Fertilizer use by crop in Zimbabwe

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Preface

This study, commissioned by the Food and Agriculture Organization of the United Nations (FAO), is one of a series of publications on fertilizer use on crops in different countries.

The aim of the series is to examine the factors underlying present fertilizer usage. These factors include the agro-ecological conditions, the structure of farming, cropping patterns, the availability and use of mineral and organic plant nutrients, the economics of fertilizers, and research and advisory requirements. The reports examine those factors that will or should determine the future development of plant nutrition on a country-by-country basis.

In the past two decades, there has been an increasing focus on the adverse environmental impact of both the underuse and the overuse of plant nutrients. The efficient use of plant nutrients, whether from mineral fertilizers or from other sources, involves the shared responsibility of many segments of society including international organizations, governments, the fertilizer industry, agricultural research and advisory bodies, traders and farmers. The publications in the series are addressed to all these parties.

Fertilizer use is not an end in itself. Rather, it is a means of achieving increased food and fibre production. Increased agricultural production and food availability can, in turn, be seen as an objective for the agriculture sector in the context of contributing to the broader macroeconomic objectives of society. The FAO/IFA 1999 publication *Fertilizer strategies* provides a review of the options available to policy-makers.

The contents of the series of studies differ considerably from country to country in view of their different structures, histories and food situation. However, in each case the aim is to arrive at a better understanding of crop nutrition in the country concerned.

Acknowledgements

This study is based on the work of Dr. D.G. Mudimu, Senior Lecturer, University of Zimbabwe. It has benefited from the contributions of K. Isherwood (consultant, FAO), J. Poulisse and T. van den Bergen (FAO).

Background photograph (maize): FAO Mediabase, FAO/20355/ P. Diana.

Other photographs: FAO Mediabase, FAO/17720/A. Conti (cotton), FAO/5215/C. Fraser (tobacco); and EcoPort (sugar cane E. van Wik).

Abstract

Zimbabwe's economy relies heavily on the agriculture sector. Agriculture contributes about 18 percent to its gross domestic product (GDP). Almost half the country's exports are derived from agriculture, especially cotton, tobacco and the horticultural crops.

The major crops grown in Zimbabwe are: maize, cotton, soybeans, wheat, tobacco and horticultural crops such as roses, cut flowers and vegetables. Maize is the country's staple crop and accounts for a substantial proportion of the fertilizers applied.

This report divides the country into five "natural regions" and describes the natural characteristics, soils and cropping patterns of each. Rainfall is the major determinant of agricultural production patterns. Most soils in Zimbabwe are of inherently low fertility and their quality declines rapidly where they do not receive regular amounts of organic and inorganic fertilizers. The soils of the smallholder subsector are particularly vulnerable. An inadequate level of investment in soil fertility is leading to soil erosion and land degradation.

Until 2000, there were two dominant farming subsectors in Zimbabwe: the large-scale commercial subsector, comprising 4 500 farmers with freehold title to 12 million ha; and the smallholder subsector, with 850 000 farmers occupying 16 million ha of communal land. The large-scale farms were located mostly in areas of greater agricultural and economic potential whereas most of the communal lands were in marginal agro-ecological regions.

In 2000, the Government embarked on an agrarian reform programme that involved redistribution of land. The State acquired almost 12 500 000 ha (6 796 farms) and transferred this land to two new categories of farming subsectors. By 2003, more than 3 000 farming units covering about 3 million ha had been established in these two new subsectors.

There has been considerable research into the use of organic manures and inorganic fertilizers on different crops in the various agro-ecological

zones. Fertilizer use recommendations have been prepared by crop/natural region/farming system. However, these blanket recommendations require refinement according to the conditions of the farm.

There are four major fertilizer manufacturers in Zimbabwe. Two companies produce ammonium nitrate and superphosphate, which they sell to two other companies that use them, together with imported intermediates, to produce NPK compound fertilizers. There are domestic phosphate rock deposits but all the potassium required has to be imported. Fertilizer production has tended to decline since the mid-1990s owing to a fall in domestic demand together with restrictions on exports, a lack of foreign exchange for the purchase of equipment and raw materials, transport problems, increasing energy costs and low profitability.

Prior to the land reform, the large-scale commercial sector accounted for more than 80 percent of fertilizer purchases. The average rate of fertilizer nutrient application was 290 kg/ha on the large-scale commercial farms compared with 15 kg/ha on the communal lands. Fertilizer consumption has fallen since 2000 owing to the disruption caused by the agrarian reform, physical unavailability, increased fertilizer prices and financial constraints. Only one-fifth of the smallholder farmers use fertilizers. In order to realize the potential for increased fertilizer use in this subsector, the farmers should have better financial and physical access to fertilizers and guidance concerning their use. However, above all, fertilizer use must be profitable.

The Government controls the prices of the main fertilizers and crops and effectively subsidizes prices for the smallholder sectors. There is freedom of entry into the inputs distribution sector but the Government's input supply schemes reduce the quantities that farmers can purchase from private distributors.

List of acronyms

ACFD	African Centre for Fertilizer Development
AEZ	Agro-ecological zone
AN	Ammonium nitrate
ARDA	Agricultural and Rural Development Authority
AS	Ammonium sulphate
B	Boron
BNF	Biological nitrogen fixation
Ca	Calcium
CEC	Cation exchange capacity
Cu	Copper
DAP	Di-ammonium phosphate
DRSS	Department of Research and Specialist Services
EM	Efficient micro-organism
Fe	Iron
FRU	Farming Systems Research Unit
GDP	Gross domestic product
GMB	Grain Marketing Board
ICRAF	International Centre for Research in Agroforestry
KCl	Potassium chloride
K_2SO_4	Potassium sulphate
LU	Livestock unit
MAP	Mono-ammonium phosphate
Mg	Magnesium
MOP	Muriate of potash (potassium chloride)
NGO	Non-governmental organization
NR	Natural Region

NRZ	National Railways of Zimbabwe
S	Sulphur
SADC	Southern African Development Community
SOP	Sulphate of potash, potassium sulphate
SSP	Single superphosphate
UZ	University of Zimbabwe
ZIMACE	Zimbabwe Agricultural Commodity Exchange
Zn	Zinc
N	Nitrogen
P_2O_5 or P	Phosphate*
K_2O or K	Potash*

* Phosphate and potash may be expressed as their elemental forms P and K or as their oxide forms P_2O_5 and K_2O. Nitrogen is expressed as N. In this study, phosphate and potash are expressed in their oxide forms.

Chapter 1
Introduction

Zimbabwe's total land area is about 39 million ha. Of this, there are about 32.6 million ha of agricultural land. National parks, wildlife areas, forests and urban settlements occupy the remaining 6.4 million ha. Agriculture has been and remains a prime contributor to the economy. It contributes 18 percent of the gross domestic product (GDP) and provides 45 percent of the exports, 60 percent of all raw materials for industry, and employment for some 70 percent of the population.

Until 2000, there were two dominant farming subsectors: large-scale farming, and smallholder farming. The large-scale farming subsector had about 4 500 farmers, with freehold title. The smallholder farming subsector consisted of about 1 500 000 farming households on communal lands, and 45 000 in resettlement areas and small-scale commercial farming households. In 2000, the Government embarked on a land and agrarian land reform programme that redistributed land from white large-scale farmers to black farmers in order to redress a historical and political imbalance in land distribution. The land redistribution process resulted in the creation of 140 135 farming units covering almost 6.3 million ha.

Zimbabwe has a growing need for fertilizers in order to increase land and labour productivity and to intensify production, especially in the smallholder farming subsector.

Increases in crop production in the past two decades have been more the result of an expansion in area rather than an increase in land and labour productivity. Crop yields in the smallholder subsector have remained low compared with similar crops in the large-scale farming subsector. Fertilizer use is falling owing to unavailability, increased prices and financial constraints. Inadequate investment in soil fertility is leading to degradation of land currently in agricultural use.

Zimbabwe has a well-developed fertilizer industry. Until 1990, the country was self-sufficient in most of its fertilizer requirements. However, unfavourable macroeconomic factors have undermined the performance of the industry, and the fertilizer manufacturers have been operating below capacity since the late 1990s. The country has become a net importer of certain fertilizers. However, studies by FAO and the African Centre for Fertilizer Development (ACFD) in 1999 showed that, if limitations such as credit availability for farmers were eliminated, demand would outstrip local production even if the maximum fertilizer production levels were reached.

Chapter 2
Zimbabwe's natural regions and farming systems

NATURAL REGIONS

Zimbabwe is divided into five agro-ecological regions, known as natural regions (Figure 1), on the basis of the rainfall regime, soil quality (Figure 2) and vegetation among other factors. The quality of the land resource declines from Natural Region (NR) I through to NR V (Moyo,

FIGURE 1
Natural regions of Zimbabwe

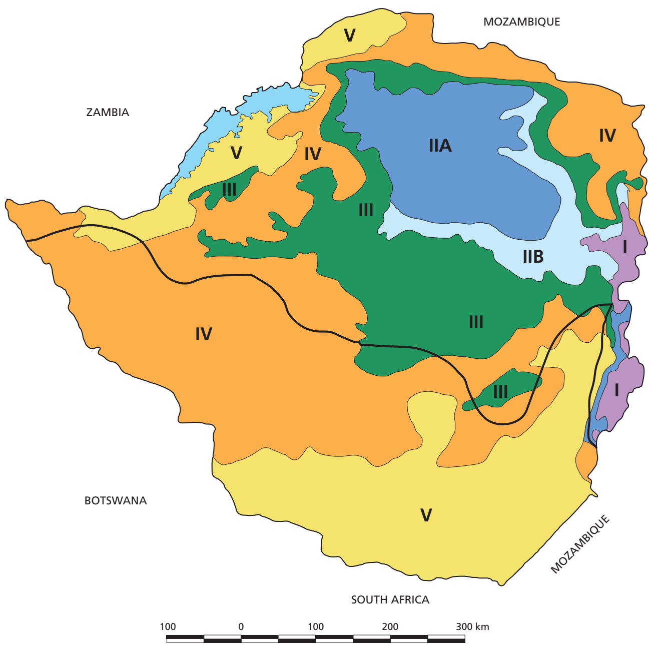
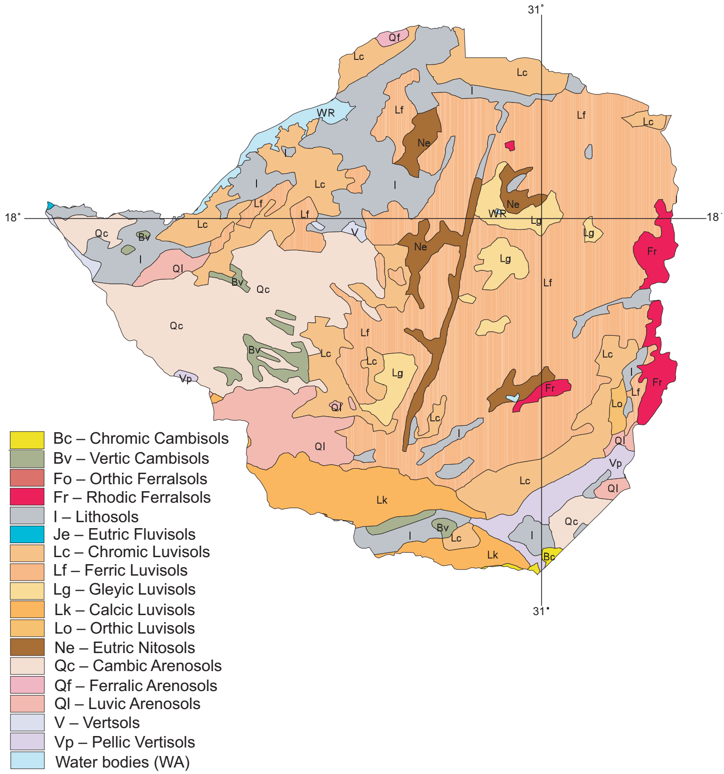


FIGURE 2
Dominant soil map of Zimbabwe



Original scale 1:5 million
Source: DSMW-FAO-Unesco

2000; Vincent and Thomas, 1961). Table 1 describes these natural regions and their farming systems.

Natural Region I

This region lies in the east of the country. It is characterized by rainfall of more than 1 000 mm/year (most of which falls throughout the year), low temperatures, high altitude and steep slopes. The country's timber production is located in this region. The plantations are owned mainly by the State through the Forestry Commission and by multinationals. There

TABLE 1
Description of the Natural Regions of Zimbabwe

Natural Region	Area (000 ha)	% of total land area (%)	Annual rainfall (mm)	Farming Systems
I	613	1.56	> 1 000. Rain in all months of the year, relatively low temperatures	Suitable for dairy farming forestry, tea, coffee, fruit, beef and maize production
II	7 343	18.68	700–1 050. Rainfall confined to summer	Suitable for intensive farming, based on maize, tobacco, cotton and livestock
III	6 855	17.43	500–800. Relatively high temperatures and infrequent, heavy falls of rain, and subject to seasonal droughts and severe mid-season dry spells	Semi-intensive farming region. Suitable for livestock production, together with production of fodder crops and cash crops under good farm management
IV	13 010 036	33.03	450–650. Rainfall subject to frequent seasonal droughts and severe dry spells during the rainy season	Semi-extensive region. Suitable for farm systems based on livestock and resistant fodder crops. Forestry, wildlife/tourism
V	10 288	26.2	< 450. Very erratic rainfall. Northern low veldt may have more rain but the topography and soils are poor	Extensive farming region. Suitable for extensive cattle ranching. Zambezi Valley is infested with tsetse fly. Forestry, wildlife/tourism

Source: Adapted from Moyo, 2000; Vincent and Thomas, 1961.

are several small owner-operated plantations and sawmills. NR I is ideally suitable for intensive diversified agriculture and livestock production, mainly dairy farming. Common crops are tropical crops such as coffee and tea, deciduous fruits, such as bananas and apples, and horticultural crops, such as potatoes, peas and other vegetables. Flowers, such as proteas (*Proteaceae* spp.), are grown for export.

Natural Region II

This region is located in the middle of the north of the country. The rainfall ranges from 750 to 1 000 mm/year. It is fairly reliable, falling from November to March/April. Because of the reliable rainfall and generally good soils, NR II is suitable for intensive cropping and livestock production. It accounts for 75–80 percent of the area planted to crops in Zimbabwe. The cropping systems are based on flue-cured tobacco, maize, cotton, wheat, soybeans, sorghum, groundnuts, seed maize and burley tobacco grown under dryland production as well as with supplementary irrigation in the wet months. Irrigated crops include wheat and barley grown in the colder and drier months (May–September). NR II is suitable for intensive livestock production based on pastures and pen-fattening utilizing crop residues and grain. The main livestock production systems include beef, dairy, pig and poultry. Prior to 2000, the region was dominated by the large-scale farming subsector characterized by highly mechanized farms of 1 000–2 000 ha under freehold title and owner-operated. Following the agrarian and land reform programmes initiated in 1999/2000, a large proportion of the farms were subdivided into smaller units and allocated to new farmers under the A1 and A2 small-scale farming system.

Natural Region III

NR III is located mainly in the mid-altitude areas of the country. It is characterized by annual rainfall of 500–750 mm, mid-season dry spells and high temperatures. Production systems are based on drought-tolerant crops and semi-intensive livestock farming based on fodder crops. The predominant farming system is smallholder agriculture. Large-scale farming accounts for 15 percent of the arable land production, most of the land being used for extensive beef ranching (Roth, 1990). Smallholder agriculture in the communal farming areas is under relatively intensive cropping systems. The main crops are maize (the staple foodgrain) and cotton (a major cash crop). NR III is suitable for the production of groundnuts and sunflowers as cash crops.

Natural Region IV

NR IV is located in the low-lying areas in the north and south of the country. The characteristics of the region are: annual rainfall of 450–650 mm, severe dry spells during the rainy season, and frequent seasonal droughts. Although NR IV is considered unsuitable for dryland cropping, smallholder farmers grow drought-tolerant varieties of maize, sorghum, pearl millet (*mhunga*) and finger millet (*rapoko*). NR IV is ideally suitable for cattle production under extensive production systems and for wildlife production.

Natural Region V

NR V covers the lowland areas below 900 m above sea level in both the north and south of the country. The rainfall is less than 650 mm/year and highly erratic. Although NR V receives reasonable rainfall in the northern part of Zimbabwe along the Zambezi River, its uneven topography and poor soils make it unsuitable for crop production. Generally, NR V is suitable for extensive cattle production and game-ranching.

Although both NR IV and NR V are too dry for crop production, households on the communal lands in these regions grow grain crops (maize and millet) for their food security and some cash crops such as cotton. Crop yields are extremely low and the risk of crop failure is high in one out of three years (Rukuni and Eicher, 1994). Cattle and goat production are major sources of cash income.

Table 2 further subdivides the five NRs into 18 agro-ecological zones (AEZs) by including information on soils and on the probability of annual rainfall exceeding 500 mm.

SOIL QUALITY AND FERTILITY

Thompson and Purves (1978) give a comprehensive guide to the characteristics of factors determining the fertility of the soils of Zimbabwe. Generally, virgin soils in Zimbabwe are infertile and deficient in nitrogen (N), phosphorus (P) and sulphur (S). About 70 percent of Zimbabwe is covered with sandy soils, mostly derived from coarse granite. Sandy soils in the south are derived from gneiss. The northwest of the country has Triassic and Kalahari sands. Zimbabwe sandy soils are low in N, P, and S and in cation exchange capacity (CEC) owing to low clay and organic matter contents (Grant, 1967a, 1967b, 1970; Nyamapfene, 1981). In addition, the sandy soils are generally acidic. According to Grant (1970), many crops on granite sandy soils on the communal lands reveal multiple nutrient deficiencies of N, P and S as well as of magnesium (Mg) and potassium (K) and of micronutrients such as zinc (Zn).

S deficiency is endemic. Mg deficiency is more pronounced where the sandy soils are cropped using fertilizer NPK alone. Zn deficiency is encountered more in intensively cropped areas. The soils are inherently deficient in boron (B). Copper (Cu) deficiency occurs in irrigated lands. Generally, there is no iron (Fe) deficiency.

TABLE 2
Agro-ecological zones

NR	AEZ	Area	Probability rainfall > 500 mm Oct. to Apr.	Length of growing period	Physiographic region	Altitude	Erosion hazard	Dominant soils		pH topsoil	CEC	NPK	Available waterholding capacity
		(million ha)	(%)	(days)		(m)					(me / 100 g soil)		
I	I	0.7	> 90	170–200	Eastern Highlands	1 100–2 600	medium	red soil	Acrisols, Ferralsols	4.4–5.1	2.0–6.0	K var., N	high
II a	IIA	4.1	> 90	140–170	Northern Highlands	1 100–1 800	variable	greyish brown sands and sandy loams derived from granitic rocks	Cambisols, Luvisols, Arenosols	4.0–4.3	1.5–5.0	K med., N	mod.–low
II b	IIB	1.8	80–90	120–150	Northern Highlands, NE & SE Middleveldt	1 100–1 600	variable	greyish brown sands and sandy loams derived from granitic rocks	Cambisols, Luvisols, Arenosols	4.0–5.0	1.0–3.0	K var., N	mod.–low
III	III(1)	0.7	70–90	100–130	Kalahari Sandveldt	1 100–1 200	medium	deep Kalahari sand	Arenosols	4.6–4.9	1.0–1.2	K med., N & P low	low
	III(2)	1.4	70–80	110	Sanyati-Sengwa Basin SE Middleveldt	600–1 200	high	very shallow	Leptosols, Lixisols	4.5	3.0–4.0	K med.	low

TABLE 2
Agro-ecological zones (Continued)

NR	AEZ	Area	Probability rainfall > 500 mm Oct. to Apr.	Length of growing period	Physiographic region	Altitude	Erosion hazard	Dominant soils		pH topsoil	CEC	NPK	Available waterholding capacity
		(million ha)	(%)	(days)		(m)					(me / 100 g soil)		
	IV(5)	7.6	40–65	100–135	NE Middleveldt SE Middleveldt	600–1 200	variable	greyish brown sands and sandy loams derived from granitic rocks	Luvisols	4.4–4.8	2.0–5.0	K & P med.	low
V	V(2)	0.7	60	100–135	Zambezi Valley	600–900	high	very shallow	Leptosols				low
	V(3)	0.5	30–40	70–100	SE Lowveldt	300–400	low	Vertisols	Vertisols	6.8	65–100		high
	V(4)	1.5	40–60	100–130	Sanyati-Sengwa Basin	500–700	medium	brown loamy sands & loams	Luvisols, Solonetz				low–mod.
	V(5)	3.9	40–60	70–100	SE Lowveldt	300–600	low–med.	Sands & sandy loams derived from granite & gneiss	Luvisols	6.0–7.0	20	K & P med.	low–mod.
		3	< 30	< 70	SE Lowveldt	300–900	high	Variable	Leptosols, Luvisols	6.0–7.0	10–20		variable

Source: FAO & ACFD, 1999.

TABLE 3
Nitrogen percentage of different soil types

Texture	Total N (%)
Clays	0.10–0.15
Sands	0.02–0.05
Sandy clay loams	0.06–0.07
Sandy loams	0.04–0.07

TABLE 4
Fertilizer nutrient requirements of soils of different fertility status

Fertilizer nutrient	Nutrient status of the soil		
	Good	Medium	Poor
	(kg/ha of fertilizer nutrient required)		
N	Up to 110	110–140	140–180
P	40–65	65–100	100–135
K	20–45	45–70	70–95

Source: AGRITEX, 1982.

As these soils are inherently of low fertility and subject to rapid depletion in fertility, regular applications of organic and inorganic fertilizers are necessary in order to obtain reasonable and sustainable yields. The soils need liming to correct soil acidity and then fertilizing to correct for low P and K levels.

The total N content of the soil varies greatly, being higher in higher rainfall areas than in lower rainfall areas, higher in wetland soils and heavy-textured soils than on sandy soils, higher in virgin soils than in cultivated soils, and lower in the subsoil than in the topsoil (Table 3).

Table 4 gives the nutrient requirements of soils of good, medium and low fertility status. Applications on a continuing basis are necessary for optimal economic production of most crops. However, for most of the farming households in the smallholder subsector, investment in soil fertility is low owing to financial constraints.

CHARACTERISTICS AND DISTRIBUTION OF FARMING SYSTEMS AND FARMING UNITS

Prior to 2000, there were four distinct farming systems or farming subsectors in Zimbabwe, determined by: agro-ecological factors, tenure systems, farm sizes, crop and livestock production systems, levels of technology use, management and income levels. The farming systems had also been determined by the political and historical development of the country during the 90 years of colonial and settler government. These systems were: communal lands, resettlement areas, small-scale commercial, and large-scale commercial (Table 5). The dominant subsectors, in terms of population size, area under production and agricultural output, were the large-scale commercial and the communal lands farming systems.

Table 6 shows the number of farming units and distribution patterns of agricultural land per farming subsector in each NR prior to the agrarian reform. In 1999, commercial farmers occupied about 12 million ha, communal farmers 16 million ha, resettlement farmers 3.6 million ha, small-scale commercial farmers 1.4 million ha and state farms 0.1 million ha. The smallholder subsector consists of the communal, resettlement and small-scale commercial farmers.

TABLE 5

Land tenure and characteristics of the farming systems

Farming system	Tenure and farming characteristics
Communal and resettlement	Communal land tenure, labour-intensive production system using ox-drawn implements, semi-commercialized
Large-scale commercial	Freehold title to land, highly mechanized, fully commercialized
Small-scale commercial	Leasehold title to land, labour-intensive production with little use of tractor-drawn implements, most production for the market

Source: Chenje, Sola and Paleczny, 1998.

The large-scale farms were located primarily in the areas of high agricultural and economic potential, in NRs I, II and III. One and a

TABLE 6

Major features of farming subsectors up to 1999

Item	Unit	Small-scale farms			Large-scale farms	
		Communal land	Resettlement area	Small-scale commercial	Private commercial	State
Farms/households	Thousands	1 500	56.8	8.5	4.8	0.06
Total land area	Million ha	16.34	3.29	1.38	10.74	0.42
Share of total agricultural land	%	50.8	10.2	4.3	33.4	1.3
Average farm size	ha	18	58	162	2 223	7 644
Average arable land size	ha	3–5	3–5	10–40	Highly varied	
NRs I & II	% of land	9	19	19	35	4
NR III	% of land	17	38	35	22	32
NRs IV & V	% of land	74	43	46	43	64
Irrigated area	'000 ha		7.2	3.6	126	13.5
National woodland area	%			21	44	35
Estimated population	Thousands	5 327	421	166	1 160	38
Population density	Persons/m^2	32.6	12.8	12.0	10.8	9.0
Cropping intensity	% planted area of total area	14.0	5.8	4.3	4.2	2.3
Stocking rates	ha/LU	5.5	8.2	6.4	9.3	

TABLE 7
A1 and A2 farming units created from acquired large-scale commercial farms, 2003

Province	A1		A2		A1	A2
	Farms (no.)	Area ('000 ha)	Farms (no.)	Area ('000 ha)	% of area	% of area
Manicaland	227	181	140	76	70.5	29.5
Mashonaland Central	344	382	295	200	65.6	34.4
Mashonaland East	358	291	350	251	60.9	39.1
Mashonaland West	573	684	424	452	56.4	43.6
Matebeleland South	246	846	65	187	81.9	18.1
Total	1 748	2 384	1 274	1 166		

Source: Government of Zimbabwe, 2003.

half million farming households in the communal lands farmed on about 49 percent of the country's agricultural land, of which more than 70 percent was in NRs IV and V. Thus, most of the communal lands are in the marginal agro-ecological regions. These are characterized by: (i) low rainfall, averaging 400–500 mm/year; (ii) severe dry spells in the rainy season; and (iii) shallow soils of low fertility. Such conditions are very marginal for the production of the major crops, even for drought-resistant grain crops such as sorghum and millets.

In the 1999/2000 season, the Government embarked on its agrarian reform programme. This entailed redistribution of land from the commercial farming subsector to new farmers. The Government moved to acquire 12.4 million ha of the 16 million ha in large-scale agriculture. This land came from 6 796 large-scale farms. Two new categories of farming subsectors were created, namely A1 and A2 farmers. A total of 127 192 households were settled under the A1 model, which consisted of demarcated villages with each household allocated five arable hectares and with communal grazing. The A2 model was based on self-contained farming units. A total of 12 943 individuals were allocated A2 model farms. Table 7 shows the number of farming units under each model per province as at March 2003.

In December 2000, the Government published Structural Instrument No. 288, which prescribed maximum farm sizes for all the NRs (Table 8).

TABLE 8
Farm classification and maximum farm size following the 2000 land/agrarian reform

Natural Region	Small-scale commercial farms	Medium-scale commercial farms	Large-scale commercial farms	Peri-urban commercial farms
	(ha maximum)			
I	15–25	100	250	
IIA	25–40	200	350	
IIB	40–50	250	400	15–50
III	60–80	300	500	
IV	150–200	700	1 500	
V	250–350	1 500	2 000	

Source: MLARS, 2000.

LANDHOLDING, LAND USE AND CROPPING PATTERNS IN COMMUNAL LANDS

Rainfall is the major determinant of the agricultural production patterns in Zimbabwe. Most crops are planted in November/December at the beginning of the rains and harvested between April and June. Winter wheat, barley and various horticultural products are grown in the dry season under irrigation. Irrigation schemes are also important in supplementing the production of wheat, tobacco, maize, cotton, soybeans, groundnuts and coffee.

The proportion of land allocated to food crops varies with the AEZ, availability or size of land, and farm productivity. In general, farm households in NRs II and III allocate 40–50 percent of the arable land under cultivation to food crops. The proportion rises to 60–70 percent in NRs IV and V.

Cropping patterns and land allocation to various crops within the communal area subsector by NR suggest the following salient features (Ashworth, 1990; Roth, 1990; Masters, 1991; National Early Warning, AGRITEX, 1994; MLAWD, 1993):

- Maize is a dominant crop across all AEZs, occupying 50–70 percent of the cropped area in NRs I, IIA, and IIB, and 40–50 percent of the cropped area in NRs III, IV and V.
- Cotton is dominant in NR III.
- Small grains, particularly sorghum and pearl millet, are dominant in NRs IV and V.

- Nationally, the major crops are maize, which occupies 45–50 percent of the cropped area, followed by pearl millet with 15–20 percent, sorghum with 10–15 percent and cotton with 7–10 percent.
- The dominance of maize and the small grains is a reflection of their importance as food crops for communal area households.
- Finger millet and sunflowers are widely grown in all NRs, except that the area of sunflower in NR I is relatively small, accounting for 2–4 percent of the cropped area. Finger millet is grown for home use while sunflowers are essentially a cash crop.

A comparative analysis of statistics on land allocated to each crop for the period 1980–1994 (National Early Warning Unit, AGRITEX, 1994) suggests:

- Maize area is fairly uniform across the communal areas in NRs IIA and IIB with an average of 1.75 ha. Maize areas are largest in relation to other crops in NRs IIA, IIB and III.
- Cotton areas are largest in relation to other crops in NR III.
- Small grains areas are largest in relation to other crops in NRs IV and V.
- Yields of all crops decrease from NR II to NRs IV and V.
- The relative ratio of land allocation per crop and yield suggests that farmers in NRs IIA and IIB have a comparative advantage in the production of maize and cotton. Farmers in NR III have a comparative advantage in the production of cotton followed by maize. For farmers in NRs IV and V, their comparative advantage is in the production of small grains.

Chapter 3
Soil fertility management

There has been much research on soil fertility management and enhancement on the basis of inorganic and organic fertilizers (Grant, 1967a, 1967b, 1981, 1995; Tanner and Mugwira, 1984; Mugwira and Mukurumbira, 1984; Mashiringwani, 1983; Piha, 1993; Mugwira and Murwira, 1997; Campbell *et al.*, 1998). The research has involved agronomic research on fertilizer types, application rates and timing of application for the different soil types, rainfall regimes and cropping and farming systems in all the NRs. The principal research organization has been the Agronomy Institute and the Chemistry and Soil Research Institute of the Department of Research and Specialist Services (DRSS). The research has been carried out in cooperation between the research institutes, farmers and the fertilizer companies. Farmers, particularly the large-scale commercial farmers, have also undertaken their own research. The research has resulted in the accumulation of considerable knowledge concerning the different fertilizers, application rates and timing. Chapter 6 discusses this information.

CATTLE MANURE AS A SOURCE OF NUTRIENTS

Cattle manure is a major fertilizer input for smallholder farmers on communal lands. The production and management of cattle manure follows a pattern common to all communal lands. Cattle are herded in grazing areas during the day and penned at night in cattle kraals (pens) located at the homestead. Manure that accumulates in the pens is dug out towards the end of the dry season. It is allowed to cure for up to three months and then spread on the fields in September/October, in time for land preparation for the next cropping season. When penned all day, one livestock unit (1 LU = 500 kg live mass) produces about 1.5 tonnes of recoverable manure per year (Rodel, Hopley and Boultwood, 1980). The amount of usable manure that cattle can provide depends on several factors such as the amount of feed, the feeding method (pen rearing, kraaling the animals at night or free range) and the manure collection efficiency. Cattle deposit a large amount of manure on the common grazing lands where it remains uncollected.

Since the early 1960s, several researchers (Grant, 1967a, 1967b, 1970, 1981; Tanner and Mugwira, 1984; Murwira, 1993; Murwira, Swift and Frost, 1995; Mugwira and Murwira, 1997; Nhamo, Murwira and Giller, 2001) have studied the value of cattle manure as a fertilizer compared with mineral fertilizers. The studies have included experiments comparing the ability of manure and inorganic fertilizers to restore and maintain soil productivity in nutrient-depleted or fallowed sands on communal lands. They have also investigated the best combination of manure and N fertilizer, the use of lime, manure and N and P fertilizers to restore the productivity of depleted sands on some communal lands (Grant, 1970, 1981). The general conclusion from these studies is that manure applied alone produces low crop yields and needs supplementing with inorganic fertilizers, particularly N, for optimal yields.

In 1962, the Agronomy Section of the Grasslands Experiment Station initiated a medium-term experiment to evaluate changes on sandy soils under continuous maize cultivation. The experiment involved annual applications of N, lime and manure treatments to maize grown continuously on granitic sand, a situation generally encountered on communal lands in NRs III and IV (Grant, 1967a, 1967b). On the basis of these trial results and other experiments, Grant (1981) observed that manure application to granitic sands overcomes or prevents deficiencies of micronutrients, including S, Mg, Zn and B, and enhances soil available N, P and K.

Quality and effectiveness of manure as a fertilizer

The quality and effectiveness of cattle manure on plant growth and crop yield has been the subject of extensive studies.

Mugwira and Murwira (1997) established that cattle manure from communal lands contains an average of 1.04 percent N, 0.15 percent P and 0.78 percent K compared with 1.87 percent N, 0.58 percent P and 0.78 percent K for manure from feedlots. According to Tanner and Mugwira (1984), cattle manure applied to fields in the communal areas has an N content that ranges from 0.5 to 1.4 percent of dry matter.

The N release is low and spread over time. Manure applications result in increases in pH, waterholding capacity, hydraulic conductivity and infiltration rates, and a decrease in bulk densities (Grant, 1967a, 1970; Murwira, Swift and Frost, 1995). Manure also has the long-term effect of raising the level of organic matter where applied in large quantities. The main determinants of the effectiveness of cattle manure as a fertilizer are its N content, location of N in organic fractions and its release, as well as the application rate.

Grant (1967b) notes that P, calcium (Ca), Mg, Fe, Zn and Cu contents are lower in manure from communal lands. However, applying manure on wetland soils may be inadequate because of its low P content. It would be necessary to apply supplementary P fertilizer. According to Mugwira and Mukurumbira (1984), the low nutrient content of the manure contributes to its limited effectiveness in improving plant growth and crop yield.

Grant (1967b) submits that, given that the manures are generally of low quality with a lot of sand and maize stover, the benefits from fertilizing with manure stem more from the bases released than from the supply of N and P. Grant (1967a) suggests that manure would not be an adequate source of N for high-yielding maize crops because of its inability to supply continuously large amounts of readily available N. Mugwira (1985) found that the supplementation of manure with mineral fertilizer applied separately was generally effective in enhancing the effectiveness of manures on communal lands.

Improving the effectiveness of manure and other options

Several trials have examined ways to improve the effectiveness of manure as a source of plant nutrients. The general observation is that farmers can use available organic matter (crop residues, weed biomass, and animal manure) more efficiently than at present. Mugwira and Mukurumbira (1984) suggested that cocomposting of manure with N and P nutrient sources in cattle pens would improve the low-nutrient manure. Suggested approaches for improving the manure include: (i) improving pastures by planting legumes in order to improve the dung quality; (ii) proper management of manures in cattle pens in order to decrease nutrient loss; (iii) storing manure in pits in order to minimize drying and leaching during hot and rainy days; and (iv) anaerobic treatment of the manure.

In 1996, the DRSS and the ACFD, with funding from the Rockefeller Foundation under the Soil Fertility Network, conducted a survey to assess traditional farmer manure-management practices on some communal lands. The management technologies identified as suitable for promotion included: the use of crop residues to absorb nutrients from urine; pit storage of manure combined with the use of crop residues in summer and winter to reduce drying and leaching in hot and wet periods; anaerobic treatment of manure; and the above-mentioned improvement of pastures by planting legumes that lead to better dung quality (Nzuma, Murwira and Mpepereki, 1998).

The ACFD has initiated a collaborative project that is using effective micro-organisms (EMs) that have the ability to fix N from the air and solubilize P, making it more available to plants. The micro-organisms can be used to inoculate composts and manure products.

Green manure

Since 1992, the Rockefeller Foundation, through the Soil Fertility Network, has funded on-farm green manure trials by the Farming Systems Research Unit (FRU) of the DRSS on several communal lands. The experiments have involved both food crops (cowpeas and soybeans) and forage legumes (velvet beans and sunhemp) intercropped or rotated with maize to improve soil fertility, reduce striga (witch weed) infestation and improve maize yield. The experiments have generally shown that green manures improve soil fertility and maize yields (Chibudu, 1998; Chivinge, Kasembe and Mariga, 2001; Hikwa and Waddington, 1998; Mapfumo and Giller, 2001; Muza, 2003). However, the use of green manures to improve the soil condition and fertility has declined to insignificant levels because of economic changes and fertilizer use.

The European Union, through the Institute of Environmental Studies at the University of Zimbabwe (UZ) and with the participation of the Soil Science and Agricultural Engineering Department at the UZ and the Southern African Development Community / International Centre for Research in Agroforestry (SADC/ICRAF), has supported on-farm trials on pigeon pea intercropped with maize and cowpea as a traditional legume. The farmers prefer a pigeon-pea crop that matures at the same time as most crops in order to avoid extra protection measures (Mapfumo *et al.*, 2000).

FERTILIZER-BASED SOIL MANAGEMENT PACKAGES

A fertilizer-based soil management package has been developed and promoted for variable rainfall regimes in communal areas in all NRs. The Rockefeller Foundation funded this initiative through the Soil Fertility Network with the participation of the Soil Fertility Network and the Department of Soil Science and Agricultural Engineering. The package includes application of mineral fertilizers at different rates at different growth stages of the plant, rather than at recommended application rates applied mainly at planting. An example is the split application of Compound D rather than the application of one dose at planting (Piha, Pangenyama and Tapfuma, 1995).

Previous research showed that soils of the marginal arid and semi-arid lands are generally deficient in N and that N supplementation is necessary in order to increase crop yields. However, as most small-scale farmers do not have adequate working capital to buy mineral fertilizers, biological nitrogen fixation (BNF) is considered an option (Mugabe, 1994). In Zimbabwe, the roots of non-leguminous crops are not colonized by N-fixing organisms and the Department of Crop Sciences of the UZ is experimenting with the use of bacterial inoculants to increase the N-fixing abilities of cereals. The work involves the use of gene-gun technology to transfer N-fixing genes to cereals. Mugabe (1994) remarks that while the potential of BNF to promote sustainable utilization of marginal lands and increasing crop yields at small-scale farms is recognized in Zimbabwe, policies on BNF research are yet to be developed. There is also limited government funding.

Other research has focused on mycorrhizal inoculation. Mycorrhiza is a fungal strain on plant roots that assists the plant to extract P and other micronutrients from the soil. The mycorrhiza used for the research was *Glomus* spp., which enhanced mycorrhizal inoculation and increased the dry weight of cowpea by 100 percent.

The soils of communal lands are generally low in P. Experiments have been carried out using a technique for improving the P content of manure (van Straaten, 1999; van Straaten and Fernandes, 1995). The work involves the pelleting of dust from phosphate rock deposits for easy handling in adding to the manure. This technique is also used for producing phosphate rock as a fertilizer for direct application and for incorporation in fertilizer mixtures. The technique is considered cheaper than that used to produce double and triple superphosphates.

Another practice that conserves soil and water and enhances soil fertility is conservation farming. This practice, refined and promoted by Oldrieve (1993), advocates minimum tillage and permanent surface cover by crop residues. The ACFD and a number of non-governmental organizations (NGOs) are promoting the practice in several communal areas.

Chapter 4
Fertilizer types, production and distribution

FERTILIZER TYPES

The straight N fertilizers used in Zimbabwe are ammonium nitrate (AN), urea, sodium nitrate, ammonium sulphate (AS) and calcium nitrate. The straight phosphate fertilizers are single, double and triple phosphates. The potash fertilizers are potassium chloride (KCl) and potassium sulphate (SOP – K_2SO_4). Tables 9 and 10 list the types and nutrient content of the fertilizers. Several fertilizers have been developed for specific crops or crops on specific soils, e.g. Sandy Maize fertilizer for maize grown in sandy soils.

The fertilizers are supplied in granular form and in bags. Bulk or liquid fertilizers are not used. The bag labels specify the content of N, phosphate (P_2O_5) and potash (K_2O). The analysis or grade refers to the percentage by weight of N, P_2O_5 and K_2O in that order. Thus, a 10–10–10 fertilizer contains 10 percent N, 10 percent P_2O_5 and 10 percent K_2O.

Table 11 gives statistics on the production, import, export and consumption of fertilizer nutrients from 1990 to 2002.

The country imports AS for the tea estates and sodium nitrate for tobacco. The horticultural industry started to import calcium nitrate fertilizer in 2002. All potash is imported.

PRODUCTION

There are four major fertilizer producers in Zimbabwe. Table 12 gives their production capacities.

Two companies are primary producers of AN and phosphates. They sell their entire production to two other companies that utilize it, together with imported intermediates, to blend and produce NPK granular compounds. The four companies are interdependent in that the

TABLE 9
Complex fertilizers used in Zimbabwe

Complex fertilizer	Nitrogen (N)	Citric-soluble phosphate (P_2O_5)	Potash (K_2O)		Min. sulphur (S)	Micronutrient Boron (B)	Micronutrient Zinc (Zn)	Main crop
	(%)							
A	2	17	15	K_2SO_4	10	0.1		Tobacco
B	4	17	15	K_2SO_4	9	0.1		Tobacco
C	6	17	15	11 as K_2SO_4, 4 as KCl	7.5	0.1		Tobacco
D	8	14	7	KCl	6.5			Maize, general
J	15	5	20	KCl	3.4	0.04		Coffee, fruit trees
K	4	10	22	KCl	6.5	0.2		Cotton
L	5	18	10	KCl	8	0.25		Cotton
M	10	10	10	KCl	6.5			Maize, general
S	7	21	7	K_2SO_4	9	0.04		Tobacco, potatoes, maize
T	22	6	10	2 as K_2SO_4, 8 as KCl	3.5			Tea
V	4	17	15	11 as K_2SO_4, 4 as KCl	8	0.1		Tobacco
X	20	10	5	KCl	3			Lawns, gardening
Z	8	14	7	KCl	6.5		0.8	Maize

granulation technology and processes used are designed to utilize AN and superphosphates produced in Zimbabwe (Kachere, 1996).

There are a number of emerging fertilizer manufacturers. In the late 1990s, three companies commissioned bulk-blending plants and they now have a combined market share of 15 percent (Kachere, 2002). Another company manufactures a range of compounds and straights including calcium nitrate. There is a factory producing organic fertilizers that is also working on producing slow-release urea. Another company has fertilizer-blending equipment and has plans to harness natural gas in the Zambezi Valley for manufacturing N fertilizers.

Zimbabwe produces ammonia (through the electrolysis method) and AN. The country's AN plant has the capacity to produce 250 000 tonnes/year. This capacity requires 115 000 tonnes of ammonia, 40 000 tonnes being imported (from South Africa) (FAO & ACFD, 1999).

TABLE 10
Fertilizer types used in Zimbabwe – blends, straights and others

Specially blended fertilizers	Nitrogen (N)	Citric-soluble phosphate (P_2O_5)	Potash (K_2O)	Minimum sulphur(S)	Boron (B)	Zinc (Zn)	
	(%)						
Blends							
All Crop blend	13	13	10				All crops
Coffee blend	17	5	20				Coffee
Lawn blend	25	5	5				Lawns
Maize blend	8	16	8				Maize
Maize blend	7	14	7				Maize
Paprika blend	5	20	15				Paprika
Potash blend	5	15	22				
Sandy Maize blend	7	14	7			10	Maize on sandy soils
Tea blend	17	5	20				Tea
Tobacco blend	5	20	17				Tobacco
Tobacco blend	7	20	17				Tobacco
Tobacco blend	6	15	12				Tobacco
Tobacco seedbed blend	7	21	18				Tobacco seed beds
Straights							
Nitrogen							
AN	34.5						
AS	21			27			
Sodium sulphate	16						
Urea	46						
Phosphate							
Double superphosphate		38		12			
SSP		19		5			
TSP							
Potash							
MOP			60				
SOP			50	16			
Gypsum							
Calcium sulphate				17.5			
Solubar					17		Eucalyptus
Other fertilizers							
Grain blend	8.3	16.5	7	8.3		0.3	Grain crops
Limestone AN	28						Grain crops
Omnia supers	3.4	24.1		11		0.5	
Vegetable blend	6.3	20	17.3	5.8	0.09	0.3	Vegetables

Source: Windmill Private Limited, 1999; Zimbabwe Fertilizer Company, 1999.

Phosphate fertilizers are produced locally. The phosphate rock for the production of phosphate fertilizers comes from the Dorowa mine. The processed phosphate products are phosphoric acid, DAP, MAP and superphosphate (single, double or triple superphosphate). Half

TABLE 11
Production, import, export and consumption of fertilizer nutrients

Year	Nitrogen				Phosphate				Potash
	Production	Imports	Exports	Consumption	Production	Imports	Exports	Consumption	Imports
	('000 tonnes nutrients)								
1990	83.3	7.2	0.7	95.0	42.3	6.7	1.7	41.6	32.5
1991	82.7	4.7	1.2	89.8	43.3		1.5	43.2	34.0
1992	66.6	4.8	2.8	57.6	45.9		3.3	34.6	39.5
1993	81.8	2.0	2.7	82.1	38.5	1.8	1.0	46.1	45.1
1994	94.0	10.4		92.9	42.0	3.0		42.3	49.9
1995	80.7	7.9	0.7	76.0	40.0	2.4		38.0	23.2
1996	86.0	30.6	2.1	94.0	36.0	2.4		37.0	48.2
1997	88.4	26.9	6.0	94.0	33.0	19.8	3.0	44.0	40.6
1998	74.1	24.1	3.2	95.0	35.5	6.3	2.0	42.0	40.0
1999	86.0	29.7	1.9	100.0	38.0	5.1		43.0	42.4
2000	71.4	21.4		87.4	30.0	14.5		43.4	34.6
2001	59.5	22.9		82.0	26.1	11.5		35.0	35.2
2002	61.1	6.94	1.6	60.0	38.3	1.4	0.6	30.0	19.4

Source: FAOSTAT.

TABLE 12
Products and production capacities

Product	Production capacity ('000 tonnes/year)
AN	250
NPK	350
NPK	350
Phosphate fertilizers	65
SSP	200
TSP	60

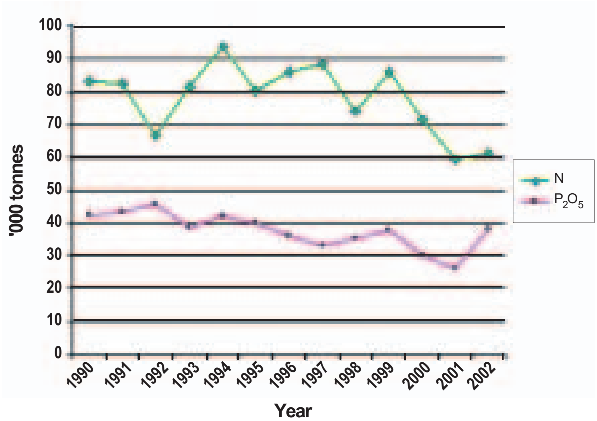
Source: FAO & ACFD, 1999; Mashingaidze, 2004.

of the elemental S for the production of sulphuric acid for manufacturing SSP comes from Canada. Zimbabwe imports all its potash, about 100 000 tonnes/year. Zimbabwe has traditionally been an exporter of fertilizers in the SADC region.

The fertilizer manufacturers have been operating below capacity since the mid-1990s. Figure 3 illustrates the trends in the production of N and P_2O_5 in the period 1990–2002. It shows a major decline in production between 1992 and 2002.

Several factors contributed to the fall in the production of fertilizers. There was a general shortage of foreign currency. This curtailed the importation of raw materials such as ammonia, potash and others. The shortage of foreign exchange also resulted in fertilizer manufacturers being unable to import equipment and machinery for maintaining, refurbishing and replacing production plants. This problem was compounded by high repair and maintenance costs caused by high

FIGURE 3
Fertilizer production trends, 1990–2002



inflation and interest rates since 2002, and the high cost of foreign exchange sourced in the "black market". High inflation increased the costs of electricity and transport.

These production problems were exacerbated by reduced fertilizer demand caused by the decline in the purchase and use of fertilizers by farmers. This in turn was made worse by government-imposed price controls on the wholesale and retail fertilizer prices, while raw material prices remained uncontrolled. The fertilizer manufacturers were not able to take advantage of more remunerative export markets owing to restrictions on exports imposed by the Government in order to reserve the sale of the fertilizer products for the domestic market.

Another problem facing the fertilizer companies was the inability of the National Railways of Zimbabwe (NRZ) to move raw materials from outside and within the country in a timely manner. The inability of the NRZ to move raw material from the Dorowa mine to the factory in Harare reduced the output of phosphate fertilizers severely. Dorowa's phosphate rock capacity is estimated at 150 000 tonnes/year. However, in 2000 it produced only 110 000 tonnes of phosphate rock concentrate because of transport constraints.

The restricted supply of raw materials to the fertilizer manufacturers resulted in their running behind schedule for most of the 2000–04 period.

In the period 2001–04, an input supply scheme for resettled farmers was implemented. The fertilizer companies were committed to supply in accordance with a government order. In some cases, this resulted in a supply shortage for fertilizer sold on the open market. Because of production problems, there were also delays in supplying government orders.

Because of the lack of foreign exchange to import anhydrous ammonia from South Africa, N-fertilizer output in 2002/03 was about 50 percent of normal. Apart from the foreign exchange shortage, it became uneconomic to import the anhydrous ammonia as the controlled price of urea was set at a level below landed cost. Another problem facing the production of ammonia and AN is the potential shortage and ever-increasing cost of electricity.

DISTRIBUTION AND MARKETING

The two companies that produce fertilizer compounds and blends in Zimbabwe distribute their compounds, straights and blends to wholesalers and retailers, who constitute the dominant marketing channels for fertilizers. The other distribution channel is the public-sector input support scheme through which the State purchases fertilizers for distribution to farmers.

Large agrotraders, including farmers' buying cooperatives and syndicates or input-buying clubs, obtain stocks from the producers for onward sale to farmers. Individual farmers and agrosupply retailers also buy fertilizers directly. Entry into and exit from the sector is easy. There are no legal restrictions on the types and numbers of marketing channels.

In the smallholder subsector (mainly communal lands and resettlement areas), the supply of inputs is mainly through general dealers and small agrodealers. These operators have the advantage of proximity to the farmers.

Some private-sector agrofirms involved in buying tobacco, cotton and sorghum have their own input support or loan schemes through which they acquire fertilizer for distribution to the producers of the relevant commodities. The farmers reimburse by selling their commodities to the companies.

A number of non-governmental community development organizations, Care International, World Vision and Citizens Network for Foreign Affairs working with the ACFD ran a programme for training and establishing agrodealers in smallholder areas. About 2 000 dealers were trained in the basic principles of storing, retailing, pricing and service.

PUBLIC-SECTOR DISTRIBUTION CHANNEL SYSTEM

The government agencies involved in fertilizers include agricultural extension departments and parastatals, the Grain Marketing Board (GMB) and the Agricultural and Rural Development Authority (ARDA). The GMB is responsible for the importation, storage, transport and wholesaling of the main foodgrains, i.e. maize and wheat. The ARDA is responsible for running State farms as well as promoting rural and agricultural development through infrastructure support and development. These channels are used by the Government to supply subsidized fertilizers, seeds and other inputs to smallholders on communal lands, resettlement areas and to A1 and A2 farmers in the new farming areas. Because of bureaucratic ordering and distribution processes and the limited amount of money, not all farmers are able to access fertilizers in a timely manner through this system. However, the major problem has been the failure by some of the farmers to repay the sums they have borrowed.

COOPERATIVES

After achieving majority rule in 1980, the Government promoted the establishment of input supply and production cooperatives. However, very few input supply cooperatives are currently functioning.

THE ROLE OF THE GOVERNMENT IN PROMOTING FERTILIZER SUPPLY AND USE

The Government of Zimbabwe has established some measures for promoting the supply and use of fertilizers. These include:

- price controls fixing the maximum wholesale and retail prices for agricultural inputs;

- subsidized credit scheme for input purchases;
- crop input schemes providing seeds, fuel and fertilizers to smallholder farmers;
- support for the agro-input dealer programmes.

CONSTRAINTS AND CHALLENGES OF FERTILIZER DISTRIBUTION IN ZIMBABWE

A major constraint facing distributors is the above-mentioned general shortage of fertilizers. The shortage is in terms of both absolute quantities and timing. Some fertilizers arrive well after peak application time. The distributors then have to carry over large unpurchased stocks. Another problem concerns the price controls. These result in reduced profit margins, particularly for rural traders who face high transportation costs. The Government input schemes through which fertilizers are provided to farmers through the GMB and other government agencies also have an adverse impact on agrodealers as they reduce the quantities purchased from the dealers. A further constraint is the lack of storage capacity among small agrodealers.

Chapter 5
Fertilizer consumption

Until 1999, the large-scale commercial farming subsector accounted for most of the fertilizer consumption. The $N:P_2O_5:K_2O$ ratio was 1.0: 0.55:0.43 in the commercial farming subsector and 1.0:0.51:0.18 in the communal subsector (Table 13).

The application rates in the large-scale commercial farming subsector were comparable with those in developed countries. The application rates in the smallholder subsector were and have remained much lower (Table 14).

The disparity in fertilizer use between the different farming sectors indicates a large potential for increased fertilizer use in the smallholder subsector.

Statistics on fertilizer use by farming subsector for the period 2000–04 are incomplete and could be misleading owing to a number of factors, for example:

TABLE 13
Consumption of fertilizer products by farming sector

Nutrient	Large-scale commercial		Smallholders		Total		Large-scale commercial	Small-holders
	('000 tonnes)	(%)	('000 tonnes)	(%)	('000 tonnes)	(%)	(%)	(%)
N	70.8	51	19.9	65	90.7	53	78	22
P_2O_5	38.7	28	7.0	23	45.7	27	85	15
K_2O	30.5	22	3.8	12	34.3	20	89	11
Total	140.0	100	30.7	100	170.7	100	82	18

Source: ACFD, 1996.

TABLE 14
The market shares of the farming subsectors

Subsector	Percent of fertilizer market (product)	No. of farmers	Average fertilizer order	Average fertilizer application
	(%)	('000)	(tonnes product)	(kg NPK/ha)
Large-scale commercial	81	2.5	165	290
Communal lands	17	850.0	0.1	15
Small-scale commercial	2	12.0	0.8	33

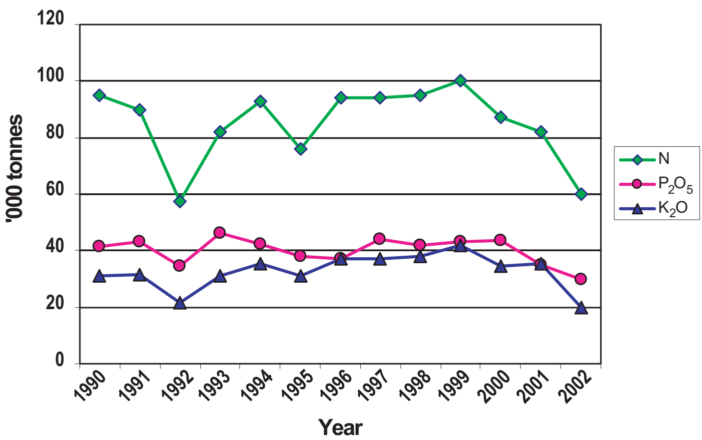
- As a result of the agrarian and land reform programme, large-scale commercial agriculture as it was before 2000 has disappeared. There are few statistics on fertilizer use by new farmers who have moved onto the former commercial farms.
- The Government input schemes could distort the actual use by the farming sectors. Some of the fertilizers intended for the smallholder subsector find their way to medium-scale commercial farmers.

TRENDS IN FERTILIZER CONSUMPTION

Aggregate figures for fertilizer consumption show an overall decline since 2000 (Figure 4).

The average annual fertilizer consumption in the period 1989–1994 was 463 589 tonnes. Consumption of N fertilizers in 1990 was 94 985 tonnes N, falling to 76 000 tonnes N in 1995. Consumption then rose to 100 000 tonnes N in 1999 before declining again to 60 000 tonnes N in 2002. The decline was in terms of both absolute levels (tonnes of fertilizer consumed) and rates of use (kilograms per hectare of arable land).

FIGURE 4
Fertilizer consumption trends, 1990–2002



Source: FAOSTAT.

FACTORS AFFECTING FERTILIZER USE BY FARMERS

Fertilizer use in the large-scale commercial farming subsector declined sharply between 2000 and 2004, the production of the major cash crops such as tobacco, cotton and soybeans being disrupted by the agrarian reform programme (Mashingaidze, 2004). Crop production by the new farmers who took over the land from white commercial farmers remains depressed at a level well below that of the former farmers. The majority of the A2 farmers had not begun production by 2003. A significant number of A1 farmers were farming with reduced levels of fertilizer use.

Fertilizer consumption by smallholders is low and variable because of several economic, political, technical and institutional factors (Bhondayi, 2004; Kanyoka, 2004; Madzara, 2003; Magara, 2002; Mangoti, 2002; Mashavave, 2003; Murwira, 1995; Nhemachena, 2004; Ngulube, 2000; Zimbabwe Farmers' Union, 2002; Zinyama, 2003). These include the poorly developed marketing system, which results in fertilizers often being unavailable to farmers when they need them. Most smallholders have to travel long distances to purchase fertilizer. The increases in rural bus fares as a result of fuel price increases since 2001 have made the purchase of fertilizers in urban centres expensive. Fertilizers in local shops tend to be more expensive as dealers increase their margins to cover their transaction. Prior to 2001, most fertilizers were sold in 50-kg bags but many farmers needed to buy in smaller quantities of 5 kg and 10 kg.

It is estimated that only one-fifth of smallholder farmers use fertilizers. One factor is the non-availability of finance as the demand for fertilizer is heavily dependent on the availability of credit and cash. The majority of smallholder farmers on the communal lands and resettlement areas and the new farmers lack the finance to purchase and use adequate fertilizer levels. In the period immediately after majority rule in 1980, the availability of subsidized credit and cash income from the sale of food and cash crops drove smallholder fertilizer demand. Fertilizer was affordable because producer prices were high in relation to the fertilizer prices. According to the Zimbabwe Farmers' Union (2002), smallholder farmers then reduced their fertilizer procurement following the Structural Adjustment Programme in 1990 as a result of the increase in the prices of fertilizer and other inputs.

A third factor is inadequate extension advice from fertilizer dealers, leading to suboptimal utilization of fertilizers and, hence, suboptimal yields.

Fertilizer use is a risky investment on most communal lands because of the low and unevenly distributed rainfall and dry spells at the critical time for fertilizer application (first eight weeks of crop establishment).

The Government input support and distribution schemes sometimes work to the disadvantage of farmers who depend on the market for their fertilizer and inputs. In 2002, 2003 and 2004, the Government's tender for the acquisition of seeds and fertilizers from producers/manufacturers led to a shortage of the inputs on the open market. In response, prices rose on the black market.

MAIZE RESPONSE TO FERTILIZER APPLICATION

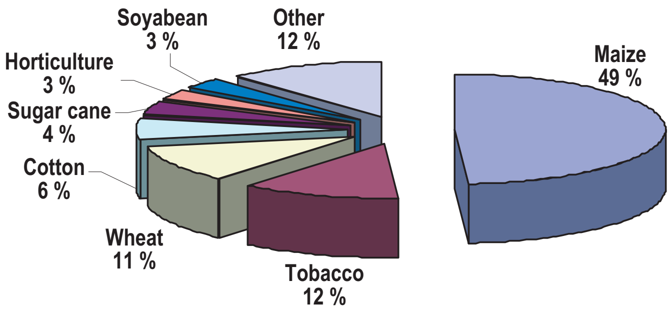
Table 15 shows the maize response to fertilizer application and the increase in maize yield through mineral and organic fertilizers. According to Shamudzarira and Robertson (2002), maize grain yield responses to varying quantities of applied N on a typical low fertility soil, based on on-farm and on-station results, range from 0 to 2 000 kg/ha with an average of 500 kg/ha. The results also showed that in one season out of five there was no benefit from applying mineral fertilizers on soils of low fertility and in the low rainfall zones (Shamudzarira, 2003). However, results from simulated maize yield responses to an application of 10 kg N/ha indicated

TABLE 15
Maize response to fertilizer application

Cattle manure	Fertilizer	Yield				Combination yield over control
		Control	Organic fertilizer only	Mineral fertilizer only	Combination	
(tonnes/ha)[1]	(kg/ha)	(tonnes/ha)				(%)
13–25	112 N 17 P_2O_5 16 K_2O[2]	0.79	1.11	1.30	1.93	160

[1] Manure broadcast and ploughed in before planting.
[2] Potash split between basal and top-dressing.
Source: Shamudzarira and Robertson, 2002.

FIGURE 5
Fertilizer use by crop



Source: Mashingaidze, 2004.

that responses to low rates of N would generally be greater on low fertility soils than on high fertility soils (Mukurumbira, 1985; Shamudzarira and Robertson, 2002).

FERTILIZER USE BY CROP

Figure 5 shows the proportions of fertilizers used on each crop. These statistics relate to the period before 2000. Maize accounted for almost half of the fertilizer consumed in the country, followed by tobacco and wheat. The production of the major cash crops, such as tobacco, cotton and soybeans, and the associated fertilizer use declined sharply in the period 2000–04, when large-scale commercial farming was disrupted by the agrarian reform programme.

Chapter 6
Fertilizer-use recommendations

GENERAL FERTILIZER RECOMMENDATIONS

Table 16 gives the general fertilizer recommendations for crops grown in communal areas.

The recommendations in Table 17 are blanket recommendations that need to be adapted to local conditions. The recommendations are for normal rather than low yields, on soils of medium fertility. Table 17 shows recommended rates according to the yield level in different AEZs.

Maize

Maize is the main staple food in Zimbabwe. The crop is cultivated in all five NRs, NRs II and III accounting for about 84 percent of total maize production. NR IV has the largest area under maize but its yields are lower than those in NRs II and III. Under Zimbabwean conditions, maize generally requires 67 kg N/ha, 30 kg P_2O_5/ha and 11 kg Ca/ha. Compound D fertilizers and AN are the most commonly used fertilizers on maize. Prior to 2000, maize accounted for one-third of the fertilizer applied in the large-scale commercial subsector and 90 percent of fertilizer use in the smallholder subsector.

Soybeans

Soybeans require a deep, fertile soil with high Ca content. They thrive on light soils, provided these contain sufficient nutrients. Soybeans absorb considerable quantities of nutrients from the soil. It is advisable to apply a light dressing of *Rhizobium* inoculant at sowing. The inoculant is produced at Morondera. Liberal application of phosphate accelerates ripening. Soybean removes nutrients from the soil at a rate of 60 kg N/ha, 35 kg P_2O_5/ha and 80 kg K_2O/ha. The crop needs 250 kg/ha of Compound L at planting (AGRITEX, 1982).

TABLE 16
Fertilizer recommendations, application rates and timing

	At planting		Top-dressing	Timing	Remarks
	Compound	Rate	Rate		
Cabbage	L	500 kg/ha	AN: 200 kg/ha	Split at 3 and 6 wap[1]	Best top-dress is (kg/ha): 100 AN 100 J
Citrus	Z	400 g/tree	J: 800 g/tree AN: 200 g/tree	According to age	Fertilizer according to yield
Cotton	L	300 kg/ha	AN: 200 kg/ha	At 8 wae[2] or flowering	Extra 50–100 kg/ha AN for irrigation
Cowpea (*nyemba*)	D	150 kg/ha	Nil	or 100 J at 6 wap[1]	J on poor sandy soils
Finger millet	D	150 kg/ha	AN: 100 kg/ha	4–6 wae[2]	
Fruit trees	Z	400 g/tree	J: 300 g/tree	In split applications	Increase fertilizer according to age and yield
Groundnuts	L	300 kg/ha	Gypsum: 150 kg/ha	Over plants at pegging	
Maize	D or Z	300 kg/ha	AN: 250 kg/ha	Split at 3 and 6 wae[2]	Z one year in three
Onions	C	1 000 kg/ha	AN: 150 kg/ha	3–4 wap[1]	
Pearl millet	D or Z	200 kg/ha	AN: 150 kg/ha	At 6 wae[2]	
Potatoes	S	1 000 kg/ha	AN: 150 kg/ha	2–3 wae[2]	
Rape	C	500 kg/ha	AN: 200 kg/ha		Extra 100 kg/ha C and AN after 6 months
Sorghum	D or Z	250 kg/ha	AN: 200 kg/ha	4–6 wae[2]	Best on clay soils
Soybean	L	250 kg/ha	Nil		Inoculants needed
Sugar beet	Z	300 kg/ha	AN: 200 kg/ha	at 4 wae[2]	Lime 3 weeks before planting. Do not apply boron
Sunflower	L	250 kg/ha	AN: 150 kg/ha	at 6 wae[2]	Boron essential
Tobacco (barley)	B	700 kg/ha	AN: 300–400 kg/ha	Half at 3 and 5 wap[1]	
Tobacco (flue cured)	B, V or C	600–700 kg/ha	AN: 100–150 kg/ha	at 3 wap[1]	
Tobacco (seed beds)	S	150 g/m^2	Sodium nitrate: 10–20 g/m^2	At 4 wae[2]	
Tomatoes	B	1 200 kg/ha	AN: 150 kg/ha MOP: 100 kg/ha	Every 2 weeks after first fruit	J is good for top-dressing
Vegetables	C	600 kg/ha	AN: 200 kg/ha	Half at 3 and 6 wap[1]	J is good for top-dressing

[1] wap = weeks after planting.
[2] wae = weeks after emergence.
Source: Zimbabwe Fertilizer Company Limited.

TABLE 17
Fertilizer rates for crop yield in various agro-ecological zones

Crop	Expected yield level (tonnes/ha)	Product	Recommended rate (kg/ha)
Maize NR I, IIA, IIB	3.0	Compound D	250
		AN	100
Maize NR III, IV	2.0	Compound A	200
		AN	100
Cotton NR IIA, IIB	1.5	Compound L	300
		AN	100
Cotton NR III, IV	0.8	Compound L	200
		AN	100
Sunflower NR IIA, IIB	0.8	Compound L	100
		AN	50
Sunflower NR III, IV, V	1.0	Compound L	50
		AN	50
Groundnuts NR I/IIA, IIB/III & III	0.8	SSP	200
		Gypsum	200
Sorghum (white) NR III, IV, V	0.8	Compound D	50
Rapoko NR III, IV, V	0.8	Compound D	50
Pearl millet	0.8	Compound D	50
Soybeans in NR I/IIA, IIB	1.0	Compound D	50

Source: Piha, 1995.

Groundnuts

Groundnuts are produced mostly by small-scale farmers in communal areas. As an N-fixing crop, groundnuts supply N to the soil. Groundnuts need 300 kg/ha of Compound L at planting and a top-dressing of gypsum fertilizer at a rate of 150 kg/ha. Groundnuts take up nutrients at the following rates: 105 kg N/ha, 15 kg P_2O_5/ha, 27 kg Ca/ha, 18 kg Mg/ha and 42 kg K_2O/ha (AGRITEX, 1982).

Wheat

Wheat requires a relatively large supply of readily available nutrients because the vegetative period is shorter under tropical conditions than in temperate regions. The amount of available N has the greatest effect on yield. The most commonly used fertilizers for wheat are Compound D and AN. Phosphate stimulates early root development and hastens maturity. Wheat is grown mainly under irrigated conditions in the dry winter period. Where rotated with soybeans, the wheat benefits from residual N from the soybeans. The required fertilizer rates vary with soil type, land history, variety and climate. Wheat removes nutrients from the soil at the following rates: 94.5 kg N/ha, 75.5 kg P_2O_5/ha and 66.5 kg K_2O/ha (AGRITEX, 1982).

TABLE 18
Cotton fertilizer rates for various yield levels

Expected yield (kg/ha)	Optimal nitrogen application
1 000	15
1 500	30
2 000	45
2 500	60
3 000	75
3 500	90

Source: AGRITEX, 1982.

Cotton

The most commonly used fertilizers for cotton are Compound L and AN. Smallholders apply 8 percent of their fertilizer on cotton. The ratio of Compound L to AN on cotton is about 1:1. Table 18 gives the average fertilizer N requirements at different expected yield levels for seed cotton.

Tobacco

Tobacco is a major cash crop, grown by both smallholders and large-scale farmers. Smallholders grow the crop under dryland conditions, while it is both a dryland and an irrigated crop in the large-scale farming systems. Tobacco grows best on sandy soils. Fertilizers used for tobacco include Compounds A, B and C. The P_2O_5 and K_2O contents in the three fertilizers are the same. National application rates in the large-scale commercial sector averaged 764 kg/ha, while smallholders applied 1 percent of their fertilizers on tobacco.

Sugar cane

The main fertilizers for sugar cane are AN (which accounts for 65 percent of the fertilizers used on the crop), SSP (20 percent), muriate of potash (MOP) (9 percent), and Compounds D (4 percent) and M (2 percent). NR V produces the bulk of Zimbabwe's sugar cane, under irrigation. Fertilizer application rates in NR V are relatively high.

Chapter 7
Economics of fertilizer use

Table 19 shows the trend in ratios of crop prices to fertilizer prices based on the prices of compound fertilizers for maize, cotton, wheat and soybeans and of AN for maize and wheat.

Until 2000, the free market determined the prices of grain crops (maize, wheat and sorghum), and there was an active agricultural commodity market, the Zimbabwe Agricultural Commodity Exchange (ZIMACE). However, in July 2001, the Government imposed price controls on maize and wheat and their products, with the GMB as the sole buyer and seller of maize and wheat. The situation became difficult for farmers because of the high transaction costs caused by poor roads, lack of transport and delays at the marketing points, especially at the GMB depots. These costs, coupled with suboptimal prices, especially of maize and cotton, made fertilizer use unprofitable for many farmers.

The prices of the inputs were market-determined until 2002. In 2003, the Government imposed price controls on agricultural inputs, including fertilizers, through the Ministry of Commerce and International Trade. Table 20 shows the controlled prices of a selection of fertilizer types in 2004.

The impact of price controls, together with the fall in fertilizer production (Chapter 4), reduced the supply of fertilizers and other inputs on the open market. The shortage of supply in relation to demand led to a black market emerging where farmers paid prices that were well above

TABLE 19
Trends in crop:fertilizer price ratios of major crops

	Crop:compound price ratio				Crop:AN price ratio	
Average of years	Maize:D	Cotton:L	Wheat:D	Soybean:L	Maize:AN	Wheat:AN
1990–92	0.44	0.21	0.86	0.79	0.46	0.92
1997–99	0.94	0.26	1.09	1.4	0.71	1.00
2002–04	0.66	1.18	0.91	1.11	0.9	1.26

Source: Commercial Farmers' Union, 2000; AREX, 2000–04.

TABLE 20
Controlled prices of selected fertilizers in 2004

Fertilizer	Producer	Wholesale	Retail
	(thousand ZWD/tonne)[1]		
AN	1 185	1 244	1 369
AS	1 682	1 766	1 943
Compound A (2–17–15)	1 998	2 098	2 308
Compound B (5–24–15)	2 358	2 476	2 723
Compound C (5–22–18)	2 333	2 450	2 695
Compound D (7–16–5)	1 585	1 665	1 831
Compound J (14–6–20)	1 776	1 813	1 994
Compound L (4–17–11)	1 773	1 861	2 047
Compound S (7–21–7)	1 943	2 040	2 244
Gypsum	425	446	491
MOP	2 169	2 277	2 506
SOP	2 800	2 940	3 234
Urea	1 685	1 769	1 946

[1] Exchange rate: US$1 = ZWD5 200 (as at September–December 2004)
Source: Ministry of Commerce and International Trade, 2004.

the stipulated controlled prices. For example, in January 2005, a 50-kg bag of Compound D was selling at ZWD120 000 while the official retail price was ZWD91 557. While the official retail price of AN was ZWD68 482 per 50-kg bag, it was selling at ZWD200 000–250 000 per 50-kg bag on the black market. Farmers had to travel to Harare in an attempt to purchase the fertilizer.

Other factors determining the profitability of fertilizer use varied with the farming subsector. In the large-scale farming subsector, the main determinant was the ability of farmers to procure fertilizer early in the year, around June/July, prior to the fertilizer price adjustment for the following season. The farmers reduced transaction costs through bulk buying and using their own transport. The large-scale farmers had appropriate equipment for precise and timely fertilizer application. The rates applied were based on individual soil analyses. The shortages and price increases had a negative impact on fertilizer use in the smallholder subsector, which tends to buy fertilizer as the need arises.

Studies on the economics of fertilizer use in the smallholder subsector have given variable results but generally show suboptimal returns owing to suboptimal application rates. This is attributed partly to farmers not applying recommended rates owing to their inability to purchase the full quantity of the required fertilizers. However, even where farmers applied fertilizer according to the general recommended rates, they were often underapplying them owing to a lack of information on their specific requirements.

The Annex to this report summarizes a number of studies on the economics of fertilizer use and on factors determining the economics and use of fertilizers in smallholder farming.

Chapter 8
Future prospects

In the smallholder subsector on the communal lands and resettlement areas, there is a need to increase land and labour productivity and to intensify production in order to ensure household food security and produce an income.

Increases in a crop production in the past two decades have resulted largely from an expansion in area rather than increases in land and labour productivity. Crop yields remain low compared with the potential in the different AEZs and with the yields of the same crops obtained in the large-scale farming subsector.

The regular application of fertilizers is necessary for the optimal economic production of most crops. However, since the start of the structural reform programme in 1990, fertilizer use in the smallholder subsector has declined owing to increased fertilizer prices and financial constraints. The inadequate level of investment in soil fertility is leading to land degradation.

Smallholder farmers account for only one-fifth of total fertilizer demand. There is ample scope for increased demand from this subsector both by those farmers already using fertilizer increasing their rates of application and by others adopting fertilizer use.

There will be an expansion of arable agriculture in the farming subsectors created as a result of the land and agrarian reform programme. However, the total fertilizer demand from the new farming subsectors may remain below that of the former large-scale farmers if the rates of application and the area of land under crop remain lower than that of the former large-scale producers.

Provided the above issues are addressed, the prospects for increased fertilizer use are favourable. However, there are a number of major constraints on fertilizer use. These include:

- Availability and affordability of the fertilizers to farmers. Improved arrangements for the financing of farmer credit are indicated.

- Access to fertilizers. Fertilizers and other inputs (such as seeds and agrochemicals) should be more readily available in the farming areas.
- Supply of fertilizers. This needs to be increased. As observed by Mashingaidze (2004), foreign exchange and credit facilities are needed for the importation of improved fertilizer production technologies, enabling them to rehabilitate current fertilizer manufacturing plants and invest in new fertilizer manufacturing facilities.
- Competition. There is a need to promote a more competitive environment for fertilizer supply.
- Price controls. Governmental price control of fertilizers needs reviewing as it does not assist the intended beneficiaries, i.e. smallholders. Price controls create opportunities for corrupt officials to sell fertilizer at prices above the level of a competitive market.

In a study on persuading farmers to use fertilizers, Rusike and Dimes (1993) highlighted the following factors:

- More precise weather forecasts concerning rainfall would enable farmers to better assess the risks of fertilizer use.
- Farmers need more precise guidance on fertilizer use than provided by the current standard or blanket recommendations.
- Selling fertilizers in small packs would encourage wider use by farmers.
- The supply of other inputs (e.g. seeds) should be linked to that of fertilizers.

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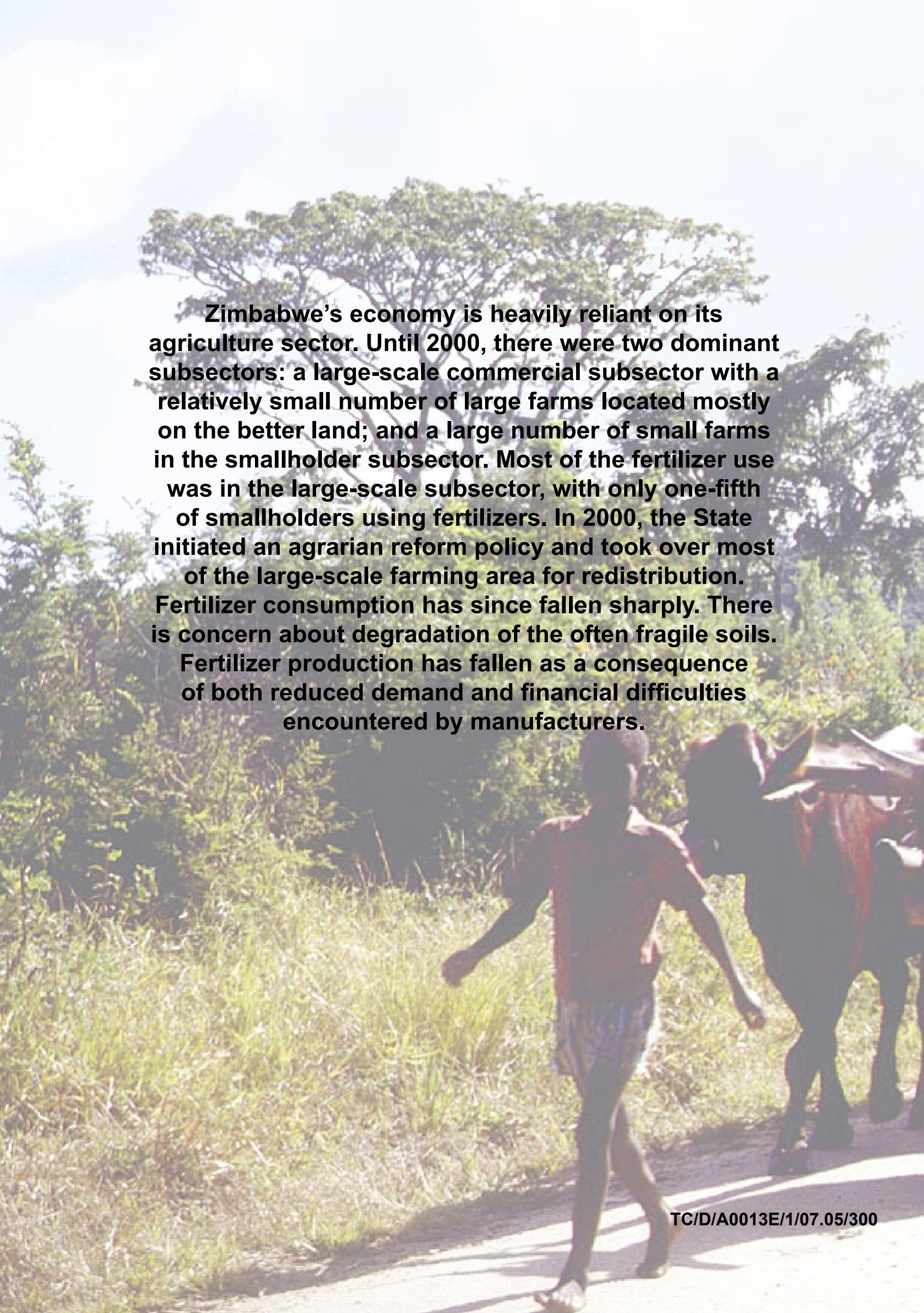
Annex
Summary of studies on factors determining fertilizer use in the smallholder farming subsector of Zimbabwe

Year	Researcher	Study	Main findings
2004	E. Bhondayi	An investigation of the determinants of fertilizer use by communal farmers in drought-prone areas of Zimbabwe. A study of Buhera District.	Fertilizer use depends on various socio-economic characteristics: arable land size, household income, distance to input purchasing point, fertilizer price and transport cost.
2004	P. Kanyoka	A comparative socio-economic assessment of the factors affecting utilization and returns to the use of organic and inorganic fertilizer in the smallholder sector. A case study of Zimuto Communal Area.	Socio-economic factors affect the intensity of soil-fertility management technologies application. Factors affecting adoption: age, education, income, access to extension services, cattle ownership, arable land, credit access, farmer group membership.
2003	M.J. Madzara	Will smallholders in semi-arid areas of Zimbabwe invest in inorganic fertilizer? A case study of determinants of fertilizer use in Gwanda and Tsholotsho.	Farmers with knowledge of soil-moisture conservation techniques used fertilizers more than those without such knowledge. Farmers favoured fertilizers supplied in smaller packages of 10 and 15 kg.
2003	T.C. Mashavave	Economics of fertilizer use for maize production by smallholder farmers in the drought-prone areas of Zimbabwe: The case of Shurugwi Ward 5- Mfiri.	Fertilizer use is associated significantly with socio-economic factors such as income from crop sales, amount of arable land owned by a household, external remittances received by households.
2003	F. Zinyama	A comparative analysis of the use of pit-stored manure on vegetables and field crops. The case of Mangwende Communal Area in Murehwa District.	Low levels of fertilizer use are attributed to fertilizer use being limited by risk, high cost of application and relative returns to investment. Application of fertilizer in 2000–03 declined as a result of the high rise in the cost of inputs.

Year	Researcher	Study	Main findings
2002	T. Magara	A comparative assessment of the determinants of household choice of soil fertility management practices.	Access to credit enables farmers to buy inorganic fertilizer and to adopt more efficient technology. Results from the survey showed that the total rates applied by farmers in the 2000/01 season were below the recommended rates.
2000	C.S.S. Ngulube	Targeting soil fertility management advice to smallholder farmers in semi-arid Zimbabwe.	The survey results showed that farmers in Tsholotsho applied fertilizer at a lower rate than recommended owing to a number of constraints but mostly because of limited resources.
1998	K. Murwira	Compilation and assessment of promoting technologies in smallholder agriculture.	Smallholder communal farmers in Zimbabwe applied an average of 18 kg/ha of mineral fertilizer, which was below the recommended rate of 300 kg/ha. Socio-economic factors such as individual household goals and resource endowments have been recognized as affecting fertilizer use.
1994	M. Jonga	Optimizing inorganic fertilizer use in dryland and maize production in Chinyika Resettlement Area of Zimbabwe.	No significant yield difference in applying basal fertilizer at planting compared with applying at two weeks after crop emergence. Under moisture stress, it is more desirable to dribble basal fertilizer along the plant row than to apply as a dollop (lump) because dribbling reduces contact between seed and fertilizer and minimizes fertilizer burning (which inhibits germination). Dribbling is less expensive than dolloping, which is labour-intensive.



Zimbabwe’s economy is heavily reliant on its agriculture sector. Until 2000, there were two dominant subsectors: a large-scale commercial subsector with a relatively small number of large farms located mostly on the better land; and a large number of small farms in the smallholder subsector. Most of the fertilizer use was in the large-scale subsector, with only one-fifth of smallholders using fertilizers. In 2000, the State initiated an agrarian reform policy and took over most of the large-scale farming area for redistribution. Fertilizer consumption has since fallen sharply. There is concern about degradation of the often fragile soils. Fertilizer production has fallen as a consequence of both reduced demand and financial difficulties encountered by manufacturers.

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