Energy and small-scale agriculture

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Executive summary

Policy context and issues

In the agricultural sector, the inequalities wrought by a long history of racial policies are at their most glaring. Black citizens have been systematically deprived of their title and access to land. In the crowded homelands, there are between 1.5 and 2.1 million rural households depending on one's definition of 'rural'. Nearly all of these families practice small-scale agriculture in some form, even if it is merely a small garden plot of maize and vegetables and a few chickens. Typically a subsistence farmer may cultivate one or two hectares of rain fed field crops, own a few cattle and/or small stock, and grow some vegetables in a homesite garden. However access to fields and ownership of livestock are characteristically skewed, and many rural families have neither.

At the same time, government policies aimed at maintaining political support in the rural areas, have propped up inefficient farmers outside the homelands. As a result of misguided policies, about three quarters of the 60 000 or so full-time commercial farmers are in the grip of a debt crisis of frightening proportions.

Agricultural policy in South Africa at the end of the 20th century faces the two urgent issues: the crisis in commercial agriculture and the inequities in the sector as a whole. This paper reviews the debate surrounding both of these policy issues and concludes that in both cases the directions point clearly towards the development of small-scale agriculture.

Some of the projections for the extent of land redistribution appear to be unrealistic. The Macro Economic Research Group report, for example, recommends the training and settlement of 1000 farmers per year on 40% of the agricultural land in South Africa over the next 33 years. Any massive land redistribution programme will face several difficulties:

- establishing objectives and criteria for redistributing land;
- attracting competent young people to agriculture;
- coping with the strains on extension services;
- dealing with the vast extent of marginal land in South Africa and the absence of realistic development and management strategies for marginal areas.

This paper suggests that the rate at which a land redistribution programme and resettlement schemes will create new commercial farmers is more likely to be of the order of 100 per year than 1000 per year. At the same time, it may be possible to help a larger number of subsistence, or sub-subsistence, farmers in the homelands become semi-commercial part-time farmers (say 500 farmers per year).

Agricultural policy will have to reconcile three broad policy objectives: (i) meeting production targets, (ii) equity, and (iii) conserving the resource base. In this paper we argue that small-scale agriculture based on mixed farming with a low level of external inputs provides one way of meeting all objectives simultaneously. Firstly, there is evidence that small farms are potentially as efficient as, or more so than large farms. Secondly, development of small farms will open the way for many people who were previously denied entry into commercial farming because of legal and economic barriers. Thirdly, small-scale agriculture is highly compatible with the management requirements of complex and biologically diverse systems.

Energy needs and constraints in agriculture in the homelands

At present, agriculture in the homelands faces many constraints, some of which are energy related. It is important to understand how these constraints are felt, and what the objectives and implications of energy interventions in agriculture might be. For example, mechanisation which brings with it certain energy demands, might be primarily aimed at easing another rural constraint such as a labour shortage rather than at increasing agricultural production per se. A surprising characteristic of the homelands is the extent to which arable land is underutilised despite the quite obvious land shortages. While the shortage of draft power (whether animal or mechanised draft) is a one of the main reasons, the paper also explores some underlying factors which act against the intensification of agriculture. These include the absence of a land rental market in the communal areas, and the migrant labour system.

Energy for land preparation is the main energy requirement in homeland agriculture, and this is probably where the most serious energy constraints are to be found. Animals are in a poor condition when the ploughing season arrives after winter. The homeland tractor fleet which numbers an estimated 11 to 12 thousand units in total, is generally in poor condition and nearly half are virtually non-operational. Access to diesel is frequently a problem for tractor operators

If every draft animal in the homelands were optimally used, they could provide just about enough draft power to plough all the fields. The tractor fleet on the other hand could potentially plough only about one third of the total arable area (though there is a distinct possibility that the number of privately owned tractors has been underestimated). In certain homelands the combined theoretical potential of the cattle herd and the tractor fleet would seem to be inadequate, or barely adequate, to plough all the fields (Bophuthatswana, Gazankulu, KwaNdebele and Venda).

Energy is also required for pumping water for agricultural purposes. It is necessary to distinguish between pumping surface water for crops and ground water for livestock since this will affect the choice of pumping technology and the type of energy. Other energy requirements include crop processing, particularly shelling and milling, as well as a whole range of new requirements for energy as agriculture diversifies. Finally agricultural extension brings with it some energy requirements: transport, and suitable venues with electricity and lighting where meetings and courses can be held.

Strategies for energy in small-scale agriculture

The paper discusses strategies for easing some of the energy constraints in homeland agriculture. There are essentially two two broad types of intervention. Firstly, supply side interventions aim to improve the following:

- the supply and delivery of energy (eg electrification, bulk diesel supplies);
- the utilisation of energy (eg improved animal-drawn equipment, tractor rehabilitation and maintenance, selection and maintenance of appropriate pumps);
- the support services required to make energy and energy technologies accessible (eg easy financing, training).

Secondly, demand side interventions aim to ease energy bottlenecks by reducing demand. Two specific examples are discussed: minimun tillage techniques; and supplementary irrigation with water conservation measures instead of full-scale irrigation. However, energy demand in agriculture cannot really be managed in isolation of all the other inputs. Energy demand management therefore opens up the subject of low-input agriculture which we introduced initially in relation to new directions for agricultural policy.

Finally, changes can be expected to the energy requirements with the emergence of a growing number of commercial and semi-commercial small-scale farmers as a result of land redistribution and possible new policies for agriculture. For example there may be a greater demand for smaller farmer-owned tractors rather than larger contractor-owned tractors. Energy needs will probably diversify, and electricity become a viable option in some settler schemes. The development of representative organisations for small-scale farmers with the influence to lobby effectively on their behalf and to influence, inter alia, energy planning is seen as a priority.

Chapter 7 provides a brief summary of the main recommendations of this report. These cover the following:

- measures to improve the utilisation of animal draft;
- rehabilitation and maintenance of the tractor fleet;
- improving access to diesel;
- energy demand management;
- development of rural service centres;
- co-ordination between agricultural development and rural electrification programmes;
- formation of farmers' associations and interest groups.

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CHAPTER ONE

Introduction

Just as agriculture is only one facet of rural development, so too, is energy only one facet of agricultural production. This paper locates energy and agriculture within the context of rural communities striving to build appropriate institutions, develop sound infrastructure and create a vibrant rural economy.

1.1 Energy and equity in agriculture

As an underlying value, it is assumed that policy will strive in a practical way to empower rural communities. This implies that participative and accountable local government institutions will be developed, which will have some power in deciding on local development priorities, and on the allocation of available resources.

In terms of agriculture, local Farmers' Associations will need to be developed and encouraged to link in forming national structures which will be able to lobby in the interests of agriculture and rural development. Empowering rural communities in practical terms means that these organisations will represent not only the commercially active farmers, but also those rural people who have hitherto lacked access to resources and have not had the benefit of an accountable public administration.

This assumed value has two main implications for energy policy: firstly, national energy policy will need to be linked to national development policy, and will need to address basic needs as well as policy instruments which aim to stimulate the economy more directly. Secondly, if local rural communities are to make informed decisions on the priorities for development and the allocation of resources at local level, a process of vision-building will be required. A range of feasible development options will need to be presented to rural communities, as well as the likely results of various development emphases.

1.2 Experience with rural electrification in India and Zimbabwe

Experiences with rural electrification in India, where two-thirds of rural villages were electrified between 1960 and 1986, showed that, even where considerable irrigation potential exists to justify rural electrification economically, only the rural elites have been able to access electricity and its benefits (Byrappa 1987). The Indian government has now provided extra funding for special attention to a 'Revised minimum needs programme', where different criteria are applied to rural energy provision. In some cases (such as Kashmir), although there is little irrigation potential, widespread cottage industries mean that availability of electricity even for lighting would increase productivity through the possibility of a longer working day. Murphy (1990) has pointed out that in southern KwaZulu, women spend more than nine hours sleeping during the winter months, mainly because the cost of lighting using candles and paraffin is excessive. Byrappa (1987) claims that whether or not there are immediate short term benefits, it has been found that rural areas that are electrified developed much faster than similar areas not electrified.

Experience in Zimbabwe, on the other hand, has not been quite so clear-cut. Although the Zimbabwean Electrification Masterplan Report No 2 (1991) notes that electrification 'can unleash a spurt of development in productive and service activities which can lead to self-sustained growth at a rapid rate', it cautions that this is only likely to happen 'where the right preconditions and complementary factors exist'. A highly successful pilot study at Gokwe is described and the conclusion reached that, although Gokwe appeared an unattractive project in terms of economic viability and geographic isolation, the presence of water, human resources in the hinterland, public investment and political support meant that electrification could help it grow from a pre-independence small business centre of less than 300 people to a District Service Centre of about 9 500 people in 1991.

In contrast, Mahusekwa opted for electrification rather than water development, but the arrival of the grid failed to stimulate growth. The Masterplan Report argues that this is because water supplies were unreliable, the road is impassable during the rainy season and the proximity to Harare (50 km distant) means that many potential customers take their business there instead.

Although some 16% of centres in the communal or resettlement areas of Zimbabwe had grid electricity in 1991, only about 9 000 people (or 0,2% of the District Council/resettlement population) benefit directly from electricity. The commercial sector consumed about 68% of energy in seven of the pilot rural electrification programme centres, with 13% industrial and 19% domestic consumption. There was little evidence of secondary development, such as irrigation schemes.

1.3 Empowerment, organisation and energy efficiency

In the South African context, the importance of allowing some local decision-making in terms of the allocation of development resources is qualified by the case of Mahusekwa, where the District Council's decision to reticulate electricity rather than water represented an ill-informed development investment strategy. A process of education and broadening the vision of local authorities will be required if they are to be expected to make well-informed decisions, but if such a process is not built into energy policy, then empowerment of local communities will remain a hollow ideal.

This will have to be presented from the perspective of the farmer, farm labourer or other rural resident, taking into account the whole system as it operates in practice, with its constraining factors and practical problems. Tackling the issue of energy in isolation from other pressing issues such as the provision of water and job creation would be pointless and counter-productive.

While traditional low-input farming systems may not be very productive in terms of yield per unit of land, they are fairly efficient in energy terms, producing more energy than they consume. In comparison, high input 'green revolution' agriculture with its high yield levels, uses large quantities of energy.

Energy efficiency, expressed as the ratio of energy produced to energy used, declines as production becomes more intensive. Systems using only hand tools for cultivation typically produce five times more energy than they use; this ratio drops to about 4:1 when animal draft is brought in, and further to less than 3:1 when operations are mechanised. For intensive horticulture in the United States of America, twice as much energy is used as is produced (energy efficiency ratio — 0,5:1, (Pimentel and Pimenetel 1979)).

At the same time, of course, yield levels increase from about one tonne of maize per hectare using hand tools only to more than five tonnes using modern technology and ten tonnes if irrigation is available. Simultaneously, the amount of labour required in food production is drastically reduced. In Egyptian times, 95% of the population were involved in agricultural production, leaving only about 5% free to construct the pyramids! In comparison, only 0,1% of the population of the United States are farmers.

It has been estimated that almost half of the energy used by modern farmers goes into increasing yields, while most of the rest goes into reducing the need for labour. A person needs about 400 hours to prepare a hectare of maize using only hand tools; a pair of oxen can do it in 65 hours, and a 38 kW tractor takes about 4 hours (Pimentel and Pimentel 1979).

If rural communities in South Africa are to be empowered, policy will need to reduce the back-breaking burden resting mainly on rural women, but it will need to avoid the trap of over-use of energy inefficient technology. Accessibility to poorer people and the long term environmental implications of green revolution technology will have to be weighed up against the possible benefits of its use. Sustainable rural development will require farming systems which are more productive and less wearisome than traditional systems, but which are based on existing understanding of the local environment.

1.4 An overview of South African agriculture

Given the history of South Africa it is hardly surprising that agricultural development has been drastically skewed in a number of directions: black citizens have been systematically deprived of title to land as well as access to land, and government policies aimed at maintaining political support in the rural areas have propped up inefficient farmers, while at the same time attempting to control the marketing of agricultural commodities through a range of control boards.

These distortions have contributed to a situation where the country has perhaps three thousand good farmers (in commercial terms at least, as they produce some 40% of the total agricultural product). Another ten thousand farmers are surviving economically (producing a further 40%), while most of the rest (forty to sixty thousand full-time farmers) are in the grip of a debt crisis of frightening proportions.

Only 12 to 14% of our 122 million hectares of land is arable, and between 1 and 3% of the total is irrigable. Rainfall in many areas is both low and unreliable, making the production of staples such as maize and wheat a hazardous undertaking in many areas. Vast areas of the country are best suited to extensive grazing of livestock, and this, in turn, has implications for the establishment of a large number of small scale commercial farmers in areas where infrastructure would be very costly to provide, and where isolation militates against the development of marketing opportunities for small operators.

In the past decades, the monetary policy of the government has inflated input prices, while food prices have been kept down by low consumer demand because of the recession. The removal of subsidies and the decrease in the political power of the rural lobby have also contributed to the worsening terms of trade experienced by commercial agriculture. Coupled with droughts and floods, this has affected red meat and summer grain production particularly badly. Other commodities (especially those with substantial export markets, such as sugar, wine, deciduous and citrus fruits and some high value vegetable crops) have prospered, partly due to currency depreciation, and partly to the opening up of the export market to South African produce during recent times.

Government policies in the past allowed commercial livestock farmers to carry more stock than the land could support, and while these farmers profited from their heavy stocking rates in the good years, they were secure in the knowledge that they would receive help in times of drought. Black livestock farmers on the other hand, were harassed by a range of 'livestock reduction schemes' aimed at reducing their cattle numbers without offering any marketing support to ensure that they obtained a fair price for animals sold (Kockott 1993).

Black farm labourers, too, were employed under whatever conditions white farmers wished to impose, and since farms are geographically scattered and farmers generally hostile to unionisation, this sector of the labour force is still the most underpaid, uneducated and socially fragmented of all.

These policies in this ecologically sensitive environment have led to the current situation, where most of commercial agriculture is not sustainable at present. This is true socially, economically and environmentally.

While the total contribution of agriculture to the Gross Domestic Product (GDP) has declined from 11% in the sixties to 4% in 1991, and food production has increased by only 0,6% per annum over the decade of the eighties, population has increased by 2,4% per annum over the same period (Bawden 1993). This has fairly dramatic implications for future agricultural policy in South Africa.

1.5 Small scale agriculture

Outside of the 'homelands', there are estimated to be about 60 000 full-time commercial farmers. There are roughly the same number of part-time commercial farmers, who generally farm on relatively small landholdings (2 to 50 ha). These small-scale farmers have had access to some support services historically, but not to subsidised financial assistance. Data on the contribution of small-scale non-homeland agriculture to the GDP has not been found, but it may be noted that in many European countries, farm units of this size are the norm rather than the exception, and the family farm has been, and still is, the cornerstone of agricultural production in Europe, in spite of the trend towards larger, more mechanised and specialised farm enterprises. In Taiwan, small farms also participate in decentralised industrial activities in order to supplement farm incomes.

The total contribution of agriculture and forestry to the GDP of the homelands in 1990 was R1,2 billion. As a percentage of the total GDP of each homeland, the contribution of agriculture and forestry varies from 1,9% in QwaQwa to 14,7% in Gazankulu. During the decade of the eighties, the Gross Agricultural Product rose in absolute terms in all the homelands, but Table 1.1 shows that its contribution to the GDP fell as other components, particularly social services, rose more sharply.

	R 000's % of total (1990)	*% of total (1990)*	*% of total (1980)*
kwaZulu	5 661 428	13.5	18.8
Transkei	319 453	11.5	21.9
Ciskei	87 224	6.8	6.9
Gazankulu	68 689	14.7	19.7
Lebowa	65 261	3.7	8.7
Venda	62 044	9.0	12.8
Bophuthatswana	18 000	4.1	4.8
kaNgane	15 247	7.2	10.4
QwaQwa	10 561	1.9	5.4
kwaNdebele	8 207	4.0	6.5

TABLE 1.1 The contribution of agriculture and forestry to the Gross Domestic Product of each of the homelands

In KwaZulu, Transkei and Gazankulu, agriculture has been an important economic activity, although the recent decline in importance has been marked, in common with the decline in South Africa as a whole. Since both Ciskei and Bophutatswana are fairly arid, agriculture has been a relatively small contributor to GDP in these areas. Current large-scale irrigation developments in KaNgwane may have considerable effects on the contribution of agriculture to GDP in the near future if they are successful.

Thus the position of agriculture in black communal and freehold areas, though very different structurally, is effectively fairly similar to that in the commercial sector. Widespread poverty has resulted from the out-migration of most of the more competent residents, and the policies of influx control resulted in the most vulnerable dependents having to remain in the rural areas with scant means of support. From as early as 1897 (the Glen Grey Act), systematic restrictions on land ownership and agricultural production by blacks, as well as minimal provision of support services for farmers and corrupt and impotent local administration have also played their part in marginalising black rural communities.

Nevertheless, although it is frequently argued that subsistence agriculture is woefully unproductive, there is evidence to suggest that in terms of its actual value to producers on a per hectare basis, it is more efficient than its commercial counterpart (Christodolou & Vink 1990). This is due partly to the fact that in the subsistence farming system, the value of produce is the cost of that produce at the nearest available source, but many researchers also question whether large farms are inherently more efficient than small ones at all. Deininger & Binswanger (1992) argue that in Southern Africa, as in South America, any apparent success of large farms over small was due more to long differential support, rather than economies of scale.

There is also much evidence to suggest that increasing production in these areas will be more related to removing socio-economic constraints than to the provision of technical information (Chambers 1983; Conway & Barbier 1990; Wilson & Ramphele 1989; Cousins 1992; Auerbach 1993a; Land & Agricultural Policy Centre, 1993). These factors will all have to be taken into account if an effective agricultural extension service is to develop (Farmer Support Group 1993; Auerbach 1993b).

CHAPTER TWO

Current energy usage, requirements and resources in small-scale agriculture

2.1 The data base

The data base on energy for small-scale agriculture in the South African homelands is very limited. Apart from a few isolated surveys of draft animals, and of tractors (much of which is unpublished), there is virtually no available data on energy usage, energy requirements or energy resources for small-scale agriculture.

The main sources of information on agriculture in the homelands are the Annual Reports of the various departments of agriculture, as well as the various Development Bank of Southern Africa (DBSA) reports containing development information for each of the homelands and the development regions.

The DBSA reports (most of which are pre-1990) emphasize the dearth of data on subsistence and sub-subsistence farming. Even estimates of proportion of land in the homelands under different types of land use are approximate, due to deficiencies of data from the subsistence sector.

2.2 Types of energy needed

It is useful to recognize the different types of energy that may be required in small-scale agriculture.

- Animal draft power
- Shaft power, for mechanized draft and transport, driving pumps, mills and other machinery
- Heat, which includes:
  - low temperature heat (up to 60°C): e.g. incubators, warm water for dairies;
  - medium and high temperature heat (60°C upwards): e.g. drying certain crops, sterilizing, welding.
- Refrigeration: marketing of perishables, storing veterinary materials.
- Lighting: may be used in poultry units for example, but the main need for lighting is in agricultural extension and organizational development and includes audiovisual equipment.

NOTE: The following two forms of energy will not be considered:

- Human energy
  In some analyses of energy in small-scale agriculture in other parts of the world, human energy is dealt with in the same way and in the same units as other energy inputs. To evaluate human effort in litres diesel equivalent or whatever is to trivialize it. In this paper, it will be more appropriate to deal with labour and management as separate inputs altogether.
- Indirect energy
  This refers to energy used in producing other inputs such as chemicals and fertilizer. While this energy is important in considerations of the overall sustainability of agriculture as a whole and will be discussed in that context, it is not directly relevant to energy supply strategies for small-scale agriculture.

2.3 Energy in the context of small-scale agriculture

2.3.1 Categories of small-scale agriculture

At the risk of over-simplification, small-scale agriculture can be divided into three broad categories, each with its own set of implications for energy.

Subsistence and sub-subsistence agriculture

This class of agriculture is made up typically of extensive grazing of livestock, dry and arable cropping and gardening on a plot, either at the homestead or in a community garden. Into this basic fabric may be woven a variety of other subsistence or semi-commercial activities: poultry, pigs or other more intensive livestock production; the production of a cash crop on an informal basis or a small food surplus for sale.

The main energy requirement is draft for ploughing and other agricultural operations. Community gardens generally need water supplies, so energy is needed for pumping. Pumps are required for boreholes to provide water for livestock, particularly in the more arid regions where reliable surface water resources are lacking. Food processing, especially milling, requires energy. The development of subsistence agriculture and the adoption of various other activities create other energy demands which are frequently for small quantities of diverse forms of energy. This presents problems in planning for the provision of energy for the transition from subsistence agriculture to viable rural livelihoods.

Small-grower schemes

Small-grower schemes have been implemented in some areas. These generally have the following characteristics:

- small-grower farmers operate under traditional tenure on their allocated land and generally retain many of the characteristics of subsistence farming life;
- small-grower schemes may operate over a fairly extensive, but defined, area;
- schemes involve a single crop, often a raw material for processing like sugar cane, cotton or timber;
- inputs and extension are made available, often by the private sector, such as a timber company or sugar association, and the farmer is generally contractually-bound to sell the crop for processing by the project;
- some small-grower schemes have actively encouraged the emergence of secondary contractors to service the farmers.

The energy requirements will obviously depend on the agricultural operations involved in the particular crop. An energy requirement which is a particular characteristic of this type of small-scale farming is for haulage, especially when a bulky raw material has to be carried a long way to a mill or processing plant. Small-growers may get access to tractors etc. through the infrastructure of the scheme itself, from the contractors, or they may have their own tractors.

Settler schemes

Settler schemes have been planned with the creation of commercial agricultural units in mind. These may consist of a group farm and/or individual plots. In order to provide a livelihood for the settlers and to cover the high management and overhead costs usually associated with such schemes, the style of agriculture tends to be intensive. There may be several diverse energy requirements, especially if the project includes some form of processing, eg of dairy products. Irrigation is commonly a major consumer of electricity on such schemes. Meeting the energy requirements is normally done on a project-by-project basis and involves a grip connection, and project-owned tractors.

It is quite possible that settler schemes will be a key part of land redistribution. If this turns out to be the case, the appropriateness and sustainability of capital and management-intensive projects will have to be questioned. Energy planning for small-scale farming on settler schemes will then be necessary.

2.3.2 Intensification and mechanization of agriculture: structural constraints

A prominent feature of agriculture in the homelands is the under-utilization of arable land (Bromberger 1982; Bromberger & Gandar 1984; Low 1986; van der Riet 1992). Surveys in which farmers have been asked what the main constraints are on agriculture, or what the reason is why some of their land has not been cultivated, have consistently identified issues related to draft power as the main ones: availability, cost, quality of service, etc. (Dlamini 1990; Auerbach 1993a).

Despite the evident immediate nature of the problems with draft power, these are to some extent thrown to the surface by underlying factors which operate counter to the intensification of agriculture. These factors include:

- The system of land rights, which brings with it a stream of benefits *provided that a permanent residence base is maintained and regular use of arable land is demonstrated.* Apart from agricultural resources, benefits include residence rights, access to a range of natural resources, security in times of unemployment or old age. People may have psychological and ancestral attachments to their land allocations.
- The migrant labour system, which confers a *relatively high opportunity cost on labour* in subsistence or semi-commercial agriculture if it means foregoing wage employment.
- The *low opportunity cost of arable land* in the absence of an efficient land rental market. Part of the reason is a fear on the part of a lessor that he/she may have difficulty regaining land at a later stage, since the person renting the land may, through continual use of the land, become the *de facto* owner.

While there is little opportunity cost in leaving land idle, there may be a considerable 'cost' if all is idle: i.e. the risk of losing one's allocation and the associated benefits. These benefits, which may be unobtainable or expensive elsewhere, can be secured by household members whose opportunity cost of time is low. They can reside and carry out the minimum requirement of agricultural tasks while wage workers become migrants or commuters. For many households, this would seem to be a rational allocation of available workpeople.

Indeed, some studies (Steyn 1988; Rose et al (no date)) have shown that only about a third of farmers believed that the cost of ploughing (rands in the case of tractors — time in the case of animal draft) was justified in terms of the yields obtained. It would appear that there is another incentive to cultivate, apart from the value of the crop, namely, the securing of land allocations.

To sum up, cultivation is carried out in a situation in which there is a low opportunity on land, a relatively high opportunity cost for some labour, and in which yield is not the only incentive for cultivation. In such a situation, it is logical that the benefit of mechanization would be seen more in terms of time-saving than in terms of intensification.

Another disincentive to mechanize relates to risk avoidance. It has been theorized that peasant farmers are more concerned with risk avoidance than maximizing yields, preferring a safe small yield than a potentially large but risky yield; a theory which has been confounded by farmers in marginal areas persisting with high risk maize rather than low risk sorghum which, admittedly, has a higher labour requirement than maize. As we have seen, subsistence agriculture has been relegated in significance in the economics of the rural household. It may still be important, but it is no longer vital for the survival of many rural households. In this situation, risk avoidance takes new meaning. Rather than aiming at avoiding crop failure altogether, it makes more sense to minimize losses in the event of failure; in other words, keep input low.

2.4 General energy-related constraints in small-scale agriculture

The foregoing section emphasized the need to see energy constraints in small-scale agriculture in the context of other logistical and structural factors which also constrain agricultural development. Energy may be a necessary condition for agricultural development, but it is not a sufficient one.

Nevertheless, there are constraints on small-scale agriculture which arise directly from inadequate availability of energy and power sources.

Of these constraints, which are dealt with individually below, the most serious are generally related to tractive power for ploughing and cultivation, whether from animal draft or tractors. Energy for pumping may be problematic, particularly for small remote projects such as community gardens.

Shelling and milling of maize are tasks which require energy and here, bottlenecks are sometimes experienced. Shelling, in particular, is frequently done by hand.

Small-scale agriculture experiences many of the general energy-related constraints which apply to the rural milieu in general. There are problems in meeting the following needs, for example: the energy requirements of rural workshops; the need for electrified venues for extension, training and organizational development; energy for refrigerated storage; flexibility and diversity of energy delivery to support diversification of rural development, including agriculture.

2.5 Requirements for traction: the extent of cultivation

It must be emphasized that any overview of agriculture in the homelands is fraught with uncertainties. For example, enumeration of the rural households depends on the interpretation of 'rural' (see Table 2.1). It can be seen that the numbers of 'official' and 'functional' rural households may differ by almost 200%.

	Area	*Population*		*No of rural households*	
	km²	*total 000s*	*density per km*	*official 000s*	*functional 000s*
Gazankulu	7 484	717	96	116	90
KaNgwane	3 917	600	153	81	30
KwaNdebele	2 208	425	192	56	21
KwaZulu	36 074	4 979	138	605	438
Lebowa	22 137	2 659	120	361	255
QwaQwa	1 040	293	282	42	18
Transkei	43 654	3 104	71	451	421
Bop'tswana	41 526	1 921	48	275	98
Venda	6 807	525	71	79	68
Ciskei	8 231	803	98	76	18
TOTAL:	173 078	16 026	93	2 142	1 457

TABLE 2.1 Details of area and population in the homelands

Rural households:

- *official* numbers of rural households based on government census statistics;
- *functional* numbers are based on DBSA criteria whereby peri-urban areas from which people commute to urban areas for work and shopping, and semi-urban concentrations in excess of 5 000 people, are regarded as being 'functionally urban'. Nevertheless, in these two types of settlement, widespread sub-subsistence agriculture might be expected.

Furthermore, little is known about the subsistence sector (including sub-subsistence) as a whole, although there have been some isolated studies. Thus, we are not able to summarize accurately the extent to which the functionally rural households engage in agriculture. In two areas for which estimates of the numbers of subsistence farmers have been attempted, these are substantially less than the number of 'functionally rural' households given in Table 2.1:

	No of subsistence farmers
KwaNgwane	11 000
KwaNdebele	2 370

It has, therefore, proved to be impossible to obtain reliable and consistent estimates of the percentage of the homelands under different forms of land use, particularly the area cultivated under subsistence farmers. There are discrepancies between estimates (Table 2.2) and evident inconsistencies in definition. The figure of only 4,7% of the portion of Transkei in region D (i.e. most of Transkei) under cultivation, certainly does not reflect the extent of subsistence cultivation. We believe that the higher estimates of the extent of cultivation present a more accurate picture of the actual situation, and that over much of the homelands, approximately 15% of the land area is cultivated.

For some homelands, we were unable to locate any information on the extent of cultivation, but in some instances the data on the arable potential was provided (Table 2.3). These also appear to cluster around 15%, but this does not imply that the areas actually cultivated coincide with those areas with arable potential.

	Cultivated	*Grazing*	*Other*	*Source*
KwaZulu (1)	10,0	67,4	22,6	1
KwaZulu (2)	17	66	17	2
Ciskei	8,1	82,4	9,5	3
Transkei (Reg. D)	4,7	92,0	3,3	3
Transkei (Reg. E)	18,1	75,7	6,2	1
QwaQwa (1982)	9,8	80,8	9,4	4

TABLE 2.2 Estimates of the percentage of land area under cultivation and grazing in certain homelands

Sources: 1 Development Bank of Southern Africa (1991); 2 Erskine (1982); 3 Development Bank of Southern Africa (1990a); 4 Government of QwaQwa/DBSA (1985).

	Arable (% of total)	dry land (% of arable)	irrigable (% of arable)
KaNgwane	17	28	72
KwaZulu	12		
Transkei	17		
KwaNdebele	18	80	20

(Note: Only 1,3% of potential irrigable in KwaNdebele is irrigated.)

TABLE 2.3 The proportion of land with potential for arable agriculture
Sources:Government of KaNgwane/DBSA (1985); Lyster (1987); Government of Transkei/DBSA (1987); Government of KwaNdebele/DBSA (1987).

Referring back again to the population data in Table 2, and making the following assumptions about the extent of cultivation per household, the percentage of cultivation may be calculated. Taking account of various studies of rural and peri-urban households (Bromberger 1982; Lyne 1989; Auerbach 1993a) it is reasonable to assume that 'functionally rural' households cultivate about 1,25 ha on average, while 'officially rural but not functionally rural' households cultivate about 0,25 ha on average. The results bear out the contention above, that roughly 15% cultivation is typical of much of the homelands. On our assumptions, the following percentages apply: Transkei 12,2%; KaNgwane 12,8%; Venda 12,9%; Lebowa 15,6%; KwaNdebele 15,8%; Gazankulu 15,9%; KwaZulu 16,3%.

For three homelands, the calculation of percent cultivation produced very different results: Bophuthatswana — 4,0%; Ciskei — 4,5%; QwaQwa — 27,4%. There are reasons for doubting these results. In the case of Bophuthatswana and Ciskei, the Development Bank of Southern Africa (DBSA) criteria for urbanization have led to 85% of households in these areas being classified 'functionally urban' and this clearly misrepresents their rural nature. In the case of QwaQwa, with the highest population density of all homelands, the arable holding of the average rural household is likely to be smaller than elsewhere. For QwaQwa and Ciskei, we shall adopt the percentage in Table 2.2. For Bophuthatswana, we assume cultivation is only 8% of total area, since much of it lies in arid and semi-arid areas unsuited to arable.

In addition to the cultivated fields, there are garden plots which need to be cultivated. The area of community gardens is negligible in relation to the total area cultivated (Table 2.4). Cultivation of these gardens is generally carried out by hand.

Information on homestead gardens is scarce, hence the gaps in Table 2.4. The method of land preparation in homestead gardens at Ndeleshane in KwaZulu was:

hand	41%
donkey	18%
ox	23%
tractor	18%

Source: Lea & Stanford (1982)

This may be typical of many areas. It is not clear whether the high percentage of land preparation by hand indicates that this is the most appropriate method, or that alternatives are not readily available to most households (Auerbach et al 1990).

	Community Gardens			Home Gardens	
	Number	Hectares	Members	Number	Hectares
Gazankulu	46		2 564		
Venda	14	14	479	1 141	
QwaQwa	38	108	902		
Transkei	500	722	18 720	360 662	90 168
KwaNdebele		81	639	(excl. Klipspruit)	

(Klipspruit Irrigation Scheme KwaNdebele: 32 ha with 1600 plots of 200 m).

TABLE 2.4 Cropped gardens in the homelands

2.6 The availability of animal draft

2.6.1 Time taken to plough

Although Pimentel and Pimentel (1979) say that an oxen pair takes 65 hours to plough a hectare, and a 38 kW tractor four hours, actual observations in KwaZulu (Auerbach et al 1991) indicate that the gap is smaller, with four oxen (the common configuration) taking about 18 hours and a 38 kW tractor six and a half hours to plough a hectare. Data from Zimbabwe indicates that a span of two oxen working four to five hours per day for a five-day week plough between 1,25 ha per week (autumn ploughing) and 0,5 ha per week (late ploughing) (P. Jordaan, unpublished data). Evidently, the time which it takes to plough with oxen is highly variable, depending in part on prevailing local conditions.

2.6.2 Assumptions.

In order to estimate the draft potential of the total cattle herd in the homelands, we made the following assumptions:

- 25% of the total herd are suitable draft animals;
- each draft animal works 200 hours per year on average;
- it requires 90 animal-hours on average to plough one hectare.

In practice, it is probable that less use is made of draft animals and that this potential is not achieved.

2.6.3 Number of draft animals in the homelands

Livestock numbers may undergo large fluctuations with weather conditions since stocking rates are held close to the ecological carrying capacity (i.e. the numbers which can survive on the veld at any given time). The numbers in most areas rose steadily from the mid-70s to 1980. With the drought of the early 1980s, these dropped to a minimum in about 1984 or 1985 (Gazankulu suffered the greatest drop in total herd: 46%). By 1990, the total herd had recovered to almost the 1980 level in most areas. The herd size in 1990 or just prior to that date, is given in Table 2.5.

Drought not only reduces the number of draft animals, but also their condition. Thus, the availability of animal draft power is severely reduced by prolonged drought and, therefore, regarded as very variable under South African conditions.

	Cattle 000s	*Horses/donkeys/mules 000s*
Gazankulu	176	16
KaNgwane	127	3
KwaNdebele	31	1
KwaZulu	1 516	46
Lebowa	503	28
QwaQwa	14	0.2
Transkei	1 463	82
Bophuthatswana	467	33
Venda	136	5
Ciskei	124	3

TABLE 2.5 The numbers of cattle and horses/donkeys/mules in homelands (data from 1988 to 1990, depending on area)
Source: Development Bank of Southern Africa (1989 & 1990b)

Based on the assumptions above and the number of cattle in each homeland, we calculated the hectares which could potentially be ploughed by cattle. This is presented in Section 2.9 below, in which draft requirements and resources are summarized and compared to the total area of cultivation and to the area which could be ploughed by the existing tractor fleets (see Table 2.10).

We have not included horses, donkeys and mules in the calculation, since their numbers are only 4% of those of cattle. They are seldom, if ever, used for ploughing fields, though donkeys are sometimes used for land preparation in homestead garden plots (see 2.5 above). Equines are generally used for transport and haulage rather than cultivation.

2.7 Size and potential of tractor fleets

Most of the information on the size, condition and possible rehabilitation of tractor fleets in the homelands was supplied by Mr. P.D. Hittersay of Hittersay and Associates. There has been no comprehensive census of tractor fleets. Much of the quantitative description is, therefore, 'best guess' based on extrapolations from isolated surveys and other pieces of unpublished information which were summarized at the Mechanization and Irrigation in Developing Areas Symposium (Hittersay, 1990).

2.7.1 Number of tractors

The number of tractors in the homelands (Table 2.6) is in excess of the number registered, particularly in KwaZulu where 93% of the tractor fleet is in private ownership and less than half are registered.

	Public sector		Private sector		Total
	Units	%	Units	%	Units
Bophuthatswana	421	40,5	1 039	59,5	1 460
Ciskei	431	61,9	265	38,1	696
Gazankulu	80	34,8	150	65,2	230
KwaZulu	131	7,0	1 733	93,0	1 864
KwaNdebele	200	80,0	50	20,0	250
KaNgwane	40	16,7	200	83,3	240
Lebowa	316	12,8	2 147	87,2	2 463
QwaQwa	96	40,0	144	60,0	240
Transkei	2 225	59,6	1 507	40,4	3 732
	147	61,0	94	39,0	241
TOTAL	4 087	35,8	7 329	64,2	11 416

TABLE 2.6 The numbers of tractors in the homelands in 1990

While every attempt was made to obtain reasonably accurate estimates from sources within the homelands, there are reasons for believing that the private sector tractor fleet is much larger, possibly by 200%.

- Some states, notably Transkei, have embarked on a policy of rapidly disposing of their public ploughing-fleet tractors to the private sector.
- The private sector tractor fleet in the ten homelands might be expected to be larger than the equivalent in the BSL countries (Botswana, Swaziland and Lesotho), whereas the estimate (or the number) of privately-owned tractors in the BSL countries is 7,200, which is very similar to the homelands total of 7,329.
- The total number of tractors registered in RSA declined by 127,919 since 1982 and it is reasonable to suspect that many of the lapsed registrations are of tractors which are now in the homelands.
- No cognisance was taken of disused tractor carcasses that could be resuscitated through a rebuilding programme (see Section 6.2).

2.7.2 Description of the private sector fleet

Tractors in the 30 to 40 kW range used to dominate the private tractor fleet, but more recently the purchase of more powerful tractors by homeland agricultural development agencies and their subsequent sale to the private sector has shifted the distribution.

Three-quarters of tractor fleets can be expected to be more than 20 years old (Table 2.7) for the following reasons:

- cost of new tractors;
- a rise in the cost of used tractors in response to demand, putting late model used tractors beyond the means of most buyers (presently the ratio of used tractor sales to new sales is 3,5 compared to 1,8 previously);
- funding agencies restricting purchase loans to approximately 20% to 30% of the price of a new tractor, since the potential income from a tractor under dry-land conditions is considered to be inadequate to repay a larger loan.

kW Class	Percent	Age (years)	Percent
30 — 40	40	30 — 39	34
41 — 50	31	20 — 29	41
51 — 50	25	10 — 19	17
Other	4	0 — 9	7

TABLE 2.7 Profiles of kilowatt ranges and ages of the privately-owned tractors in the homelands

Generally, the operational status of the private sector tractors can be expected to be:

- operational — 54%
- non-operational — 46%

The distinction between operational and non-operational is not a clear one. Some of the tractors in the homelands are considered to be operational when they would not be classified as such in the commercial agricultural sector. Also, non-operational tractors are not necessarily inoperable, but those whose use is considerably restricted by operational faults. The faults of operational and non-operational tractors are compared in Table 2.8.

In a KwaZulu survey (Auerbach et al 1990), the condition of tractors was classified as good (41%), fair (28%) and poor (31%). Only the 'good' tractors were in frequent use.

Faults	Operational (% of tractors)	Non-operational (% of tractors)
Engine	12	77
Starter	42	60
Electrics	46	50
Gearbox	nil	9
Hydraulics	12	36
Wheels	35	9
Tyres	7	5

TABLE 2.8 Operational faults of privately-owned tractors

2.7.3 Tractors and ploughing

Privately-owned tractors operate over a spectrum from fully commercial tractor contracting with two or more tractors and paid drivers, to tractors which stand idle nearly all the time and only plough the owner's fields and possibly those of a few neighbours. Most of the tractors are not fully operational.

Ploughing is the main task carried out by privately-owned tractors in the homelands. Contractors and customers are agreed that for a tractor to be occupied for most of the year, it is important that the owner be equipped to handle haulage requirements of rural people and that a trailer is as essential as a plough (Auerbach et al 1990). This is borne out by a study in KaNgwane by Peter Hittersay and Associates (1990) which recorded the time which contractors' tractors spent on different tasks over the cropping period (Table 2.9).

	November	December	January	February
Ploughing	79	82	76	14
Transport	16	8	14	85
Other work	5	10	10	1

TABLE 2.9 Average tractor-hours spent on different tasks based on a survey of contractors in KaNgwane
Source: Peter Hittersay and Associates (1990)

A 38 kW tractor is said to be able to plough a hectare in 4 hours (Pimentel and Pimentel 1979). Observations in the homelands vary from 3 hours per hectare to 6,5 hours per ha. In Bophuthatswana (Taung), a combination job of ploughing, discing, fertilizing and tilling in with a 50 kW tractor took 4,5 hr/ha.

2.7.4 Assumptions

On the basis of the above information, we make the following assumptions in order to estimate the ploughing *potential* of the tractor fleet in the homelands:

- Under the conditions in the homelands, the operational privately-owned tractors plough an average of 80 hectares per year. Although some may exceed that, we expect the present average to be lower than that. Note that this represents a kW/ha ratio of about 0,5 to 0,75, compared to the recommended ratio of 0,75 for commercial agriculture.
- Public sector tractors plough on average 80 hectares per year. This too probably overestimates the actual situation since some tractor schemes have failed dismally and much of the public sector fleet is presently being privatized.
- Privately-owned, 'non-operational' tractors plough on average 10 ha per year.

In every homeland except QwaQwa, the ploughing potential of the tractor fleet calculated on the above assumptions is much less than the total area of cultivation (Table 2.10). Over all the homelands, tractors can meet only 31% ploughing requirements.

2.8 Summary of the requirements and resources for ploughing

It must be emphasized that the information summarized in Table 2.10 is based on limited hard data and on some untested assumptions. The estimates of cultivation are reasonable approximations. However, the estimates of animal draft potential are probably greater than what is available in practice due to a number of constraints which we discuss below. The estimate of mechanized draft potential is harder to evaluate. While we may have slightly over-estimated the average area ploughed by each tractor, we suspect that the number of tractor units may have been grossly under-estimated (Section 2.7.1).

Table 2.10 does indicate that there is little or no room for inefficient use of traction power resources and that shortages of traction may be expected locally and regionally. It also indicates that animals presently represent a greater potential traction resource for land preparation than do tractors.

Based on the above profile of the tractor fleet, the maximum available tractive power would be just over 500 000 kW *if every tractor were fully operational.* This represents a kW:ha ratio of 0,24 averaged over all arable lands the homelands, compared to the recommended ration of 0,75 for commercial agriculture.

	Cultivation (ha x 1000)	*Animal draft potential (ha x 1000)*	*Tractor potential (ha x 1000)*
Gazankulu	119	98	14
KaNgwane	50	71	13
KwaNdebele	35	17	12
KwaZulu	589	842	89
Lebowa	345	279	128
QwaQwa	10	8	15
Transkei	534	813	250
Bophuthatswana	334	259	83
Venda	88	76	16
Ciskei	67	69	47
TOTAL	2 171	2 532	677

TABLE 2.10 The requirements for ploughing expressed in hectares is compared to the resources of animal and mechanized draft expressed in terms of the hectares which each could potentially plough, given the assumptions in sections 2.6.2 and 2.7.4 above.

2.9 Animal draft: shortages, constraints and issues

The preceding discussion has attempted to quantify the requirements and resources for ploughing in gross terms. Here, we focus on issues and constraints as they affect the farmers.

2.9.1 Local accessibility of animal draft

The extent to which rural households use animal draft varies with area. Some surveys have recorded percentages of households ploughing with animals:

Peddie, Ciskei	25%	(Steyn 1988, in Rose et al. no date)
Alice, Ciskei	32%	(Rose et al, no date)
Biyela, KwaZulu	67%	(Auerbach et al 1990)
Nhlangwini, KwaZulu	71%	(Auerbach et al 1990)
Amatola Basin, Ciskei	almost 100%	(Steyn 1982)

There is much evidence that problems with draft represent the main identifiable *felt* constraint on arable agriculture. Numerous surveys of subsistence agriculture have shown that most households own insufficient cattle for their basic requirements of draft, even though draft may be the main consideration in keeping cattle (Bembridge 1979; Steyn 1982; Colvin 1983).

In one study in KwaZulu (Auerbach et al 1990), it was shown that there was a theoretical surplus of animal draft assuming that all the oxen were healthy and that all members of the population had access to animals. These conditions are not met in practice.

2.9.2 Use of animals for other agricultural tasks

The mechanization of subsistence agriculture has not progressed much beyond ploughing. Other agricultural tasks are seldom carried out by tractors, with planting and secondary cultivation normally being done by hand.

Even where tractors are available for primary cultivation, the ox-plough is still often retained to pull furrows, especially for the planting of potatoes and ox-drawn tine cultivators are widely used for inter-row cultivation. Since these applications have low draft requirements, this is a rational production practice which should be encouraged. However, only a few farmers in the homelands own appropriate equipment for such tasks.

The use of draft animals for secondary cultivation does not reduce the available draft for ploughing since the operations are carried out at different times.

The availability of labour for cultivation is a major production constraint (Auerbach 1993a) and most farmers are only able to weed their crops once. Increased use of animal draft for secondary cultivation is thus likely to be a major factor in increasing yields, although the absence of men is problematic, since they traditionally manage the oxen.

2.9.3 Constraints on the optimal and efficient usage of animal draft.

Labour

Labour is a constraint on the use of animal draft. It takes anything from just under a week to over two weeks to plough a hectare with oxen. The absence of migrant labourers from rural households places a strain on the available labour for agriculture. Sometimes cultivation is carried out by migrants during leave, in which case the time needed for ploughing with animals is a constraint.

Skills and tradition

The skills needed for ploughing with animals are acquired by experience and passed on from father to son. However, this is not a tradition which goes back for many generations. Early this century, ploughing with animals was practised by white farmers, while black farmers cultivated by hand. It was only from the 1920s that black farmers began adopting animal draft to a significant extent (Joubert 1993). This in-family apprenticeship in animal-drawn cultivation has also suffered frequent interruptions as a result of migrancy.

Training and extension

Consequently, there is a great need for training and extension in animal-drawn cultivation, but this is something which has not received any attention in South Africa.

Skewed ownership of livestock

Numerous livestock surveys have shown that the distribution of cattle ownership is skewed, with the majority of households owning less than the mean number of cattle. Many have too few (or no) cattle for cultivating. To some extent, this is mitigated by limited lending and borrowing of oxen, or ploughing for one's neighbour. However, unlike tractors, there is no established practice of hiring of cattle, and a system of reciprocity operates instead. While this may have advantages for households unable to afford the possible cost of hire, it does not make for efficient utilization of the 'village herd'.

Condition of animals

Draft animals are generally in a poor condition, reflecting the poor condition of grazing and inadequate animal husbandry. Animals used for spring ploughing will have been further weakened by the dry winter in the semi-arid summer rainfall areas.

Because of the general shortage of oxen, cows and heifers may occasionally be used for draft. For example, Steyn (1982) reports 61% of farmers in the Amatola Basin ploughing with cows or heifers.

Implements

Sales of implements for animal traction have increased steadily through the 1980s, but there is still a shortage of implements in use and a very restricted range: roughly 50% of households own implements, but very little other than ploughs (Auerbach et al 1990; Rose et al, no date).

The design and quality of implements available in South Africa for animal draft varies from poor to moderate (interviews with a few retailers of agricultural equipment). Very good equipment was available from Zimplow Ltd. in Zimbabwe until recently. At the end of 1991, duty on these goods was increased from 5% to 45% as a result of lobbying by South African manufacturers, which effectively knocked Zimplows out of the market here.

Considerable research and development of improved and appropriate implements and tool carriers has been carried out in other parts of the world, including Zimbabwe and Botswana. Many of these may be unsuitable for conditions in South Africa. But there has been no equivalent research here and no attempt to adapt innovations elsewhere to local conditions.

Status of animal draft

While much use is made of animal draft in the United States and Europe for example, it has very low status here. This can be an obstacle to any programme to improve and develop animal draft.

2.9.4 Policy and planning implications

One of the most intractable problems in the development of subsistence agriculture is the whole question of livestock and grazing management. Overgrazing is a perennial phenomenon, and there are no solutions in sight. One school of thought believes that some form of commercialization of livestock will be one component of the solution, and planning interventions such as improving marketing infrastructure have sometimes been made with this in mind.

The issue of animal draft cannot be divorced from the broader context of livestock. Indeed, animal draft must be a crucial consideration in livestock development programmes; for example, the enhancement of animal draft power through improved animal husbandry, fodder banks for late winter feeding of draft animals. Further, the development of animal draft could provide an additional avenue for commercialization of livestock to sales, and possibly a more appropriate one.

The inclusion of animal draft in agricultural extension and training needs to be addressed. Support services are needed in order to enhance and promote animal draft.

A co-ordinated programme of research and development is required. This should:

- investigate appropriate and energy-efficient yokes and implements from overseas;
- improve local equipment;
- research existing practices;
- investigate appropriate animal husbandry practices to enhance draft power;
- investigate tillage systems compatible with animal draft.

2.10 Access to better machines

2.10.1 Limitations

There is limited access to good used tractors of acceptable makes and appropriate models at fair prices from reputable sources. This is exacerbated by rising costs of used tractors in response to demand, putting late model used tractors beyond the means of most buyers. Presently, the ratio of used tractor sales to new sales is 3,5:1, compared to 1,8:1 previously.

Allied to this is the limited and/or onerous access to funds to purchase and subsequently maintain the tractors. Funding agencies generally restrict purchase loans to approximately 20% to 30% of the price of a new tractor, since the potential income from a tractor under dry-land conditions is considered to be inadequate to repay a larger loan.

2.10.2 Rehabilitation and maintenance

The condition of many tractors indicated that maintenance is far from adequate. The tractor owners themselves, however, do not see it as a constraint and claim that spares are easily available and that they carry out regular servicing of the tractors themselves, though how regular and thorough is questionable. The need for regular servicing is appreciated, but only practised by the serious contractors. Servicing is done out of doors, and may be reasonably quick and efficient (Auerbach et al 1990).

Nevertheless, access to direct inputs for maintenance might be a constraint. There is also a need for suitable training for tractor operators and drivers, and a need for mechanization extension officers.

A programme of reconditioning and rehabilitating could potentially increase the availability of mechanized draft very significantly. Details of how such a programme might operate are given in Section 6.2.1 below.

2.10.3 Access to diesel

Access to diesel is a serious constraint for tractor owners. There are very few points of sale in rural subsistence farming areas, and obtaining diesel from towns poses serious difficulties for many owners. It is theoretically possible for a tractor contractor to obtain a bulk tank, but in practice this has proved extremely difficult for them to negotiate with petrol companies.

Serious contracting is really only feasible if the contractor also has a LDV to fetch diesel from the nearest town. It is evident, in parts of KwaZulu at least, that there is a correlation between tractor contracting and ownership of a store. One explanation is that one LDV can serve both businesses.

Where alternative means of transport are unavailable, a trailer becomes an essential attachment for a tractor, if only for carrying fuel.

2.10.4 Implements

Tractor owners have a very limited range of implements, generally just a plough and a trailer (Auerbach et al 1990). This reflects the fact that mechanization of agriculture in the homelands has not progressed much beyond ploughing and that out-of-season operations are generally confined to haulage. A very small number of tractors are used to power hammer mills.

2.10.5 Out-of-season work for contractors

The tractor service in the homelands would be greatly improved if the economic viability of contractors could be ensured. One way of achieving this is to make greater and more diverse use of the tractors. Diversification of tractor use is not likely to happen without some form of State intervention, (Auerbach et al 1990) such as giving contracts to private tractor operators for dam building, road maintenance and other works. Road maintenance has already been contracted out in Ciskei. This example has highlighted a few problem areas that need attention: the system of tendering for example.

2.10.6 Appropriateness of tractors

For the tasks which tractors are generally called on to do in the homelands, power in the 30 kW to 40 kW range is appropriate. Most tractors do, indeed, fall into this category.

Nowadays, more and more tractors of over 40 kW are finding their way into private ownership in the homelands. Many of these have originated from inappropriate tractor fleet schemes of homeland governments and development corporations.

In view of the large proportion of time tractors spend on haulage and on simply travelling between fields, the haulage tractor might be an appropriate tractor fleet scheme of homeland governments and development corporations.

In view of the large proportion of time tractors spend on haulage and on simply travelling between fields, the haulage tractor might be an appropriate machine for black tractor contractors. However, haulage tractors are a relatively new innovation and have not yet penetrated the secondary market. Haulage tractors are aimed mainly at the sugar industry, where haulage accounts for much tractor time and incorporate special features in the gearbox, braking system, hitches and hydraulics.

Two-wheeled tractors and Tinkabis are not used in subsistence agriculture. The former are imported and expensive. Tinkabi tractors, developed in Swaziland, are now manufactured in South Africa. However, the new Tinkabis are aimed at specialized operations in commercial agriculture and are fitted with 47 kW imported diesel engines, which contradicts the original Tinkabi concept.

2.10.7 Research needs in mechanized draft

The most immediate research priorities are in the area of costs, economic viability, efficiency of operation, tariffs, etc., rather than technical matters.

2.11 Implications for small-scale agriculture of inadequate draft power

Small-scale farmers may experience serious problems in obtaining adequate and/or timeous draft power. It is one of the most frequently voiced constraints facing farmers in the homelands, leading either to under-utilization of arable land or to delayed planting.

Timeous ploughing and planting is essential for good crop yields. Farmers are often unable to procure a source of tractive power at the optimum time. A one-month delay may lead to a reduction of maize yield to less than 50% of potential (Cairns & Lea, 1990).

The quality of land preparation is often inferior and leads to reduced yields. The reasons include the poor condition of animals, tractors and implements or their incorrect use. Many farmers also complain of hurried and sloppy work performed by contractors.

Double cropping could theoretically be an option in the higher potential areas, provided the crop turn-around time can be kept short. Without ready access to a tractor, this is not possible.

2.12 Agricultural water: energy for pumping

2.12.1 Irrigation needs

Irrigation in small-scale agriculture generally takes one of two forms. In development schemes with high capital and management input (Section 2.3.1: *Settler schemes*), energy in the form of grid connection and/or bulk diesel supply is generally part of the project infrastructure.

On the other hand, a prominent feature of subsistence agriculture is community gardens. These are generally between 1 and 3 hectares in extent and in total, benefit over 40 000 families (Table 2.4). One localised study showed that only one in seven gardens have pumps (Gosnell & Eberhard 1993). In most instances, water is carried by the gardeners from a nearby stream or spring.

Community gardens have low power pumping requirements. Most of the gardens are situated near a surface water source to reduce the amount of carrying. When pumps are fitted, the heads involved are low: 5 to 25 metres. Furthermore, gardeners use water frugally with a daily water demand of 6 kl/ha or less: that is to say, a maximum demand of roughly a sixth of the conventional figure for commercial horticulture.

Very few gardens use borehole water. Under South African conditions, it is not advisable to use ground water for irrigation.

There are very few examples of individual commercial or semi-commercial small-scale farmers using irrigation outside or larger development projects. They would face similar conditions and requirements as those pertaining to community gardens.

2.12.2 Watering livestock

In the arid and semi-arid areas where extensive grazing is practised, borehole water is used for livestock. In other areas, surface water resources are adequate and pumping is unnecessary.

2.12.3 Pumping options

The choice of appropriate pump and energy carrier depends a lot on the specific requirements and conditions. The advantages and disadvantages of the different options are discussed in Chapter 6 (Energy supply options and strategies).

2.13 Energy for processing

We have not attempted to describe the situation pertaining to the processing of crops in quantitative terms. There is little or no published data, so to do so would have entailed primary data collection beyond the scope of this paper.

Shelling/threshing and milling are the main forms of primary processing within the small-farm sector. Other forms of processing are generally carried out once the crop has entered the commercial sector, with the small-farmer selling the crop (sugar, timber, cotton, etc.) directly to the processing plant or mill.

2.13.1 Shelling and threshing

Second-hand equipment from the commercial sector (e.g. portable PTO-driven thresher) has occasionally been noted in the homelands, but is uncommon.

The usual practice is to use a hand sheller for maize and is evidently a time-consuming occupation. Beating with sticks is commonly practised on dry bean crops and occasionally, on maize.

2.13.2 Milling

There are various avenues for a small-farmer to mill a maize crop.

- Small hand mills are sold extensively.
- In some areas (e.g. Transkei), trading store millers process a significant proportion of the crop.
- In parts of the Natal/KwaZulu region, small producers of maize (including subsistence farmers) have access to commercial facilities (e.g. Natalse Landbou Ko-operasie — NLK) in towns.
- Four large milling centres were built in Transkei and supplied with grid electricity. These are reported to be standing unused now.
- Some tractor operators in the homelands have acquired PTO-driven hammer mills. Some of the homeland finance and development corporations are prepared to finance such enterprises.

2.13.3 Improving the processing capacity

Experience indicates that supporting dispersed entrepreneurs with diesel (PTO) mills is a preferable route to follow than big intervention such as the establishment of large centralized electrified mills.

The support might consist of finance, advice on buying and training (technical and financial). Given the extreme variability of subsistence production, milling would probably provide a supplementary income, not a regular one. The support for millers would fit easily into a wider programme of support for tractor operators.

At present, the availability of suitable machines is a constraint.

There is evidence that milling facilities at centres, where other economic activity is carried out, will be supported. If the concept of rural development in the future encompasses the concept of rural service centres (Section 6.6), then milling could be part of the services offered despite the past failure of some large interventions.

From an energy perspective, milling should be based mainly on diesel as the energy carrier. However, a niche is foreseen for medium-sized electrically powered mills at rural service centres.

Interventions with regard to shelling are constrained by the bulk of unshelled maize and the consequent transport problems. There may be a small role for small dispersed PTO-driven shellers. However, hand shelling at home is likely to remain the most common supplementary domestic energy source.

2.14 Energy for agricultural extension

Many of the constraints experienced by agricultural extension staff are energy-related.

Transport is one, though the problem is one of vehicles and funds, rather than fuel.

Extension is constrained by the lack of suitable venues with lighting and electricity for the use of audiovisual equipment. This is one aspect of the general lack of rural infrastructure and lends weight to the argument for making some form of electrical power (grid or Remote Area Power Supply — RAPS) available for rural schools and/or other community centres. It also lends weight to the argument for electrified rural service centres, where facilities for short training courses might be available.

2.15 Other energy requirements

As agriculture in the homelands diversifies, so too will the requirements for energy. At present, these additional requirements are not large and it is questionable whether the policies with respect to other energy carriers such as liquid petroleum gas (LPG) should be driven specifically by agricultural needs. The issue is a wider one of rural infrastructure and access to energy for domestic and non-agricultural uses, although there may be benefits for aspects of agriculture. For example, improved LPG distribution might help a few poultry producers who use it for brooders, even though the quantity of LPG used in small-scale agriculture generally is negligible.

Ideally, these minor energy requirements for small-scale agriculture should be dealt with at local and district levels of integrated energy planning. However, the farmers themselves lack the influence to see that their interests are taken into account.

CHAPTER THREE

Changing policy environment for small-scale agriculture and factors affecting future energy demand

3.1 Land redistribution and agricultural support services

The World Bank is currently manoeuvring to influence South African agricultural and development policy. It has commissioned a number of in-depth studies of the situation in agriculture, and is proposing that unless land redistribution occurs on a massive scale, an ongoing civil war will cripple the country's development (Binswanger & Deininger 1993), while a Macro Economic Research Group report recommends the training and settlement of 1000 farmers per year on 40% of the agricultural land of South Africa over the next 33 years (Jack 1993). There is broad agreement from everyone except current landowners that redistribution of land should occur on a large scale, but there is little practical appreciation of the fact that three hundred years of state support for white farmers have seen the emergence of only about 3 000 good commercial farmers in this country.

Daniel Bromley (1993) points out the similarities between the South African and Russian economies in transition. He claims that in both countries the agricultural systems are explicit instruments of the state for its larger social purposes. In Russia, Stalin forced the collectivisation of peasants, while South Africa used commercial agriculture as a vehicle for settling a certain class of people on the land, and for removing others. Both systems operated with massive subsidies, with very tight control over certain prices and with limited outlets for most products. Both countries are now faced with the problem of rebuilding the small family farm.

Although there are many people ready to accept land which may be redistributed, the number of people actually wishing to farm seems to be far lower. The problem of attracting competent young people to agriculture is a major cause for concern, requiring urgent attention through a range of initiatives which could help to improve the status of agriculture in the eyes of the young. A process of marketing agriculture as an honourable, socially important and financially attractive career would need to demonstrate that the farmer is a cornerstone of the development process, upon whom will rest much of the responsibility for future national food security, as well as the possibility to reverse (or at least, slow down) the current trend towards urbanisation. Young people will have to be attracted to agriculture, trained to be competent farmers, assisted with settlement schemes and supported in establishing themselves.

The question of sensible criteria for land redistribution (and, indeed, for rural energy supply) is a problematic one. Are we looking for economic growth? Generation of employment? Affirmative action targeting the very poor? Each of these has vastly different implications for selection of land redistribution beneficiaries, and experience in Zimbabwe has shown that the government of the day will be subjected to a range of extreme pressures from conflicting sources concerning the question of access to land.

Jack (1993: 43-6) summarises the agricultural policy objectives of the democratic movement as: redistributing under-utilised land (± 40% of white farmland) to black farmers; restructuring farmer support services to bring in 12 000 black commercial farmers over the next twelve years; helping the 1,4 million peasant producers in the communal areas to produce a surplus for sale; helping black farmers to participate in development policy formulation; reviewing control boards and ensuring sustainable use of agricultural resources.

Jack's proposal of settling 33 000 commercial farmers over the next 33 years is a very useful concrete target around which discussion can be based. The target of helping each of these farmers to acquire a viable commercial farm (with an average size of some 300 hectares) is very optimistic. As mentioned, the first three years of this programme would aim to equal three hundred years of commercial agricultural development.

If Jack's suggestion of starting in the first phase with the resettlement of 12 000 farmers over the next 12 years (in four three year programmes each involving 3 000 farmers) is taken up, 3,6 million hectares of land will be involved. If one accepts that these farmers will need extension support, and that an extension officer can handle no more than 50 new farmers effectively, even with good training and organizational support, then 60 agricultural extension officers will be required during the first three year phase. Authorities such as Bembridge (1993) point out that present ratios of 1 000 farmers to each agricultural officer are untenable, and call for a maximum of 250 farmers per officer. However, the realities of effectively settling new farmers on commercial farms will demand that each farmer has at least four days of individual attention for each of the first three years, as well as group interaction and, therefore, in this specific case (new farmer settlement schemes), far more extension officers will be required in practice, if the scheme is to produce viable farming enterprises.

Once the new farmers have established themselves, most of this core of trainers could be used for the next resettlement phase, but this is likely to take at least six years, and this implies that another 60 agricultural officers would be required for the second phase, after which capacity could largely be made up through transfers of staff to new projects.

Training these officers to be effective in this new milieu will pose major challenges to both training institutions (for new officers) and retraining centres (for re-orienting existing commercial and homelands agricultural officers. Ben Cousins (1984) has described some of the experiences in Zimbabwe, in the immediate post-independence era, when CONEX and DEVAG were being combined into the new Agritex.

In Kenya, where 100 000 out of the total of 200 000 tenant farmers had been evicted after mechanisation in the white highlands (1945 — 1951), many of these people joined the Mau-Mau rebellion (Deininger & Binswanger 1992). As part of the independence negotiations, about 420 000 ha of land was bought from European owners at market prices and redistributed to African farmers. A British grant covered one-third of the total cost, but the remainder had to be financed by African settlers using credit. Most resettlement was on high density schemes in which plots averaged 10 ha (lower density schemes had an average plot size of 16 ha). Although the new settlement farms did not achieve their production targets during the first phase of resettlement, aggregate production exceeded the output of the large farms that had previously occupied the area.

Deininger & Binswanger (1992) cite this as evidence that small family farms, with their close supervision and ability to provide effective incentives, are inherently more efficient than large, industrialised farms. In South Africa, repeated petitions for restrictive legislation to limit competition to European agriculture from African farmers during the 1890 diamond and gold booms are also brought as evidence of the development of inefficient large-scale European agriculture at the expense of more efficient family-based African agriculture. Bundy (1985) comments that the area farmed by Europeans increased from 35 000 ha in 1890 to 225 000 ha in 1909. The Glen Grey act of 1894 restricted the ownership of land by Africans to 3 ha, levied a labour tax on all men living in the reserve but not owning land and banned the sale, subdivision or rental of land, thus assuring a flow of surplus labour after one generation. The Land Acts of 1913 and 1936 further restricted black land ownership and agricultural production.

Thus the establishment of the European farming sector was similar in Kenya, Zimbabwe and South Africa. Where policy reversals have taken place, the effect has been to allow small family farms to regain ascendancy. In Kenya, elimination of restrictions on access to output markets alone led to a threefold increase in total coffee production between 1955 and 1968, with the percentage produced by African farmers climbing from 10% to more than 50% of the total, since many commercial farmers sold their farms. Pyrethrum production quadrupled, with smallholders' share jumping from 10% to 90%.

In Zimbabwe from 1979 to 1989, area under cotton increased by 25% annually, with output per ha increasing by 1,3% per year. During the same period, maize production per ha increased by 6,7% per year. Deininger & Binswanger (1992) claim that Kenyan land resettlement tackled less land and less settlers, but provided extension and technical services, while in Zimbabwe, technical services were not adequate, nor was settler selection based on either need or ability: settlers chosen lacked knowledge and capital and were often unable to use the land productively.

Deininger & Binswanger (1992) state that little progress has been made in either Kenya or Zimbabwe in dismantling state-monopoly marketing systems, and that these take up large amounts of government money and result in propping up large scale farms at the expense of small-holders. They recommend that settlers should be selected according to their farming skills and ability to pay for part of the land cost. They should be encouraged to buy relatively small parcels of land which could be increased by means of rental or additional purchases. A settlement agency should only be responsible for very basic infrastructure, but initially extension and marketing services should be organised by government. They agree that such an approach means that settlement schemes will not benefit the poorest, who lack the skills and capital resources to be successful, but assert that these people would be able to derive considerable benefits as tenants or workers.

3.1.1 Settlement schemes

In the South African context, therefore, it is likely that settlement schemes will require both specialised support services at a high level of intensity and competence, and appropriate infrastructure, including the same kind of services as commercial farmers currently enjoy. The most important aspects are likely to be grid electricity, a bulk diesel distribution network, and support for irrigation development. Given the intention to sub-divide farms into smaller units, intensification is likely to take place, and the development of all water resources available is likely to be a priority.

If settlement schemes are on farming units of several hundred hectares, as proposed by Jack (1993), each unit is likely to require at least a 38 kW tractor, as well as a support network capable of keeping tractors in good order. Some contractors may develop to service these schemes, but widespread haulage of the kind presently found in the homelands is unlikely to be required for these less densely populated farms, as they are likely to be able to produce their own fuelwood requirements.

3.1.2 South African Development Trust land

Most settlement schemes are likely to take place initially on SADT land, where much of the required infrastructure is in place, as these lands were expropriated from commercial farmers. Other SADT land is already settled under communal tenure, but this is unlikely to be affected much by land redistribution; some farmers may move away to settlement schemes and an optimistic scenario would see some easing of the intense overcrowding currently experienced.

3.1.3 Marginal land

A worrying aspect of the current debate on land redistribution is the emphasis on land currently farmed by bankrupt farmers being made available for resettlement. While some good farms have been badly farmed and could become highly productive if well managed, much of the land will be found to be marginal in its productive capacity (soils, rainfall, etc). Infrastructure is likely to be inadequate in these areas, and the temptation to resettle people on this land will be great. Subsequently, government will be faced with the same calls for ongoing support which have been heard in the past from white farmers.

Marginal land requires realistic development and management strategies, which avoid overcapitalisation and try to find optimal densities for both settlement and utilisation of resources. Much of this land should be managed as natural grazing and not used for rain-fed crop production unless strategies can be implemented which optimise water-harvesting and bring about biological diversity.

3.1.4 Commercially productive land

Here, infrastructure should be present to support modern high-input agricultural production, although if used for settlement schemes, some additional reticulation may be required. Farm labourers at present suffer very primitive housing conditions, and this will require some attention.

Policy-makers will have to ask, however, whether it is justifiable to support energy-inefficient production systems simply in order to increase national food production. First world experience has shown that intensive use of fertilizers and biocides leads to environmental problems. The real costs of agricultural production, including rehabilitating the environment and the irreplaceable loss of non-renewable resources, has yet to be calculated.

Third world experience has been rather mixed, with Asia and South America experiencing growth in per capita food production over the past two decades, but Africa's per capita production falling steadily. This has been due partly to population growth, but also to unreliable rain and a reliance on maize as a staple, while Asia and Latin America have had the benefit of the development of high-yielding varieties of rice and wheat (Conway & Barbier, 1990).

The question of sustainability of farming systems will be examined in more detail in Chapter 4.

3.2 Re-incorporation of the homelands

The imminent re-incorporation of the homelands will allow for the rationalisation of an extremely irrational situation, where services are duplicated and haphazard. The opportunity exists for integrated energy planning to take place on a regional basis.

Current supplies of electricity via homeland energy supply authorities can be supplanted by regional distribution networks and the same will apply to distribution of diesel fuel.

Energy planning for the homelands will need to plan for providing maximum benefit to the maximum number of people. This could be done by constructing rural service centres at growth nodes, or by concentrating on cluster supply. The Indian approach to supplying energy only where it can be productively used has been shown to lead to access only by rural elites and an affirmative action programme targeting poorer or isolated people will be required if access to energy is to be broadened.

These options can be described in terms of three likely scenarios for energy policy:

- Scenario 1
  Cost effective economic energy provision (use nodes, trickle-down theory).
- Scenario 2
  Energy provision to benefit maximum number of rural people (grid based on demography, just need to provide infrastructure theory).
- Scenario 3
  Affirmative action programme to put energy into the homes of the poor basic needs approach (bias in favour of poor and isolated, cross-subsidisation of energy).

Selection of the appropriate scenario will probably depend more upon the political and economic climate than rational planning criteria.

3.3 Implications for agricultural support services

3.3.1 The current state of agricultural support services

As with most government services, homelands extension services at present suffer from very high levels of inefficiency and low morale among staff. Professor Tim Bembridge and his colleagues have conducted a number of studies into the agricultural extension services of Transkei, Ciskei, KwaZulu and Bophutatswana. Conclusions include the need for staff support, professional training and salaries and a policy framework which takes cognisance of the differing needs of a range of rural clients.

The current emphasis on the Transfer of Technology (TOT) model of extension, which assumes that agricultural experts have the knowledge concerning farming practices, is deeply flawed. It is not surprising that little progress is made in the third world, when the farmer is assumed to be an ignorant peasant to whom the knowledge of the university and the department of agriculture must be extended. The World Bank's preferred system of extension, the Training and Visit (T & V) system, is one such application of a TOT management system, which sends out the evangelists, armed with a uniform simple message which tells all farmers what they should do for the coming fortnight. Such oversimplifications are both arrogant and ineffective in all but the most simple of farming systems.

3.3.2 Research into transitional support services

Current research (Farmer Support Group 1993) involving a range of senior agriculturalists from the current government departmental structures, as well as non-government and community-based organisations has proposed that a future agricultural extension system would:

- operate within a national policy framework;
- be cost-effective, with some payment by commercial farmers for services;
- include strong extension-research-farmer linkages, within a framework of mutual accountability and learning;
- use financial mechanisms to enhance user-control;
- be available to all groups;
- target the different needs of different groups;
- encourage farmer participation in the development of research-based recommendations;
- emphasise organisational development and group formation;

- include input from both private and public sectors;
- emphasise the need for sustainable farming systems.

The need to train women as extension officers, and to develop support services in ways which would make them more accessible to the special needs of women has become a major issue, as most communities experience high levels of migrancy, especially of men.

3.4 Mobilising small-scale farmers

If farmers are to participate in policy-formulation and in the research process, they will need to develop strong representative bodies which are able to lobby at a range of levels. Such bodies are at present fragmented and often not very democratic or effective, and have little or no voice.

Any development policies which hope to broaden access to resources will need to find ways of enhancing participation of rural people in analysis of their situation and devolve some decision-making to local level.

Effective farmers' associations will need to work together with local government structures, and unions will need to work at regional and national level in order to ensure that the problems of the farmer are understood and effective support is forthcoming. Without adequate emphasis on the mobilisation of farmers and other rural people, development policy, no matter how well-meaning, is likely to be applied in an authoritarian manner.

3.5 Summary of energy implications

Important implications for energy policy are thus:

- grid electricity;
- a bulk diesel distribution network;
- support for irrigation development;
- for settlement schemes, at least a 38 kW tractor, as well as a support network capable of keeping tractors in good order;
- withdrawal of subsidisation of fertilisers and biocides.

3.6 Demand management projections

3.6.1 Projection assumptions

Based on the above discussion, combined with the data on current energy usage in Chapter 2, it is possible to make some projections on future energy demand. It is assumed that the rural population will grow slowly, since urbanisation will take up much of the natural growth.

Current population levels are approximately 4 million farmworkers and their families (representing approximately 0,4 million households) on white commercial farms, 9 million *de facto* residents (1,8 million households) in communal areas (TBVC and self-governing territories), 60 000 part-time commercial farmers and 60 000 full-time commercial farmers. This gives a total rural population of some 13 million people, with about 2,3 million rural households.

It is further assumed that equity is accepted as an important policy determinant, with the accompanying implication that low-input systems would have a large, though not exclusive, part to play in agricultural development.

3.6.2 Commercial agriculture

In practice, in spite of the best will in the world, resettlement schemes are unlikely to establish more than 100 commercial farmers per year. It is likely that many of these farmers will replace existing commercial farmers (full-time or part-time), and that total numbers of commercial farmers requiring agricultural support services in areas other than communal areas will be around 100 000 for the next fifty years.

3.6.3 Semi-commercial agriculture

Likely demographic scenarios in the communal areas are more difficult to predict: in practice, probably some 400 000 homesteads will be involved in agricultural production, the vast majority of these involving resource-poor farmers. At present, probably 95% of these people produce well below their subsistence requirements, even in terms of maize grain only (Auerbach 1993a). It should be possible to help 500 of these homesteads to become semi-commercial part-time farmers each year. Some would be equipped with an electricity point, a bulk diesel tank, a rebuilt small tractor, trailer and hammer mill, while some would be helped to upgrade their animal traction capabilities. Such a planning target could be used to organise training, electrification and the provision of support services.

This number may sound small, but in practice, as explained with reference to commercial agriculture, it will be very difficult to achieve, even if the farm units are relatively small (10 to 50 ha.). Where possible, these farm developments should concentrate on areas with a potential for irrigation development, or should aim to establish the farmers as contractors in order to supplement their income from agriculture.

3.6.4 Planning projections

Planning targets of 100 new full-time commercial farmers, and 500 part-time semi-commercial farmers are the maximum that can be realistically expected, even with major inputs into retraining agricultural officers, providing financial assistance and land, and directing research into small-scale sustainable farming systems. It may be practical to group these farmers (perhaps ten full-time or twenty part-time farmers to a group) in one area in each region of the country, supported by an agricultural officer per region whose primary task would be supporting these farmers for their first six years. This would thus require some thirty-five specially trained agricultural officers per year, which is probably as many as could realistically be made available to new development without depriving existing farmers of their already overstretched support services.

Each group of farmers could have access to a rural service centre, which could be linked in with the other development needs of the area. Such a centre could also house a co-operative produce storage and marketing facility, with appropriate supplies of agricultural inputs, and a venue for a local farmers' association.

Provision of 200 to 400 rebuilt small tractors per year would not pose a problem to a tractor industry which is currently experiencing one of its worst slumps ever, and electrification and diesel distribution, while requiring planning and rationalisation, would not present major difficulties. The single greatest difficulty is likely to be finding the appropriate people with the necessary skills, energy, experience and ability to make a success of farming. Given the right selection, training and incentive packages, these problems could be overcome. Political pressures are, however, likely to play a major role in distorting such a programme of training and settlement.

Adequate monitoring of farmer performance will be a vital part of understanding the changing needs of these developing farmers. A research and development programme which monitors sustainability of such initiatives in social, economic and environmental terms would be a very important aspect of any such programme.

CHAPTER 4

Rural development scenarios and their policy implications

4.1 Three development perspectives

Although sustainable agriculture is generally considered desirable, there are many different perspectives concerning what constitutes sustainability. Each commentator emphasises the most important aspects from their perspective, and these often appear irreconcilable. Agriculturalists and planners want enough food to be produced to feed the nation. Those with a socio-political perspective argue for greater equity: wider access to the means of production, with an emphasis on household, rather than national, food security. The environmental lobby argues that if the nation wishes to survive in the long term, the resource base must be preserved.

In the last few years all three groupings have come to realise that a longer term approach is needed, but one which remains people centred rather than technology centred. In this chapter, the policy implications of each of the three perspectives are analyzed in turn, after which the elements of an approach which combines the critical elements of each is outlined.

4.1.1 Food self sufficiency — profit and production

As mentioned earlier, there are currently approximately 3 000 highly successful full-time farmers in the country, with perhaps a further 10 000 who are faring reasonably well. The simple short-term solution to national food self sufficiency is to make sure that these productive farmers are well-supported, and are allowed to carry on producing at present levels. This option might look attractive to a government with few resources available for agricultural development.

Critical aspects of policy would then focus on:

- ensuring that research keeps up with international trends in production technology;
- maintaining a small but highly efficient agricultural extension service to meet the needs of these farmers;
- cutting assistance to less efficient farmers;
- dealing with the enormous pressure which a new government will undoubtedly face to make land available to those who are able to lobby for access to land;
- dealing with widespread rural poverty, starvation, disease and probably insurrection;
- strategies to avoid accepting responsibility for the deteriorating resource base.

Probably, much of the poorer land would be redistributed without a great deal of attention being given to how this land is used. Some food subsidies and welfare in the form of poverty-relief measures would be likely. Rural infrastructure, being costly, would probably receive relatively little attention.

The main result of this approach would be continuing massive urbanisation as a result of continuing poverty in the rural areas. This scenario is probably the most likely realistic one, as it is the 'path of least resistance' from the point of view of a new administration faced with massive inherited problems and challenges, many of which will take decades to resolve.

4.1.2 Equitability — broadening access to the means of production

The socio-political perspective is the most difficult of the three to achieve, although it probably is the most discussed perspective. Here, the emphasis would be on measures designed to counter poverty at the household level. Past inequalities would be redressed, while efforts were made to avoid creating new divisions and inequalities within society.

Key interventions would be widespread access to land and support in land development, provision of rural services through a series of costly rural infrastructure development programmes, credit and marketing initiatives aimed at supporting the small-scale farmer.

Policy implications of this approach would be:

- the need for massive funding inputs for infrastructure, land purchases (if compensation s to be paid to present land-holders) and farmer support (e.g. World Bank loans);
- commitment to a poor initial rate of return on these investments, in the hope that long term growth and stability would make up for this;
- commitment to dealing with the probable decline in commercial production from current commercial farmers, who would tend to feel unsupported and threatened;
- an acceptance that less resources would be available for urban development than might otherwise be the case;
- long-term commitment to the building up of a large and more efficient government-sponsored agricultural extension service.

All resettlement schemes would attempt to provide adequate training and farmer support for new farmers and existing rural people, and the research and extension emphasis would be on developing viable small-scale agricultural production systems.

A massive extension training initiative would be required, both to equip new agricultural officers with the necessary skills, and to retrain existing officers to function in the new milieu.

National food security could well be an issue, at least initially while commercial production's decline had not yet been adequately supplemented by small-scale production; food imports might become necessary during this phase. Foreign exchange earnings from agricultural exports would probably decline.

4.1.3 Conservation of natural resources

With a long term perspective emphasising the conservation of the resource base would come the need for stricter control on land use, and government intervention in areas where degradation was occurring.

Eco-tourism would become a major consideration, and research resources would be directed towards developing systems which encouraged bio-diversity, reduced the need for chemical inputs and sought to promote conservation-oriented land-use.

High levels of production would be less of an issue than stable long-term production, and consequently national food security might also be problematic in this scenario. This could be balanced by international marketing of the green development policy.

Implications of this approach would include:

- conflict with rural communities whose short-term needs were different to the long-term aims of government planners;
- conflict over land-claims and issues surrounding access to land and natural resources);
- a high level of control over land-use through some sort of environmental protection agency;
- a massive retraining of agricultural officers to re-orient them towards an ecological perspective;

- a major initiative aimed at attracting ecologically-minded people into agriculture.

Traditional conservation has tended to be technocratic in its approach, and has been perceived by many rural poor people as an approach where the environment is more important than people, and where resources which were traditionally available to people are fenced off and patrolled by game guards.

The face of conservation is changing, and the International Conservation Strategy of the World-wide Fund for Nature makes the point that conservation of resources cannot be achieved separately from sustainable utilisation of resources by people. The consequences of such a shift in emphasis, as the recent Rio Earth-summit showed, include attempts to reconcile the three perspectives into a philosophy of sustainable development.

4.2 Reconciling these perspectives: sustainable development

The resources and the people are inextricably linked, and if a programme of sustainable rural development is to be designed and implemented, it will need to reconcile the above perspectives.

The three perspectives upon which the above scenarios are based, as well as a sustainable development scenario, can be located on a matrix diagram where one pair of coordinates represents a continuum from short-term to long-term time frames, and another pair of coordinates covers the range from technology-centred to people-centred approaches. Figure 4.1 illustrates the characteristics of each of the four approaches.

Within such a continuum, national food self sufficiency in itself is seen as a short-term priority, with mainly technological solutions, while the need for a more equitable distribution of resources is an equally short-term, but more people-centred imperative. Traditional conservation has been distant from the people although more long-term in its time horizon; the resolution of the three perspectives requires a movement towards sustainable agriculture in the context of sustainable development, where the push is towards systems which are sound in the long-term, but people-centred and people-driven.

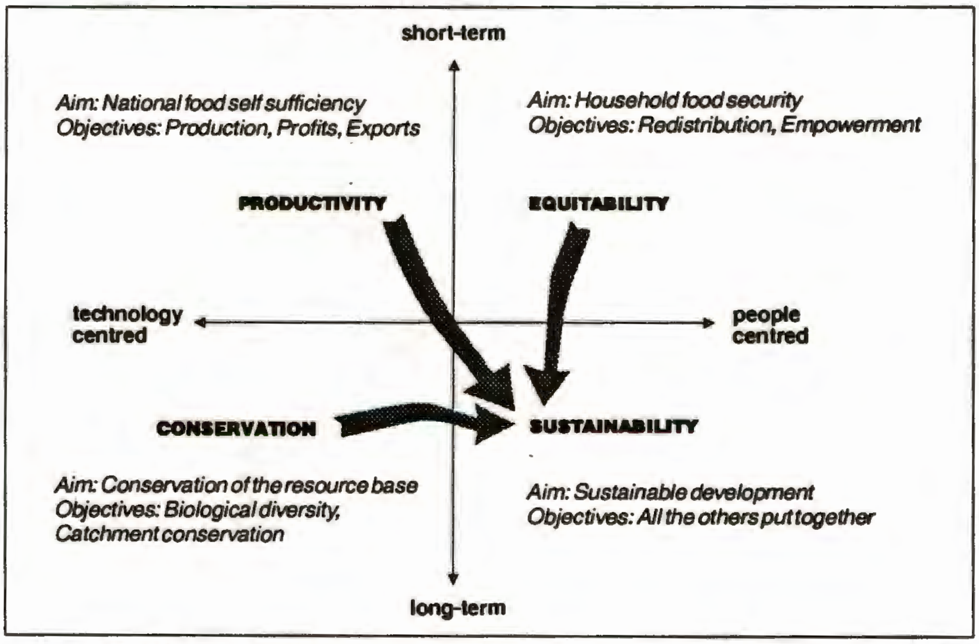

FIGURE 4.1 Productivity, equitability and conservation as perspectives of sustainable development (after Auerbach, 1993b)

Sustainable agriculture is not an end in itself, but should rather be seen as an objective of the other three perspectives, which should be striving to reconcile the short term needs of the moment with the longer-term needs of the nation. Technology has a role to play, but local people should control technology, and not need to lose their independence in order to access it.

Conservation needs to become more people centred, as does agricultural technology. Agriculture in general needs to develop a longer time horizon if it is to become more sustainable, and the advocates of household food security and other issues of equity need to use technology as a tool of development.

The implications of adopting a sustainable development orientation are:

- an agricultural extension department with an emphasis on community extension facilitators (local farmers with a short training in adult education and participatory techniques) and farming systems research and extension;
- a rural development programme which emphasises organisational development: development of local government structures and farmers' associations will require major training initiatives involving elected representatives of rural interest groups; as mentioned earlier, empowerment means helping people to gain access to means of making informed decisions, as well as helping them to access resources;
- an attempt to maintain commercial agricultural production, while helping it to reorient itself towards more sustainable production practices;
- settler schemes which are preceded by thorough training and accompanied by adequate farmer support services;
- a national job creation programme based on provision of rural water facilities, tree planting and catchment rehabilitation;
- deregulation of marketing except where direct production incentives are provided.

Small-scale agriculture would be better able to reconcile these perspectives than large-scale agriculture, because it is highly compatible with the management requirements of complex and biologically diverse systems. Similarly, both equity and productive efficiency would be served by a greater emphasis on small-scale agriculture.

Such a programme would require substantial funding, but has a potential to attract considerable overseas and local support because of its long-term environmental orientation. The potential for marketing a development programme which emphasises these considerations while remaining people-centred is great, and the development of accompanying eco-tourism based on integrating the rural production of communities with the enjoyment of the natural environment of a nature reserve should not be difficult.

CHAPTER FIVE

Energy demand management in small-scale agriculture

5.1 Objectives of energy demand management

The EPRET Project has been primarily concerned with energy supply options for the rural and urban poor, rather than with energy demand strategies. However, in the case of agriculture, demand management strategies may change the energy requirements several fold. The differences between the requirements of high input and low input techniques is so marked that energy demand management strategies may have a greater impact than supply strategies.

Energy demand management in small-scale agriculture cannot make a significant impact on national energy consumption. The energy consumption by the whole agricultural sector is only about 5% of the total energy consumption in South Africa.

The savings to be achieved in energy in small-scale agriculture on its own will be insignificant in comparison with the national energy budget. The objectives of energy demand management strategies should rather be to ease certain energy constraints on small-scale agriculture.

Demand management strategies may have other non-energy benefits which are as, or more, important than the energy saving. For example, by reducing the cost of inputs, small-scale agriculture may be made more economically viable and less risk prone. The investment and financing requirements for agricultural development programmes may be reduced. There may also be benefits for the rural environment, if some of the social and environmental problems associated with high input agriculture are avoided.

5.2 Examples of energy demand management

5.2.1 Traction

There are two distinct aspects to demand management with regard to traction: energy demand management and power demand management.

1 Energy demand management

There are countless variations on the theme of minimum or zero tillage for all the permutations of crops and conditions. Much has been published on minimum tillage systems and even more exists in unpublished reports. However, these systems remain difficult to evaluate, since so much depends on other inputs, conditions, etc. It is not the intention of this paper to attempt a detailed review of the subject.

Apart from the saving of energy, advantages claimed for no-tillage systems include:

- reduction of soil moisture loss;
- up to a 90% reduction in soil loss;
- Possibility of crop production on land unsuitable for conventional crop production practices;
- preservation of soil structure and water retention capacity.

Apart from zero tillage, there are other methods for reducing energy requirements, such as shallow tillage, sweep tillage or strip tillage. Shallow tillage may be interspersed with occasional (five yearly, say) deep ploughing instead of annual deep ploughing. Alternatively, rotation with a deep rooting plant like cowpea, can achieve soil loosening at depth. An increase in the ratio of perennial to annual crops would obviously reduce the requirements for tractive power.

2 Power demand management

A reduction of power requirement can be achieved by spreading a given energy demand over a longer period of time. Farmers in the homelands often extend the ploughing and planting season. This is partly a risk aversion strategy under rain-fed agriculture and partly a response to the shortage of tractive power to complete the preparation of all the arable land within a short period. In much of the country, the climatic conditions do not allow much latitude in planting time, but by mixing crops, land preparation may be staggered up to a point.

5.2.2 Irrigation

An example of energy demand management which is receiving attention is supplementary, or partial irrigation. Apart from the reduced energy requirement, compared with reduced irrigation, there may also be a 40% reduction in the power demand and, consequently, a lower capital cost.

Supplementary irrigation is sometimes taken to mean simply topping up the water received from rain as required and applying enough during dry spells for the plants to survive. But strictly speaking, partial irrigation should also include water conservation measures such as mulching, planting windbreaks and entrapment of run-off in contour ridges.

There has been a tendency to over-design irrigation schemes for developing areas so that water availability is out of balance with other inputs. The water conserving practices of farmers and vegetable gardeners (e.g. applying water carefully to each plant) is also often overlooked in sizing irrigation systems.

5.3 Low-input agriculture

Energy is just one of many inputs to agricultural inputs which should be kept in balance with one another. Thus, energy demand strategies for small-scale agriculture will have an effect on the requirements for other inputs. It does not make sense to apply water conservation techniques, for example, while still applying massive amounts of fertilizer.

Low-input agriculture is an approach to farming which strives to keep these inputs in balance and, at the same time, keeping external inputs as low as possible. This is achieved by making as much use as possible of ecological processes in the system. The aim of low-input agriculture is basically to attain environmental and economic sustainability. It is much more than an energy strategy, though it has energy implications. The methods of low-input agriculture are highly compatible with small farm systems, but do involve new and innovative techniques and a need for diversity. The more complex systems of low-input agriculture compared with conventional mono-cropping have shown up deficiencies in the orthodox approaches to research and extension. In short, it requires a profound re-orientation of approaches to agriculture and of agricultural support systems.

Purist organic farmers reject technology *in toto*: no tractors, no fertilizers, no biocides, even no ploughing in some approaches. However, pragmatic farmers through the ages have taken what appeared useful from technological developments, and built these applications into their farming systems. As pointed out in section 1.3, increasing technological inputs result in increased production per unit area and decreased reliance on human labour, but they are also less energy efficient in terms of energy requirement per unit of energy output.

Sustainable agriculture would need to incorporate technology which is practically available and efficient. Where it is not available to farmers, or is inefficient in terms of national priorities or real costs (including environmental costs), alternatives need to be developed based on sustainable agricultural principles. Auerbach (1990) defines these as: increasing biological diversity, promoting correct land use, adopting a long term approach to improving soil fertility and reducing chemical inputs. He argues that as these four principles are applied to farming systems, stability and sustainability improve.

In practical terms this would mean the diversification of rain-fed arable agriculture to include mixed cropping systems such as those which have been traditionally used for many years (e.g. maize, beans and pumpkins (*bheca*). In addition, trees for fruit, fodder and fuel-wood can complement the crop mixture, reducing the actual area which needs to be cultivated annually. Systems such as this only function effectively if they are built around a homestead situation; those areas where 'betterment planning' has removed people from their fields into village situations may have more cost effective prospects for service provision, but will find the establishment of sustainable low-input farming systems difficult.

The higher proportion of perennial crops brought into systems of this sort will serve both to provide fuel-wood and to reduce ploughing needs; inter-cropping also increases the proportion of ground covered by crops. As an example, where the maize-beans-pumpkin combination is planted, pumpkins tend to smother all weeds except the early ones; which are relatively easy to control. Although the need for ploughing, fuel-wood transport and weed control does not disappear with low-input sustainable systems, it is much reduced and less concentrated peak demands occur. The emphasis is on adapting the farming system to the environment, rather than trying to make the environment adapt to the farming system.

Where successful indigenous small-scale farming has developed, the pattern has been for highly complex crop mixtures and rotations to evolve through a process of understanding the local environment. The hedge and drainage systems of England and the complex cropping systems of the Indian Punjab are examples of such systems. Locally, the Kosi Bay farmers in northern Natal have found ways of interacting sensitively with their environment, which they have managed sustainably for generations.

5.4 Demand management recommendations

5.4.1 Agricultural policy

There should be a national policy for agriculture which will promote and favour low-input techniques and discourage processes which consume excessive energy and energy-intensive inputs. This would follow directly from two fundamental principles of agricultural policy:

- a commitment to promote agricultural systems which are environmentally and economically sustainable;
- to develop small-scale agriculture as a means of redressing some of the past inequalities in the access to land and agricultural resources.

5.4.2 Research on low-input agricultural techniques

This would require a profound re-orientation of approaches to agriculture and of agricultural support systems. It might necessitate retraining of agricultural extension workers and the development of new curricula for agricultural colleges.

5.4.3 Research on low energy input techniques

Priorities for research on low energy input techniques should be identified. These would probably include:

- a thorough investigations of minimum tillage techniques for South African conditions;
- regional trials in different conditions of soil and climate;
- optimum combinations of animal and mechanized draft and deep-rooting crops to reduce soil density;
- extensive research and monitoring of partial irrigation systems.

5.4.4 Institute for Sustainable Farming Systems

It is suggested that the Agricultural Research Council or its successor establish an Institute for Sustainable Farming Systems which would:

- conduct research on low-input and sustainable agriculture;
- initiate the process of policy formulation on sustainable agriculture, drawing in the expertise and experience of research institutes and development NGO's;
- develop the appropriate training modules and curricula for the training of farmers and agricultural extension workers.

CHAPTER SIX

Energy supply options and strategies

Energy supply strategies for small-scale agriculture have to look beyond the supply of a particular energy carrier and deal with the energy system including fuel, power source and end-use. For example, it is not sufficient to address diesel distribution without also addressing the question of tractors and the environment in which they work. The objective is to supply an energy service (such as draft power or pumping power), not merely a fuel. Thus, this discussion of supply strategies will consider technology choices and access to technologies, as well as to the energy carriers.

6.1 Animal draft

It is quite clearly unreasonable to aim supply strategies at increasing the number of draft animals. Instead we focus on a two-point strategy:

- livestock management to improve the power output of existing animals and minimise the drop in available animal draft power which follow prolonged drought;
- more efficient use of the existing draft power resource.

6.1.1 Improving the condition of draft animals

The issue of animal draft cannot be divorced from the broader issue of livestock and grazing management. However, this particular sphere has proved to be one of the most intractable areas in the development of subsistence agriculture. Overgrazing is a perennial problem over large portions of the communal grazing areas, and there are no easy solutions in sight.

Strategies to improve the amount of animal draft power available must be located within long term strategies to improve veld management and animal husbandry, and thereby improving the condition of draft animals, particularly at the end of winter when animals are weakest but which is also a time when the demand for draft is high. Access to more land, as part of a wider strategy for livestock, would also decrease the pressure on grazing land.

It is not the purpose of this paper to review or recommend livestock strategies for communal areas, except to suggest that interventions which concentrate on a single factor such as tenure or economic incentive have little chance of success. There is a complex and dynamic set of interactions between socio-economic, political, ecological and technical factors (Cousins 1992). Livestock owning tends to be enmeshed in overall livelihood strategies, and these show regional variation. Management objectives and strategies must be based on the multiple needs of the communities involved.

One possible intervention with direct bearing on the availability of animal draft power would be the use of fodder banks for late winter feeding of draft animals. Such schemes might be undertaken co-operatively through local livestock owners associations, or may be a service provided through a network of rural service centres (see Section 6.6). Fodder banks might take the form of stored feeds (eg hay or silage), or more likely be based on perennial fodder crops such as tagasastes, Leucaena or Acacia species.

6.1.2 Optimal use of animal draft

Support services
The inclusion of animal draft in agricultural extension and training needs to be addressed. Agricultural extension officers should be equipped to give advice on the use of animal draft. This would mean additional training for the existing extension workers, and the inclusion of animal draft in the curriculum of the colleges at which agricultural extension workers are trained.

Implements
The lack of variety of available implements needs to be address-ed, and programmes set up to disseminate energy efficient yokes, appropriate ploughs, equipment for inter-row cultivation, multi-purpose tool bars, etcetera. To this end, the heavy import tariffs (Section 2.9.3) on imported equipment should be lifted.

There is also need for a four stage programme of research involving both technical and on-farm research:

- investigation of animal drawn equipment in other countries
- testing and adapting such equipment under South African conditions
- developing new equipment if and as required
- selection of a range of technologies for extensive on-farm trials and market research.

Centre for animal draft
A centre for animal draft should be set up at an existing agricultural training and research institution. The Centre would be responsible for the research and training outlined above, as well as demonstrations, dissemination of information, networking, and publicity. A start has been made with such a centre at Fort Hare University and the Land and Agriculture Policy Centre is currently coordinating a research project examining animal draft development requirements.

The Centre for animal draft might possibly be a model for other regional centres, and should therefore be set up as a pilot project.

6.1.3 Land redistribution and animal draft

The question of adequate animal draft might also arise in some resettlement schemes as part of a policy of land redistribution, notwithstanding the argument in Section 3.1.1 that a tractor of about 35 kw would be appropriate for the typical small farm units which are envisaged by some of the scenarios outlined in Section 3.1. However, given the scale of redistribution put forward in some scenarios, it is inevitable that some of the land involved will be low potential land suitable only as extensive rangeland. Scenarios have been put forward of up to 40% of land being redistributed: that is three times the total arable land in the country.

In resettlement schemes in Zimbabwe which included a high percentage of rangeland, a grazing right was allocated, tied to the arable holding. The allocations were based, inter alia, on the draft requirements (Pariawa 1992). However, such a system frequently led to understocking due to a high percentage of households with no or few cattle (op cit), so further interventions would be necessary to ensure equitable access to animal draft power.

6.2 Mechanised draft

6.2.1 Rehabilitation of tractors

The description of the tractor fleet in the homelands, given in Chapter 2 above, indicates that there are many non-operational or partially operational tractors.

Altogether, these tractors represent a significant potential resource of tractive power if they were optimally used.

Against the background that state and parastatal organisations have by-and-large failed to address the tractive power constraints adequately, we propose that a private organisation be involved in establishing a tractor renovation programme.

As just over half of the tractors are Massey-Fergusons and about half of the remainder are Fords, it is suggested that Massey-Ferguson, and possibly Ford as well, be approached in this regard. Massey-Ferguson Rebuild Operations of England have extensive experience in the field having rehabilitated/rebuilt over 5 000 tractors, and completed 12 projects with renovation operations spanning 30 countries. The Ford Foundation is a major donor to developing countries.

The implementation of such a project would be preceded by two studies.

1 Preliminary study
Massey-Ferguson Rebuild Operations would assess the feasibility of tractor renovation in the potential project area, drawing on their own data and experience and such local information as is available. An initial proposal, covering the likely scope of the project would be prepared.

2 Major survey
Once approval in principle is granted, a field study would be conducted paying particular attention to the condition of operational, non-operational, and derelict tractors, and their location and ownership. An assessment would be made of rebuild premises, facilities, resources and training needs. Detailed project costings in terms of parts kits, equipment and resources would be drawn up.

6.2.2 Support for tractor operators

Such a major survey as that described above would also address all the main constraints on the delivery of tractive power, and identify the infrastructure and methodology required during, and subsequent to, the renovation programme. However, the support services for tractor operators have merit in their own right, and might be implemented whether a full-scale tractor renovation scheme is put in place or not. These would include the following.

- Repair and maintenance services should be provided through rural workshops. These could be part of the network of workshops of a renovation scheme, or associated with rural service centres. Surveys indicate that the demand for routine servicing and minor repairs will be low, with owners preferring to do their own (Auerbach et al 1990). Workshops would be required for larger jobs.
- With operators doing their own basic maintenance, there is a need for extension/training in mechanical skills, assistance with the choice and acquisition of the proper tools, and the setting up of a home-based work space. They will need easy access to parts and lubricants, though most tractor operators do not regard this as a particular problem at the present (op cit). Access to fuel is a problem which is dealt with below (Section 6.4).
- In addition to mechanical skills, extension/training needs to concentrate on management and tractor operating, both through short courses and an advisory service attached to agricultural extension services.
- Potential buyers need advice about buying and access to good used reconditioned tractors.
- Appropriate credit and insurance facilities should be available to tractor owners.

6.2.3 Institutional arrangements

A full programme of tractor renovation together with support and extension/training for tractor owners and operators in the homelands should be planned and implemented by a partnership involving:

- one or two major tractor manufacturers;
- an appropriate college or technikon;
- the relevant department of agriculture;
- a suitable small-business finance institution.

6.2.4 Tractor rehabilitation costs and investment requirements

The following is a tentative estimate of the cost of rehabilitation the tractors in private hands in the homelands. For this projection, we have assumed that 60% of these tractors will be rehabilitated (i.e. 4 400 units) and that those designated operational will be reconditioned, while those designated non-operational will require more drastic rebuilding.

Operational tractors:				
	kW Class	*Quantity*	*Cost/unit (rands)*	*Total cost (rands)*
	30 — 40	950	24 600	23 370 000
	41 — 50	737	30 700	22 625 900
	51 — 60	594	32 800	19 483 200
	other	95	35 800	3 401 000
Sub-total:		2 376		65 819 200
Non-operational tractors:				
	30 — 40	810	49 200	39 852 000
	41 — 50	627	61 500	38 560 500
	51 — 60	506	65 700	33 244 200
	other	81	71 500	5 791 500
Sub-total:		2 024		117 448 200
TOTAL:		4 400		183 267 400

TABLE 6.1 The costs of rehabilitating tractors in the homelands
(Estimates provided by Peter Hittersay & Associates)

In this scenario, the total direct cost of rehabilitation is R183m, of which about half would be required for the purchase of components from overseas and half being used in local added value. These direct rehabilitation costs could be partially or wholly recovered through the provision of long-term soft loans to tractor owners, supplemented by the profits generated by locating, purchasing, rebuilding and re-selling the derelict tractors that must be lying around somewhere, and the supply of other maintenance and repair services.

However, additional funds would be required to cover the costs of surveys, training and management. Funds would also be required for infrastructure (premises, tools, equipment, service vehicles), where the existing infrastructure is inadequate or not suitably positioned.

The benefits of a rehabilitation programme would include:

- an improvement in tractor fleet and an increased availability of mechanized draft power;
- a saving of foreign exchange if viewed against replacing these tractors with equivalent new units;
- the creation of local employment opportunities;

- the transfer of skills, technology and experience;
- the development of rural infrastructure for the repair and maintenance of equipment and machinery.

6.3 Pumping of water for agricultural purposes

There are two related areas to consider with regard to the delivery of power for the pumping of water for agricultural purposes: firstly, the choice of the right technology and secondly, the form and quantity of energy to match it. Factors which affect the choices include:

- physical requirements: volume and head
- characteristics of the site
- capital costs
- maintenance requirements and costs
- access to fuel
- fuel costs

There will inevitably be trade-offs between some of these factors, and communities or individuals may be faced with complex technological choices with which they require guidance. Some of the more common options are summarised below.

6.3.1 Options for pumping surface water for small-scale irrigation

Given the low power requirements and the characteristically remote situations of most gardens, grid electricity is not a realistic option for powering community garden pumps unless it is an unusually large garden and there are multiple users to share the line costs. Even under fairly favourable conditions, electricity could only compete with diesel at pumping requirements of over 550 kl.m/day, which is high for a community garden (Gosnell & Eberhard 1993). Conventional wind pumps are generally used for greater static heads, so the choice is essentially between diesel, petrol and photovoltaic-powered pumps (hand pumps are not considered here).

Petrol-powered pumps
Advantages:

- available in different sizes from small, fairly inexpensive portable systems;
- can delivery large volumes — short pumping times.

Disadvantages:

- access to fuel;
- high maintenance costs and risk of breakdown.

Diesel-powered pumps
Advantages:

- can deliver large volumes — short pumping times;
- More reliable than petrol-powered pumps : lower revving, no centrifugal clutch.

Disadvantages:

- access to fuel;
- higher capital cost than petrol-powered pump.

Diesel-powered generator/electric pump
Advantages:

- possibility of leading electricity to nearby homes;
- easy to install automatic cut-out to prevent dry-pumping.

Disadvantages:

- access to fuel;
- capital cost twice that of belt-drive from diesel engine to pump.

Photovoltaic (PV) pumps
Advantages:

- no fuel requirements;
- low maintenance;
- low (almost zero) running cost.

Disadvantages:

- high capital cost: PV panels expensive, large storage reservoir needed for sunless periods;
- high risk: expensive equipment vulnerable to theft, vandalism, flood damage, etc.

Comparing the life-cycle costs of PV and diesel systems, PV-pumped water was projected to be twice as expensive as diesel-pumped water when the pumping demand was 40 kl.m/day and the systems were operating under normal conditions (Gosnell & Eberhard 1993). The gap could be narrowed by optimizing the efficiency of the PV system. As pumping demand increases, PV becomes progressively less competitive and, at 1 200 k.m/day, it is about four times as expensive as diesel.

Nevertheless, gardeners were prepared to pay twice as much for water in order to have a PV system rather than a diesel, thus avoiding the tedious bus rides to town to fetch diesel in 25 litre containers (Gosnell & Eberhard 1993).

6.3.2 Options for pumping ground water for livestock

The options described above for pumping surface water are suitable for boreholes too, though the high power requirement for deep boreholes will count against PV on the grounds of cost. Wind-powered pumps are a further option.

Wind-pump
Advantages:

- no fuel required:
- normal positive-displacement pump mechanism is simple to maintain and repair;
- low maintenance costs.

Disadvantages:

- dependent on wind and much of South Africa has low to medium wind potential;
- requires regular maintenance;
- has to be accurately matched to the borehole capacity;
- risk of damage in very high winds;
- very poor reliability record in practice.

As an indication of the poor reliability record of wind-pumps, the average time between breakdowns of wind-pumps installed by the Transkei Government was reported to be three months (Wiseman 1986, quoted by Gosnell & Eberhard 1993). In an unpublished survey in an area of Transkei, the rural Advice Centre found 90% of wind-pumps out of order. A decision was made to install diesel-powered pumps rather than repair or replace the wind-pumps.

The past experience with wind-pumps is probably a reflection, not of the technology, but the way in which it has been installed, without adequate provision for routine maintenance and ensuring that the local community has the basic skills, tools and organization to see that it is carried out.

6.3.3 Facilitating access to pump-sets

Potential users of pumped water need advice on the choice of the most suitable pumping system for their needs and resources. They would need advice on cost recovery, the pricing of water, and the economic viability of the scheme.

They would very likely need some form of credit, particularly for the purchase of the more capital expensive options such as PV systems.

The possibility of a PV tariff has been raised in connection with PV pump-sets (Gosnell & Eberhard 1993). Eskom has already formulated a tariff for PV known as an R Tariff. It is, in effect, a fee for the rental of a PV system and for a maintenance contract, since Eskom would still own the PV equipment and would maintain it. Eskom's R Tariff is based on conservative cost estimates, and it likely that more affordable arrangements could be made. There are proposals to establish a Joint Maintenance Fund which would offer administration and supervision of maintenance contracts for Remote Area Power Supply (RAPS) systems (Hofmeyr 1993). Such a system could benefit farmers or gardening groups, especially if the contract were to include the whole pumping system and not just the power supply component.

6.3.4 Maintenance of pump-sets

Routine maintenance should be distinguished from major repairs and overhauls. Routine maintenance and minor repairs should be carried out by members of the local community as far as possible. The preconditions for this are:

- local people with the necessary skills;
- access to the proper tools, lubricants, etc.;
- a degree of local organisation.

The project implementation package ought to include steps to see that these are in place.

A technical support programme would be needed to carry out major repairs.

6.3.5 Institutional requirements

Facilitating the access pump-sets and developing the capacity to supervise local maintenance and carry out bigger repair jobs on a lot of scattered pump-sets raises some institutional issues. As in the case of tractors, the direct involvement of major pump manufacturers is recommended.

Water development in the homelands is such an urgent and basic necessity, that a comprehensive and holistic water programme is an obvious priority. The form that this might take is beyond the scope of this paper, but it would need to fit into the wider development of rural infrastructure and services.

Energy is an essential and inseparable component of water development. There are potential linkages between water supply and extension of the electrical grid, the diesel and petrol distribution networks, or RAPS programmes.

At the same time, small-scale agriculture is only one of many users of water albeit an important one. In addition to the energy sector, agriculture should also be part of an integrated institutional structure for the development of water supplies. Such a structure should devolve local decision making to local level, but facilitate regional and national catchment planning.

6.4 Access to diesel

6.4.1 Quantity of diesel needed by tractor operators

There is evidence that fuel consumption by tractors operating in the homelands is 6 to 7 litres of diesel per hour (Crosby 1990). This is lower than the normal rate in commercial agriculture of about 10 l/hr, and the theoretical rate of 12 to 14 l/hr. In Bophuthatswana, a combination job of ploughing, discing, fertilizing and tillering in with a 50 kW tractor was also observed to use less than the theoretical quantity of diesel (Crosby 1993).

The assumption was made in Section 2.7.4 that a typical tractor in the homelands might plough about 80 ha per year. Contractors in Kangwane take 3 hours per hectare to plough (*including* travelling time) at 6 l/hr or 18 l/ha, though longer ploughing times have been observed in other homeland areas (see Section 2.7.3). Thus a typical tractor might use about 1 500 litres of diesel per year for agricultural operations. Some will use more, many will use less. In addition, tractors perform haulage tasks outside of ploughing season, but this is a relatively low fuel consuming operation, and since it is mostly short haulage, the actual travelling time is short compared to loading/off loading time.

Assuming that operational tractors in the homelands use 2 000 litres of diesel per year, and 'non-operational' tractors use 200 litres, the total diesel demand of the homeland tractor fleet is roughly 13 million litres of diesel per year.

6.4.2 Bulk supplies of diesel for rural requirements

Access to diesel is a problem for tractor operators and for farmers and community gardens with diesel pumps.

There is a need to facilitate access to bulk diesel supplies for tractor operators and for farmers/communities requiring diesel for pumping. The marketing side of petroleum companies must be more visible, accessible and responsive to the needs of rural users.

The agricultural support and extension services ought to encourage users to apply for bulk supplies and assist in the submission and processing of applications. To accomplish this, formal links would be required between the diesel suppliers and the agricultural support and extension services. Furthermore, linking diesel supply to a programme of facilitating the emergence of farmers associations could enable some degree of rationalisation of bulk supplies and redistribution from these sources.

The normal 2 200 litre bulk tanks would be too large for certain users (e.g. community gardeners with a diesel pump) and smaller options should be readily available. This implies a change in the present distribution policy of not delivering less than 1 500 litres at a time.

6.4.3 Fuel levy: refunds for agriculture

Provision is made for a refund of a portion of the fuel levy on diesel used in agriculture. Farmers buying diesel from petrol stations pay the full price and then submit refund claims to the Department of Customs and Excise (Custex). Net prices are paid if the diesel is bought through registered agricultural co- operatives or directly from petroleum companies, as in the case of bulk tanks. Sales of diesel from co-ops are regulated so as to prevent sales to non-agricultural users. In these two cases, the levy refund is claimed by the co-op or the petroleum company.

While, in theory, all farmers irrespective of size can be registered with Custex, operators in the informal sector need active support in practice and end up paying the full price for diesel inclusive of levy. The regulations also prevent groups or associations of small-farmers or tractor owners with bulk tank supplying to individuals, even for agricultural purposes, unless formally registered as agricultural co-operative.

The diesel fuel levy refund is, in effect, a subsidy to farmers. Whether there should be a subsidy, and if so whether a fuel levy refund is an appropriate form of subsidy is open to question. Firstly, the system is open to abuse, with cheap diesel commonly being diverted to non-agricultural purposes. Secondly, a fuel subsidy is an anti-conservation measure in that the largest users of fuel get the most benefit.

We recommend that the system of refunding fuel levies on diesel for agriculture be abolished and a fair and uniform price for diesel be set. Failing that, the regulations regarding levies on diesel used in the agricultural sector should be reviewed, and at the very least, be amended to (a) benefit operators in the informal and subsistence sector and (b) facilitate further internal distribution from rural bulk tanks.

6.5 Small-scale agriculture and rural electrification

Possible uses of electricity in small-scale agriculture have emerged a number of times in this paper. Pumping, processing (grain milling, saw milling etc) and storage (refrigeration) are the main potential end-uses at present.

Co-ordination between agricultural development programmes and electrification programmes is essential. Electricity for small-scale agriculture must be addressed in the wider context of rural electrification. All possible opportunities for agricultural and associated developments to sustain grid extensions to previously non-electrified communities should be identified. Rural electrification programmes should focus on those areas where

- viable, cost effective irrigation is possible;
- processing of food or other agricultural products might becost-effective;
- agricultural support services such as training facilities, repair workshops and supply depots might be located.

Nevertheless, it is expected that the number of agricultural developments in the homelands which justify significant extensions of the grid will be limited. Instead, agriculture- related activities requiring electricity will, as far as possible have to be sited near presently electrified centres, or use RAPS options. It seems unlikely that rural electrification will be agriculture-driven to any notable extent.

A new set of circumstances would be thrown up by processes of land redistribution. It is envisaged that farms, most of which will already have grid connections, will be divided into small-farm units. Electrification of these units will consequently be a matter of reticulation rather than grid extension.

6.6 Rural service centres

Rural service centres have received some attention in rural development circles, although the nature of such centres is conceived in a variety of ways (Thom 1993). In some models, rural service centres are very small, meeting some of the basic requirements for materials and agricultural inputs of the neighbouring community. Such centres themselves may be poorly served by the regional infrastructure. In other models, these centres are focal points for services and development within a district. Such centres would have an infrastructural base (energy, water, telephone, road and transport links). These models are not mutually exclusive, and together could serve somewhat different functions within a regional economy.

Rural service centres are conceived primarily as support centres for development, but they could bring considerable benefits for energy provision as well (Thom 1993).

There are several references to rural service centres in the course of this paper. These centres were mentioned as possible locations for a number of energy demanding functions related to small-scale agriculture:

- an electrified and equipped venue which could support training and extension programmes to farmers (Section 2.14);
- facilities for maintenance and repair of tractors, pumps and other equipment (Section 6.2.1);
- a grain mill, probably electrically driven (Section 2.13.2);
- fodder banks for late-winter feeding of draft animals (Section 6.1.1);
- an energy centre which would cater, inter alia, for the different energy requirements and technologies arising from diversification of small-scale agriculture (Section 2.15);
- diesel sales facilities from bulk supplies (Section 6.4.2).

Recommendations for the establishment of rural service centres can be supported from the perspective of energy for small-scale agriculture.

At present the mechanisms to undertake such a broad rural development initiative as the establishment of an extensive network of rural service centres are lacking. The question of co-ordination of rural development across sectors and across regions needs to be addressed and the necessary linkages established, but this falls outside the scope of this paper.

CHAPTER SEVEN

Summary of recommendations

7.1 Animal draft power

Animals are an important source of draft power. This fact must be recognised and steps taken to improve the use of animal draft.

- A centre for research and training in animal draft power should be established at an existing agricultural training institution. The centre should be regarded as a pilot project with a view to the possible establishment of regional centres for animal draft.
- Livestock improvement programmes should be initiated. While such programmes are not specifically energy orientated, they would enhance animal draft power by improving the condition of animals. Programmes should include late-winter feeding of draft animals.
- Agricultural extension services should equip themselves to assist farmers in the efficient use of animal draft, and to encourage the use of animals for secondary cultivation in particular.
- Import tariffs on animal-drawn equipment should be reduced. Steps should be taken to improve the availability and variety of animal drawn equipment, especially that for secondary cultivation.
- Interventions to improve animal draft should be the responsibility of the relevant department of agriculture, and involve the appropriate agricultural research and training institutions.

7.2 The tractor fleet

The homeland tractor fleet is operating sub-optimally due to the poor condition of the tractors, inadequate support services to operators, and the modus operandi of tractor contracting.

- Support services are required for tractor owners, particularly contractors. These include:
    - suitable arrangements for finance and insurance;
    - assistance for buyers of tractors;
    - rural mechanical service centres;
    - training: operating, maintenance, business management
    - advisory service attached to agricultural extension.
- A tractor renovation project should be implemented. The process would be to conduct an in-depth survey of the existing tractor fleet. On the basis of the survey, a strategy for rehabilitation and reconditioning of should be initiated, beginning with a pilot programme in one or two areas. The programme should be planned and implemented by a partnership involving:
    - one or two major tractor manufacturers;
    - an appropriate technikon;
    - the relevant department of agriculture;
    - an appropriate agricultural finance institution.

- Tractor operators are seen as the main point of intervention in the provision of adequate milling facilities. Promoting the acquisition and use of PTO-driven hammer mills should be a component of programmes directed at tractor operators.

- Tractor operators in the homelands should be given government contracts to carry out infrastructural development and maintenance as far as possible (e.g. dam building, road construction and maintenance). This would necessitate a system of loan or lease of the required accessories, as well as additional technical and business training for the tractor operators.

- The needs of emergent commercial small-farmers will have to be taken into account in as land redistribution programmes take shape. There will likely be a large demand for small used tractors. A programme to recover and rehabilitate derelict and/or disused tractors from the commercial agricultural sector may be indicated. This could be a component of the tractor renovation programme above, and draw support from organised agriculture.

7.3 Distribution of diesel

- There is a need to facilitate access to bulk diesel supplies for tractor operators and for farmers/communities requiring diesel for pumping. The marketing side of petroleum companies must be more visible, accessible and responsive. To achieve this, formal links are required between the diesel suppliers and the agricultural support and extension services.

- The regulations regarding levies on diesel used in the agricultural sector must be amended to (a) benefit operators in the informal sector and (b) facilitate the further distribution from rural bulk tanks.

- The normal 2200 litre bulk tanks would be too large for certain users (e.g. community gardeners with a diesel pump) and smaller options should be readily available. This applies a change in the present distribution policy of not delivering less than 1500 litres at a time.

7.4 Energy demand management

- Systems of cultivation should be promoted which:
  - have low tillage requirements;
  - keep tillage in balance with other inputs;
  - have a higher proportion of perennial crops;
  - match the power source to the cultivation needs;
  - reduce the draft power demand by spreading cultivation over a longer season.

Similarly, partial irrigation combined with methods of agriculture which conserve water should be promoted to reduce the power demand and energy consumption compared to conventional irrigation methods.

- There should be a national policy for agriculture which will promote and favour low-input techniques and discourage processes which consume excessive energy and energy intensive inputs. This would require a profound re-orientation of approaches to agriculture and of agricultural support systems. It is suggested that the Agricultural Research Council establish an institute for research into sustainable farming systems, and that this institute initiate the process of policy formulation on sustainable agriculture, drawing in the expertise and experience of research institutes and development NGOs.

7.5 Rural service centres

- Rural Service Centres, which have been proposed in the broad rural development context, would bring considerable benefits for energy provision as well. Recommendations for the establishment of Rural Service Centres can be supported from the perspective of this paper on energy for small-scale agriculture.
- Rural Service Centres should be electrified (either grid or RAPS) and should be able to provide:
  - an electrified and equipped venue which could support training and extension programmes to farmers;
  - facilities for maintenance and repair of tractors, pumps and other equipment;
  - a grain mill, probably electrically driven (although the primary energy carrier for milling will probably be diesel for PTO-driven mills);
  - fodder banks for late-winter feeding of draft animals;
  - an energy centre which would cater, inter alia, for the different energy requirements and technologies arising from diversification of small-scale agriculture.
- At present the mechanisms to undertake such broad rural development initiatives are lacking. The question of co-ordination of rural development across sectors and across regions needs to be addressed and the necessary linkages established, but falls outside the scope of this paper.

7.6 Electricity and small-scale agriculture

- Co-ordination between agricultural development programmes and electrification programmes is essential. All possible opportunities for agricultural and associated developments to sustain grid extensions to previously non-electrified communities should be identified. Nevertheless, the extension of the grid in the homelands is unlikely to be agriculture-driven to any notable extent.
- Agriculture-related activities requiring electricity will, as far as possible have to be sited near presently electrified centres, or use RAPS options.
- Suitable financing arrangements are needed for the installation of PV electric pumping systems in situations where it is the most appropriate technology. A PV tariff system might have significant benefits outside the agricultural sector as well.
- These issues related to electricity for small-scale agriculture must be addressed in the wider context of rural electrification.

7.7 Representation of small-scale farmers

- The development of representative organisations for small-scale farmers with the influence to lobby effectively on their behalf is a priority. Furthermore, particular interest groups within the small-farm sector, as well as tractor operators and millers for example, need to have a voice. Provision must be made for such organisations to influence energy planning for small-scale agriculture at local and regional levels.

- Since advocacy and lobbying will be an important function of the interest groups, they should be established outside of government structures. The existing networks of development NGO's could play an essential facilitating role.

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PROJECT DESCRIPTION

A major two year research project was launched by the Energy for Development Research Centre in April 1992. It aims to investigate policy options for widening access to basic energy services for the urban and rural poor in South Africa. Research papers are being produced in the following areas:

Background papers
Research outline
Integrated energy planning: a methodology for policy analysis and research
Development context for energy planning in South Africa
Background on South African energy system

Energy demand analysis
Energy demand in underdeveloped urban and rural areas

Rural areas
Energy for rural development: an introduction and overview
Energy and small-scale agriculture
Rural household energy supply options
Afforestation and woodland management
Remote area power generation options

Urban areas
Household energy supply in formal and informal urban settlements
Energy and informal sector production

Ancillary sector
Energy and mass transportation*

Key supply sector
Electricity distribution sector*

Cross-sectorial studies
Energy efficiency and conservation*
Energy and environment*
Southern Africa linkages*
Investment requirements and financing mechanisms*
Pricing policy*
Institutional analysis*

Policy options
A concluding document will draw together key policy conclusions
** The scope of these studies is restricted to energy issues concerning the urban and rural poor.*

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PAPER No 7

Energy and small-scale agriculture

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SOUTH AFRICAN ENERGY POLICY RESEARCH AND TRAINING PROJECT

widening access to basic energy services for the urban and rural poor

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