CODEX PLANETARIUS

Environmental Standards for Maize Production in South Africa

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About *Codex Planetarius*

Codex Planetarius is a proposed system of minimum environmental performance standards for producing globally traded food. It is modeled on the *Codex Alimentarius*, a set of minimum mandatory health and safety standards for globally traded food. The goal of *Codex Planetarius* is to measure and manage the key environmental impacts of food production, acknowledging that while some resources may be renewable, they may be consumed at a faster rate than the planet can renew them.

The global production of food has had the largest impact of any human activity on the planet. Continuing increases in population and per capita income, accompanied by dietary shifts, are putting even more pressure on the planet and its ability to regenerate renewable resources. We need to reduce food production's key impacts.

The impacts of food production are not spread evenly among producers. Data across commodities suggest that the bottom 10-20% of producers account for 60-80% of the impacts associated globally with producing any commodity, even though they produce only 5-10% of the product. We need to focus on the bottom.

Once approved, *Codex Planetarius* will provide governments and trade authorities with a baseline for environmental performance in the global trade of food and soft commodities. It won't replace what governments already do. Rather, it will help build consensus about key impacts, how to measure them, and what minimum acceptable performance should be for global trade. We need a common escalator of continuous improvement.

These papers are part of a multiyear proof of concept to answer questions and explore issues, launch an informed discussion, and help create a pathway to assess the overall viability of *Codex Planetarius*. We believe *Codex Planetarius* would improve food production and reduce its environmental impact on the planet.

This proof-of-concept research and analysis is funded by the Gordon and Betty Moore Foundation and led by World Wildlife Fund in collaboration with a number of global organizations and experts.

For more information, visit www.codexplanetarius.org

Declaration

The author of this report is a soil scientist of more than 40 years' experience. He has a PhD in soil science from the University of Pretoria, South Africa, and was employed by the Agricultural Research Council-Natural Resources and Engineering, also in Pretoria, as a research manager until his retirement in 2024.

The report has been compiled to the highest standards of scientific competence, and impartiality. All references and other sources of information have been listed accordingly.

Dr. Garry Paterson

NOTE: The South African government department responsible for most agricultural activities has undergone various transformations in the recent past, both in terms of its organization and its official name.

Thus, for the sake of simplicity, this report will refer to the "National Department of Agriculture," and any references used under slightly different names can be considered to come from the same basic source.

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Abstract

Maize is the staple crop in South Africa and most of the broader region. Dr. Garry Paterson, a retired soil scientist from Pretoria, looks at all the relevant aspects of maize production in South Africa, from the natural resources to the broader industry and the unique socio-economic environment of the country. He provides an overview of all the relevant data and its availability, as well as the areas where further work can be done to optimize the implementation of the *Codex Planetarius* principles and standards in South Africa.

1 Sector Baseline

1.1 Introduction

Maize (*Zea mays*) is an important agricultural crop worldwide, both for human and animal food. Approximately 1,160 million tons is grown annually (FAO, 2025), with South Africa producing around 14.75 million tons on average, which is around 1.3% of the world's total production.

1.2 Background

Codex Planetarius is a set of minimum environmental performance standards to reduce the six key impacts of producing globally traded food including:

- Soil health
- Water use
- Effluent
- Biodiversity
- Emissions
- Land use change

When *Codex Planetarius* is operationalized and underpinned by data and science, it will aim to:

- Provide a baseline for environmental performance in global production and trade of food and soft commodities that serves as a means for continuous improvement of performance globally.
- Serve to inform regulatory guidelines for governments and global trade that would apply initially to trade agreements and eventually to the World Trade Organization.
- Provide standards and data that accompany the product and systems that improve supply chain transparency and traceability at the commodity and producer level.

The current proof-of-concept phase involves research and data collection to inform decisions for the future development of *Codex Planetarius*, in part by application of *Codex* principles to ten real world supply chains through desktop pilot studies.

One of these is the production of maize in South Africa, and this report focuses on that specific national pilot study.

South Africa is (since 1994) a democratic country at the southern tip of the African continent, bordered to the north by Namibia, Botswana, and Zimbabwe; to the east by Mozambique and Eswatini (formerly Swaziland); and wholly enclosing Lesotho (Figure 1, next page). It lies between latitudes 22° and 35° S and between 16° and 33° E. With an area of around 120 million hectares (463,000 sq. miles), the highest points lie at the top of the Drakensberg mountains, along the Lesotho border, at around 11,000 feet (3,350 metres).

It has nine provinces, further divided into a number of districts or urban municipalities. The largest city is Johannesburg, while the administrative capital is Pretoria, with Cape Town being the legislative capital (seat of Parliament).

Figure 1: South African provinces and districts

1.3 Maize Production

As mentioned above, South Africa produces around 15 million tons of maize per year, ranking first in Africa and tenth in the world, after USA, China, Brazil, Argentina, EU, India, Mexico, Ukraine, and Indonesia (FAO, 2025).

Within the South African sphere, this production has increased over the past couple of decades, from around 10 million tons in the early 2000s, but is still variable (DALRRD, 2023), depending mainly on the expected market price, as well as the amount and distribution of rainfall across the growing season.

1.3.1 Maize-Producing Environment

Rainfall – In the South African context, the vast majority of maize is grown under dryland (rain-fed) conditions, during the southern hemisphere summer rainfall growing season (around October to April). Maize generally requires approximately 750 mm (30 inches) of rainfall in this period, with lower totals leading to more marginal production conditions, and higher totals leading to possible crop damage due to waterlogging from the excess moisture.

An important factor is the rainfall variability, both from season to season, as well as within each season. Southern Africa endures periodic cycles of variation in rainfall, linked mainly to the two global climatic phenomena, El Niño and La Niña, which lead to either below-average or above-average rainfall respectively. The full name of the phenomenon is the El Niño Southern Oscillation (ENSO). The cycles usually last several years (three to seven), but with increasing climate change, possibly linked to global warming, this pattern is becoming more difficult to predict (Moeletsi and Walker, 2012). Within the growing season, if there is a hot, dry spell in one of the critical stages, it can severely reduce yield, even if the overall rainfall across the season is still fairly normal. Research from the Free State Province of South Africa (Moeletsi et al., 2011) has shown that rainy season onset can vary by 10 days from the long-term mean, and cessation by as much as 15 days. Under these variable circumstances, maize production for the province can vary from the long-term mean of 3 tons ha-1, to as high as 5 tons ha-1 in a La Niña year, and as low as <1 ton ha-1 in an El Niño year. This is significant as the Free State produces around 35-40% of all maize in South Africa (DAFF, 2025)

Temperature – The main limiting factors are the minimum temperatures at the start and end of the growing season, linked to the occurrence of frost, and maximum temperatures during the season, which can lead to heat stress, especially in times of drought.

Hail – Due to the occurrence of often intense, convectional rainfall in the summer months across the interior of South Africa, hail is a real risk to maize production. While exact data is somewhat problematic, Punge, *et al.*, (2023) found almost 1,500 claims to insurance companies between 1984 and 2017. In the most severe cases, crop destruction can be total.

Soil – The most suitable soil for maize production is a medium-textured, relatively non-structured sandy loam to sandy clay loam (15-30% clay is ideal), with an effective depth of at least 60 cm (24 inches), but a greater depth is preferred. The majority of the soils cultivated to maize have a brown topsoil, with a reddish or yellow-brown, apedal (unstructured) subsoil, often on a mottled, grey, soft plinthic subsoil. (In isolated areas, at lower levels in the landscape, a bleached unstructured subsoil horizon may occur immediately below the topsoil). Soils with an underlying hard rock or weathering rock (saprolite) horizon are also common. In occasional areas, a cemented, hard plinthite (ferricrete or petroplinthite) horizon occurs below the red or yellow subsoil.

Within the South African soil classification system (Soil Classification Working Group, 2018), the main maize-producing soils are classified as follows:

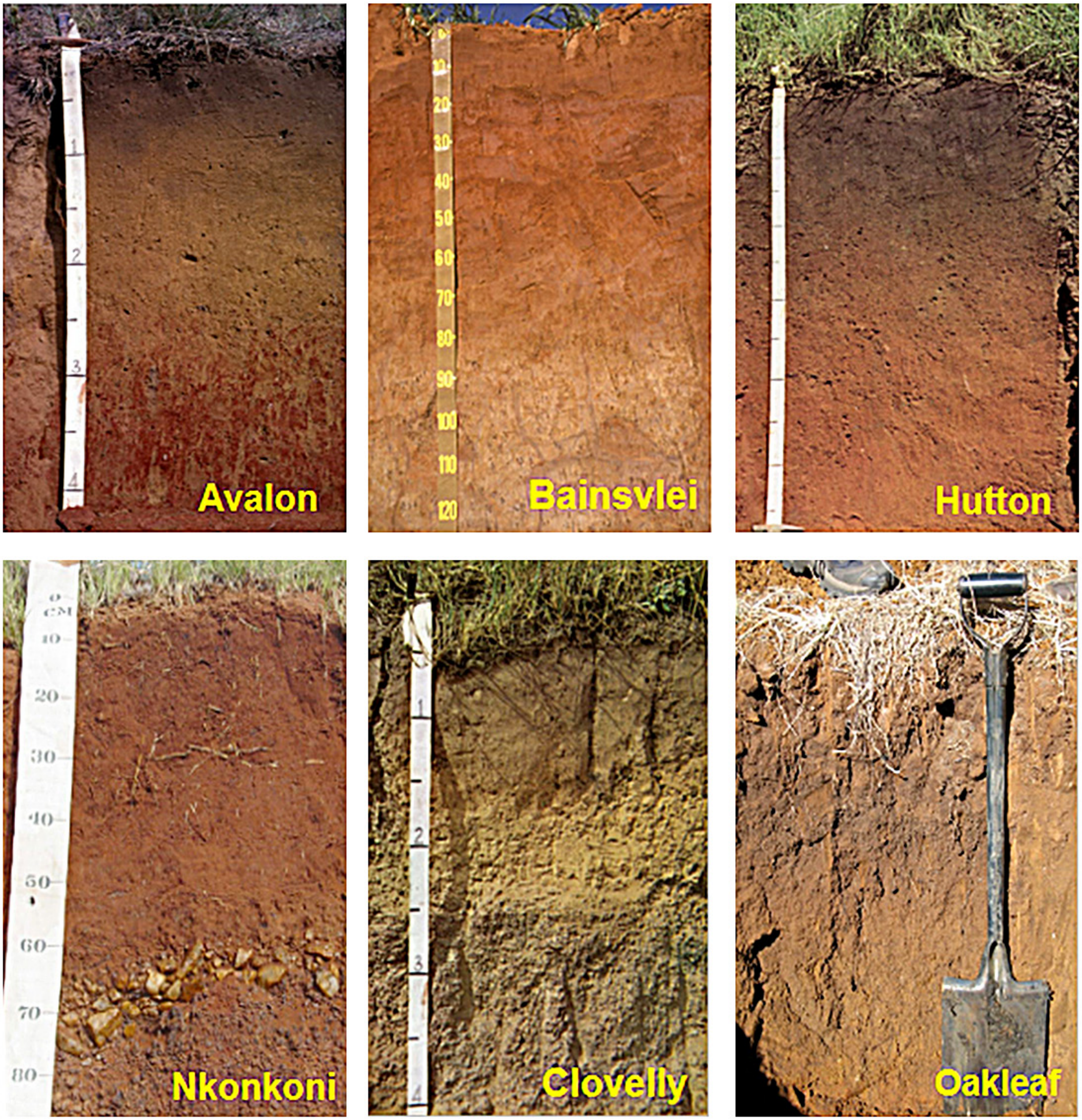
Table 1. Common maize-producing soils in South Africa

Soil Form	Topsoil	Subsoil 1	Subsoil 2
Ermelo	Orthic	Yellow-brown apedal	
Avalon	Orthic	Yellow-brown apedal	Soft plinthite
Glencoe	Orthic	Yellow-brown apedal	Hard plinthite
Clovelly	Orthic	Yellow-brown apedal	Lithic
Carolina	Orthic	Yellow-brown apedal	Hard rock
Hutton	Orthic	Red apedal	
Bainsvlei	Orthic	Red apedal	Soft plinthite
Lichtenburg	Orthic	Red apedal	Hard plinthite
Nkonkoni	Orthic	Red apedal	Lithic
Vaalbos	Orthic	Red apedal	Hard rock
Oakleaf	Orthic	Neocutanic	

When converting these soils to other soil classification systems (van Huyssteen, 2020), the *approximate* correlation to the WRB classification (IUSS Working Group WRB, 2022) is usually Cambisols (Plinthic or Haplic) or Acrisols (Plinthic or Haplic), with the redder soils having either a Chromic or Rhodic qualifier. For the USDA classification (Soil Survey Staff, 1999), the soils are mostly Alfisols or Oxisols.

Examples of some of the soils are shown below in Figure 2 below.

Figure 2. Examples of common South African maize-producing soils



Terrain – Most maize cultivation takes place on fairly flat to gently sloping land. Slopes of as much as eight degrees (18%) are possible, but gentler slopes of 0-3 degrees (0-8%) are more usual.

Drainage – The maize plant does not thrive in wet conditions, especially in the rooting zone. Such conditions could be caused by high clay content (35-50% clay), leading to restricted profile drainage, or by landscape position, where subsurface water tables may be present in the rainy season. Production is therefore largely confined to soils with no signs of wetness in the profile.

In Figure 3, examples of soils with poor drainage and signs of wetness, which are unsuited to maize cultivation, are shown.

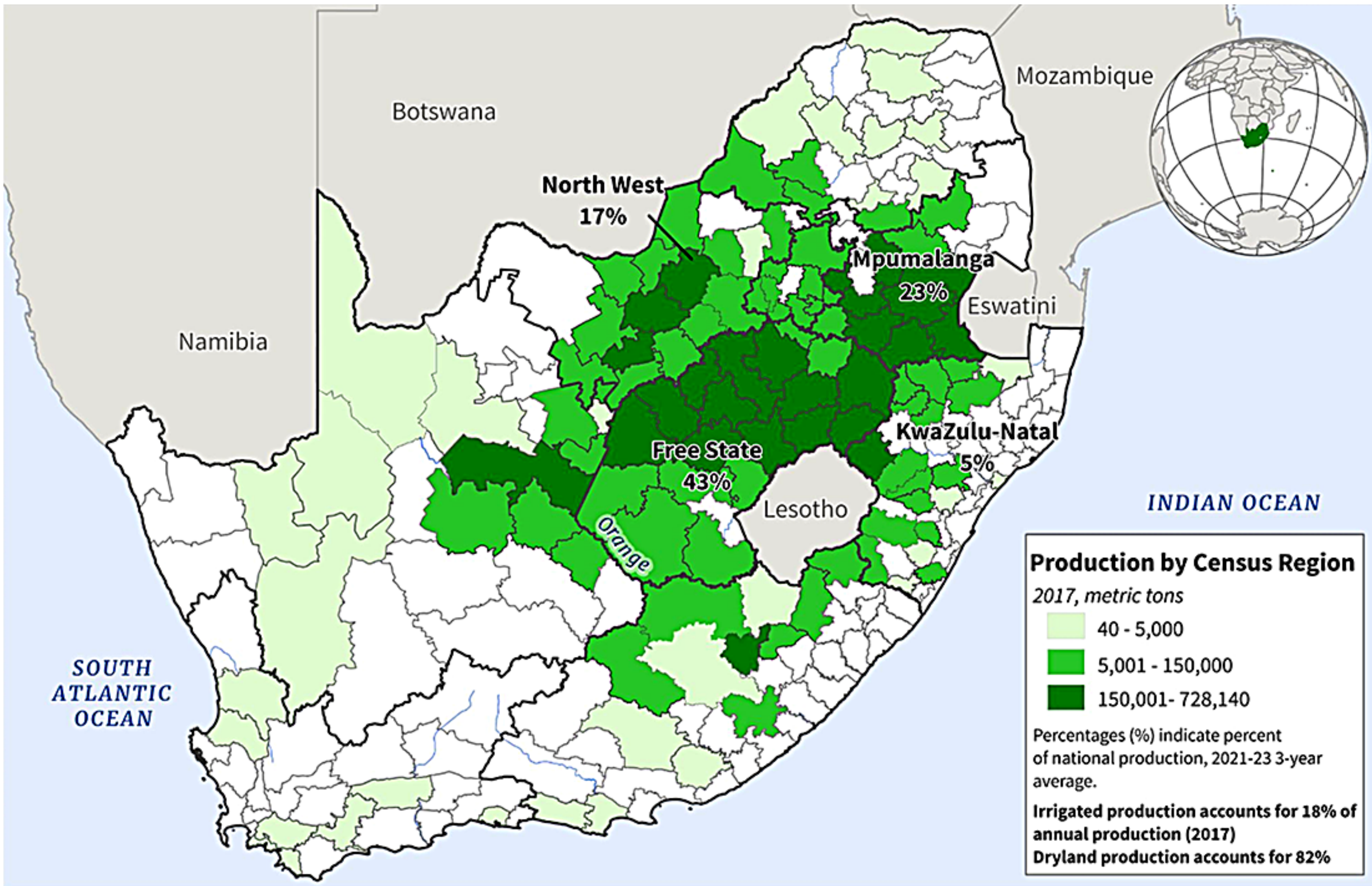
Figure 3. Examples of South African soils with poor drainage

Regions – As previously mentioned, maize production in South Africa is largely defined by the best soil and climate conditions.

The main maize-producing provinces are North West, Mpumalanga, and Free State, accounting for around 80-85% of the total.

The map in Figure 4 was produced from data collected by the Crop Estimates Committee of the Department of Agriculture, as reported in the Census of Commercial Agriculture (Stats SA, 2017). It shows the general distribution, with the major production districts in dark green, the less important in medium green, and the negligible areas in light green.

Figure 4. Map of main maize-producing areas in South Africa



USDA Foreign Agricultural Service
U.S. DEPARTMENT OF AGRICULTURE

Source: South Africa Crop Estimates Committee, Department of Agriculture, Land Reform, and Rural Development, 2023. South Africa 2017 Census of Commercial Agriculture.

1.3.2 Cultivation Practices

This section gives a brief summary of the main issues, but most will be expanded upon elsewhere in the report.

Crop development stages (approximate):

- Germination and emergence 0-7 days
- Plant establishment 7-21 days
- Growth and cob development 21-45 days
- Pollination 45-55 days
- Kernel development 55-84 days
- Grain filling and nutrient transfer 84-105 days
- Physiological maturity 105-140 days
- Harvesting (optimal moisture content) >140 days

Seed – Most maize seed is specially bred hybrid seed (DALRRD, 2022), and is available through commercial seed companies such as Pannar, Syngenta, Bayer, Intergrain, and others. However, small-scale producers are forced, due to financial restraints, to retain seed from the previous season for planting.

Yield – Yield varies considerably, mainly according to climatic conditions and the level of inputs that apply. Across much of the maize-producing area of South Africa, general yield is around 5-9 tons ha-1 (DAFF, 2025). Yields of yellow maize were in the order of 40% higher than those of white maize.

However, in certain more high-input situations (e.g., Precision Agriculture, below), or under irrigated conditions (below), yields can reach as high as 18 tons ha-1 (N. Miles, personal communication). At the other end of the scale, due to lack of financial inputs, small-scale or subsistence producers routinely only obtain yields of 1 to 3 tons ha-1 (Beukes et al., 2011).

Tillage – Traditionally, maize is grown in a monoculture system under annual tillage, with limited rotation. However, increasingly, Conservation Agriculture (CA) is gaining favor, especially among larger commercial farmers. Smith (2021) found that in 2021 CA was applied on 1,607,081 ha, comprising 25% of the total area under commercial annual crop-livestock systems in South Africa.

CA involves three main pillars, namely (1) continuous zero or minimum soil disturbance, (2) permanent organic soil cover, and (3) crop diversification, especially with inclusion of legumes or cover crops (Swanepoel et al., 2017).

Also utilized in maize production is limited tillage, or strip tillage, where only the row being planted is ploughed (usually by mouldboard plough or rotating disc), with the area in between being left under stubble mulch. While no widespread data exists, research has shown that CO_2 emissions from maize under CA were approximately 27% less than maize under conventional tillage (Kidson, 2016).

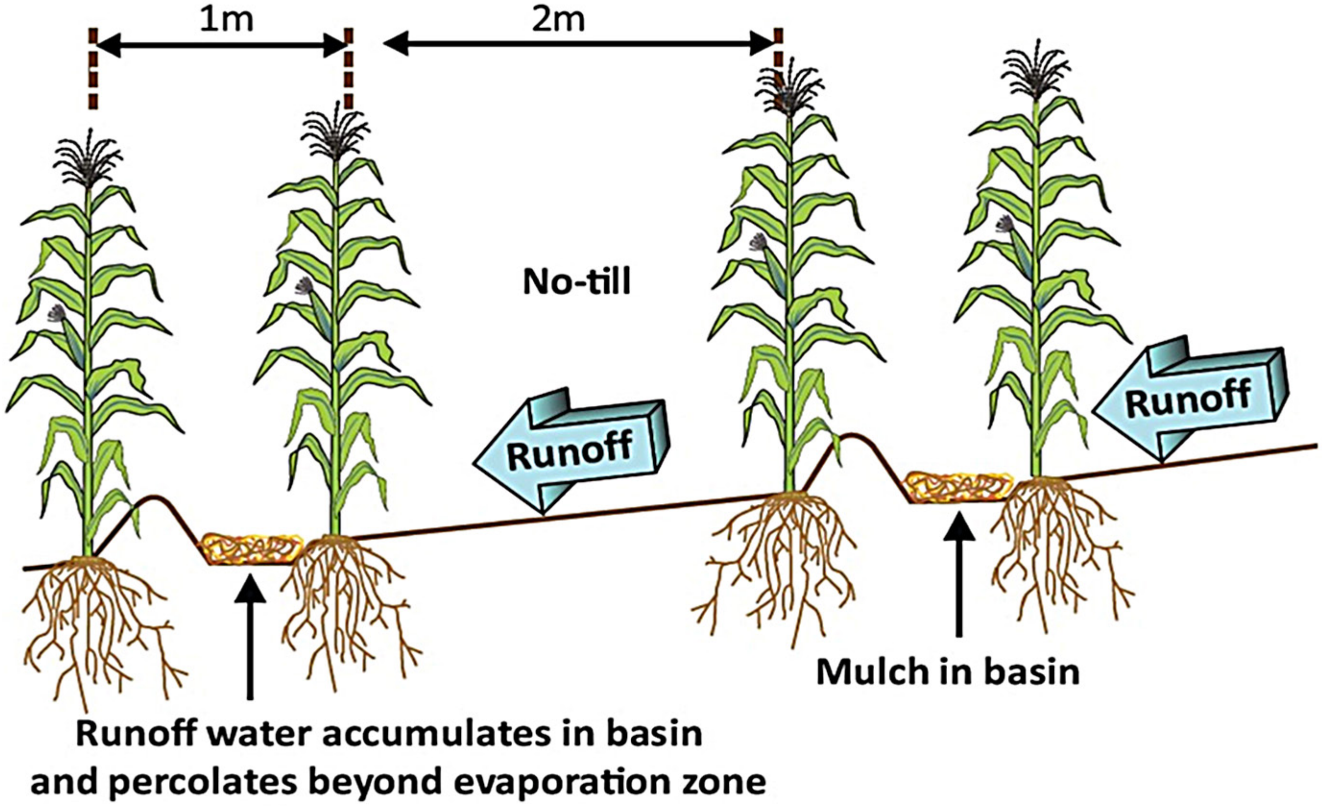
Irrigation – The majority of maize in South Africa is produced under rainfall (dryland or rain-fed cultivation), but there is a significant amount of production under irrigation. In 2017 (the most recent Agricultural Census produced), 82,748 ha of white maize out of 1,262,433 ha (6.5%) and 146,793 ha yellow maize out of 910,937 ha (16.1%). These figures do not distinguish between full irrigation (100% of the crop requirement) and supplementary irrigation (for dry periods within the season).

Commercial vs small scale – Most maize in South Africa (around 80%) is produced by commercial farmers, mostly white. Over the past half century, over half of the commercial field crop area within South Africa was planted to maize (Greyling, 2019). However, there is a small, but significant proportion of maize cultivation that takes place under small-scale to subsistence conditions. Due mainly to maize being the staple food crop in South Africa, in many of the former black homeland areas, and other rural or urban settings, small patches of maize, from one-to-two hectares down to a few square meters in a back garden, are produced.

This is a very unregulated and unrecorded part of the maize cultivation situation, so exact figures are scarce, if not non-existent. However, discussions with staff from the various provincial Departments of Agriculture (Mr Jan Venter, Mpumalanga Province; Mr Cobus Botha, KwaZulu-Natal Province), as well as from the Grain SA (the national grain production organization) indicate that 20% of annual production is a reasonable figure.

Water harvesting – This is a technique whereby mechanical or hand-made basins are constructed on the soil surface, in order to capture and retain rainwater for the longest possible time, with maize (or other crops) being planted on the rows next to the basins (Figure 5). This is an especially valuable technique in the more marginal rainfall areas and works best on clay soils that have a reduced infiltration tempo. Much work has been done in this area by the Agricultural Research Council at Glen, near Bloemfontein, in the Free State Province (Joseph *et al.*, 2011).

Figure 5: Schematic diagram of in-field water harvesting



Cultivars – The majority of maize cultivars in South Africa are provided by one or other of the larger commercial agricultural companies, such as Sensako, Pannar, United Seed, and others, and the majority are genetically modified (GM). Since around 2000, the percentage has grown from almost zero to around 65-70% (BFAP, 2022).

The main traits that are bred into GM seed include insect resistance, cold tolerance (to extend the growing season), and plant vigor (for increased yield). While exact figures are difficult to obtain, probably around 50-100 cultivars are in use across South Africa at any one time.

Precision Agriculture - This is an area of maize cultivation that has become more prevalent in recent years. It involves the use of the most modern technology, including GPS, drones, soil and crop sensors, AI and big data analytics, automation, smart irrigation, and more.

A few years ago, it was estimated (Hendricks, 2011) that just over half the farmers in the summer grain producing region of the North West and Free State provinces practiced some form of precision agriculture, but it is unclear whether this figure remains at that level today.

1.4 Industry Issues

1.4.1 Political

One of the biggest issues affecting maize production in South Africa today is the background political environment. The government is dominated by the ANC, largely a "black" party, while the majority of the commercial farmers are white, and support one or other of the opposition parties, either the Freedom Front Plus (FF+, a mainly "white" party) or the Democratic Alliance (DA, a party with a mixed racial support base). The DA is the second largest party in South Africa and is currently in a ***Government of National Unity*** (GNU) with the ANC and some other smaller parties. The current Minister of Agriculture, Mr John Steenhuisen, is also the leader of the DA.

The ANC regards maize production as critical to food security in South Africa, so very little direct political interference takes place. However, there is always the underlying fear (real or imagined) amongst white farmers that at some stage (not any time soon), there might be a push from the majority black population to take over farmland (even without compensation) to redistribute among the black population. This is a far-fetched scenario at present, but various left-wing "black" parties, such as the Economic Freedom Fighters (EFF, under the leadership of Julius Malema), have land seizure as one of their cornerstone policies.

Against this background, there is a widespread distrust of government by white farmers, with the result that data concerning their on-farm production and other issues is almost impossible to come by. This data is often held by commercial organizations, such as regionally based agricultural co-operatives, who supply services to the farmers and see the farmers as clients, protected by confidentiality.

In addition, in many parts of South Africa, the land is under the custodianship of either a local chieftain, or, in the case of KwaZulu-Natal, the Ingonyama Trust. This trust is under the sole trusteeship of the King of the Zulu "nation," and it covers 2.8 million hectares. Land cannot be "owned" by local individuals but is allocated by the Trust. This makes long-term tenure problematic, as well as access to funds to improve the land, as security for loans cannot be provided.

1.4.2 Safety and Security

One of the prevailing issues affecting commercial agriculture in South Africa, including maize production, is the high crime rate in the country. One of the areas where this manifests itself is in the high numbers of farm attacks, and assaults and murders of farmers, their families and workers. Statistics are somewhat unreliable, one reason being that the South African Police Service (SAPS) stopped releasing homicide statistics on farm murders in 2007, instead merging them with all homicide figures. This has increased the difficulty of accessing reliable statistics on the phenomenon with most studies since relying on data from organizations such as Agri SA, AfriForum, Solidarity, Institute of Security Studies and others.

Self-reported data from these sources state that 1,544 people were killed in farm attacks from 1990 to 2012. Since then, approximate figures are that a further 675 people have been murdered from 2013 to 2024, making a total of 1,719 murders over 35 years.

1.4.3 Population

The South African population is growing rapidly (as in many areas of Africa), with a current estimate (2025) of approximately 63 million. The growth over the past few decades has been reasonably steady, from 25 million in 1975, 33 million in 1985, 42 million in 1995, 48 million in 2005, and 55 million in 2015 (www.worlddata.com). This increase puts pressure on all forms of food production, however, with maize being the staple crop, the pressure is clear. Increases in production have been achieved through cultivar development, water-use efficiency and other means, but the situation remains delicate, mainly due to the annual climatic uncertainty (such as the El Niño/La Niña situation mentioned above).

1.4.4 Domestic Use vs Exports

This is largely governed by the prevailing climate of any one season. In most "normal" years, South Africa exports a percentage of its maize, mainly to the rest of sub-Saharan Africa, but this will fall away when the national production is below-average, so that the production is reserved for domestic use.

From 2000-2001 to 2024-2025, maize production varied from 6,618,000 tons to 16,395,000 tons, while the percentage exported ranged from 4.2% to 33.8%.

1.4.5 Farm Size (Commercial vs Small Scale)

As previously mentioned, South African agriculture, as a whole, is extremely polarized, with a smaller number of large commercial farms against a much larger number of small-scale producers utilizing small areas of land.

Commercial - Stats SA (2017) estimate that the number of commercial farms in South Africa is around **40,000**. It was estimated that in September 2018, the total land used for commercial agriculture was **46.4 million hectares,** (37.9% of the total South African land area of 122.5 million hectares). This gives a (very approximate) **average farm size of 1,160 ha.**

Of the agricultural production area mentioned above, grazing land comprised (36.5 million hectares) and arable land (7.6 million hectares). Grazing land is used for livestock and game farming, and arable land is used for crop production.

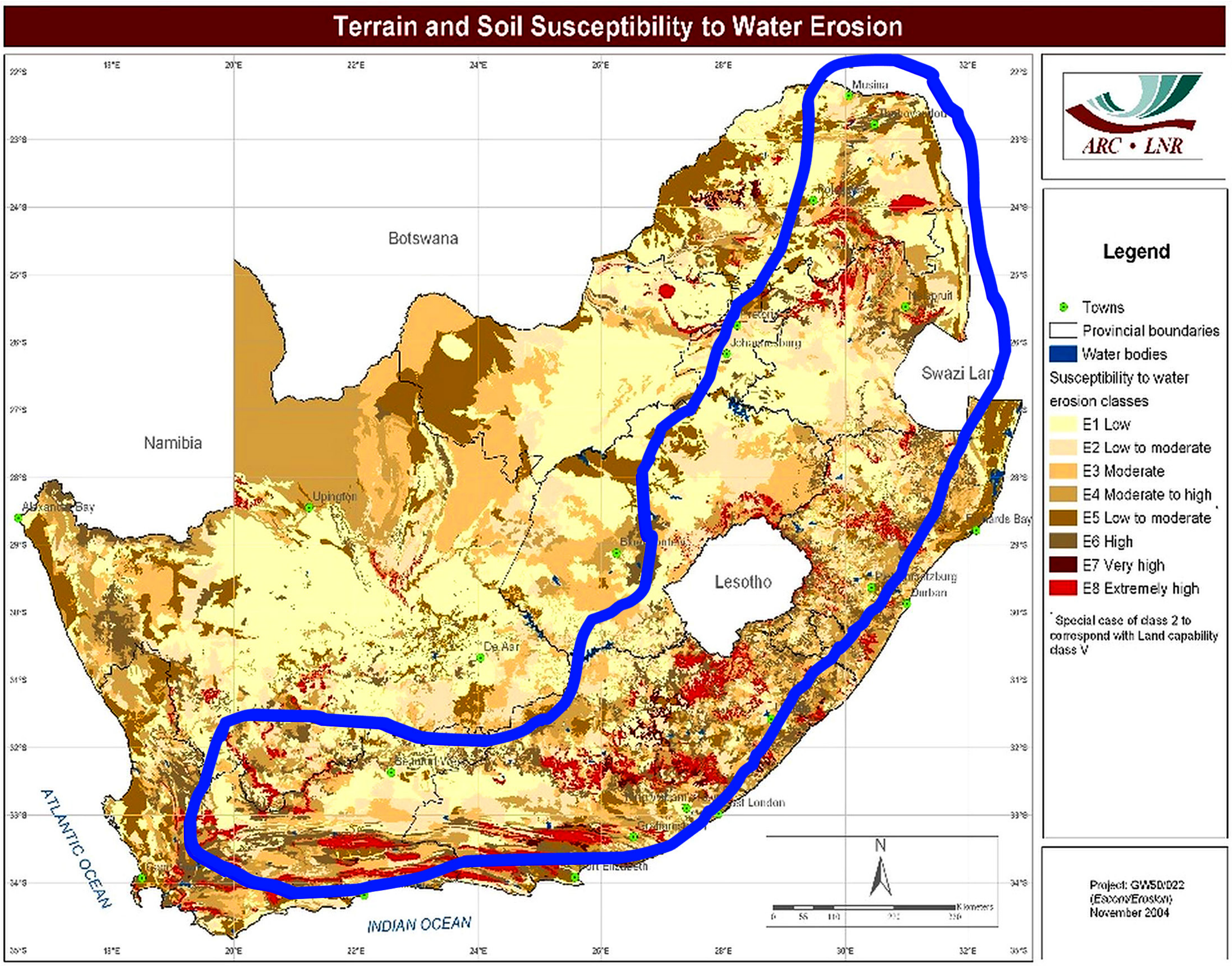
Small-scale – While exact figures are almost impossible to confirm, there are approximately 2 million small-scale producers in

South Africa. The rural areas where most of these are located cover around 15,600,000 ha, which equates to an **average farm size of 7.8 ha.** This exact figure will vary widely, with settlement areas playing a role, but many small settlements have backyard gardens that are cultivated. In any case, it contrasts significantly with the approximate commercial farm size of 1,160 ha as listed above.

1.4.6 Erosion

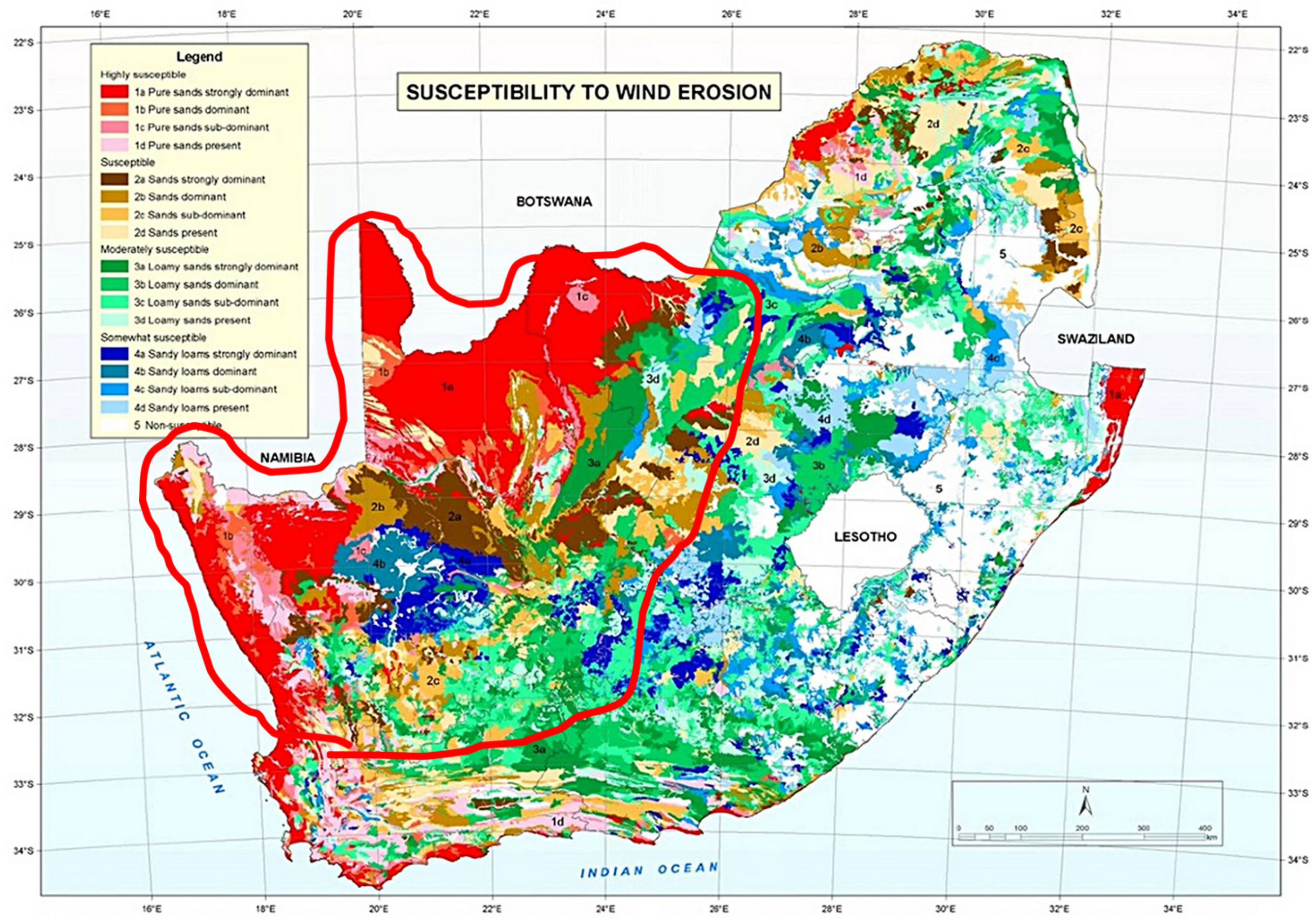
In any landscape affected by human activities such as agriculture, there will be effects on the soil, and one of the most significant, yet insidious, is loss of valuable topsoil due to erosion. This can take the form of soil being washed away by water flow, or blown away by wind action, and the two areas are virtually mutually exclusive in South Africa, as shown on the maps below, where the most susceptible areas are shown by the **blue line** (water erosion, Figure 6) and **red line** (wind erosion, Figure 7).

Figure 6: Soil susceptibility to water erosion in South Africa



This information is derived from the same 1:250,000 scale soil database mentioned in Section 1.3.1, and can be applied at various scales, but with the limitation of the scale and level of detail of the original data set.

Figure 7: Soil susceptibility to wind erosion in South Africa



Implications for maize production are significant, especially under traditional monoculture practices with conventional tillage. When the crop is harvested (usually around May/June), there will generally be a stubble covering left on the soil surface. This is either left undisturbed until the next season's planting ("no-till"), slightly disturbed prior to planting ("stubble mulch" or "reduced tillage"), or completely ploughed under, leaving a bare soil surface ("conventional tillage") (DALRRD, 2022).

Generally, the producer will aim to have planting take place as close as possible to the start of the rainy season, usually after the first rain has fallen. However, if the soil is left uncovered for any length of time, or if there is a prolonged dry spell, so that emergence is slow or delayed, then erosion can occur. If the soils have a relatively sandy texture, especially with a fine sand grade, then particles can be dislodged and be blown into the atmosphere. More clayey soils have a stronger adherence, but an intense rain event (common in South Africa, where 50 mm or more can easily fall within an hour or two) can lead to topsoil being washed away.

1.4.7 Pest and Disease Control

As with most crops, maize is subject to a range of pests and diseases.

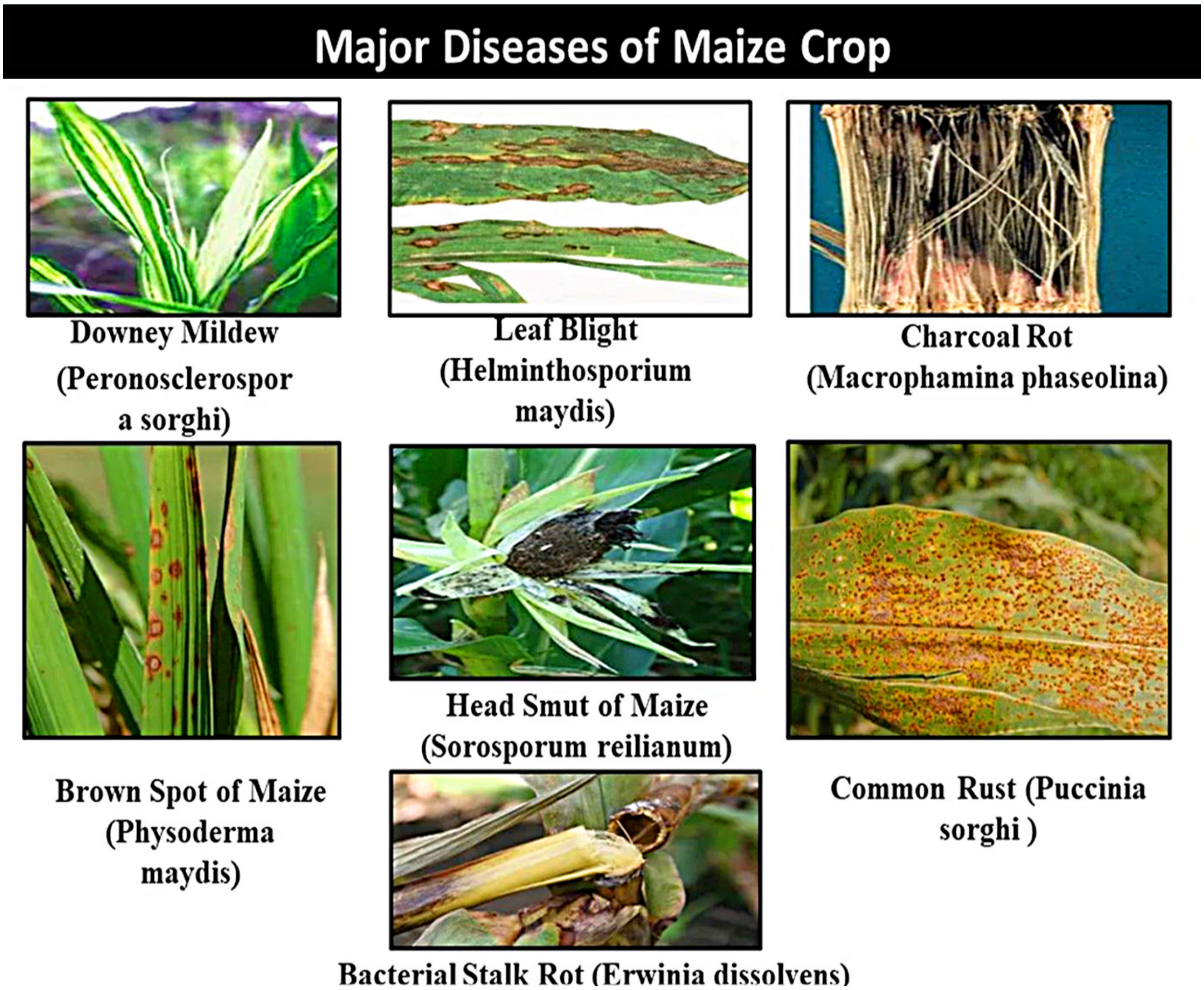
Pests – These include (Farmers Weekly, 2024):

- Maize stalk borer (*Busseola fusca*) – accounts for around 10% of annual crop losses
- Cutworm (*Agrotis segetum*) – attacks the base of the seedling stem, especially young plants
- Black maize beetle (*Heteronychus arator*) – found mainly in cooler areas, young plants most susceptible
- Fall army worm (*Spodoptera frugiperda*) – especially active since 2017, mainly warmer areas, difficult to detect early

Diseases – These include (Grain SA, 2020):

- Northern corn blight – fungus, later-growth stages
- Grey leaf spot – fungus, mid-growth stages
- Maize streak disease – virus, various growth stages
- Bacterial streak – bacterium, from flowering
- *Phaeosphaeria* leaf spot – fungus/bacterium, mid-growth stages
- Downy mildew – fungus, early-growth stages

Figure 8: Some common maize diseases



1.4.8 Pollution

This is applicable in specific localities, mainly adjacent to industrial and/or mining sites. By far, the most important of these is the coal mining region on the Highveld of Mpumalanga Province, approximately 100–150 km east of Johannesburg. Here, open-cast coal mining has caused around 80,000 hectares to be disturbed, mainly by excavation and later rehabilitation (Rethman, 2006). However, close to the mining sites, there is a range of other impacts. These include possible surface runoff with affected mine water, underground drainage (e.g., acid mine drainage), and wind deposition of coal dust on crops (affecting respiration and photosynthesis) as shown in Figure 9 (next page).

Figure 9: Cultivated lands close to mining activities showing coal dust accumulation

1.5 Environmental Regulations

There are a number of pieces of legislation in place in South Africa which have a direct or indirect effect on maize production.

These are:

- **CARA** – Conservation of Agricultural Resources Act (Act 43 of 1983)
- **SALA** – Subdivision of Agricultural Land Act (Act 70 of 1970)
- **PDAL** – Preservation and Development of Agricultural Land Act (Act 39 of 2024)
- **NWA** – National Water Act (Act 36 of 1998)
- **NEMA** – National Environmental Management Act (Act 107 of 1998)
- **APA** – Agricultural Pests Act (Act 36 of 1983)
- **FFFSA** – Fertilizers, Farm Feeds, Seeds and Remedies Act (Act 36 of 1947)

CARA – "To promote the conservation of the soil, the water sources and the vegetation and the combating of weeds and invader plants; and for matters connected therewith"

The objectives of this act are to provide for the conservation of the natural agricultural resources of the republic by the maintenance of the production potential of land, by the combating and prevention of erosion and weakening or destruction of the water sources, and by the protection of the vegetation and the combating of weeds and invader plants. The act is implemented at a national level, with the assistance of provincial offices manned by Resource Auditors.

SALA – "To control the subdivision and, in connection therewith, the use of agricultural land."

All land in South Africa is zoned for a specific land use, and agricultural land can only be subdivided or have a change of land use on application to the national department. This involves an Environmental Impact Assessment (EIA) where the merits of the application (natural and social factors) can be assessed.

At present, the criteria for a commercially viable farming enterprise are one of the following:

- >100 hectares dryland cultivation
- >10 hectares irrigated cultivation with >20 hectares water rights
- Sufficient land to run >60 large stock units at the prevailing grazing potential

SALA is, like CARA, administered nationally through provincial offices.

PDAL - To provide that the act applies to all agricultural land within the republic; to provide principles for the management of agricultural land; to provide for agricultural land evaluation and classification; to provide for the preparation, purpose, and content of provincial agricultural sector plans; to provide for the declaration of protected agricultural areas; to provide for the general objectives of agro-ecosystem management, agro-ecosystem authorizations, the listing and de-listing of activities or areas within agro-ecosystems.

The objectives of this Act are to:

(a) ***Promote the preservation and sustainable development of agricultural land***

(b) Establish evaluation and classification systems for agricultural land

(c) Demarcate protected agricultural areas to ensure that agricultural land is preserved and protected against non-agricultural uses in order to promote long-term agricultural production

(d) Implement a coordinated national framework, including norms, standards and authorizations for the use of agricultural land to:

(i) Promote and encourage viable farming units from a long-term economic, environmental, and social perspective

(ii) Discourage land-use changes from agricultural to non-agricultural uses to prevent the fragmentation of agro-ecosystems

(iii) Facilitate concurrent land uses on agricultural land without jeopardizing long term food security

(e) Provide for mitigating measures to counteract the loss of agricultural land and the impact of non-agricultural developments on agricultural production capacity

(f) Establish a national agro-eco information system

NEMA – While the previous acts are applied through the National Department of Agriculture, NEMA is administered under the Department of Environmental Affairs. Its aim is to ensure that environmental development is sustainable and responsible. It is not specifically aimed at agriculture, but there may be various scenarios where agricultural use (including maize) would be involved.

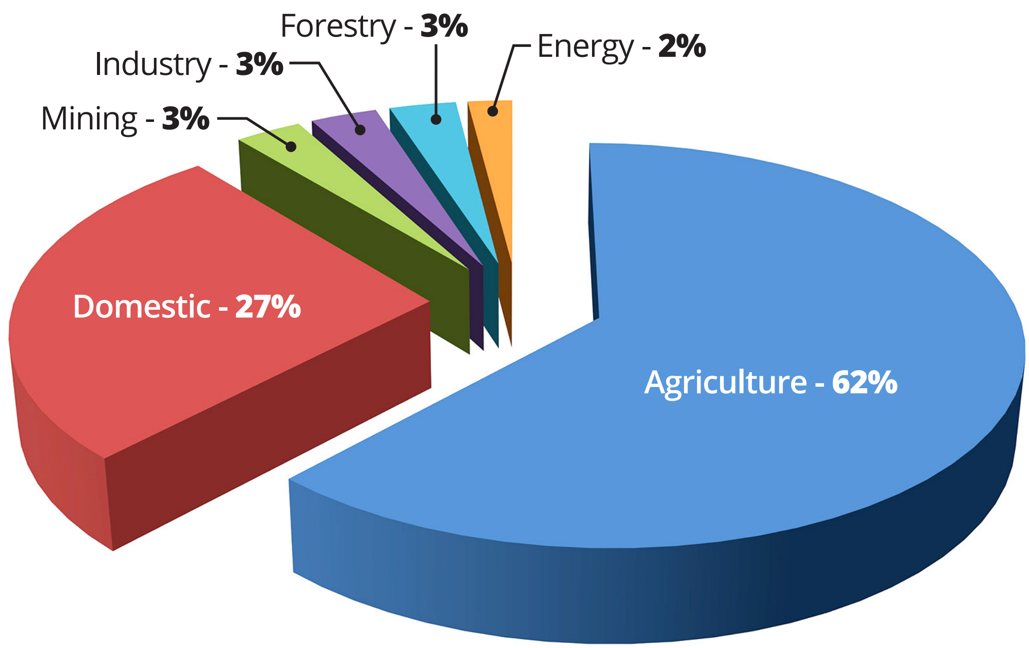
APA – The Agricultural Pests Act falls under the Department of Agriculture and is designed to control the import of anything that could be considered as an agricultural pest, such as insects, pathogens, and others.

FFFSA – All agri-chemicals (inorganic fertilizers, pesticides, herbicides, insecticides, fungicides, etc.) that may be used by maize producers need to be registered with the Department of Agriculture under the Fertilizers, Farm Feeds, Seeds and Remedies Act. An organization known as Fertasa (Fertiliser Association of South Africa) offers a service to help manufacturers with the application process.

NWA – The National Water Act provides for the control and management of water resources in South Africa, including water rights for irrigation. It is administered by the Department of Water Affairs and involves a "National Water Resource Strategy," broken down into natural catchments in the landscape. Given that South Africa is a water-scarce country, the main aim is to ensure long-term water supply for all of the country's needs.

As shown in Figure 10 (below), agriculture (mainly through irrigation) is the main user of water, so in times of drought there is always a conflict between the agricultural, industrial/mining, and domestic sectors.

Figure 10: Water use in South Africa per economic sector



In general, it can be stated that South Africa has a comprehensive set of environmental legislation covering the various aspects of maize (or any specific crop) production. The issue, however, is enforcement of this legislation, due to such constraints as budget restrictions, limited manpower and infrastructure, as well as a general lack of law-and-order support in many areas.

1.6 *Codex* Categories

As part of the *Codex* approach, several categories have been identified for agricultural production, and maize cultivation in particular. These are:

Table 2. *Codex Planetarius* categories

Codex Category	Metric
Soil Health	Farm soil organic matter (SOM/area) or SOC or similar
Water Use	Farm blue water withdrawal (m3/unit production) or local water table stress or similar
Water Effluent	Biological Oxygen Demand (BOD/TSS) or Nitrogen Use Efficiency or similar
Emissions	Farm emissions (MT CO_2e/unit of production) or similar
Biodiversity	Farm natural/restored habitat (%/area) or other IUCN species/Red List area measures
Land-Use Change	Deforestation & Conversion Free (DCF) or other land-use change/compliance measures

Not all of these categories apply equally to maize production in South Africa. The table below gives some details:

Table 3. *Codex Planetarius* categories and their relevance in South Africa

Codex Category	Relevance* (Scale of 1-5)	Measured?	Metrics	Issues (Cost/Accuracy/Availability/Frequency)
Soil Health	4	Yes	• Soil organic matter • Microbial diversity	• SOM easy to measure, relatively inexpensive • Microbes difficult (cooler box) and expensive
Water Use	3	Yes	• Water demand per ton	• Good general information, easy to measure
Water Effluent	2	Not commonly	• Only in mining areas?	• Very site-specific, needs careful measurement
Emissions	2	Not commonly	• CO_2 emissions	• Complicated to measure, some info on CA vs conventional
Biodiversity	3	Yes	• Species proportion • Cultivation percentage • CA implementation?	• Needs specialized monitoring
Land-Use Change	4	Yes	• Hectares under production • Annual change (+ or -)	• Not always available at farm level • Government department stats

*** 1 = Not relevant; 2 = Slightly relevant; 3 = Moderately relevant; 4 = Generally relevant; 5 = Extremely relevant**

2 Pilot Data

2.1 Introduction

Data (plural of "datum") are defined by the Cambridge Dictionary as:

".. information, especially facts or numbers, collected to be examined and considered and used to help decision-making, or information in an electronic form that can be stored and used by a computer."

2.1.1 Classes of Data

Data can be ***spatial***, such as geographically defined maps, shape files, or the like; or ***tabular***, usually presented in a table or spreadsheet form. This is true of maize production in South Africa, whereby, for example, maps showing production areas and other criteria are available, as well as tables showing exact production over the years.

Spatial data can be interpreted and manipulated according to the content of each spatial unit (such as a shape file polygon), while tabular data, especially in a spreadsheet, can be interpreted by such statistical techniques as average, mean, standard deviation, and many more.

2.1.2 Scale of Data

The data pertaining to maize cultivation in South Africa can be divided into the following classes:

- **Farm scale** – Each specific farm (or farm portion) that can be regarded as an economic production unit.
- **Local/Regional scale** – This will refer to an administrative unit, such as a local or district municipality.
- **Provincial scale** – Refers to one of the nine provinces of South Africa.
- **National scale** – Data pertaining to the whole of South Africa.

The usefulness of the data will generally depend on the purpose for which it is required.

2.1.3 Availability of Data

Data pertaining to maize production in South Africa generally falls into one of the following categories:

- **Available** – Can be obtained from various sources, mainly on relevant websites or by enquiry at various organizations.
- **Restricted** – Is available to a greater or lesser degree, but needs either to be purchased for a fee, or the use thereof be negotiated. Such negotiations will usually involve a specific or personalized motivation.
- **Unavailable** – The data exists, but for one or other reason, its supply and use is not permitted. The main reason will be confidentiality, such as farm-level data held by various agri-industries (co-operatives, seed, and fertilizer companies etc).
- **Non-existent** – The data does not exist at all or has not been collected in South Africa. This is usually due to either difficulty of collection or expense, or both.

The various types of data and their availability will be discussed in more detail in this section of the report.

2.1.4 Sources of Data

2.1.4.1 Government

There are several main sources of data in South Africa, mostly through **Government Departments or Parastatal organizations**. The main source is the Department of Statistics South Africa ("Stats SA"), mainly through its regular **Agricultural Census**, the last one of which was carried out in 2017 but released a couple of years later (Stats SA, 2017). Unfortunately, the next one is only planned for later this decade, meaning that regular updates on a wide range of agricultural production are difficult to come by.

However, there is an initiative called the **Crop Estimates Committee**, which is responsible for compiling crop estimates in South Africa on an annual basis. It comprises officials from various institutions, including the Department of Agriculture, Land Reform and Rural Development, and several Agricultural Research Council institutes. The committee's primary function is to provide accurate and timely information regarding crop production forecasts, which is essential for agricultural planning and policymaking. Maize is obviously one of the main crops that is included.

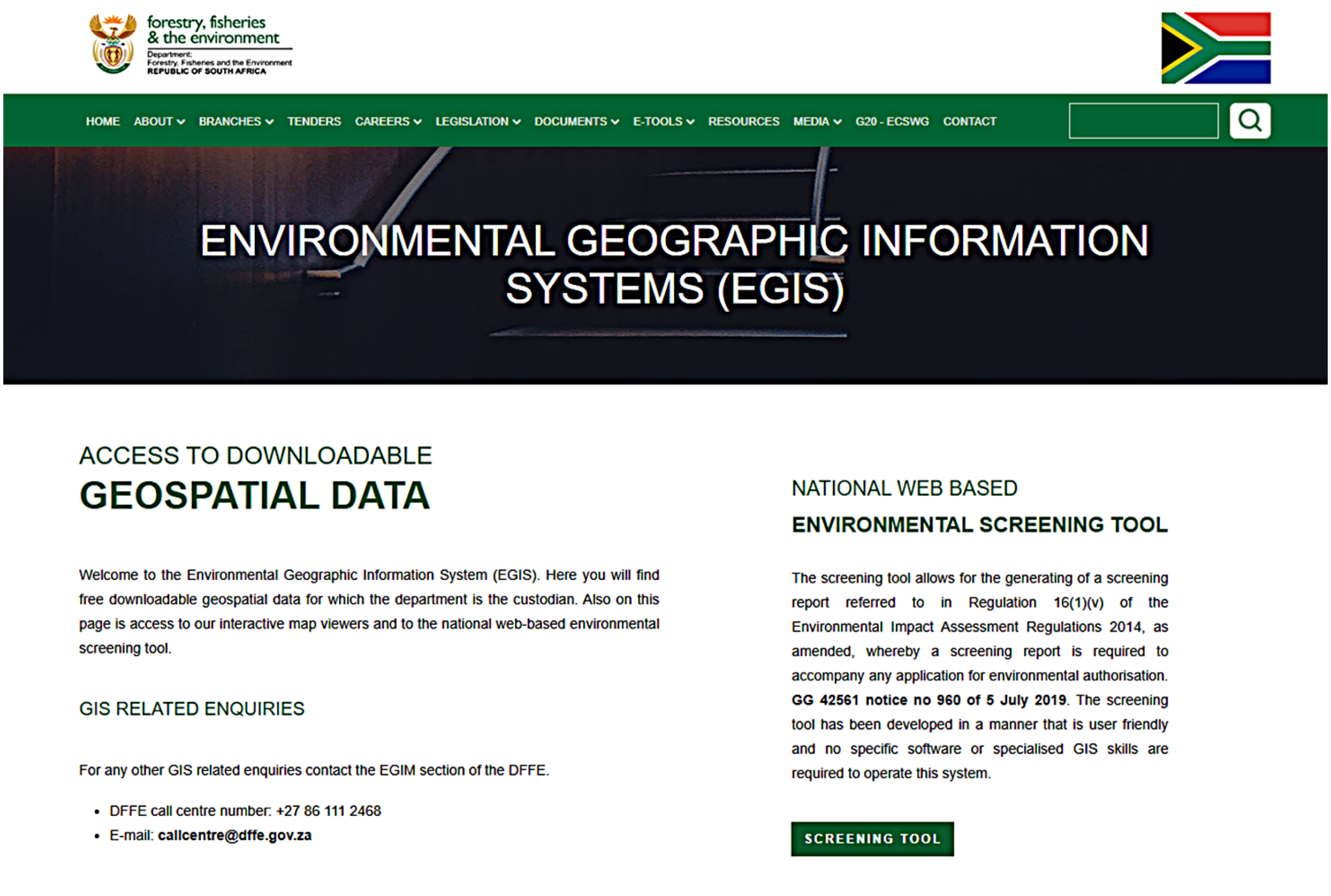
According to the ARC representative on the committee (J.G. Chirima, personal communication), the Committee only reports down to provincial level, not to districts.

A third source is the **National Land Cover** (NLC) initiative, which uses remote sensing imagery that is ground-truthed and has produced various publications over the past +/-30 years. It is a joint initiative between the Agricultural Research Council (ARC), the Council for Scientific and Industrial Development (CSIR), and the Department of Agriculture. It can be confusing, as often data was collected in one specific year, but then only released in a subsequent year.

The first NLC was released in 1994, followed by a second version in 2000. The third version was released in 2013-14, and the latest version in 2018-19 (available for download from the E-GIS website). It can be downloaded by using the following link:

https://www.dffe.gov.za/

Figure 11: EGIS website home page



While not providing information on maize specifically, there are various land cover classes dealing with cultivated areas, as well as irrigated areas.

2.1.4.2 Private Institutions

These include **commercial agri-industries**, with organizations such as agricultural co-operatives (usually regionally based), seed companies, fertilizer companies, etc.

There is also an organization called Grain SA (www.grainsa.co.za), which is a non-profit organization funded largely by membership fees from grain producers to promote the interests of the industry. It supplies various types of general data.

2.1.4.3 Other

These would include various **academic institutions** (largely those with an agricultural-related faculty where crop-related research takes place) as well as various **community-based organizations**, some privately funded, mainly at a small scale.

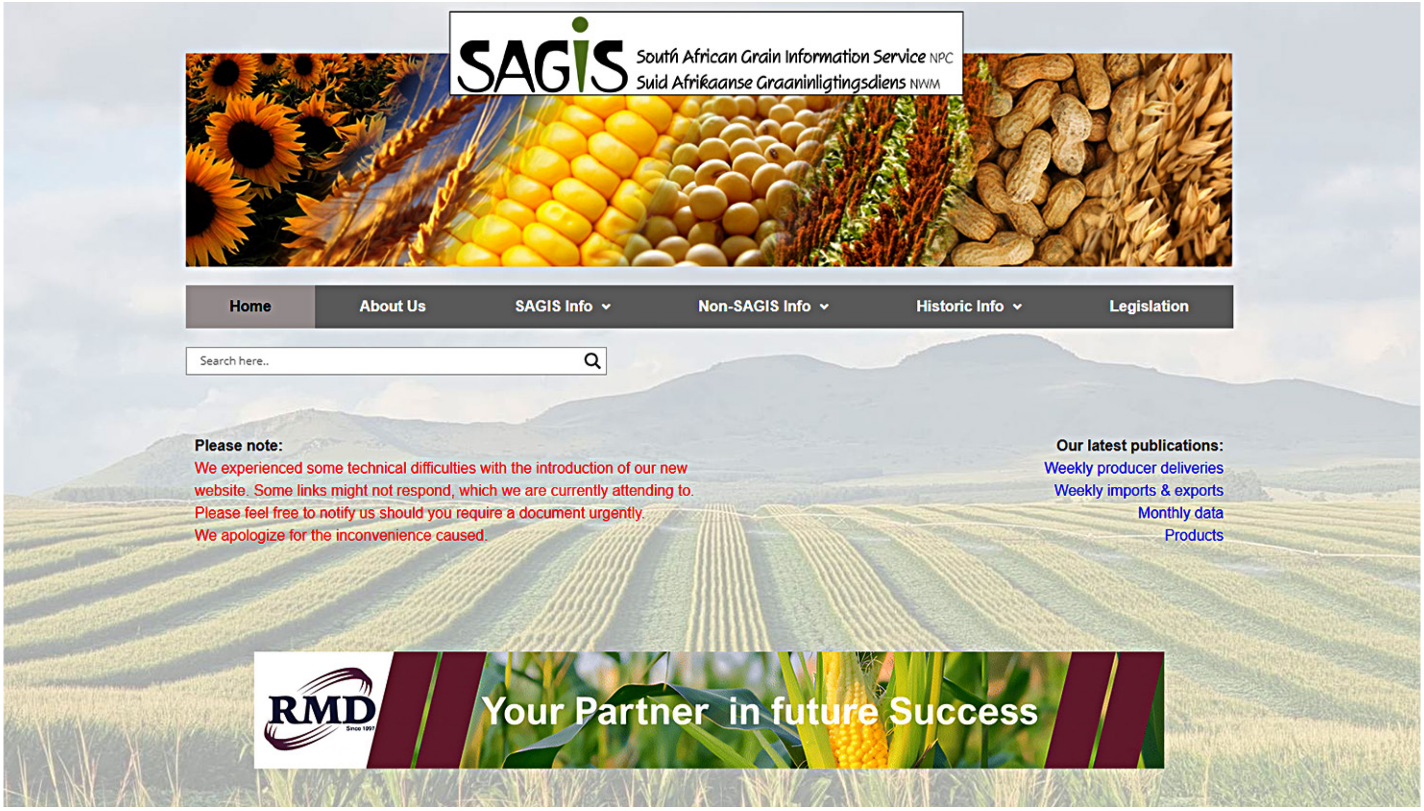
Research projects have been carried out in a variety of areas, and using a variety of scenarios, and there is data available (sometimes with difficulty) from such sources.

Agricultural Research Council (ARC) – Often with funding from the National Department of Agriculture, various projects have been carried out over the years, often at a relatively small scale, and often using community agriculture projects, such as comparing Conservation Agriculture (CA) with conventional tillage (CT), such as the trial at Roodeplaat, outside Pretoria (Beukes & Swanepoel, 2017), in eastern Mpumalanga (Jansen van Rensburg, 2002), and in KwaZulu-Natal (Smith et al., 2005).

The Maize Trust has funded a number of projects, including an economically based assessment of various production systems (Maluleke et al., 2024).

In addition, the Maize Trust is one of the sponsors of the South African Grain Information Service (SAGIS). Its website is www.sagis.org.za

Figure 12: SAGIS website home page



The information/data released to role-players and published on the SAGIS website includes:

- **Monthly data** (Whole grain and oilseeds). This includes:
  - – Monthly data
    - Producer deliveries (per province)
    - Imports & exports
    - Utilization (human, animal feed, and industrial)
    - Grain transport per component
- **Monthly products data** – Manufactured, imports, and exports (**maize**, wheat, and oilseeds)
- **Weekly information:**
  - – Imports and exports (wheat and **maize**)
  - – Intentions to import and export (**maize** and wheat)
  - – Producer deliveries (wheat, **maize**, sunflower seed, and soybeans)
  - – Import tariffs on wheat and **maize**
- **Parity prices**
- **Historic information (SAGIS and non-SAGIS):** Some data dates back as far as 1936
  - – Producer deliveries, consumption, imports and exports
  - – Historic summary: hectares and production
  - – Price information
  - – Parity prices
  - – Population data
- **Weekly bulletin:** A collection of local and international information such as prices, stock, import parity prices, etc.

Various **academic institutions** have produced research, either as funded projects or by post-graduate students. An example is a Coaltech-funded project currently under way at the University of Pretoria concerning irrigating maize using rehabilitated coal mine soils and mine water in Mpumalanga.

An excellent assessment of CA research in South Africa (including maize as the focus crop) was provided by Dr. Corrie Swanepoel (Swanepoel *et al.,* 2017), also reported in her PhD thesis.

A source of data is a model known as SPAM (Spatial Production Allocation Model), driven by the Institute on the Environment at the University of Minnesota (web site link https://www.mapspam.info/) which takes available geo-spatial crop production data and allows the creation of products at more detailed scales.

Figure 13: SPAM website home page

From the SPAM website:

Using a variety of inputs, SPAM uses a cross-entropy approach to make plausible estimates of crop distribution within disaggregated units.

1. *We start with the administrative (geopolitical) units for which we have been able to obtain production statistics. These may typically be national or sub-national administrative regions such as countries, states, districts, or counties. The smaller the administrative units, the better the results.*

2. *We receive an already classified land-cover image, where crop land has been identified.*

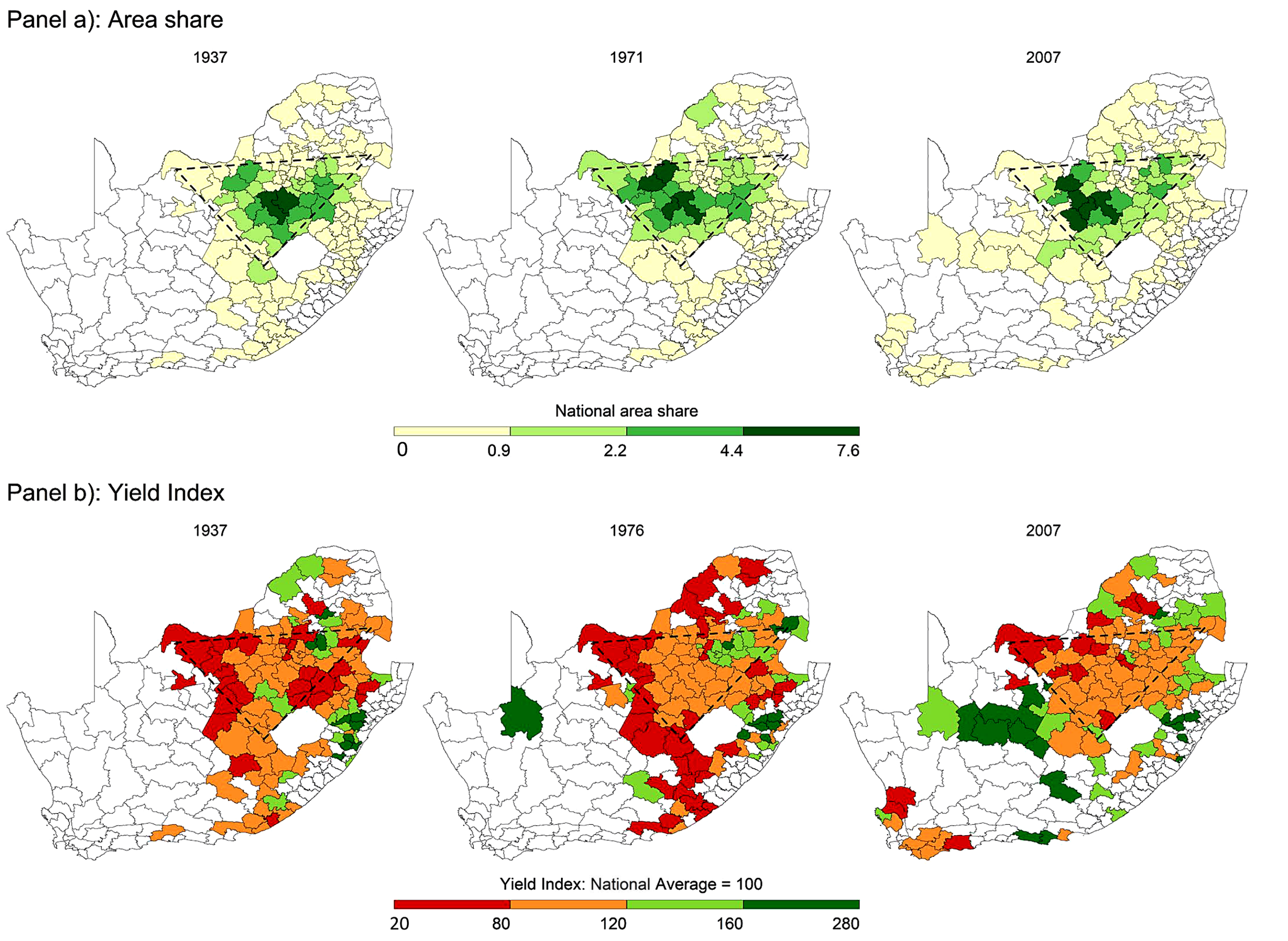
3. *We integrate crop-specific suitability information baswed on local landscape, climate and soil conditions, which provides information on how MUCH crop land exists at the pixel level.*

4. *Combining all these input data and some more parameters, the model applies a cross-entropy approach to obtain the final estimation of crop distribution.*

5. *SPAM relies on a collection of relevant spatially explicit input data, including crop production statistics, crop land data, biophysical crop "suitability" assessments, population density, as well as any prior knowledge about the spatial distribution of specific crops or crop systems. Some of the data is year specific, like crop statistics or population density, while other data is not really tied to a year, like suitability assessment.*

In his PhD thesis (Greyling, 2019), the author used the model to convert province-level data on maize production in South Africa to district level, as shown in Figure 14 below.

Figure 14: Derived district level maize data



SPAM is useful where there is sufficient input data, albeit at a different scale (Point 5 above), but it requires a degree of GIS expertise to maximize the outputs, so is probably not universally applicable across all of the *Codex* indicators.

2.2 Types of Data

The available data can be divided into:

Natural Resources

- Area cultivated
- Soil (land types)
- Climate (weather station network)
- Land use (current and past/future changes)
- Water quality & water use

Production

- Production
- Yield
- White maize vs yellow maize
- Maize vs other grains
- Local consumption vs export
- CA vs conventional

2.2.1 Area Cultivated

As mentioned in Section 2.1.4.1 above, the area under maize cultivation is provided each year by the Crop Estimates Committee. It is presented per province as well as nationally, and the areas under white and yellow maize, as well as the total area, for the past decade, are shown in the table below.

Table 4. Maize cultivation in South Africa, 2015-2025

Season	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25*
White Maize ('000 ha)	1014.75	1643.10	1268.10	1298.40	1616.30	1691.90	1575.00	1521.30	1554.75	1599.70
Yellow Maize ('000 ha)	932.00	985.50	1050.75	1002.10	994.50	1063.50	1048.00	1064.80	1081.50	997.00
Total Area ('000 ha)	**1946.75**	**2628.60**	**2318.85**	**2300.50**	**2610.80**	**2755.40**	**2623.00**	**2586.10**	**2636.25**	**2596.70**

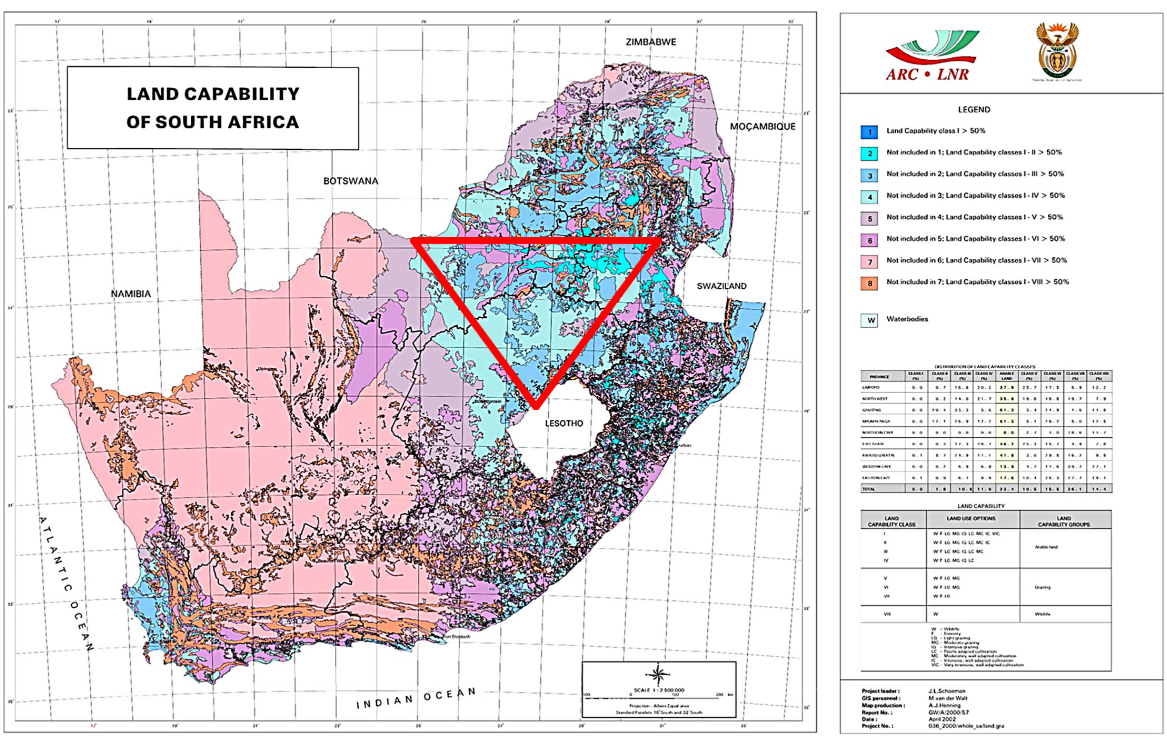
**Production estimate*

2.2.2 Soil Resources

As specified in Section 1.3.1, maize has a specific soil requirement, and the distribution of the soils in South Africa at 1:250,000 scale is contained in the Land Type Survey, with the data being administered by the Agricultural Research Council-Institute for Soil, Climate, and Water (Land Type Survey Staff, 1972-2002). From this data set, various interpretations, such as agricultural potential, can be made. Figure 15 below shows the distribution of the various land capability classes, according to the South African Land Capability classification (Schoeman *et al.*, 2000).

Figure 15. Land capability map of South Africa

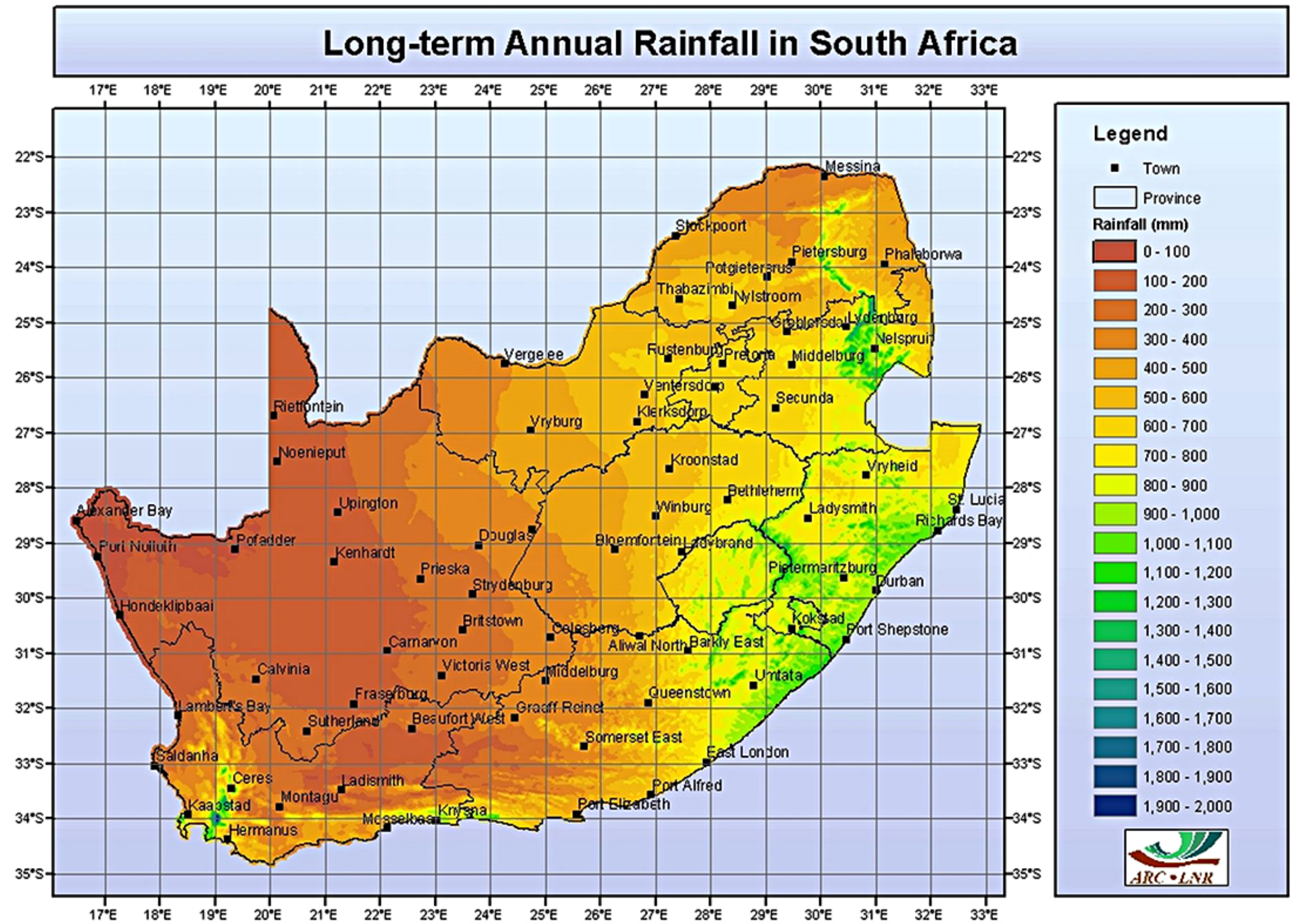
The best soils (land capability classes 1-3), are shown by the blue areas, and correspond well with the maize producing areas of the country (approximately the red triangle).



2.2.3 Climate

Just as for soil, maize has a climatic requirement, mainly concerning rainfall within the summer (Oct-Apr in the southern hemisphere) growing season. Records of rainfall are obtained from the weather station network maintained by ARC-ISCW. When this data is extrapolated and geo-referenced, maps of long-term average rainfall can be produced, such as the one shown in Figure 16 below. The black line shows the approximate 550 mm cut-off, with areas to the west being too dry (and hot) for rain-fed cultivation, and the areas to the east having sufficient rainfall, improving farther eastward.

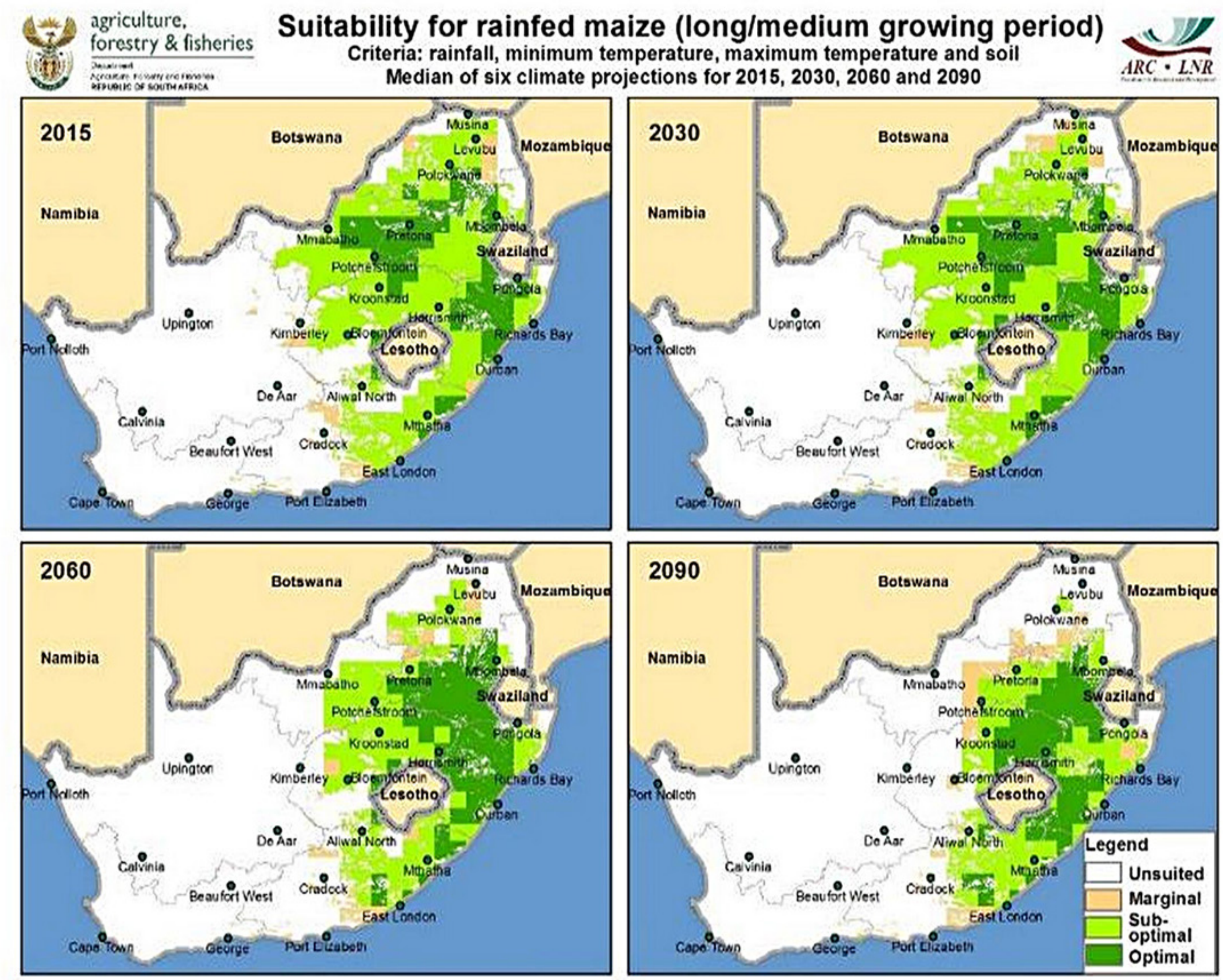
Figure 16. Average rainfall for South Africa



Regarding climatic conditions, there is a worldwide focus on possible future climate change, and how this may affect agriculture. Much research has been done, and South Africa is no exception. Work by the Agroclimatology unit at ARC-Soil, Climate and Water in Pretoria has produced a number of possible scenarios and how they may influence future maize production (Weepener *et al.*, 2014)

An example of such scenarios is seen in Figure 17 (next page), where a number of criteria have been combined with possible long-term trends to give an idea of possible changes to the maize-production area over the next several decades. The main projection is that the growing areas will probably move eastward and probably become smaller. Such research allows focus on such aspects as cultivar development and infrastructure planning.

Figure 17. Possible future maize production scenarios

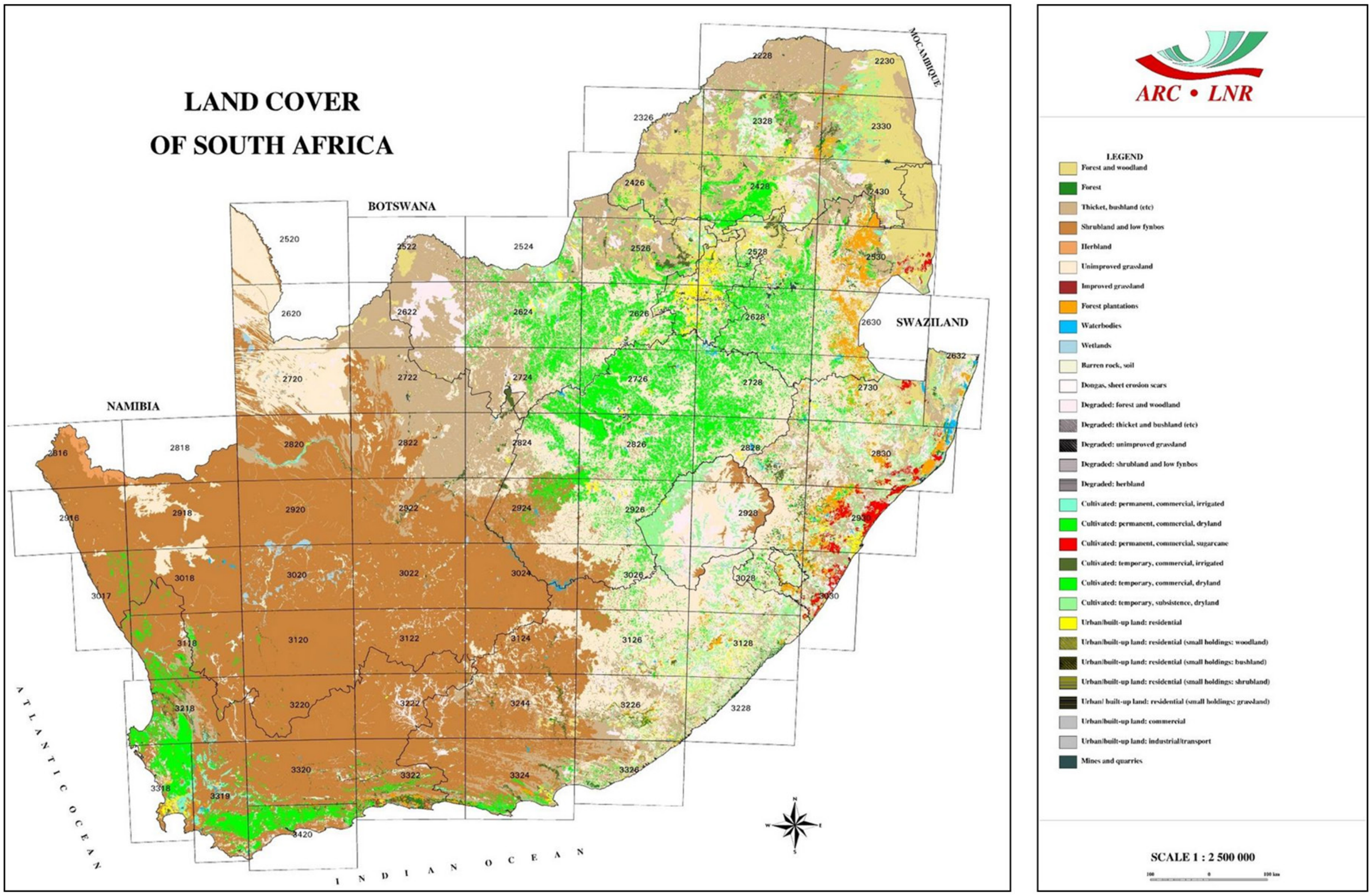


2.2.4 Land Use

As mentioned in 2.1.4.1, the National Land Cover used remote sensing data that was ground-truthed to look at various classes of land use.

Figure 18 below shows clearly the extent and distribution of the cultivated areas (shown in green), where the majority of the maize production occurs.

Figure 18. Land cover map of South Africa



2.2.5 Water Quality and Water Use

The majority of maize grown in South Africa is rain-fed, but where there is a supply of water, it may be used, either completely (90-100% of the crop water requirements) or, more usually, as a supplementary source to complement gaps in the usual supply process (such as drought periods at critical times during the growing season). At farm level, most water supplied for irrigation is from on-farm sources, such as springs, boreholes or farm dams. Very little such data is available.

2.2.5.1 Water Quality

In any case, across the maize-producing zone of South Africa (see Figure 11, page 21), water quality is not generally an issue if one looks at the main possible issues, which include:

- Acidity/Alkalinity (pH)
- Electrical Conductivity (EC)
- Salt content – sodium adsorption ratio (SAR)
- Nitrates
- Total dissolved solids (TDS)

Water quality data that is readily available can be obtained from the National Department of Water and Sanitation and is obtained from monitoring points on most of the major rivers across the country. It is therefore most useful to some of the producers in larger irrigation schemes that extract water from these rivers, although maize cultivation in these areas is in the minority.

The water quality data can be compared with the published guidelines for South Africa (DWAF, 1996), which cover water quality for a number of uses, namely:

- **Volume 1:** South African Water Quality Guidelines – Domestic Water Use
- **Volume 2:** South African Water Quality Guidelines – Recreational Water Use
- **Volume 3:** South African Water Quality Guidelines – Industrial Water Use
- ***Volume 4: South African Water Quality Guidelines – Agricultural Water Use: Irrigation***
- **Volume 5:** South African Water Quality Guidelines – Agricultural Water Use: Livestock Watering
- **Volume 6:** South African Water Quality Guidelines – Agricultural Water Use: Aquaculture
- **Volume 7:** South African Water Quality Guidelines – Aquatic Ecosystems
- **Volume 8:** South African Water Quality Guidelines – Field Guide

Volume 4 is the one that has most relevance to maize production.

2.2.5.2 Water Use

This is difficult, if not impossible to determine. While figures on the area of maize under irrigation are available, the actual amount of water used is not possible to determine, and that will in any case vary greatly from season to season, depending on rainfall that is recorded.

2.2.6 Production and Yield

The information is freely available, mainly from the Crop Estimates Committee (DAFF, 2025).

Table 5. Maize production and yield in South Africa, 2015-2025

Season	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25*
White Maize ('000 tons)	3408.50	9916.00	6540.00	5545.00	8547.50	8600.00	7789.80	8500.00	6055.00	7395.70
Yellow Maize ('000 tons)	4370.00	6904.00	5970.00	5730.00	6752.50	7715.00	7597.45	7895.26	6795.00	6515.45
Total Production ('000 tons)	**7778.50**	**16820.00**	**12510.00**	**11275.00**	**15300.00**	**16315.00**	**15387.25**	**16395.26**	**12850.00**	**13911.15**
Yield (t ha^{-1})										
White Maize	3.36	6.03	5.16	4.27	5.29	5.08	4.95	5.59	3.89	4.62
Yellow Maize	4.69	7.01	5.68	5.72	6.79	7.25	7.25	7.41	6.28	6.54
Total Average Yield	**4.00**	**6.40**	**5.39**	**4.90**	**5.86**	**5.92**	**5.87**	**6.34**	**4.87**	**5.36**

**Production estimate*

2.2.7 White Maize vs Yellow Maize

In South Africa, **white maize** is predominantly used for human consumption, accounting for 74% of the production in 2015, mainly in the form of maize meal. In contrast, **yellow maize** is primarily used for animal feed, with 88% of the production being utilized for poultry and beef, although some is used for "corn-on-the-cob" sold in supermarkets and other food outlets.

As seen in Table 6, the proportions of white and yellow maize are approximately equal, varying from year to year due to yield, livestock numbers, and other requirements.

In addition, some of the plant material is harvested early, when still relatively green, to be processed and used as silage for livestock (Farmers Weekly, 2017).

2.2.8 Maize vs Other Grains

Grain SA reports that maize, as previously stated, is the most prevalent crop in South Africa (Grain SA, 2024).

Table 6. Grain crops in South Africa, 10-year average

Crop	Area Cultivated (ha)	Amount Produced (tons)
Maize	**2,505,910**	**13,490,970**
Soya bean	803,800	1,574,530
Sunflower	578,060	751,801
Sorghum	44,565	124,998
Groundnuts	40,490	51,545
Wheat	516,600	186,267
Barley	105,500	366,766
Canola	90,496	142,900

Notes:

1. *These data are for commercial scale production. Small-scale/subsistence cultivation is not included.*
2. *Barley production is largely for the local brewing industry.*

2.2.9 Local Consumption vs Export

South Africa usually has a maize surplus to enable exports. If maize is exported from South Africa, it will very largely be to the neighbouring SADC (Southern African Development Community) countries, such as Namibia, Botswana, Angola, Zimbabwe, Mozambique and/or Zambia. As previously stated (Section 1.4.4), the quantity depends largely on prevailing climatic and economic conditions in any particular season.

The relative export percentages for the past few years are shown in Table 7 (next page).

Table 7. South African maize exports, 2001-2024

Year	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
White maize*	4260.30	5537.50	6365.60	5805.00	6540.70	4187.40	4315.00	7480.00
Yellow maize*	3226.50	4194.40	3025.90	3677.00	4909.30	2430.60	2810.00	5220.00
Total*	**7486.80**	**9731.80**	**9391.50**	**9482.00**	**11450.00**	**6618.00**	**7125.00**	**12700.00**
Exports*	**1448.00**	**1335.00**	**1188.00**	**1185.00**	**832.00**	**2237.00**	**597.00**	**534.00**
% of Total	***19.34***	***13.72***	***12.65***	***12.5***	***7.27***	***33.8***	***8.38***	***4.2***

Year	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
White maize*	6775.00	7830.00	6052.00	6903.40	5606.50	7710.00	4735.00	3408.50
Yellow maize*	5275.00	4985.00	4308.00	5217.00	6203.80	6540.00	5220.00	4370.00
Total*	**12050.00**	**12815.00**	**10360.00**	**12120.40**	**11810.30**	**14250.00**	**9955.00**	**7778.50**
Exports	**2269.00**	**1796.00**	**2194.00**	**2575.00**	**1946.00**	**2233.00**	**2156.00**	**880.00**
% of Total	***18.83***	***14.01***	***21.18***	***21.25***	***16.48***	***15.67***	***21.66***	***11.31***

Year	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
White maize*	9916.00	6540.00	5545.00	8547.50	8600.00	7789.80	8500.00	6055.00
Yellow maize*	6904.00	5970.00	5730.00	6752.50	7715.00	7597.50	7895.30	6795.00
Total*	**16820.00**	**12510.00**	**11275.00**	**15300.00**	**16315.00**	**15387.20**	**16395.20**	**12850.00**
Exports	**1026.00**	**2482.00**	**2284.00**	**1810.00**	**2868.00**	**4060.00**	**3175.00**	**1448.00**
% of Total	***6.1***	***19.84***	***20.26***	***11.83***	***17.58***	***26.39***	***19.37***	***11.27***

**Numbers given in thousands of tons*

With South Africa being the largest producer of maize on the continent (DALRRD, 2022), it is in a strong political and strategic position regarding food security, especially with the relative inefficiency of some of the agricultural production in neighbouring states.

2.2.10 Commercial vs Small-Scale Production

In terms of commercial maize (or most other crop) production, little or no actual farm-scale data is available in terms of actual input costs and the relevant enterprise budget.

However, some research has been done and various concepts or "best estimate" figures have been produced. A project co-ordinated by the Agricultural Research Council has been looking at enterprise budgets for a range of crops. Using inputs from a range of researchers and other experts, they have concluded the following for maize, at 2024-25 prices (USD conversion **in red**):

Table 8. Estimated enterprise budgets for maize

Crop	Production Level	Annual Offtake ($t\ ha^{-1}$)	Price per Unit (R/ton) ($/ton)	Costs %	Revenue (R) ($)	Potential Net Income (R) ($)
Maize, Dryland	**Conservative**	4.5	**R 4,500** **$257.14**	60	**R 20,250** **$1,157**	**R 8,100** **$462**
	Fair	5.8	**R 4,500** **$257.14**	75	**R 26,100** **$1,491**	**R 6,525** **$373**
	Good	6.5	**R4,500** **$257.14**	88	**R29,250** **$1,671**	**R3,510** **$200**
Maize, Irrigated	**Conservative**					
	Fair	12	**R 4,500** **$257.14**	80	**R 54,000** **$3,085**	**R 10,800** **$617**
	Good	16	**R 4,500** **$257.14**	88	**R 72,000** **$4,114**	**R 8,640** **$494**

Notes:

1. *$1USD = R17.50 (As of July/August 2025)*
2. *Production Level – "Conservative" = basic management skills, minimum inputs; "Fair" = better management, average inputs; "Good" = optimum management and inputs*
3. *It is not envisaged that "Conservative" management will be sufficient for sustainable production under irrigation.*

For more detailed figures, various institutions such as the North West Co-operative ("NWK") and the Central West Agricultural Co-operative ("Senwes") produced concept figures in 2008, which have been updated according to the prevailing intervening inflation rate (Table 10, USD conversion **in blue**).

Table 9. Concept enterprise budget

Enterprise Budget for Dry Land Maize: 2008/09 and 2024/25 Production Season (R/ha)									
Cost and Income Breakdown	**Land Suitability Class**								
	Highly Suitable or Suitable (>3 t/ha)								
Potential Yield (t/ha)	**3.5 – 4.5**			**3.0 – 4.0**			**2.5 – 3.5**		
Target Yield (t/ha)	**5**			**4**			**3**		
Price (R/t), 2008-09 and 2024-25 (adjusted) and USD conversion	1,850	**4,255**	**243**	1,850	**4,255**	**243**	1,850	**4,255**	**243**
Price with Yield		**21,275**	**1,216**		**17,020**	**973**		**12,765**	**729**
Variable Cost Before Top Dressing									
Seed	435	**1,001**	**57**	348	**800**	**46**	391	**899**	**51**
Seed treatment	63	**145**	**8**	51	**117**	**7**	57	**131**	**7**
Fertilizer* (1,2)	1,225	**2,817**	**161**	1,103	**2,537**	**145**	1,225	**2,817**	**161**
Pesticides	111	**255**	**15**	96	**221**	**13**	111	**255**	**15**
Risk management	399	**917**	**52**	330	**759**	**43**	350	**805**	**46**
Fuel	427	**982**	**56**	428	**984**	**56**	427	**982**	**56**
Maintenance and repairs	216	**497**	**28**	216	**497**	**28**	216	**497**	**28**
Interest* (3)	356	**818**	**47**	318	**732**	**42**	344	**790**	**45**
Total Variable Cost Before Top Dressing	3,231	**7,432**	**425**	2,890	**6,647**	**380**	3,120	**7,177**	**410**
Variable Cost with Top Dressing									
Fertilizer	751	**1,727**	**99**	613	**1,410**	**81**	576	**1,325**	**76**
Pesticides	209	**481**	**27**	122	**281**	**16**	209	**481**	**27**
Herbicides	18	**41**	**2**	18	**41**	**2**	18	**41**	**2**
Part-time labor	57	**131**	**7**	41	**94**	**5**	57	**131**	**7**
Fuel	130	**299**	**17**	130	**299**	**17**	130	**299**	**17**
Maintenance and repairs	51	**117**	**7**	51	**117**	**7**	51	**117**	**7**
Interest* (3)	100	**231**	**13**	80	**185**	**11**	86	**198**	**11**
Total Variable Cost with Top Dressing	1,316	**3,028**	**173**	1,055	**2,428**	**139**	1,127	**2,592**	**148**
Variable Harvest Cost									
Part-time labor	49	**113**	**6**	49	**113**	**6**	49	**113**	**6**
Fuel	296	**681**	**39**	149	**343**	**20**	271	**623**	**36**
Maintenance and repairs	154	**354**	**20**	71	**163**	**9**	143	**329**	**19**
Interest	21	**47**	**3**	11	**26**	**1**	19	**44**	**3**
Total Variable Harvest Cost	520	**1,195**	**68**	280	**644**	**37**	482	**1,109**	**63**
Total Variable Cost* (3)	5,067	**11,655**	**666**	4,226	**9,719**	**555**	4,729	**10,878**	**622**
Gross Margin Above Direct Variable Cost	4,183	**9,620**	**550**	3,174	**7,301**	**417**	821	**1,887**	**108**
Fixed Cost									
Labor	177	**407**	**23**	177	**407**	**23**	177	**407**	**23**
Insurance and licenses	32	**74**	**4**	32	**74**	**4**	32	**74**	**4**
Diverse	233	**536**	**31**	233	**536**	**31**	233	**536**	**31**
Depreciation	262	**602**	**34**	262	**602**	**34**	262	**602**	**34**
Total Fixed Cost	704	**1,618**	**92**	704	**1,618**	**92**	704	**1,618**	**92**
Total Production Cost	**5,771**	13,273	758	**4,929**	11,337	648	**5,433**	12,496	714
Gross Margin Above Specified Cost	**3,479**	8,002	457	**2,471**	5,683	325	**117**	269	15
Break-Even Yield (t/ha) *(5)	**3.12**	3.12	3.12	**2.66**	2.66	2.66	**2.94**	2.94	2.94
Break-Even Point (R/t) *(6)	**1,154**	2,655	152	**1,232**	2,834	162	**1,811**	4,165	238

Notes:
*(1) Nitrogen, herbicides, and pesticides to be applied on recommendation of an agricultural advisor
*(2) Agricultural lime not included
*(3) Interest calculated at 16.5%
*(4) Costs to be financed (total variable cost excluding seasonal labor and interest on seasonal labor cost
*(5) Break-even cost calculated at target yield and according to the applicable product price
*(6) Input and hail insurance

2024-25 prices adjusted for 230% inflation since 2008-09; USD exchange rate $1 = ZAR17.5 (Aug 2025 rate)

Source: NWK and SENWES

A paper published by authors including agricultural economists (Maluleke *et al.*, 2024) looked at comparisons between Conventional Tillage systems (CT) and Conservation Agriculture (CA), but this was also at a commercial level.

In contrast with commercial information, however, similar data or figures for small-scale or semi-subsistence maize production are not generally available. It is thus not clear whether the same input ratios or other cost relationships are relevant, even if actual costs are lower.

This was confirmed (personal communication) by Ms. Patience Chauke, a researcher at ARC-SCW with more than a decade of experience in small-scale agriculture research. Some of the issues include:

- Lack of knowledge and/or insight among small-scale producers as to the benefits of keeping records
- Financial restrictions, that require seed from the previous season to be retained for planting in the next season. Also, commercial fertilizer is expensive, so many producers apply cattle or chicken manure with little or no thought to their actual requirements
- "Free" labor within the immediate or extended family is often available for field preparation, harvesting, etc., so labor costs are not recorded.
- Often, there may be some sort of subsidy from local government (e.g., mechanical tillage), so accurate costs are not applicable
- Transport is expensive and roads are often in a poor condition, so the majority of the production is sold locally (often informally, e.g., using a barter system), rather than being delivered to a local silo.

One recent study that has been carried out uses physical farm income to determine farm viability thresholds, rather than actual size (Zantsi et al., 2025). With actual data gathered from case studies across six of the former homeland rural areas across South Africa, they looked at the comparison between commercial and small-scale farm viability. Consensus was reached that for a commercial farm to be viable, the income ***after tax*** should be in the region of R807,000 (**$46,114**), with a pre-tax threshold of around R1m (R57,142). For smallholder agriculture, the scenario is obviously different, and classes were established with approximate annual income thresholds as follows:

- Low-aspirant farm households – less than +/-R260,000 ($14,857)
- Moderate-aspirant farm households – between +/-R260,000 ($14,857) and +/-R550,000 ($31,428)
- High-aspirant farm households – above +/-R550,000 ($31,428)

An important caveat here is that over 90% of the respondents in the study cannot survive solely from agriculture, and a supplementary source of income is required, such as other employment or even social grants.

2.3 Conclusion

The amount of data that is available varies greatly. Table 10 gives a summary of accessibility at various scales, as defined in Section 2.1.3.

Table 10. Data availability summary

Scale	National	Provincial	District	Farm	Note/s
Area Planted (ha)	Available	Available	Non-existent	Non-existent	District data can be estimated using GIS processing
Soil Pattern	Restricted	Restricted	Restricted	Unavailable/ Non-existent	Some farm data has been collected
Climate	Restricted	Restricted	Restricted	Unavailable/ Non-existent	Some farm data has been collected
Land Use	Available	Available	Available	Available	Only specific land use classes
Water Quality	Available	Available	Available	Non-existent	At specific river monitoring points
Water Use	Available	Available	Unavailable	Unavailable	
Production & Yield	Available	Available	Non-existent	Unavailable	District data can be estimated using GIS processing. Farm data held by producers/co-ops.
White/Yellow Maize	Available	Available	Non-existent	Unavailable	District data can be estimated using GIS processing. Farm data held by producers/co-ops.
All Grains	Available	Available	Non-existent	Unavailable	District data can be estimated using GIS processing. Farm data held by producers/co-ops.
Exports	Available	Available	Non-existent	N/A	
Enterprise Budgets	Unavailable	Unavailable	Unavailable	Unavailable	Farm data held by producers. "Best estimates" derived in many areas.
Small-scale	Non-existent	Non-existent	Non-existent	Non-existent	Very rough estimates

3 Analysis and Recommendations

3.1 *Codex* Categories

If one looks at the *Codex* categories, as defined in the Terms of Reference for this report (summarized in Table 3, page 18), the following can be stated:

- **Soil Health** – This is a relevant indicator for maize production, as monoculture (although often with regular rotation) is used for the majority of production at this stage. This causes soil depletion (nutrients, organic matter etc.), as well as possible erosion. The change to a minimum-tillage or conservation agriculture approach (where possible) will have significant benefits to soil health, and there is a lot of data to quantify this, but only in certain areas.
- **Water Use** – Not so relevant, since maize is usually cultivated in zones where the long-term average rainfall is adequate (sometimes only just), and no external water input is required. The relatively small areas of maize under irrigation are either at farm level, where a specific supplementary amount may be supplied as necessary, or within a formal (usually river- or dam-based) irrigation scheme, where water allocations are calculated each season, so that planting can be done accordingly.
- **Water Effluent** – There is evidence of excessive water effluent leaving the farm, with a eutrophication effect on groundwater or other sources, so this is a relevant indicator. One area where it may be especially significant is Mpumalanga province (see Figure 1), where the proximity of coal mines can have an effect on the water supply, both coming into the farm, as well as on the groundwater and other watercourses.
- **Emissions** – Also not a highly relevant indicator, and the main issue is that of CO_2 emissions (possibly also N_2O and/or NH_4). Research has indicated that CA has a meaningful benefit in this regard as compared to conventional monoculture.
- **Biodiversity** – By its definition, maize under conventional tillage has a clear detrimental effect on biodiversity, as most of the natural vegetation is replaced by the crop, often along with an increase in weeds, which can easily spread across the landscape. A lot here will depend on the proportion of cultivation to "natural" veld on any farm, as often a surprising amount of wildlife (usually smaller species such as hares, rodents, owls, and other birds) may be present in reasonable numbers. In addition, many farms within the Highveld maize-producing zone have pans and other natural wetlands adjacent to the maize fields, which can also be a significant source of wildlife.
- **Land-Use Change** – This can be an important indicator, especially in more marginal areas, where the natural resources do not usually allow full yield potential to be achieved. There may be pressure on the agricultural resource (especially in areas close to urban centers, or where mining or other industrial development is proposed), so that there is a danger of available agricultural land being steadily reduced. There is a recent Act of Parliament (PDAL, as defined in Section 1.5) that attempts to control this issue.

3.2 Risk-Based Approach

Due mainly to the fact that there are a number of **data gaps** (more fully defined in Section 3.3 below), some of the required research (especially as specified in Section 3.3.3) could be done by using a **risk-based approach (RBA)**, which is a strategy that involves identifying, assessing, and prioritizing risks to allocate resources effectively.

It typically includes the following steps:

- **Risk assessment:** Identify potential risks that may affect the organization or project
- **Risk mitigation:** Develop strategies to manage and mitigate identified risks based on their potential impact
- **On-going monitoring:** Continuously monitor risks and the effectiveness of mitigation strategies to adapt to changing circumstances
- **Implementation in compliance:** The RBA helps organizations comply with regulations by focusing on higher-risk areas

This approach is widely used in various sectors, including finance, compliance, and project management, to enhance decision-making and resource allocation.

Managing risks requires them to be evaluated and prioritized based on expected risk occurrence and potential negative impact. The aim is to allocate often-limited resources by implementing risk mitigation actions in areas where they are most likely needed. It aims to prevent or mitigate the negative impact of a risk.

A risk-based approach will:

- Identify potential risks (e.g., during protocol development and the identification of critical study processes)
- Evaluate risks based on their likelihood of occurrence, detectability, and expected impact
- Prioritize risks, and define risk deduction and mitigation measures proportionate to risk significance

Aspects of small-scale maize production research that can benefit from the RBA include:

1. **Trial site identification** – Use existing natural resource and other research data to identify the *most representative areas*. This is vital, since if site selection is done properly, using a variety of sources (natural resource base data, relevant local research specialists, etc.), there will be maximum representivity and applicability outside any specific research site.
2. **Staff training** – Essential to obtain trained and experienced staff, who can carry out research far from resource centers
3. **Community involvement** – Buy in from the small-scale producers is vital in order to obtain as much data as possible, so this aspect should be emphasized
4. **Information dissemination** – Data obtained should be in such a format to enable optimal dissemination of knowledge, by way of training, workshops and other demonstration techniques. In this way, the benefits of the research can spread throughout the community.
5. **Monitoring and feedback** – The (continuous) review process is important for any project, to keep the activities on track, on schedule, and within budget.

Applying a risk-based approach provides the opportunity to focus on the most risk-relevant tasks needed to conduct a study (e.g. the protection of study participants and the integrity of study data). While a RBA will be most applicable in the small-scale agriculture sector (due the extreme non-existence of data), the commercial sector (where data is available but mostly inaccessible) can also benefit, if those sources that are available (even if "best estimate" data), are used to extrapolate and expand relevant findings.

3.3 Data Gaps

3.3.1 Production Environment

The growth conditions for maize in South Africa are well-established, in terms of soil, climate and terrain. Assessment of suitability for maize production can thus be done against a set of robust parameters.

Regarding both soil health and the wider environment, some data is lacking in this regard.

Soil organic matter – Maize, as with almost every other crop, will have an effect on the soil properties due to cultivation. The most obvious is the loss of soil organic matter, usually regarded as being approximately a 50% decrease. This is supported by widespread soil analysis data in both the commercial and research environment. A **representative** sampling exercise could incorporate all existing data as well as collect new data comparing soil organic status of cultivated maize fields and adjacent virgin land. An approximate cost, involving the major maize regions, could be around R1 million (**$57,000**).

Microbiology - Regarding the effect of cultivation on the microfaunal and wider microbiological environment, this will generally be detrimental, regarding both the number of species present and the amount of microbial activity. In reality, little or no work has been done in terms of comparing a maize-cultivated soil with a similar, adjacent virgin soil. Such data would provide good baseline conditions as to the effect of cultivation on soil, but both the collection of soil samples for microbiological analysis (keeping them cool, sterilizing of tools, etc.) as well as the analysis itself (costly and complicated, +/- R7,500 per sample, or **$430**) mean that such a data collection exercise would be costly, probably in the region of R5 million (**$285,000**).

3.3.2 Commercial Cultivation

The field of maize production in South Africa is well-known and well understood, at a commercial level. The key aspects, such as area cultivated, yields, etc., are easily available. When one focuses on ***farm level***, however, the data is not easily available, although production is closely monitored, so that the amounts delivered to the silos, which are then consolidated upwards to eventually form the provincial or national figures, are known.

A definite requirement is the collection of more **actual farm data**. This would have to be on a confidential/anonymous basis, probably co-ordinated by a neutral body, so that data can be used without identifying the actual producer. Given the reluctance of farmers to release such data, it will be difficult but should be pursued. Important differences, such as a "wet" year vs a "dry" year, or comparison between various production ecozones, could then be quantified.

Cost – This is not an expensive exercise, as all the data exists, the issue is access and availability. If sufficient response could be received, it would mainly involve manpower costs, estimated at around R500,000 (**$28,500**).

3.3.3 Small-Scale Production

For small-scale or smallholder maize production, however, there is a serious lack of data on all aspects. This sector does make a significant contribution to maize production in South Africa, and there is definite room for improvement, so it is important to try and improve the data availability levels.

Aspects such as those highlighted in Section 2.2.10 should receive priority, and the more case studies the better. In addition, the various aspects of land tenure in some of the rural areas could be addressed, such as those producers who actually own their land (no matter how small) as opposed to those who have had land allocated to them on a communal basis, or under a local tribal authority.

Cost – This will be an expensive exercise, probably best conducted under the auspices of an organization such as the Agricultural Research Council, and will probably involve data collection over at least two growing seasons. However, it could be combined with research into conservation agriculture to optimize the results. A ***rough estimate*** would be an amount of R20 to R25 million (**$1.14 to $1.43 million**). Much of this would involve travel and manpower, as the trial sites would, of necessity, be situated in the more rural areas, relatively far from the main research centers, such as Pretoria/Johannesburg and Cape Town.

3.3.4 Funding of Research

Within the South African agricultural research environment, there is a serious lack of funding available. The National Department of Agriculture has as part of its mandate the advancement and upliftment of the small-scale agriculture sector, but little funding has been made available in the last decade or so. In addition, the Department of Rural Development (now split from Agriculture) has been involved in a program of re-allocating unused or derelict farms to black beneficiaries under the PLAS (Proactive Land Allocation System) initiative. However, in most cases, the measurable target is simply the number of farms re-distributed, with no thought or money given to the subsequent viability of agriculture on such farms.

While funding for research is available within South Africa, it comes mainly from the Department of Agriculture and is limited by strong competition for funds from other aspects of government. Private-sector-funded research is mainly in the very applied fields, such as cultivar development, seed quality, and fertilizer/ameliorant improvement. Some internationally-funded projects exist (either currently or previously).

One aspect to bear in mind is the strict, often very restrictive financial environment involved in state (or parastatal) research. Under the auspices of the Public Finance Management Act (Act 1 of 1999), there can be significant delays in procurement and other organizational expenses, so that private sector funding can be most efficient (even if public entities are subcontracted to carry out some of the work).

3.3.5 Modelling

Within the agricultural sphere, there are a host of models that attempt to use existing data and predict scenarios, responses, and other answers to agricultural issues where data is limited. Such models include economics, water use, yield prediction, and more, many having been developed specifically for the South African environment (e.g., a summer rainfall growing season). Efforts should be made to contact relevant modelling specialists to assess how much use can be made of these tools in the area of maize production.

3.4 Potential Impact of *Codex*

As specified in Section 1.2, the main aims of *Codex* are:

- Baseline for environmental performance
- Inform regulatory guidelines
- Provide standards and data

In this regard, the following can be stated:

3.4.1 Environmental Performance

The existing data on commercial maize cultivation has enabled, and should continue to enable, the sustainable levels of production, and even improvement, by such methods as cultivar and seed development, CA implementation, and others. However, there is a huge potential for improvement within the small-scale sector, and this should enjoy priority.

3.4.2 Regulatory Guidelines

Maize in South Africa is produced within a well-established regulatory framework, and while it is not traded worldwide, the exports to the SADC countries can benefit from such a framework. In addition, the *Codex* principles can easily be expanded to other South African agricultural products that are traded more on a global scale. However, implementation of that framework is not always carried out effectively or consistently, due to budgetary and manpower restrictions.

3.4.3 Standards and Data

As mentioned in Section 2.2.10 and in 3.4.1 above, the aim should be to bring the whole maize-producing environment up to a uniform level in terms of production systems, supply chain, and food security. This will require investment in areas wider than the immediate maize production base (roads, rail network, training of producers, and more), but if one looks at the wider community, not just agriculture, it should be the ultimate aim.

3.4.4 *Codex* Categories

If the specific *Codex* categories (as listed in Table 2, page 17, and Table 3, page 18) are listed, the following can be stated:

3.4.4.1 Soil Health – This is one of the more relevant categories within the South African environment. Soil conditions can be measured (Section 3.3.1), but more widespread data is required.

3.4.4.2 Water Use – This is important in the irrigation sector, but perhaps not so critical across the majority of the maize-producing area, where rain-fed cultivation is the norm. However, tying in with previous comparisons between traditional cultivation and conservation agriculture, data is needed on water conservation by the latter, leading to less water use per unit of crop yield.

3.4.4.3 Water Effluent – This is not generally critical or exceptionally relevant in South Africa.

3.4.4.4 Emissions – Emissions are not generally critical or exceptionally relevant in South Africa.

3.4.4.5 Biodiversity – This is important at farm level, specifically regarding the condition of the natural vegetation on a farm. Such information may need to be obtained in conjunction with specialist botanists, such as at the South African National Botanical Institute (SANBI) in Pretoria. Also, an important issue is the amount of land occupied by cultivation on any specific farm, as this has a direct effect on biodiversity. This can be assessed using satellite imagery, as provided by the Land Cover database (Section 2.1.4.1).

3.4.4.6 Land-Use Change – This is important in an indirect way, more specifically at a wider level (municipal up to national). The various editions of the Land Cover database (Section 2.1.4.1) can give a timeline with respect to trends, as continuous loss of land will affect broad food security. In rural areas, where mainly small-scale cultivation is practiced, the situation is more fluid and will have a greater annual change, as well as being more difficult to determine and monitor.

3.5 Conclusion

3.5.1 Contrast

The most significant aspect of maize production in South Africa is the massive dichotomy between the commercial and small-scale sectors, where almost every issue shows huge differences. These include: level of management, yields and inputs, amount of data collected (whether readily available or not), long-term security, and many more. Every effort should be made to uplift the small-scale sector, while obtaining as much data and information as possible from commercial producers that might help in this process. This is especially important with the likelihood of future tightening of production margins (BFAP, 2024), meaning that all producers will have to produce as optimally as possible.

3.5.2 Scale

There is no single suitable scale for all the data. Some exists very well at provincial level, and it is difficult to "drill down" further, although mechanisms exist to try and improve the local or district coverage ("SPAM," Section 2.1.4.4). There is a lot of data for farms in the commercial sector, but almost nothing in small-scale areas. Even the most comprehensive sources of data (Stats SA, 2017; DALRRD, 2023) focus exclusively on the provinces. There may be a way to approach the various provincial offices of the Department of Agriculture for more detailed data within each province, but this is not likely to yield consistent results.

3.5.3 Metrics

Most of the metrics for the various *Codex* categories either exist and are well applied or hardly exist at all (except for a few isolated research sites). This was addressed in Section 3.3 (Data Gaps).

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