hybrids and burley tobacco boosts demand from the smallholder side.

Table 17 — Projected Growth Rates in Income Per Capita and Smallholder Subsector Output under Three Different Policy Scenarios

Scenario	Farm Income per capita Annual Growth Rate	Smallholder Subsector Annual Growth Rate	Subsector Growth Rate excluding burley tobacco[a]
Continuation of Present Policies	0.6	3.6	3.2
Policy Reforms	2.3	5.3	4.2
Rapid Policy Reforms	3.1	6.1	4.2

[a] Estimated subsector growth rate excluding only the direct effects of increased smallholder burley tobacco production. Burley production provides additional indirect stimulus to smallholder production through increased availability of cash to buy inputs for other crops. Only the direct effect is excluded from the growth rates in this column.

The distribution of the growth in returns to farming is an important component of the proposed policy reform. With a majority of smallholders in the Small category it is essential that their rate of growth be strong enough to drive the growth of the smallholder subsector. The LP model results project average annual overall growth in farm net returns of 12.7 percent for the Small area cultivated group, 2.7 percent for the Medium group, and -1.0 percent for the Large group. The decline in average farm returns for the Large group is primarily due to the reduction in the numbers of households in that category, as arable land in the smallholder subsector becomes increasingly fragmented with population growth. Taking into account the change in population distribution for these three groups, the average annual growth rates in farm returns for the Small, Medium, and Large land holding groups on a per capita basis are 8.4, 1.3, and 0.7, respectively.

Increased maize production is made possible largely by the improved availability of flint hybrid maize seeds, which have consumption and storage attributes desired by smallholder households, and increased yields. The LP model results indicate an increase in the use of organic fertilizers as experience with agroforestry practices is gained and *Acacia albida* trees mature. The constraint limiting maize and *Acacia albida* intercrops to no more than one-tenth of the total cultivated area in each group was binding in all cases, indicating that agroforestry growth is limited more by technical and extension factors than by its financial aspects. The attractiveness of organic nitrogen sources is due in large part to the assumption that the price ratio of nitrogen to maize would continue to be high because of high transport costs and no subsidies on fertilizer. In such a situation either intercropping maize with *Acacia albida* or employing a rotation of maize with soybeans is a very cost-effective way of providing nitrogen to maize plants. These organic sources of nitrogen may be used as either substitutes for low levels of inorganic nitrogen fertilizer application or in addition to inorganic sources. The former option would be most attractive to farmers with very limited cash and credit resources, whereas the latter would prove more cost-effective than exclusive use of inorganic fertilizers for any farmer. The model results for this scenario showed a predominance of hybrid maize intercropped with *Acacia albida*, with hectarage split almost evenly between that receiving no inorganic fertilizer and that receiving 80 percent of recommended fertilizer levels.[9] As expected, smallholders in the Small category were less likely to apply additional fertilizer and more likely to plant local maize under the *Acacia albida* canopy than farmers in the other two categories.

The increase in farm incomes will lead to an increase in the effective demand for maize. Analysis of recent expenditure data collected by the Ministry of Agriculture reveals an expenditure elasticity for maize of approximately 0.9 at the sample mean, indicating that a 10 percent increase in total household

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[9] Recall that in an LP modeling context, this could alternatively be interpreted as applying 40 percent of recommended levels of fertilizer to the total area, or any other linear combination of the agroforestry cropping patterns shown in Table 15.

expenditure (income) would lead to a 9 percent increase in household expenditures on maize. This elasticity declines as incomes increase, as households increasingly direct incremental expenditures towards other items after the need for staple food has been met. It is not possible to make a direct calculation of the effect of a 26 percent increase in average farm incomes on maize demand for two reasons. First, crop production is only one source of income for smallholder households, who often derive income from off-farm labor, crafts, trading, and other nonfarm activities. Thus, a 26 percent increase in crop income would generally lead to a smaller increase in total household income. Second, the elasticity measure is only applicable to small changes in total expenditure, and a 26 percent increase is far from small.

However, with a few caveats in mind it is possible to estimate the effect of increased incomes on maize demand. If it is assumed that crop production accounts for three-quarters of all household income, then a 26 percent increase in crop income would translate into a 20 percent increase in total household income and expenditure. Assuming a slow decline in the magnitude of the maize expenditure elasticity, which is a reasonable assumption for Malawi smallholders, this 20 percent increase in total expenditure would include an increase in maize expenditure of approximately 15 percent.[10] This would raise the average effective maize demand from the base year level of 194 kilograms per capita to about 223 kilograms per capita. This small but significant increase in effective demand may manifest itself as increased quantities of maize retained after harvest, or increased purchases in maize, or both. This level of consumption is roughly equal to projected maize production levels, placing Malawi in the position of reducing their apparent surplus while simultaneously enhancing household food security.

MODEL RESULTS — RAPID POLICY REFORM SCENARIO

The last column in Table 14, labeled "Rapid Reforms - 2002/03", shows the results under policy reforms similar to that described above, but taken at a faster pace. In particular, the number of smallholders participating in the smallholder burley tobacco program is assumed to be 333,000 with a corresponding increase in the amount of credit available to smallholders. Even at this high level of participation, however, only about one in seven smallholder households would grow burley tobacco. Compared to the results in the Policy Reforms - 2002/03 column, there is an additional 7.3 percent increase in total net farm returns, due almost entirely to smallholder burley production that is double that in the Policy Reforms case, with total smallholder output rising to 50 million kilograms. The increase in incomes leads to a further increase in effective maize demand, while total maize production is slightly higher than in the Policy Reforms - 2002/03 scenario. The net result is increased maize consumption by smallholder households and a small maize deficit in this subsector, totaling

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[10] Similar calculations were used to derive estimates of effective maize demand for the other scenarios.

68,000 tons per year. Fertilizer use, both organic and inorganic, is largely the same under the two policy reform scenarios.

AGGREGATE RESULTS — BY AREA CULTIVATED GROUP

The dual objectives of the policy strategy are the rejuvenation of smallholder agriculture combined with reduction of the poverty which pervades the subsector. In this context it is useful to examine the distribution of agricultural production and growth under the four scenarios considered in Table 14. The differential growth rates in farm returns under varying policy scenarios have already been discussed above.

The total area and output for each of the cropping activities under the four scenarios are shown in Table 15. The table shows not only the crop grown, but also the technology used, e.g., no fertilizer, intercropped with *Acacia albida*, etc. The notations "fertilizer" or "no fertilizer" in the table refer only to inorganic fertilizer applications. Many observations may be made from this table, but the most salient is the greatly increased share of production accounted for by smallholders in the Small category under the two policy reform scenarios. There are two reasons for this increase. One is the increased proportion of smallholders in the Small category as the population grows while the arable land base remains fixed. This portion of the increase is also reflected in the Area Planted columns. The second and more significant reason for the increased share of production by Small smallholders is their increased use of improved agricultural technologies, including hybrid seed, fertilizer, and agroforestry practices. This effect may be seen by comparing the distribution of production across the different technologies in the top two scenarios (Base Year and Continuation of Status quo 2002/03) with the distribution in the bottom two scenarios (Policy Reform and Rapid Policy Reform). This increase in the use of improved technologies is made possible by expanded credit, increased availability of inputs such as flint hybrid seed, and increased incomes from burley tobacco production, which also helps to finance household food production.

Table 18 summarizes some of the results in Table 15, showing maize production and consumption by area cultivated group under each of the scenarios, as well as off-farm labor supply and agricultural labor demand by smallholders. These are shown both as household averages and in the aggregate. Turning first to aggregate maize production, we see that in the base case the Small smallholder households produce approximately one-third of all smallholder maize, while consuming well over half of production, having to buy almost 250,000 tons to try to meet basic calorie intake requirements. If present trends continue, maize production by Small smallholders increases significantly, but not as fast as necessary increases in consumption, so that the food production deficit of Small smallholders almost doubles, rising to over 410,000 tons. Under each of the policy reform scenarios, however, Small smallholders grow about one-half of all maize.

Table 18 - Maize Production and Consumption, Credit Taken, Maize Purchases, Labor Demand and Supply by Area Cultivated Group

	Base Year			Continue Present policies - 2003/03		
Household average levels	**Small**	**Medium**	**Large**	**Small**	**Medium**	**Large**
Net return (MK)	153	718	1,106	253	763	1,116
Grain consumption (kg)	739	993	1,179	733	992	1,182
Maize production (kg)	525	1,168	2,442	486	1260	2,357
Maize sales (purch) (kg)	(214)	175	1,264	(247)	268	1,176
Credit used (MK)	48	57	129	40	99	117
Burley Production (kg)	0	0	0	2	5	5
Hired labor (person-days)						
October & November	0	0	26	0	0	15
December	0	0	1	0	0	0
January	0	0	14	0	0	10
February & March	0	0	0	0	0	0
Off-farm labor (person-days)						
October & November	20	15	0	20	16	1
December	10	10	10	10	10	10
January	9	3	0	10	4	0
February & March	19	20	19	20	20	20

Aggregate totals	**Small**	**Medium**	**Large**	**Total**	**Small**	**Medium**	**Large**	**Total**
Net return (million MK)	174	280	304	758	423	339	315	1,078
Grain consumption (1,000 tons)	839	388	324	1,550	1,225	441	334	2,001
Maize production (1,000 tons)	596	456	671	1,723	813	561	666	2,040
Maize sold (purch) (1,000 tons)	(243)	68	347	173	(412)	119	332	39
Credit used (MK 1000)	54,542	22,430	35,317	112,288	66,905	44,120	33,201	144,046
Burley production (1000 kg)	0	0	0	0	2,888	2,040	1,296	6,224
Hired labor (1000 person-days)								
October & November	0	0	7,233	7,233	0	0	4,335	4,335
December	0	0	141	141	0	0	48	48
January	0	118	3,805	3,923	0	2	2,774	2,777
February & March	0	0	0	0	0	0	0	0
Off-farm labor (1000 person-days)								
October & November	22,202	6,049	7	28,258	33,452	7,309	166	40,928
December	11,354	3,898	2,663	17,915	16,726	4,451	2,765	23,942
January	10,332	1,085	0	11,416	16,586	1,948	0	18,533
February & March	22,089	7,808	5,293	35,190	33,452	8,903	5,566	47,921

Table 18 — Maize Production and Consumption, Credit Taken, Maize Purchases, Labor Demand and Supply by Area Cultivated Group (continued)

	Policy Reform - 2002/03				Rapid Policy Reform - 2002/03			
Household average levels	**Small**	**Medium**	**Large**		**Small**	**Medium**	**Large**	
Net return (MK)	343	820	1,189		384	853	1,222	
Grain consumption (kg)	837	992	1,182		837	992	1,182	
Maize production (kg)	694	1,235	2,371		708	1,248	2,382	
Maize sales (purch) (kg)	(143)	243	1,189		(128)	256	1,201	
Credit used (MK)	100	94	121		117	111	138	
Burley production (kg)	10	10	10		21	21	21	
Hired labor (person-days)								
October & November	0	0	15		0	0	15	
December	0	0	0		0	0	0	
January	0	0	10		0	0	10	
February & March	0	0	0		0	0	0	
Off-farm labor (person-days)								
October & November	20	16	0		20	16	0	
December	10	10	10		10	10	10	
January	10	4	0		10	4	0	
February & March	20	20	20		20	20	20	
Aggregate totals	**Small**	**Medium**	**Large**	**Total**	**Small**	**Medium**	**Large**	**Total**
Net return (million MK)	574	365	336	1,275	643	380	346	1,368
Grain consumption (1,000 tons)	1,400	441	334	2,175	1,400	441	334	2,175
Maize production (1,000 tons)	1,161	550	670	2,381	1,185	555	674	2,413
Maize sold (purch) (1,000 tons)	(238)	108	336	206	(215)	114	339	238
Credit used (MK 1000)	167,262	41,937	34,185	243,384	195,697	49,257	38,888	283,842
Burley production (1,000 kg)	17,353	4,618	2,933	24,905	34,707	9,236	5,867	49,810
Hired labor (1,000 person-days)								
October & November	0	0	4,105	4,105	0	0	4,150	4,150
December	0	0	122	122	0	0	122	122
January	0	0	2,803	2,803	0	0	2,825	2,825
February & March	0	0	0	0	0	0	0	0
Off-farm labor (1,000 person-days)								
October & November	33,452	7,228	126	40,807	33,452	7,209	123	40,784
December	16,726	4,451	2,765	23,942	16,726	4,451	2,765	23,942
January	15,994	1,976	0	17,969	15,925	[illegible]	0	17,844
February & March	33,452	8,903	5,600	47,955	33,452	8,903	[illegible]	47,946

Table 18 also shows that while increased smallholder maize and tobacco production will require more farm labor, the increases will be small relative to population growth and the already large surplus of available labor that exists during most of the year. Demand for labor by Large smallholders, as well as the more modest demands of smallholders working Medium and Small areas, should be easily met by the supply of labor from households in the Small and Medium groups. This large amount of available labor would need to find employment in the estate subsector or in nonagricultural pursuits, or might be idle. The magnitude of the projected labor surpluses reinforces the need for increased employment in the nonfarm sectors of Malawi's economy, especially in rural areas.

As labor immobility is often a source of disequilibrium, it is worthwhile to look at the supply and demand for labor by smallholders on a regional basis, as is done in Table 16. In the base case surplus labor appears to be the norm, except for demand slightly in excess of supply during land preparation in Mzuzu, Kasungu, and Ngabu ADDs, and during January weeding in Mzuzu and Kasungu ADDs. Continuation of present policies indicates surplus labor in all four areas at all times, with the exception of weeding in Mzuzu and Kasungu ADDs, where the average area cultivated is much higher than the national average. Under the two policy reform scenarios, surplus labor is the rule, with the exception of December in Ngabu ADD, where there is a very slight excess demand for labor. Thus, while the proposed policy reforms will raise labor productivity by increasing use of improved inputs and production of high value crops, they are not expected to generate sufficiently high demand for agricultural labor to increase smallholder employment off of their own holdings. Demand for additional labor, especially during slack periods in the agricultural calendar, will have to come from estates or from the nonagricultural sector.

6. SUPPORTING POLICIES AND PROGRAMS REQUIRED FOR ADOPTION AND SUCCESS OF OPTIONS

FLINT HYBRID MAIZE

These policy scenarios represent the combinations of technological improvements and supporting policies that are necessary to implement the technology. For example, it has long been government policy to promote the use of improved agricultural technology among smallholder farmers, and HYV maize and fertilizer have been at the forefront. The new hybrid varieties MH17 and MH18 are not only high yielding but also appear to meet the processing and storage requirements of smallholders, two important requirements that impeded the widespread adoption of previous dent hybrid varieties. However, these were not the only factors that inhibited adoption of HYVs, and attention must be paid to these other elements if promotion of MH17 and MH18 is to be successful. Items of critical importance include availability of seed and fertilizer, provision of finance to purchase inputs, prices set for maize and fertilizer, and dissemination of appropriate information to farmers.

In the two years that it has been available, demand for MH17 and MH18 seed has outstripped supply, and is likely to continue to do so for the near future even without a surge in demand. If these varieties are to be promoted vigorously, steps must be taken to increase multiplication of these seeds. There is some indication that Lever Brothers is interested in producing these seeds; National Seed Company (NSCM) is the main supplier at present. ADMARC should consider the possibility of procuring seeds from both firms, for while there is nothing to prevent Lever from selling at market prices, the potential for increasing adoption of MH17 and MH18 is obviously much greater if additional seed is available at ADMARC's subsidized price. Alternatively, removal of the hybrid maize seed subsidy would level the playing field for seed producers without requiring changes in ADMARC's procurement practices.

The full benefits of hybrid maize seed can only be realized if fertilizer is available. Widespread adoption of hybrid maize implies increased demand for fertilizer, which requires increased mobilization of resources to import and distribute fertilizer. Fertilizer and seed inputs are covered in a separate working paper for the Agricultural Sector Memorandum, so they are not analyzed in detail here. Let it suffice to say that physical availability of fertilizer and flint hybrid maize seed are presently constraining factors that need to be addressed if this technology is to be promoted effectively.

In addition to physical availability, the issue of financial availability of improved inputs needs to be addressed. Lack of credit has been an important factor constraining hybrid maize adoption in the past. A major reorientation of rural credit is currently being considered by the government, and the need to reach the large proportion of the smallholders that have not received credit in the past will need to be taken into account, as will the needs of past credit recipients who have defaulted.

Linked to agricultural credit is agricultural pricing policy, especially the relative prices of maize and fertilizer. It has been noted elsewhere that Malawi has one of the highest nitrogen:maize price ratios in the world, leading to low value: cost ratios (VCR) for the use of fertilizer on maize. This high relative price of nitrogen is influenced by three major factors: high transport costs incurred by importing fertilizer make fertilizer expensive; most of the population comprises low-income net buyers of maize, making it desirable to keep a cap on maize consumer prices for reasons of social and economic welfare; and the government's limited financial resources and ADMARC's mandate to be self-supporting restrict the scope for subsidizing consumer maize prices. The government's commitment to remove all subsidies over the next few years will of course raise fertilizer prices further.

Nevertheless, the government needs to review the mechanism by which official prices are set for maize and fertilizer. Under the present system, fertilizer prices are taken as the starting point, and a maize producer price is set that results in a VCR of 2.0, which is generally taken as the *minimum* level required to induce a farmer to take on a risky investment such as fertilizer. Many farmers, especially poorer households with few assets to draw on, require a VCR greater than 2.0 to undertake such risk. The importance of relative prices of fertilizer and maize to adoption of improved technology, and why success on this front in Malawi has been limited, can be illustrated by a simple example. Presumably, some sort of representative farm is used to calculate the maize producer price that gives a VCR of 2.0. For the sake of argument, say this representative farm is at the median. Then by definition, one-half of all smallholders will have VCRs of less than 2.0, and will not find the returns to fertilizer enough to compensate for the risk involved, so they will not adopt HYVs. Of the 50 percent of farmers who have VCRs of 2.0 or greater, some are undoubtedly risk averse and require a VCR greater than 2.0 to adopt HYVs. If we assume that one-third of these have VCRs lower than they require to undertake the investment, that leaves the remaining two-thirds of smallholders with VCRs greater than 2.0, or only one-third of all smallholders, with VCRs high enough to induce them to adopt HYVs. In other words, *on the basis of VCRs alone* two-thirds of all smallholders would not adopt HYVs. Naturally, other factors such as poor access to credit also limit fertilizer use and HYV adoption.

The issue of fertilizer and maize pricing has been the subject of much discussion recently. Future discussions should reconsider the appropriateness of using a VCR of 2.0 when setting maize producer prices, with a view toward possibly choosing a higher threshold VCR to make investments in improved technology more attractive to the representative farmer and to all farmers. Of course, movements in this direction will need to be tempered with consideration of the impact on consumer welfare of a maize price increase, as increases in producer prices will necessarily filter through to consumer prices. Consumer prices are already being pushed upward by an increase in the trading margin — the difference between producer and consumer prices — as ADMARC eliminates its implicit subsidy on maize consumer prices. The sharp increase in the consumer price of maize for 1992/93 was rationalized, in part, by reference to increases in the statutory minimum wage and widespread formal sector pay increases granted in 1992. However, most Malawians are not at all affected, or at best indirectly affected, by changes in formal sector wages. Even in the formal sector, the consumer price increase for maize simply wiped away any wage gains achieved in 1992.

Successful adoption of hybrids and fertilizer also depends upon effective research and extension. Extension and research are investigated in detail in other ASM working papers, so they are addressed only briefly here. At least three broad areas deserve mention. First, as MH17 and MH18 are relatively new varieties there is still much adaptive research to be done to determine optimum practices under the various field conditions that are found around the country. Second, extension will also have to reach the large proportion of farmers who have hitherto been neglected by the extension system. The de-linking of extension and credit services should facilitate this, although credit will also have to reach a larger number of farmers. Extension will also need to tailor messages to farmers' resource endowments, e.g., if labor availability and funds do not permit application of both a basal fertilizer and a top dressing, the farmer needs information on the correct fertilizer and timing for a single application. Third, it has been shown elsewhere that micronutrient deficiencies are a limiting factor for maize yields on some soils. This may not be readily apparent, or even a limiting factor at all, on plots where local maize is grown without fertilizer and yields are low. Such differences are likely to come into play when other soil nutrients are present in sufficient quantities. If the other components supporting flint hybrid maize adoption are successful, providers of research, extension, and fertilizer inputs will need to be prepared to devote considerable resources to solving micronutrient deficiency problems.

SMALLHOLDER BURLEY TOBACCO

In contrast to flint hybrid maize, burley tobacco is not a new technology in Malawi. It is not even a new technology for many smallholders, who may have experience as estate tenants, as participants in the smallholder burley pilot program begun in 1990, or growing burley illegally and marketing it through estates. The major impediment to date has been the restriction of burley production to estates, and to an extremely small number of smallholders over the past two years. After some difficulties experienced in the first year, especially with regard to input supply and marketing, the smallholder burley tobacco program appears to be proceeding reasonably smoothly. The critical elements for expansion of smallholder burley production are legal and organizational, especially the organizational requirements of quota allocation, input supply, and marketing.

Early reviews of the smallholder burley tobacco program have pointed up a few areas that need to be improved. Improving and extending some of these services to more farmers is in some cases a simple matter of "more of the same," but in other cases overcoming difficulties becomes progressively harder as the number of farmers increases. An example of the latter is the labor shortages that have been reported in some of the areas where smallholder burley has been introduced. As smallholder burley licensing expands it is likely that smallholders who previously sold some of their labor will choose instead to stay on their own gardens and perhaps start hiring labor (assuming they receive a burley quota). This will be felt in the estate subsector as a potential drain on the supply of tenants and casual laborers. One would expect the increased demand for labor to push up wage levels, reducing growers' profits while increasing incomes of laborers, most of whom are likely to have small cultivated areas. The resulting shifts in labor allocation are complex and highly specific to particular situations, but these need to be monitored to avoid potentially undesirable effects. For example, it may not be desirable for households, especially large numbers of households, to desert their food crops completely to work at wage labor, especially if food availability in the market is not assured for some reason.

A second area where extension becomes progressively more difficult is the allocation of quotas. Especially relevant here is not the logistical issues, but rather the distribution of economic rents associated with a licensed (rationed) crop. The small size of the smallholder program to date has not posed a real threat to estate producers. However, limits in marketing infrastructure, and more importantly limits in world demand, imply that at some point increases in quotas allocated to smallholders might have to come from decreases in estate quota allotments. However, as was shown in Table 12, it is most likely that the estate subsector can continue to enjoy significant growth in burley quota allocations, even with the growth in smallholder allocations indicated in the Policy Reforms scenario. The government's policy on quota allocations between subsectors will need to be clear, and there should be other crops attractive to estates that can be promoted to ease the impact on estates of slower growth in burley quotas. Opportunities for more diversified export crops could figure prominently here.

Investments in most other support services for smallholder burley will need to grow at a pace with the number of participant farmers or volume of burley tobacco marketed. Much of the need for infrastructure (institutional as well as physical) to support the smallholder burley program has drawn from the existing base. If access to burley production is expanded significant investments will need to be made in administrative capacity to register burley growers and to allocate quotas. Even at a constant level of total production, an increase in the proportion of burley grown by smallholders implies greater administrative costs because of the larger number of farmers to register and individual quotas to allocate. The same argument applies to extension, input supply, and credit, with the additional consideration that responsibility will shift from institutions associated with estate agriculture (e.g., EEST, Optichem, ATC, commercial banks) to those serving the smallholder subsector (e.g, MOA Extension, ADMARC, SACA).

Marketing infrastructure will also need to be enhanced, especially if grouping to sell burley directly on the auction floors is to be a competitive option for smallholders. The number and capacity of Auction Holdings depots, or some other intermediate station, will need to be increased. Something will also need to be done about the delays in selling at auction due to congestion, a problem that is not unique to smallholders and is likely to get worse if the number of sellers increases. There is also a need for greater availability of vehicles to transport tobacco to auction. Training in grading also needs to be expanded.

AGROFORESTRY

Agroforestry has long played a minor role in farming systems in Malawi. The prominence of that role has diminished over time with increased population pressure on land and fuelwood resources, so that now only a small minority of farmers engage in such practices. Promotion of these practices requires further research, especially adaptive research, increased distribution and perhaps production of tree and hedge seedlings, and development of appropriate extension messages on agroforestry. There is still considerable work to be done in identifying the best agroforestry crops and cultural practices for specific areas. Research must also address the different constraints farmers face: severe land constraints suggest minimizing displacement of annual crops by tree crops, whereas severe labor constraints suggest practices requiring little additional labor input timed to avoid conflicts with the annual crop. The presence or absence of livestock in the farming system, and the dominant practices regarding control of livestock at different times of the year in a particular area, are also important elements that need to be addressed.

SOYBEANS

Relaxing constraints to increased soybean production requires attention to the same areas as those listed above for flint hybrid maize: development of extension messages appropriate to local conditions, increased availability of seeds, and possibly inclusion of soybean seeds in credit packages. It is also necessary to address constraints on the consumption side, in particular education on the high nutritive value of soybeans, especially as a calorie-dense weaning food. It will also be necessary to develop extension materials to teach methods of preparing soybeans that are compatible with tastes and fuelwood availability, such as roasting in a clay pot for ten minutes as opposed to boiling them for hours.

Soybeans did not appear in the optimal solutions for any of the model runs because other cropping patterns were able to generate higher farm returns while meeting all of the constraints. Nevertheless, soybeans are potentially attractive as a cheap source of nitrogen for the following maize crop, as an excellent source of calories and protein in the diet, or as a cash crop. At present the demand for soybeans in Malawi is low, as evidenced by the sharp decline in real terms of the official producer price this past year. However, there are several possibilities for increased use of processed soybean products. Projects such as that at the Ekwendeni CCAP Mission have shown the viability of small-scale production of Likuni phala, a highly nutritious weaning food. The technology is simple, and local participation rates have been high.

If conditions changed such that soybean production became more profitable and expanded rapidly in Malawi, it is possible that the volume of soybeans could provide adequate throughput to justify operation of at least one plant to extract soybean oil by a solvent method. This results in higher oil extraction rates, and high protein soybean cake, which can be used as an animal feed. The analysis of expenditure data from the Ministry of Agriculture shows that oils and fats claim a very small budget share, but that the expenditure elasticities are well above 1.0, on the order of 1.2 to 2.0. Thus, demand for cooking oil can be expected to increase very rapidly with rising incomes, with at least three clear benefits for the country. First, increased intake of oils is essential to increasing the calorie intake of children in Malawi, which is a necessary but not sufficient condition to reducing the very high rates of malnutrition and growth faltering in the country. Children are too small to consume enough calories from bulky staple foods alone, and thus need calorie dense foods such as oils. Second, whether small-scale or large-scale, soybean processing can generate new nonfarm employment opportunities in Malawi. Third, much of the cooking oil that is sold commercially in Malawi is imported in either oil or oilseed form, largely due to volatility in the production and price of groundnuts. Any substitution of domestically produced sources of cooking oil for imported sources is a benefit to the country.

7. INCREASING AGRICULTURAL GROWTH AND REDUCING SMALLHOLDER POVERTY: A STRATEGY TO INTEGRATE POLICY AND TECHNOLOGICAL OPPORTUNITIES

Although much of the preceding discussion has examined individual policy and technology opportunities in isolation, in fact they must be considered as components of a larger strategy to increase the incomes of smallholders, expand employment and earnings from nonfarm rural employment, reduce soil nutrient depletion, and ensure adequate food supplies at the national, household, and individual levels. All of these objectives serve to reduce poverty. The components discussed in this paper are certainly not the only means available to achieve these objectives, but they share the important qualities of being relatively inexpensive and realistically attainable over the course of the next decade.

Two important aspects of the strategy to consider are the phasing of the different components and roles of different types of households. Phasing of components is largely guided by biological and institutional constraints. For obvious but quite different reasons, neither the maize and *Acacia albida* intercrop opportunity nor an expanded smallholder burley tobacco program with 100,000 producers can be achieved in the next growing season. Trees take time to grow, institutions take time to grow and evolve, and farmers take time to adopt new techniques and learn how to use them optimally. Likewise, it will take time to multiply enough flint hybrid seeds to meet the demand indicated in Table 14.

There are inevitable lags in the growth and evolution of these opportunities, but that is not to say that delays in initiating programs are necessary or advisable. Smallholder agriculture has stagnated over the past decade, with adverse consequences for most Malawians. As was shown in Table 14, a continuation of present trends over the next ten years will lead to a further decline in farm incomes, food intake, and soil fertility, which Malawi cannot afford. While the goals outlined in this paper are attainable in the near term, they are not easily attainable, and the necessary changes should be treated with the utmost urgency.

Of the four options discussed in this paper, agroforestry is the least established in Malawi and has the longest gestation period between investment and payoff. As noted earlier, research station and farm-level trials have been conducted and are ongoing, but considerably more research and extension needs to be done to develop appropriate messages and communicate them to farmers, especially as many of the recommendations will need to be quite site-specific. It should also be remembered that only one agroforestry practice was discussed in this paper, while there are literally dozens of possibilities. Research and extension methods need to be stepped up, followed by propagation and dissemination of suitable planting material. Even under ideal circumstances it will take several years for the first substantial benefits to adoption of agroforestry are realized for the early adopters, which emphasizes all the more the need to make investments in this area as early as possible.

Increases in the application of inorganic fertilizers are necessary, but are severely constrained in Malawi by the lack of purchasing power of most smallholder farmers and the high cost of fertilizer relative to maize regardless of capital availability. Increasing smallholder fertilizer application requires both expansion of access to credit and, more importantly, an improvement in the value-cost ratio of fertilizer on maize. Technically speaking, some improvement in VCR could be made by increasing yields through improved cultural practices, but this is unlikely to generate any large increases in VCR. Substantive changes in the VCR of fertilizer use on maize can only come about by increases in the price of maize or decreases in the price of fertilizer, which puts the government in a bind when formulating pricing policy. The government is already committed to eliminating subsidies on fertilizers and seeds. Although some hope that a liberalized fertilizer market will foster increased competition and keep a lid on fertilizer prices this is by no means a certainty. The reopening of transport routes through Mozambique provides the only reasonable hope for a real reduction in fertilizer prices, but that is certainly not within the policy domain of Malawi at this time. The scope for increasing maize prices is constrained by food security and welfare concerns, as increases in producer prices would be passed through to consumer prices, with adverse consequences that are potentially severe in a country where 70 percent of the population are net buyers of maize in a normal year.

It is for these reasons that it is important to seek cheaper sources of plant nutrients, including nitrogen fixed by soybeans, trees, and hedge crops. An advantage of using soybeans as a source of nitrogen is that, unlike *Acacia albida*, the beneficial effects of the nitrogen fixation can be realized in the first year after planting the soybean crop. Now that Magoye soybean has been approved for distribution in Malaŵi, concerted extension efforts need to be made to familiarize smallholders with appropriate practices for both producing and consuming this crop.

Soybeans and agroforestry can provide important sources of food and plant nutrients. However, the components that form the core of the strategy are those most often associated with Malaŵi: maize and tobacco. The most promising technological advance in agriculture in Malaŵi in recent years is the development of MH17 and MH18, which provide a realistic opportunity for smallholders who retain most or all of their production to take advantage of improved maize varieties. Although smallholders will be more willing to adopt these varieties than the dent varieties, the problem of affordability of an HYV and fertilizer package remains. Finding cheaper sources of plant nutrients goes some way toward addressing the problem, as does improving access to credit. As noted above, multiplying sufficient quantities of flint hybrid seed is also essential. For the large numbers of smallholders cultivating small areas, however, it will be difficult or impossible to grow enough flint hybrid maize to feed themselves, pay for inputs, and make the necessary expenditures on nonfood items. Increased opportunities to grow high-value crops and increased off-farm employment opportunities are critical to improving the incomes and welfare of these households.

Of high-value cash crops grown in Malawi, burley tobacco is certainly the most prominent, and one in which Malawi has been able to increase export volume considerably over the past several years. Even under the most optimistic scenario, it is not realistic to expect every smallholder in Malawi to grow burley tobacco. This is the case even if smallholder quotas were limited to those farming less than one hectare. Those who are able to obtain a quota will experience large increases in income. Even on microplots of 0.1 hectare, burley tobacco could generate enough income to finance hybrid seed and fertilizer inputs for a food crop and leave some funds remaining for nonfood items. Given the considerable importance of the extended family and support networks in Malawi, it can be expected that income gains will generally be distributed over a larger group than the household who produced the crop. This built-in mechanism for ensuring that the benefits are distributed over a wider group of people has its obvious benefits. However, it also implies that in many cases the profits from burley will in the end not be entirely at the disposal of the household growing the tobacco, and that this will have an effect on the rate at which these profits can be reinvested in agriculture.

A recent broad-based analysis of poverty in Malawi concluded, "It is clear that Malawi cannot continue to rely on agriculture for its economic growth and improvement of welfare" (UNICEF 1992). While it is true that the essence of economic development is the transformation from an agrarian-based economy dominated by extraction and production of primary commodities to a diversified economy with strong secondary and tertiary sectors, it does not follow that one should be abandoned for the other. The manufacturing and service sectors in the Malawian economy are small, especially in rural areas. A major reason for this is the low purchasing power of people in rural areas, which leads to a very limited market for goods and services other than those related to staple food production and consumption (e.g., hoe handles and maize milling). The limited market for items produced by nonagricultural enterprises is a reason for the low level of employment in these activities. In the Malawian context the most direct way of raising rural purchasing power is increasing agricultural incomes. It is in this way that agriculture can serve as the engine of growth for the nonfarm sector.

Analysis of smallholder expenditure patterns has shown that, on average, households spend over 60 percent of their budgets on food items, one-half of that on maize. This reflects the low incomes of smallholders, in that they have little income left over after providing for basic necessities and, in fact, many are too poor to provide for these necessities. Nevertheless, the proportion spent on food does decrease with increases in income, increasing the market for nonfood commodities. Furthermore, nonfood items such as clothing and footwear, household durables, and transportation have high expenditure elasticities. Many of these items can be produced locally (as some already are), increasing employment and incomes in rural areas. A preliminary multiplier analysis indicates that each MK 1.00 increase in income in agriculture would generate an indirect gain in incomes of MK 0.50 in the rural nonagricultural economy, largely due to the farm sectors strong consumption linkages with the rural nonfarm sector.

An interesting and important result of the multiplier analysis is that the size of the farm-nonfarm multiplier is roughly the same across households with different sizes of available land. That is, it is not necessary to target agricultural income growth to a particular group or class of smallholders because they have "more favorable" expenditure patterns in terms of generating nonfarm economic growth, and then hope for trickle-down effects for help other households which depend upon agriculture. Thus a strategy which favors the smallest smallholders in the promotion of cash crop opportunities and improved maize production is entirely consistent with a goal of broad-based economic growth and development throughout the rural economy.

Given its ratio of people to arable land, a climate permitting only one growing season per year, and its high population growth rate Malawi has no choice but to promote expansion of nonfarm rural industries and services. This will be necessary to absorb a growing labor force that is already underemployed for most of the year. Key to promotion of rural nonfarm enterprises is the creation of an "enabling environment" which fosters rather than hinders small enterprise. Important features of this environment are adequate transportation, communication, and market infrastructure, rural electrification (at least in market towns), regulations which do not impose an unduly burden on small businesses, access to credit, and technical and management support.

It is clear that generating the agricultural growth that is necessary to improving the incomes, food security, nutrition, and overall welfare of Malawians will require considerable efforts on several fronts. There are no "magic bullets," but there are a few areas where immediate progress can be made, and where these efforts will need to begin. The policy environment of the past decade has been partially successful at stabilizing the Malawian economy, but in many respects the performance of smallholder agriculture in this environment is better characterized as stagnant. Adoption of a coherent, consistent set of policies, such as those discussed in this paper, to promote smallholder agriculture, especially smallholders on very small landholdings, is necessary to prevent stagnation from becoming a disastrous decline.

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Appendix Table 1 - Partial Budgets for Main Activities Included in Linear Programming Models

	Appl. rate (kg/ha)	Base year (1992/93) Karonga Salima	Mzuzu Kasungu	Lilongwe Liwonde Blantyre	Ngabu	Projected (2002/03) Karonga Salima	Mzuzu Kasungu	Lilongwe Liwonde Blantyre	Ngabu
Local maize - no fertilizer									
Seed cost (MK)	25	14.05	14.05	14.05	14.05				
Urea cost (MK)	0	0.00	0.00	0.00	0.00				
DAP cost (MK)	0	0.00	0.00	0.00	0.00				
Total Inputs cost		14.05	14.05	14.05	14.05	14.05	14.05	14.05	14.05
Assumed yield (Kg/Ha)		700	850	700	550	700	850	700	550
Value of production (MK)		393.40	477.70	393.40	309.10	393.40	477.70	393.40	309.10
Gross Margin (MK)		379.35	463.65	379.35	295.05	379.35	463.65	379.35	295.05
Local Maize - HAF, high level									
Seed cost (MK)	25	14.05	14.05	14.05	14.05				
Urea cost (MK)	80	124.25	124.25	124.25	124.25				
DAP cost (MK)	20	33.93	33.93	33.93	33.93				
Total Inputs cost		172.23	172.23	172.23	172.23	172.23	172.23	172.23	172.23
Assumed yield (Kg/Ha)		1100	1400	1100	900	1200	1500	1200	1000
Value of production (MK)		618.20	786.80	618.20	505.80	674.40	843.00	674.40	562.00
Gross Margin (MK)		445.97	614.57	445.97	333.57	502.17	670.77	502.17	389.77
Hybrid dent maize - no fertilizer									
Seed cost (MK)	25	115.79	115.79	115.79	115.79				
Urea cost (MK)	0	0.00	0.00	0.00	0.00				
DAP cost (MK)	0	0.00	0.00	0.00	0.00				
Total Inputs cost		115.79	115.79	115.79	115.79	115.79	115.79	115.79	115.79
Assumed yield (Kg/Ha)		800	1025	800	625	800	1025	800	625
Value of production (MK)		449.60	576.05	449.60	351.25	449.60	576.05	449.60	351.25
Gross Margin (MK)		333.81	460.26	333.81	235.46	333.81	460.26	333.81	235.46
Hybrid dent maize - HAF, high level									
Seed cost (MK)	25	115.79	115.79	115.79	115.79				
Urea cost (MK)	175	271.80	271.80	271.80	271.80				
DAP cost (MK)	80	135.73	135.73	135.73	135.73				
Total Inputs cost		523.32	523.32	523.32	523.32	523.32	523.32	523.32	523.32
Assumed yield (Kg/Ha)		2400	2800	2200	1300	2600	3000	2400	1500
Value of production (MK)		1348.80	1573.60	1236.40	730.60	1461.20	1686.00	1348.80	843.00
Gross Margin (MK)		825.48	1050.28	713.08	207.28	937.88	1162.68	825.48	319.68

	Appl. rate (kg/ha)	Base year (1992/93) Karonga Salima	Mzuzu Kasungu	Lilongwe Liwonde Blantyre	Ngabu	Projected (2002/03) Karonga Salima	Mzuzu Kasungu	Lilongwe Liwonde Blantyre	Ngabu
Hybrid flint maize - no fertilizer									
Seed cost (MK)	25	115.79	115.79	115.79	115.79				
Urea cost (MK)	0	0.00	0.00	0.00	0.00				
DAP cost (MK)	0	0.00	0.00	0.00	0.00				
Total Inputs cost		115.79	115.79	115.79	115.79	115.79	115.79	115.79	115.79
Assumed yield (Kg/Ha)		800	1025	800	625	800	1025	800	625
Value of production (MK)		449.60	576.05	449.60	351.25	449.60	576.05	449.60	351.25
Gross Margin (MK)		333.81	460.26	333.81	235.46	333.81	460.26	333.81	235.46
Hybrid flint maize - HAF, high level									
Seed cost (MK)	25	115.79	115.79	115.79	115.79				
Urea cost (MK)	175	271.80	271.80	271.80	271.80				
DAP cost (MK)	80	135.73	135.73	135.73	135.73				
Total Inputs cost		523.32	523.32	523.32	523.32	523.32	523.32	523.32	523.32
Assumed yield (Kg/Ha)		2400	2800	2200	1300	2600	3000	2400	1500
Value of production (MK)		1348.80	1573.60	1236.40	730.60	1461.20	1686.00	1348.80	843.00
Gross Margin (MK)		825.48	1050.28	713.08	207.28	937.88	1162.68	825.48	319.68
Local maize following soybean crop (no additional fertilizer)									
Seed cost (MK)	25	14.05	14.05	14.05	14.05				
Urea cost (MK)	0	0.00	0.00	0.00	0.00				
DAP cost (MK)	0	0.00	0.00	0.00	0.00				
Total Inputs cost		14.05	14.05	14.05	14.05	14.05	14.05	14.05	14.05
Assumed yield (Kg/Ha)		833	942	833	667	933	1042	933	767
Value of production (MK)		468.15	529.40	468.15	374.85	524.35	585.60	524.35	431.05
Gross Margin (MK)		454.10	515.35	454.10	360.80	510.30	571.55	510.30	417.00
Hybrid maize following soybean crop (no additional fertilizer)									
Seed cost (MK)	25	115.79	115.79	115.79	115.79				
Urea cost (MK)	0	0.00	0.00	0.00	0.00				
DAP cost (MK)	0	0.00	0.00	0.00	0.00				
Total Inputs cost		115.79	115.79	115.79	115.79	115.79	115.79	115.79	115.79
Assumed yield (Kg/Ha)		1333	1617	1267	850	1533	1817	1467	1050
Value of production (MK)		749.15	908.75	712.05	477.70	861.55	1021.15	824.45	590.10
Gross Margin (MK)		633.35	792.96	596.26	361.91	745.75	905.36	708.66	474.31

	Appl. rate (kg/ha)	Base year (1992/93) Karonga Salima	Mzuzu Kasungu	Lilongwe Liwonde Blantyre	Ngabu	Projected (2002/03) Karonga Salima	Mzuzu Kasungu	Lilongwe Liwonde Blantyre	Ngabu
Local maize with Acacia albida (no additional fertilizer)									
Seed cost (MK)	25	14.05	14.05	14.05	14.05				
Urea cost (MK)	0	0.00	0.00	0.00	0.00				
DAP cost (MK)	0	0.00	0.00	0.00	0.00				
Total Inputs cost		14.05	14.05	14.05	14.05	14.05	14.05	14.05	14.05
Assumed yield (Kg/Ha)		833	942	833	667	933	1042	933	767
Value of production (MK)		468.15	529.40	468.15	374.85	524.35	585.60	524.35	431.05
Gross Margin (MK)		454.10	515.35	454.10	360.80	510.30	571.55	510.30	417.00
Local maize with Acacia albida plus 80% of recommended fertilizer level									
Seed cost (MK)	25	14.05	14.05	14.05	14.05				
Urea cost (MK)	64	99.40	99.40	99.40	99.40				
DAP cost (MK)	16	27.15	27.15	27.15	27.15				
Total Inputs cost		140.60	140.60	140.60	140.60	140.60	140.60	140.60	140.60
Assumed yield (Kg/Ha)		1100	1400	1100	900	1200	1500	1200	1000
Value of production (MK)		618.20	786.80	618.20	505.80	674.40	843.00	674.40	562.00
Gross Margin (MK)		477.60	646.20	477.60	365.20	533.80	702.40	533.80	421.40
Hybrid maize with Acacia albida (no additional fertilizer)									
Seed cost (MK)	25	115.79	115.79	115.79	115.79				
Urea cost (MK)	0	0.00	0.00	0.00	0.00				
DAP cost (MK)	0	0.00	0.00	0.00	0.00				
Total Inputs cost		115.79	115.79	115.79	115.79	115.79	115.79	115.79	115.79
Assumed yield (Kg/Ha)		1333	1617	1267	850	1533	1817	1467	1050
Value of production (MK)		749.15	908.75	712.05	477.70	861.55	1021.15	824.45	590.10
Gross Margin (MK)		633.35	792.96	596.26	361.91	745.75	905.36	708.66	474.31
Hybrid maize with Acacia albida plus 80% of recommended fertilizer level									
Seed cost (MK)	25	115.79	115.79	115.79	115.79				
Urea cost (MK)	140	217.44	217.44	217.44	217.44				
DAP cost (MK)	64	108.58	108.58	108.58	108.58				
Total Inputs cost		441.81	441.81	441.81	441.81	441.81	441.81	441.81	441.81
Assumed yield (Kg/Ha)		2400	2800	2200	1300	2600	3000	2400	1500
Value of production (MK)		1348.80	1573.60	1236.40	730.60	1461.20	1686.00	1348.80	843.00
Gross Margin (MK)		906.99	1131.79	794.59	288.79	1019.39	1244.19	906.99	401.19
Soybeans (in rotation with maize)									
Seed cost (MK)	60	63.00	63.00	63.00	63.00				
Urea cost (MK)	0	0.00	0.00	0.00	0.00				
DAP cost (MK)	0	0.00	0.00	0.00	0.00				
Total Inputs cost		63.00	63.00	63.00	63.00	63.00	63.00	63.00	63.00
Assumed yield (Kg/Ha)		800	800	800	800	800	800	800	800
Value of production (MK)		520.00	520.00	520.00	520.00	520.00	520.00	520.00	520.00
Gross Margin (MK)		457.00	457.00	457.00	457.00	457.00	457.00	457.00	457.00

	Appl. rate (kg/ha)	Base year (1992/93) Karonga Salima	Mzuzu Kasungu	Lilongwe Liwonde Blantyre	Ngabu	Projected (2002/03) Karonga Salima	Mzuzu Kasungu	Lilongwe Liwonde Blantyre	Ngabu
Burley tobacco									
Seed, seedbed & other costs	1	754.50	754.50	754.50	754.50	754.50	754.50	754.50	754.50
D compound cost (MK)	600	1105.20	1105.20	1105.20	1105.20	1105.20	1105.20	1105.20	1105.20
CAN cost (MK)	400	547.73	547.73	547.73	547.73	547.73	547.73	547.73	547.73
Total Fertilizer cost (MK)		1652.93	1652.93	1652.93	1652.93	1652.93	1652.93	1652.93	1652.93
Assumed yield (Kg/Ha)		1500	1500	1500	1500	1500	1500	1500	1500
Value of production (MK)		10125.00	10125.00	10125.00	10125.00	10125.00	10125.00	10125.00	10125.00
Gross Margin (MK)		7717.57	7717.57	7717.57	7717.57	7717.57	7717.57	7717.57	7717.57

Assumptions made	
Local maize seed (MK/kg)	0.56
Hybrid maize seed (MK/kg)	4.63
Soybean seed (MK/kg)	1.05
Urea (MK/kg)	1.55
DAP (MK/kg)	1.70
"D" compound (MK/kg)	1.84
CAN (MK/kg)	1.37
Maize producer price (MK/kg)	0.56
Maize consumer price (MK/kg)	0.85
Increase in fertilized local maize yields (Kg/Ha)	100
Increase in fertilized hybrid maize yields (Kg/Ha)	200
Increase in soybean yields	0
Soybean producer price (MK/kg)	0.65
Burley non-fertilizer costs (MK/ha)	754.50
Burley producer price (MK/kg)	6.75

Appendix Table 2 - Linear Programming Models - Base Year and Policy Reforms

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1		LP Model. Karonga & Salima ADDs – Base year model (status quo ante)																				
2		LMNF	LMF	HFMNF	HDMNF	HDMF	HFMF	LMSOY	HMSOY	SOYMZ	LMAA	LMAAF	HMAA	HMAAF	MMIX	GNUT	MILLET	CASSAVA	SORGHUM	RICE	COTTON	BURLEY
6	RETURN	379	446		333 81	825									776	641		466		932	932	
7	Land	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	FoodSec	700	1100												258			1400		1600		
9	Budget	379	446	0	333 81	825	0	0	0	0	0	0	0	0	776	641	0	466	0	932	932	0
10	InputBuy	14 06	172 23		115 79	523 32									20	300		20		80		
11	CashAvl																					
12	SeasCons																					
13	CredMax																					
14	BurMax																					1
15	MzSoyR							1	1	-1												
16	MaxSoy	1	1	1	1	1	1	1	1	-.9	1	1	1	1	1	1	1	1	1	1	1	1
17	MaxAA	1	1	1	1	1	1	1	1	1	.9	.9	.9	.9	1	1	1	1	1	1	1	1
18	MinMix	1	1	1	1	1	1	1	1	1	1	1	1	1	.5	1	1	1	1	1	1	1
19	JnSpLab	23	29	23	23	29	29	29	29	13	23	29	29	29	18	81	47	31	15	12	78	77
20	OcNvLab	49	49	49	49	49	49	49	49	59	49	49	49	49	57	68	10	40	46	39	56	77
21	DecLab	10	20	10	10	20	20	20	20	35	12	20	22	20	10	18	17	2	10	13	34	33
22	JanLab	17	27	17	17	27	27	27	27	16	17	27	27	27	22	31	4	17	17	32	17	32
23	FbMrLab	4	20	4	4	20	20	20	20	28	4	20	20	20	13	20	27	4	4	33	32	106
24	ApMyLab	27	35	27	27	35	35	35	35	8	27	35	35	35	27	66	18	13	32	59	72	90
25	OfONMax																					
26	OfDEMax																					
27	OfJAMax																					
28	OfFMMax																					
29																						
30																						
31																						
32																						
33		LP Model. Karonga & Salima ADDs – Continue present policies 2002 03 model																				
34		LMNF	LMF	HFMNF	HDMNF	HDMF	HFMF	LMSOY	HMSOY	SOYMZ	LMAA	LMAAF	HMAA	HMAAF	MMIX	GNUT	MILLET	CASSAVA	SORGHUM	RICE	COTTON	BURLEY
38	RETURN	379	446	333 81	333 81	825	825	454 10	633 35	457 00	454 10	477 60	633 35	906 99	776	641		466		932	932	7718
39	Land	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
40	FoodSec	700	1100	800			2400	833	1333	100	833	1100	1333	2400	258			1400		1600		0
41	Budget	379	446	333 8083	333 81	825	825	454 096	633 3543	457	454 096	477 6039	633 3543	906 9873	776	641	0	466	0	932	932	7718
42	InputBuy	14	172	116	116	523	523	14	116	63	14	141	116	442	20	300		20		80		1653
43	CashAvl																					
44	SeasCons																					
45	CredMax																					
46	BurMax																					1
47	MzSoyR							1	1	-1												
48	MaxSoy	1	1	1	1	1	1	1	1	-.9	1	1	1	1	1	1	1	1	1	1	1	1
49	MaxAA	1	1	1	1	1	1	1	1	1	-.9	-.9	.9	.9	1	1	1	1	1	1	1	1
50	MinMix	1	1	1	1	1	1	1	1	1	1	1	1	1	-.5	1	1	1	1	1	1	1
51	JnSpLab	23	29	23	23	29	29	29	29	13	23	29	29	29	18	81	47	31	15	12	78	77
52	OcNvLab	49	49	49	49	49	49	49	49	59	49	49	49	49	57	68	10	40	46	39	56	77
53	DecLab	10	20	10	10	20	20	20	20	35	12	20	22	20	10	18	17	2	10	13	34	33
54	JanLab	17	27	17	17	27	27	27	27	16	17	27	27	27	22	31	4	17	17	32	17	32
55	FbMrLab	4	20	4	4	20	20	20	20	28	4	20	20	20	13	20	27	4	4	33	32	106
56	ApMyLab	27	35	27	27	35	35	35	35	8	27	35	35	35	27	66	18	13	32	59	72	90
57	OfONMax																					
58	OfDEMax																					
59	OfJAMax																					
60	OfFMMax																					
61	MaxTech	1	1	-4	1	1	-4	-4	-4	-4	-4	-4	-4	4	1	1	1	1	1	1	1	1
62																						
63																						
64																						

	A	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AR	AS	AT
1		LP Model: Karonga & Salima ADDs – Base year model (status quo ante)																			
2		BUYM	CREDIT	CASHSAV	CASHSPD	LOFFJS	LOFFON	LOFFDEC	LOFFJAN	LOFFFM	LOFFAM	HLJNSP	HLOCNV	HLDEC	HLJAN	HLFBMR	HLAPMY		Small	Medium	Large
6	RETURN	-0.85	-0.12			0.00	3.30	3.30	3.30	3.30		-0.05	-3.35	-3.35	-3.35	-3.35	-0.05				
7	Land																	<=	0.45	1.107	2.133
8	FoodSec	1																>=	852	1000	1199
9	Budget	-0.85	-0.12	0	0	0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
10	InputBuy		-1		-1													<=	0	0	0
11	CashAvl			1	1													=	10	60	150
12	SeasCons	-0.85		1		0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
13	CredMax		1															<=	50	128	146
14	BurMax																	<=	0.004321	0.004321	0.004321
15	MzSoyR																	<=	0.00	0.00	0.00
16	MaxSoy																	>=	0	0	0
17	MaxAA																	>=	0	0	0
18	MinMix																	<=	0	0	0
19	JnSpLab					1						-1						<=	128	150	180
20	OcNvLab						1						-1					<=	64	75	90
21	DecLab							1						-1				<=	26	30	36
22	JanLab								1						-1			<=	26	30	36
23	FbMrLab									1						-1		<=	51	60	72
24	ApMyLab										1						-1	<=	64	75	90
25	OfONMax						1											<=	20	20	20
26	OfDEMax							1										<=	10	10	10
27	OfJAMax								1									<=	10	10	10
28	OfFMMax									1								<=	20	20	20
29																					
30																					
31																					
32																					
33		LP Model: Karonga & Salima ADDs – Continue present policies 2002/03 model																			
34		BUYM	CREDIT	CASHSAV	CASHSPD	LOFFJS	LOFFON	LOFFDEC	LOFFJAN	LOFFFM	LOFFAM	HLJNSP	HLOCNV	HLDEC	HLJAN	HLFBMR	HLAPMY				
38	RETURN	-0.85	-0.12			0.00	3.30	3.30	3.30	3.30		-0.05	-3.35	-3.35	-3.35	-3.35	-0.05		Small	Medium	Large
39	Land																	<=	0.405	1.06272	1.9197
40	FoodSec	1																>=	809	1000	1199
41	Budget	-0.85	-0.12	0	0	0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
42	InputBuy		-1		-1													<=	0	0	0
43	CashAvl			1	1													=	10	60	150
44	SeasCons	-0.85		1		0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
45	CredMax		1															<=	40	110	125
46	BurMax																	<=	0.003055	0.003055	0.003055
47	MzSoyR																	<=	0.00	0.00	0.00
48	MaxSoy																	>=	0	0	0
49	MaxAA																	>=	0	0	0
50	MinMix																	<=	0	0	0
51	JnSpLab					1						-1						<=	128	150	180
52	OcNvLab						1						-1					<=	64	75	90
53	DecLab							1						-1				<=	26	30	36
54	JanLab								1						-1			<=	26	30	36
55	FbMrLab									1						-1		<=	51	60	72
56	ApMyLab										1						-1	<=	64	75	90
57	OfONMax						1											<=	20	20	20
58	OfDEMax							1										<=	10	10	10
59	OfJAMax								1									<=	10	10	10
60	OfFMMax									1								<=	20	20	20
61	MaxTech																	>=	0	0	0
62																					
63																					
64																					

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
65																						
66		LP Model: Karonga & Salima ADDs – Policy reform model																				
67		LMNF	LMF	HFMNF	HDMNF	HDMF	HFMF	LMSOY	HMSOY	SOYMZ	LMAA	LMAAF	HMAA	HMAAF	MMIX	GNUT	MILLET	CASSAVA	SORGHUM	RICE	COTTON	BURLEY
71	RETURN	379	502	333.81	333.81	938	938	510.30	745.75	457.00	510.30	533.60	745.75	1019.39	776	641		466		932	932	7718
72	Land	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
73	FoodSec	700	1200	800			2600	933	1533	100	933	1200	1533	2600	258			1400		1600		0
74	Budget	379	502	333.8083	333.81	938	938	510.296	745.7543	457	510.296	533.8039	745.7543	1019.387	776	641	0	466	0	932	932	7718
75	InputBuy	14	172	116	116	523	523	14	116	63	14	141	116	442	20	300		20		80		1653
76	CashAvl																					
77	SeasCons																					
78	CredMax																					
79	BurMax																					1
80	MzSoyR							1	1	-1												
81	MaxSoy	1	1	1	1	1	1	1	1	-.9	1	1	1	1	1	1	1	1	1	1	1	1
82	MaxAA	1	1	1	1	1	1	1	1	1	-.9	-.9	-.9	-.9	1	1	1	1	1	1	1	1
83	MinMix	1	1	1	1	1	1	1	1	1	1	1	1	1	-.5	1	1	1	1	1	1	1
84	JnSpLab	23	29	23	23	29	29	29	29	13	23	29	29	29	18	81	47	31	15	12	78	77
85	OcNvLab	49	49	49	49	49	49	49	49	59	49	49	49	49	57	68	10	40	48	39	56	77
86	DecLab	10	20	10	10	20	20	20	20	35	12	20	22	20	10	18	17	2	10	13	34	33
87	JanLab	17	27	17	17	27	27	27	27	16	17	27	27	27	22	31	4	17	17	32	17	32
88	FbMrLab	4	20	4	4	20	20	20	20	28	4	20	20	20	13	20	27	4	4	33	32	106
89	ApMyLab	27	35	27	27	35	35	35	35	8	27	35	35	35	27	66	18	13	32	59	72	90
90	OfONMax																					
91	OfDEMax																					
92	OfJAMax																					
93	OfFMMax																					
94																						
95																						
96																						
97																						
98		LP Model: Karonga & Salima ADDs – Rapid policy reform model																				
99		LMNF	LMF	HFMNF	HDMNF	HDMF	HFMF	LMSOY	HMSOY	SOYMZ	LMAA	LMAAF	HMAA	HMAAF	MMIX	GNUT	MILLET	CASSAVA	SORGHUM	RICE	COTTON	BURLEY
103	RETURN	379	502	333.81	333.81	938	938	510.30	745.75	457.00	510.30	533.60	745.75	1019.39	776	641		466		932	932	7718
104	Land	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
105	FoodSec	700	1200	800			2600	933	1533	100	933	1200	1533	2600	258			1400		1600		0
106	Budget	379	502	333.8083	333.81	938	938	510.296	745.7543	457	510.296	533.8039	745.7543	1019.387	776	641	0	466	0	932	932	7718
107	InputBuy	14	172	116	116	523	523	14	116	63	14	141	116	442	20	300		20		80		1653
108	CashAvl																					
109	SeasCons																					
110	CredMax																					
111	BurMax																					1
112	MzSoyR							1	1	-1												
113	MaxSoy	1	1	1	1	1	1	1	1	-.9	1	1	1	1	1	1	1	1	1	1	1	1
114	MaxAA	1	1	1	1	1	1	1	1	1	-.9	-.9	-.9	-.9	1	1	1	1	1	1	1	1
115	MinMix	1	1	1	1	1	1	1	1	1	1	1	1	1	-.5	1	1	1	1	1	1	1
116	JnSpLab	23	29	23	23	29	29	29	29	13	23	29	29	29	18	81	47	31	15	12	78	77
117	OcNvLab	49	49	49	49	49	49	49	49	59	49	49	49	49	57	68	10	40	48	39	56	77
118	DecLab	10	20	10	10	20	20	20	20	35	12	20	22	20	10	18	17	2	10	13	34	33
119	JanLab	17	27	17	17	27	27	27	27	16	17	27	27	27	22	31	4	17	17	32	17	32
120	FbMrLab	4	20	4	4	20	20	20	20	28	4	20	20	20	13	20	27	4	4	33	32	106
121	ApMyLab	27	35	27	27	35	35	35	35	8	27	35	35	35	27	66	18	13	32	59	72	90
122	OfONMax																					
123	OfDEMax																					
124	OfJAMax																					
125	OfFMMax																					

	A	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AR	AS	AT
65																					
66		LP Model: Karonga & Salima ADDs -- Policy reform model																			
67		BUYM	CREDIT	CASHSAV	CASHSPD	LOFFJS	LOFFON	LOFFDEC	LOFFJAN	LOFFFM	LOFFAM	HLJNSP	HLOCNV	HLDEC	HLJAN	HLFBMR	HLAPMY				
71	RETURN	-0.85	-0.12			0.00	3.30	3.30	3.30	3.30		-0.05	-3.35	-3.35	-3.35	-3.35	-0.05		Small	Medium	Large
72	Land																	<=	0.405	1.06272	1.9197
73	FoodSec	1																>=	852	1000	1199
74	Budget	-0.85	-0.12	0	0	0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
75	InputBuy		-1		-1													<=	0	0	0
76	CashAvl			1	1													=	20	60	150
77	SeasCons	-0.85		1		0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
78	CredMax		1															<=	100	100	125
79	BurMax																	<=	0.006917	0.006917	0.006917
80	MzSoyR																	<=	0.00	0.00	0.00
81	MaxSoy																	>=	0	0	0
82	MaxAA																	>=	0	0	0
83	MinMix																	<=	0	0	0
84	JnSpLab					1						-1						<=	128	150	180
85	OcNvLab						1						-1					<=	64	75	90
86	DecLab							1						-1				<=	26	30	36
87	JanLab								1						-1			<=	26	30	36
88	FbMrLab									1						-1		<=	51	60	72
89	ApMyLab										1						-1	<=	64	75	90
90	OfONMax						1											<=	20	20	20
91	OfDEMax							1										<=	10	10	10
92	OfJAMax								1									<=	10	10	10
93	OfFMMax									1								<=	20	20	20
94																					
95																					
96																					
97																					
98		LP Model: Karonga & Salima ADDs -- Rapid policy reform model																			
99		BUYM	CREDIT	CASHSAV	CASHSPD	LOFFJS	LOFFON	LOFFDEC	LOFFJAN	LOFFFM	LOFFAM	HLJNSP	HLOCNV	HLDEC	HLJAN	HLFBMR	HLAPMY				
103	RETURN	-0.85	-0.12			0.00	3.30	3.30	3.30	3.30		-0.05	-3.35	-3.35	3.35	-3.35	-0.05		Small	Medium	Large
104	Land																	<=	0.405	1.06272	1.9197
105	FoodSec	1																>=	0	0	0
106	Budget	-0.85	-0.12	0	0	0.00	3.30	3.30	3.30	3.30	0.00	-0.05	3.35	3.35	3.35	-3.35	-0.05	>=	0	0	0
107	InputBuy		-1		-1													<=	0	0	0
108	CashAvl			1	1													=	20	60	150
109	SeasCons	-0.85		1		0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	3.35	-3.35	-0.05	>=	0	0	0
110	CredMax		1															<=	117	117	142
111	BurMax																	<=	0.013833	0.013833	0.013833
112	MzSoyR																	<=	0.00	0.00	0.00
113	MaxSoy																	>=	0	0	0
114	MaxAA																	>=	0	0	0
115	MinMix																	<=	0	0	0
116	JnSpLab					1						-1						<=	128	150	180
117	OcNvLab						1						-1					<=	64	75	90
118	DecLab							1						-1				<=	26	30	36
119	JanLab								1						-1			<=	26	30	36
120	FbMrLab									1						-1		<=	51	60	72
121	ApMyLab										1						-1	<=	64	75	90
122	OfONMax						1											<=	20	20	20
123	OfDEMax							1										<=	10	10	10
124	OfJAMax								1									<=	10	10	10
125	OfFMMax									1								<=	20	20	20

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1		LP Model: Mzuzu & Kasungu ADDs – Base year model (status quo ante)																				
2		LMNF	LMF	HFMNF	HDMNF	HDMF	HFMF	LMSOY	HMSOY	SOYMZ	LMAA	LMAAF	HMAA	HMAAF	MMIX	GNUT	MILLET	CASSAVA	SORGHUM	RICE	COTTON	BURLEY
6	RETURN	464	615		460 26	1050									622	641	116.5					
7	Land	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	FoodSec	850	1400												891		400					
9	Budget	464	615	0	460 26	1050	0	0	0	0	0	0	0	0	622	641	116.5	0	0	0	0	0
10	InputBuy	14.05	172.23		115.79	523.32									20	300		20		80		
11	CashAvl																					
12	SeasCons																					
13	CredMax																					
14	BurMax																					1
15	MzSoyR							1	1	-1												
16	MaxSoy	1	1	1	1	1	1	1	1	-.9	1	1	1	1	1	1	1	1	1	1	1	1
17	MaxAA	1	1	1	1	1	1	1	1	1	-.9	-.9	-.9	-.9	1	1	1	1	1	1	1	1
18	MinMix	1	1	1	1	1	1	1	1	1	1	1	1	1	-.5	1	1	1	1	1	1	1
19	JnSpLab	23	29	23	23	29	29	29	29	13	23	29	29	29	18	81	47	31	15	12	78	77
20	OcNvLab	49	49	49	49	49	49	49	49	59	49	49	49	49	57	68	10	40	46	39	56	77
21	DecLab	10	20	10	10	20	20	20	20	35	12	20	22	20	10	18	17	2	10	13	34	33
22	JanLab	17	27	17	17	27	27	27	27	16	17	27	27	27	22	31	4	17	17	32	17	32
23	FbMrLab	4	20	4	4	20	20	20	20	28	4	20	20	20	13	20	27	4	4	33	32	106
24	ApMyLab	27	35	27	27	35	35	35	35	8	27	35	35	35	27	66	18	13	32	59	72	90
25	OfONMax																					
26	OfDEMax																					
27	OfJAMax																					
28	OfFMMax																					
29																						
30																						
31																						
32																						
33		LP Model: Mzuzu & Kasungu ADDs – Continue present policies 2002/03 model																				
34		LMNF	LMF	HFMNF	HDMNF	HDMF	HFMF	LMSOY	HMSOY	SOYMZ	LMAA	LMAAF	HMAA	HMAAF	MMIX	GNUT	MILLET	CASSAVA	SORGHUM	RICE	COTTON	BURLEY
38	RETURN	464	615	460.26	460 26	1050	1050	515 35	792 96	457.00	515 35	646 20	792 96	1131 79	622	641	116 5					7718
39	Land	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
40	FoodSec	850	1400	1025			2800	942	1617	100	942	1400	1617	2800	891		400					0
41	Budget	464	615	460 2583	460 26	1050	1050	515 354	792 9623	457	515 354	646 2039	792 9623	1131.767	622	641	116 5	0	0	0	0	7718
42	InputBuy	14	172	116	116	523	523	14	116	63	14	141	116	442	20	300		20		80		1653
43	CashAvl																					
44	SeasCons																					
45	CredMax																					
46	BurMax																					1
47	MzSoyR							1	1	-1												
48	MaxSoy	1	1	1	1	1	1	1	1	-.9	1	1	1	1	1	1	1	1	1	1	1	1
49	MaxAA	1	1	1	1	1	1	1	1	1	-.9	-.9	-.9	-.9	1	1	1	1	1	1	1	1
50	MinMix	1	1	1	1	1	1	1	1	1	1	1	1	1	-.5	1	1	1	1	1	1	1
51	JnSpLab	23	29	23	23	29	29	29	29	13	23	29	29	29	18	81	47	31	15	12	78	77
52	OcNvLab	49	49	49	49	49	49	49	49	59	49	49	49	49	57	68	10	40	46	39	56	77
53	DecLab	10	20	10	10	20	20	20	20	35	12	20	22	20	10	18	17	2	10	13	34	33
54	JanLab	17	27	17	17	27	27	27	27	16	17	27	27	27	22	31	4	17	17	32	17	32
55	FbMrLab	4	20	4	4	20	20	20	20	28	4	20	20	20	13	20	27	4	4	33	32	106
56	ApMyLab	27	35	27	27	35	35	35	35	8	27	35	35	35	27	66	18	13	32	59	72	90
57	OfONMax																					
58	OfDEMax																					
59	OfJAMax																					
60	OfFMMax																					
61	MaxTech	1	1	-4	1	1	-4	-4	-4	-4	-4	-4	-4	-4	1	1	1	1	1	1	1	1
62																						
63																						

	A	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP
1		LP Model: Mzuzu & Kasungu ADDs – Base year model (status quo ante)																			
2		BUYM	CREDIT	CASHSAV	CASHSPD	LOFFJS	LOFFON	LOFFDEC	LOFFJAN	LOFFFM	LOFFAM	HLJNSP	HLOCNV	HLDEC	HLJAN	HLFBMR	HLAPMY				
6	RETURN	-0.85	-0.12			0.00	3.30	3.30	3.30	3.30		-0.05	-3.35	-3.35	-3.35	-3.35	-0.05		Small	Medium	Large
7	Land																	<=	0.486	1.116	2.1645
8	FoodSec	1																>=	812	881	1195
9	Budget	-0.85	-0.12	0	0	0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
10	InputBuy		-1		-1													<=	0	0	0
11	CashAvl		0	1	1													=	10	60	150
12	SeasCons	-0.85	0	1	0		3.30	3.30	3.30	3.30		-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
13	CredMax		1	0	0													<=	50	128	146
14	BurMax																	<=	0.004321	0.004321	0.004321
15	MzSoyR																	<=	0.00	0.00	0.00
16	MaxSoy																	>=	0	0	0
17	MaxAA																	>=	0	0	0
18	MinMix																	<=	0	0	0
19	JnSpLab					1						-1						<=	122	132	179
20	OcNvLab						1						-1					<=	61	66	90
21	DecLab							1						-1				<=	24	26	36
22	JanLab								1						-1			<=	24	26	36
23	FbMrLab									1						-1		<=	49	53	72
24	ApMyLab										1						-1	<=	61	66	90
25	OfONMax						1											<=	20	20	20
26	OfDEMax							1										<=	10	10	10
27	OfJAMax								1									<=	10	10	10
28	OfFMMax									1								<=	20	20	20
29																					
30																					
31																					
32																					
33		LP Model: Mzuzu & Kasungu ADDs – Continue present policies 2002/03 model																			
34		BUYM	CREDIT	CASHSAV	CASHSPD	LOFFJS	LOFFON	LOFFDEC	LOFFJAN	LOFFFM	LOFFAM	HLJNSP	HLOCNV	HLDEC	HLJAN	HLFBMR	HLAPMY				
38	RETURN	-0.85	-0.12			0.00	3.30	3.30	3.30	3.30		-0.05	-3.35	-3.35	-3.35	-3.35	-0.05		Small	Medium	Large
39	Land																	<=	0.4374	1.07136	1.94805
40	FoodSec	1																>=	792	881	1195
41	Budget	-0.85	-0.12	0	0	0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
42	InputBuy		-1		-1													<=	0	0	0
43	CashAvl		0	1	1													=	10	60	150
44	SeasCons	-0.85	0	1	0		3.30	3.30	3.30	3.30		-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
45	CredMax		1	0	0													<=	40	110	125
46	BurMax																	<=	0.003055	0.003055	0.003055
47	MzSoyR																	<=	0.00	0.00	0.00
48	MaxSoy																	>=	0	0	0
49	MaxAA																	>=	0	0	0
50	MinMix																	<=	0	0	0
51	JnSpLab					1						-1						<=	122	132	179
52	OcNvLab						1						-1					<=	61	66	90
53	DecLab							1						-1				<=	24	26	36
54	JanLab								1						-1			<=	24	26	36
55	FbMrLab									1						-1		<=	49	53	72
56	ApMyLab										1						-1	<=	61	66	90
57	OfONMax						1											<=	20	20	20
58	OfDEMax							1										<=	10	10	10
59	OfJAMax								1									<=	10	10	10
60	OfFMMax									1								<=	20	20	20
61	MaxTech																	>=	0	0	0
62																					
63																					

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
64																						
65		LP Model: Mzuzu & Kasungu ADDs – Policy reform model																				
66		LMNF	LMF	HFMNF	HDMNF	HDMF	HFMF	LMSOY	HMSOY	SOYMZ	LMAA	LMAAF	HMAA	HMAAF	MMIX	GNUT	MILLET	CASSAVA	SORGHUM	RICE	COTTON	BURLEY
70	RETURN	464	671	460 26	460.26	1163	1163	571.55	905 36	457 00	571.55	702 40	905.36	1244.19	622	641	116 5					7718
71	Land	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
72	FoodSec	850	1500	1025			3000	1042	1817	100	1042	1500	1817	3000	891		400					0
73	Budget	464	671	460 2583	460 26	1163	1163	571.554	905 3623	457	571 554	702 4039	905 3623	1244 187	622	641	116 5	0	0	0	0	7718
74	InputBuy	14	172	116	116	523	523	14	116	63	14	141	116	442	20	300		20		80		1653
75	CashAvl																					
76	SeasCons																					
77	CredMax																					
78	BurMax																					1
79	MzSoyR							1	1	-1												
80	MaxSoy	1	1	1	1	1	1	1	1	-9	1	1	1	1	1	1	1	1	1	1	1	1
81	MaxAA	1	1	1	1	1	1	1	1	1	-9	-9	-9	-9	1	1	1	1	1	1	1	1
82	MinMix	1	1	1	1	1	1	1	1	1	1	1	1	1	-5	1	1	1	1	1	1	1
83	JnSpLab	23	29	23	23	29	29	29	29	13	23	29	29	29	18	81	47	31	15	12	78	77
84	OcNvLab	49	49	49	49	49	49	49	49	59	49	49	49	49	57	68	10	40	46	39	56	77
85	DecLab	10	20	10	10	20	20	20	20	35	12	20	22	20	10	18	17	2	10	13	34	33
86	JanLab	17	27	17	17	27	27	27	27	16	17	27	27	27	22	31	4	17	17	32	17	32
87	FbMrLab	4	20	4	4	20	20	20	20	28	4	20	20	20	13	20	27	4	4	33	32	106
88	ApMyLab	27	35	27	27	35	35	35	35	8	27	35	35	35	27	66	18	13	32	59	72	90
89	OfONMax																					
90	OfDEMax																					
91	OfJAMax																					
92	OfFMMax																					
93																						
94																						
95																						
96																						
97		LP Model: Mzuzu & Kasungu ADDs – Rapid policy reform model																				
98		LMNF	LMF	HFMNF	HDMNF	HDMF	HFMF	LMSOY	HMSOY	SOYMZ	LMAA	LMAAF	HMAA	HMAAF	MMIX	GNUT	MILLET	CASSAVA	SORGHUM	RICE	COTTON	BURLEY
102	RETURN	464	671	460 26	460.26	1163	1163	571 55	905 36	457 00	571.55	702 40	905 36	1244.19	622	641	116 5					7718
103	Land	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
104	FoodSec	850	1500	1025			3000	1042	1817	100	1042	1500	1817	3000	891		400					0
105	Budget	464	671	460 2583	460 26	1163	1163	571 554	905 3623	457	571 554	702 4039	905 3623	1244 187	622	641	116 5	0	0	0	0	7718
106	InputBuy	14	172	116	116	523	523	14	116	63	14	141	116	442	20	300		20		80		1653
107	CashAvl																					
108	SeasCons																					
109	CredMax																					
110	BurMax																					1
111	MzSoyR							1	1	-1												
112	MaxSoy	1	1	1	1	1	1	1	1	-9	1	1	1	1	1	1	1	1	1	1	1	1
113	MaxAA	1	1	1	1	1	1	1	1	1	-9	-9	-9	-9	1	1	1	1	1	1	1	1
114	MinMix	1	1	1	1	1	1	1	1	1	1	1	1	1	-5	1	1	1	1	1	1	1
115	JnSpLab	23	29	23	23	29	29	29	29	13	23	29	29	29	18	81	47	31	15	12	78	77
116	OcNvLab	49	49	49	49	49	49	49	49	59	49	49	49	49	57	68	10	40	46	39	56	77
117	DecLab	10	20	10	10	20	20	20	20	35	12	20	22	20	10	18	17	2	10	13	34	33
118	JanLab	17	27	17	17	27	27	27	27	16	17	27	27	27	22	31	4	17	17	32	17	32
119	FbMrLab	4	20	4	4	20	20	20	20	28	4	20	20	20	13	20	27	4	4	33	32	106
120	ApMyLab	27	35	27	27	35	35	35	35	8	27	35	35	35	27	66	18	13	32	59	72	90
121	OfONMax																					
122	OfDEMax																					
123	OfJAMax																					
124	OfFMMax																					

	A	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP
64																					
65		LP Model: Mzuzu & Kasungu ADDs – Policy reform model																			
66		BUYM	CREDIT	CASHSAV	CASHSPD	LOFFJS	LOFFON	LOFFDEC	LOFFJAN	LOFFFM	LOFFAM	HLJNSP	HLOCNV	HLDEC	HLJAN	HLFBMR	HLAPMY				
70	RETURN	-0.85	-0.12			0.00	3.30	3.30	3.30	3.30		-0.05	-3.35	-3.35	-3.35	-3.35	-0.05		Small	Medium	Large
71	Land																	<=	0.4374	1.07136	1.94805
72	FoodSec	1																>=	812	881	1195
73	Budget	-0.85	-0.12	0	0	0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
74	InputBuy		-1		-1													<=	0	0	0
75	CashAvl		0	1	1													=	20	60	150
76	SeasCons	-0.85	0	1	0		3.30	3.30	3.30	3.30		-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
77	CredMax		1	0	0													<=	100	100	125
78	BurMax																	<=	0.006917	0.006917	0.006917
79	MzSoyR																	<=	0.00	0.00	0.00
80	MaxSoy																	>=	0	0	0
81	MaxAA																	>=	0	0	0
82	MinMix																	<=	0	0	0
83	JnSpLab					1						-1						<=	122	132	179
84	OcNvLab						1						-1					<=	61	66	90
85	DecLab							1						-1				<=	24	26	36
86	JanLab								1						-1			<=	24	26	36
87	FbMrLab									1						-1		<=	49	53	72
88	ApMyLab										1						-1	<=	61	66	90
89	OfONMax						1											<=	20	20	20
90	OfDEMax							1										<=	10	10	10
91	OfJAMax								1									<=	10	10	10
92	OfFMMax									1								<=	20	20	20
93																					
94																					
95																					
96																					
97		LP Model: Mzuzu & Kasungu ADDs – Rapid policy reform model																			
98		BUYM	CREDIT	CASHSAV	CASHSPD	LOFFJS	LOFFON	LOFFDEC	LOFFJAN	LOFFFM	LOFFAM	HLJNSP	HLOCNV	HLDEC	HLJAN	HLFBMR	HLAPMY				
102	RETURN	-0.85	-0.12			0.00	3.30	3.30	3.30	3.30		-0.05	-3.35	-3.35	-3.35	-3.35	-0.05		Small	Medium	Large
103	Land																	<=	0.4374	1.07136	1.94805
104	FoodSec	1																>=	812	881	1195
105	Budget	-0.85	-0.12	0	0	0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
106	InputBuy		-1		-1													<=	0	0	0
107	CashAvl		0	1	1													=	20	60	150
108	SeasCons	-0.85	0	1	0		3.30	3.30	3.30	3.30		-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
109	CredMax		1	0	0													<=	117	117	142
110	BurMax																	<=	0.013833	0.013833	0.013833
111	MzSoyR																	<=	0.00	0.00	0.00
112	MaxSoy																	>=	0	0	0
113	MaxAA																	>=	0	0	0
114	MinMix																	<=	0	0	0
115	JnSpLab					1						-1						<=	122	132	179
116	OcNvLab						1						-1					<=	61	66	90
117	DecLab							1						-1				<=	24	26	36
118	JanLab								1						-1			<=	24	26	36
119	FbMrLab									1						-1		<=	49	53	72
120	ApMyLab										1						-1	<=	61	66	90
121	OfONMax						1											<=	20	20	20
122	OfDEMax							1										<=	10	10	10
123	OfJAMax								1									<=	10	10	10
124	OfFMMax									1								<=	20	20	20

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1		LP Model, Likangwe, Liwonde & Blantyre ADDs -- Base year model (status quo ante)																				
2		LMNF	LMF	HFMNF	HDMNF	HDMF	HFMF	LMSOY	HMSOY	SOYMZ	LMAA	LMAAF	HMAA	HMAAF	MMIX	GNUT	MILLET	CASSAVA	SORGHUM	RICE	COTTON	BURLEY
6	RETURN	379	446		333.81	713									633	524						
7	Land	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	FoodSec	700	1100												800							
9	Budget	379	446	0	333.81	713	0	0	0	0	0	0	0	0	633	524	0	0	0	0	0	0
10	InputBuy	14.05	172.23		115.79	523.32									20	300						
11	CashAvl																					
12	SeasCons																					
13	CredMax																					
14	BurMax																					1
15	MzSoyR							1	1	-1												
16	MaxSoy	1	1	1	1	1	1	1	1	-9	1	1	1	1	1	1	1	1	1	1	1	1
17	MaxAA	1	1	1	1	1	1	1	1	1	-9	-9	-9	-9	1	1	1	1	1	1	1	1
18	MinMix	1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1	1	1	1
19	JnSpLab	23	29	23	23	29	29	29	29	13	23	29	29	29	18	81	47	31	15	12	78	77
20	OcNvLab	49	49	49	49	49	49	49	49	59	49	49	49	49	57	68	10	40	46	39	56	77
21	DecLab	10	20	10	10	20	20	20	20	35	12	20	22	20	10	18	17	2	10	13	34	33
22	JanLab	17	27	17	17	27	27	27	27	16	17	27	27	27	22	31	4	17	17	32	17	32
23	FbMrLab	4	20	4	4	20	20	20	20	28	4	20	20	20	13	20	27	4	4	33	32	106
24	ApMyLab	27	35	27	27	35	35	35	35	8	27	35	35	35	27	66	18	13	32	59	72	90
25	OfONMax																					
26	OfDEMax																					
27	OfJAMax																					
28	OfFMMax																					
29																						
30																						
31																						
32																						
33		LP Model, Likangwe, Liwonde & Blantyre ADDs -- Continue present policies 2002.03 model																				
34		LMNF	LMF	HFMNF	HDMNF	HDMF	HFMF	LMSOY	HMSOY	SOYMZ	LMAA	LMAAF	HMAA	HMAAF	MMIX	GNUT	MILLET	CASSAVA	SORGHUM	RICE	COTTON	BURLEY
38	RETURN	379	446	333.81	333.81	713	713	454.10	596.26	457.00	454.10	477.60	596.26	794.59	633	524						7718
39	Land	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
40	FoodSec	700	1100	800			2200	833	1267	100	833	1100	1267	2200	800							0
41	Budget	379	446	333.8083	333.81	713	713	454.096	596.2623	457	454.096	477.6039	596.2623	794.5873	633	524	0	0	0	0	0	7718
42	InputBuy	14	172	116	116	523	523	14	116	63	14	141	116	442	20	300						1653
43	CashAvl																					
44	SeasCons																					
45	CredMax																					
46	BurMax																					1
47	MzSoyR							1	1	-1												
48	MaxSoy	1	1	1	1	1	1	1	1	-9	1	1	1	1	1	1	1	1	1	1	1	1
49	MaxAA	1	1	1	1	1	1	1	1	1	-9	-9	-9	-9	1	1	1	1	1	1	1	1
50	MinMix	1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1	1	1	1
51	JnSpLab	23	29	23	23	29	29	29	29	13	23	29	29	29	18	81	47	31	15	12	78	77
52	OcNvLab	49	49	49	49	49	49	49	49	59	49	49	49	49	57	68	10	40	46	39	56	77
53	DecLab	10	20	10	10	20	20	20	20	35	12	20	22	20	10	18	17	2	10	13	34	33
54	JanLab	17	27	17	17	27	27	27	27	16	17	27	27	27	22	31	4	17	17	32	17	32
55	FbMrLab	4	20	4	4	20	20	20	20	28	4	20	20	20	13	20	27	4	4	33	32	106
56	ApMyLab	27	35	27	27	35	35	35	35	8	27	35	35	35	27	66	18	13	32	59	72	90
57	OfONMax																					
58	OfDEMax																					
59	OfJAMax																					
60	OfFMMax																					
61	MaxTech	1	1	-4	1	1	-4	-4	-4	-4	-4	-4	-4	-4	1	1	1	1	1	1	1	1
62																						
63																						

	A	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP
1		LP Model: Lilongwe, Liwonde & Blantyre ADDs -- Base year model (status quo ante)																			
2		BUYM	CREDIT	CASHSAV	CASHSPD	LOFFJS	LOFFON	LOFFDEC	LOFFJAN	LOFFFM	LOFFAM	HLJNSP	HLOCNV	HLDEC	HLJAN	HLFBMR	HLAPMY				
6	RETURN	-0.85	-0.12			0.00	3.30	3.30	3.30	3.30		-0.05	-3.35	-3.35	-3.35	-3.35	-0.05		Small	Medium	Large
7	Land																	<=	0.477	1.089	2.016
8	FoodSec	1																>=	697	1021	1141
9	Budget	-0.85	-0.12	0	0	0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
10	InputBuy		-1		-1													<=	0	0	0
11	CashAvl			1	1													=	10	60	150
12	SeasCons	-0.85		1		0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
13	CredMax		1															<=	50	128	146
14	BurMax																	<=	0.004321	0.004321	0.004321
15	MzSoyR																	<=	0.00	0.00	0.00
16	MaxSoy																	>=	0	0	0
17	MaxAA																	>=	0	0	0
18	MinMix																	<=	0	0	0
19	JnSpLab					1						-1						<=	123	153	171
20	OcNvLab						1						-1					<=	62	77	86
21	DecLab							1						-1				<=	25	31	34
22	JanLab								1						-1			<=	25	31	34
23	FbMrLab									1						-1		<=	49	61	68
24	ApMyLab										1						-1	<=	62	77	86
25	OfONMax						1											<=	20	20	20
26	OfDEMax							1										<=	10	10	10
27	OfJAMax								1									<=	10	10	10
28	OfFMMax									1								<=	20	20	20
29																					
30																					
31																					
32																					
33		LP Model: Lilongwe, Liwonde & Blantyre ADDs -- Continue present policies 2002/03 model																			
34		BUYM	CREDIT	CASHSAV	CASHSPD	LOFFJS	LOFFON	LOFFDEC	LOFFJAN	LOFFFM	LOFFAM	HLJNSP	HLOCNV	HLDEC	HLJAN	HLFBMR	HLAPMY				
38	RETURN	-0.85	-0.12			0.00	3.30	3.30	3.30	3.30		-0.05	-3.35	-3.35	-3.35	-3.35	-0.05		0.9	0.96	0.9
39	Land																	<=	0.4293	1.04544	1.8144
40	FoodSec	1																>=	697	1021	1141
41	Budget	-0.85	-0.12	0	0	0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	3.35	-3.35	-0.05	>=	0	0	0
42	InputBuy		-1		-1													<=	0	0	0
43	CashAvl			1	1													=	10	60	150
44	SeasCons	-0.85		1		0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
45	CredMax		1															<=	40	110	125
46	BurMax																	<=	0.003055	0.003055	0.003055
47	MzSoyR																	<=	0.00	0.00	0.00
48	MaxSoy																	>=	0	0	0
49	MaxAA																	>=	0	0	0
50	MinMix																	<=	0	0	0
51	JnSpLab					1						-1						<=	123	153	171
52	OcNvLab						1						-1					<=	62	77	86
53	DecLab							1						-1				<=	25	31	34
54	JanLab								1						-1			<=	25	31	34
55	FbMrLab									1						-1		<=	49	61	68
56	ApMyLab										1						-1	<=	62	77	86
57	OfONMax						1											<=	20	20	20
58	OfDEMax							1										<=	10	10	10
59	OfJAMax								1									<=	10	10	10
60	OfFMMax									1								<=	20	20	20
61	MaxTech																	>=	0	0	0
62																					
63																					

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
64																						
65		LP Model: Lilongwe, Liwonde & Blantyre ADDs – Policy reform model																				
66		LMNF	LMF	HFMNF	HDMNF	HDMF	HFMF	LMSOY	HMSOY	SOYMZ	LMAA	LMAAF	HMAA	HMAAF	MMIX	GNUT	MILLET	CASSAVA	SORGHUM	RICE	COTTON	BURLEY
70	RETURN	379	502	333 81	333 81	825	825	510 30	708 66	457 00	510 30	533 80	708 66	906 99	633	524						7718
71	Land	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
72	FoodSec	700	1200	800			2400	933	1467	100	933	1200	1467	2400	800							0
73	Budget	379	502	333 8083	333 81	825	825	510 296	708 6623	457	510 296	533 8039	708 6623	906 9873	633	524	0	0	0	0	0	7718
74	InputBuy	14	172	116	116	523	523	14	116	63	14	141	116	442	20	300						1653
75	CashAvl																					
76	SeasCons																					
77	CredMax																					
78	BurMax																					1
79	MzSoyR							1	1	-1												
80	MaxSoy	1	1	1	1	1	1	1	1	-.9	1	1	1	1	1	1	1	1	1	1	1	1
81	MaxAA	1	1	1	1	1	1	1	1	1	-.9	9	-.9	-.9	1	1	1	1	1	1	1	1
82	MinMix	1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1	1	1	1
83	JnSpLab	23	29	23	23	29	29	29	29	13	23	29	29	29	18	81	47	31	15	12	78	77
84	OcNvLab	49	49	49	49	49	49	49	49	59	49	49	49	49	57	68	10	40	46	39	56	77
85	DecLab	10	20	10	10	20	20	20	20	35	12	20	22	20	10	18	17	2	10	13	34	33
86	JanLab	17	27	17	17	27	27	27	27	16	17	27	27	27	22	31	4	17	17	32	17	32
87	FbMrLab	4	20	4	4	20	20	20	20	28	4	20	20	20	13	20	27	4	4	33	32	106
88	ApMyLab	27	35	27	27	35	35	35	35	8	27	35	35	35	27	66	18	13	32	59	72	90
89	OfONMax																					
90	OfDEMax																					
91	OfJAMax																					
92	OfFMMax																					
93																						
94																						
95																						
96																						

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
97		LP Model: Lilongwe, Liwonde & Blantyre ADDs – Rapid policy reform model																				
98		LMNF	LMF	HFMNF	HDMNF	HDMF	HFMF	LMSOY	HMSOY	SOYMZ	LMAA	LMAAF	HMAA	HMAAF	MMIX	GNUT	MILLET	CASSAVA	SORGHUM	RICE	COTTON	BURLEY
102	RETURN	379	502	333 81	333 81	825	825	510 30	708 66	457 00	510 30	533 80	708 66	906 99	633	524						7718
103	Land	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
104	FoodSec	700	1200	800			2400	933	1467	100	933	1200	1467	2400	800							0
105	Budget	379	502	333 8083	333 81	825	825	510 296	708 6623	457	510 296	533 8039	708 6623	906 9873	633	524	0	0	0	0	0	7718
106	InputBuy	14	172	116	116	523	523	14	116	63	14	141	116	442	20	300						1653
107	CashAvl																					
108	SeasCons																					
109	CredMax																					
110	BurMax																					1
111	MzSoyR							1	1	-1												
112	MaxSoy	1	1	1	1	1	1	1	1	-.9	1	1	1	1	1	1	1	1	1	1	1	1
113	MaxAA	1	1	1	1	1	1	1	1	1	-.9	-.9	9	-.9	1	1	1	1	1	1	1	1
114	MinMix	1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1	1	1	1
115	JnSpLab	23	29	23	23	29	29	29	29	13	23	29	29	29	18	81	47	31	15	12	78	77
116	OcNvLab	49	49	49	49	49	49	49	49	59	49	49	49	49	57	68	10	40	46	39	56	77
117	DecLab	10	20	10	10	20	20	20	20	35	12	20	22	20	10	18	17	2	10	13	34	33
118	JanLab	17	27	17	17	27	27	27	27	16	17	27	27	27	22	31	4	17	17	32	17	32
119	FbMrLab	4	20	4	4	20	20	20	20	28	4	20	20	20	13	20	27	4	4	33	32	106
120	ApMyLab	27	35	27	27	35	35	35	35	8	27	35	35	35	27	66	18	13	32	59	72	90
121	OfONMax																					
122	OfDEMax																					
123	OfJAMax																					
124	OfFMMax																					

LP Model: Lilongwe, Liwonde & Blantyre ADDs -- Policy reform model

	A	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP
64																					
65																					
66		BUYM	CREDIT	CASHSAV	CASHSPD	LOFFJS	LOFFON	LOFFDEC	LOFFJAN	LOFFFM	LOFFAM	HLJNSP	HLOCNV	HLDEC	HLJAN	HLFBMR	HLAPMY				
70	RETURN	-0.85	-0.12			0.00	3.30	3.30	3.30	3.30		-0.05	-3.35	3.35	3.35	3.35	-0.05		0.9	0.96	0.9
71	Land																	<=	0.4293	1.04544	1.8144
72	FoodSec	1																>=	820	1021	1141
73	Budget	-0.85	-0.12	0	0	0.00	3.30	3.30	3.30	3.30	0.00	-0.05	3.35	3.35	3.35	3.35	-0.05	>=	0	0	0
74	InputBuy		-1		-1													<=	0	0	0
75	CashAid			1	1													=	20	60	150
76	SeasCons	-0.85		1		0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	3.35	3.35	-0.05	>=	0	0	0
77	CredMax		1															<=	100	100	125
78	BuyMax																	<=	0.006917	0.006917	0.006917
79	MzSoyR																	<=	0.00	0.00	0.00
80	MaxSoy																	>=	0	0	0
81	MaxAA																	>=	0	0	0
82	MinMix																	<=	0	0	0
83	JnSpLab					1						-1						<=	123	153	171
84	OcNvLab						1						-1					<=	62	77	86
85	DecLab							1						-1				<=	25	31	34
86	JanLab								1						-1			<=	25	31	34
87	FbMrLab									1						-1		<=	49	61	68
88	ApMyLab										1						-1	<=	62	77	86
89	OfONMax						1											<=	20	20	20
90	OfDEMax							1										<=	10	10	10
91	OfJAMax								1									<=	10	10	10
92	OfFMMax									1								<=	20	20	20
93																					
94																					
95																					
96																					

LP Model: Lilongwe, Liwonde & Blantyre ADDs -- Rapid policy reform model

	A	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP
97																					
98		BUYM	CREDIT	CASHSAV	CASHSPD	LOFFJS	LOFFON	LOFFDEC	LOFFJAN	LOFFFM	LOFFAM	HLJNSP	HLOCNV	HLDEC	HLJAN	HLFBMR	HLAPMY				
102	RETURN	-0.85	-0.12			0.00	3.30	3.30	3.30	3.30		0.05	-3.35	3.35	3.35	3.35	-0.05		0.9	0.96	0.9
103	Land																	<=	0.4293	1.04544	1.8144
104	FoodSec	1																>=	820	1021	1141
105	Budget	0.85	0.12	0	0	0.00	3.30	3.30	3.30	3.30	0.00	0.05	3.35	-3.35	3.35	3.35	0.05	>=	0	0	0
106	InputBuy		-1		1													<=	0	0	0
107	CashAid			1	1													=	20	60	150
108	SeasCons	-0.85		1		0.00	3.30	3.30	3.30	3.30	0.00	0.05	-3.35	3.35	3.35	3.35	-0.05	>=	0	0	0
109	CredMax		1															<=	117	117	142
110	BuyMax																	<=	0.013833	0.013833	0.013833
111	MzSoyR																	<=	0.00	0.00	0.00
112	MaxSoy																	>=	0	0	0
113	MaxAA																	>=	0	0	0
114	MinMix																	<=	0	0	0
115	JnSpLab					1						-1						<=	123	153	171
116	OcNvLab						1						-1					<=	62	77	86
117	DecLab							1						-1				<=	25	31	34
118	JanLab								1						-1			<=	25	31	34
119	FbMrLab									1						-1		<=	43	61	68
120	ApMyLab										1						-1	<=	62	77	86
121	OfONMax						1											<=	20	20	20
122	OfDEMax							1										<=	10	10	10
123	OfJAMax								1									<=	10	10	10
124	OfFMMax									1								<=	20	20	20

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1		LP Model: Ngabu ADD – Base year model (status quo ante)																				
2		LMNF	LMF	HFMNF	HDMNF	HDMF	HFMF	LMSOY	HMSOY	SOYMZ	LMAA	LMAAF	HMAA	HMAAF	MMIX	GNUT	MILLET	CASSAVA	ORGHUM	RICE	COTTON	BURLEY
6	RETURN	295	334		235.46	207									429		109.51		32.62		764.24	
7	Land	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	FoodSec	550	900												300		385		250			
9	Budget	295	334	0	235.46	207	0	0	0	0	0	0	0	0	429	0	109.51	0	32.62	0	764.24	0
10	InputBuy	14.06	172.23		115.79	523.32									20	300	15		15			
11	CashAvl																					
12	SeasCons																					
13	CredMax																					
14	BurMax																					1
15	MzSoyR							1	1	-1												
16	MaxSoy	1	1	1	1	1	1	1	1	-9	1	1	1	1	1	1	1	1	1	1	1	1
17	MaxAA	1	1	1	1	1	1	1	1	1	-9	-9	-9	-9	1	1	1	1	1	1	1	1
18	MinMix	1	1	1	1	1	1	1	1	1	1	1	1	1	-5	1	1	1	1	1	1	1
19	JnSpLab	23	29	23	23	29	29	29	29	13	23	29	29	29	18	81	47	31	15	12	78	77
20	OcNvLab	49	49	49	49	49	49	49	49	59	49	49	49	49	57	68	10	40	45	39	56	77
21	DecLab	10	20	10	10	20	20	20	20	35	12	20	22	20	10	18	17	2	10	13	34	33
22	JanLab	17	27	17	17	27	27	27	27	16	17	27	27	27	22	31	4	17	17	32	17	32
23	FbMrLab	4	20	4	4	20	20	20	20	28	4	20	20	20	13	20	27	4	4	33	32	106
24	ApMyLab	27	35	27	27	35	35	35	35	8	27	35	35	35	27	66	18	13	32	59	72	90
25	OfONMax																					
26	OfDEMax																					
27	OfJAMax																					
28	OfFMMax																					
29																						
30																						
31																						
32																						
33		LP Model. Ngabu ADD – Continue present policies 2002/03 model																				
34		LMNF	LMF	HFMNF	HDMNF	HDMF	HFMF	LMSOY	HMSOY	SOYMZ	LMAA	LMAAF	HMAA	HMAAF	MMIX	GNUT	MILLET	CASSAVA	ORGHUM	RICE	COTTON	BURLEY
38	RETURN	295	334	235 46	235 46	207	207	360 80	361 91	457 00	360 80	365 20	361.91	288 79	429		109 51		32.62		764 24	7718
39	Land	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
40	FoodSec	550	900	625			1300	667	850	100	667	900	850	1300	300		385		250			0
41	Budget	295	334	235 4583	235 46	207	207	360 804	361 9083	457	360 804	365 2039	361 9083	288 7873	429	0	109 51	0	32 62	0	764 24	7718
42	InputBuy	14	172	116	116	523	523	14	116	63	14	141	116	442	20	300	15		15			1653
43	CashAvl																					
44	SeasCons																					
45	CredMax																					
46	BurMax																					1
47	MzSoyR							1	1	-1												
48	MaxSoy	1	1	1	1	1	1	1	1	-9	1	1	1	1	1	1	1	1	1	1	1	1
49	MaxAA	1	1	1	1	1	1	1	1	1	-9	-9	-9	-9	1	1	1	1	1	1	1	1
50	MinMix	1	1	1	1	1	1	1	1	1	1	1	1	1	-5	1	1	1	1	1	1	1
51	JnSpLab	23	29	23	23	29	29	29	29	13	23	29	29	29	18	81	47	31	15	12	78	77
52	OcNvLab	49	49	49	49	49	49	49	49	59	49	49	49	49	57	68	10	40	46	39	56	77
53	DecLab	10	20	10	10	20	20	20	20	35	12	20	22	20	10	18	17	2	10	13	34	33
54	JanLab	17	27	17	17	27	27	27	27	16	17	27	27	27	22	31	4	17	17	32	17	32
55	FbMrLab	4	20	4	4	20	20	20	20	28	4	20	20	20	13	20	27	4	4	33	32	106
56	ApMyLab	27	35	27	27	35	35	35	35	8	27	35	35	35	27	66	18	13	32	59	72	90
57	OfONMax																					
58	OfDEMax																					
59	OfJAMax																					
60	OfFMMax																					
61	MaxTech	1	1	-4	1	1	-4	-4	-4	-4	-4	-4	-4	-4	1	1	1	1	1	1	1	1
62																						
63																						
64																						

	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP
66																				
66	LP Model: Ngabu ADD – Policy reform model																			
67	BUYM	CREDIT	CASHSAV	CASHSPD	LOFFJS	LOFFON	LOFFDEC	LOFFJAN	LOFFFM	LOFFAM	HLJNSP	HLOCNV	HLDEC	HLJAN	HLFBMR	HLAPMY				
71	-0.85	-0.12			0.00	3.30	3.30	3.30	3.30		-0.06	-3.35	-3.35	-3.35	-3.35	-0.06		0.9	0.96	0.9
72																	<=	1.0773	1.84032	3.3291
73	1																>=	1004	1376	1550
74	-0.85	-0.12	0	0	0.00	3.30	3.30	3.30	3.30	0.00	-0.06	-3.35	-3.35	-3.35	-3.35	-0.06	>=	0	0	0
76		-1		-1													<=	0	0	0
76			1	1													=	20	60	150
77	-0.85		1		0.00	3.30	3.30	3.30	3.30	0.00	-0.06	-3.35	-3.35	-3.35	-3.35	-0.06	>=	0	0	0
78		1															<=	100	100	125
79																	<=	0.006917	0.006917	0.006917
80																	<=	0.00	0.00	0.00
81																	>=	0	0	0
82																	>=	0	0	0
83																	<=	0	0	0
84					1						-1						<=	151	206	233
85						1						-1					<=	75	103	116
86							1						-1				<=	30	41	47
87								1						-1			<=	30	41	47
88									1						-1		<=	60	83	93
89										1						-1	<=	75	103	116
90						1											<=	20	20	20
91							1										<=	10	10	10
92								1									<=	10	10.	10
93									1								<=	20	20	20
94																				
95																				
96																				
97																				
98	LP Model: Ngabu ADD – Rapid policy reform model																			
99	BUYM	CREDIT	CASHSAV	CASHSPD	LOFFJS	LOFFON	LOFFDEC	LOFFJAN	LOFFFM	LOFFAM	HLJNSP	HLOCNV	HLDEC	HLJAN	HLFBMR	HLAPMY				
103	-0.85	-0.12			0.00	3.30	3.30	3.30	3.30		-0.05	-3.35	-3.35	-3.35	-3.35	-0.05		0.9	0.96	0.9
104																	<=	1.0773	1.84032	3.3291
106	1																>=	1004	1376	1550
106	-0.85	-0.12	0	0	0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
107		-1		-1													<=	0	0	0
108			1	1													=	20	60	150
109	-0.85		1		0.00	3.30	3.30	3.30	3.30	0.00	-0.05	-3.35	-3.35	-3.35	-3.35	-0.05	>=	0	0	0
110		1															<=	117	117	142
111																	<=	0.013833	0.013833	0.013833
112																	<=	0.00	0.00	0.00
113																	>=	0	0	0
114																	>=	0	0	0
116																	<=	0	0	0
116					1						-1						<=	151	206	233
117						1						-1					<=	75	103	116
118							1						-1				<=	30	41	47
119								1						-1			<=	30	41	47
120									1						-1		<=	60	83	93
121										1						-1	<=	75	103	116
122						1											<=	20	20	20
123							1										<=	10	10	10
124								1									<=	10	10	10
125									1								<=	20	20	20

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