CHAPTER 2 : AGRICULTURE AND THE CLIMATE IN SOUTH AFRICA

2.1 Introduction

The vulnerability of a country to climate change includes the extent to which current temperatures or precipitation patterns are close to or exceed tolerance limits for important crops, per capita income, the percentage of economic activity based on agricultural production, and the pre-existing condition of the agricultural land base (IPCC, 1997).

This chapter describes current South African agriculture across the landscape, the climate and land use and natural resource patterns of the country. Furthermore, the importance of the agricultural to South Africa's economy is discussed. Finally, the chapter emphasizes the influence of climate on the patterns of agricultural crops produced across the country and provides an overview of the crops included in the study.

2.2 Land use, Climate and the Natural resources of South Africa

The Republic of South Africa covers an area of 122.3 million ha divided into nine provinces. The total population of South Africa is estimated at 43,586,097 million people. Approximately 20 million hectares are used for non-agricultural purposes and 2 million hectares for nature conservation. The outstanding 100.7 million hectares, the largest part of the land is used for agriculture and forestry. However only 15.8 million hectares of the agricultural land are potentially arable.

South Africa is located in a predominantly semi-arid part of the world. The climate varies from desert and semi-desert in the west to sub-humid along the eastern coastal area, with an average rainfall for the country of about 450 mm per year. Evaporation is comparatively high. Rainfall is distributed unevenly across the country with an

increase in rainfall from the western to the eastern parts. The 500 mm rainfall line actually divides the country into two sections. The country has three main rainfall regions:

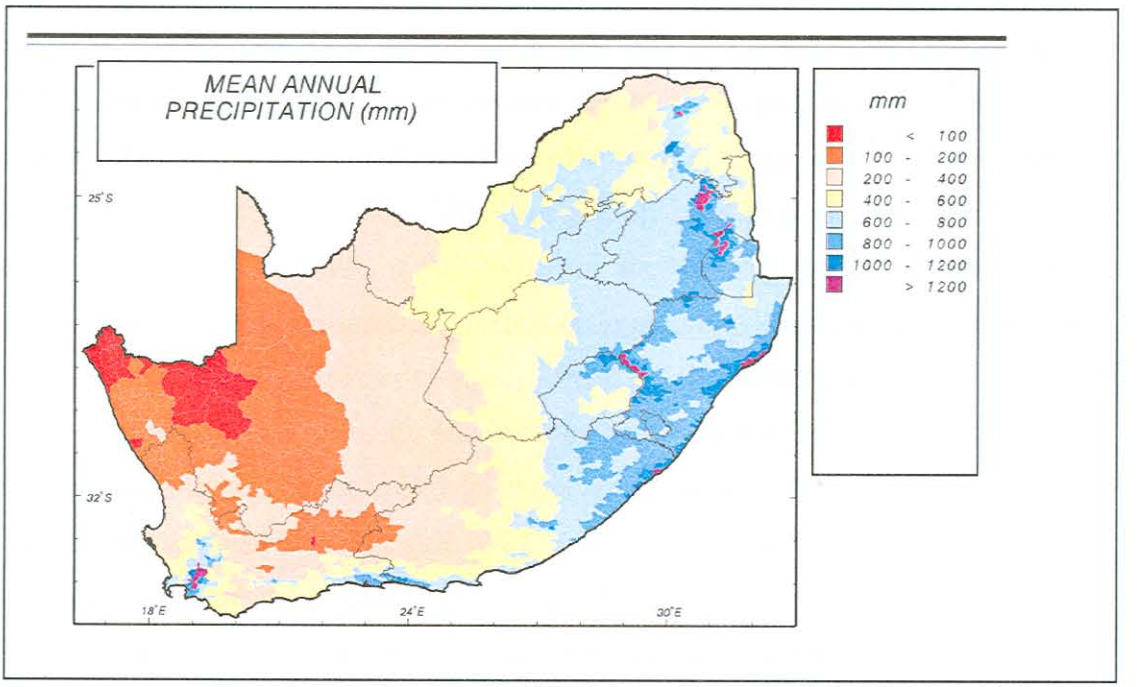
(1) The winter rainfall region in the southwestern cape with less than 500 mm per year;

(2) The area with rainfall throughout the year along the southern coastal region of more than 700 mm per year and;

(3) The summer rainfall area in the rest of the country with rainfall between 500 and 700 mm per year. Only 10% of the total area receives an annual precipitation of more than 750mm (Figure 2-1).

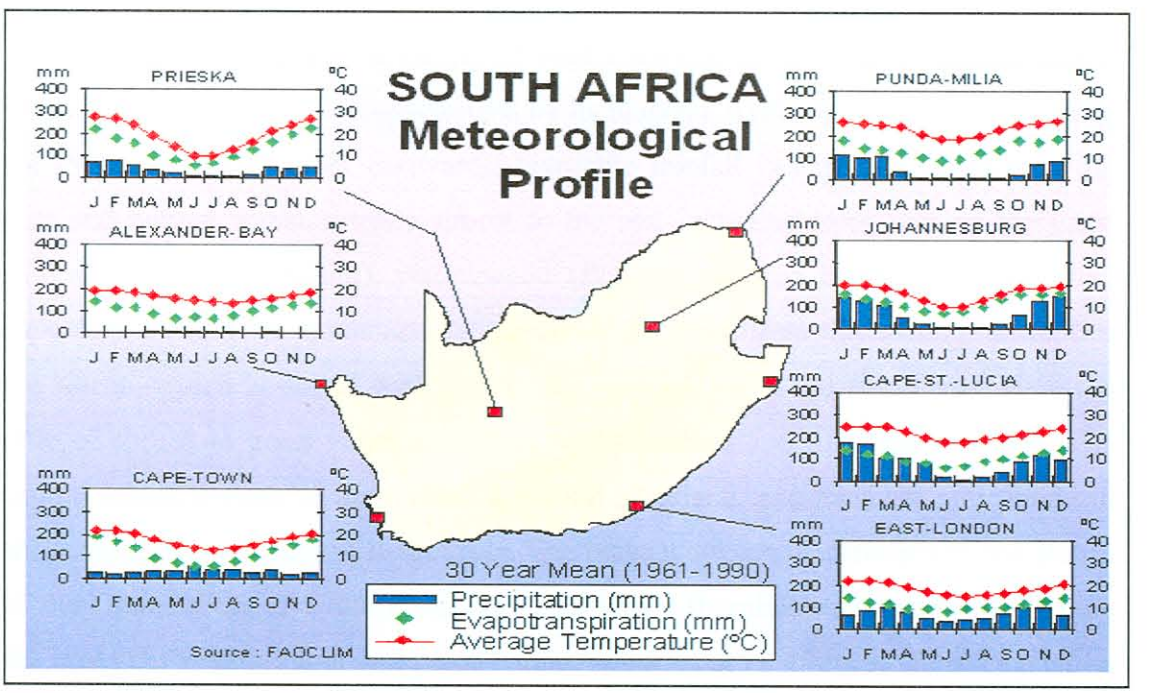
South African weather can be divided into two main periods: (1) summer seasons from October/November to March/April and (2) winter seasons from April/May to August/September. Summer temperatures on average vary across the country between mid thirties to twenties degree Celsius and the winter's between twenty and ten degree Celsius. Indeed, summers are generally warm while winters are not extremely cold except in certain regions where the night-time minimum temperatures can drop to a freezing point for at least 30 days a year over the entire high-lying inferior (about 50% of the country). Figure 2-2 gives an overview of the meteorological profile of South Africa.

Figure 2-1: South African Mean Annual Precipitation (1960-1990)



Source: Schulze (2003)

Figure 2-2: South Africa Meteorological Profile

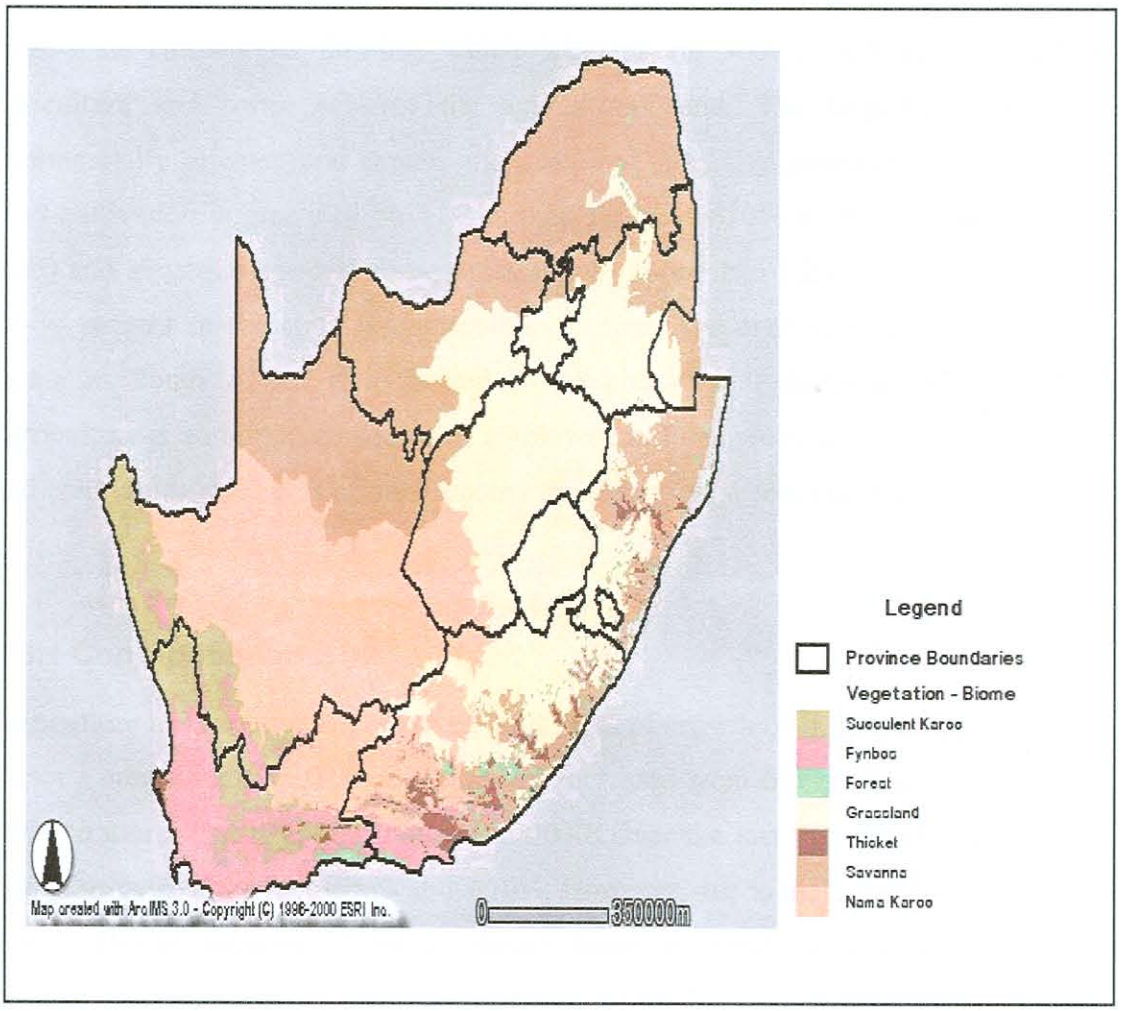


Source: FAO/GIEWS (2001)

South Africa's water resources are, in global terms scarce and extremely limited. The natural availability of water across the country is very unevenly distributed, with more than 60% of the rivers' flow arising from only 20% of the land area (Basson *et al.*, 1997). The four main rivers in the country are the Limpopo, Inkomati, Pongola and Orange, which together drain about 60% of the land area and contribute over 30% of the country's total surface runoff. There are no truly large or navigable rivers in South Africa and the total flow of all rivers in the country combined amounts to approximately 49 200 million cubic meters (m3) per year, less than half of that of the Zambezi River, the closest river to South Africa. South Africa is also poorly endowed with groundwater, as it is mainly underlain by hard rock formations, which, although rich in minerals, do not contain any major groundwater aquifers, which could be utilized on a national scale (Basson *et al.*, 1997). Indeed, water is the resource most limiting to national development particularly for agriculture. Almost 50% of South Africa's water resources are already used for agricultural purposes. There is evidence that climate change could cause increased variability of rainfall over the eastern parts of South Africa, and a decrease in rainfall from the west and over the Western Cape region (DWAF, 2002). Thus, plant and therefore irrigation water requirements will also increase should warmer climatic conditions manifest.

South Africa is covered by a variety of vegetation due to its diverse climatic zones. The winter rainfall area is characterized by its macchia (fynbos) vegetation, including the Protea family. Further eastwards, favorable rainfall is expected throughout the year and natural forest extends almost to the sea, including trees such as the Cape stinkwood (*Ocotea bullata*), yellowwood (*Podocarpus*) and black ironwood (*Olea capensis*). Behind the mountains, which divide the coast from the inland plateau, lies the Karoo, which is dotted with dwarf trees, shrubs, grass and succulents. Here the ratio of shrubs to grass varies according to the rainfall and livestock numbers. The central inland plateau or highveld is a natural grassland, and trees are only found in sheltered kloofs or along watercourses. The plateau stretches eastwards to the slopes of the Drakensberg and into KwaZulu-Natal where thornbushes predominate. Along the coast the vegetation is typical of humid, subtropical conditions. Other vegetation zones include the sparse desert flora along the west coast, which gradually changes eastwards to a savannah type with many *Acacia* spp. and other thorn-tree species (Figure 2-3).

Figure 2-3: South Africa vegetation- biome



Source: SAAGIS (2000)

2.3 The importance of agriculture to the South African economy

Agriculture in South Africa is widely regarded as a highly sophisticated and successful sector. The dominant form of agricultural production in South Africa is the large-scale commercial farming, which accounts for 90% of the value added in agriculture and owns 86% of the agricultural land. The large-farm sector is commercially oriented and capital-intensive, and generally produces surpluses. Dry land cultivation is practiced on 11.2 million ha (about 10% of the total agricultural land) and irrigation agriculture occupies slightly more than 1.2 million ha producing 25-30 percent of the country's agricultural output. The average size of commercial farms in South Africa is estimated to be about 1200 hectares (SSA, 2002b). Agriculture is an important source of employment, foreign exchange and food supply and contributes to the rest of the economy through strong economic multipliers.

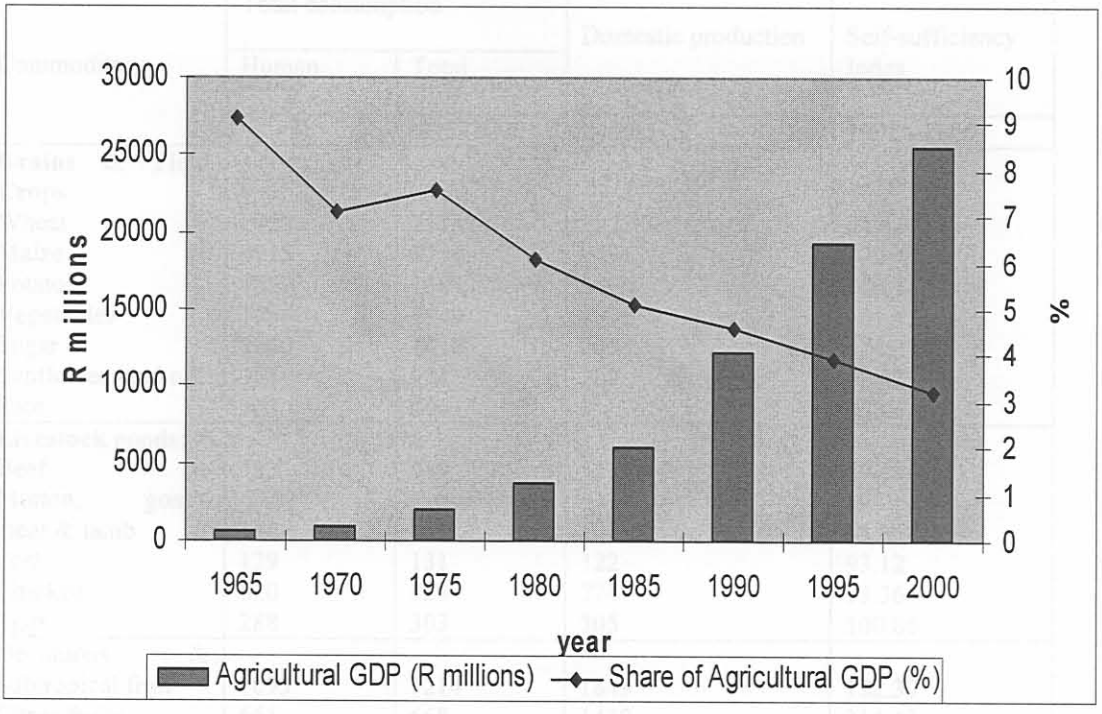
2.3.1 Contribution to GDP

Agriculture has experienced relatively high rates of growth over the past century. The sector's contribution to GDP at factor cost increased from 687 millions Rand (R)[3] in 1965 to more than R 25000 millions in 2000. Over the last two decades the annual rate of growth of the sector was about 10%. However, due to the transformation of the South African economy from a primary based economy to a more diversified economy, the share of the sector to GDP has declined (Figure 2-4). Indeed, the share of agriculture in total GDP has been decreasing over the years from 20% in 1911 to 10% in 1965 and to less than 5% in the late decade (AAS, 2002).

Agriculture contributed about 3.5% to the total value added of the country in 2002. Kwazulu Natal province made the largest contribution (28.3% of the total) followed by Western Cape (22.6%). Three categories of products contributed to the agricultural GDP namely: (1) Field Crops; (2) Horticultural products; and (3) Livestock. Over the past two decades the average contribution to the gross value of the agricultural sector was about 37%, 20% and 43%, respectively, from field crops, horticulture and livestock (AAS, 2002).

[3] Rand (R) is the local currency of the Republic of South Africa and 1 US $ was equal to approximately R 7 in 2000.

Figure 2-4: Contribution of the South African Agriculture to Gross Domestic Product (1965-2000)



Source: AAS (2002)

2.3.2 Food supply and food security

The National Department of Agriculture (NDA) reports that at the national level, South Africa is food secure. It produces most of its main staple foods exporting surpluses (NDA, 2002). Except for rice, for which the country has no domestic resource base and is imported, the country has met the needs for its main staple food by over 160%, 100%, 95%, and 80%, for sugar, maize, livestock needs and wheat, respectively (Table 2-1). However, future trends projections indicate that should current production trends continue, domestic production would be outstripped by domestic consumption for most major agricultural commodities by over 20% in 2010 and 30% in 2020 (Table 2-2). Therefore, with the likely adverse impacts of climate change, the predicted figures may be worse.

Table 2-1: Average production and consumption and Self-Sufficiency Indices (SSI) of selected agricultural commodities in South Africa (1995- 2000)

Commodity	Total consumption		Domestic production	Self-sufficiency Index
	Human	Total		
	1995- 2000 (1000 tons)			1995 - 2000
Grains & Field Crops:				
Wheat	2458	2513	2222	88.41
Maize	4213	7754	9496	122.47
Potatoes	1350	1584	1598	100.88
Vegetables	1754	1949	1976	101.42
Sugar	1260	1410	2453	174.01
Sunflower seed oil	301	331	207	62.42
Rice	501	506	0	0.00
Livestock goods:				
Beef	523	589	525	89.19
Mutton, goat's meat & lamb	164	165	105	63.36
Pork	129	131	122	93.12
Chicken	820	829	774	93.36
Eggs	288	303	305	100.86
Deciduous & Subtropical fruit	1093	1214	1849	152.30
Citrus fruits	661	668	1432	214.43
Diary products:				
Condensed milk & powder milk	313	313	302	96.74
Fresh milk	1565	2724	2724	100.00
Cheese	39	39	37	96.37
Butter	14	14	11	77.94

Note: Self-Sufficiency Index= (domestic production/total consumption) x 100

Source: NDA (2002)

Table 2-2: Expected requirements of basic agricultural products in South Africa by the years 2010 and 2020

Product	Per capita consumption (kg)	Expected demand growth by years (%)		Expected requirement by years ('000 ton)		Current production ('000 ton)	Estimated difference between projected consumption and current production ('000)			
		2010	2020	2010	2020		2010		2220	
							ton	%	ton	%
Maize	174.6	1.64	1.46	8371	10363	7299	1072	14.7	3064	42.0
Wheat	55.9	1.26	1.12	2670	3307	1763	907	51.4	1544	87.6
Potatoes	31.4	3.53	3.14	1533	1895	1218	315	25.9	677	55.6
Fresh milk	28	1.85	1.65	1345	1665	1082	263	24.3	583	53.9
Beef	18.3	3.07	2.73	889	1099	685	204	29.8	414	60.4
Mutton	5.0	1.85	1.65	240	297	177	63	35.6	120	67.8
Pork	3.2	3.07	2.73	156	192	121	35	28.9	71	58.7
Poultry	19.3	4.71	4.19	953	1176	747	206	27.6	429	57.4
Eggs	5.4	1.72	1.53	258	321	264	-	-	57	21.6

Source: NDA (2002)

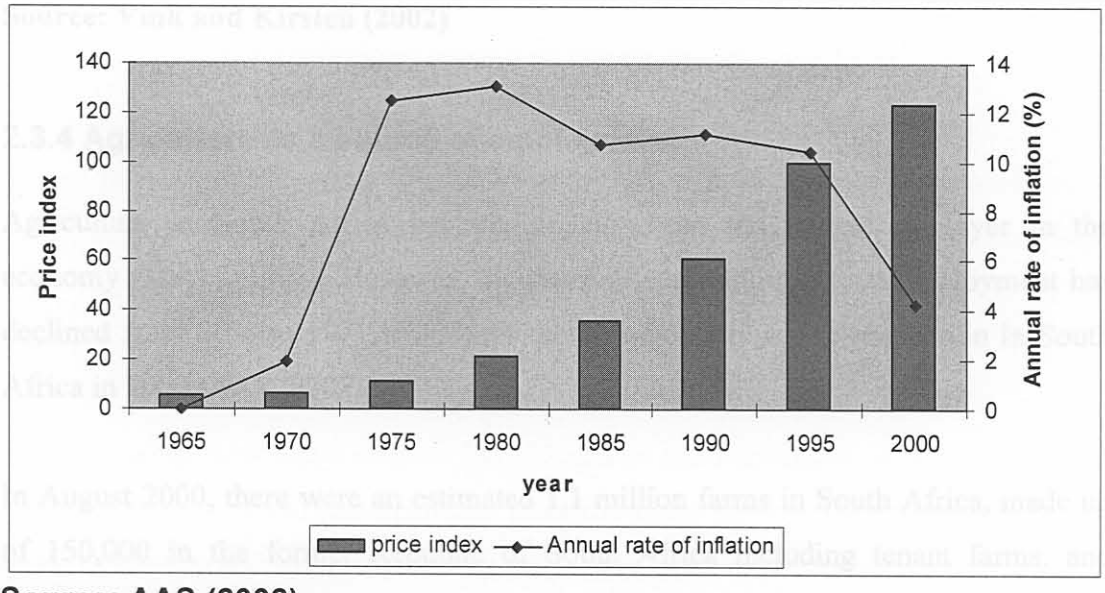
Another important role of the Agricultural sector is to provide food to consumers at reasonable prices. South Africa appears to be much less expensive in terms of food prices than the rest of the Southern Africa region. Indeed, the basket of basic food is around 50% more expensive in Mozambique and Zambia compared to South Africa, and twice as expensive in Malawi (Vink and Kirsten, 2002). Food prices in South Africa, however, have been increasing significantly over the years. The annual rate of growth of food prices over the period 1965 to 2000 show three main periods (Figure 2-5) reflecting different changes in agricultural policy in South Africa:

(1) 1965- 1980: This period witnessed sharp increases in producer prices as a result of the high protection in agriculture with marketing boards controlling trade in all agricultural commodities.

(2) 1980- 1995: Producer prices slightly declined during this period when the country has undergone changes in the broader political economy (financial sector, labour market) that induced important shifts in agricultural policy (e.g. reduction of budget allocation to farmers, scrapping of the Land Act, etc.).

(3) 1995 – 2000: This period is characterised by a sharp decline in producer prices due to the process of deregulation and liberalization in the agriculture sector that took place after the promulgation of the Marketing of Agricultural Products' Act in1996.

Figure 2-5: Trend of Producer prices of agricultural products at 1995 prices (1965- 2000)



Source: AAS (2002)

2.3.3 Agriculture as a source of foreign exchange

South Africa's agriculture has a positive trade balance. Agricultural exports have grown rapidly, especially from 1990. In 2000 the sector exported about R16 billion worth of products, or nearly 6 % of South Africa's total exports. Sugar, accounted for the largest agricultural export value and the top three countries to which it was exported are Iran, Korea and Saudi-Arabia. South Africa also exports wine, citrus fruit, grapes, preserved fruits and nuts. However, agricultural imports have grown even faster. Therefore, the agricultural terms of trade have decreased from 5.56 in 1980 to 1.6 in 2000. The trade performance of South Africa's agriculture over the past two decades is depicted in Table 2-3.

Table 2-3: Trends in South Africa's agricultural exports (1980-2000)

	1980	1990	2000
Exports			
Total SA exports (R millions)	19 915.4	60 770.0	253 809.0
Total agricultural exports (R millions)	2 052. 5	5 289.8	15 819.0
Agricultural exports as % of total exports	10.3	8.7	6.2
Imports			
Total SA imports (R millions)	14 381.3	44 141.5	227 918.0
Agricultural imports (R millions)	369.2	2 203.3	9 643.7
Agricultural imports as % of total imports	2.6	5.0	4.2
Exports + Imports/ Total production (%)	**34.5**	**34.5**	**57.5**
Agricultural terms of trade (Ag exports/Ag imports)	**5.56**	**2.4**	**1.6**

Source: Vink and Kirsten (2002)

2.3.4 Agriculture as a source of employment

Agriculture in South Africa has traditionally been the largest employer in the economy (Meyer, 1998). However, the share of agriculture in total employment has declined from 30% in 1971 to 13% of the economically active population in South Africa in 2000 (AAS, 2002).

In August 2000, there were an estimated 1.1 million farms in South Africa, made up of 150,000 in the former Republic of South Africa including tenant farms, and 943,000 in the former homelands (SSA, 2002b). Commercial farms provide livelihoods and housing to about six million family members of 1 million employees

and provide for their educational needs. There are also 240,000 small farmers who provide a livelihood to more than one million of their family members and occasional employment to another 500,000 people. Furthermore, there are an estimated three million farmers, mostly in the communal areas of the former homelands, who produce food primarily to meet their own family needs (NDA, 2000).

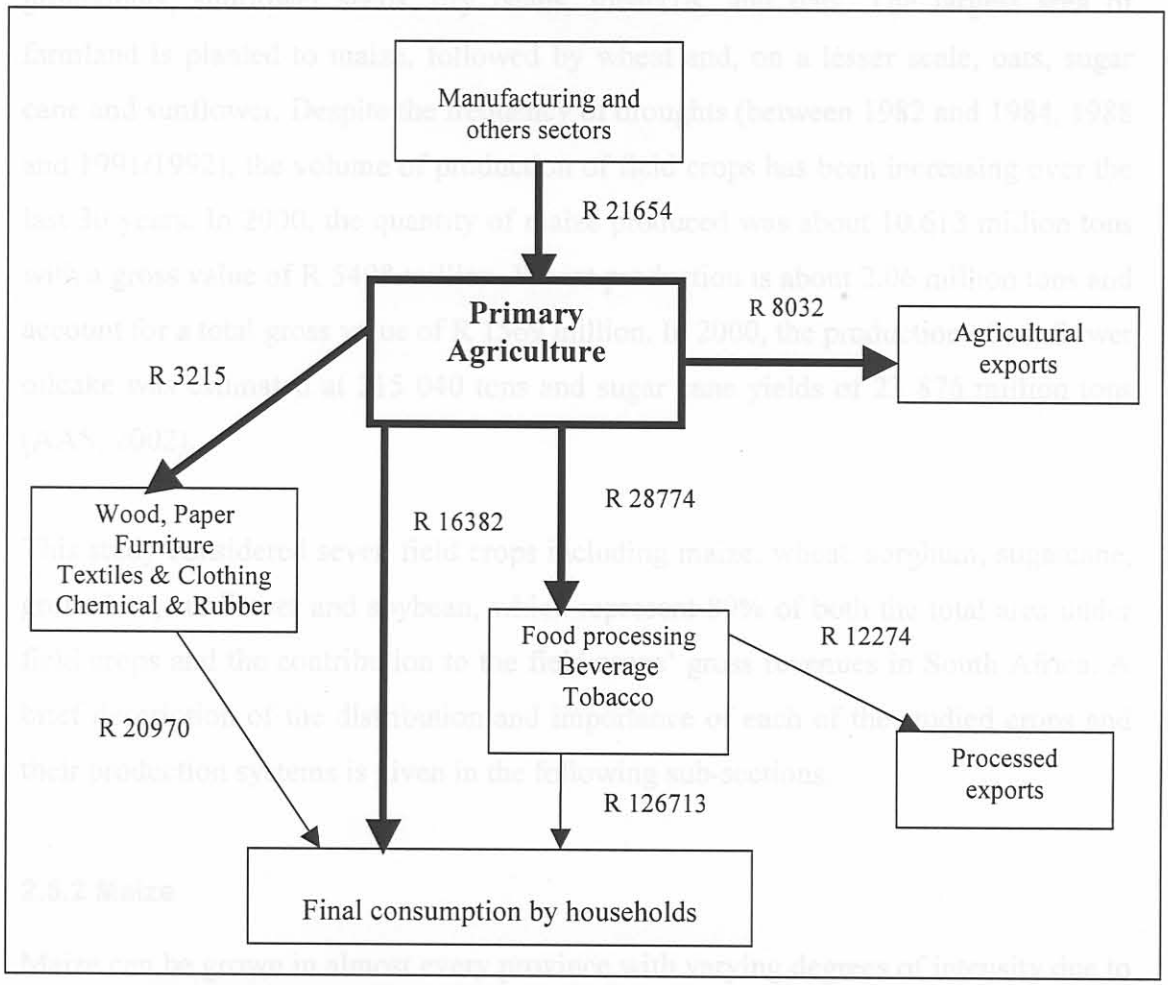
2.3.5 Economic multipliers of South African Agriculture

Many development economists (Lewis, 1954; Mellor, 1979; and Rostow, 1960) support the argument that agriculture has a very important role in the economic development process of a nation, stressing that improving agricultural productivity is the basis for a successful development strategy. Indeed through the interrelationships and the multiplier effects between food supply, rural purchasing power, labour and capital markets agriculture could stimulate overall economic growth.

In South Africa, agriculture is an important sector despite its relatively small share of total GDP. The sector has strong backward and forward linkages to the rest of the economy through the input supply and financial sectors as well as the agro-processing firms. Together, the agro-food complex contributes between 14% and 20% of the GDP (NDA, 2002). The input-output tables for 1993 (SSA, 1999) indicate that 60% of agricultural output is in the form of intermediates goods, suggesting that the downstream or forward linkages from the sector are relatively high. Using a quasi-input –output analysis, Hassan (2003) shows that for the sugar cane industry only, total employment benefits (direct and indirect) amount to about 1.02 full-time jobs per ha and total economic multipliers range from 1.82 to 8.71. Furthermore estimates of multipliers from studies using the Social Accounting Matrix (SAM) ranging from 4.39 to 5.54, showed that, in general, multipliers of agriculture in South Africa are relatively higher than international ones (Hassan *et al.*, 2002).

The following flow chart (Figure 2-6) illustrates the importance of the agricultural sector to the South African economy from the input level to the consumer level in terms of the demand by agriculture for outputs from other sectors (backward linkages) and the demand by the agro-based processing industries for the agricultural outputs (forward linkages).

Figure 2-6: Value of transactions of the Agro-food complex in 2000 (R millions)



Source: Conningarth Economists (2000)

2.4 The field crops' sector

2.4.1 Overview of the South African field crops sector

South Africa is suitable for the cultivation of a large variety of field crops. The main field crops of South Africa are maize; wheat, sugarcane, sorghum and minor crops are groundnuts, sunflower seeds, dry beans, tobaccos, and oats. The largest area of farmland is planted to maize, followed by wheat and, on a lesser scale, oats, sugar cane and sunflower. Despite the frequency of droughts (between 1982 and 1984, 1988 and 1991/1992), the volume of production of field crops has been increasing over the last 30 years. In 2000, the quantity of maize produced was about 10.613 million tons with a gross value of R 5498 million. Wheat production is about 2.06 million tons and account for a total gross value of R 1569 million. In 2000, the production of sunflower oilcake was estimated at 215 040 tons and sugar cane yields of 23 876 million tons (AAS, 2002).

This study considered seven field crops including maize, wheat, sorghum, sugarcane, groundnut, sunflower and soybean, which represent 80% of both the total area under field crops and the contribution to the field crops' gross revenues in South Africa. A brief description of the distribution and importance of each of the studied crops and their production systems is given in the following sub-sections.

2.5.2 Maize

Maize can be grown in almost every province with varying degrees of intensity due to climatic conditions. The Free State is the major maize-producing region whereas, Limpopo, Gauteng, Mpumulanga and KwaZulu-Natal are the minor growing regions in South Africa. Maize is the only crop that has two planting and harvesting periods depending on the region. In the Western part of the country, planting starts in December and January whereas in the eastern region planting starts in October to December.

Maize is the most important crop in South Africa, being both the major feed grain and staple food for the majority of the South African population. Maize accounts for approximately 40% of the cultivated area and generates 15% of the gross value of all

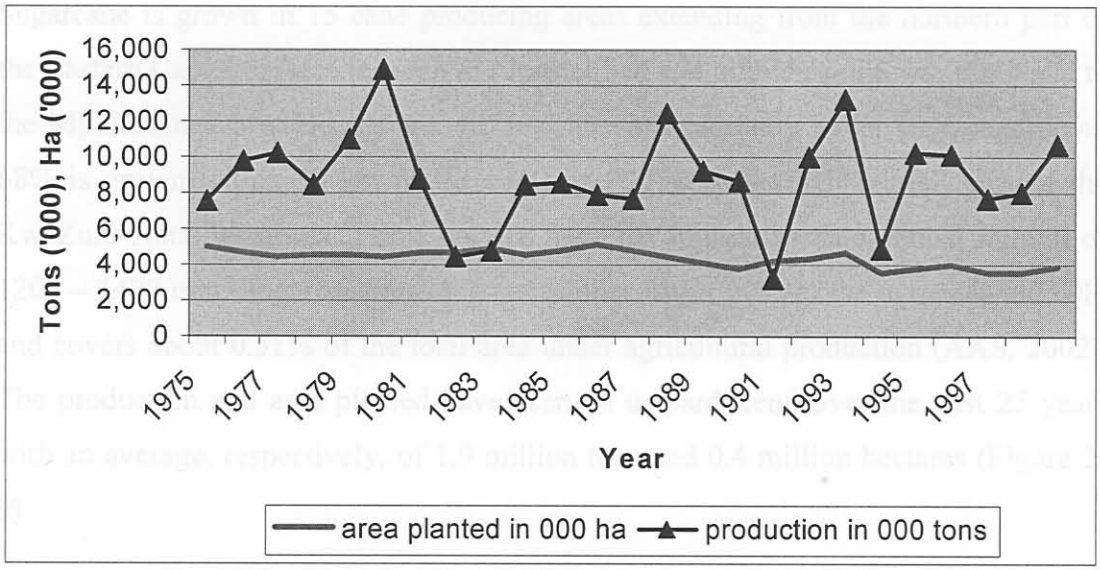
agricultural products (World Bank, 1994). The maize industry is also an important earner of foreign revenue for South Africa through the export of maize and maize products. South Africa mainly exports maize to Zimbabwe, Japan, Zambia, Malawi, Mauritius, Kenya and Mozambique.

The area planted to maize declined from 5 million hectares in the mid eighties, to approximately 3.5 million hectares in 1998/1999. Annual average maize production for the past decade has been approximately 8 million tons. Although the area planted declined over the past years, production has been erratic with slight upward trend (Figure 2-7). The decline in area planted was due to the changes in agricultural policies. The country produces two types of maize, white and yellow. The local consumption requirements are estimated at 7.5 millions tons. This can be split up into 4.4 million tons of white maize and 3.1 million tons of yellow maize.

2.5.3 Wheat

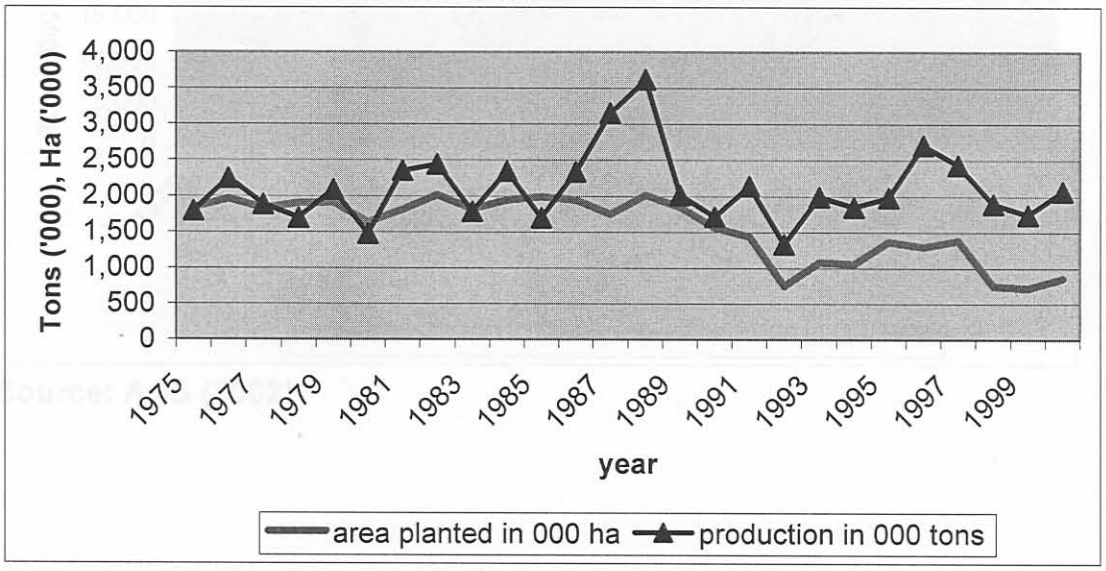
Wheat is the second most important grain crop in South Africa. Wheat, a winter crop is produced in the Western Cape, the Free State, the North West and the Northern Cape provinces. Wheat could be planted from mid-April to end-July. Domestic consumption is estimated at 2.4 million tons per annum. South Africa regularly imports wheat. During 2000/2001 season, 2.35 million tons of wheat were produced locally and approximately 300,000 tons of wheat were imported (12% of the domestic production). Over the two past decades, production quantities have been erratic with an average of about 2 million tons per year. Area planted under maize has declined over the years (Figure 2-8). The reduction in area planted in recent years was due mainly to droughts experienced by the country's central wheat regions and changes in government agricultural policies (Jooste and Van Zyl, 1999).

Figure 2-7: The trend in maize production and area planted (1975-2000)



Source: AAS (2002)

Figure 2-8: The trend in wheat productions and area planted (1975-2000)

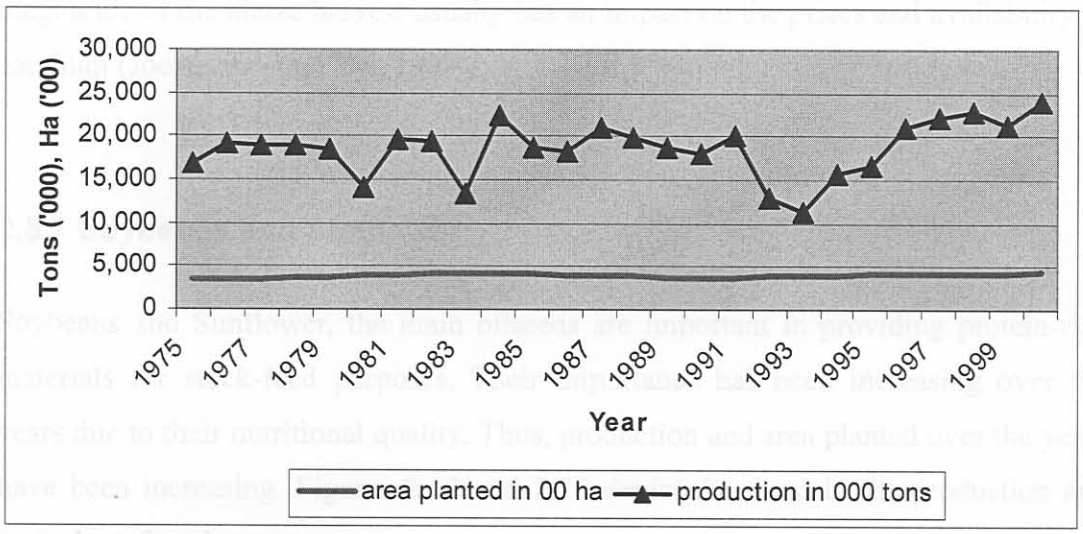


Source: AAS (2002)

2.5.4 Sugarcane

Sugarcane is grown in 15 cane producing areas extending from the northern part of the Eastern Cape Province through the coastal belt and midlands of KwaZulu-Natal to the Mpumalanga lowveld. Of the 427,000 hectares currently under sugarcane about 68% is grown within 30 km of the coast and 17% in the high rainfall area of the KwaZulu Natal midlands. These regions have the highest median annual rainfall of 1200 – 1400 mm. Sugarcane farming contributes about 20% of the agricultural GDP, and covers about 0.51% of the total area under agricultural production (AAS, 2002). The production and area planted have seen an upward trend over the past 25 years with an average, respectively, of 1.9 million tons and 0.4 million hectares (Figure 2-9).

Figure 2-9: The trend in sugarcane production and area planted (1975- 2000)



Source: AAS (2002)

2.5.5 Groundnuts

Groundnut, a summer crop is mainly grown in the summer rainfall areas of the North West Province and the Free State Province. Planting dates are mainly determined by the climatic conditions but normally fall between mid October and mid November when higher temperature and rainfall ensure good germination. Groundnuts are used principally for own –consumption in KwaZulu Natal and Mpumalanga provinces. Groundnuts production quantity and area planted have fluctuated over time with a downward trend and a slightly upward trend, respectively (Figure 2-10).

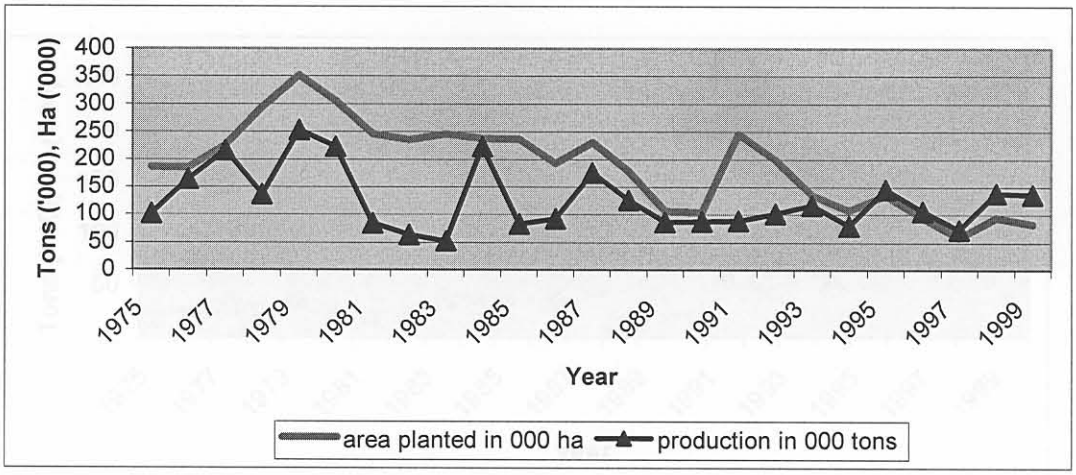
2.5.6 Sorghum

Sorghum due to climatic conditions is mainly produced in the Free State (64%), Mpumalanga (15%) and NorthWest (11%) (AAS, 2002). Production and area planted recently experienced a downward trend after a slight increase during the period 1975-1990. Figure 2-11 depicts production and area planted over the period 1975-2000. The magnitude of the maize harvest usually has an impact on the prices and availability of sorghum (Jooste and Van Zyl, 1999).

2.5.7 Soybeans and Sunflower

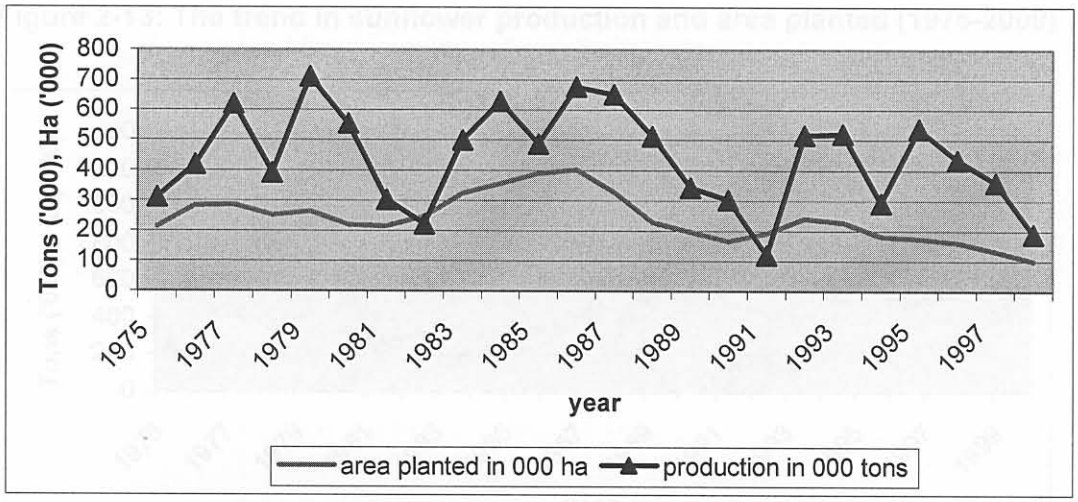
Soybeans and Sunflower, the main oilseeds are important in providing protein-rich materials for stock-feed purposes. Their importance has been increasing over the years due to their nutritional quality. Thus, production and area planted over the years have been increasing. Figures 2-12 and 2-13 depict the trend in the production and area planted to these two crops.

Figure 2-10: The trend in groundnut production and area planted (1975- 2000)



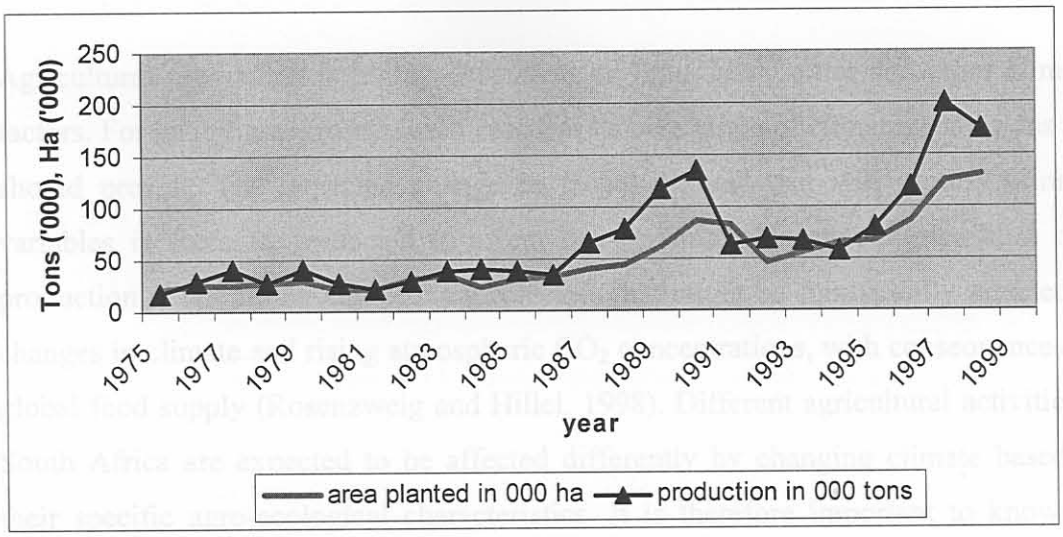
Source: AAS (2002)

Figure 2-11: The trend in sorghum production and area planted (1975-2000)



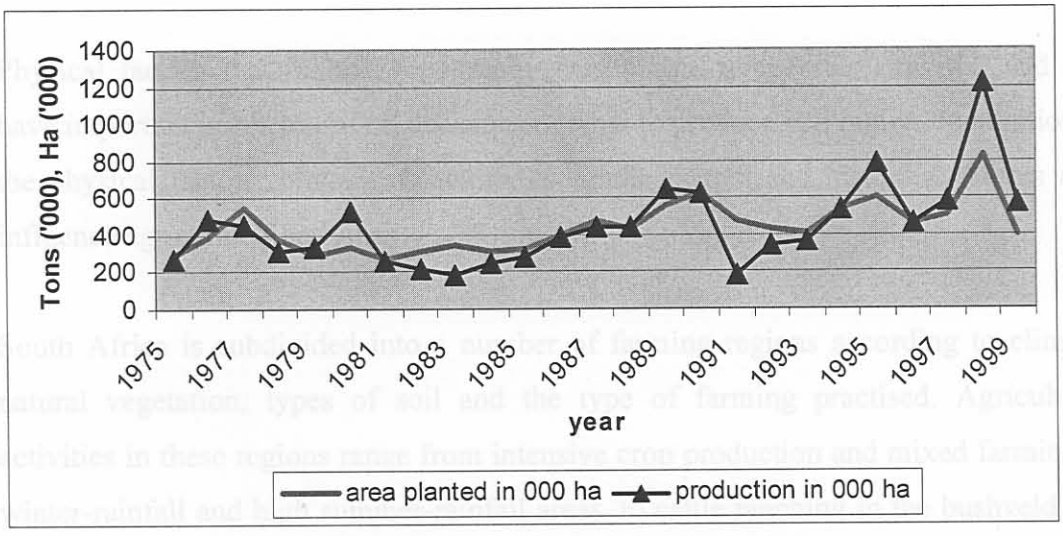
Source: AAS (2002)

Figure 2-12: The trend in soybean production and area planted (1975- 2000)



Source: AAS (2002)

Figure 2-13: The trend in sunflower production and area planted (1975-2000)



Source: AAS (2002)

2.5 Physiological vulnerability to climate change of field crops in South Africa

Agricultural production is highly dependent on light, heat, water and other climatic factors. For an optimal growth, each crop has its own range of climatic conditions that should prevail. The expected change in global climate that will modify climatic variables is therefore expected to affect the agricultural sector. Agricultural crop production is one of the key economic sectors that might be significantly affected by changes in climate and rising atmospheric CO_2 concentrations, with consequences for global food supply (Rosenzweig and Hillel, 1998). Different agricultural activities in South Africa are expected to be affected differently by changing climate based on their specific agro-ecological characteristics. It is therefore important to know the agro-ecological location and characteristics of the field crops studied and their sensitivity to climate variability.

2.5.1 The Agro-ecological features of South Africa

Physical factors that include topography, vegetation, temperature, rainfall and soil have important implications on decisions of what to produce in a region. In addition to the physical factors, biological factors, economic factors and historical factors also influence agricultural activities.

South Africa is subdivided into a number of farming regions according to climate, natural vegetation, types of soil and the type of farming practised. Agricultural activities in these regions range from intensive crop production and mixed farming in winter-rainfall and high summer-rainfall areas, to cattle ranching in the bushveld and sheep farming in the more arid regions. Jooste and Van Zyl (1999) identified six agro-economic zones in South Africa based on the differences in rainfall, vegetation, erodibility, biological productivity, water availability, resource quality and output and input price ratio of the regions. These are the Cape Fold region, the Nama Karoo Region, the Interior region, the Kalahari/Limpopo Plain region, the Eastern Plateau Slope or Lowveld region and the High Veld Region. The Joint Agriculture and Weather Facility of the National Oceanic and Atmospheric Administration (NOAA)

of the United States determined four climatic zones for South Africa based on crop areas and climate profiles: steppe (arid), the desert, the sub-tropical wet and the sub-tropical winter rain zones (Figure 2-14).

Thus, due to the diversity in the country in terms of ecological and climate factors, each crop has its main production areas. Figure 2-15 below shows the geographical distribution of the main field crops' zones in South Africa. For example, Wheat is produced in the western cape and the Free State (the cooler provinces) while Sorghum is produced in the warmer eastern part of the country. However, climate change may alter the distribution of agroecological zones with highlands getting longer growing seasons (Hulme, 1996).

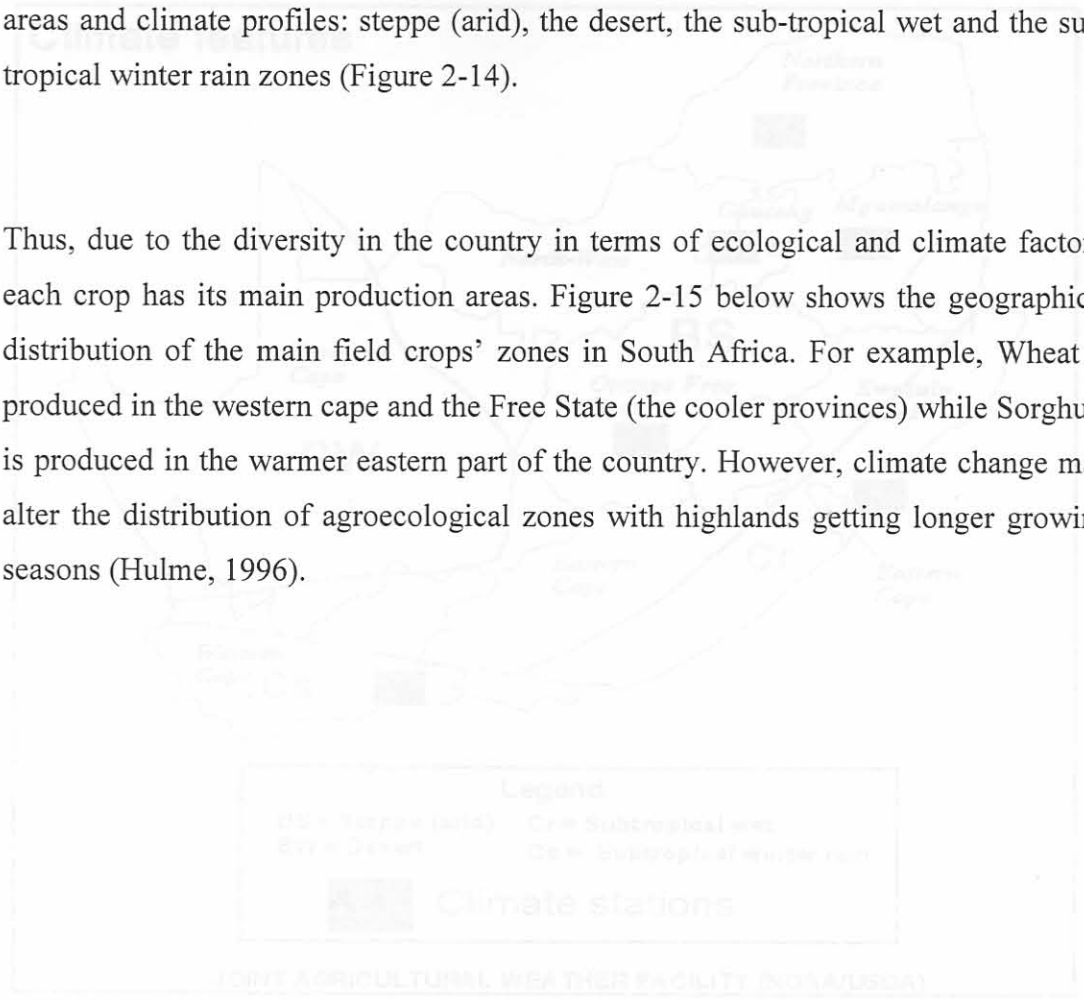


Figure 2-14: The Agro-climatic zones in South Africa

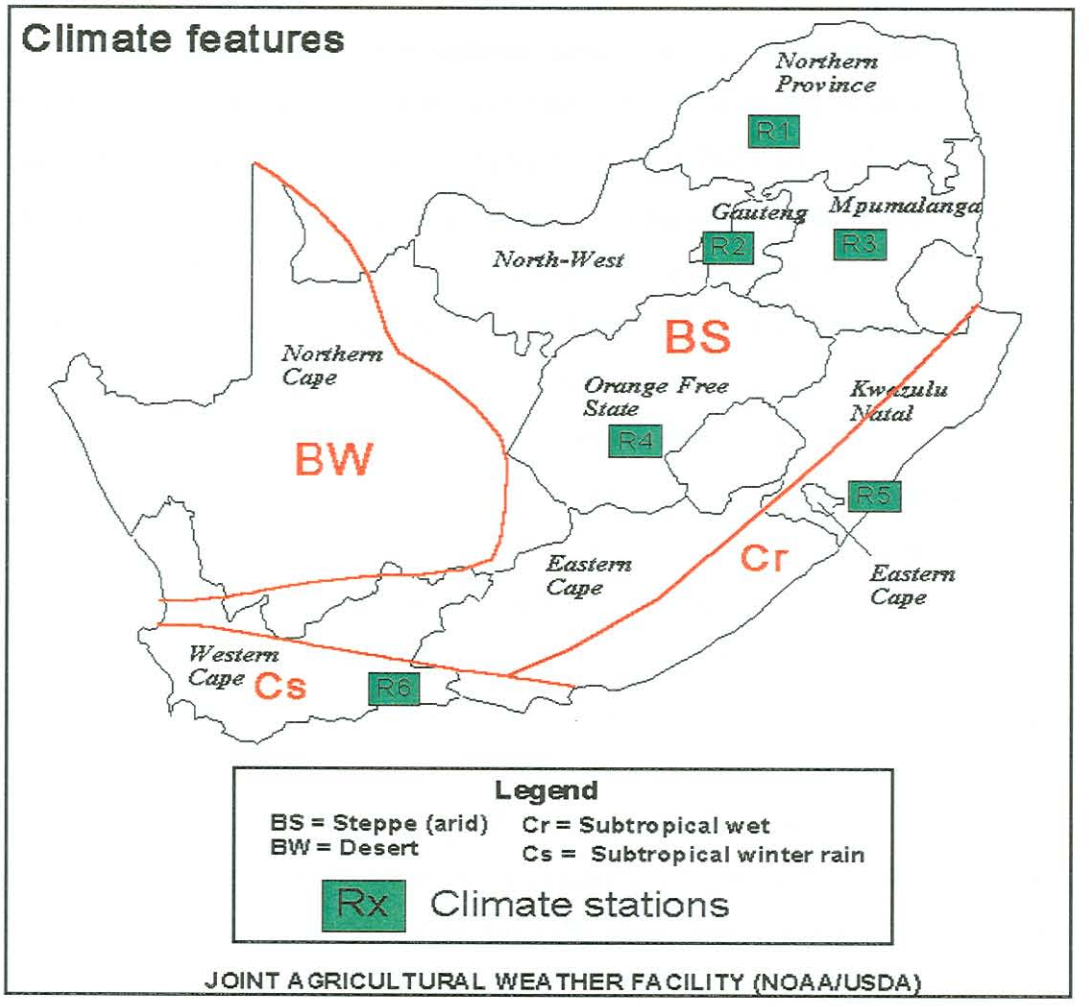
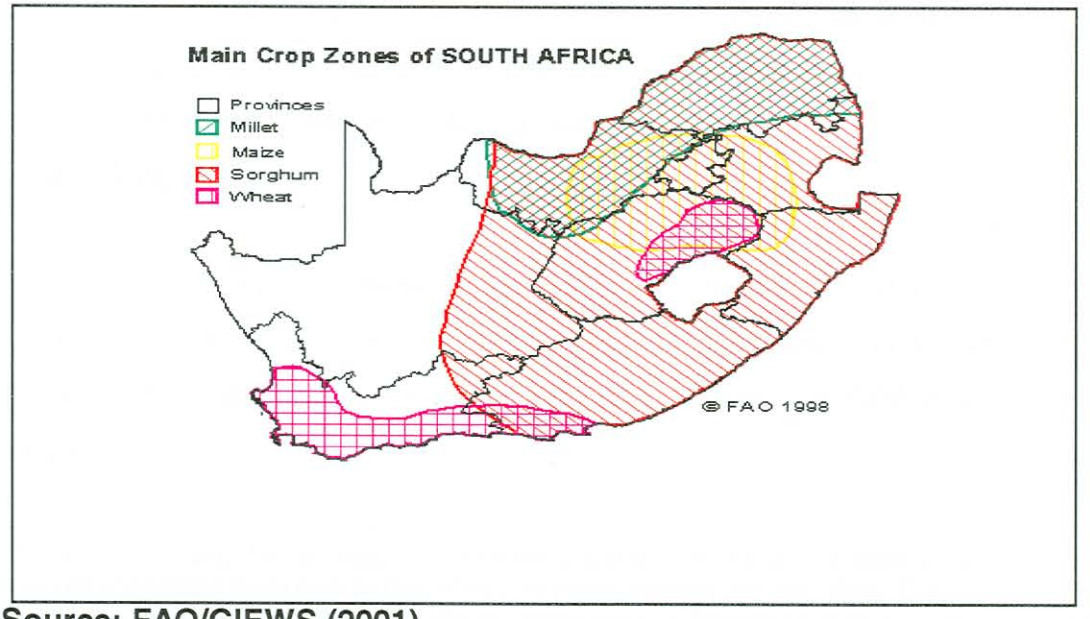


Figure 2-15: The main cropping zones of the field crops



Source: FAO/GIEWS (2001)

2.5.2 Vulnerability of field crops to climate change

Temperature, precipitation, atmospheric carbon dioxide content, the incidence of extreme events and sea level rise have been identified as the main climate change related drivers, which impact agricultural production (McCarl *et al.*, 2001). A rise in carbon dioxide concentration for example, is expected to have a positive effect on crop yield due to the increase in water use efficiency and rate of photosynthesis. The impact of carbon dioxide on field crops will differ depending on whether the crop is C_3 or C_4 plants[4]. Rosenzweig and Hillel (1995) observed that C_3 plants like wheat and soybeans respond readily to increased carbon dioxide while C_4 plants like maize; sorghum, sugarcane and millet respond less to increased carbon dioxide. On the other hand, rising temperature has generally a negative impact on crop yield. Pimentel (1993) noticed that global warming is likely to alter production of wheat, maize and beans. Staple crops such as wheat and maize that are associated with subtropical latitudes may suffer a drop in yield as a result of increased temperature. The severity of the impacts of higher temperatures could be detrimental specifically for wheat in South Africa due to the fact that in many areas where the crop is grown, temperatures are already at the tolerance limit for its optimum growth. Indeed, high temperatures severely limit wheat yield by accelerating the plant development, affecting the floral organs and fruit formation and the functioning of the photosynthetic apparatus. Moreover, a rise in temperature is expected to increase evapotranspiration, coupled with the fact that precipitation is likely to decrease; water balances will be adversely affected. Hence, increased evaporation from the soil and accelerated transpiration in the plants cause moisture stress. The occurrence of moisture stress during flowering, pollination and grain filling is harmful to most crops particularly to maize, soybeans, wheat and sugarcane.

In general South Africa climatic conditions are suitable for the cultivation of field crops except with regard to rainfall where the required optimum levels are not reached (NDA, 2000). Table 2-4 gives a summary of conditions for field crops' growth suitability.

[4] C_3 plants are plants that produce a three-carbon compound during photosynthesis, including most trees and agricultural crops such as rice, wheat, soybeans, potatoes and vegetables. C_4 plants are plants that produce a four-carbon compound during photosynthesis (mainly of tropical origin), including grasses and the agriculturally important crops maize, sugar cane, millet, and sorghum.

Table 2-4: Optimal climatic conditions for growth of field crops

Crop Type	Growing days	Climate	Optimum Temperatures	Optimum Precipitation	Soils	Photoperiod Response
Maize (***Zea mays*** subsp. ***Mays),***	88 to 140	Tropical-wet and dry Steppe and semi-arid Subtropical-dry	Max: 33^{0}C Min: 18^{0}C	1200 mm	medium-textured organic soils, well drained with a pH of 5.5 to 7.5	short day and day neutral photoperiod response and need a bright light intensity
Sorghum (***Sorghum bicolor)***	90 to 300	steppe and semi-arid, temperate, tropical-wet and dry, subtropical	Max: 35^{0}C Min: 25^{0}C	900 mm	light-loams and heavy clays soils, well drained with a pH of 5.5 to 7.5	short day photoperiod response and need a bright light intensity
Wheat ***(Triticum aestivum*** subsp. ***Aestivum)***	90 to 120	tropical-rainy, dry climate, subtropical, temperate climate	Max: 23^{0}C Min: 15^{0}C	750 mm	silt and clays loams soils, well drained with a pH of 5.5 to 8	long day and day neutral photoperiod response and need a very bright light intensity
Groundnut ***(Arachis hypogaea)***	90 to 150	in Tropical-wet and dry, steppe and semi-arid, subtropical-humid climate	Max: 32^{0}C Min: 22^{0}C	1200 mm	light, sandy loam soils, well drained with a pH of 5.5 to 6.5	a long day, short day and day neutral photoperiod response and need a bright light intensity
Sunflower ***(Helianthus annus)***	70 to 200	steppe and semi-arid, tropical-wet and dry, subtropical, temperate climate	Max: 34^{0}C Min: 17^{0}C	1200 mm	medium light soils, well drained with a pH of 6 to 7.5	short day photoperiod response and need a bright light intensity.
Soybean ***(Glycine max)***	75 to 180	Subtropical-dry summer, steppe and semi-arid, tropical-wet and dry	Max: 33^{0}C Min: 20^{0}C	1200 mm	fertile loams soils, well drained with a pH of 5.5 to 7.3	short day photoperiod response and need a bright light intensity.
Sugar cane ***(Saccharum officinarum*** L.*)*	Perennial crop	Warm Temperate Dry to Moist through Tropical Very Dry to Wet Forest Life Zones	Max: 25^{0}C Min: 15^{0}C	1500 mm	loamy soils with good Proportions of sand, silt and clay with good water storage and drainage characteristics. A pH range of 6-8	Long day photoperiod and very bright light intensity.

Source: Illinois State Water Survey (2004)