NATURAL RESOURCES INSTITUTE

Soil Fertility in Malawi

A Review of Policies, Productivity and Perceptions

June 1998

Natural Resources Institute

the UNIVERSITY of GREENWICH

DISCUSSION PAPER

SOIL FERTILITY IN MALAWI: A REVIEW OF POLICIES, PRODUCTIVITY AND PERCEPTIONS

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June 1998

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ACRONYMS AND ABBREVIATIONS

ADD	Agriculture Development Division
AMARC	Agricultural Development and Marketing Corporation
B	Boron
BLADD	Blantyre ADD
CAN	Calcium ammonium nitrate
Cu	Copper
DAP	Diammonium phosphate
DARTS	Department of Agricultural Research and Training Services
DFID	Department for International Development (formerly ODA)
EPA	Extension Planning Area (subdivision of an ADD)
GIS	Geographical information system
K	Potassium
KADD	Kasungu ADD
KRADD	Karonga ADD
LADD	Lilongwe ADD
MADD	Machinga ADD
MAI	Ministry of Agriculture and Irrigation
MRFC	Malawi Rural Finance Company
MPTF	Maize Productivity Task Force
MK	Malawi Kwacha
MZADD	Mzuzu ADD
N	Nitrogen
NGO	Non-governmental organisation
ppm	parts per million
PRA	Participatory rural appraisal
S	Sulphur
SACA	Smallholder agricultural credit association
SLADD	Salima ADD
SOM	Soil organic matter
SVADD	Shire Valley ADD

ACKNOWLEDGEMENTS

The authors would like to thank Peter Brinn, NRI for his co-ordination of the project and to acknowledge the assistance of all those who provided information, ideas and literature. This work was funded under DFID's Advisory and Support Services Contract (ASSC).

RESPONSIBILITY

The views and ideas expresses in the report are those of the authors. Although the report was commissioned by the Department for International Development, DFID bears no responsibility for it and is in no way committed to the views and recommendations expressed herein.

EXECUTIVE SUMMARY

This report synthesises information from the literature and key informants on agricultural production and soil fertility in Malawi and proposes options for investment in this area. The main points, highlighted below, were presented to the Ministry of Agriculture and Irrigation's Soil Fertility Round Table in Lilongwe in June 1998.

Malawi's situation is far from secure with its high population density and growth rate, land shortages, malnutrition, decreasing life expectancy and deteriorating infrastructure. The country has recently experienced some extreme shocks and changes - repeated droughts, democratisation, devaluation and liberalisation. These have impacted on the agricultural sector both positively and negatively. On the positive side, there is increasing crop diversification and production at national level. Negatively, increases in the price of fertiliser and declining access to credit have adversely affected many smallholders, particularly in the south. The population is increasing at a steady rate and maize production, while varying with rainfall, appears not to be increasing at the same rate. The situation at household level in many areas is worsening. The soils, on which the country is so dependent, are no longer able to provide sufficient nitrogen to achieve acceptable yields of maize.

The key findings of the report are summarised below.

1. Soil infertility is a symptom of an impoverished agricultural system. Consideration must be given to the cause of the decline and address this rather than concentrate solely on measures to enhance soil fertility. It has been suggested that policy reforms should emphasise better terms of trade for agricultural products to give smallholders an incentive to invest in technologies which improve soil fertility to increase land productivity.

2. Farmer perceptions suggest that soil fertility is declining, along with both food and cash crop production, resulting in increasing poverty. Growing food insecurity is perceived as being related to soil infertility but drought, increasing fertiliser prices, lack of credit, increasing population, decreasing land size are also identified as important causes. This implies that even if soil fertility were maintained these other factors would increase the dependence on non-agricultural income sources; the decline in soil fertility further increases an already growing dependence on non-farm incomes.

3. Farmers face the challenge of feeding themselves from a declining natural resource base. While most have used fertiliser at some time or other and are vociferous in their demand for it the relative difficulty of regular access may have caused farmers to sometimes be negative about its impact. Alternative methods of coping with soil fertility, while not as effective as fertiliser, may have some attraction to farmers as they are more within their control and less dependent on external inputs.

4. The necessity of relying on crop production and population data whose accuracy is questioned makes it difficult for Government and donors alike to be sure of the true situation and to agree on what should be done to improve it. Better systems for production, monitoring and evaluation of data are required.

5. It is important there is agreement on the problems and that Government develops a strategic approach to agree on what needs to be done, with support from donors. This will involve male and female farmer representatives, ministries, departments, research, extension, the media and the private sector.

6. Approaches to smallholder soil fertility management should encourage the efficient use of all available nutrient sources - both mineral and organic - in an integrated strategy. Such a strategy must recognise the wide variety in quality among potential sources of organic matter, which strongly influences nutrient supply. Enhanced management of legume crops - groundnuts, pigeon pea and soybean - through fertilisation with phosphorus and denser planting, could increase the provision of both calories and protein, and help to slow the rate of soil fertility decline, by maximising the contribution from biological nitrogen fixation.

7. There is need to recognise the opportunities for partnership with its neighbours with respect to cross-border trade. Tanzania, Mozambique and Zambia, are endowed with abundant land suitable for food production. There is already considerable informal cross border trade between these countries, particularly of food and agricultural inputs. A common food strategy by all the four countries to allow open and legal informal trade would have significant positive food security implications for the region.

8. Agriculture is likely to remain the engine of growth for the foreseeable future. This will require intensification through increasing quantities of inputs, particularly fertiliser, improvement in skills, markets and other agricultural services including a well-informed proactive extension service, employing interactive methods. Crops that serve several criteria should receive particular attention.

9. Although there is evidence of increasing crop diversification and importance of off-farm income, considerable importance is still attached by most rural households to maize self-sufficiency. Household food security is thus still a very relevant conceptual framework within which to discuss the related issues of food security and soil fertility. There is particular need to support women farmers, who are largely responsible for household food crop production and child welfare.

10. The Government is committed to deregulation of agricultural marketing and input supply, and the private sector is responding with the number of large-scale companies and individual traders growing. However, markets are still far from perfect and problems and opportunities are often location specific. Parastatals are still very involved in the sector.

11. Greater provision of rural services are required to help traders move out surplus production and move food into deficit areas – roads and storage facilities. Attention must also be given to better security, enforcement of trading and quality standards, provision of timely information on prices and market conditions, rural banking and credit, and support to livestock ownership. Since the demise of the Smallholder Agricultural Credit Association and its farmers' clubs access to credit has become much more restricted. The formal credit system reaches few people in the rural areas, particularly women. Although it is often argued that credit is necessary for smallholders to buy hybrid maize seed and fertiliser other factors, such as stable or guaranteed prices, may be more important.

Borrowing is now so costly, in nominal terms, that people may try to purchase fertiliser for cash, to avoid interest payments and to ensure timely availability.

12. The report advocates the support of 'Best Bet' strategies. These are approaches and technologies which, coupled with good crop and land husbandry methods are likely to have significant benefits in food production and to play a role in slowing, and in some cases reversing, the decline in soil fertility. Some are ready for immediate dissemination; others require on-farm verification, a few need further research.

PART I. SYNTHESIS OF FINDINGS AND PROPOSED PATHWAYS TO ADDRESS KEY ISSUES

I.1 Introduction

This report attempts to present and analyse many of the issues surrounding agricultural production and soil fertility in order to put forward options for investment in this sector. The analysis is based on the study of many published and unpublished documents and numerous interviews with representatives from research, industry, Government and NGOs in Malawi. The main conclusions were presented at the Ministry of Agriculture and Irrigation's Soil Fertility Round Table in Lilongwe in June 1998[1].

The report is organised in the following way. Part I is a synthesis of the main findings on the policy environment, the supply and use of fertiliser, technical aspects of soil fertility management and farmer perceptions on soil fertility. This is followed by a series of pathways to address the key issues. Finally a series of specific interventions are presented for consideration by DFID. Part II provides more comprehensive, referenced, information under the same subject headings upon which the synthesis findings are based. The terms of reference for the study are given in appendix I. Some current initiatives on soil fertility are given in appendix II and details on soils are given in appendix III.

Our analysis assumes that the restoration of soil fertility is a long-term process, and that it is not just a technical issue. Economic and social considerations are also involved. It has much to do with people and their relationship with the land and the economic benefits they obtain from it. A better understanding of the way people perceive and relate to their environment will assist in making more appropriate interventions.

In our review we observed that the topics of both soil fertility and food security in Malawi can be emotive issues. There is considerable lack of agreement by experts on the best route to tackle them. However, our conclusion is that there is no single solution, and various pathways need to be followed to improve the situation. In proposing solutions to problems it is also easy to make incorrect assumptions. Markets are far from perfect, problems and opportunities are often location specific. This presents challenges to large-scale interventions (whether commercial or non-commercial), particularly when the target audiences have very limited resources, low levels of literacy and access to information, and are responsible for the survival of their families under very difficult circumstances. Problems of jealousy, envy, traditional beliefs and politics all affect the way people think and behave.

To address the issue of soil fertility we need consider what has caused the decline and address those factors, rather than concentrate solely on measures to enhance soil fertility. The main task is to identify the major existing problems, which are seen as insufficient food and inadequate incomes. From this perspective, soil fertility is a symptom of an impoverished agricultural system. Recent work by Diagne (1998) on socio-economic determinants of household productivity and technical efficiency in growing maize and tobacco concludes that policy reforms should put more emphasis on promoting better terms of trade for agricultural products to give smallholders incentives to invest in soil fertility technologies.

[1] Of the possible pathways presented the opening up of regional trade and increasing regional specialisation, as well as developing a regional approach to food security invoked the most discussion.

I.2 Background to soil fertility issues

Malawi's current situation is far from secure with its high population density, land shortages, huge population growth, deteriorating infrastructure, AIDS, malnutrition and decreasing life expectancy (Coulter, 1998; Daily Times 15.5.98). In recent times the country has experienced some extreme shocks and changes - repeated droughts, democratisation, devaluation and liberalisation (FEWS, 1996).

These shocks and changes have had both positive and negative impacts on the agricultural sector. On the positive side, there is increasing crop diversification and production at national level. Negatively, increases in the price of fertiliser and declining access to credit, coupled with declining soil fertility, have adversely affected many smallholders, particularly in the southern half of the country. The situation at household level in many areas is worsening. This difference, between the macro and micro picture, was echoed recently by Lucius Chikuni, Controller for Disaster Preparedness, Relief and Rehabilitation, (The Nation 9-10 May), in a front page article entitled 'No food shortage'.

> "I would cautiously say that the worries should not be at the national level. The biggest worry should be at the household level. Families in thickly populated districts, where land holdings are small, will end up with food shortages, even when the national picture is good"...1.86 million tonnes of grain are required annually and this year's grain yield is estimated at 1.7 million tonnes"

I.3 The Policy Environment

There is general support for liberalisation by government. There is increasing involvement of the private sector in supply of agricultural inputs and purchasing of outputs, although the parastatal ADMARC is still one of the main agents. Farmers are responding to deregulated maize prices and there are encouraging figures for growth in production of crops other than maize. On the input supply side the high price of fertiliser gives cause for concern. Maize yields are declining and the country cannot grow enough maize to feed itself. The cost of importing maize adds greatly to the trade deficit. There appears to be disagreement by the main donors on the best way to tackle the situation. A free market approach, in which market prices determine optimum resource use, is promoted by some donors. Other donors consider that Malawi's unique situation and highly impoverished population means that few farmers can respond to higher prices, while the majority will suffer further because they have to purchase food.

I.4 Supply and Use of Fertiliser

Since the liberalisation of agricultural input marketing there are at least a dozen operators supplying fertilisers and many private traders selling fertilisers in the villages. The price of fertiliser has a very high transaction cost element and is affected by the weakness of the Kwacha against the major trading currencies. Few smallholders can afford to apply fertiliser to maize. Little appears to being done to assist farmers other than to allow donor schemes to provide inputs on credit to poor households. The recently developed area-specific fertiliser recommendations, which substantially reduce recommended amounts, may have some impact by assisting farmers in decision making about appropriate application rates. However, they may not make much difference to the many farmers who have not been applying recommended rates for some time.

Until the early 1990s fertiliser was fairly accessible to smallholders, mainly via credit schemes, and was used to maintain food production levels. It has been estimated that between 70 and 80 per cent of farming households have had access, at one time or another, to fertiliser although only 30-35% may have used it in any one year (HIID, 1994). Results from field trials in 1995/96 indicated that it was not economic for farmers in most parts of the country to apply fertiliser to hybrid maize.

Over concentration on maize production with continual cropping may have been largely responsible for declining soil fertility. Maize is demanding of nutrients, particularly on nitrogen, the availability of which is strongly linked to soil organic matter.

I.5 Access to credit

The formal financial sector reaches very few of the smallholder population. The Malawi Rural Finance Company is the main institution mandated to supply credit to smallholders but currently only reaches five per cent of the rural population. Lending to smallholders is restricted to those growing cash crops which show a positive gross margin from which the loan and interest can be repaid. Loans are issued for one season and borrowers have to be a member of a savings group who undertake to repay the loans of any members who default. Female headed households are underrepresented as members of such credit programmes as they tend to be less involved in cash crop production. The informal sector plays an important, though largely undocumented, role in supplying short-term credit.

It is frequently argued that credit is necessary to enable smallholders to take up hybrid maize and fertiliser. A study of access to credit in 1995 (Diagne *et al.*) found that participation in formal credit schemes was a major factor in the adoption of hybrid maize and tobacco and that production of these two crops significantly raised farm incomes. However, other factors such as holding size, wealth or income may be more important in explaining farmers' willingness to adopt improved maize technologies (Buckley, 1996). Policy factors, particularly the price of maize, may have been more influential in persuading farmers to use, or not to use fertiliser. The cost of borrowing is now so high, in nominal terms and there is anecdotal evidence (De Gabriel, personal communication) that farmers try to purchase inputs with cash to avoid interest charges, and to ensure timely availability of their fertiliser.

I.6 Technical analysis of Soil Fertility Management

I.6.1 Soil Fertility Status

The Maize Productivity Task Force, established by the Government, has played a pivotal role in developing current understanding of the nutrient constraints, which limit soil productivity. Extensive research on farmers' fields, conducted throughout the main agro-ecological zones of Malawi, in the past five years has defined areas in which particular nutrients are deficient for crop production. Research conducted by scientists from the Department of Agriculture and Technical Services (DARTS) and from Bunda College, University of Malawi has explored a wide range of options for biological management of soil fertility. Here we use the term 'soil fertility' to reflect the general productivity of the soil, acknowledging that this encompasses both provision of nutrient and water, and a good physical environment for root development.

Four points are evident from the review :

- The soils of Malawi are not inherently infertile, in that they are generally not strongly acidic, and have moderate clay contents, and they do not pose any particular physical or chemical problems for soil fertility management and crop production.

- As the majority of smallholder land is cropped to unfertilised maize, sustainable productivity gains in agriculture of the scale required to feed the population are impossible without inputs of nutrients.

- The key nutrient required to increase agricultural production in Malawi is nitrogen. Deficiencies of other nutrients are more localised and/or not yet critical.

- Biological sources of nitrogen (N) - from biological nitrogen fixation or recycling of N from a wider area - are sufficient for only small increases in maize production. However, biological nitrogen fixation is highly important in providing legume grain as a protein source for the population.

A summary of the requirements for addition of nutrients to remove constraints to food production, in order of priority, is as follows:

N	• Most soils are unable to provide sufficient N from mineralisation of soil organic matter (SOM) to achieve acceptable yields of maize. • Legume crops can meet their own N requirements through atmospheric nitrogen and will contribute N to the system if well managed.
S	• The main source of sulphur (S) in most soils is the SOM. Without additions, S deficiencies are likely to become more widespread and as S requirements in fertilisers can be met with a small content of S (4%) it is recommended that this is adopted as a standard.
P	• Most soils contain sufficient available phosphorus (P) for maize. • Yields of legumes are increased in response to small amounts of P fertilisers applied to maize in the previous season. Although P not generally required for maize, fertiliser recommendations should aim to include small additions of P as direct application of fertilisers to the legumes is unlikely.
Zn	• Zinc (Zn) is severely deficient in localised areas. • Deficiencies of other micronutrients reported but evidence is equivocal and considered of secondary importance. Given the adequate supply of P, and the moderate acidity of most Malawian soils, large additions of P, whether in the form of soluble P fertilisers (e.g. TSP) or as rock phosphates, could lead to changes in the availability of micronutrients and exacerbate deficiencies of Zn.
K	• Potassium (K) not currently a problem although rates of K offtake will rise if crop production is increased; the requirements for K fertilisers should be kept under periodic (5 yearly) review.

Recent research has established area-specific fertiliser recommendations. These recommendations are based on 1,680 on-farm, researcher-managed fertiliser trials conducted in the 1995/96 season throughout Malawi. Even small fertiliser additions (30 kg N ha^{-1}) however were not economic at the beginning of the 1997/98 season in virtually all parts of Malawi. Maximum maize yield responses are seen at much larger fertiliser rates (> 90 kg N ha^{-1}) which are unlikely to be economic for maize under any medium-term pricing scenario.

Improved biological soil management is essential to meet the longer-term demands of agricultural production, but cannot satisfy immediate or long-term food requirements without supplementation of mineral fertilisers. Enhanced management of legume crops (through basic fertilisation with P, denser planting etc.) could increase the provision of both calories and protein by maximising the contribution from biological N_2-fixation. New approaches to smallholder soil fertility management should encourage the efficient use of all available nutrient sources - both mineral and organic - in an integrated strategy. Any such strategy must recognise the wide variety in quality among potential sources of organic matter, which strongly influences the ability to supply nutrients.

I.6.2 'Best Bets' for soil fertility management

'Best bet' strategies can be identified which, coupled with good crop and land husbandry methods (timely weeding, soil conservation etc.), are likely to have significant benefits in food production and to play a role in slowing, and in some cases reversing, the decline in soil fertility. These 'Best Bet' technologies have been divided into four classes:

I. Interventions which can be *immediately recommended* that are likely to bring immediate benefits in food production and soil fertility and for which there is little risk of failure of repayment on investment:		
A.	Area-specific fertiliser Recommendations	If fertiliser use is economic the amounts of fertilisers used should exploit the maximum yield response per unit fertiliser added, and combine this with additions of good quality organic matter where possible.
B.	Magoye soyabean rotation	This variety nodulates well under farmers' conditions and contributes a substantial amount of N to the soil.
C.	Maize + pigeonpea intercropping	Maize yields are unaffected by intercropping and pigeon pea continues to grow through the dry season contributing substantial amounts of N through fallen leaves.
D.	Use of animal manure	The benefits of animal manure on soil fertility and nutrient supply are well known but amounts of cattle manure are very limited.

II. Interventions *recommended for wide-scale farmer evaluation* that have yet to have wide-scale farmer evaluation which show considerable promise for improving soil fertility.		
A.	Undersowing with green manures	e.g. *Tephrosia vogelii* with maize provides a large input of N-rich biomass which can help to reduce N fertiliser requirements.

B.	Transfer of available biomass	e.g. *Tithonia* – where biomass of weeds such as *Tithonia* is available, farmers could make valuable use of it to provide additional nutrients for crops.

III. Interventions that are likely to make a small contribution to soil fertility at the farm scale in the short term but represent *investments for the future*		
A.	Planting of *Faidherbia albida* within fields	Will produce 'islands of fertility' but is likely to take at least 15 years before significant impact is shown
B.	Boundary planting and rotational woodlots of legume trees (e.g. *Gliricidia* and *Sesbania*).	Nitrogen fixing trees can provide fuelwood and biomass for soil amendment , as well as restoring fertility of degraded soils if left for several seasons.

IV. Interventions, which have yet to be tested for long term soil fertility improvement but where the knowledge base is insufficient to allow critical assessment of their potential. Research focused on the maintenance of soil fertility is warranted *under soil fertility status relevant to smallholder farmers* examining, as examples:	
A.	The long-term implications of maize stover management on SOM status and maintenance of soil fertility.
B.	Screening of alternative legume species for undersowing as green manures.
C.	Alternative food and cash crops to promote smallholder crop diversification which would give more scope for rotations
D.	Processing research and extension and market research and promotion.
E.	Investigation of relay cropping systems, following early maturing cereals with legume in the same season.
F.	Research into a wider range of food legumes (e.g.cowpeas, chickpeas, *Dolichos lablab*) which may fit into the various farming systems and have potential markets.

I.7 Small-holder farmer perceptions and circumstances

Analysis of intervention pathways needs to take account of the perceptions which small-scale farmers have about soil fertility and the circumstances they operate within.

I.7.1 Farmer awareness of fertility decline

While, in objective terms, the fertility of land may have been declining at a fairly gradual rate since the early 1980s, the "external shocks" of climatic and policy related changes highlighted above are seen by farmers as having had a particularly critical effect on their production levels and on food security. In this respect farmers' views are similar to those of some policy analysts. The available evidence suggests that farmers attach importance to soil fertility and soil conservation, and attribute important problems, particularly hunger, increased dependence on off-farm employment and even fuel wood availability, to its decline. The picture suggested by farmers' views on various issues is that of an overall decline in livelihoods over the last decade, and a greater dependence for many of the rural poor on the wider economy, and on and relief. There is potential to build on existing levels of farmer awareness of the causes and consequences of declining soil fertility.

I.7.2 Food security and soil fertility

The central importance attached by most rural households to maize self-sufficiency as an indicator of welfare (Smale et al, 1998), suggests that household food security is still a very relevant conceptual framework within which to discuss the related issues of agricultural productivity and soil fertility.

I.7.3 Soil fertility and land quality

Returns from a unit area of land are likely to become more important to farmers as land becomes a scarcer factor of production. However, any economic analysis needs to be wary of divorcing aggregated national data from the context of local farming and livelihood systems. There is significant variability in spatial land quality. Possible areas of intervention relate to increasing the productivity of the higher potential land, such as the dambo areas, as well as arresting the decline in the upland arable areas.

I.7.4 Soil fertility and labour

The overall ratio of labour to land and capital is increasing dramatically and is unlikely to improve in the medium term. This implies that labour intensive technologies are likely to be more acceptable, and are probably being implemented in various ways independently of planned interventions. Farmers face the challenge of feeding themselves from a declining natural resource base. In order to add to the stock of ideas for future development initiatives more research is required into how farmers are innovating in order to meet this challenge.

There are times of the year when more surplus smallholder household labour is available, and there are limited local employment/piecework opportunities. Such times present a potential opportunity for using this labour in interventions that will improve soil productivity. More labour intensive measures to conserve soil and enhance its fertility may be adopted by the poorer households, particularly those that are fairly well established in farming. There is evidence that, in individual cases, resource poor farmers are adopting organic technologies for soil conservation and are realising improved yields.
Fertiliser not only increases returns to land, but is a labour-saving technology for all households. It reduces the amount of land, and therefore labour, required to produce a certain quantity of maize. Returns to fertiliser use are likely to increase, particularly if other soil improving and conserving technologies are used in combination with fertiliser.

With declining real cash income levels from farming, more attention should focus on labour-intensive soil improving methods, if possible linking these to the production of cash crops and highly valued food crops.

I.7.5 Extension recommendations and farmer perceptions

There is a tendency by some agencies involved in agricultural extension to add a moral ('Green') dimension to messages, presenting fertiliser as a dangerous soil damaging technology, and organic methods as a panacea to soil improvement. Organic technologies may become more attractive to farmers if they are not presented as alternatives to fertiliser, but as useful and complementary ways of increasing productivity which have lower risks and greater longer term benefits.

In locations where they have a role to play, longer acting fertilisers (such as lime and phosphates), which carry over the benefits into several seasons, may be more attractive to resource poorer farmers because they would be less likely to fear the consequences of adverse weather and of being unable to access fertiliser in the following season. Similarly, strategies for economising on fertiliser use, and maximising the benefits from limited quantities, would increase the viability of inorganic fertiliser options for the poorer farmers (e.g. targeting specific crops or patches of land, optimal timing to reduce risk, optimal combinations with crop management and other soil amending technologies).

The extension approach to soil fertility, including fertiliser management, clearly needs to be more flexible than in the past. The adoption of the area specific fertiliser recommendations is a step forward. An "options" approach to fertiliser use may be still more useful, perhaps combined with a farmer group approach where strategies can be discussed early on in the season, when the fertiliser availability situation (types and amounts) is known and the weather pattern has become somewhat clear, and when reliable information on cash crop markets and options is widely available. In implementing extension, more attention should be paid to farmers' perceptions and practices of soil and water conservation. Agricultural research and extension staff may require further sensitising to the importance and benefits of understanding and building upon farmers' local knowledge and practises.

Interventions should be based on an understanding of current systems, how they are evolving, under what pressures, and what the scope for further adaptation and development of these systems is. It would be naive to look for an "indigenous system" which has been practised for many years, which could be widely promoted

I.7.6 Understanding local socio-cultural constraints and opportunities

In many local communities, the cultural conditions for investment, innovation and accumulation of wealth may not be very favourable due to the nature of the matrilineal kinship system and its related system of beliefs and practises. However, it is important to examine any exception to these to see what can be learned in terms of their implications for investment in soil improvement.

I.8 Pathways to address key issues and opportunities for DFID contribution

I.8.1 A long-term approach is necessary

The immediate need is for continued commitment and strong leadership by Government to address the issues and to initiate activities, such as those outlined below (see also appendix II), with support from donors where necessary. The Soil Fertility Round Table, organised by the MAI in May this year, is an encouraging first step but much more must be done to co-ordinate approaches, provide information and to monitor and evaluate what is being done. Strong local ownership will be vital if such a programme is to be successful. One of the recommendations of the meeting was the establishment of a lead unit to co-ordinate food security/soil fertility enhancing activities. This organisation will need the full support of Government and will require a mandate to allow it to get things done.

We recognise that ensuring sufficient food production in Malawi is a complex problem, which cannot be solved by short-term interventions. However, there is an immediate need for enhanced agricultural production to increase household food security. A plan has been developed by the Government and donors to provide a pack containing fertiliser and hybrid seed sufficient to plant 0.1 ha. (7.5 kg of urea and 7.5 kg of 23.21.0, which amounts to just over 5 kg of N, and 2.5 kg hybrid seed). It is assumed that in the absence of the pack a farmer would grow local maize without fertiliser which would yield about 100 kg. The starter package plot is assumed to yield 200-250 kg. The proposal thus projects an additional 100-150 kg of maize from 0.1 ha. This yield seems plausible - experience of trials in Malawi indicate yields of about 1,000 kg/ha for 30 kg N/ha added – with good management, timely planting fertiliser application and adequate rainfall. Ideally the starter packs would include seed/planting material of alternative crops including grain legumes and potential soil-improving species such as green manures or agroforestry legumes, though this is unlikely to be included in the coming season due to the lack of time for organisation of the inputs.

At the moment the plan is to make the pack available to households, but consideration should be given to targeting the pack to women who are largely responsible for household food production. Women have much less access to fertiliser than men. Advances in increasing food production may be constrained due to their limited access to improved inputs.

There is a need to monitor what actually happens in the farmers' fields – how, when and where is the package applied, what yield increases are obtained, what was the rainfall pattern, and farmers' views on the pack's usefulness. Such information is needed for decisions on the continuation of the programme.

Some misgivings have been voiced about the potential impact of the scheme on the fledgling rural input supply market. There may be a trade-off between the short-term need to assist households improve their food security and the ongoing necessity to provide the private sector with the right conditions for them to operate an efficient and effective input supply and crop marketing system. The packs are to be distributed via ADMARC but consideration should be given to allowing all fertiliser traders an opportunity to be involved in distribution. There is also some concern that provision of free inputs could undermine credit programmes where farmers have been given fertiliser and seed on loan.

I.8.2 There is a need to increase land productivity

As household economies are highly dependent on agriculture, other crops are required to provide alternatives to maize. Tobacco, of various types, has long been the main smallholder cash crop. The opening up of burley production to smallholders has had a big impact for those with the resources to produce it. However, it is not an option open to all farmers. The crop requires good land management as it is highly demanding of nutrients and product quality is vital if good prices are to be obtained.

A number of grain legumes are grown by smallholder farmers and cultivation of these crops is identified as a strategy for improving livelihoods, nutrition and soil fertility. DFID has supported the Bean Improvement Programme in Malawi which has developed varieties with large productivity gains under smallholder farmers' conditions and similar approaches with other grain legumes will have a major impact on farmers' livelihoods. Increased grain legume production will also assist in suppression of problems such as *Striga* through crop rotation effects.

At present barriers to more widespread cultivation of grain legumes such as soyabean and pigeonpea are lack of established market infrastructure for these crops, despite the existence of a large market in South Africa and access to improved seed. Serious consideration should be given to support for schemes, which can assist in developing more assured markets for grain legumes. This will require a detailed examination of current markets with attention to possibilities for cost reduction in the marketing chain.

Malawi's central position amongst high output, low cost agricultural economies and its potential to capitalise on this has not received much official recognition, although this is being investigated by some donors (Coulter, 1998). Informal trade between Malawi and Mozambique, Tanzania and Zambia has been found to be considerable and to be of benefit to Malawi. A study by the Agricultural Policy Research Unit (Minde and Nakhumwa, 1997) indicates that the implicit welfare gains from informal cross border trade in food commodities surpass the value of lost import tax revenues. The study shows that export diversification should also focus on regional markets and recommends that governments in the region should view the movement of food commodities across their borders in a positive manner and remove import duties. To validate the results on informal cross border trade a longer observation period over three years is recommended.

Outgrower and co-operative schemes offer potential for assisting smallholders to diversify into high-value crops and intensify production of existing crops. In Malawi there are very few out-grower schemes. These were addressed by Coulter (1988) in a report for DFID. Such schemes require much stronger management than has generally been provided but offer potential for partnership with the private sector and potential for greater attention to investment in soil fertility. The UN Situation Analysis Poverty report (UN/Government of Malawi, 1993) calls for the production of high-value export crops and high-yielding food crops to create more employment and reduce food shortages. Outgrower schemes are an approach which may have considerable potential to assist smallholders obtain vital inputs. Outgrower schemes could be targeted to particular groups and could also have a farmer learning and soil fertility management component (see below). Some preliminary ideas have been developed for a study on farmer linkage initiatives in Malawi and northern Mozambique working with private sector and non-governmental organisations. The development of approaches to reduce the transaction costs of outgrower schemes is required.

I.8.3 Building stronger linkages between farmers, NGOs, extension and research

A clear outcome of this review is the opportunity which exists for harnessing the knowledge and capacity of different organisations involved in agricultural development in Malawi. The Maize Productivity Task Force has brought expertise within Malawi to focus on particular problems of maize production. A number of reviews, including this report, have highlighted low-cost interventions which may have widespread applicability within different regions of Malawi. A major challenge exists, as with the starter-pack approach, to make the knowledge on low-cost technologies widely available within Malawi. The present poor outlook for fertiliser applications to maize farmers favours adoption of low-cost interventions for improving soil fertility, such as the use of undersown green manures and management of organic resources within farms.

The capacity of the extension service to conduct experiments and demonstration trials has been proven through the nation-wide activities of the MPTF and a number of NGOs also have widespread activities targeting smallholder food production. A well-targeted programme of training for extension and NGO staff highlighting the strengths of potential interventions (including soil conservation practices) and their suitability to different climatic regions is required to provide them with good information on various options. Provision of training in participatory adaptive methods is also required to assist the extension/NGO workers in encouraging farmers to experiment with and adapt proposed approaches to suit their particular environments and needs. A programme which addresses the provision of knowledge, together with seeds of grain and green manure legumes for local multiplication and testing across the country could provide the impetus for major adaptation and changes within farming systems. At present much is being proposed on alternatives to reduce requirements for inorganic fertilisers, but little is being done to address the issue of how this might be brought about on a large scale.

I.8.4 Support for the poorest

There is concern over the impact of liberalisation on poorer households which has affected their ability to obtain inputs and to purchase food. Some studies have shown the importance of off-farm income– casual labour, trading of goods – as a supplementary source of income, but it is not clear to what extent such options are sufficient to lift households out danger (Minae, 1998; Peters, 1997). There is now information at a national level (FEWS, 1996) which identifies the most vulnerable areas in terms of poverty, food deficiency and malnutrition which could be used to target support to the poorest and most vulnerable households, many of which are female headed. Options proposed to target women farmers include fertiliser vouchers, small fertiliser packs, free grants of fertiliser, use of organic materials, combination of organic and inorganic materials, improving access to cash crop markets. (Gladwin, 1997)

While the trend in rural livelihoods is generally away from a maize mono-culture agricultural production system, much of the proposed "safety net" programmes tend to reinforce this "maize production-centric focus" to propping up livelihoods. "Food for work" programmes are mostly "maize for work", and the new starter packs proposed are for maize rather than other crops. Moreover, soil fertility itself is analysed almost exclusively in relation to maize productivity. From this point of view, many of the donor interventions and analysis of soil fertility and food security are somewhat conservative, going against processes of development some of which have been accelerated by liberalisation of the agricultural sector. More thought is required as to how the incomes of the poorest can be improved in the non-maize sector, including non-farm employment.

I.8.5 Integrated support for environmental conservation and improved land productivity

A number of initiatives have been established which support environmental conservation including soil conservation – such as the National Environmental Action Plan, the National Forestry Action Plan, water catchment schemes, community based natural resource conservation. It is important that these are linked to any action on improving land productivity including improving soil fertility. The limited success of soil conservation schemes may be attributed, in part, to insufficient consideration being given to economic and social aspects. There is scope for enhancing the effectiveness of these programme by incorporating socio-economic analysis during their planning, implementation and monitoring.

I.8.6 Development of rural infrastructure and institutional support to market liberalisation

Greater provision of rural services is required to assist traders to become more involved in input distribution and crop marketing. In order to do this rural infrastructure must be upgraded - more and better maintained roads to allow traders to get to the surplus producing areas and supply maize to the deficit areas. Improved water supplies in villages will allow people to spend their time more productively, and reduce the risk of sickness from water-born diseases.

Institutional support is also required. There needs to be enforcement of trading and quality standards, provision of timely information on prices and market conditions, rural banking and credit mechanisms to reach more households, support to livestock and poultry ownership through provision of veterinary services and law enforcement to ensure the safety of rural entrepreneurs. Thought should also be given in how traders can be encouraged to combine input supply and marketing functions with small-holder credit.

I.8.7 Support for value-adding enterprises

To increase the value of current agricultural production, more support should be given to processing and storage methods which allow value to be added in rural areas. This could be done by providing support to private initiatives to reduce the risk of investing in rural areas. Industrial and indigenous technologies for processing and storing maize are already well developed. There are possibilities for support to well-focused research and extension on the processing of non-maize crops such as sweet potato, cassava, groundnuts, sunflower, soybeans, sorghum, fruits and vegetables. This may offer a way of targeting help to females, young people, and the households with limited land areas.

I.9 Opportunities for DFID investment

We recommend that DFID provide complementary inputs to existing interventions in the short term, while supporting the development of a longer-term strategy by Government for improving the economic viability of the rural sector. Four areas for immediate support are recommended.

1. Support to monitoring and evaluation of the Starter Pack Programme to provide information on the success and targeting of this approach. The starter pack programme represents an opportunity to a) ascertain household numbers, responses, farming practices including soil fertility management, incomes, livelihood strategies which could be used to develop extension recommendation domaines, better target research and to be better informed on where to target development, on a geographic and household-type basis, and b) provide information to all rural households on the most efficient use of fertiliser, good husbandry practices and additional means by which yields can be improved through soil fertility management. In addition to providing information material for the packs, a national campaign on soil fertility would strengthen the initiative. Ideally the starter pack should include seed of appropriate varieties of alternative crops for the different agroecological regions, such as the promiscuous soyabean and groundnut, and other components of the 'Best Bet' technologies (see below).

2. Support for dissemination and increased seed availability of grain legumes. DFID has the opportunity to apply results of research it has already funded on beans and extend activities to strengthen dissemination of improved varieties of groundnuts, pigeonpeas, beans and soyabean. This requires back-up to address the wider issues of providing more assured markets for grain legumes, ways in which value can be added to these crops in the rural areas through processing, storage and marketing improvements.

3. Support for a widespread programme of information dissemination and training to strengthen linkages between farmers, extension, NGOs and research to test and further develop low-cost interventions to address the soil fertility decline at a national scale. Such a programme could be linked to the starter pack initiative, but would focus on developing the capacity of development workers to implement management interventions or 'Best Bet' technologies identified as having the most promise for smallholders. At present the promising results with these technologies are restricted to trials and demonstrations fairly limited in number and distribution, but they could be scaled up for widespread evaluation and adaptation by farmers. There is a huge gap between research and farmers, which needs address both to achieve the scale of impact required, and improvement at the farm scale. Involvement of major Malawian research team in this activity would also serve to inform and focus future research.

4. Promotion of business partnerships to support development of outgrower schemes; encouragement of linkages between estates and smallholders, particularly for assistance in crop marketing, and in support to development of rural infrastructure and marketing services through assistance to traders (training, credit, storage facilities, market information).

PART II. REVIEW OF INFORMATION

1. THE POLICY ENVIRONMENT

Introduction

Malawi's fertile soils may have, in part, contributed to the current, regrettable state. Successive waves of people from other parts of Africa and Europe were attracted by the availability of fertile land. Population densities are now some of the highest in Africa and households are dependent on plot sizes averaging 0.5 ha with one rainy season to support them. Maize began to take over from sorghum as the staple food in the early part of the century – it offered a much higher calorie content per hectare, was relatively pest resistant and performed well under smallholder conditions.

Under the command economy type approach adopted by the previous government, great reliance was placed on maize production to meet food consumption requirements and on tobacco to generate foreign exchange. Diversified cropping systems were discouraged, even where this was more appropriate from an agro-ecological, economic and cultural perspective. Pressure was exerted on smallholders to monocrop, particularly hybrid maize, including areas not suitable for maize and in regions where it was not a staple food. Though the country was forced to import maize as early as the late 1970s (Dorward, 1987) food (which was equivalent to maize in policy terms) self-sufficiency was the core policy goal which guided sector strategies. More than 75 per cent of cultivatable customary land was allocated to maize. Production of maize on unsuitable land such as steep slopes, contributed to erosion and land degradation and did not generate food self sufficiency (Mataya, 1998).

Although agriculture was given a high priority, with the aim to develop both the estate and the smallholder sectors, estates were emphasised largely at the expense of smallholders (Gulhati, 1989). ADMARC was established as a parastatal to develop estates and promote industrial and commercial ventures. It was a major source of financing for tobacco estates which it obtained from the large financial surpluses generated from the difference between the low prices paid to smallholders for export crops (tobacco, groundnuts and cotton) and the border prices it received for the sale of these commodities. As a result smallholders diverted land from cash crops to maize (Gulhati, op.cit.). The heavy taxation of cash crops reduced the real rate of return to smallholder labour, and led to a transfer of labour from small-holdings to estates in order to provide a source of income, in spite of a continuous decline in real wage rates (Kydd and Christianson, 1982). Productivity in the smallholder sector is estimated to have grown, at most, by three per cent per annum in the 1970s. Population growth was 2.9 per cent so annual smallholder production per head of population remained more or less constant (Rees-Jones, 1986).

Liberalisation measures were introduced gradually from the 1980s onwards during the structural adjustment programme. These initially focused on 'getting the prices right' particularly for smallholder export crops and then extended to removing the fertiliser subsidy in order to remove price distortions and reduce the budget deficit. Liberalisation of marketing of smallholder crops was also introduced though initially given less priority (Owens, 1997). The change in government in 1994 has enabled greater adherence to the reforms. Agricultural prices were fully liberalised in 1995, with the exception of maize (Ng'ong'ola et al, 1997a).

Encouragement of smallholder households to meet their own needs and to produce a maize surplus has long been equated to national food self-sufficiency and is still the main avenue followed by government. In the past this approach ignored the importance of other crops in meeting food requirements particularly in times of drought (Mataya, 1998) and still gives little credence to the importance of informal cross border trade with neighbouring countries as a source of agricultural inputs and food crops (Minde, 1997). While adequate supply of maize as the main staple is still very important (Conroy, 1998) in this land-locked, drought-prone country, economic efficiency in its provision needs to be considered.

There is increased recognition of the need to move away from "our dangerous dependence on maize for food and tobacco for cash" as highlighted by the Minister for Agriculture and Irrigation, the Hon. Aleke Banda in his inaugural ministerial speech (Banda, 1997). He stressed the need to speed up the transfer of productive innovation from research via improved extension to assist farmers raise their production and income. He called on farmers to diversify into drought-resistant food crops, and produce cash crops other than tobacco.

1.1 Government policies on prices and procurement of agricultural inputs, outputs and taxation policies which may encourage or discourage agricultural production

The Agricultural and Livestock Development Strategy and Action Plan of 1995 outlines government policy on procurement of agricultural inputs and outputs.

> "The Government is committed to achieving a stable economic environment through implementation of effective macroeconomic and microeconomic policies. With regard to agricultural outputs and inputs it will, with its policy of liberalising markets for both goods and services, produce a competitive and rewarding environment for increased and sustainable agricultural production. It will use the minimum of market and price interventions consistent with these aims. All barriers to firms or individuals producing or marketing agricultural products will be removed ... MoALD will strengthen its monitoring activity on the development of liberalised markets in order to pay due attention to mitigating the negative impact of market failure on poverty alleviation." (Ministry of Agriculture and Livestock Development, 1995).

1.1.1 Agricultural inputs

Since 1993 there has been significant liberalisation of the fertiliser market with the removal of subsidies and of restrictions on fertiliser trade. The issuing of import licenses was abandoned and the Fertiliser Farm Feeds and Remedies Act was amended in 1994 facilitating private traders to supply fertiliser, animal feed and seeds. In the same year ADMARC became involved in the commercialisation of fertiliser distribution, and maximum retail selling prices were abolished. Subsidies were fully removed 1995/96 and the private sector was allowed access to the Fertiliser Buffer Stock in 1997. These reforms have contributed to the dynamic growth of private sector operations in fertiliser imports, blending, and distribution (Conroy, 1998).

Production and marketing of hybrid maize seed was liberalised in 1993/94 and seed is widely available. Price subsidies of approximately 10 per cent were removed in 1994/95 (Ng'ong'ola, 1997a). Tobacco seed is available from input suppliers. The supply of seeds of other crops is more problematic. Some vegetable seed is produced locally and some is imported. Seed of crops such as groundnuts, soybean and beans is hard to obtain, particularly of improved varieties.

The government does intervene in supply of inputs in special circumstances, such as in disaster and drought relief. In 1994/95 seed and fertiliser packages (5 kg maize and 50 kg CAN) were distributed to 80,000 poor households in the most drought-affected EPAs.

The APIP, supported by the EU, was initiated in 1997 to supply hybrid maize seed and small packs of fertiliser, from the fertiliser buffer stock, on credit to smallholders. This programme is targeted at poor smallholders to increase their marketed surplus.

1.1.2 Agricultural outputs

Market liberalisation has led to several significant changes in the economic environment over the past decade. These include deregulation of prices for most commodities including maize, and cash crops; restrictions removed on production of crops by smallholders, particularly burley tobacco; and increase in the involvement of the private sector and a reduction of importance of ADMARC in agricultural output trading (Brown et al., 1996; Gulharti, 1987). The sequencing of output and input marketing forms has created problems in some rural areas. Liberalisation of output marketing began in 1987 and ADMARC markets were closed in some areas (to reduce their costs) with the expectation that private traders would move in and purchase farmers' crops. In some areas it was not profitable for private traders to operate either and farmers suffered. They were also unable to obtain agricultural inputs since the input market was not liberalised until 1993/94 (Ng'ong'ola et al, 1997a)

A price band for maize was introduced in 1995. A maize price floor is supposed to protect producers and to ensure that farmers are able to recover the cost of using fertiliser and hybrid maize seed. The price ceiling is to protect consumers from extreme increases in maize prices when production is low. The impact has been mixed. Problems have included:

i) lack of resources to defend the producer price floor and the consumer price ceiling;
ii) delays in decision making related to revising the upper limit of the price band;
iii) poor timing of some interventions related to purchasing and selling maize from the Strategic Grain Reserve, and
iv) problems of implementation including non-transparent procedures for drawing grain from the SGR by ADMARC and others (Conroy, 1998).

The Maize Pricing and SGR Management Committee have recommended a new price band to the Cabinet Committee on the Economy (May 1998). The proposed floor price is MK3.00/kg and the consumer price ceiling is MK7.00/kg. The price band has been approved in principle but there is concern that resources in the SGR account may not be adequate to defend the price ceiling (Conroy, op.cit.).

Liberalisation has not removed the dominance of maize on most smallholdings. However, there are indications that production of staple and cash crops other than maize has increased significantly over the past eight years, with increasing attention given to beans, groundnuts, rice, sorghum and millet, cassava, sweet potatoes and Irish potatoes as given in the MAI crop estimate data.

The number of private traders is growing and there has been an increase in the volume traded in local markets. There are increasing price differentials between local market prices and the Government producer price though ADMARC markets are still important in areas where maize is sold in bulk. Private traders are critical for bulky commodities such as vegetables, cassava and sweet potato which have a short storage period and were not traditionally handled by ADMARC (Minae, 1998). There is also growing spatial and temporal variation in crop prices. The average selling prices of the main agricultural commodities in the main markets are published each week by the Agro-Economic Survey. These show considerable variation between different areas. Private traders operating in the rural areas, unable to bear the losses which ADMARC absorbs, offer prices 20-30 per cent below the official floor price, which narrows the profit margin on maize (Carr, 1997).

1.1.3 Taxation

Fertiliser is surtax (value added tax) exempt but surtax is charged, at 20 per cent, on agrochemicals, equipment, spare parts, packing materials and fuel. A charge of one per cent is levied on fertiliser imports to cover SGS (Société Génerale de Surveillance) verification for surtax and product content. Smallholders do not pay any form of income tax. Estate owners may be liable for company and income tax.

1.1.4 Policies on soil fertility

Prior to Malawi's independence, soil conservation, including aspects of fertility, was high on the colonial agricultural policy agenda. The enforcement of conservation measures became a focal point for political action during the independence struggle. After independence soil conservation received a low profile in the Department of Agriculture (Wellard, 1996).

Increased attention to soils came mainly through government and donor soil conservation initiatives during the 1980s and early 1990s, but few of these addressed soil fertility as a specific issue. The 1995 Agriculture and Livestock Strategy highlighted, for the first time, the need to tackle the issue of soil and land degradation. The policy objective is stated as 'prevention of degradation and restoration of soil fertility'. The strategies to attain the policy include: i) developing and promoting economically viable sustainable farming systems (responsibility: MoALD/DAR; time frame: short - medium); ii) encouraging watershed management as an integral part of targeted interventions for the resource poor; iii) publicising the security and vulnerability of natural resources. Strategy components include and soil moisture conservation to prevent soil degradation and improve productivity; agroforestry and intercropping to raise and maintain soil nutrient status (MoALD, 1995).

The Land Conservation and Resources Department of the Ministry of Agriculture and Irrigation is in the process of preparing a strategic plan.

1.2 Co-ordination among ministries on above policies

The Ministry of Finance tends to be at the forefront of negotiations with the IMF and World Bank with the Technical ministries having less direct involvement, which lead to tensions. A lack of concerted action between the two main ministries concerned - Ministry of Finance and the Ministry of Agriculture - has been observed which is considered to have had an impact on the way in which policies are developed and implemented. During the negotiations of the second Structural Adjustment Loan in the mid-80s it is alleged that the Ministry of

Finance agreed to the World Bank's fertiliser subsidy removal conditions without consulting the Ministry of Agriculture, even though the latter were supposed to implement the reform (Owens, 1997).

Following donor pressure, the issue of soil fertility is beginning to receive more attention. A sub committee of the Food Security Committee (FSC) has been formed recently to look at soil fertility. The FSC falls under the jurisdiction of the National Economic Council which is part of the Office of the President. Although Ministry of Agriculture staff are members of the sub-committee they are not directly responsible for it.

There are a number of initiatives concerned with food security, soil fertility, land and water conservation, and approaches being implemented, but concern has been voiced that information about these are not well co-ordinated or documented. There is a danger that in the absence of good documentation research is repeated and lessons learned in one project or department are not made easily available to others, and mistakes are repeated or resources wasted.

Mechanisms for implementation, commitment to the process and liaison with other departments also concerned with the environment, such as the National Environmental Action Plan (NEAP) are mentioned in the Agricultural Strategy document but not well developed. The Planning Division is designated to play a key role in co-ordination and to undertake initiatives to improve institutional linkages while technical departments are detailed to develop consultative arrangements to improve technical operation (Ministry of Agriculture and Livestock Development, 1995).

1.3 Degree of agreement among donors and government on such policies

Considerable polarisation is observed amongst the donors over recommended courses of action on the best ways to address food security and improved agricultural productivity (Mataya, 1998). While many of the measures introduced under structural adjustment have removed barriers and opened up markets they may have been implemented quickly and with insufficient consideration to possible disbenefits and problems.

For some donors the problem of food security is a supply side issue, while for others it is perceived as a effective demand problem. This is turn affects how soil fertility is viewed, and what interventions are recommended and supported (Mataya, op.cit.).

The World Bank has insisted on removal of fertiliser subsidies as part of the Structural Adjustment Programme and promoted the need to improve agricultural productivity by relying on the market to provide the right signals to farmers. The USAID supports a market-led approach although it acknowledges the need for a safety net programme to protect the most vulnerable of the population.

The EU and other European donors appear less convinced of relying on the private sector and consider that many of the conditions necessary for the efficient and fair operation of the private sector are not sufficiently developed for such a process to work without penalising the poorer smallholders. The EU is supporting several programmes to provide fertiliser to smallholders. However, it is also considering supporting development of rural infrastructure through construction of rural roads.

1.4 Impact of exchange rate policy, including unstable exchange rates, on agricultural production

Foreign trade - exports of semi-processed agricultural commodities and imports of agricultural inputs, machinery and vehicles – accounts for a large sector of economy (approximately 50 per cent of GDP). Fluctuations in trade have a major impact on the level of economic activity (Gulhati, 1989). Deterioration in terms of trade has deleterious impact on the economy and on the exchange rate.

Exchange rate policy is based on a managed float, with the key objective of maintaining foreign exchange reserves equal to four months of imports. The main source of foreign exchange earnings is the sale of tobacco and the exchange rate is closely associated with the value of the annual tobacco crop. The prices obtained at the start of the 1997/98 season have been poor, due to oversupply of tobacco on the world market and to the mixed quality of tobacco offered particularly smallholder burley tobacco. It is likely that the value of the Kwacha will need to realigned against the major currencies during the year.

The declining value of the Malawi Kwacha against the hard currencies has had a major impact on the cost of fertiliser, the main agricultural input. See table 2.1 (section 2.1). The price of fertiliser in US$ terms has been static for the past two to three years. Smallholders, whose maize yields are falling, are blaming the increasing Kwacha cost of fertiliser for its declining use. This has serious implications for national food production and food security.

The poor exchange rate also affects the cost of other imported agricultural inputs, locally made goods with a high import content and the transportation of goods.

1.5 Legislation on the identification and quality control of fertilisers and on their sale and use

The Farm Feeds Fertiliser Act provides guidelines for the quality of fertilisers and mechanisms exist for checking the content and quality of fertiliser. The Malawi Bureau of Standards (MBS) is responsible for monitoring the quality of fertiliser supplied. The SGS is responsible for verification of consignment contents with stated contents at the border check posts.

The objectives of the national fertiliser policy are to introduce competition into the domestic smallholder fertiliser marketing at all levels by eliminating the SSFRM monopoly; to improve access of fertiliser by smallholder farmers in a timely manner, at affordable prices and encourage them to use suitable and recommended fertilisers which are area specific, and to terminate subsidies on fertiliser, thus encouraging companies to emerge and enhance importation, distribution and retailing of the commodity and also reduce the budget deficit (anon, 1997).

Concern has been voiced, however, at the lack of monitoring and inspection of consignments and of the weight of fertiliser supplied. It is recommended that the government monitor the standards of fertiliser supplied in terms of quality and weight and establish a penalty for infringement of trading standards (Anon., undated).

Several examples were given by key informants of the poor fertiliser storage practices which affect the quality of the product. Bagged fertiliser should be stored on wooden pallets (dunnage) as is the practice in the SSFRM storage depots. It has been observed that some fertiliser suppliers and traders are not observing such practice, particularly in rural areas where purpose-built stores are not available and use has to be made of existing buildings not designed for the purpose. Fertiliser sacks are stacked up to roof level of unventilated store rooms. Water leakage into stores has caused burns from leached urea and caked the fertiliser. Tampering of fertiliser is alleged. Very little control is exercised by the MBS, particularly in the rural areas.

A very clear guide on fertiliser retailing by small traders was produced by the FAO in 1990 ('Fertiliser Retailing Guide'). It covers managing a fertiliser business, storage and handling, nutrients and products and the economics of fertiliser use and application. This guide could be publicised on the radio and made available to fertiliser retailers.

1.5.1 Implications

Farmers appear to be reacting to commodity prices, and are now less affected by ADMARC's pan-territorial and pan-seasonal pricing policies (although the private fertiliser suppliers do effectively subsidise fertiliser prices in the north). As a result, distinctive patterns of regional differentiation and seasonality are emerging (Jaffee, 1997; Minae, 1998).

Aggregate data show increasing crop production and increasing per capita food availability, although with large inter-year fluctuations (Table 1.1) and seasonal and geographic variations. Doubt has been expressed over the accuracy of this data, particularly pertaining to the contribution of root crops (cassava and sweet potato) to overall calorie availability, although a large increase in the production of cassava and sweet potato has been observed (.[2] The removal of subsidies, price control and trade restrictions are considered to have affected the vulnerability of some groups more than others. Farmers who practice mixed agriculture, growing some maize with cash crops, are considered to have been adversely affected by the removal of the subsidy on fertiliser (FEWS, 1996) but may have begun to benefit from increases in crop prices.

Table 1.1 Changes in population and food per capita availability, 1990-1998

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Population ('000)	8,774	9,005	9,345	9,644	9,952	10,271	10,599	10,939	11,289
Per capita kcal/day	1,819	2,127	919	2,500	1,239	1,805	2,593	2,246	2,715*
Per capita kg maize equiv/yr	192	225	97	264	131	191	274	238	287*

[2] Root crops are often intercropped with maize or grown along field boundaries making national yield estimation more difficult. It is important to calculate the dry weight rather than the wet weight as cassava contains 70-80% moisture, and to use an accurate representative unit weight for calculating annual yield – cassava can be left in the ground for more than a year which affect growth rates.

Source: MAI 3rd round crop estimate data * 1st round estimate
NB kilocalorie figures relate to cereal and grain crops and do not include fruit, vegetable, cooking oil, meat

The above figures have given grounds for optimism that the situation is improving. However, there has been some dispute about the accuracy of the data used, particularly some of the root crop yield figures. The wide variations in food availability from year to year even where rainfall was good (e.g. 1995 onwards) are indicative of the inaccuracy of these estimates. There are also discrepancies on the number of rural households – several reports quote a report of 1.8 million households; a recent livestock survey quotes over 2.2 million households. Without reliable data it is extremely difficult for policy makers to develop appropriate strategies. An area which has gone largely unreported is that of informal cross border trade and its importance to Malawian food security. This is discussed briefly below.

1.5.2 National and regional considerations

Considerable quantities of maize and other food crops are being brought into Malawi from across its borders by traders. Greater consideration needs to be given to Malawi's strategic position at the heart of a rich agricultural hinterland (Coulter, 1998) which includes northern Mozambique, southern Tanzania and eastern Zambia. In spite of press misgivings about declining self sufficiency in maize, "Malawi should at least be self-sufficient in maize but the country will never achieve this as long as fertiliser prices are exorbitant" (Daily Times 27.5.98), traders from northern districts of Malawi have already visited Mozambique to look at the possibility for buying maize surpluses (The Nation, 14.4.98). The volume and importance of informal cross-border trade is examined by Minde (1997). This study attempts to quantify the value of trade and to estimate its costs and benefits. It describes a dynamic, well-organised sector which, in 1995/96 had an estimated value of US$60 million.

Malawi needs to consider a) how to use its limited land resource to maximum potential and b) how to take advantage of its position and relatively high level of industrial processing capacity to act as the regional centre for agro-processing and value adding to agricultural and forestry resources.

2. SUPPLY AND USE OF FERTILISER

2.1 The use of fertilisers by smallholders over the past ten years; types, quantities, and the crops and soils on which they are mainly used

2.1.1 Use of fertilisers by smallholders over the past ten years

The total consumption of fertiliser by the smallholder sector has fluctuated considerably over the past ten years (see table 2.1. below). The major causes of these fluctuations are access to credit, changes in the retail price, and the price of maize. Increasing fertiliser use in the late 1980s and early 1990s is attributed to the growth of smallholder credit schemes and subsidies. In 1993 some 25 per cent of smallholders had access to credit for agricultural inputs under the Smallholder Agriculture Credit Administration (SACA) (see section 2.6). The Malawi Rural Finance company, which replaced SACA, reaches less than five per cent of smallholders. It is estimated that 65 per cent of fertiliser used by smallholder households was financed by seasonal agricultural credit (Conroy, 1998a).

Table 2.1 Smallholder fertiliser consumption, 1987-1997

Year	Consumption (tonnes)
1987/88	73,588
1988/89	87,612
1989/90	99,389
1990/91	114,578
1991/92	131,682
1992/93	142,605
1993/94	83,073
1994/95	120,263
1995/96	176,863
1996/97	92,096

Source: MAI Inputs Section, 1988

Fertiliser use by smallholder households is highly skewed to households in the highest income quartile. It is estimated from survey data from the early 1990s that 70 per cent of fertiliser was used by the richest twenty-five per cent of households; the second wealthiest quartile used 21 per cent while the poorest half of smallholder households used less than ten per cent (Conroy, op.cit). Female-headed households are disproportionately represented in poorest household groups.

Conroy suggests that these findings are likely to have been affected by market liberalisation and the growing importance to some smallholders of burley tobacco production. She considers that fertiliser use is likely to have become even more skewed to the richer households. The increased price and reduction in the availability of credit means that fertiliser is likely to be purchased by richer households, particularly those producing burley tobacco, for application to their burley crop. The decline in the maize-nitrogen price relationship means it is not economic to apply fertiliser to hybrid maize (MPTF, 1997b).

Women have much less access to fertiliser than men do. Data from Malawi collected in 1991 showed that the majority of women farmers did not use inorganic fertiliser because they had no cash or access to credit (Gladwin, 1997). In many households women have little control over household income and its use (Minae, 1998; Nelson, 1998). Women are largely responsible for producing food crops while men are more likely to grow cash crops for which they can obtain fertiliser on credit.

Fluctuating fertiliser use and an increasing population has led to a slight decline in capita fertiliser consumption, both in terms of purchased fertiliser consumption and fertiliser obtained on credit (Conroy, op.cit.).

2.1.2 Types, quantities, and the crops and soils on which they are mainly used

Most fertiliser sold is used for tobacco, which is generally grown on sandy loam soils, and to other high-value crops such as vegetables. Preferred fertilisers for tobacco are a basal dressing of Compound C or Super D or CAN (Calcium Ammonium Nitrate) and a top dressing of CAN. For maize, which ideally should be grown on a heavier soil, the recommended fertiliser type is DAP (Diammonium Phosphate) followed by a top dressing of urea. Farmers are said not to like to use urea as, if incorrectly applied, it can burn the maize roots.

2.2 Prices paid over the last ten years in 1998 Kwacha

Table 2.2 Fertiliser prices in 1998 MK (per 50kg bag)

Year	23:21:0+4S	DAP	CAN	Urea	Maize MK/kg	US$/MK[1]	MK/1998MK
1987/88	-	357	278	306		2.2134	11.34
1988/89	318	338	269	294		2.5644	9.79
1989/90	370	388	318	346		2.6818	9.36
1990/91	415	405	387	375	2.49	2.7245	9.21
1991/92	445	436	427	400	2.67	2.8217	8.90
1992/93	488	461	484	424	2.99	3.6013	6.97
1993/94	465	403	414	366	2.68	4.3996	5.71
1994/95	303	289	300	240	2.00	9.032	2.78
1995/96	651	570	473	562	2.05	15.2741	1.64
1996/97	615	594	469	588	2.54	15.3027	1.64
1997/98	448	-	448	586	2.36	16.489	1.52
1998/99		633	417	570		25.1[2]	1.00

Source:
Fertiliser prices - 1987/88-1996/97 Inputs section, MAI; 1997/98 FAO report; 1998/99 Daily Times 27.5.98;
Exchange rates - Ministry of Finance; [1] Annual average exchange rate; [2] May 1998 exchange rate
Maize prices – Symons, 1998

The Government began subsidising fertiliser in 1982 to encourage production of hybrid maize. When traditional supply routes were cut as a result of the civil war in Mozambique the subsidy helped cushion the impact of higher transport costs (Ian Twyford, personal communication). Fertiliser subsidies were gradually phased out, as part of the structural adjustment programme – the final element of subsidy was removed in 1993/94. This has had some impact on fertiliser prices. High analysis maize fertilisers - urea and DAP - were heavily subsidised (between 20 and 25 per cent). These recorded the highest price increase between 1987/88 and 1997/98 of 91 per cent and 68 per cent respectively. CAN was less heavily subsidised, at around 15 per cent, and the price increase over the last ten years is lower at 44 per cent. The cause of larger price increases since 1995/96 has been as a result of the devaluation of the Malawi Kwacha against the US$ since its flotation in 1994 (see Table 2.2). Due to the absence of reliable estimates of inflation the US$:MK exchange rate has been used as a proxy to convert fertiliser and maize prices into constant values.

2.3 The main suppliers of fertilisers and issues in importing and financing of fertiliser supplies

Currently some 12 companies account for 75 to 80% of the fertiliser market (Conroy, 1998). The main suppliers of fertiliser are Optichem, now a wholly-owned subsidiary of Kynock of South Africa, Norsk Hydro (Malawi), Interrep, Farmers' World, Agora, Farm wise, Lufina, Maxifert, and Hardware and General. Together these account for approximately 80 per cent of the market. The Smallholder Farmer Fertiliser Revolving Fund (SFFRFM), a parastatal being put up for privatisation, accounts for the remainder of the market. ADMARC acts as a distributor for SFFFRM and supplies smallholders through its large network of rural markets. In the north of the country it is one of the main retailers of fertiliser.

The large agricultural estate companies such as Press Agriculture, CDC, and a group of tea and tobacco estates import their own fertiliser. Prices obtained by direct purchase are reported to be lower than those obtained on the local market and the existence of a private input supply company is said to have contained the price at which fertiliser is sold locally (Coote, 1997). The fertiliser suppliers either import fertiliser on their own account, purchase from the larger importers or, in some circumstances, from the fertiliser buffer stock.

The SFFRFM sets the retail price level for fertiliser in discussion with Optichem and other suppliers. During the last two seasons the price of fertiliser has not increased significantly, in current prices, due to there being sufficient carry over stock from previous years (Conroy, 1998a). Large price increases have been announced for the 1998/99 season due to the need to import new stock, which are between 13 and 56 percent higher (in nominal Kwacha) than last season's which has caused considerable outcry (Daily Times 27.5.98).

The main issues in supplying the local market are the high internal transport costs and the high cost of holding stock and developing a retail network. Other issues include theft in transit and from storage and damage to stock as a result of poor storage.

2.4 Factors influencing the transaction costs of fertilisers and the efficiency of the delivery services

The main factors affecting transaction costs are i) the size of the order, source of supply and time of ordering, ii) distance to be transported, iii) cost of finance and foreign exchange and risk of devaluation and iv) mark up. Packaging of fertiliser into smaller bags also increases costs. Efficiency of delivery is related to good management, effective, timely and reliable delivery including minimal border check delays and interference.

2.4.1 Size of order, source of supply and time of ordering

The size of Malawi's fertiliser market is estimated to be between 150,000 and 180,000 tonnes though no-one is quite sure of the figure as smallholder demand fluctuates considerably. This amount is now divided up between a number of importers instead of the two main importers prior to liberalisation. This may affect the unit price obtained. The greater the size of the order the greater the discount that can be expected.

At present urea is very cheap in Europe (farm gate prices about £100-£110/tonne; US$80 per tonne f.o.b. Black Sea ports) due to a glut on the market. It should be possible to land urea in Malawi for US$ 250 – 300 per tonne. South African fertiliser tends to be more expensive as it is produced from imported feedstock. However, the main fertiliser importers have links with the more expensive South African and Zimbabwean producers and may not be interested in sourcing cheaper supplies from elsewhere.

The time of ordering also affects the price paid. Fertiliser prices are lower in winter in Europe, by as much as 20 per cent. Considerable savings can be made by ordering in the off season from Europe.

2.4.2 Transport costs

Most of Malawi's fertiliser comes via South Africa, which adds considerably to the cost compared to delivery to a Mozambican port (Beira, Nacala). The transport cost from Johannesburg to Blantyre is currently US$96/tonne (MK2,400/tonne) which equates to around 22% of the 1997 retail price of urea in Blantyre. The SFFRFM has tried importing loose fertiliser via the Nacala line but experienced a lot of theft and loss which they were unable to recover from insurance.

Internal freight costs are also high. The current cost (1998) per tonne kilometre is MK2 (US$0.08/tonne kilometre) which adds considerably to retail prices. The main fertiliser companies practice pan-territorial pricing with fertiliser is sold for the same price in Chitipa as in Blantyre. The higher costs involved in distributing fertiliser in the north are subsidised by users in the south. This practice is said to benefit the smallholders in the north at the expense, mainly, of the estates in the south. However, it may reduce the scope for regional specialisation, and adversely affect the higher density areas of the south where additional fertiliser is most urgently needed.

2.4.3 Cost of finance and foreign exchange and risk of devaluation

When imports are purchased with a letter of credit 'at sight' the importer needs to obtain the foreign exchange in advance. If by the time the goods are available for sale the local currency has lost value in hard currency terms the seller will increase the retail price in order to be able to purchase the same value of goods for the next order.

2.4.4 Profit margins

It was difficult to obtain any figures for profit margins for fertiliser sales though anecdotal evidence suggests that they are at 12-17 per cent or more of the Malawi landed price. From discussions with the trade it would appear that the main operators are more interested in increasing market share than increasing the size of the market. Because of the nature of the market operators may prefer to maximise their return from supplying a limited quantity. Suppliers do not seem to be particularly interested in developing the higher cost end of the market unless there is some support from a donor project and a guaranteed return.

2.4.5 Small packs

The availability of smaller pack sizes has been suggested as a means of encouraging greater use of fertiliser. Experience with small packs has been mixed. The SSSRM has supplied small packs in the past but these were not found to be commercially viable and production was stopped. Norsk Hydro still packages a small proportion of fertiliser in 5, 10, and 20 kg bags. The increased cost of handling and packaging is passed on to customers. For example, an 18 per cent price difference, on a per kilogram basis, between 5 and 50 kg bags was observed for CAN fertiliser sold by Agricultural Trading Company. The Situation Analysis of Poverty report (UN/Government of Malawi, 1993), based on survey work in the early 1990s noted a positive response to the introduction of smaller fertiliser pack sizes of 10 and 15kg.

Anecdotal evidence indicates that people club together to buy a bag of fertiliser and that children working in towns give fertiliser to their parents. Fertiliser is sold loose in local markets.

2.5 Government attitudes to private enterprise in the supply of inputs

Although through its policy statements it appears committed to handing over agricultural input supply to private enterprise in practice ADMARC still dominates marketing activities in some rural areas. Liberalisation has attracted a number of individuals and firms to fertiliser trading and it is considered that this has been to the benefit of farmers who no longer have to travel so far to purchase fertiliser. In a survey of traders conducted by APRU (Ng'ong'ola et al, 1997) several points were raised for improving the efficiency of the marketing system. These included using the extension services to improve the linkage between private traders and farmers by creating awareness of the types of fertiliser on the market and by feeding back information from farmers on types required. Traders felt there was a need for facilitating access to credit for capital investment – for warehousing, heavy goods vehicles – and for working capital to enable traders to acquire stocks and have them delivered to the required centres on time.

A large informal market in supplying fertiliser from outside the country also exists. Some 17,000 tonnes of fertiliser were said to have been imported from Zambia in 1995/96 (Minde, 1997), and fertiliser from Mozambique and Tanzania regularly finds its way onto the Malawi market.

2.5.1 Other issues

The quality of imports and adherence to stated contents is supposed to be checked by SGS at the border, (for which a 1% charge is levied). The Malawi Bureau of Standards is supposed to carry out checks within the country but testing is not undertaken on a regular basis. The maintenance of quality is important as differences in formulation and mixing methods can affect nutrient availability to the crop and hence yields.

Farmers are used to using prilled fertiliser in which all ingredients are equally distributed in a granule. One company has started to import raw ingredients and blend, but not prill, them locally. It is not advisable to transport blended fertilisers over long distances as the contents separate out, but this is being done. Farmers may not be aware of the need to remix the fertiliser before application and end up applying different nutrient quantities to each plant. This could be a particular problem where farmers are sharing a bag.

Proper storage on dunnage in well-ventilated dry stores is necessary for fertiliser. There are reports that traders are not following such practices. In the rural areas fertiliser is being stored in old stores and buildings, stacked directly onto the concrete floor up to the roof. Caking and water damage and leaching may occur and farmers may have little choice but to purchase this if they need fertiliser at that time.

Concern has also been voiced about the possibility of unfair trading, where loan officers tell their clients they have to obtain their loan fertiliser from a particular supplier, who is not necessarily the cheapest, adding to their repayment burden.

2.6 The credit systems, both informal and formal, which are currently operating in rural areas and they degree to which they are effective and efficient

The financial system is small and undeveloped and the formal financial sector largely ignores smallholders and the rural poor (Buckley, 1996). Formal credit organisations do operate in rural areas but reach only a small number of people. Female-headed households are underrepresented as members of credit programmes (Diagne et.al, 1995). The three credit institutions serving the rural population are the Malawi Rural Finance Company (MFRC) which took over from the Smallholder Agricultural Credit Association (SACA); Promotion of Micro-enterprises for Women (PMERW), operated by the commercial Bank, and the Malawi Union of Savings and Credit Co-operatives (MUSCCO). A few NGOs, and donor-funded projects operate credit schemes.

The informal financial sector plays a vital role in providing, mainly short-term, credit. It includes money lenders, traders and grain millers, estate owners, employers, co-operative savings associations, community funds, and friends, neighbours and relatives. The size of the informal sector credit is not known but it is estimated to be much larger than the formal sector (Buckley *op.cit.*).

The profit-oriented MFRC is a government-owned institution, though destined to become at least 80 per cent privately owned by 1999. The MRFC receives funding via lines of credit from the IDA and IFAD with a ten year repayment grace period to build up its capital. It provides finance to smallholders and small estates at commercial rates of interest with a three-tiered interest structure, currently 34 per cent for prime customers; 36 per cent for repeat customers and 37 per cent for new borrowers charged on a reducing balance basis.

Smallholders (those who farm customary land without title) must belong to a group or club to qualify for MRFC loans which are repayable over one season (one year). They must be growing a cash crop (e.g. maize, cotton, rice, paprika, groundnuts, soya, vegetables) with a positive gross margin from which to repay the loan and they have to be able to make a ten per cent down payment. The average size of a loan is K1,800; average repayment time is ten months. Although the MRFC's aim is to become the bank with the largest number of customers currently it only reaches about five per cent of rural households. In 1996/97 the MRFC had 102,362 seasonal loan customers.

The Malawi Mudzi fund, established in 1989, has been amalgamated into the MRFC. It is which is based on similar principles as the Grameen bank in Bangladesh. It now operates two loans schemes for resource poor people (whose net worth does not exceed the equivalent of five bags of maize) – the Mudzi Small Business Loans which provides loans to individuals with no collateral who are members of a group and who undergo training and the Mudzi Tikolore ('let us gather') scheme in which group of farmers without cash collateral can obtain a loan. To date this scheme has not have a large impact due to the small membership. In 1997/98 MRFC had 1,513 Mudzi business customers and 636 Mudzi seasonal (Tikolore) customers.

It is often argued that credit to buy hybrid seeds and fertilisers is a prerequisite for increased food production. A study of access to credit in the mid 1990s found that participation in formal credit schemes was a major factor in the adoption of hybrid maize and tobacco. Adoption of these two crops was found to significantly raise farm incomes which led to significantly increased consumption expenditure. It also found women generally have less access to both formal and informal credit than men (Diagne, op.cit.) do.

However, it has been suggested (Buckley op.cit.) that factors such as land holding size, wealth or income are more important than credit in explaining farmers' willingness to adopt new "maize packages", and other studies argue also that it is the policy factors rather than the quality of the technology that have been most influential in more recent years (Smale et al, 1998 and Zeller, et al 1997)[3]. The pricing policy for maize is also important. Purchase of fertilisers implies a high credit liability which is often too risky for most smallholders, when maize prices are low and/or not guaranteed. Borrowing is now so costly (with nominal rates around 35 per cent) that people may try to purchase inputs with cash to avoid the added burden of interest, and to ensure timely application -delays in supplying loans can lead to late application of fertiliser (Joe de Gabriel, personal communication).

The most well-known organisation concerned with agricultural input supply was the Smallholder Agricultural Credit Administration (SACA). Credit packages for hybrid seeds and fertilisers were given to members of farmers' club credit groups. However, it is alleged that this programme favoured farmers in the richer Central Region while farmers' needs in the Northern and Southern regions were neglected and, although SACA's target group were poor smallholders, the actual beneficiaries were the better-off farmers (Buckley, op.cit.). The "core-poor" (less than 0.5 ha) and the "poor" (between 0.5 and 1.5 ha) had hardly any access to this credit scheme. Repayment rates were high because defaulters were severely dealt with.

The rate of loan defaulting on agricultural credit worsened dramatically after the 1991/92 drought. This was followed by the build up to the referendum and multi-party elections in which farmers were encouraged by politicians to believe that such loans no longer should be repaid. The huge default on repayment led to the demise of SACA. The MRFC screens clubs for defaulters and will not lend to a club or group if a loan defaulter is a member. A scheme has been developed to enable defaulters to take out loans. They must repay a third of their outstanding loan and agree to a rescheduling of the remainder of their debt before they are

[3] Other reasons for rejecting hybrid maize are taste, storage, pounding qualities and the feeling "better the seed you know". However, a recent study (Smale et al, 1998) shows that the new flint hybrids, which have been specially bred to match the qualities of local maize varieties, have removed these reasons. Moreover, many farmers are no longer planting true "local" maize, but "degenerated" hybrids and indeed the distinction between local maize and recycled hybrid seed is often a conceptual distinction rather than one based on actual genetic traits (Smale et al 1991 and 1998).

allowed new credit. Due to the difficulties of finding out about lending schemes (and possibly, defaulters,) the MRFC plans to establish a database on the micro finance database.

Dorward *et al.*1(998) argue that politicians now have a key role to play in encouraging the faithful repayment of loans. The same article argues that donors and government should support private traders "to develop interlocked input and output transactions", and also stimulate competition between traders, so that the transaction costs of fertiliser supply and marketing of produce are lowered, and the benefits of lower input prices and higher market prices are passed on to the farmer. This could be done if the traders provided inputs on credit on the understanding that they would buy the produce at a fair price, and shared information with each other regarding loan defaulters.

2.7 Sources of information and advice to farmers on use of fertilisers

Information on fertiliser application rates for maize is given in the agricultural handbook 'A guide to agricultural production' last revised in 1995, which each farm assistant (extension officer) receives. Field assistants advise farmers countrywide that they should apply 87 kg of Diammonium Phosphate (DAP) as a basal fertiliser and 175 kg urea fertiliser as a top dressing to every hectare of hybrid maize. This gives crops 92 kg nitrogen and 40 kg phosphate per hectare (MPTF, 1997b). This rate is rarely applied by farmers who have strong ideas on how much to apply and when. Most can only afford to apply fertiliser once, around the time of tassling. Data from the 1995/96 Fertiliser Application Trial (MPTF, 1997a) indicated that at the then prevailing fertiliser and maize prices it was not economic to apply fertiliser to hybrid maize in most areas of the country.

Application rates for tobacco are supplied to the tobacco farmers' clubs. The fertiliser companies supply information to their customers - tobacco estates and larger smallholders. Other crops are rarely fertilised but crops such as beans may benefit indirectly from being intercropped with maize that is fertilised or benefit from residual fertility if crop rotation is followed. A book called 'Primary Agriculture', intended for schoolchildren, gives fertiliser application rates for a number of crops.

2.7.1 Area-specific recommendations

Area-specific recommendations have been developed by Action Group 1 of the Maize Productivity Task Force for hybrid maize (MPTF, op.cit.). These are based on economic optimum rates of application and depend on whether a farmer is growing hybrid maize for sale or home consumption and the type of soil the crop is to be grown on. Four recommended rates are offered for each extension planning area (EPA) by way of a decision tree. The manual also shows farm assistants how to modify the recommendations to meet a farmer's particular need and to maximise their benefit from using fertiliser.

Action Group I plans to develop a series of simple brochures on fertiliser use in the latter half of 1998 which will be directed at farmers, rather than Field Assistants. These will be printed in Chichewa and Chitumbuka. Each will deal with a single issue which farmers need to consider in using fertiliser including:

- which fertiliser to purchase when the full package recommended is unaffordable
- crop management and fertiliser use
- modifying recommendations with changing prices
- fertiliser application methods

- combining organic and inorganic sources of fertility

There is a need for mass-media campaigns to extend this information. The radio could be the most useful medium for this.

2.7.2 Type, quantity, costs and constraints

The optimal rate of application is determined by maximising the net benefit from fertiliser use which in turn depends on the fertiliser cost including cost of credit and the value of maize. The fertiliser – maize price ratio determines the optimum level of application. When the price of fertiliser is high and the price of maize is low it may not be profitable to use fertiliser, particularly if the crop is intended for sale. A number of reports (Symons, 1998; Wooning; 1998; whiteside and Carr, 1997) calculate the cost of using fertiliser on hybrid maize and show it is uneconomic to apply.

A possible constraint of the area-specific method is the need to estimate the maize selling or buying price at the time of planting in order to work out the optimal fertiliser application rate. To explain the application rates to farmers and to help them recalculate them if prices change may take up a lot of a farm assistant's time. However, the system may be similar to what farmers have been doing all along.

3. SOIL FERTILITY MANAGEMENT

This review of the technical aspects of soil fertility management attempts to synthesise the major sources of information on nutrient availability and limitations for crop growth in Malawi. Inevitably the discussion is centred on maize as the major staple crop on which the largest research effort has been focused. The review draws heavily on research conducted in recent years by scientists from the Department of Agriculture and Technical Services (DARTS) and from Bunda College, University of Malawi which has explored a wide range of options for management of soil fertility both using mineral fertilisers and by biological means. The major study of fertiliser responses in maize and residual responses in grain legumes conducted across Malawi under the Maize Productivity Task Force provides broad scale, up-to-date information and is a key source for the analysis.

The major soil types found in Malawi are described in Appendix III.

3.1 Soil fertility status in each region or agroecological zone

3.1.1 Current maps of nutrient response zones in Malawi

All the current maps of nutrient response zones are based on the yield data from the 1995/96 Fertiliser Verification Trial, from which 1680 sites provided results for analysis. For the analysis presented here the sites were grouped according to natural region using the agro-ecological classification developed by Brown, Young, and Stobbs. They delineated 55 natural regions covering the country but the classification was simplified here to 30 natural regions. This was done by first characterising all trial sites by natural region using GIS. The sites within an EPA were then examined to see which natural region was the predominant region for agriculture in that EPA, and that natural region was assigned to all sites in that EPA. The end result was the 30 natural regions used here. The number of sites grouped within a natural region ranged from 14 to 277, with a mean of 56 sites and a median number of 42 sites per natural region. The maps were then generated from an EPA map, although the analysis was done on the natural region grouping, with the categorised results then assigned to each EPA according to its natural region.

It is important to recognise that the Fertiliser Verification Trial design is not ideal for judging nutrient response. This is acknowledged in the discussion below. Although the results shown are strong evidence for the likely pattern of response, they certainly are not conclusive.

In this analysis, the trial results were not desegregated by soil texture at the site although this is likely to provide clearer patterns of response, particularly for N, as well as remove some inconsistencies in the patterns. Desegregation of N-response by soil texture needs to be done for this data set, but has not yet been attempted. The yield data used here were adjusted yield figures, in which the actual trial data yields were adjusted downwards by 26 percent in total to more closely reflect the yields farmers might achieve using good management practices. This analysis and the maps generated have been instrumental in developing the area-specific fertiliser recommendations.

Nitrogen

The current "Nitrogen-use efficiency map (Fig. 3.1) clearly shows that Malawian farmers receive considerable grain from the application of nitrogen alone to their maize. The actual pattern could perhaps be refined by desegregating sites by soil texture, as N-use efficiencies on medium-textured soils on the lakeshore and in the Upper and Lower Shire Valley are likely to be significantly smaller. The only detailed work on fertiliser use efficiency in Malawi by Itimu (1997) indicated that N recoveries on the sandy soils of the Kasungu plain measured using ^{15}N-labelled fertilisers in a wet year amounted to 50% of the fertiliser recovered in the crop and soil, with half of this in the crop. These fertiliser recoveries are comparable to those measured elsewhere in Africa.

A review of past fertiliser response experiments clearly showed that substantial responses in maize yields were found on virtually all of the soils of Malawi in all of the major studies conducted (Benson, 1997). The earliest work of Brown and others (Anonymous, 1960; Anonymous, 1962; Anonymous, 1965; Brown, 1962; Brown, 1966) and subsequent studies of Bolton and Bennett (1975) indicated that N should be applied to maize on all but the alluvial soils where responses tended to be small. These results have been confirmed by all the major subsequent studies and the recommendation of 96 kg N ha^{-1} for maize hybrids is thought to have arisen from the work of Bennett in the 1970's (Benson, 1997). Economic analysis of the responses found in these trials indicated that it was not profitable to use any N fertilisers in most areas of the country given prevailing prices (Fig. 3.2, MPTF, 1997 p. 15). The potential for profitability of fertilisers for maize production is discussed in Section 2 of this report.

Phosphorus and sulphur

Only when nitrogen is supplied are responses seen in maize yield to additions of phosphorus or sulphur. Brown (1962) produced a map indicating fertiliser response zones for phosphorus and sulphur (Fig. 3.3). It is not clear how these maps were derived but they presumably refer to areas where responses in maize yields were found when N was supplied. P responses were rarely found on low altitude and alluvial soils (Bolton and Bennett, 1975; Saka, 1989). Brown (1962) recommended application of 40 kg P_20_5 ha^{-1} (18 kg P ha^{-1}) would give an optimum responses in maize yields, and this became adopted as the recommended rate for P fertilisation of hybrid varieties. Later researchers have invariably concluded that this rate was excessive (Benson, 1997) and may induce zinc deficiencies in certain areas of Malawi (Matabwa and Wendt, 1993). Although soil testing was used to map sulphur deficiencies (Matabwa and Wendt, op.cit.), there are no soil tests which can predict crop responses reliably and thus this data should be treated as indicative of problems rather than definitive.

Examining the current map (Fig. 3.4), the regions where Brown found significant response to P and S lie within the area where significant responses were found in the recent study. However the area has expanded to encompass the Upper Shire Valley, Kawinga, and the Lake Chilwa/Phalombe plains. Moreover, the problematic phosphorus areas for Brown (the 3rd and 4th categories in the legend of Fig. 3.3) now show a response to P, except in the Thyolo/Blantyre area and in the Kirk Range to the west.

Response to P and S at a moderate level of N-applied (35 kgN ha^{-1}) was evaluated by using a t-test to examine whether there was a significant difference in mean yield for each grouping between the two treatments, 35:0:0 and 35:10:0+2S on all sites grouped by natural region (Fig 3.4a). In all but three natural regions, the mean yield of the latter treatment was the higher. As these sites were on-farm, with mean CVs for the treatment yields for the groupings of sites being 45% and 41% respectively, the level of significance was relaxed to $P<0.33$. As it happened, there was a natural break in the distributions of the probabilities between 0.3 and

0.6. In none of the three regions where the mean sole N fertiliser package yield was higher was the difference in mean yields between the two treatments significant. The map was then made based on the categorisation of natural regions into those where a significant response to P and S was found and those with no significant response.

The largest responses to P and S were found in the Chitipa Plains, the Mzimba area, and the Kasungu plains in the same areas Brown noted as being responsive to P. It is not possible to separate out the yield effects of phosphorus from those of sulphur using this data.

An attempt was also made to understand where sulphur responses occur (Fig. 3.4b). This is based on a comparison of the yields resulting from the application of 96:40:0 and 92:21:0+4S. The mean yield of the latter treatment - with slightly less N, significantly less phosphorus, but some added sulphur - was higher for all natural region site groupings, except in one region where the mean yield difference was not statistically significant. Again, given the trial design, it was impossible to quantify the yield effects of sulphur, as the different phosphate application rates confound such an analysis.

Here the questionable assumption is made that nitrogen and phosphorus are not limiting crop growth is questionable particularly with regard to phosphorus, with one treatment only receiving 21 kg of phosphate per ha. Yet, nonetheless, a clear sulphur response is seen in this treatment. This map was developed in the same manner as the first map. T-tests were run on each natural region group. Again, a critical probability level of 0.33 was used. The mean CVs for these two treatments for the groups were 36% and 34%, respectively.

This map reveals that there is a large expanse where there is a response to sulphur when N and P are supplied at higher rates, which goes far beyond the zone delineated by Brown. This is not unexpected for two reasons. First the increasing intensity of cropping over the past several decades has led to a decline in soil organic matter, the principal reserve of sulphur in the soil. Secondly, while sulphur-containing fertilisers were common in Malawi until the early-1980s, since then it has been government policy to promote high-analysis fertilisers, such as urea and DAP, which do not contain sulphur. Indeed when government formulated a policy to encourage the importation of such fertilisers, concern was expressed on the likelihood of sulphur deficiencies emerging (Maida and Saka, 1986).

From both of these maps it is clear that it is appropriate for farmers to be using 23:21:0+4S on their maize. There are responses in maize yields, over large areas of the important maize-growing areas of the country, to the application of phosphorus and sulphur when applied with nitrogen.

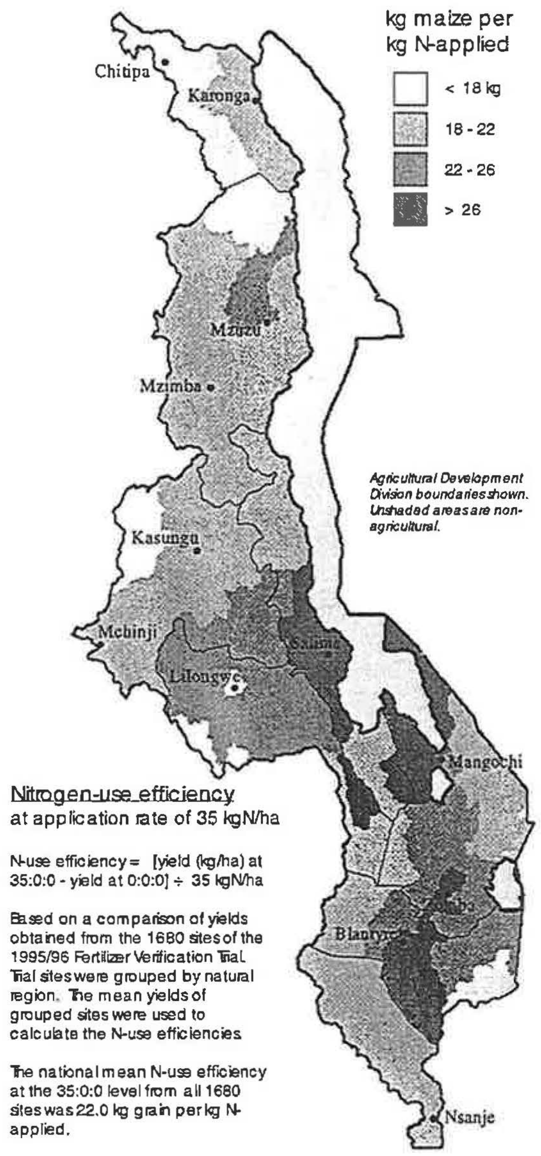
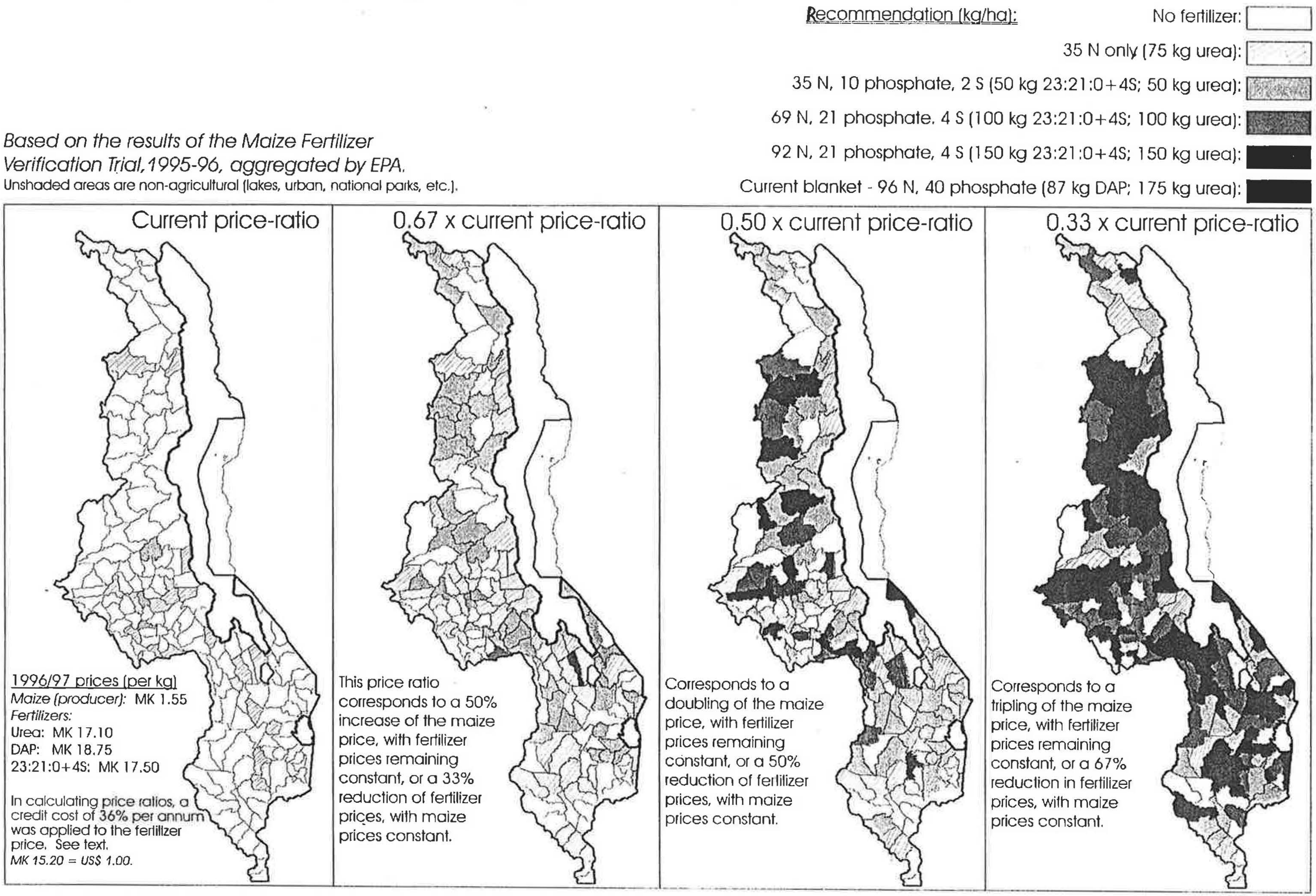


Fig. 3.1 Map of Malawi showing nutrient use efficiency for nitrogen in terms of kg of maize produced per kg of N applied at an application rate of 35kg N/ha. Derived from data produced from the 1995/1996 Fertilizer Verification Trial (for further details see MPTF, 1997)

Fig. 3.2 Sensitivity analysis of economic analysis of fertlizer use for maize based on the 1995/1996 Fertilizer Verification Trial using 1996/1997 prices (from MPTF, 1997).



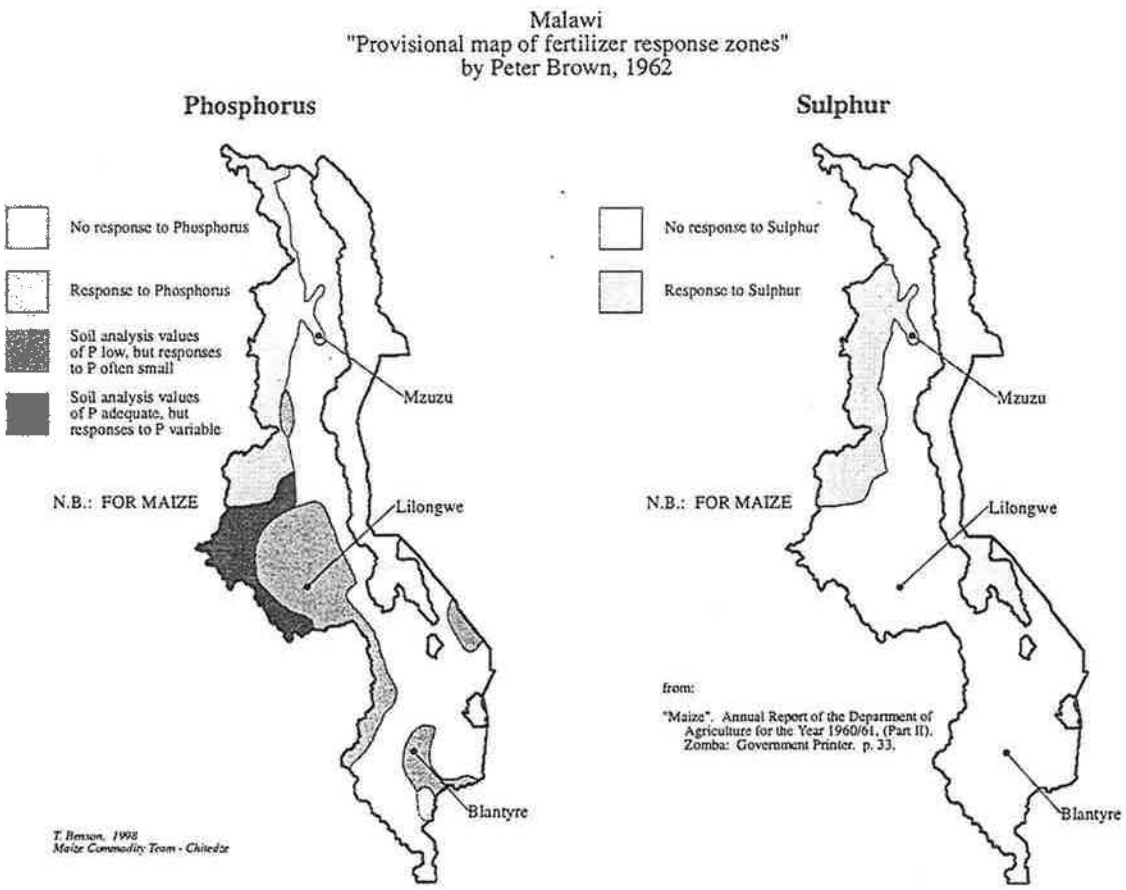


Fig. 3.3 Map of Malawi showing the provisional maize response zones to phosphorus and sulphur fertilizers produced by Peter Brown in 1962.

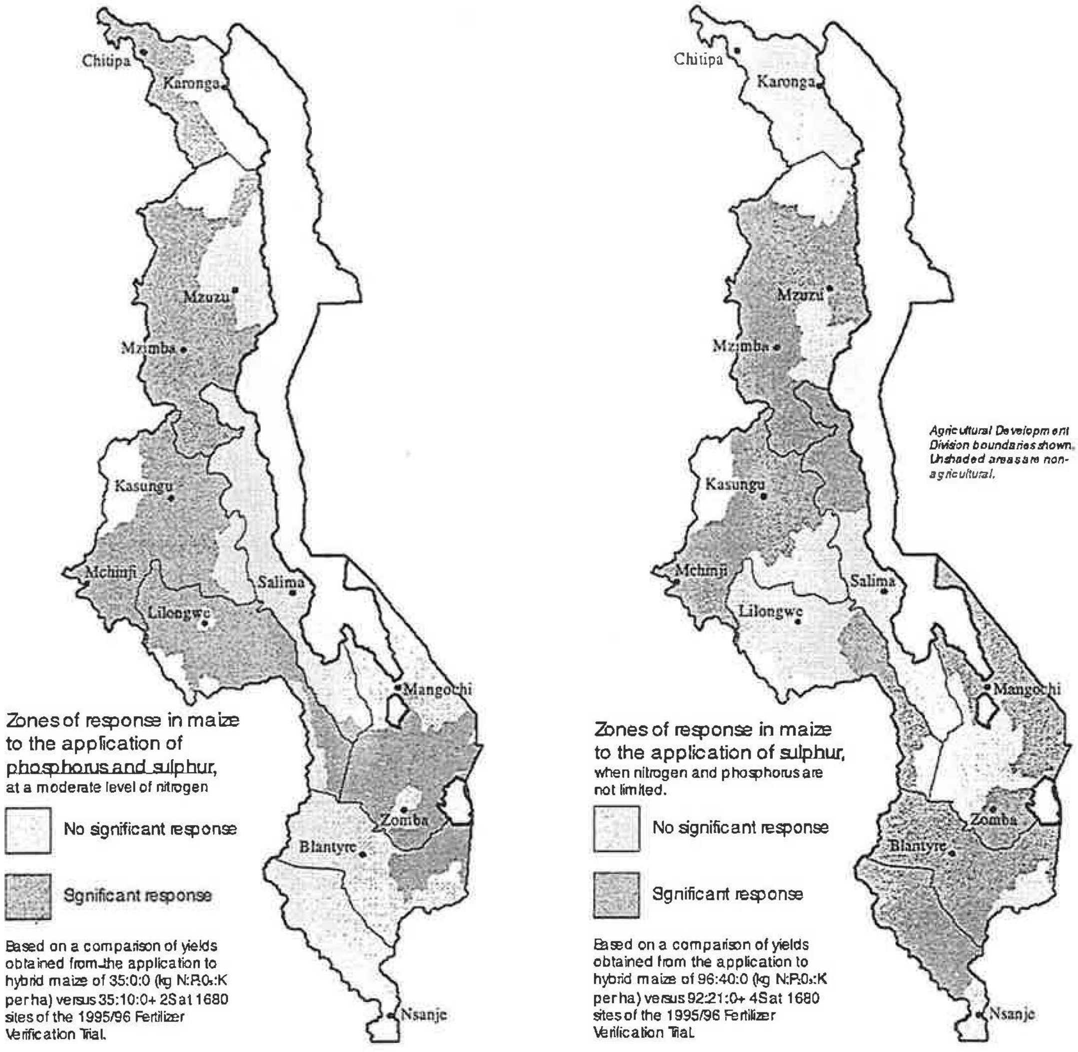


Fig. 3.4 Map of Malawi showing current maize response zones to applications of phosphorus and sulphur fertilizers. Derived from data produced from the 1995/1996 Fertilizer Verification Trial (for further details see MPTF, 1997).

3.1.2 Potential Use of Tundulu Rock Phosphate

Tundulu Phosphate Rock (TPR) is of low solubility, even on very acid soils. In view of this technologies that improve the availability of this unreactive phosphate rock are required before it can be used. Direct application of phosphate rock is only effective in situations when the PR is highly reactive, such as the Minjingu Phosphate Rock and on acid soils. Comparison of five African Phosphate Rock samples show that Tundulu phosphate rock is very unreactive (Table 3.1)

Table 3.1. Analysis of five African Phosphate Rock samples by the International Fertiliser Development Center, Muscle Shoals, Alabama

% Composition	Tanzania	Zimbabwe	Uganda	Malawi	Togo
P_2O_5	28.6	35.2	38.8	22.3	37.0
CS P_2O_5[1]	5.3	0.8	1.5	0.6	3.9
CaO	41.8	50.2	50.4	37.5	52.4
SiO_2	n.a	4.9	3.3	16.5	3.1
F	3.1	1.7	2.4	2.1	3.9
Al_2O_3	0.9	0.5	0.7	0.4	0.94
Fe_2O_3	1.1	1.9	2.7	5.9	1.0
Na_2O	0.6	0.2	0.2	0.4	0.15
MgO	2.4	0.3	<0.1	0.3	0.08
K_2O	0.7	0.1	<0.1	0.4	0.02
TS[2]	0.1	<0.1	<0.1	<0.1	0.1
Cl	150 ppm	50 ppm	55 ppm	50 ppm	0.02 ppm
CO_2	4.3	3.3	0.4	7.9	2.0
Oven H_2O[3]	4.4	0.1	0.2	0.2	6.5
Organic C	0.1	0.1	0.1	0.1	0.08
LOI[4]	11.0	3.2	1.0	9.2	9.3
Acid insol[5]	11.2	6.5	n.a.	n.a.	n.a.

n.a. Data not available

[1]Citric acid soluble; [2]Total Si

[3]Moisture Content; [4]Loss on ignition (at least 30 minutes, 110 °C)

[5]Insoluble in perchloric acid

Source: (Lowell, 1994).

Tundulu Phosphate Rock has a high content of silica and iron oxides. Of these rocks tested the Tundulu PR that had the lowest total P content and the smallest content of citric acid soluble P which is an indication of P availability.

Whereas Minjingu Phosphate Rock is being used for direct application in Tanzania (Ikerra *et al*., 1995), the other phosphate rocks are very unreactive. Unreactive PRs can be partially acidulated with sulphuric acid which will supply not only phosphorus, but also sulphur. In Malawi, Chilimba (1996) used acid forming fertilisers with Tundulu Phosphate Rock. In his experiment, it was observed that the use of acid forming fertilisers such as ammonium sulphate or urea acidified the TPR, and gave positive benefits in maize yields (Table 3.2)

Table 3.2. Grain yield of maize (kg/ha) as affected by fertiliser treatments to examine the effect of ammonium fertilisers on release and availability of Tundulu Phosphate Rock

Treatments	Bembeke	Bvumbwe
No fertiliser	11868c	3571 b
Sulphate of ammonia	5906 a	2170 bc
TPR at 60 kg P_2O_5 kg/ha plus sulphate of ammonia	3874 ab	6181 a
TPR at 60 kg P_2O_5 kg/ha plus urea	3997 ab	5632 a
Single superphosphate (60 kg/ha P_2O_5 kg/ha)	5014 a	5632 a
TPR at 120 kg P_2O_5/ha plus sulphate of ammonia	5014 a	5632 a
TPR at 120 kg P_2O_5/ha plus urea	4808 a	4258 b
LSD	1964	813.7
CV %	33.88	11.19

Source: Chilimba (1996).

In greenhouse experiments, Mughogho and Weil (1998a) observed that Tundulu PR was more inferior to Minjingu PR when applied directly. Interestingly, there was a slight increase in dry matter production when TPR was composted with maize residues.

3.1.3 Rainfall effects on nutrient response in maize

When past nutrient trial data for the various seasons were categorised by rainfall quality, only for the light-textured uplands provisional recommendation zone was there a significant seasonal effect. The linear response equation for poor rainfall years was $y = 1725 + 15.6N$. For years of good rainfall, the resulting equation was $y = 1747 + 20.4N$. In this zone, moisture stress limits nitrogen response more significantly than does leaching. Yet, even in good years, the response on these predominantly lighter soils remains lower than for all years for the sites in medium-textured uplands provisional recommendation zone.

3.1.4 Residual benefits of fertilisers

There is no evidence of residual benefits of N fertilisers, although over the longer term the increased yields of crops will result in larger inputs of organic residues, both above and below ground which will contribute to maintenance of soil organic matter.

Follow up experiments from the multilocation MPTF trials on fertiliser response in maize on more than 170 sites showed a significant residual effect of P fertiliser applied in the 1995/96 season on growth and yield of soyabean and groundnut grown in the 1996/97 season (R. Gilbert, personal communication; see graphs in Blackie, 1998). Yields of soyabean were increased by approximately 15% and groundnut yields by over 20%, and all rates of P from 10-40 kg P_2O_5 ha^{-1} gave detectable residual benefits in legume production. Similar trends were observed with Bambara groundnut.

3.1.5 Responses to other nutrients

Potassium

Virtually all discussions of nutrient requirements for maize in Malawi highlight that potassium is not generally deficient, but suggest that deficiencies are likely to arise with continued cropping (Bolton and Bennett, 1975; Brown and Young, 1965; Maida, 1980). Using soil analysis Matabwa and Wendt (1993) found that K was deficient at 20% of sites in

Lilongwe ADD and 30% of sites in Kasungu ADD although fertiliser response trials did not show positive responses to K (Jones *et al.*, 1994).

Potassium is an important nutrient element for tobacco and sugarcane are crops which require a large supply of this nutrient. Potassium can be very deficient in Dwangwa (Mughogho, unpublished data).

Micronutrients

Micronutrient deficiencies are notoriously difficult to diagnose accurately using soil or plant analysis. This means that suspected nutrient deficiencies must be confirmed with crop response experiments before firm conclusions can be made as to whether micronutrients are deficient.

There is clear evidence that zinc (Zn) is severely deficient in localised areas (Dedza and Thiwi-Lifidzi). In such soils, one ought to supply Zn to sustain good maize yields. Given the adequate supply of P, and the moderate acidity of most Malawian soils, large additions of P, whether in the form of soluble P fertilisers (e.g. TSP) or as rock phosphates, could lead to changes in the availability of micronutrients and exacerbate deficiencies of Zn.

Deficiencies of other micronutrients have been reported but evidence is equivocal and currently they are considered to be of secondary importance (Matabwa and Wendt, 1993). There are areas where boron may be deficient in Malawi. Interestingly, only about 0.5 kg B ha^{-1} should be applied. Any amount over and above this level will be toxic for plant use, more especially maize and *Phaseolus* beans. Cu is also thought to be deficient in some soils, especially around Nkhata Bay.

3.2 Nutrient response curves

3.2.1Nitrogen

The report of the MPTF, Action Group I from January 1997, *The 1995/96 Fertiliser Verification Trial - Malawi, Economic analysis of results for policy discussion*, pages 8-11 provides a response curve analysis of the results of the trial.

Nutrient response curves are usually generated by conducting complete factorial trials involving the nutrients of interest. This trial was not a factorial trial, but involved six different fertiliser packages and consequently, the response in maize grain yield to applied nitrogen from response to applied phosphorus or sulphur cannot be separated Nevertheless, by utilising the yields of the control and the three treatments that included both sulphur and phosphorus - treatments 2, 4, 5, and 6 - and assuming that the effects of phosphorus and sulphur are minor, one can crudely estimate the N-response function for each provisional recommendation zone (Table 3.3).

The linear coefficient of the linear response function indicates the units of maize grain which one would receive from the application of one unit of nitrogen. The adjusted-yield national value of 18.7 corresponds to an unadjusted (12.5% moisture) value of 23.4. This is higher than coefficients generated from aggregated past on-farm trial results of between 17 and 19 (Kumwenda *et al.* 1996, 4). However, as sulphur and phosphorus contributed positively to the value of this coefficient and optimum fertiliser management practices were followed, the higher coefficient is expected.

Table 3.3. Estimated nitrogen response functions using treatments 2, 4, 5, and 6, adjusted yields (trial yields adjusted downwards by 26 percent)

	Linear response function	*Adj. R^2*	Quadratic response function	*Adj. R^2*
Lower Shire Valley zone	y = 2014 + 11.5N	*0.13*	y = 1960 + 17.3N - $0.063N^2$	*0.13*
Lakeshore zone	y = 1740 + 17.0N	*0.25*	y = 1626 + 29.1N - $0.133N^2$	*0.26*
Medium-textured Upland zone	y = 1451 + 19.7N	*0.33*	y = 1330 + 32.6N - $0.141N^2$	*0.34*
Light-textured Upland zone	y = 1238 + 21.3N	*0.38*	y = 1129 + 33.0N - $0.128N^2$	*0.38*
National	y = 1531 + 18.7N	*0.30*	y = 1417 + 30.8N - $0.132N^2$	*0.31*

This value is comparable to or slightly greater than the mean nitrogen response coefficients reported from several other countries in sub-Saharan Africa (Heisey and Mwangi 1996, 12). A further analysis of trial data from several years was made (Table 3.4), with adjustment of the intercept and coefficients downwards to allow comparison of the yields with data in Table 3.3. Although the correlation between the two data sets is far from perfect, there are no major contradictions. No national response curve analysis was done on this data.

Table 3.4. Response curves generated by examining nutrient response trial data over several years

Zone	**Linear response function**	**Quadratic response function**
Lower Shire Valley (n= 24 trials at 13 sites)	y = 2790 + 0.6N	y = 2657 + 6.2N - $0.028N^2$
Lakeshore (n=92 trials at 43 sites)	y = 2164 + 13.6N	y = 2001 + 20.4N - $0.035N^2$
Medium-textured upland (n= 340 trials at 215 sites)	y = 2133 + 20.9N	y = 2042 + 24.8N - $0.020N^2$
Light-textured upland (n= 44 trials at 22 sites)	y = 1749 +18.9N	y = 1571 + 26.1N - $0.037N^2$

3.2.2 Phosphorus

Detailed soil sampling shows that field to field variability in available P concentrations within the same village is very high. At the village scale, P responses on farmers' fields appear to be as strongly related to past farmer management as they are to inherent chemical and physical properties of the soil. Various factors are known to affect the P status of the soils, which include soil acidity, soil texture, SOM content and addition of ash from burning of crop residues. Mughogho (1975) compared the P-fixing capacity of four red Malawi soils and observed that even in the most highly weathered soils from Mimosa in Mulanje district, there was not as much P fixation as is observed in other parts of the world. The least P fixed in these red soils was found in the Lilongwe soil series, which apparently has some weatherable minerals. This conclusion is also supported by the fact that soils in Malawi are generally not very acid. The soluble P sources, particularly the N-P combined sources are generally more effective for fresh dressing, while rock P sources have a stronger residual effect (Mughogho and Weil, 1998).

Bennett conducted 302 full N and P factorial response trials in the early 1970s across the country. Of these trials, only 94 provided a significant positive P-response and six gave a significant negative P-response. It is likely that one would find a greater proportion of P-responsive sites today - the map of P and S responses (Fig 3.4a) is evidence of this. The problem comes in assigning P-response curves.

Faced with that problem, the 21 kg P_2O_5 ha^{-1} rate of application seems to have been a good, pragmatic rate to use. The map of S-responses (Fig. 3.4b) provides some evidence that there is little need to apply more phosphate than that, at least in the absence of sulphur.

3.2.3 Sulphur

The importance of S as a plant nutrient in Malawi was already observed in tea plantations during the 1930s by Story and Leach (1933), but its importance in food crop production was not recognised until the 1950s (Greenwood, 1951). Despite its importance in affecting crop yield and protein quality, little research is available on S. This is mainly due to the fact that in many instances, the use of N, P and K fertilisers which contain S has masked a deficiency of S. A major portion of S in some soils in Malawi is associated with organic matter, which is a reserve for plants but must undergo mineralisation to sulphate before becoming available.

Although large yield response to S application were observed in food crops, as shown in the data by Mughogho and Weil (1998b), the S rate required is generally small. With all the nitrogen and phosphorus supplied, it was observed that there was a response to applied sulphur (Fig. 3.5). In all areas, that is Lilongwe and Mzuzu in the residual soils, and Salima and Balaka in the alluvial soils, there was an increase in maize production resulting from applied sulphur. It is import to note that the response was found only up to 5 kg S ha^{-1}. This is strong evidence to support the use of the new basal fertiliser which is 23:21:0 + 4S. For 100 kilogram of this basal fertiliser applied per hectare, there will be only 4 kilogram of S per hectare, which is similar to the rate found to be optimal by Mughogho and Weil (1998). There is little or no residual effect of soluble S sources in sandy soils. In heavy texture and low pH soils, there may be a build up of S contents with continuous S application.

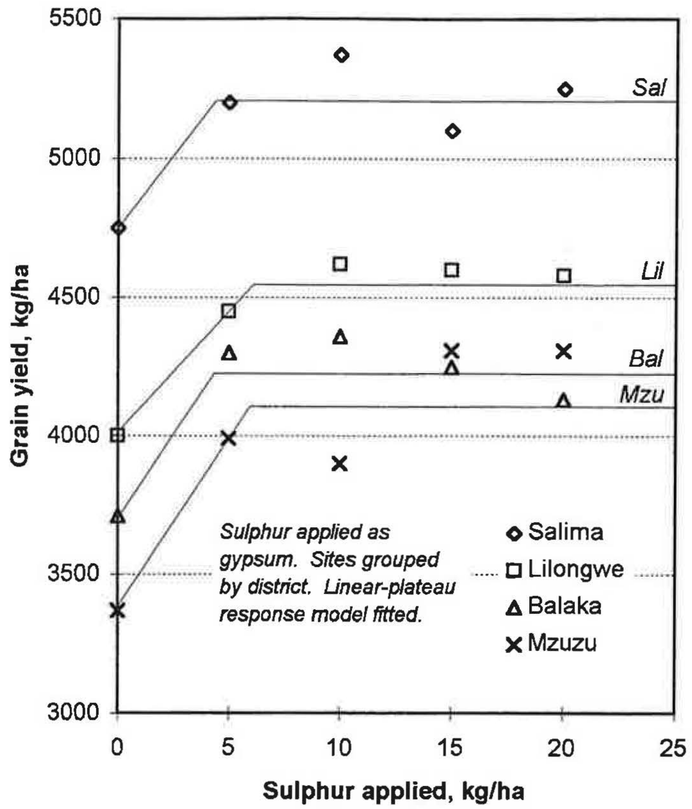


Fig. 3.5 Responses to S addition in maize supplied with adequate N and P fertilisation across 18 on-farm sites in four districts (from Mughogho and Weil, 1998)

3.2.4 Fertiliser management

Though N is known to be deficient in most Malawi soils, it is also the most costly among the major nutrients. It is, therefore, essential that efforts be made to ensure a high efficiency of applied N use in Malawi. Several management factors have a profound effect on N-use efficiency in Malawi. These include: (a) timing of N application; (b) method of N application; (c) N-source; and (iv) soil and crop husbandry. Better farmer understanding of the interaction of these factors with crop N-use is important for obtaining maximum uptake of applied N.

In particular efficient fertiliser application is strongly dependent on timely weeding, during a period of the cropping calendar when there are many other demands on farmers' time. In the 1996/97 growing season, approximately 150 Extension Field Assistants throughout Malawi implemented farmers' fields implemented a demonstration of the interaction between weed management and fertiliser on the yield of hybrid maize. The aim was to convey the message to farmers that fertiliser use on maize cannot be effective unless good crop management practices are followed, particularly good weeding. The trial included combinations of weeding once or twice and fertilisers applied at two different rates. With half the provisional area-specific fertiliser rate the mean yields were 2.46 t ha^{-1} with a single weeding but 2.89 t ha^{-1} with two weedings. At the full provisional area-specific rate the respective yields for the two fertiliser rates were 3.10 and 3.70 t ha^{-1}. This clearly demonstrated the strong interaction between timely weeding and maize yield responses to fertiliser that has been demonstrated earlier by results from the Maize Commodity Team at Chitedze. Good weed management is already practised in the southern region of Malawi. It remains a problem in the northern region and the central region, where labour is a constraint during the rainy season.

Fertilisers are almost always applied by dolloping into holes close to maize planting stations which is a very labour intensive method. As the fertiliser is covered with soil immediately it is unlikely that ammonia volatilisation losses often associated with broadcasting of urea fertilisers will be high. As might be expected, band application was shown to give better responses to P fertilisers than dolloping (Wendt and Jones, 1993).

There has also been discussion as to whether urea will give less leaching losses than other fertilisers that contain nitrate (such as calcium ammonium nitrate), but it is unlikely that there will be any significant differences in leaching as urea is rapidly hydrolysed and nitrified to nitrate.

3.3 Sources and Quantities of Organic Matter used by Farmers

There has been no detailed survey of farmers' practices with regard to management of crop residues in Malawi. Because of the important role of soil organic matter in furnishing a large portion of the exchange sites in soils of low buffering capacity, it follows that the capacity and intensity of the soils to supply nutrients to the growing plants will greatly depend on the soil organic level. It is thus important that crop residues or other organic matter sources are used to maintain adequate soil organic matter contents. The importance of crop residue management and fallowing in maintaining high soil organic matter level and cation exchange capacity (CEC) has been demonstrated.

For the farmer to benefit from the use of crop residues, it is important that the residues are incorporated into the soil. Failure to do this will result in slow decomposition rates for the crop residues. Moreover, incorporation ensures good moisture retention in the organic materials. Incorporation of maize stalks is difficult for smallholder farmers, whose main cultivation equipment is the simple hand hoe. In areas where there are more livestock, maize stover is used as an animal feed. Food legume crop residues are much finer in size than maize stalks and do not have the same problems for incorporation. The main problem with using maize residues for soil amendment is the strong immobilisation effect when incorporated into the soil. This is due to the wide C:N ratio and lack of lignification in maize stover which means that it decomposes readily but the decomposing micro-organisms use soil nitrogen for their growth resulting in immobilisation of soil N. Recent studies by Sakala (1998) showed that maize stover results in net immobilisation of N for more than a year after incorporation. The strong immobilisation is confirmed by Snapp (1998) at ICRISAT (Table 3.5 below).

The results highlight the benefit of adding green legume material to soil both because of its N content, and as the N is released rapidly. Residues of legumes such as soybeans at harvest, contain little N as this is translocated to the grain so that the stalks contain little nitrogen. If these residues are incorporated into the soil, they will contribute little N for the subsequent maize crop, but much of the residual effect of soyabeans is due to leaves which fall before harvest. Malawian researchers have been working on the use of *Tithonia diversifolia* which has been highlighted as an organic residue by researchers in Kenya as a source of nitrogen and phosphorus. This is a useful material for providing nutrients although the amounts available limit the area over which this could be used.

Table 3.5. Nitrogen release from different types of organic materials available for soil amendment in Malawi

Residue	%N	% Lignin	N equivalent in residue (kgN ha^{-1})	N (mg mineralised)	% residue N mineralised
Pigeonpea	2.9	8	116	404	76
Gliricidia sepium	4.2	4	168	501	61
Sesbania sesban	3.5	4	140	367	56
Faidherbia albida	4.0	8	160	411	52
Senna spectabilis	3.5	5	140	318	46
Phaseolus bean	1.8	3	72	152	44
Tephrosia	2.9	4	116	231	42
Groundnut	1.6	6	64	88	30
Mucuna	3.3	7	132	172	28
Gmelina	4.1	19	164	197	24
Tithonia	3.0	16	120	101	18
Soyabean	1.2	12	48	31	14
Mango	3.0	21	120	54	10
Maize	0.6	9	24	0	0

All residues amended in the top 15 cm of leaching tubes at the rate of 4 t ha^{-1}
Source: Snapp, 1998

Mineralization of organic S appears to parallel that of N. About 80% or more of the sulphur in savannah soils is present in the organic matter, and thus its rate of mineralisation may affect crop growth. Moreover, organic matter rapidly forms complexes with heavy metals, so it can act both as a source and a sink for micronutrients in the soil.

3.3.1 Management of Maize Stover

In most of Malawi, the hoe is the most common means for ploughing the land, making ridges and weeding. Most of the stover, after the maize grain has been harvested, is left in the field. The amount of maize stover produced depends on the varieties that have been produced. Chilimba (1989) for example found out that open pollinated varieties produced almost double the maize stover compared to the hybrid varieties (Table 3.6).

Table 3.6. The effect of nitrogen application on the stover yield of four maize varieties

	Nitrogen applied kg/ha					
Variety	0	50	100	150	200	Mean
MH12	4121	5495	6223	5179	5865	5377
MH16	4217	4574	4492	4767	4670	4544
CCA	7322	9794	10893	10302	9437	9550
UCA	5907	7102	6868	7734	8242	7171
Mean	5392	6741	7119	6996	7054	6660

SE Variety = 168 SE Nitrogen = 188
SE Variety x Nitrogen = 376 CV = 9.8

At the Bunda site, the CCA open pollinated variety produced the highest quantities of maize stover. In fact, maize stover yield increased with the nitrogen rate increased, so did the up to the 100 kg N/ha rate where the maize stover yield was recorded at 10893 kg/ha whereas the hybrid maize variety MH16 produced only 4492 kg maize stover at the same nitrogen rate. There was a very low Harvest Index (0.39) for the open variety CCA where as the H.I. for the hybrid MH16 was 0.63 at the 100 kg N/ha. This clearly shows that the favourite open pollinated maize variety for most farmers in Malawi, CCA produced more biomass and yet the grain yield was much smaller.

Maize stover left in the fields is eaten by cattle and goats which graze freely in the dry season over the land, including the fields of farmers who do own cattle. Maize stover is rarely used for stall feeding animals. Where maize stover remains in the field at the time of land preparation before the rains in October/November, the maize stover, together with the weeds, is gathered into several heaps or windrows in the field and set on fire. The ash is then scattered. At planting time, pumpkins are normally planted in areas of ash where there is a concentration of nutrient elements.

In some areas like Matapwata in Thyolo, some parts of Ntchisi, Misuku Hills, and some areas in Nthalire, where there is prolonged rainfall of the Chiperoni type, most of the maize leaves are pulled from the plants at time of physiological maturity. These are usually buried between rows and made into ridges where beans are planted as a relay crop. The leaf removal from the maize stalks allows a lot of light to pass through and as the maize leaves are still yellowish green they will decompose quickly these were left to remain dry. At the onset of the rains, maize will be planted on these ridges.

Burying of dry maize stover is rare, though more common in the south. Reasons why farmers do not practice this include:

(a) the hoe is not an appropriate equipment for burying maize stover;
(b) the practice of burning stover is effective in killing weeds;
(c) it has been observed that where maize stover has been buried, there may be many termites which may attack the maize growing during the subsequent growing season, more especially when there is a dry spell during the rainy season; and
(d) burying maize stover, which is very poor in nitrogen may immobilise N at the onset of the rains.

Group IV of the Maize Productivity Task Force has the mandate:

i) to show how soil fertility and crop yields can be increased/improved and sustained through the additions of organic materials to the soil; and
ii) to evaluate the performance of different organic matter technologies under smallholder farms, and at Extension Planning Areas (EPAs) and Training Centre management conditions.

These demonstrations are located at sites that reflect different agro-climatic (or ecological) zones and soil types, as well as farmer variation in the management of the different soil organic matter technologies. Table 3.7 shows some of the interventions carried out in the 1997-98 cropping season.

Table 3.7. Distribution of Action Group IV activities by ADD in 1997-98 crop season

Agric. Develop Division	Organic Matter Technology	Crop Residue	Compost Making	Total
SVADD	48	51		99
BLADD	104	113	1590	1807
MADD	136	93	167	396
LADD	40	43	141	224
SLADD	39	43	115	197
KADD	46	19	--	65
MZADD	198	83	--	281
KRADD	200	130	4940	5270
TOTAL	811	575	6953	8339

It is interesting that Karonga ADD leads in the amount of interventions that were requested by the Crops Officers and Development Officers to be conducted in their ADDs. There was a request that 38 compost heaps per field assistant were to be carried out. This is in view of the fact that farmers have recognised that there is a great need to have alternative sources of nutrients for their crops. What remains to be reported is whether these interventions are really working as they were supposed to.

3.2.2 Combinations of organic and inorganic sources of fertility

The combinations of inorganic fertilisers, and manures from cattle or legume crops is recognised as one way of reducing the costs of inorganic fertilisers and to reduce the decline in soil fertility under smallholder cropping systems in Malawi. Research by Itimu (1997) demonstrated that legume tree leaves at moderate rates of 1-2 t ha^{-1} of leaves applied could assist in providing N such that the rate of N fertiliser required to raise maize grain yields from 1 to 2.5 t ha^{-1} maize could be halved from 60 to 30 kg N ha^{-1}. The organic amendment alone had only a small effect on maize production.

An experiment was conducted from the 1994/95 to the 1996/97 cropping seasons to determine the effects of organic legume residues and inorganic fertiliser nitrogen (N) on soil N and maize yield (Kumwenda et al., 1998). Results showed that the initial release of N was high from plots which received inorganic fertilisers without the addition of legume residues. The release of N from legume residues was slow initially due to high lignin and polyphenol contents of the residues in relation to the nitrogen contents (L + PP)/N ratios).

Nitrogen application resulted in significant yield increases over no fertiliser application. The application of 48 kg N/ha gave the largest yield increments of 982 and 1196 kg/ha respectively in 1995/96 and the 1996/97 cropping seasons. The highest grain yields of maize were obtained when maize was grown in rotation with legume crops (pigeonpea-maize, sunnhemp-maize or Mucuna-maize). In the 1995/96 cropping season, grain yields of maize from these legume-maize rotation systems were 25 to 29%, respectively, higher than maize yields from the continuous maize system (maize-maize) which yielded 4669 kg/ha.

Table 3.8. Maize yield (kg/ha) as influenced by incorporation of legume residues and inorganic fertilisers at Chitedze Research Station, Malawi, 1995/96

Cropping System	Crop Residue	0 kg N/ha	48 kg N/ha	96 kg N/ha	Mean
Maize - Maize	None	3547	5167	5267	4669
Maize/PP intercrop	Pigeonpea	3696	5108	5415	4739
Maize/Sunnhemp	Sunnhemp	4635	5233	5324	5064
Maize/Mucuna	Mucuna	3599	3972	4745	4101
Maize after PP	Pigeonpea	5729	6073	6104	5968
Maize after SunnH	Sunnhemp	5477	6121	6516	6038
Maize after Mucuna	Mucuna	4484	6357	6598	5813
Mean		4451	5433	5714	5199

SED (Cropping Systems) 296
SED(Nitrogen rates) 123
SED(Cropping Systems x N rate) 326NS
Source: Kumwenda *et al.* (1998) Unpublished.

Work by Kumwenda (unpublished) shows that if the green manures are incorporated when they have already produced seed, there will be very low contribution to the nitrogen for the subsequent crops. For example, Mucuna has to be applied early in the season while it is still green (before seed production). Once the seed has been harvested, there will be little contribution to the soil. In fact, there may be a need for supplemental N if all the legumes have been incorporated after seed formation and harvest. It is also important to note that maize yields at Lisasadzi, a very sandy soil, are very poor when the green manure legume was not incorporated. With the incorporation of green manure residues, there was a great increase in maize yields.

Results by Kumwenda have shown that not only do the green manures respond to applied P, but that there is a residual response to P as shown in table 3.9 below.

Table 3.9. Influence of early and late incorporation of green manures on maize yields (kg/ha)

Location	Zombwe 1997/98		Kasungu (Lisasadzi) 1997/98	
Fertiliser Rate:	0	35:10:0+ 2S	0	35:10:0+ 2S
Maize:Maize –P	1077	-	150	-
Maize:Maize +P	1759	-	406	-
Mucuna:maize + P/Early	4963	5918	3264	4579
Mucuna:maize - P/Early	3538	5568	1474	4470
Crotalaria + P/Late	2467	5016	1364	2831
Mucuna:maize – Plate	1010	3364	839	2266
Crotalaria + P/Early	3491	5437	2617	3587
Crotalaria - P/Early	3453	4719	2962	3773
Crotalaria + P/Lime	2467	5016	1616	1916
Crotalaria - P/Lime	2500	3990	1490	2634
Tephrosia + P/Early	2358	6542	2592	3035
Tephrosia - P/Early	3250	5172	1608	2350
Tephrosia + P/Late	2467	4013	2214	3144
Tephrosia - P/Late	2500	4404	1813	1377

P = phosphorus at 100 kg P_2O_5/ha; E = incorporated early; L = incorporated late.
Source: Kumwenda, 1998 (unpublished).

3.4 The Role of Grain Legumes and Green Manures

The main legume crops in Malawi differ according to the agroecological zone. Main grain legumes are pigeonpea, groundnut, *Phaseolus* beans and, more recently, soyabean. Other legumes grown for grain include cowpea (*Vigna* unguiculata), Bambara groundnut (*Vigna subterranea*) and lab-lab bean (*Lablab purpureus*). Residual benefits of the legumes are mainly a function of the amount of legume biomass (and N) left in the field after the crop. This means that for a given amount of total N accumulated in the crop, there is a direct trade-off between seed production and soil fertility benefit from legumes. Grain legumes that are highly efficient in converting their N into protein tend to contribute less N to subsequent crops, whereas leafy legumes with a small harvest index, such as pigeonpea, contribute more to the soil. However factors which lead to improved yields of grain legumes will only increase the residual benefit from the legume *if the legume residues are returned to the soil.* For example, if groundnuts are pulled at harvest and the shoots are not left in the field, then residual benefits will be minimal. In the cases of pigeonpea and soyabean most of the leaves fall from the plants before harvest so this is not such a problem.

Residual benefits from legumes are thus also closely related to legume management - all factors which reduce legume cover and biomass, such as sparse planting, will reduce the residual benefit from the legumes. Sole crops thus have a much greater benefit than intercrops, possibly with the exception of maize-pigeonpea intercropping where biomass production of sole or intercropped pigeonpea does not differ significantly as the majority of pigeonpea growth occurs after maize harvest due to the strong temporal complementarity of these two crops (Sakala, 1998).

Of the major grain legumes, significant benefits to soil fertility are likely from promiscuous soyabean, groundnut and pigeonpea if they are well-managed, but not from *Phaseolus* bean. Work by Nawale (1992) showed that of four food legumes, there were differences in both the grain production of the legumes and in their N-contribution to subsequent crops. As much as there was a higher grain yield with soyabean, the amount of N returned for subsequent crops is much higher with Bambara groundnut, followed by groundnut. Interestingly, little N was left for subsequent crops in fields which were cropped to soyabean and bean. Soyabean reduced residual N as results of its high N-harvest index. However, leafy varieties such as Magoye (see below) are likely to contribute more N to the soil.

Table 3.10. Comparative soil mineral N contents (kg/ha) after growth of major legume crops in Malawi

Legume	N at Pre-Plant	N at Harvest	Difference
Bambara groundnuts	41.0	117.0	76.1
Groundnuts	49.1	118.6	69.3
Soyabeans	51.0	105.0	54.0
Beans	54.0	109.0	55.4

Source: Nawale (1992)

Table 3.11. Comparison between N left in the soil and that removed through seed harvest of major legume crops in Malawi

Legume	Residue N ($kg\ ha^{-1}$)	Seed N ($kg\ ha^{-1}$)
Bambara groundnuts	76.1	14.2
Groundnuts	69.3	35.6
Soybeans	54.0	77.3
Beans	55.4	26.0

Source: Nawale (1992)

The study by Mughogho and Kumwenda (1993) indicates that there was a greater response to residual N in the subsequent maize crop where Bambara groundnuts were planted than in those fields where beans or groundnuts were planted the previous year. Although Bambara groundnuts have a low harvest index, this practical experience whereby Bambara groundnuts are continuously producing high maize yields in subsequent years warrants further study of this crop. This was also found in Zimbabwe where Mukurumbira had similar results when rotating maize with Bambara groundnuts (Mukurumbira, 1985).

Table 3.12. Effect of Nitrogen fertiliser and previous legume crop on grain yield of maize (kg/ha)

Nitrogen rate (kg/ha)	Maize	Bambara groundnut	Groundnut	Bean	Mean
0	4095	6541	5132	6586	5589
40	4577	5709	6629	5699	5654
80	5244	6994	5417	6952	6152
120	5005	7239	6026	5374	5611
Mean	4731	6621	5801	6153	5826

CV = 22.48%; SE = +/- 649; Source: Mughogho and Kumwenda (1991).

3.4.1 Distribution of grain legume production in Malawi

Groundnuts are grown extensively throughout the country (Tables 3.13a and b). Lilongwe ADD has the largest land area allocated to groundnuts with 36,996 hectares, followed by Kasungu ADD with 33,845 hectares, although Kasungu has the highest production with 29,222 tonnes while Lilongwe has only 26,442 tonnes.

Table 3.13a. Estimated grain legume production - Smallholder farms (land area in ha.)

ADD	G/nuts	Beans	P/Peas	Cowpeas	Soybeans	Bambara
KRADD	4,736	5,544	903	301	395	386
MZADD	14,753	30,150	75	168	4,998	478
KADD	33,845	25,416	-	551	11,575	2,720
SLADD	8,487	508	2,190	2,220	951	388
LADD	36,996	71,568	111	2,618	16,896	1,915
MADD	19,955	11,870	33,276	20,853	1,618	333
BLADD	17,371	23,101	78,523	27,093	3,992	1,262
SVADD	3,073	1,511	7,499	14,727	132	156
Total	139,276	169,657	122,577	68,531	40,557	7,250

Table 3.13b. Estimated grain legume production - Smallholder farms (tonnes)

ADD	G/nuts	Beans	P/Peas	Cowpeas	Soybeans	Bambara
KRADD	2,482	2,683	442	81	286	239
MZADD	8,858	8,813	31	56	3,446	263
KADD	29,222	9,470	-	178	10,689	1,797
SLADD	8,137	486	1,590	875	707	249
LADD	26,642	21,811	55	898	12,051	1,058
MADD	15,034	6,385	28,415	9,280	1,033	560
BLADD	10,974	9,444	46,347	8,595	1,778	520
SVADD	2,314	1,368	6,335	8,784	48	73
Total	103,663	60,460	83,215	28,747	30,038	4,759

It is observed that Lilongwe ADD produces the highest tonnage of beans (21,811) followed by Kasungu ADD and Blantyre ADD with 9,470 and 9,444 tonnes, respectively. Beans are extensively grown across the country. Interestingly, pigeon peas are mostly concentrated in the Southern Region where BLADD leads with a total production of 46,347 tonnes, followed by Machinga ADD with 28,415 tonnes. Even Shire Valley ADD has more pigeon peas than the entire central and northern ADDs combined. Cowpea production is concentrated mostly in the southern region, whereby MADD has the highest with 9,280 tonnes and SVADD with 8,784 tonnes, and BLADD with 8,595 tonnes. The yields of pigeonpea for some regions appear rather high (e.g. 720 kg/ha in Salima ADD and 850 kg/ha in Machinga ADD) and again might represent inaccuracy in yield estimates, although yields of 2 t/ha have been recorded in experimental plots (Sakala, 1994).

3.4.2 Agronomy and cropping patterns

Sole crops of pigeonpea, *Phaseolus* and lab-lab are rarely seen whereas groundnut, soyabean and Bambara groundnut are more frequently grown in pure stand. Grain legumes can potentially meet their N requirements through symbiotic N_2-fixation, but legume yields and N inputs to the cropping system are limited by poor agronomic management of legume crops. Very often plant populations of the legumes are sub-optimal, with single rows of legume sown in the centre of large ridges spaced 90 cm apart, when double rows per ridge will give much greater yields. More robust legumes such as the promiscuous soyabean can form a closed canopy if sown at higher densities, reducing the requirements for second weeding.

*Groundnut (***Arachis hypogaea***)*

The large amount of nitrogen present in groundnut stover when the crop is harvested can provide a significant input of N to the cropping system if the stover is returned to the soil (Giller and Cadisch, 1995). Amounts of N in groundnut stover can be as much as 130 kg N ha^{-1} with the creeping Virginia varieties (Toomsan *et al.*, 1995). The benefit of including groundnut in crop rotations with maize was recognised in early work on the Lilongwe plain of Brown (1958), though the amounts of N contributed on farmers' fields may be very limited due to poor agronomy and disease incidence.

In recent trials at 39 sites of the MPTF groundnut yields ranged from 1560-1890 kg ha^{-1}, greater yields and substantially more profitable than unfertilised maize (R. Gilbert, personal communication, Blackie *et al.*, 1998). ICRISAT have shown that a new variety CG7 substantially outyielded the local Chalimbana variety on both experimental stations and on farmers' fields indicating that substantial improvements in both yields and soil fertility benefits are possible through varietal selection.

*Common bean (***Phaseolus vulgaris***)*

The common bean (*Phaseolus vulgaris*) is an important food crop widely grown as an intercrop by smallholder farmers in Malawi. Among legumes *Phaseolus* is generally considered to be poor in N_2-fixation although recent results indicate that beans often fix more than 50% of their N from N_2-fixation on-farms in Eastern Africa (Wortmann and Giller, unpublished results). Comparable estimates in Malawi are not available but given the poor yields of beans on smallholder farms (>500 kg ha^{-1}) it is unlikely that this crop will contribute much to soil fertility. The importance of beans as a major source of dietary protein for poor farmers should not be underestimated.

An approach to selecting bean for soils poor in P has successfully identified varieties which grow well on P-limited soils in Africa (Wortmann *et al.*, 1995). This approach has been used in Malawi and has identified several varieties of beans that have yield potential roughly three times that of local varieties under on-farm conditions.

Promiscuous soyabean

Soyabean is a grain legume which can produce more calories per unit of land than unfertilised maize in Malawi, besides providing large amounts of protein and fixing N_2 from the atmosphere. Soyabean is well-known to be highly-specific in its requirement for rhizobium bacteria so that application of rhizobium inoculants are required to ensure that soyabean can N_2-fixation yield well. As inoculants are not available for smallholder farmers this means that most soyabean varieties are unsuitable for cultivation, including many of the varieties grown commercial farmers in neighbouring countries.

Some naturally-nodulating or 'promiscuous' varieties of soyabean are available that fix N with a wider range of rhizobia often found in smallholder fields. The best known of these is 'Magoye' which was selected in Zambia by Javaheri (1996), although there are several other varieties which are similarly able to nodulate with rhizobia indigenous to southern African soils (Mpepereki *et al.*, 1996). Naturally-nodulating soyabean such as Magoye has a large above-ground biomass, a lower grain and N harvest index and a more indeterminate development pattern than most specifically-nodulating types. Initial results of experiments in Malawi and Zimbabwe indicate that Magoye is a net contributor of N to the soil. Magoye yields an average of 2.2 t grain per ha in monoculture and 0.86 t per ha when intercropped in Malawi by smallholders. Many Malawian smallholders have planted soyabean in the last two years and extensive demonstrations of Magoye + maize rotations were mounted in 1996/97 (although these used the wrong varieties). A recent problem has been a collapse in the market price of soyabean within Malawi.

A current project funded under the Rockefeller Forum is investigating N_2-fixation the soil fertility benefits of Magoye soyabeans under smallholder conditions in southern Malawi (Mkandawire *et al.*, in progress). Although general experience of NGOs with Magoye has indicated that this genotype nodulates widely on smallholder farms in southern Malawi a wider survey is required to confirm the distribution of compatible rhizobia. Nothing is known of which species/types of rhizobia nodulate the promiscuous soyabeans in Malawian soil.

Maize + pigeonpea intercropping

Optimal planting patterns have been established, in which pigeonpea (three seeds/hill) is interplanted between maize stations (also three seeds/hill giving 37, 000 plants per ha) within the ridge (Sakala, 1994). The recommended variety is ICP 9145 pigeonpea, a long-duration variety that has resistance to *Fusarium* wilt and is higher yielding than local varieties. With this spacing arrangement maize yields are not decreased in the intercrop as the long-duration pigeonpea grows slowly during the rainy season. Pigeonpea then grows on through the dry season using residual moisture from deeper soil horizons. Late maturing pigeonpea intercropped with maize can often produce a dry matter yield of 3 t per ha from leaf litter and flowers and, even if the seed is harvested for food, the leaf fall is sufficient for N accumulation.

Pigeonpea can regrow readily if ratooned (cut back at 30-50 cm above the soil) at the start of the rains, which reduces seed costs, except on sandy soils such as those found on the Kasungu plain where high rates mortality of ratooned pigeonpea were found (Sakala, 1998). Studies over several years are required to examine the long-term benefits of this intercrop on soil fertility. Experiments which were established by Webster Sakala of the Maize Commodity Team as part of his PhD studies have been running for three years and will be continued with funding from SoilFertNet to address the longer-term effects on soil fertility.

Although the recommended variety ICP 9145 (a land-race collection from East Africa) is one of the main sources of resistance to *Fusarium* wilt in pigeonpea, there have been recent reports that it has been affected by *Fusarium* in southern Malawi. ICRISAT have several other promising varieties which have been subjected to widespread testing in Malawi (8,000 sites in the 1997/8 season) and efforts need to be made to diversify the number of recommended varieties

A disadvantage of pigeonpea is that it is highly attractive to livestock, and therefore it has been considered that pigeonpea cannot be grown in the central plain or the north of Malawi where cattle are more abundant than in the south. As this is currently largely supposition a much wider survey and farmer testing is required to evaluate the potential for wider distribution of pigeonpea.

Legume green manures

There is a long history of experimentation with legume green manures for improving soil fertility in Malawi (Davy, 1925), but few reports of their use by smallholder farmers. Interestingly legumes studied by Davy - *Mucuna, Tephrosia* and *Crotalaria* - are the same legumes still being studied currently. Seed of a range of other potentially suitable species has recently been collected through SoilFertNet and several species are now under preliminary evaluation.

Ongoing research is focused on the potential of undersowing maize with green manures for improving soil fertility. Undersowing with the 'fish bean' *Tephrosia vogelii* appears to be one of the most promising legumes as it grows through the dry season and produces a large amount of organic matter. Several groups are testing use of *Tephrosia*, including the Maize Commodity Team at Chitedze who have a series of fairly detailed experiments on farmers' fields examining the benefits to N cycling and maize yields of the sole green manures and

Tree legumes

Alley cropping has received substantial research attention in Malawi, although as elsewhere a consensus view has developed that it is not an appropriate technology. A large extension programme of alley cropping to smallholder farmers in southern Malawi was conducted through the EU-funded ADDFood Programme. The majority of farmers were supplied with trees of *Senna spectabilis.* This species was chosen for recommendation largely because seed was available in sufficient quantity whereas seed of *Gliricidia sepium* was not available. *Leucaena leucocephala* was not widely used as the psyllid insect pest (*Heteropsylla cubana*) had recently arrived in Malawi and was causing severe damage to this species, which was also often killed on farms by termites. Agronomic experiments had been conducted with a variety of legume trees, including *Leucaena leucocephala, Gliricidia sepium* and *Senna spectabilis* at the Chitedze Research Station and at various other locations in Malawi. These experiments indicated the benefits of these trees to maintain maize yields of 4 t ha^{-1} without N fertilisation. However, detailed investigations revealed that the legume trees were rooting in the surface soil horizons and *Senna* in particular was highly competitive with maize, rooting densely in the surface soil horizons up to 8 m away from the tree rows (Itimu, 1997).

A variant of alley cropping, the planting of trees on vegetated contour bunds for soil conservation bunds is perhaps appropriate for areas where steeply sloping land is cultivated, but with much wider spaced rows of trees than that commonly recommended in the past.

The Msangu tree (*Faidherbia albida*) is maintained on farmers' fields and the benefits to growing crops and enhancements in soil fertility under the trees have been demonstrated (Saka *et al*., 1994). *Faidherbia* is largely a riparian species in eastern and southern Africa (Vandenbeldt, 1992), and the majority of *Faidherbia* trees in farmers' fields are found along the lakeshore, although this species grows well on top of the escarpment between Lilongwe and Salima. Ongoing research has shown that roots of *Faidherbia* trees do not extend far horizontally from the trees so that tree/crop competition is minimal (Phombeya, personal communication). The trees obtain water and nutrients from the water table which is found at depths of more than 20 m below the trees. It is not known how long it takes for *Faidherbia* trees to have a significant effect on soil fertility, though given the rates of growth commonly seen it is likely that 15-20 years are required before effects are detectable.

The Regional Co-ordinator for ICRAF, Dr Freddie Kwesiga contributed the following: "ICRAF has been involved in Malawi and working with the commodity team in Chitedze since 1988. On-farm testing of technologies for integrated soil fertility management was conducted with Rockefeller Foundation support from 1990 to 1997. Research at Makoka has focused on the simultaneous integration of trees with maize in the cropping system. Gliricidia mixed intercropping and sesbania relay cropping have been examined as complements and/or improvements to maize-pigeonpea intercropping. Soil nitrate and ammonium dynamics were monitored for two years (1995 to 1997) in on-station trials with gliricidia mixed intercropping and sesbania relay cropping. Results suggest that levels of preseason soil nitrate are dependent upon previous season rainfall and maize production. The performance of gliricidia mixed intercropping and sesbania relay cropping continues to be examined on farm, and researcher-managed trials are examining whether these systems exploit subsoil water and nutrients that might be underutilized by existing cropping systems.

In lower populated areas (such as the lakeshore and non acid soils between Lilongwe and Mzuzu), planted trees grown for two years in rotation with maize (two year improved fallow as developed in eastern Zambia) are a potential technology. Two-year fallows with sesbania and tephrosia were tested at diverse sites as part of the regional multilocational trial on the biophysical limits to improved fallows. In 1997, farmers from Kasungu Agricultural Development Division in Central Malawi participated in an exchange visit with farmers in Zambia to gain familiarity with sesbania improved fallows. As a result of this farmer-to -farmer exchange, 135 farming families in Kasungu established their own tree nurseries and planted sesbania fallows in the 1997-1998 cropping season.
In densely populated areas in southern Malawi, gliricidia mixed intercropping and the sesbania relay cropping continue to be tested in researcher-managed trials in farmers' fields. These technologies require more examination on how they differ from alley cropping in resource use. They are not considered ready for dissemination to farmers. Approaches for 1998 are:

1) Continue working with farmers in lower populated areas on improved fallow technology.
2) Screen *Tephrosia* germplasm for suitability in undersowing, intercropping and rotational systems. The germplasm is currently being collected.
3) Screen promising sesbania germplasm. Previous screening of 106 *Sesbania* provenances in the region for two-year fallow identified 24 perennials suitable for fallows and 4 provenances tolerant to *Mesoplatys* beetle.

4) Explore options for use of natural vegetative strips for soil conservation on sloping lands in southern Malawi. This technology is currently very promising with farmers in the Philippines.
5) Continue measurements of water and nitrogen use by maize-tree and maize-pigeonpea systems in order to assess the potential for exploiting underutilized subsoil water and nutrients.
6) Explore options for greater integration of livestock and trees within the farming systems.
7) More thoroughly co-ordinate activities on agroforestry with other research activities in Malawi. It is proposed that this be initiated through a meeting of key researchers in Malawi in June 1998 in order to inform others of activities, identify comparative advantages of research groups, discuss the role of trees for soil fertility interventions, and identify ways for closer linkages among researchers in Malawi."

3.5 The role of livestock in farming systems and production of manure

The livestock population and the number of households owning livestock and poultry are small. The total head of cattle is under 600,000 and there are just over 1.5 million goats. Only four per cent of households have cattle pens; 15 per cent have goat pens and 55 per cent own free range chickens and layer and broiler units (Customary Land Annual Livestock Census, 1998). Livestock are concentrated in the Northern Region of Malawi (Table 3.14; Fig. 3.6). Although numbers of goats and sheep exceed numbers of cattle, cattle manure is of greatest importance for agriculture. Very few animals are stall fed in Malawi - the latest annual census recorded only 529 stall-fed cattle. As most of the cattle range freely, much of the manure is lost during the day in the bush.

There are only 75,00 working oxen or just over 37,000 pairs of working oxen; nearly 80 per cent of which are in the three most northern ADDs. The total cultivated area is approximately 60-70,000 hectares farmed by 2.2 million households, which means that virtually all energy for cultivation is supplied by human labour.

Table 3.14. Numbers of livestock in the Agriculture Development Divisions of Malawi in March, 1998

ADD	CATTLE	WORK OXEN	GOATS	SHEEP	POULTRY (Free range chickens)
Shire Valley	81,129	1,584	219,370	2,987	61,837
Blantyre	42,547	852	211,666	2,482	241,631
Machinga	3,876	1,977	217,001	3,8391	271,117
Lilongwe	73,128	9,333	349,680	9,544	172,694
Salima	44,965	2,137	149,930	13,499	121,395
Kasungu	91,501	17,147	264,822	11,913	106,325
Mzuzu	130,502	29,480	130,345	14,580	94,660
Karonga	86,687	12,217	23,700	4,521	46,340
Total	589,175	74,997	1,566,514	97,916	1,115,999

Source: Customary Land Annual Livestock Census, 1998

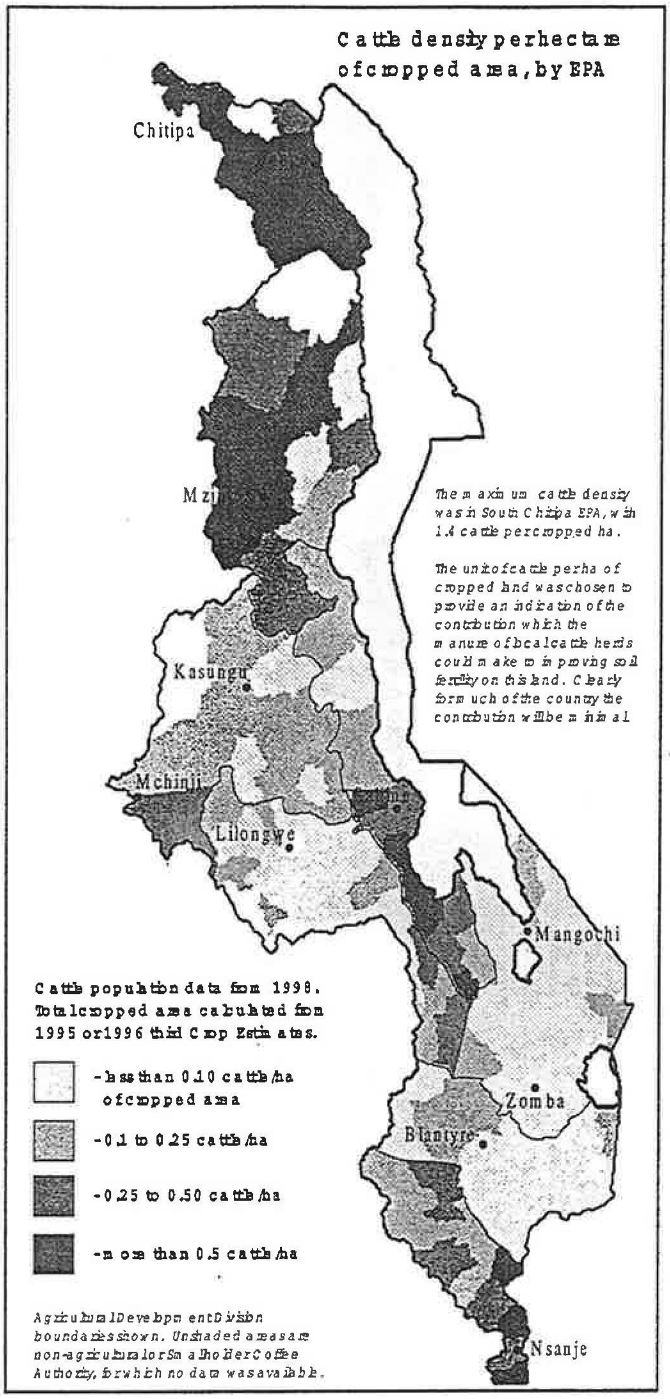


Fig. 3.6 Map of Malawi showing current cattle numbers in relation to the cropped area of land. The cattle population data was taken from 1998 estimates for each EPA and the area of cropped land from 1995 or 1996 third crop estimates.

Analysis of cattle numbers, based on 1998 estimates, demonstrates how limited the supply of cattle manure is in relation to the area of cropped land (Fig 3.6). The maximum density of cattle (1.4 cattle per hectare of cropped land) was in South Chitipa EPA, in the far north of the country. Cattle numbers were less than 0.25 cattle per hectare of cropped land in the majority of the land area. Estimates from West Africa suggest that one cow will produce around 0.8 ton of manure in a year, of which less than 50% (>0.4 t) will be collected if the animals are only kept in kraals at night (Fernández-Rivera *et al.*, 1995). This is supported by estimates in Malawi that cattle excrete roughly 3 kilograms of manure (dry weight) per day per animal (Dr. Joshua Mtimuni, personal communication). This would suggest that the amount of manure available on a broad scale would be around 1 ton of manure per 10-25 hectares across much of Malawi. From this analysis it is clear that the amounts of manure available within the farming systems will limit its use to those farmers with cattle, or to very small areas of land in the case of farmers who may purchase manure

The use of cattle manure is one of the most researched inputs for the maize production. This research includes studies on the difference between manure from open and from closed kholas (kraals). Results have shown little difference in maize response to manure from open or closed kholas, although theoretically one might conclude that there would be more nutrients in the manure from closed kholas. The closed kholas, more especially during the rainy season, will have considerable amounts of nutrients leaching out of the manure. Those farmers who practice stall feeding their steers in kholas which have a bedding of maize stalks will improve the retention of nutrients in the stalks, and when the manure decomposes in the field more nutrients will be released for maize. There has been no detailed research to document the quality of cattle manure in Malawi, although it is expected to be one of the best sources of organic matter for soil amendment.

Results from Chitedze show that manure does not contain as much nutrients as might be expected (Table 3.15). The largest advantage of using manure is the supply of potassium into the soil system, and there is not much advantage in terms of phosphorus supply resulting from use of local manure from open kraals.

Table 3.15. Chemical analysis of khola manure from Malawi

Site	%C	%N	%P	%K
Nyankwi	4.23	0.69	0.39	1.04
Kabwazi	4.15	1.00	0.15	1.34
Mtegowagwa	4.19	0.81	0.43	1.22
Mphalapala	4.19	0.43	0.43	0.56
Nankumba	4.27	0.42	0.80	1.16

Benefits of manure in increasing crop growth are readily demonstrated (Table 3.16). In trials at four locations, the greatest increase in the maize grain yield was observed in the treatments at Simbi. In fact, the two handfuls of manure applied per planting hole gave much higher yields than all the other treatments, including where 2 bags of 20-20-0 plus 2 bags of CAN were applied indicating the other benefits of manure beyond nutrient supply. Generally, low rates of manure gave inferior yields. Increasing the rate of manure from 2.5 to 5.0 tonnes/ha without inorganic fertilisers had no appreciable effect, but the addition of inorganic fertilisers significantly ($P < 0.01$) increased yields by 54%.

Table 3.16. Effect of manure x fertiliser rate on the yield of local maize at different locations

Treatment	Nambuma	Khota Kota	Simbi	Chulu	Mean
Control	1460	700	650	1060	970
2.5 tonnes manure	1740	780	1830	910	1310
5 tonnes manure	1900	650	1790	1270	1400
2.5t + 1bag CAN	2630	1580	1310	1300	1700
2.5t + 2 bags CAN	2260	1860	2340	2000	2130
5 t + 1 bag CAN	1590	1710	2400	1740	1860
5 t + 2 bags CAN	2230	1780	2430	1980	21110
2 handfuls manure	1790	2020	3000	2290	2310
2bags 20-20 + 2 bags CAN	2200	2590	2100	2340	2310

Source: (DAR, 1987)

Greenhouse experiments by Mateo (1997) have showed that treatments that contained manure plus earthworms and Tundulu PR had significantly the highest amount of phosphorus in the plant tissue and in the soil than those treatments with only manure or Tundulu PR alone. This experiment is being tried in the field during the 1997/98 growing season, and the general observation have shown that Tundulu PR + manure + earthworms are superior to where single super phosphate was applied (Nyirongo, 1997).

3.6 "Best Bet" Technologies for Improving Soil Fertility

'Best bet' strategies can be identified which, coupled with good crop and land husbandry methods (timely weeding, soil conservation etc.), are likely to have significant benefits in food production and to play a role in slowing, and in some cases reversing, the decline in soil fertility. Apart from the important criteria of proven technical efficacy on farmers' fields under research conditions, the criteria of compatibility with existing farming practices, and with the resources available to the small-holders are also important (i.e. those with larger or smaller holdings, those with more or less labour, those with or without access to cash or credit, soil types and slope of land, level of conservation in the field, current fertility status of land, proximity to markets, access to manure, protection of fields from livestock etc.). These factors will determine whether particular approaches and crops are appropriate for different farmer groups.

The selection of these has been made on the basis of the evidence presented above and of numerous discussions with scientists in the region mainly through the SoilFertNet. In particular discussions took place at a workshop in July 1997 in Mutare where this issue was debated and the proceedings of that workshop will be available during June/July 1998. These 'Best Bet' technologies have been divided into four classes:

1) Interventions which can be **immediately recommended**. These are interventions which are likely to bring some immediate benefits in food production and soil fertility and for which there is little risk of failure of repayment on investment:
   i. Area-specific fertiliser recommendations
   ii. Magoye soyabean rotations
   iii. Maize + pigeonpea intercropping
   iv. Use of animal manure (where available)

2) Interventions that are recommended for wide-scale farmer evaluation have yet to be subject to wide-scale farmer evaluation but which show considerable promise for improvement of soil fertility. These interventions have immediate scope for farmer adaptation and adaptive experimentation by farmers and other agencies such as extension and interested NGOs:
   i. Undersowing with green manures (e.g. *Tephrosia vogelii*)
   ii. Transfer of available biomass (e.g. *Tithonia*)

3) Interventions which have likely to make a small contribution to soil fertility at the farm scale in the short-term but represent **investments for the future**:
   i. Planting of *Faidherbia albida* within fields
   ii. Boundary planting (e.g. *Gliricidia*) and rotational woodlots (e.g. *Sesbania sesban)* of legume trees

4) Interventions which have yet to be tested but **deserve research attention** be useful for long-term soil fertility improvement but where the knowledge base is insufficient to allow critical assessment of their potential. Research programmes focused on the maintenance of soil fertility is warranted *under soil fertility status relevant to smallholder farmers* examining, as examples:
   i. the long-term implications of maize stover management on SOM status and maintenance of soil fertility
   ii. Screening of alternative legume species for undersowing as green manures
   iii. Alternative food and cash crops to promote smallholder crop diversification which would give more scope for rotations
   iv. Processing research and extension and market research and promotion
   v. Investigation of relay cropping systems, following early maturing cereals with legume in the same season
   vi. Research into a wider range of food legumes (e.g. cowpeas, grams, chickpeas, *Dolichos lablab*) which might fit into the various farming systems and have potential markets

The classification of the technologies is intended to give a clear idea of how far advanced testing has been developed. The most rapid means of addressing farmers' needs is probably to begin a large-scale, participatory testing of these approaches by farmers through NGOs and extension agents. It is likely that different selections of the approaches will be appropriate to different groups of farmers depending on their wealth and location within Malawi's agro-ecology.

4. FARMERS' PERCEPTIONS AND PRACTICES RELATING TO SOIL FERTILITY

Introduction

Farmers' perceptions are closely inter-linked with their practices. It is important to describe both in order to consider the implications for soil fertility related interventions. The small-scale farming and livelihood systems of rural Malawi can be seen as the product of the ideas and practices of the farmers (males and females, young and old) who are involved in agriculture in the country. These practices and ideas, and emerging patterns or systems of behaviour are dynamic, being influenced by past experiences, and also by responses to emerging pressures and shocks, both internal and external. This part of the review describes, in summary form, farmers' perceptions and practices specifically in relation to soil fertility and related aspects of soil and land conservation (and degradation). It also considers the implications of these for development interventions addressing soil fertility.

The description provided here is not only qualitative, but partial and to some extent intuitive. This is because recent (i.e. within the last decade) sources of information which we could find on farmers' perceptions and practise relating to soil fertility were few. The literature, most is grey, documents observations made in a small number of communities, mainly in central and southern Malawi. The most focused study of farmer perceptions relating to soils is that of Wellard (1996), covering two catchments fairly typical of the southern and central plateau regions. Some more focused maize-oriented technical surveys of farmer practices have been undertaken with support from CIMMYT (Smale *et al.*, 1991 and Smale et al, 1998). A few area specific, mainly qualitative PRA studies have general information on agriculture and natural resource management, but without soil fertility as the prime focus. A number of more general PRA studies reflect farmers' views and researchers observations on the importance of soil fertility and related aspects. These cover a wide geographical range of areas, mainly in the central and southern region and including the far south and the lake shore. In addition, there are observations and data from on-farm research programmes, mostly in the south. Data from in-depth studies of soil degradation in eastern Zambia with similar farming systems, language and culture to central Malawi, has also been used (ARPT, 1991).

In examining the relevance of the data in these reports, we acknowledge the various influences on farmers' perceptions recorded in PRA and similar reports, including the type of questions framed, how the questions were asked, and how the responses were recorded. Farmers often say what they think is required, while the researchers may re-interpret the responses of farmers to questions, and in the process insert their own ideas. In most of the studies reported, there is the familiar bias in the information provided – older male and better-researched farmers provided much of the information.

4.1 Farmer perceptions of change (over the last ten years)

Most of the PRA type surveys did not focus on soil fertility as a topic, but on wider issues such as food security and environmental management. Farmers raised the issue of soil fertility in discussing the causes of other problems. The extent to which farmers' attribution of causes was influenced by prompting from the PRA teams is not clear, but some influence is likely.

4.1.1 General perceptions on changes in soil fertility

Farmers' general perceptions of soil fertility decline can be gleaned from the PRA rankings of problems, trend analysis, historical time lines (oral history of important events usually relating to a particular topic), and from farmers' comments about the causes of their problems such as hunger, sickness and declining yields and income from farming (see Table 4.1). These provide some insight into farmers' perceptions of change. The oral histories do not suggest a gradual decline in yield levels, but rather a crisis arising, relating to "outside pressures" such as poor rainfall and changing fertiliser prices and credit policies.

While, in objective terms, the fertility of land may have been declining at a fairly gradual rate since the early 1980s, the "external shocks" of climatic and policy related events are seen by farmers as having a more critical effect on yield levels than is the decline in soil fertility.

A study conducted near Lilongwe in 1995 (Action Aid, 1996) presents a snapshot view on farmer perceptions of changes in their livelihood base over the past 25 years. Farmers from Chitseme (EPA 11) identified the period from 1981 to 1989 as one in which there was adequate food, and fertiliser was used. In 1989 the drought started and continued up to 1992. In 1993 political events took over with general elections in 1994 and inadequate food in 1995. In the same study, farmers expressed the decline in soil fertility from the 1970s to 1995 over ten and five year periods, using a participatory indicative scoring system. They estimated that in the decade from 1970 to 1980 fertility declined from 12 points to 8 points, and further down to 6 points in 1985, 4 points in 1990, to just 2 points in 1995 (points being represented by stones). A similar scoring system indicated that land-holdings had declined in similar proportions over the same period, and access to loans even more so.

In terms of livelihood base, dependence on off-farm income had increased in Chitseme from just 2 points in the 1970s to19 points in 1995 (as per the farmers' scoring scheme), and over the last decade was estimated to have increased from five points to nineteen points. Since the 1970s, farmers estimated that diseases had increased from five points to 38 points while population size from three points to 29 points. Diseases were perceived to have increased from 13 to 38 points in the decade 1985 to 1995. In answering a question about their welfare, more farmers (44%) felt that they were worse off in 1997 than in 1991, than that they were better off (32%) (Smale et al 1998). In short, farmers' perceptions in this study indicate an overall decline of the contribution of agriculture to livelihoods. Some of the studies also indicate increasing health and nutrition related poverty in rural areas over the last decade.

Summary

While the data is patchy, the overall evidence of farmer awareness of soil productivity decline is clear. Farmer perceptions suggest that soil fertility is declining along with both food and cash crop production, resulting in increasing poverty. Farmers attach importance to soil fertility and soil conservation, and attribute important problems, particularly hunger, increased dependence on off-farm employment and even fuel wood availability, to its decline. This suggests an overall decline in the self-sufficiency in rural peasant family livelihoods, and a greater dependence for many of the rural poor on the wider economy and relief handouts.

Implications

Future programmes can build on existing levels of awareness of the causes and consequences of declining soil fertility among farmers. Given the existing level of awareness of many farmers, there is considerable scope for using the mass media for the further promotion of extension and development initiatives relating to soil fertility decline in order to:-

a. further raise awareness levels among small-scale farmers with access to radio,
b. debate the soil fertility issue, share ideas and explore possible ways of addressing it,
c. broadcast relevant technical and market information relating to profitable or useful soil improving and conserving technology options.

4.1.2 Yields and returns per unit area

Specific information on farmers' perceptions of yields and returns per unit area, and also on actual returns, over the last ten year is sparse, apart from limited experimental data (see section 3 of this report and Table 4.2). The detailed maize technology adoptions study conducted around the time that fertiliser prices began to increase in 1990, did not cover trend data on yield (Smale *et al.*, 1991). Data on farmers' perceptions in this maize adoption study indicated that in two of the three sites surveyed, farmers expected returns from using fertiliser on local maize were higher than what they actually got. An impact study of the effect of packaged handouts to poorer farmers, including maize packages, found that many farmers actually got lower returns to the hybrid seed and fertiliser packs than what had been expected (Action Aid, 1996). Apart from tobacco, there is very little information on economic returns to other crops. The report by Jaffee (1997) suggests, using an aggregated economic analysis, that returns vary markedly from year to year, depending on input and market prices. Recent rises in world grain prices may make maize more attractive than it has been in recent years, when compared with crops like tobacco. However, this type of economic analysis largely applies to the estate sector, and to the more wealthy elements of the small-holder sector consistently able to produce an agricultural surplus. For the vast majority of poorer small-holders, an analytical framework which looks at food security and livelihood coping strategies may be a better tool for predicting behaviour, than market-oriented farm management models. The high importance still attached by most rural households to maize self-sufficiency as an index of welfare (Smale et al, 1998), suggests that household food security is still a very relevant conceptual framework within which to discuss the related issues of agricultural productivity and soil fertility.

Implications

Returns to unit area are likely to become more important to farmers as land becomes a scarcer factor of production. However, any economic analysis needs to be wary of the risks of aggregating data, making assumptions and extrapolations based on experimental data and market prices, and divorcing data from the context of the local farming and livelihood systems. Land quality does vary significantly. Possible areas of intervention relate to increasing the productivity of the higher potential land, such as the dambo areas, as much as arresting the decline in the upland arable areas. However, not all farmers have access to the higher potential land, and conservation of the poorer land is likely to require some form of "subsidy" (from the land holders and/or the state), or conservation which is motivated by non-economic factors.

4.1.2 Returns per Labour Day

The organisation of labour in agriculture is a fairly complex topic. Understanding the labour data is important when evaluating the possible impact of interventions relating to soil fertility, either by increasing or decreasing the labour demands. Men and women are likely to be affected differently, and there is generally adequate information to anticipate the probable effects.

Data in the literature on returns to labour is based largely on aggregated analysis at national level, rather than on local studies of farmers' perceptions and practises. This data suggests that returns vary greatly from one crop to another, and also from year to year, as prices change. At farm level the reality is more complex. Direct farmers' perceptions and observations on returns to labour, and on trends over time, are very limited in the literature. The PRAs have labour data in the form of seasonal calendars, many of which are dis-aggregated by gender, which is useful information (see also Table 4.3).

Some inferences can be made, from the labour calendars and from trends in the farming systems, about the way labour is organised that are relevant when thinking of possible interventions. Most of the calendars suggest that the rainy season is the busiest time, with the more strenuous work taking place when food is scarcest, when there is more disease and when people are weaker. Time-consuming tasks tend to peak from when the maize harvest starts in late May through to August, when women are particularly affected, but when the diet is better and diseases are fewer. Even where a husband lives with the woman and jointly manages the household, woman most often depend on their own labour for tasks related to maize production from land preparation, planting, weeding, to storage and seed selection (Davison, 1993). Dimba gardening has an added effect on household labour demands, particularly during the month of February.

It is widely reported that the poorer households often do not cultivate all the land at their disposal, due to a labour constraint. Hunger forces them to go for piecework (*ganyu*) instead of working on their own fields during planting and weeding time (from November through to early January). Many of them only do a single weeding on their maize crop (Riches, 1998 field visit report). Smale *et al.* (1991), found that about half of local maize was weeded only once. As a result the returns to their labour input in making ridges, planting and doing the first weeding is reduced. Some households do not use their dimba lands because of limited labour, and rent them out instead.

Talk of the "opportunity cost" of labour may be misleading, particularly in the case of poorer households. Theoretically, the returns to the poorer households' labour would be higher if they worked more on their own land (e.g. weeded earlier or cultivated a large area) rather than working for another farmer in return for food. In reality the choice they face is whether to work for a meal, or work for longer on their own land and not eat. This is not a choice at all. Their lack of access to fertiliser further reduces the productivity of their labour, particularly on the maize crop.

Implications

There are times when more surplus labour is available, and there are limited local employment/piecework opportunities. Such times present a potential opportunity for using this labour in interventions which will improve soil productivity. More labour intensive measures to conserve soil and enhance its soil (e.g. soil conservation structures, increased area of leguminous crops, composting etc.) may be difficult for many poorer households to adopt. However, the evidence is that many of them (particularly those which are poor, but are made up of older people and fairly well established in farming and therefore in less of a crisis state) are willing to invest in such activities and technologies. Fertiliser is a labour saving technology for all households as it allows farmers to produce more maize from a smaller area of land (less labour is required for land preparation, planting, weeding, and due to larger cob size also harvesting and threshing). Returns to its use are likely to increase, particularly if other soil improving and conserving technologies are used in combination with fertiliser. Farmers are more likely to combine organic and inorganic methods if the extension approach is less value laden in favour of one or the other. Willingness to engage in more labour intensive practises may depend as much on knowledge, attitudes and commitment to farming, as upon some semi-objective measure of poverty. In general the overall ratio of labour to land and capital is increasing, which implies that labour intensive technologies are likely to be more acceptable, and in all probability are being implemented in various ways independently of planned interventions. At the same time, other opportunities for using labour will develop as the local economies, develop. These may include hawking, construction, handicrafts, and various types of mining (sand, building stones, semi-precious stones etc.).

4.1.3 Impact of soil fertility decline on household food security and income

There is strong evidence from reported problem analysis discussions with farmers in several communities that growing food insecurity is perceived as being related to declining soil fertility (Leach and Marsland, 1994; Drinkwater, 1995 and Nelson, 1998) although when farmers speak of a decline in soil fertility they are talking about productivity. But soil fertility is not the sole factor identified by farmers. Drought, increasing fertiliser prices and lack of credit are also identified as important causes of household food insecurity, and in the shorter term are seen to have a much more devastating impact on food security. A significant observation from the PRA reports on farmers' (food security) coping strategies is that these do not mention measures to improve soil fertility. Instead, farmers look for ways of working for food or for cash with which to buy food. For the farmers most affected, soil improvement is not currently perceived as an immediately obvious or viable coping strategy for improving their household food security status. This may explain why some recipients of free fertiliser are reported to have sold it rather than using it on their own farms.

The association between declining soil fertility and income is similarly complex. For example, in a PRA conducted Lilongwe rural, declining soil fertility, in combination with increased population, decreasing land size and lack of credit, is associated with increasing dependence on off-farm income sources (Drinkwater, 1995). The implication is, that even if soil fertility was maintained, increasing population and decreasing land size and lack of credit would increase the dependence on non-agricultural income sources; the decline of soil fertility further increases an already growing dependence on non-farm income sources.

The extent to which non-agricultural income is used to finance investments in soil improvement (e.g. fertiliser, soil conservation and even livestock purchase) is not well documented, but limited evidence indicates that it may be declining. Smale's study (1991) indicated that in 1990, farmers in the Blantyre area were investing into hybrid maize production from their off-farm income sources, much more than were farmers in the more remote rural areas of Malawi. Wellard suggests that in 1996, the scope for this type of investment had been reduced considerably, because most urban families had very few cash resources left to invest back into the rural areas after meeting their immediate needs, due to rising urban living costs.

Implications

Farmers face the challenge of feeding themselves from a declining natural resource base. In order to add to the stock of ideas for future development initiatives, more research is required into how farmers are innovating in order to meet this challenge. With declining real cash income levels, more attention should focus on labour intensive soil improving methods, if possible linking these to the production of cash crops, highly valued food crops and off-farm income.

4.2 Farmers' views on the use of organic and inorganic fertilisers

There is limited information on this topic, particularly on the specific merits and "demerits" of particular technologies for particular ecological niches, soil types, crops, and types of farmers (see also Table 4.4).

While farmers clearly value fertiliser, their view of it comes across as somewhat ambivalent. Over the past 30 or so years since fertiliser was introduced, most farmers have experience with using it, an estimated 88% in the main maize producing areas (Smale et al, 1998). However, in any one particular year, a rather small percentage actually get access to significant amounts of fertiliser, and in the main maize producing areas only 15% of households report using it continuously (Smale, et al, 1998). The relative difficulty of regular access to fertiliser may have caused farmers to be sometimes negative about its attributes[4]. They often claim that using it does adversely affect the soil for crops in the following seasons, and some farmers in Eastern Zambia deliberately avoid applying fertiliser to their local maize fields for fear it will spoil the longer term productivity of these soils (ARPT, 1991). The other negative attribute of fertiliser is that it can lead to debt, particularly following drought years. Fertiliser may now increasingly be regarded by many poor farmers as useful a technology, but one which is for the better off farmers, who can get credit, buy it for cash and regularly produce a surplus?

Alternative methods of coping with declining soil fertility, while clearly not as effective as fertiliser in the short term, have some attractions to farmers. In some ways the organic options of; fallowing, crop rotation, soil conservation structures, controlled burning, green manures, composting, incorporation of crop residues (e.g. systematic incorporation into crop ridges as part of a sustainable rotation system as reported by Shaxson and Riches, 1998) may be perceived by many farmers as better than fertilisers, in the sense that they are more within their control, and less dependent on external inputs. Moreover, these methods do not adversely affect yields in the following seasons, and do not result in debt in the event of a crop failure caused by drought, excess rains or major pest attack. However, just as poverty limits access to fertiliser, it also constrains access to these alternative technologies. The poorer households have less land and poorer access to the seeds and labour required for organic approaches to soil amendment.

[4] Distribution of free fertiliser will not necessarily make a difference to household food production as people may sell it to meet immediate cash needs rather than invest it on their land.

Implications

Farmers' perceptions of fertiliser raise the issue of how various agencies present information to farmers. In locations where they have a role to play, longer acting fertilisers (such as lime and phosphates), which carry over the benefits into several seasons, may be more attractive to resource poorer farmers because they would be less likely to fear the consequences adverse weather and of being unable to afford or get fertiliser in the following season. Similarly, strategies for careful application of fertiliser use, and maximising the benefits from limited quantities, would increase the viability of inorganic fertiliser options for the poorer farmers (e.g. targeting specific crops or patches of land, optimal timing to reduce risk, optimal combinations with crop management and other soil amending technologies).

There is also tendency by some agencies involved in agricultural extension to add a moral/emotional (even spiritual) dimension; presenting fertiliser as a dangerous soil damaging technology, and organic methods as a panacea to soil improvement. Other soil fertility, and soil and water, enhancing and conserving technologies may become more attractive if they are not presented as alternatives to fertiliser, but as useful and complementary ways of increasing productivity which have lower risks and greater longer term benefits.

4.2.1 Constraints to the use of chemical fertiliser and organic options

All the reports make it very clear that the main constraint to using fertiliser is now perceived as lack of access to credit, or lack of cash with which to buy it. Also mentioned as a constraint is the risk of using fertiliser during a drought year. In a few cases advice on how to use fertiliser is also mentioned, not so much as a constraint, but as something that would be appreciated so that better use of it could be made.

Constraints to the use of organic options are less clear in the literature, but in may cases they can be deduced from other information provided by farmers in the reports and from the authors' direct contact with farmers (see Table 4.5).

Some of the constraints to using organic techniques relate to the natural environment, with soils of varying quality and slope, and with demographic pressures forcing changing patterns of land use. For example, organic materials and water for compost making are often not available. Major variations of soils within a farm may encourage niche farming, rather than use of a rotation or improved fallowing system which can be applied to the whole farm. Important constraints also related to social and community organisation, including the regulation of fires, grazing, hunting of mice, land borrowing, land allocation and boundary demarcation systems and the regulation of labour. Other contributing factors were more specific to households, such as labour shortage and lack of stored food entitlements, necessitating working for food rather than cultivating household fields. Another category of constraints relates to the need for external inputs. These include specialist technical advice for "more complex technologies" (such as alley cropping and various physical structures), planting material and seed of improved varieties, and access to markets.

Farmers receive very little information about the use of organic fertilisers from extension officers. NGO projects promoting agroforestry and soil conservation approaches find it hard to make much impact with farmers without the support of local agricultural officers. However, few extension officers have received any training on these methods or been encouraged to promote them. Attention has been entirely focused the promotion and use of inorganic fertilisers (Robert Kafakoma, personal communication).

Implications

There is evidence that, in individual cases, resource poor farmers are adopting the organic technologies in spite of the apparent constraints. Farmers themselves tend to talk more of attitudes, such as "laziness" and "pride", as being important factors in influencing adoption rather than resources per se.

4.3 Farmer adoption and modification of advisory recommendations

Wellard (1996) notes that Malawi's extension services have modified their recommendations in response to information from international sources and national research programmes. They have also developed specific messages to address soil erosion and soil fertility as distinct issues, along with the promotion of agro-forestry to address multiple problems (see also table 4.6).

Information of farmer modification of advisory recommendations relating to soil fertility is limited. Wellard notes that farmers plant cassava and pigeon peas on contour bunds (when extension recommends grass), and bananas and sugar cane in gullies. Dropping beneficial practices practised previously such as crop rotation and fallowing has been necessitated by land shortage - leading to maize mono cropping often on unprotected hillside fields (particularly by young households in their establishment phase).

Farming systems type surveys containing information on the use of recommendations were conducted in the early to mid 1980s, but mostly stopped with the effective abandonment of the adaptive research teams in favour of a commodity research approach about 10 years ago. Adoption of maize technology was conducted by the CIMMYT regional programme from 1989 to 91 (Smale *et al.*, 1991) and a restudy of the same farmers was conducted in 1997 (Smale et al, 1998). Smale's earlier study indicated that farmers changed their fertiliser rates from season to season, though the reasons for these changes are not explored in the report. Moreover, as most farmers were applying lower than recommended rates (and a few much higher rates), the study estimated (possibly over-estimated) that in the 1990-91 season 93% of the total hybrid maize area was fertilised and 42% of the total local maize area (farmers had diverted some fertiliser supplied on credit from hybrid to local maize).

A semi-formal survey of 40 farming households in Kasungu and Machinga (Rohbach and Snapp, 1997) to assess fertility management practices by farmers found that although use of chemical fertiliser had dropped significantly over the past four years a significant proportion were still using small quantities of fertiliser. The increase in cost had generated an interest in a wide range of soil fertility management practices. Experimentation with and the use of alternative fertility management practices was found to be increasing including use of, particularly, goat, manure, incorporation of maize residues (maize and legume residues are normally burnt), rotations, composting and a mixture of these with small quantities of fertiliser. Farmers expressed strong interest in grain legumes and less interest in green manures though two farmers growing Velvet bean (*Mucuna*) in rotation with maize reported it was very effective at increasing subsequent maize yields and also provided a bean crop.

Blanket fertiliser recommendations for maize are currently being modified to regional (ADD) specific recommendations on the basis of multi-locational on-farm fertiliser trials (Maize Productivity Task Force, 1997). The fact that some farmers have requested advice on fertiliser application methods may be interpreted in different ways. Farmers may have been following the blanket recommendations and are not sure about them, they may have received no advice at all, or perhaps they are thinking that saying this will increase their chances of getting a loan or free fertiliser in the future.

The trend in eastern Zambia during the 80s and early 90s, which had similar blanket fertiliser recommendations to Malawi, was that farmers made significant modifications of recommendations, and that their practises varied over time and from one farmer to another, depending on circumstances. In areas and at times where labour was limiting, but fertiliser was very cheap, higher than recommended rates were used as a labour saving weed-suppressing device. When fertiliser prices increased, farmers began to "economise" by applying lower than recommended rates, and targeting fertiliser (particularly top dressing) to plants that showed signs of nitrogen deficiency. Other forms of economising which took place were post-emergence application of basal dressing, split applications of top dressing, substituting manure for basal dressing and mixing fertiliser with manure for spot/station applications. Farmers cultivating light sandy soils in order to reduce the effects of leaching commonly used post emergence and split applications. Subsequent on-farm trials validated these farmer practises which then became official recommendations for farmers in particular provinces. Other modifications were made in response to late arrival of fertilisers, getting the less preferred type of fertilisers as part of a loan package, or labour constraints for application. These included mixing top and basal dressing in various combinations, and making banded rather than spot applications of basal dressing.

Implications

The extension approach to soil fertility, including fertiliser management, clearly needs to be more flexible than in the past. The adoption of the area specific fertiliser recommendations is a step forward. However, this in itself may also lead to further prescriptive extension advice which does not take account of local (field specific) variations. An "options" approach to fertiliser use may be more useful, perhaps using a farmer group approach where strategies can be discussed early on in the season, when the fertiliser availability situation (types and amounts) is known and the weather pattern has become somewhat clear, and reliable information on cash crop markets and options is widely available.

4.4 Indigenous soil fertility maintenance systems

There is limited evidence in the available studies that farmers are currently operating "indigenous" systems of soil fertility maintenance. Wellard (1996) notes that some farmers do not perceive the fertility of their soils to have declined. Apparently, it is the younger households who perceive this, rather than the older households. Moreover, it is the same younger households who are the least skilled and able to use soil conservation, such as cover crops, rotation and construction of contour bunds and ridges which are known and practised by the older and more experienced farmers (who also usually have more land, and land of better quality).

What is clear from a short review of the available historical data is that patterns of land use and cultivation have changed dramatically over the last century (Hornby, 1934 and Wellard, 1996). In this context, talk of "indigenous soil fertility maintenance systems" is fairly meaningless. Hornby argues that before the Ngoni invasion, most of the cultivation was on the plains and flatter low lying areas which had been made naturally fertile by the very long-term process of soil run-off from the surrounding wooded hills. The Ngoni invasion (and possible slave raiding before that), forced people to move into the hills where they practised more extensive slash and burn agriculture based on finger millet cultivation. The colonial administration tried to stop this practise by passing laws, and by enforcing construction of terraces on sloping land. The terraces were adopted under the threat, and use, of force, but people still continued to practise a modified form of fallowing in most areas up to the early 1980s, when land pressure became particularly noticeable. Fallowing is now increasingly rare, as population pressure continues to increase. Livestock populations (particularly cattle) declined rapidly from the 1970s as dimba grazing land came under the hoe, grass fallow areas declined and hillside browsing came under the axe and hoe from hillside firewood collection and gardening. The decline of livestock meant that use of manure was not well established for most households in most areas. Crop rotation was a part of traditional cultivation systems which was further developed and promoted during the colonial period and since independence. Hornby speaks of fairly widespread cultivation of soybean in the south of Malawi 1930s (but he may be referring to phaseolus beans). While rotation continues to be viable in various forms (e.g. a soybean maize, maize, soybean rotation - with groundnuts, beans and cowpeas also added in) for the few households better endowed with land and labour, it is difficult for those with smaller upland land holdings. Another soil conservation practice promoted in colonial times, and widely adopted by farmers, was the replacement of mounds with ridges. This was done in the name of improved soil conservation, but farmers have adapted the ridging system further, in different ways, to suit their local situation, one of which in Ntotokalino east of Lake Malawi is well described by Shaxson and Riches (1997). In some forms of ridging, the crop residue from the previous season is laid in between the planting ridges and then covered up in the making of new planting ridges. Chewa farmers in parts of eastern Zambia cultivating more fertile clay soils claim that using this system, with low plant populations, local maize yields have been sustained at about 1 ton/ha for over twenty years (ARPT, 1991).

More intensive soil amending strategies are practised by some households which are less land-demanding than crop rotation. For example various forms of inter-cropping of maize with groundnuts, cowpeas, beans, velvet beans and pigeon peas. Another strategy is early land preparations and incorporation of crop residue into ridges, before it is browsed by livestock in the dry season.

The use of dimba gardens has increased dramatically over the last twenty years, and for many households these have equal or greater economic importance than the upland 'munda' (rainfed upland). In many areas where soil conservation in the uplands is still poor, the dimba gardens continue to be enriched by run-off from the uplands. This is not an indigenous fertility maintenance system, but rather part of a natural process, influence by human farming and tree cutting activities, which some farmers have taken advantage of. Cultivation of the dimbas, and maintenance of soil fertility in them is not without its difficulties. Much of the animal manure is probably applied to these areas which tend to give much higher cash returns per unit area than the upland fields. Long-term soil fertility maintenance in dimba gardens is an under-researched area.

Implications

Interventions should be based on an understanding of current systems, how they are evolving, under what pressures, and what the scope for further adaptation and development of these systems is. It would be naive to look for some "indigenous system" which has been practised for many years which could be widely promoted.

4.5 Farmers' view on the benefits of investment in land and constraints including land tenure

This section is based on the work of Wellard (1996) including her review of literature. Soil and water conservation measures can be regarded as an investment in land since extra labour and sometimes other extra costs are involved. It is unlikely that farmers will undertake a soil and water conservation measure unless they see the benefits of it (see also Table 4.1).

The limited literature on farmers' perceptions of soil and water conservation measures gives two somewhat conflicting viewpoints. In most literature it is stated that soil degradation is increasing, whereas there are some reports that according to farmers soil erosion declining because they undertake some soil and water conservation measures[5]. This difference is closely connected with a difference of perception of what constitutes soil and water conservation. According to the view point presented by government, extension and project workers, farmers apply very few soil and water measures (Bishop, Moodie and Kamwendo cited in Wellard, 1996). The "official" view focused on technologies traditionally promoted by extension such as contour bunds and vetiver grass (which is not easily obtainable nor multi-purpose). The farmers, however, report that they use other soil and water conservation techniques which are probably better adapted to local conditions. Examples of these are: large bunds to prevent water-overflow reinforced with pigeon pea and cassava, stone bunds, intensive intercropping to maximise production, moisture utilisation and groundcover, and bananas and sugarcane planted in gullies (Kasomekera cited in Wellard and Wellard, 1996).

With regard to whether or not soil degradation is increasing, officials warn of a further serious decline of soil fertility. However some farmers say that they have experienced an improvement of land degradation, because they have started some soil and water conservation techniques. Most of the farmers have started these conservation measures themselves. Some stated that they began to realise the need for soil conservation after extension workers' visits to their fields. In some cases farmers also requested extension workers to come to their field for contour bunds construction with the help of A-frames. It is also stated that soil degradation in flat areas is increasing since these farmers do not undertake any conservation measures (Wellard).

To some extent the apparent discrepancy could be because officials are talking in absolute terms about degradation, whereas farmers are talking about a slowing down of the rate of

[5] It is not clearly indicated whether the rate of degradation has gone down or the overall degradation. Levels of erosion are referred to as "worsening", "improving", "constant" or no erosion at all.

degradation. It is also likely that farmers are much more observant of local improvements in soil conservation, whereas officials are looking at the larger picture.

A further discrepancy exists on the rationale for conservation and the level of soil and water conservation management undertaken. Wellard (1996) argues that there is a clash in perceptions held by officials and farmers concerning water and soil conservation. It is reported that most farmers do not undertake soil and water conservation measures due to poverty, that smallholders tend to discount long term costs and benefits heavily, especially where major changes are involved (Bishop, 1995). In areas facing serious degradation, farmers might perceive that some SWC measures have a direct benefit on agricultural productivity. Some of the poorest farmers who are cultivating on rocky slopes are undertaking some SWC but these are not very effective (e.g. rock piling). According to Bishop most farmers can not afford any better conservation measures due to lack of credit, labour and food (the UN report on situation poverty analysis of Malawi presents a similar picture). Farmers are restricted by the vicious circle of poverty with low food production and low incomes. Smallholders are often forced to do some piecework to make ends meet. Their low agricultural productivity provides few possibilities for investing in their land (Moodie and Kamwendo in Wellard, 1996).

However, Wellard's data on farmers' perceptions point out a high rate of farmers' involvement in soil and water conservation (88 % and 72% respectively for two study areas in Ntcheu and Zomba). Farmers distinguished three broad management strategies for their hill gardens (a) managing the land under mainly natural vegetation, (b) periodic fallowing and (c) continuous cultivation with differing degrees of soil conservation. Incentives for farmers to invest in conservation measures depend on perceived erosion and social and economical factors. According to Wellard a strong correlation exists between signs of erosion as well the slope of the field and farmers' decisions to take soil conservation measures. Of particular importance is the immediacy of need to begin cultivation. For example, young couples or recently divorced women might be forced to start cultivation to meet the demands for their food production while paying little or no attention to soil and water conservation. Gradually they might develop their hill gardens as soon they have time and resources. Further, Wellard points out that in both areas where she conducted research, factors such as wealth, education and age are not significant determinants in most conservation strategies of smallholders. Thus, poverty seems to be a less serious restriction for farmers to undertake conservation techniques than is often stated.

4.5.1 Land tenure

Land farmed by smallholders is held under customary land tenure systems. In the north these are predominantly patrilineal while in the centre and south these are predominantly matrilineal (Dickerman, 1991). Under the patrilineal system land is passed from father to son. In the matrilineal system land, particularly munda land, passes from a mother to her daughters. Sons may receive land from their mother's brother and a mother may give her son or son-in-law dimba land. Men generally move to their wife's village on marriage under the system of uxorilocal residence practised by most ethnic groups in the centre and south.

The customary land tenure system, particularly the matrilineal inheritance system, are regarded by some observers as being responsible for low levels of production, inappropriate cultivation techniques and a disincentive for investment in soil fertility (Mataya, 1998). Attempts were made by the colonial administration to increase maize production in the 1940s through monocropping and soil conservation methods that included enforced ridging and contour cultivation. This met with stern resistance especially on the part of the women on 'whom much of the burden fell' (Davison, 1993). Davis contends that the matrilineal system of inheritance contributes to male emigration. The lack of security in land for out-marrying males, as well as increasing land scarcity means that men are less willing to make a labour investment to *Banja* (household) production, preferring wage labour as a more secure means of generating income and maintaining control over its distribution. Several studies found high proportion of households had no husband around for much of the year.

Other researchers argue there is no evidence to support this contention (Dickerman, op.cit.). Dickerman points out that 'the principle of matrilineal inheritance represents an ideal rather than an obligation', and that there are a range of ways of acquiring land. She also suggests that matrilineal succession systems may be weakening in the face of land shortages, land infertility and the increasing dependence on cash incomes.

It is possible, that it is not just customary land tenure system per se, but the kinship and inheritance system which discourages individual initiative, and tends to stigmatise the attempts by individuals to innovate and accumulate within a village setting. Egalitarian values associated with matrilineal systems, supported by underlying beliefs giving rise to the fear of witchcraft accusations, may present an obstacle to innovation in some communities. There may also be other factors, such as the longer time taken to get the returns from land improvement measures, which makes such investment unattractive.

Lack of land to land hinders farmers in acquiring credit (Sahn and Arulpragasam, 1993).

4.5.2 Summary and implications

These discrepancies between the perceptions of officials and farmers can be explained in part by the fact that farmers' knowledge about soil erosion is different from scientific knowledge of soil erosion. Farmers considered more farming techniques to be part of their soil and water conservation management than "traditional official" techniques usually include. This difference of perceptions also indicates that because farmers may think more broadly than officials about soil conservation (i.e. beyond a prescriptive and engineering influenced paradigm), they are also likely to engage in a range of activities to conserve soil which may not normally be considered by officials. These activities may have multiple objectives, including soil conservation.

More attention should actually be paid to farmers' perceptions and practices of soil and water conservation instead of focusing on "scientific" or "official" perspectives. Agricultural research and extension staff may require further sensitising to the importance and benefits of understanding and building upon farmers' local knowledge and practises.

4.6 Village and other credit groups

Information on the types of credit systems operating in rural areas is given in section 2.6.

Informal financial markets are more important than formal credit to most households in rural areas. However, informal lending and own savings are mainly for meeting emergency needs, consumption purposes and as starting capital for micro-enterprises. Lending money for agricultural inputs and investments is unusual because of the long-term nature of such loans (Buckley,1996). Not much has been written about the operation of the informal credit sector.

NGO and donor projects are a source of credit in some areas. These may target a particular group and provide credit, in cash or in kind, for an income-generating or farming activity.

There are formal credit organisations operating in the rural areas that people can join by setting up a savings group but these are not yet widespread. Establishing a savings group usually requires attending training sessions, saving regularly and the availability of literate people to act as treasurers and chairmen. People are reported to be scared of credit and the danger of becoming indebted.

4.6.1 Implications

Donors and government should look more critically at the scope for providing credit lines through private traders, and also at the effects of providing free handouts of seed and fertiliser on the farmers' attitude to repayment of loans (Dorward et al 1998).

4.7 Farmers' involvement in cash raising activities on and off-farm

It is estimated that no more than 16-20 per cent of smallholder farmers have access to formal credit (Carr, 1998) but most rural Malawians live in a highly commercialised economy where cash is needed for a wide variety of goods and services and even the poorest households are drawn into markets, as suppliers of labour for others, to earn money (Peters, 1997). Peters argues that diversification is not new to Malawian farmers but a long-established practice, "a large diversity in crops and crop mixes and a diverse range of income activities typify many rural households".

The sale of agricultural and forest products is an important source of income. Depending on the season people sell items such as sugar cane, vegetables, potatoes, groundnuts, rice, wild and cultivated fruit, mushrooms, mice and chickens to raise money for other needs.

Maize is sold immediately after the harvest to repay debts and raise funds to pay for urgent needs. The government tries to discourage farmers from selling maize that is needed for home consumption, telling people that they should not be profligate and to hold on to what they have produced rather than selling it, or using it for making beer. However, Peters (op.cit.) argues that it the timing of maize sales rather than the sales per se that indicates whether households are under stress. Those who sell maize later in the year do so to provide investment capital, which is used to purchase other goods for trade (other agricultural or commercial items). Such strategies attempt to benefit from the regional and seasonal shifts in prices and are followed in the expectation of making higher returns than merely storing the maize. Women sell maize to buy ingredients for cakes to sell at local markets or brew beer or *Kachasu* to sell when people are rich after the harvest.

4. 8 Wealth perceptions and patterns of socio-economic differentiation

Four wealth categories are identified in the rural areas based on wealth-ranking exercises. These are 1)"well off" (*wopeza bwino*), 2)fairly well off (*wopeza bwino pang'ono*), 3)poor (*wosauka*) and 4)very poor (*wosauka zedi*).

Unlike in many parts of Asia, perceptions of wealth in Malawi do not refer to land quality or size. Importance is attached to food, livestock, housing, clothing and movable property. This was clearly indicated in a recent nation wide survey covering more than 300 households (Smale et al 1998).

In some areas, all except the well off rely on piecework a lot as a coping strategy. In some areas the very poor make large part of income from renting out dimba gardens. The well off rent or buy garden land, provide food and cash loans, and grow more than one cash crop. They are more likely to cultivate dimba gardens and to have larger upland fields than the poor. Wealth is also associated with food security. The better off have access to food all year-round, buy fertiliser with cash and own livestock.

Often the perspective of the poorest does not come over in PRAs and other meetings. For example, during the ADDFood PRA in Mangazolimba, the very poor did not participate. The beneficiary assessment looking at adoption only included the high and medium success adopting farmers. The very poor, were low adopters and did not show up at meetings because they were ashamed or felt that the meetings were not relevant for them.

Little is said in the literature about the influence on agricultural investment and accumulation of wealth of the matrilineal kinship systems that prevail in most of rural Malawi. However, it is well known from studies of these kinship systems in other areas, such as in neighbouring Zambia, that they do have an important influence on patterns of socio-economic differentiation. In general the matrilineal systems tend to be more egalitarian than the patrilineal ones, and to impose more limitations on the accumulation and transmission of property from parents to children. The implication is that wealth status is often very closely tied in with the developmental status of households, rather than with differential access to inherited wealth. However, it is not known to what extent social changes, including the erosion of the importance of extended family ties and beliefs relating to supernatural sanctions (witchcraft, sorcery and curses) are currently having an influence. These factors can often be very important when it comes to decisions about investment of a longer-term nature in land, and they have a critical influence on the customary land tenure systems.

4.8.1 Implications

In many local communities, villages, the cultural conditions for investment, innovation and accumulation of wealth may not be very favourable due to the nature of the kinship system and its related system of beliefs and practises. However, it is important to examine any exception to see what can be learned in terms of their implications for investment in soil improvement.

SOURCES OF INFORMATION

Table 4.1 Data extracts: general perceptions on soil fertility decline

SOURCE	AREA	Perceptions of Soil Fertility Decline
Wellard (1995:44)	NCH and Zomba	Over 50% farmers perceived that soil erosion was decreasing, and nearly 25% saw an increase.
Wellard (1995:44)	Ncheu and Zomba	Over 75% farmers felt that the fertility of their soils had declined since they started farming. Little differences in perceptions between men and women and farmers of different socio-economic status. Farmers aware and use many local indicators of fertility decline, including crop yields, plants, and soil colour, depth, structure,
Wellard (1995:46)	Ncheu	Decline in fertility linked to decline in use of fallowing.
Drinkwater (1995:23)	EPA 11 Lilongwe	sixfold decline from 1970s to 1995
Drinkwater (1995:46)	EPA 11 Lilongwe	Soil fertility decline perceived as one cause of hunger, but not as a problem in its own right. linked to striga
Drinkwater (1995:20)	EPA 2 Lilongwe	Low soil fertility one of causes of low yields. Soil fertility decline caused by over-use of chemical fertilisers, lack of crop rotation and poor soil management methods resulting in low yields.
Leach and Marsland (1994:28)	Mzikamanda, Salima	Declining soil fertility
Leach and Marsland (1994:101-102)	Chididi, Machinga	Prunings of Leuceana improves soil fertility. Soil fertility improvement included in farmers ranking of Addfood project benefits.
Nelson (1998)	Thyolo	Farmers concerned about loss of soil fertility and soil erosion. Main problems identified included decline of soil fertility and soil erosion. Soil fertility decline caused by lack of fallowing.
Nelson (1998)	Nsanje	Soil fertility is declining. Loss of Soil fertility is linked to fuelwood problems. Soil erosion and loss of fertility caused by bare land, lack of fallowing, breakdown of social rules regarding tree cutting after refugees came. Crop yields are declining.
Nelson (1998)	Rhumpi	Soil erosion and loss of fertility caused by lack of fallowing, soil erosion and leaching.
Chanika and Ritchie (1998)	Blantyre/Shire	Clear association by farmers of parasitic weeds striga and alectra vogelli with soil infertility

Table 4.2 Data extracts: yields and returns per unit area

SOURCE	AREA	Yield Decline Evidence
Wellard (1995:28)	Gowa	On experimental plot with no soil conservation methods, yields of unfertilised maize dropped from 0.8 ton/Ha to 0.15 tonnes/Ha. over a six year period. Yields on an adjacent leucaena alley plot remained constant at 1.5-2 tonnes/Ha over the same period.
Smale *et al.* (1991)	Blantyre	1989-91 Farmers actually get .7 t/ha. from unfertilised local maize and 1.2 t/ha. from fertilised Farmers expected to get .6 t/ha. from unfertilised local maize and 1.1 t/ha. from fertilised
Smale *et al.* (1991)	Kasungu	Farmers actually get .9 t/ha. from unfertilised local maize and 1.4 t/ha. from fertilised Farmers expect to get 1.0 t/ha. from unfertilised local maize and 1.7 t/ha. from fertilised
Smale *et al.* (1991)	Mzuzu	Farmers actually get .7 t/ha. from unfertilised local maize and 1.2 t/ha. from fertilised Farmers expect to get .7 t/ha. from unfertilised local maize and 1.5 t/ha. from fertilised
Jaffee (1997)	National	Suggests that tobacco is a more profitable crop than maize particularly for small estates.
Jaffee (1997:20)	National	95/96 season: net profit and value added per ha. is much higher for non-maize crops, except for soybean and sunflower. Crops such as groundnuts, cassava, beans/maize, pigeonpea/maize and tomato give much higher returns to land than sole maize

Table 4.3 Data extracts: Labour calendars - peak periods

SOURCE	AREA	Perceptions of Labour Peaks and Patterns
Drinkwater (1995:28)	EPA 11 Lilongwe	Matrix ranking by month indicated that for women the busiest month is February, when work on the dimba gardens also starts and for men it is August during field preparations. Dependence on *ganyu* increases each month from Sept to January for men and from November to March for women. Men are forced to migrate in search of work, but there are fewer urban employment opportunities than previously.
Drinkwater (1995)	EPA 2 Lilongwe	Based on ranking of a range of womens' seasonally related work, June, July and August are the busiest months.
Leach and Marsland (1994:45)	Mzikamanda, Salima	Dec to February – planting and weeding the busiest times - including off-farm activities
Leach and Marsland (1994:74)	Namwini	December and January is when labour demand exceeds supply
Leach and Marsland (1994:111)	Chididi, Machinga	Rain season is the busiest time Dec-January. Leads to fallowing of land.
Leach and Marsland (1994:136)	Mangazolimba	November and December busiest months for both men and women
Nelson (1998)	Thyolo	Ganyu reduces food production on own field. Female headed households not able to utilise all their land due to labour constraint. Labour not listed as a specific problem in relation to NR conservation. Bunds are associated historically with forced labour.
Nelson (1998)	Nsanje	Poor households less time to collect firewood. Maize stalks are free and used for fuel. Refugee influx may have provided more labour.
Nelson (1998)	Rhumpi	Labour peak during tobacco harvest, March to May. Poor households less time to collect firewood. Labour not listed as a problem in relation to NR conservation. Tobacco cultivation reduces time for growing subsistence food crops.
Jaffee (1997:20)	National	95/95 season: Groundnuts, cassava, maize legume intercrops, rice and tomato give higher returns per manday than maize – local maize gives a higher return to labour than hybrid maize.

Table 4.4 Data extracts: farmer perceptions of organic and chemical fertilisers

SOURCE	AREA	Perceptions of organic and chemical fertilisers
Drinkwater (1995)	EPA 11 Lilongwe	Period 1990-95 hunger associated with lack of access to fertilisers. In 1994-5, lack of inputs (including fertiliser) attributed to "fall of farmer's clubs"
Drinkwater (1995)	EPA 2 Lilongwe	1995, free fertiliser stolen by civil servants Over-use of fertiliser causes decline in soil fertility. Free fertiliser is sold to buy food. Crop rotation is good for the soil.
Leach and Marsland (1994)	Mzikamanda, Salima	Adoption of alley cropping is not clearly linked to socio-economic differences of households, including female headed households. Soil conservation structures recommended in colonial times were too big, and caused more problems. 60% of farmers in an Addfood village estimated to have applied leuceana prunings, all said that organic material was inadequate. No farmers in the village owned cattle (hence minimal manure).
Leach and Marsland (1994)	Namwini	Low levels of farmers pruning *Senna Spectabolis* alleys. No "cattle" in the village - only 2 work oxen
Leach and Marsland (1994:111)	Chididi, Machinga	No cattle, 50% have goats 30% pigs. Goats damage alleys. Very little pruning of planted alleys was reported.
Leach and Marsland (1994:136)	Mangazolimba	No cattle, 36% men have goats 60% chickens. Goats damage alleys. Fertiliser use decline due to cessation of free handouts and loan defaults, resulting in lowered access to credit overall. Short-term natural fallows are used to restore fertility. Lower lands are more fertile due to depositions of soil from higher lands. Farmers indicated that matrilocal marriage did not adversely influence husbands' willingness to invest in soil improvement measures.
Wellard (1995:28)	Gowa	Farmers' enthusiastic about "soil fertility augmenting technology" in the face of escalating fertiliser prices.
Nelson (1998)	Thyolo	Better off households have access to fertilisers. Requested advise on inorganic fertiliser use and fertiliser loan facilities. Crop rotation, fallowing, controlled burning, crop diversification, bund protection and composting all seen as helpful measures to address soil fertility decline within the control of the village.
Nelson (1998)	Nsanje	Fertiliser seen as necessary for reasonable yields. Fallowing bare land can increase soil run-off. Resistance to idea of communal woodlots - want individual woodlots.

Nelson (1998)	Rhumpi	Bunds, controlled burning, fallowing and regulation outsiders' access to land seen as achievable village level strategies for soil conservation.
Chanika and Ritchie (1998)	Blantyre/Shire	Fertiliser use rationing strategies: applied late to stunted maize, applied to part of field only, Farmers use velvet bean (mucuna) and very interested in use of tephrosia and also sunhemp for green manure.

Table 4.5 Data extracts: some constraints to using inorganic soil improving technologies

TECHNOLOGY	CONSTRAINTS TO USE
Animal manure	Declining ownership of cattle. Distance to fields. Use of manure on dimba gardens rather than main upland fields. Limited knowledge on how to use fowl manure? Cultural taboos on the direct use of pig and human manure.
Green manure	Lack of seed of green manure species, limited knowledge on management aspects such as timing, management and incorporation, lack of spare land, competition with other crops, poor soils.
Contour bunds	Labour demanding. Lack of knowledge on how to lay out terraces (correct spacing, dimensions and how to follow the contour). Children and other adults damage these, risks of breaking in heavy storms, damage from upslope run-off. Negative association with forced labour dating back to colonial times.
Alley cropping	Advice on species choice. Establishment problems (watering and termites), protection from livestock, labour for pruning, pest harbouring risks, competition with crops for moisture and nutrients. Technical benefits not well defined and proven.
Crop rotation	Limited land, labour (for extra legume production), seed and markets for crops other than maize.
Fallowing traditional	Limited land and possibly increasing "family/individual" de facto land tenure which limits the scope for systematic fallowing in a village basis.
Improved fallowing (sesbania sesban)	Limited land, limited knowledge, fire damage risk, poor seedling establishment.
Increase of legumes	Limited seed and markets. Extra labour required for planting, weeding, harvesting and processing.
Crop diversification	Limited access to alternative planting materials and varieties. Limited knowledge in production and utilisation. Markets not well developed.
Composting	Lack of water, organic material in the dry season and knowledge of the process.

Table 4.6 Data extracts: evidence of adoption of soil related extension recommendations

SOURCE	AREA	Evidence of adoption of soil related extension recommendations
Wellard (1995:33)	Salima ADD Ncheu District	1995, 87% farmers appear to have no form of erosion control measures, even though they were aware of erosion and its hazards
Wellard (1995:33)	Nchetu RDP	90% farmers claimed to be using soil conservation measures. Less than half of these were initiated by extension workers, and mostly only at the request of farmers
Wellard (1995:53)	Nchetu RDP	Over half farmers use contour bunds, 37% box ridges, and 16% protect gullies. Hill plots had less contour bunds than gardens on more level grounds. Parents and neighbours were cited as the most common source of knowledge on technology.
Wellard (1995:53)	Zomba	Only 16% farmers use contour bunds, 5% box ridges, and 8% protect gullies
Leach and Marsland (1994:35, 38,39)	Mzikamanda, Salima	Farmers adoption of coutour bunds hampered by lack of knowledge/skills on pegging. Depend on LHA. Some farmers make unaligned contour bunds and also plant leucaena alleys not on the contour. Farmers prune leucaena later than recommended for various reasons. But also evidence of mixed messages and advise on pruning. Farmers in a neighbouring village were aware of the general extension messages on contour bunds and alley cropping but said they felt unable to take these up without close technical guidance. Said the would prefer to plant Senna as less likely to be eaten by goats. Some fears that the government may take land in return for free food.
Leach and Marsland (1994:69-74)	Namwini	Inappropriate soil and water recommendations for dambo areas. Adoption of Sena Alleys associated by farmers with differences of commitment and attitude, more than other constraining factors.
Leach and Marsland (1994:111)	Chididi, Machinga	Taking biomass from alleys in upland munda to apply to vegetables in dimba
Leach and Marsland (1994:136)	Mangazolimba	Extension describe alleys as a complex technology and say only 30% farmers competent to do it. 50% need close supervision on construction of physical SWC measures. Adoption influenced strongly by favourable physical conditions for technologies.

Table 4.7 Data extracts: cropping decisions and diversification trends

SOURCE	AREA	Perceptions of Crop Production Trends
Drinkwater (1995:26-27)	EPA 2 Lilongwe	Overall decrease. Shift from maize and beans to cash crops including soybeans, sunflower and vegetables. From 1985, pumpkin leaves replaced by Chinese cabbage. Estimate of a 40% decline in maize production over decade 86 to 95.
Nelson (1998)	Rhumpi	Male HH head decides what is grown (at least the main cash crop). Women ensure food crop production is sufficient before engaging in cash cropping.
Leach and Marsland (1994:119)	Mangazolimba	When own produced maize runs out farmers depend mainly on fruit sales. Questions Addfood project focus on maize rather than other crops such as fruit.
Jaffee (1997:17)	National	Data from MOALD indicates significant diversification away from maize (20% reduction in planting share) in the five years since 1991. An increase (ranging from 30-45%) in plantings of pulses, oilseeds, roots and tubers, industrial crops and other cereals.

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APPENDIX I TERMS OF REFERENCE

To collect and review existing ideas and information from the literature and from knowledgeable people in three (amended to four) major areas (given below) and to provide pointers for an investment programme for DFID.

1. The Policy Environment

1.1 Government of Malawi policies on prices and procurement of agricultural inputs, outputs and taxation policies which may encourage or discourage agricultural production.

1.2 Co-ordination among ministries on above policies.

1.3 Degree of agreement among donors and government on such policies.

1.4 Impact of exchange rate policy, including unstable exchange rates, on agricultural production.

1.5 Legislation on the identification and quality control of fertilisers and on their sale and use.

2. Supply and use of fertiliser

2.1 The use of fertilisers by smallholders over the past ten years; types, quantities, and the crops and soils on which they are mainly used.

2.2 Prices paid over the last ten years in 1998 Kwacha.

2.3 The main suppliers of fertilisers and issues in importing and financing of fertiliser supplies.

2.4 Factors which influence the transaction costs of fertilisers and the efficiency of the delivery services.

2.5 Government attitudes to private enterprise in the supply of inputs.

2.6 The credit systems, both informal and formal, which are currently operating in rural areas and they degree to which they are effective and efficient.

2.7 Sources of information and advice to farmers on use of fertilisers.

- 2.7.1 Area-specific recommendations.
- 2.7.2 Type, quantity, costs and constraints.

3. Soil fertility management

3.1 Soil fertility status in each region or agro-ecological zone in terms of responses to N, P, K and trace elements, and the residual effects on these soils.

3.2 Response curves for the major nutrients as influenced by rainfall, with an economic analysis of such responses, and the importance of risk.

3.3 Sources and quantities of organic matter used by farmers

- 3.3.1 Labour requirements for its transport
- 3.3.2 Crop yield responses, including residual effects when it is used.

3.4 The present role of legumes and green manures in the farming systems

- 3.4.1 Their potential value taking into account the rainfall, soil fertility and land availability limitations.

3.5 The role of livestock in farming systems and production of manure.

- 3.5.1 Trends in livestock keeping and species kept.

3.6 "Best Bet" technologies for improving soil fertility; their applicability, costs and benefits, and limitations.

4. Farmers' perceptions of soil fertility and management

4.1 Farmers' perceptions of the changes over the last 10 years of:

- 4.1.1 Yields
- 4.1.2 Return per unit area
- 4.1.3 Return per labour day
- 4.1.4 Impact on food security and household income.

4.2 Farmers' views on the use of organic matter and fertilisers in increasing soil productivity

- 4.2.1 Major constraints to their use.

4.3 How farmers modify recommendations made by the advisory services.

4.4 Indigenous systems farmers use, or have used, to maintain soil fertility.

4.5 Farmers' views on the benefits of investment in land improvement and the constraints, including land tenure, which discourage this.

4.6 The existence of village and other groups for credit.

4.7 Farmer involvement in cash-raising activities on and off-farm.

APPENDIX II CURRENT INITIATIVES IN SOIL FERTILITY MANAGEMENT

Department of Land Resources Conservation

1. The Department of Land Resources Conservation is in the process of compiling a strategy plan on soil and water conservation. This is intended to provide a common and acceptable framework for undertaking soil and water conservation. The preparation of this plan will involve consultation with the many stakeholders who have an interest in conserving soil and water. Land users have been invited to a) provide information on measures employed to reduce soil erosion and enhance soil moisture, b) give an assessment of the efficacy of such measures, and c) type of soil and water conservation measures that the stakeholder would like to see taking place with respect to their establishment and to Malawi in general and institutional collaboration that needs to be established or enhanced.

2. The annual conference of the Land Resources and Conservation Branch brings together representatives from government, NGOs, project and college staff. At the 1997 conference nine issues were identified as requiring close attention. These were:

- *reduced tillage demonstration trials*
  Implementation of demonstrations and trials were constrained by lack of land to carry them out. Low yields were incurred as a result of non-application of fertiliser to crops by farmers in the demonstration plots and livestock damage to the trial plots. Inadequate time was allowed for communication and preparation for the demonstrations and trials in some ADDs. Several remedial measures were agreed upon.

- *information flow on technologies in land resources and conservation*
  Technical messages on land resources and conservation are communicated adequately to field staff, leading to conflicting messages given out to the farm communities. ADD SMSs will prepare or revise technical messages on relevant subject matters and disseminate them to staff at workshops and meetings. NGOs to be provided with the new and revised messages.

- *land husbandry technical messages for flat areas*
  There is low adoption of planting on ridges in flat areas such as Shire Valley ADD. Technical messages need to be developed and disseminated to field staff in these areas in order to control sheet erosion and promote moisture retention. Such information to include vetiver grass hedgerow planting, intercropping poor cover crops with good cover crops and mulching.

- *establishment of a vetiver grass resource centre*
  The conference saw the need to establish a Vetiver Grass Resource Centre. The centre will act as a bank for different vetiver germplasm; undertake problem-solving research on vetiver and act as an information centre. A project proposal for the establishment of the centre will be prepared.

- *promotion of local initiatives*
  Indigenous knowledge or technologies are not necessarily inferior to scientifically proven technologies. Farmers can play an important part in technology development and

dissemination. Field assistants need to be encouraged to identify and report innovative farmers and document their innovations.

- *GIS and remote sensing applications in the Branch;*
  GIS and remote sensing play a vital role in tracking land resource degradation and processes related to it. All land husbandry officers will be trained in GIS application. Hard and software will be made available to the Department.

- *priority research in land resources conservation*
  Information gaps in the LRCB require priority research. These include screening of agroforestry species, monitoring and evaluation of runoff on various land-use systems, germplasm evaluation of various vetiver species, review of water harvesting, permaculture, terracing, evaluation of nutrient content of existing indigenous technologies in soil and water conservation and soil fertility improvement.

- *LRCB/ICRAF collaboration;*
  In view of the large amount of information available at ICRAF a need is envisaged for ICRF and LRCB to meet and discuss establishing strong collaborative links amongst all stakeholders (NGOs and parastatals) in areas of on-farm demonstrations, joint planning, training and procurement of training materials and germplasm acquisition and distribution. There is also a need for a directory of key players in soil and water conservation so as to facilitate communication.

- *LRCB vision in retrospect and workplan*
  At the previous meeting the LRCB was detailed to produce a vision document. This meeting recommended the production of the following:
  a situation analysis of the Branch,
  streamlining of government and donor support,
  institutional capacity building,
  consolidation of research needs in land resources and conservation
  linkages with other relevant stakeholders.

  Source: CURE Newsletter, 1997 3 (4)

PROSCARP (Promotion of soil conservation and rural production)

The main activities of this EU-funded, $30 million, project are to redress the accelerating land degradation both through soil and water conservation and soil fertility improving measures. These activities are complemented by interventions in sanitation and hygiene and rural water supply. It also seeks to support the government food security initiatives by promoting crop diversification. The project began in July 1997, taking over from the PAPPPA (previously ADDFOOD) project, and covers all ADDs. It is implemented at 215 village catchment sites. By September 1997 the 215 sites had an average of 400 ha each, a total of 83,000 ha and reached approximately 44,500 households. In each catchment there is an elected Catchment Area Development committee through whom farmers are linked to project staff and ADD extension staff.

The project is implemented by the Department of Land Resources Conservation, under the Ministry of Agriculture. At each ADD there is a project co-ordinator who co-ordinates delivery of project inputs to the ADD. The co-ordinator reports to the Programme Manager of the ADD and works with the ADD Contract Trainer and contract Accountant.

Soil and water conservation
The main thrust is to train farmers in the use of the A-frame and the line level for marking out contours and realignment of crop ridges to the contour. Vetiver grass hedges are planted in contour marker furrows. Farmers are encouraged to plant multipurpose trees and shrubs along contours adjacent to contour hedgerows.

Demonstrations of reduced tillage, with husbandry of crop residue mulch, have been established in farmers' fields for participatory observation, evaluation and possible dissemination. Reduced tillage has shown tremendous potential in soil conservation by reducing erosive raindrop impact and improving water filtration. It decreases the requirement for farm labour and increases crop yields.

Soil fertility improvement
For the improvement of soil fertility the systematic interplanting of *Faidherbia albida*, alley cropping, boundary planting and other spatial patterns of trees and crops are being promoted. Short maturity trees and shrub species are also being encouraged – Tephrosia, Cajanus and Sesbania.

Crop diversification
The major crops promoted are legumes, particularly soya, pigeon peas, soya and cowpea., because they have a good market, add to household protein nutrition and fix nitrogen. The Malawian-bred improved open pollinated maize is being multiplied and disseminated. Farmers are involved in bulking up production of improved varieties. Planting material of sweet potato and cassava is being distributed and multiplied.

Source: Monitoring and Evaluation Section, PROSCARP Management Unit

MALAWI AGROFORESTRY EXTENSION PROJECT (MAFEP)

MAFEP is a co-operative grant agreement between USAID and Washington State University with the Ministry of Agriculture and Irrigation. Its objective is to increase farmer adoption of proven agroforestry and soil conservation practices by strengthening the extension delivery of needed inputs and services. After successful technology development and testing from 1992 to 1996 the programme has shifted its focus to farmer adoption through a partner support network with 29 public, donor, NGO and private sector organisations. All have produced their own agroforestry workplans and budgets to target specific areas and communities.

MAFEP has been instrumental in developing a diverse range of agroforestry technologies available to Malawi's farmers today. These technologies have undergone rigorous testing and refinement with farmers to ensure impact and compatibility. Technologies include: contour planting of vetiver grass; interplanting soil improving trees (*Faidherbia albida, Acacia polyacantha* and *Acacia galpinii*); undersowing fast-growing shrubs such *Tephrosia vogelii* which can restore soil fertility after 1-2 seasons; woodlots and homestead planting of multi-purpose planting; living tobacco barns, living fences particularly of species which offer additional products.

Source: Malawi Agroforestry Extension Project, Overview of objectives, achievements and challenges, 1998

PERMACULTURE NETWORK

The Permaculture Network is a group of Malawians and residents which shares ideas on implementation of permaculture methods of farming. Particular attention is paid to water conservation on farmland and preventing rapid runoff; improvement of soil fertility; reduced dependence on organic fertiliser; adoption of sustainable practices such as natural pest control, organic fertilisers.

Source: Permaculture Network in Malawi, Newsletter #17, October 1997, PO Box 46, Monkey Bay

SOIL FERTILITY RESEARCH – ICRISAT, MALAWI

The goal is to develop new recommendations that farmers can adopt in riskier, drought-prone regions in Southern and Eastern Africa, focussing on Malawi and Zimbabwe. Concurrently a practical methodology is being developed to conduct farmer participatory research on natural resource management. ICRISAT works closely with national research and NGO partners to document case studies of organic and low cost soil fertility technology options adopted by smallholder farmers.

Priority research areas include:

1. Characterise farmer priorities, constraints and soil fertility options in target communities in Malawi, Zimbabwe drought-prone environments.

2. Develop farmer participatory methods to improve research on soil fertility technologies and dissemination.

3. Analytical methods to predict the contribution of new options to sustainability and nutrient efficiency in a smallholder farm context. Emphasis is on legume residue management and pigeon pea intensification of cropping systems, evaluated through nutrient budgeting, N release studies, biological soil management and simulation modelling.

4. Facilitate soil and crop management experimentation by smallholder farmers.

5. Document case studies of farmer adoption and synthesise guidelines for integrating farmer assessment of technology options into national research and extension programmes, including NGOs.

ICRISAT, Malawi have submitted a research proposal for DFID funding entitled "Will women farmers invest in improving their soil fertility management? Participatory experimentation in a risky environment". This project seeks to develop practical investment options for the management of soil fertility in drought-prone areas: Mangochi, Kasungu and Dedza have been selected as possible sites.

Source: Soil Fertility Research, ICRISAT, Malawi, S. Snapp, 1998

ICRAF

The Zambesi basin project, an 8 year initiative funded by CIDA, is investigating ways in which impact can be made on food security, poverty alleviation and environmental sustainability through the extension of agroforestry technologies. The project is looking into ways of developing pathways to address various problems and development of partnerships with different types of organisations such as estates, NGOs, church groups. A need has been identified to work with groups which have developed good community contacts but which lack technical expertise to assist farmers' groups. The project has also identified the need to create awareness of more sustainable production and to make people aware of limitations of some existing policies e.g. subsidised prices for blue gum and pine trees. A technical challenge is to produce sufficient seed to meet the chronic shortage of germplasm for many of the promising agroforestry technologies. A social challenge is to find a use for unemployed labour during 11 months of the year. Trees spread labour requirements and provide products which can be sold. Potenial/existing technologies include: rotational woodlots – yr 1: trees intercropped with maize; yr 2 – grazing; yr 3 trees; yr 4 – trees harvested; improved 2 yr fallow using sesbania; simultaneous rotation using gliricidia, sesbania and tephrosia and pigeon peas.

RURAL DEVELOPMENT DEPARTMENT, BUNDA COLLEGE

Several initiatives are being undertaken within this Department.

BIOMASS TRIALS, SONGANI

These on-farm trials are being carried out with farmers living in a mountain valley in Zomba district. The objective of this work is to evaluate various biomass treatments for their improvements to soil fertility. Treatments include incorporation of biomass from planting of trees and shrubs: *Gliricida sepium*; *sesbania*, Tephrosia and pigeon peas. This process requires additional labour because in addition to burying maize stover soon after harvest the green manures have to be incorporated close to the onset of the rains. Results show that incorporation of stover and biomass is not enough to produce acceptable maize yields and a supplement of 25 to 50 per cent CAN or Urea of the recommended rate, applied as a top dressing, is necessary. The project is also looking at crop rotations, including groundnuts, and other options to improve grain yields. One farmer has been applying sheep manure but the opportunities for others to try this are limited as livestock production is discouraged in this area. The small plot sizes (0.4ha) are intensively farmed throughout the year.

Source: Dr G Kanyama-Phiri

DECISION TREE TO INCREASE SOIL FERTILITY WITH MAIZE CROP

A decision tree has been developed, based on farmer trials in four areas – Mangochi, Bembeke, Kasungu and Songani, to assist Farm Assistants (FA) help farmers make informed decisions about what to plant depending on the soil type and the resources at the farmer's disposal. The use of the decision tree requires the FA and farmer to test the soil using a simple soil testing kit. The objective is to keep the decision tree as simple as possible and yet offer choices. Only one model will be developed which is applicable to the whole country, which will include an adequate number of options to compensate for different needs, to reduce confusion by users.

Source: Ms. V. Morrone

APPENDIX III SOILS OF MALAWI

The soils of Malawi have been surveyed and described using the FAO classification system. In broad terms, soils can be divided into two groups, namely (a) the residual (upland) soils and (b) alluvial soils. The major soils have been grouped using the FAO legend, and are summarised as follows:

I.i Ferralsols

Ferralsols, also known as Oxisols (Taxonomy) or Ferrallitic soils (Malawi Classification system) are widely prevalent in the country.

a. Xanthic Ferralsols (Orthox in Soil Taxonomy): These are strong brown or yellower soils. The topsoil texture is normally sandy loam or sandy clay loam; the lower horizons range from sandy clay loam to clay. The topsoil is normally structureless; the lower horizons are either structureless (massive) or only weakly structured. Some are massive and hard when dry but others are friable. They are normally deep but others are shallow. The Xanthic ferralsols are moderately acid to acid (pH 5.5-5.7) with a low to moderate base saturation (44-70%). The cation exchange capacity (CEC) of the soil is low to medium (3.34-7.50 cmol/kg soil). Both nitrogen (0.05-0.12%) and organic matter (0.4-1.6%) are very low to low. Available phosphorus ranges from trace (0-22 mg/kg), and potassium ranges from low to medium (0.11-0.36 cmol/kg soil). Both calcium and magnesium are low or very low.
b. Rhodic Ferralsols (Ustox): They fall into two local groups, the Ferrisols and Weakly Ferrallitic soils (Malawi classification). They are dark red to red soils. Topsoil texture is sandy clay loam and lower horizons are sandy clay or clay. The soil structure is weak, and the consistence is friable. These soils are deep. The Rhodic Ferralsols are acid to strongly acid (pH 4.6-5.2) and have very low base saturation (21-45%) and CEC is just 2.48-3.61 cmol/kg. Organic matter is medium at 1.7-3.6% while nitrogen is medium (0.08-0.15%). Available phosphorus ranges from trace to moderately high (0-30 mg/kg) and potassium is low to medium (0.15-0.30 cmol/kg soil). Both calcium and magnesium are very low.

I.ii Ferric Luvisols

Ferric Luvisols are known in local classification as ferruginous soils or as Ferric Rhodustalf (Taxonomy). These soils are dark or red. The topsoil is sandy clay loam while the lower horizons are sandy clay or clay. They have moderate to strong structure. The consistence is hard or slightly hard down to about 60 cm depth where the soil becomes very friable. They are normally deep soils except on dissected sites.

The ferric Luvisols are acid to almost neutral (pH 5.3-6.7), and the base saturation is moderate to high (60-90%). The CEC is low to moderate (5.44-8.50 cmol/kg soil). Organic matter is low to high (0.5-4.5%) while nitrogen is low to medium (0.04-0.20%). Available phosphorus is trace to medium (0-24 mg/kg). Ferric Luvisols are the most productive upland soils in Malawi.

I.iii Ferric Acrisols

Ferric Acrisols or Rhodulstalff/Haplustult (Taxonomy) are locally classified as the Ferrallitic group. The topsoil texture is sandy loam or sandy clay loam. The lower horizons range from sandy clay loam to clay. The topsoil is structureless or only weakly structured. The lower horizons have a weak or moderate blocky structure down to about 60 cm; the soil becomes structureless below this depth. The Ferric Acrisols are acid to strongly acid (pH 4.7-5.7) and have a low base saturation (27-47%). The organic matter is low to medium (1.0-2.0%) while nitrogen is very low to medium (0.07-0.13%). Available phosphorus is trace to medium (0-25 mg/kg).

I.iv Dystric Nitosols

These soils are also known as Paleustult (Taxonomy) or Ferrisols (Malawi) These soils have a low CEC, and that they are highly weathered. They are usually very deep (>150 cm), well drained with a dark or red colour and clay texture throughout the profile. They are usually found in areas where there is high rainfall. The topsoil is sandy clay loam or sandy clay. Below, the texture is clay to a great depth normally. They have a weak blocky structure, and are very friable.

For most of the soils in the Dystric-ferralic group, aluminium toxicity is one of the major limiting factors for sustainable crop production. In such soils, it is observed that phosphorus is also limiting because either the high aluminium and iron oxides fix the P, or that the P may also be inherently deficient. Most soils have low potassium content, a good example of which is the Bembeke soil series, Thyolo, Mulanje, Chikangawa, and soils in some parts of Nkhata Bay.

The Dystric Nitosols are strongly to very strongly acid (pH 4.3-5.0) and the base saturation ranges from very low to low (17-19%). The CEC is very low (1.97-2.73 cmol/kg soil). The organic matter is medium to high (1.7-46%), and nitrogen ranges from low to high (0.08-0.23%). Available phosphorus is low to moderately high (10-33 mg/kg). Potassium, magnesium and calcium are very low

I.v Eutric Fluvisols

Most of these soils are classified as Usifluvents (Taxonomy) or Alluvial soils according to Malawi Classification system. Fluvic soils are soils that are continuously rejuvenated through the deposition on the surface of sediments transported by water. They are derived from alluvium and are mostly very deep. There maybe a considerable variation in particle size, both vertically in the profile (stratification) and horizontally. Gravelly layers can be observed in a minority of the profiles. They are characterised by stratification of sandy and clayey layers. They are associated with flood plains on the Lakeshore plain and along the dambos on the uplands. These soils are commonly found along the LakeShore areas and along the mouths of major rivers as they enter the lake, and Upper and Lower Shire Valley. They are characterised by stratification of sandy and clayey layers. They are associated with flood plains on the Lakeshore plain and along the dambos on the uplands.

The Eutric Fluvisols are moderately acid to neutral (pH 5.7-6.8) with very high base saturation (80-100%). The CEC is high (19-22 cmol/kg soil). Organic matter is 1.1-4.5% and nitrogen 0.07-0.33%, range from low to very high. Available phosphorus ranges from moderately high to very high (30-90 mg/kg).

I.vi Eutric Gleysols

These are Ustochrepts (Taxonomy) and according to Malawi classification, they are Hydromorphic soils. Gleyic soils have seriously impeded drainage. They often have a high groundwater table during at least part of the year. Gleyic soils lack the diagnostic characteristics of soil group u and f. Most soils are classified as Gleysols.

Soils that have a high water table constitute 381,850 hectares (4.4%) of the total soils that are found in Malawi. The highest concentration of Gleyic soils is in Kasungu and Machinga ADDs where each has 7.55% of the total soils in this group. Lilongwe ADD has about 5.30% followed by Salima which has 2.23%; Karonga ADD 1.8%, Mzuzu ADD 1.62% with Blantyre having to lowest, with only 0.60% gleyic soils. Although these soils have impeded drainage, they have a medium to high cation exchange capacity (CEC) and also have a high nutrient content. For most crops, therefore, the only constraint is too much water in the rooting zone, since they are characterised by waterlogging and clayey texture. The topsoil texture ranges from sandy loam to sandy clay loam but is immediately underlain by heavy clay. When dry, the soil has a coarse prismatic structure.

The Eutric Gleysols are moderately acid to alkaline (pH 6.9-7.5) and have very high base saturation (85-100%) and CEC of around 13.21-15.13 cmol/kg soil. Organic matter is low to very high (1.5-7.5%) while nitrogen is medium (0.1-0.17%). Available phosphorus is low or very low (0-10 mg/kg) while potassium is low to medium (0.16-0.33 cmol/kg soil. Calcium is medium (7.26-9.44 cmol/kg soil) and magnesium is high (4.30-5.57 cmol/kg soil).

I.vii Pellic Vertisols

In the Taxonomy, these soils are classified as Pellustert, whereas in the Malawi classification system, they are Hydromorphic soils. Vertic soils have more than 30 percent clay in the upper 18 cm and develop wide cracks up to a depth of at least 50 cm when dry. They are mostly very deep. Cracking is caused by the presence of montmorillonitic clay minerals that shrink when dry and swell when moist. Seasonal shrinking and swelling causes a slow but continuous mixing of the soil material in at least the upper 50 cm of the soil. Soils in this group are those that are classified as Vertisols, although there are some that are Vertic Luvisols and some are Cambisols.

They are characterised by very firm (heavy) plastic dark clays. The clay content is high right from the topsoil and the soil develops many, wide, deep cracks during the dry season. The topsoil has a strong blocky structure, while the underlying soil has coarse, prismatic structure. Vertisols have very low hydraulic conductivity when moist.

The soils are alkaline or neutral (pH 6.6-8.2) and have very high base saturation (80-100%) and CEC is also high at 33-43.8 cmol/kg soil. Organic matter is medium (1.6-3.0%) and nitrogen is low to medium (0.08-0.13%). Available phosphorus is low to medium (7-21 mg/kg) whereas potassium is medium to high (0.55-0.80 cmol/kg soil); calcium is high (19.72 cmol/kg soil) and magnesium is very high (10.33-14.72 cmol/kg soil).

Soils with vertic properties comprise about 1.62 percent of the total soil groups. Of the eight ADDs, Blantyre ADD has the highest percentage of the land in this soils group (10.76%). Salima has 4.75% of the soils in this group while Shire Valley ADD has 2.60%, Karonga 0.65% and Machinga ADD 0.34% of the land area classified as Vertic group. These soils have a very high CEC, and that some have a high K content. Interestingly, most of the soils in this group have low P content. The major constraints of this soil group is mostly physical in that these soils shrink and become hard during the dry season and when wet, they swell and become sticky and plastic during rainy season, thus making cultivation very difficult for farmers in both the dry and wet seasons.

I.viii Regosols

These soils are very common in Malawi, and are classified as Orthents (Taxonomy) or Sandy Ferrallitic soils (Malawi). The term Arenic soils means that these soils have a sandy or loamy sand texture throughout the upper 100 cm or less if the soil depth is less, and lack the diagnostic characteristics of other soil groups. The most common soils are classified as Arenosols. In Malawi, these soils are classified as Sandy Ferrallitic Soils. They are sandy soils formed from old beach deposits or sandy materials. The texture of the topsoil is normally loamy sand and lower horizons below 45 cm are not heavier than sandy clay loam. Regosols are stuctureless soils.

Low water holding capacity is very common among the soils that are sandy. Interestingly, most of the soils in this group have a low cation exchange capacity. This means that over and above low water holding capacity, these soils will also have low nutrient retention capacity. This in itself means that there will be leaching of nutrient elements from these soils. The Action Group I of the MPTF is suggesting an application of high nitrogen rates at three per growing season in order to reduce this leaching.

Regosols are moderately to strongly acid (pH 4.9-6.0) with variable base saturation (30-90%). Organic matter is low to medium (0.9-2.7%) and nitrogen ranges from low to medium (0.05-0.13%). Available phosphorus is trace to medium (0-27 mg/kg) and potassium is very low (0.36-1.14 cmol/kg soil) while calcium is low (2.30-4.19 cmol/kg) and magnesium is very low (0.36-1.14 cmol/kg).

I.ix Orthic Solonetz

These soils in Malawi are classified as Mopane soils or Mopanosols, while the Taxonomy classifies these soils as Natrulstalf. Mopanic soils have within the upper 50 cm a horizon with high bulk density and low porosity, resulting in a very hard consistence when dry and very low permeability. The cause of the unfavourable physical properties of mopanic soils is not known. A high exchangeable sodium percentage in the past and present may have caused dispersion of clay and loss of structure. The mopane tree (Colophospermum mopane) is one of the few trees in Malawi tolerant of the compact and dry nature of this group. These soils are partly Stagnic, Calcic of Haplic Luvisols, with a fragipan phase.

The topsoil is sandy and is immediately underlain by sandy clay. These soils are extremely hard when dry. Soil structure ranges from massive to moderate. These soils have low permeability. They are neutral or alkaline (pH 6.8-8.0) and have very high base saturation (95-100%). Organic matter is low to medium (1.1-2.0%) and nitrogen is very low (0.03-0.10%). Available phosphorus ranges from very low to high (4-46 mg/kg). Potassium is low to medium (0.16-0.23 cmol/kg). Calcium is medium (6.26-8.92 cmol/kg) while magnesium is medium to high (2.54-5.86 cmol/kg).

I.x Lithosols

These soils are also known as Lithosols in the Malawi classification or Lithic subgroups (Taxonomy). They are soils that are shallow and stony. However, they deserve to be mentioned because they are widely prevalent in Malawi. Lithic soils have a depth of 30-50 cm over hard rock or other material not permeable by roots, and more than 20 percent fine earth (small materials with a diameter of 2 mm or less). Characteristics other than depth may vary widely. These soils therefore have a lithic phase.

Results show that in the Lithic soil group, a total of 116600 hectares or 1.3% of the total of 13 soil groups are found in Malawi. The distribution varies among districts. Kasungu and Blantyre ADDs have very few soils in the lithic phase, and Shire Valley ADD has the highest. The main constraint of these soils is the rooting zone because these soils are shallow.