The development of a map showing the soybean production regions and surface areas of the RSA

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CS Blignaut.

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Development of a map showing soybean production regions and surface areas[1]

1. Introduction

On request of the Protein Research Foundation (PRF), the process of developing a map to identify the existing and potential soybean production regions, and to calculate and map surface areas, commenced in June 2008. The point of departure of the PRF executive was that any area suitable for maize production is also suitable for soybean production. This statement is based on logic, because as long as moisture is not a limiting factor, soybeans can be produced under higher temperature conditions than maize (Smit, 2000).

Compiled in Appendix A are some published minutes, reports, papers and maps with regard to the soybean production regions (SPRs) in the Republic of South Africa (RSA)..

With regard to the compilation of the maps and the various publications in Appendix A, the purpose, reason and method differ. Armour and Viljoen (2003) analysed and reflected the financial benefits of soybean crops planted in rotation with maize crops in the Eastern Free State. In this regard, they made use of research findings and an inter-temporal mathematical model. Lemmer, Botha, Van Zyl and Louw (2007), based their analysis and answers to questions on soybean production potential for industrial use on relevant price ratios between soybeans and maize. The soybean potential map drawn by Schoeman and Van der Walt (2006) was based on biophysical parameters in order to identify SPRs under rainfall conditions and to classify these into different classes of production potential (Map 4: ARC: Rainfall areas suitable for soybean production.). The map of Grain SA (GSA) divides the soybean production regions into four climate zones (Map 1: Climate zones of soybean production regions.).

The International Food Policy Research Institute (IFPRI, 2007) showed that in the fight against global hunger, soybeans may just be the solution.

Although these research documents no doubt hold the answers to all the questions put to the auditors, the needs of the PRF differ somewhat. They wish to differentiate cartographically between the production levels of soybean crops in existing and potential production regions. The surface areas must also be determined.

[1] The inputs and comments of Mr Wessel van Wyk, soybean contractor with the PRF, and Dr Michiel Smit, soybean specialist with the Cane Growers' Association, are gratefully acknowledged.

2. Methodology

The authors studied the aforementioned literature[2], as well as other international publications (see list of references) in order to gather more information on the most common local and international factors that influence soybean supply and demand, thus shaping all aspects of the soybean industry.

2.1 Existing soybean production and suitability maps

GeoTerraImage (GTI) and Producer-Independent Crop Estimate System (PICES) specialise in long-distance observation techniques. They formed a Consortium ("the Consortium"), assisting the National Crop Estimates Committee of the Department of Agriculture, Forestry and Fisheries (DAFF) with the identification of regions where soybeans, amongst other crops, are cultivated annually, as well as the calculation of the surface areas of those regions.

The Consortium-demarcated soybean production areas (Map 2) are broadly defined as those areas suitable for soybean cultivation. The dots that appear in the soybean production areas identified by the Consortium (Map 3) serve as the control in order to verify the surface area demarcation at ground level, as shown in Map 2. The control points shown in Map 3 were determined according to a statistically random method. The Consortium's teams on ground level paid on-site visits to these points and confirmed that soybeans are in fact being cultivated there. The ground-level teams did not determine the surface area planted to soybeans.

In the eastern parts of South Africa, where rainfall is sufficient for soybean production (see Map 4 ARC: Rainfall areas suitable for soybean production), the Institute for Soil, Climate and Water (ISCW) of the Agricultural Research Council (ARC) classified the area into different suitability classes, i.e. potential production in tons/Ha (Map 14: RSA: Rainfall zones and soybean production regions).

Even a simple comparison of Map 1, Map 3 and Map 4 reveals that GSA and ISCW have not included the irrigation areas in the vicinity of Kimberley, Douglas and Prieska. Note that this was not part of their original assignment. Map 1, Map 3 and Map 4 also differ in respect of the Eastern Cape Province. Map 4 contains more information on soybean suitability classes in the Eastern Cape Province than Map 3, while Map 1 makes only brief reference to this region.

Although these three maps do not meet the requirements of the PRF, they served as important building-blocks for the rest of the investigation.

Raath (2004) developed a soybean potential map for the Eastern Cape (Map 5: Eastern Cape Province: Soybean production potential under dry land conditions). Raath's work is

[2] The international factors are not discussed in detail in this document.

significant in that it identifies those areas in the Eastern Cape that are suited to soybean production. See also Appendix B for the surface area per municipal district in the Eastern Cape Province.

2.2 Expert survey

It is always difficult to obtain an unknown spatial dataset with a relatively high level of accuracy, as in this case with regard to soybean production levels and surface areas in different regions. The problem was overcome in this instance by interviewing experts (professionals) in the various regions about the production of soybeans and the level at which this production takes place. As with any personal interview, cross-control is important in the case of an expert survey. This allows for expert A's opinion to be verified by expert B without him/her being aware of this control function. Experts from TRIOMF Fertilizer and PANNAR Seed were involved throughout. Where possible, the experts from the two agricultural input companies shared the verification function..

Experts in the different production regions were identified and interviewed. Since the recommended fertilizer and seed quantities are based on production potential, these two groups were well equipped to give a reliable answer when asked about soybean production and/or potential in their respective service areas. AGIS (DAFF) produced enlarged versions of Map 2[3], on which the experts outlined the different regions with the same long-term average yield (LTAY) or with the same production potential.

Dr Michiel Smit[4], a soybean cultivation specialist, was subsequently used as sounding-board and arbitrator to evaluate the accuracy of this information.

The findings of the cross-controllers and of Dr Smit differed only slightly overall. The different opinions of the cross-controllers in respect of soybean production in the various regions are shown in Table 2 and Table 3, as well as Map 17 (SPRs: Soybean areas and comments).

2.3 Development of a soybean production and potential map

The PRF requested the mapping of soybean production and surface areas. In complying with this request, PICES launched a comprehensive project (Fourie, Annelie). The experts outlined manually the different production regions on enlargements of Map 2. Annelie Fourie (PICES) quantified (digitised) it on computer, and the surface areas of the various polygons (outlined areas) were calculated. Michael Taute and Johan Duvenhage at AGIS (DAFF) stored this spatial database on computer for further manipulation and application as a mask for processing purposes.

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[3] Presented as working documents/maps to PRF.

[4] Currently employed as a soybean specialist with the Cane Growers' Association, Mount Edgecomb, after having previously worked at the ARC's Grain Crops Institute in Potchefstroom.

This processing was not only comprehensive, but also time-consuming. For this purpose, spatial datasets consisting of spatial databases, which are represented spatially, were used.

Spatial datasets consist of spatial databases. The soybean production areas as defined by the Consortium (Map 2 and Map 3), as well as the additional work done with the help of the expert survey (e.g. Map 7), form the basis or the primary spatial dataset. On the basis of this spatial dataset – the cookie cutter – those characteristics that have no relationship, or a detrimental relationship, to soybean production were eliminated from the spatial databases of other spatial datasets. For example, from the spatial dataset containing rail and road networks (Map 9), surface areas encompassing the rail and road networks within the soybean production regions were identified and then eliminated with the cookie cutter.

Diagram 1 is a flow diagram showing the processes used to eliminate selected characteristics from the different spatial databases. Different spatial datasets, for example the RSA environmental potential atlas (Map 10), which contains a variety of datasets – including plantations, protected areas, etc. – were obtained from different state departments and research institutes, as well as through the authors' own research efforts. With the aid of a series of processes, the cookie cutter was used to eliminate specific characteristics from the databases. Diagram 1 also illustrates the interwoven nature of the processes (Taute, 2009).

In Diagram 1, the oval shapes on the left-hand side of the end points of the different branches (blue in colour) represent spatial datasets or spatial databases. The square shapes represent the processes whereby the characteristics of the datasets (as variables) could be selected – for example, from the dataset "land-use classification" (Map 7), the area planted to permanent crops is identified for elimination.

The outputs of the selection process (square) are captured in the next oval (green), which are the inputs in the next process (square). The outputs of these processes are captured in the next oval and then converted into a raster[5].

The results of the flow diagram (Diagram 1) are subsequently illustrated by means of a series of maps. (See also Map 16.)

Harvesters with soybean plates do not work effectively on inclines exceeding 10 degrees. Since the purpose of the development of the map was to determine the areas planted to soybeans that can be commercially cultivated and harvested, land with an incline greater than 10 degrees was identified for elimination. Michael Taute of AGIS (DAFF) made use of NASA's Digital Elimination Method (DEM) to develop an incline raster dataset for South Africa (Map 6: Identification of inclines greater than 10 degrees in soybean production regions). All areas with an incline exceeding 10 degrees were eliminated.

[5] "In computer graphics, a **raster graphics** image or bitmap is a **data structure** representing a generally rectangular grid of pixels, or points of colour, viewable via a monitor, paper, or other display medium. Raster images are stored in image files with varying formats."

Whether farmers overshoot or undershoot the mark in respect of the 10 degree incline is one variable that is subject to debate. This is a factor of unknown significance that can influence, to a greater or lesser extent, the total area that is eventually cultivated.

The land-use classification of AGIS, as shown in Map 7 (RSA: Land-use classification and soybean production regions according to the expert survey, 2009) is a spatial database that was used together with the databases shown in Map 10 (RSA: Environmental potential atlas: Overall land use) to determine the surface areas being used for residential purposes (Map 8), rail and road networks (Map 9) and protected areas (Map 11), as well as permanent crops and forestry. These different surface areas were used to eliminate agricultural land not currently suitable for one-year summer crops from the PICES database. The databases in Map 8 (Residential areas) and Map 9 (Roads and rail networks) are identified separately, because any changes that occur here can serve to permanently remove land from agricultural use, and the situation can change at any time.

The Department of Water Affairs and Environmental Affairs was approached for a spatial dataset with spatial databases for streams, rivers, watercourses and dams. The fact that the databases for more than 172 000 individual dams and 1030 595 rivers, streams and watercourses and sections thereof had to be processed, gives some idea of the scope of work involved. Map 12 shows dams of all sizes in the SPRs, while Map 13 shows rivers and watercourses in the SPRs. In the case of rivers, streams and watercourses and sections thereof, a 50-metre buffer of unploughed land on either side was accepted, identified and eliminated. As a result of this assumption and the calculations, the surface areas of dams were calculated separately from those of rivers.

2.4 Rainfall and temperature maps

The ARC's rainfall map (Map 14: Rainfall zones and SPRs), in combination with the ISCW's map of heat units[6] (Map 15: RSA: Preliminary heat units in soybean production regions[7]) (Van Wyk, 2009), gave in-depth information on soybean production. Personal communications with Killian (2008), De Beer (2009) and Van Wyk (2009) revealed that heat units and moisture (*as well as soil types*) determine to a large extent the regions where soybean production is possible, as well as the potential production levels. According to Smit (2000), temperature plays an important role in the growth rate of soybeans, and temperatures above and below the optimum level can impede growth.

The criteria Van Wyk (2009) used to develop the heat unit map (Map 15) were the number of heat units from October up until and including March, which is the general growing season for soybeans. The whole concept of heat units is based on the fact that a plant needs a certain amount of heat during the growing season to ensure optimal production. The heat units in South Africa differ tremendously from place to place, and it

[6] According to Van Wyk (2009) isothermic lines were used in the past to determine the effect of heat on the choice of cultivar, but more recent cultivars are not highly sensitive to the number of daylight hours. However, this may still play a major role in the case of certain cultivars.
[7] The temperature map according to heat units is a preliminary map that is subject to further refinement.

is not uncommon to find three areas with different heat units within a 10 km range. Van Wyk (2009) calculates heat units as follows:

[[Maximum temperature (Celsius) + Minimum temperature (Celsius)]/2] - 8°C

Certain conditions are attached to the formula, such as that if the temperature should rise above 32°C, then 32°C is still used as the threshold value. Should the temperature drop below 8°C, then 8°C is still used as the threshold value – *in other words*, the plant will not grow in temperatures lower than 8°C. The high yields found in warmer regions can be ascribed to higher night-time temperatures and not higher day-time temperatures. The lack of an accumulation of sufficient heat units in colder regions where night-time temperatures drop too low is also a problem when it comes to good production levels (Van Wyk, 2009).

For purposes of Map 15, De Beer (2009) and Van Wyk (2009) made six different group classifications (Table 1).

Table 1: Classification of heat units

Heat units
Less than 1800
1800 - 1900
1901 - 2000
2001 - 2100
2101 - 2200
More than 2200

Source: Van Wyk (2009)

Taking the analogy of the USA where cultivars can be precisely classified into groups such as group 3.1 and group 3.5, the circumstances in South Africa are "different" in the sense that in this country, there are mountain ranges set in strange patterns. For example, we may have a plateau ridge that brings about a dramatic drop in height above sea level, and a Highveld area with a variety of soil types.

In the latter case for example, when drawing up a soybean production potential map, degree of latitude cannot be used in isolation (Van Wyk, 2009).

Areas where heat units (Map 15) prevent soybean production were eliminated on the basis of this vector data. However, irrigation areas known for successful soybean cultivation under unfavourable heat unit conditions were included, e.g. the Prieska-Douglas area and north of the Soutpansberg. The same was achieved when eliminating SPRs falling within the band of annual rainfall of between 400 and 500 mm, but these were brought back into consideration with certain production and processing conditions attached (see discussion below).

Although Smit (2000) does not explicitly discuss soybean production under rainfall conditions, it can be surmised that 500 mm of rainfall, occurring at regular intervals throughout the rainy season, is the lowest cut-off point for low-risk, dry land soybean production (Smit, 2000: 16 & 51).

The rainfall zones in Map 14 and Map 18 surrounding Bloemfontein bisect the area showing crop cultivation under rainfall conditions into a north-south band.. The central "Bloemfontein band" represents rainfall of between 400 mm and 500 mm per year. Personal communication with Dr MA Smit (2008) revealed that soybean production west of Kimberley, on the western border of the "Bloemfontein band", occurs only under irrigation. Map 4, indicating the rainfall zones where soybean production occurs, shows the westernmost (?) border for soybean production as running east from Bloemfontein and Bothaville along a vertical line that roughly connects Koster and Welkom. However, according to Map 18, soybeans are cultivated within the band that experiences 400 mm to 500 mm rainfall annually. According to Smit (2008), such cultivation must occur in conjunction with good moisture retention techniques and the right choice of cultivar. Soybean production within this band is discussed again at a later stage.

Killian (2008) used the ISCW's rainfall zones of the Eastern Cape (Map 18) to divide the region into different SPRs. The rainfall line in Map 18, which indicates an average rainfall of 650 mm – 750 mm (isocontour), forms Killian's western border for soybean production in the Eastern Cape. (Note that west of this isocontour are isolated areas that experience 650 mm – 750 mm rainfall.) The latter area is suitable for soybean production.

The various processes used to identify SPRs, as described above and summarised in Diagram 1, are summarised and cartographically illustrated in Map 16.

The end result of this long and drawn-out process is Map 17 (RSA: Approximated soybean production regions – actual and potential, 2009).

3. Discussion of potential and current soybean production regions

For easy reference, the information in Table 2 and Table 6 is included in Map 17 and repeated in the text below. Table 2 shows the estimated existing dry land and irrigation areas suitable for soybean production under commercial conditions.

The numbered zones in Table 2 refer to the different areas (zones) identified by means of the expert survey within the different SPRs of the Consortium (Map 2). Map 17 shows a summary of each expert's LTAY per zone, along with their comments.

The processes in Diagram 1 are subject to certain assumptions and technical factors, the first being the human factor. Although the use of the expert survey ensured that the greatest care and control was exercised, e.g. by means of the cross-verification of production levels and the outlining of the zones, this did not eliminate the possibility of over- or under-estimation of the surface areas. The authors trust that the Law of Large Numbers will eliminate such errors on either side.

Possible technical errors include differences in the scale used to map the different spatial databases, which varies between 1:250 000 and 1:50 000.

Reference has already been made to the buffer zones on either side of a river, watercourse or river section (Map 13), as well as the different approaches that farmers may take when making decisions in respect of certain processes. The heat units (Map 15) are not yet final and may also influence the SPRs.

Where possible, the factors that could lead to either over- or under-estimation were controlled and managed, as in the case of the processes shown in Diagram 1.

During the above-mentioned processes (Diagram 1), certain areas west of Kimberley and north of the Soutpansberg – despite being under irrigation – were eliminated on the basis of heat units and rainfall. In the same way, the zones reflected in Table 2 were initially eliminated from the processes shown in Diagram 1. Since these regions are existing and potential SPRs, it was logical for them to be included, which was subsequently done.

Note from Table 2[8] that the zones falling mainly within the "Bloemfontein band" and experiencing rainfall of 500 mm and less require specific management practices. The heat units in these areas vary from extremely high to mild (Map 15). Since the combination of heat units and rainfall in this region place it on the lowest threshold for low-risk soybean production, the region is exposed to climatic risks. In Map 14, the ARC's illustration of SPRs on the basis of rainfall excludes soybean production in the high-risk rainfall areas. Soybean production in these high-risk regions is subject to certain conditions – the most important being the application of good moisture retention techniques and the right choice of cultivar.

The "total" estimated existing surface area on which soybeans are cultivated can be calculated as 2610 346 Ha (Table 2). A number of factors determine actual annual soybean cultivation.

- Keep in mind when considering the surface area that soybean crops are usually planted in rotation with other crops. The ratio of soybeans to other crops can vary between 20% and 30%.
- A second important factor is the price ratio between maize and soybeans.
- The price ratio between soybeans and other competing crops, such as certain bean varieties, as well as the price tendencies of those crops, can have an effect on soybean cultivation.
- Soybean crops face the threat of oilcrop-specific plant diseases, such as schlerotina.

[8] Zones 42, 43, 48, 52, 53 and 83. Potential zone 81 is favourable due to the clay content of the soil.

- Alternative uses for soybeans, such as the production of biofuels from soybeans and other crops, remain an important variable that can have an effect on the area planted to soybeans internationally and locally.
- Decisions on the part of government can be of strategic importance, for example the decision made locally about the production of maize for ethanol. The recent increase in the export tax on soybean products from Argentina has also had a global effect on the price and supply of such products.
- There is a growing demand for soybeans in emerging markets such as India, China and others.
- Any rise or drop in the profitability levels of concurrent crops will have an effect on soybean production.

Table 3 reflects the estimated total surface area (dry land and irrigation, both existing and potential) suitable for soybean production under commercial conditions, i.e. 2 992 993 Ha. This area is 362 647 Ha larger than the current estimated total area of 2 610 346 Ha reflected in Table 2. This represents a potential 14.7% increase in the surface area of potential SPRs.

Table 4 summarises the zones identified in Table 3 as existing and potential new SPRs under irrigation. The total surface area is 218 226 Ha. The potential new SPRs that can be irrigated (57 134 Ha) represent a 35% increase in the surface area of SPRs under irrigation.

The preceding comments regarding factors that can influence soybean cultivation also apply to the different surface areas of the zones shown in Table 4 and Table 5.

Potential new SPRs in zones 79, 80 and 87 (Table 5) fall within the sugar production region of KwaZulu-Natal and the Eastern Cape respectively. Zones 79 and 87 contain relatively large areas of land with inclines of 10 degrees and more (Map 6). Relatively vast tracts of potential SPRs were consequently eliminated due to the harvesting problems caused by such steep inclines. Lack of fences and the presence of small farming units hinder the commercial cultivation of soybeans in zone 87, which has an estimated surface area of 185 Ha (Table 5). Fenced units do exist, but the surface area thereof would have to be determined on site. The availability of the 185 362 Ha in zone 87 is therefore uncertain.

Of the total 218 226 Ha under irrigation, 57 134 Ha are, from a soybean point of view, a new surface area (Table 4). The availability of this new irrigation area for soybean cultivation is questionable. For example, in zones 76 and 78 in the Western Cape Province, which measure 2 320 Ha in total, soybeans must compete with permanent crops and vegetables (Map 10 and Map 18). The availability of irrigation water in the marginal sugar production region (zone 22; surface area 9 460 Ha) is also uncertain. On some of the irrigation land west of Kimberley, in the direction and vicinity of Douglas in particular, the local co-operative (GWK) is planning to construct a lucerne oil-extraction and pellet-production unit.

One should therefore not automatically assume that the total area of potential new SPRs under irrigation (57 134 Ha) is available for the cultivation of soybeans. The PRF's request, however, was the identification of ALL existing and potential land suitable for soybean cultivation.

4. Conclusion

The PRF requested and funded this study, with the goals being to identify, calculate and map the total land surface area suited to the commercial cultivation of soybeans. A guideline from the PRF was that where maize production is possible, so is soybean production.

As the point of departure, existing maps indicating SPRs, as well as local reports and study materials relating to decisions about soybean production, were consulted in order to determine the availability of existing surface area calculations that would meet the PRF's requirements. For certain legitimate reasons, such calculations could not be acquired, but this part of the study did prove useful during the rest of the investigation. The basic map drawn up by the Consortium for the Crop Estimates Committee of the DAFF was used as the point of departure. This map was enlarged with the help of AGIS (DAFF) and used to conduct an expert survey. Experts from PANNAR Seed and OMNIA Fertilizer were mainly used for this purpose.

To minimise survey error, soybean experts performed cross-control and evaluation functions. The result was acceptable, forming the spatial dataset used further in the mapping process.

Michael Taute, contracted to AGIS, subsequently used the spatial dataset as a cookie cutter to eliminate those surface areas in databases that are not available or suitable for soybean production. For this purpose, Taute developed a model to calculate the relationship between the different databases in the elimination process.

In the process of developing the dataset and using the different databases, there was a risk of human error and other technical problems that could influence the accuracy of the results. The calculation of surface areas within the different SPRs therefore had to rely on certain assumptions, with the accuracy of those assumptions being strongly influenced by differences in the human decision-making process (e.g. deciding how far away from a stream or watercourse floodline one will plant one's crops). For this reason, the authors refer to the calculated surface areas as estimations.

The final outcomes of this study are as follows:

- Existing dry land and irrigation areas in which soybean production is possible under commercial conditions are shown in an SPR map.
- The processes followed are indicated in a series of explanatory maps.
- The estimated areas available for commercial soybean production in the different SPRs and in total are summarised in a number of tables.

The total existing area under both dry land and irrigation conditions, which is suitable for commercial soybean production, is estimated at 2 610 346 Ha. The estimated existing and potential surface areas suitable for soybean production are summarised in Table 6.

Table 6: Summary of existing and potential surface areas suitable for soybean production under commercial conditions, estimated during 2008/09

Production conditions	Hectares	Percentage growth
Dry land and irrigation:		
Existing	2 610 346	
Existing + potential	2 992 993	
Growth	161 092	14.7
Irrigation:		
Existing	161 092	
Existing + potential	218 226	
Growth	57 134	35.5
Dry land		
Existing	2 449 254	
Existing + potential	2 774 767	
Growth	325 513	13.3

Source: Authors

Table 2: Estimated existing dry land and irrigation surface areas suitable for soybean production under commercial conditions, 2008/09				
Area	**Irrigation**	**Soybean yields**	**Comments**	**Hectares**
1	Yes	3 tons/Ha	Soybeans in crop rotation with maize	13 674
3	Yes	3 tons/Ha; MS: 3 - 4 tons/Ha	Soybeans in crop rotation with wheat	1 132
4	Yes	3 tons/Ha; MS: 3 tons/Ha	Soybeans in crop rotation with wheat	883
6	Yes	3 -3.5 tons/Ha	Crop rotation: Maize, wheat (winter), soybeans, limited potatoes	45 743
7	Yes	SCH: 3 tons/Ha; JB: 3 - 3.5 tons/Ha; MS concurs	Crop rotation: Maize, wheat (winter), soybeans, limited potatoes	51
8			Rocky, no soybeans/ Unsuitable	0
9		R Bosch: Marginal with high temperature	Informal settlements. No soybeans	0
10		JB: 1.3 - 1.5 tons/Ha; MS: < 2 tons/Ha		5 052
11	Yes	3 tons/Ha	-	450
11	Yes	3 tons/Ha	-	15 423
12		2 tons/Ha; MS: Note	Springbok Plains	129 408
13		MS: Doubtful about soybeans	Marginally dry and hot	23 405
14		MS: 2 -3 tons/Ha		9 072
15		JB: 1.3 - 1.5 tons/Ha; MS: < 2 tons/Ha		15 523
16		MS: 1.8 -2.5 tons/Ha		156 333
17		LTAY: 2 tons/Ha	Small lands, rocky, short contours, difficult to harvest	0
18		MS: 2 tons/Ha	Hail occurs sporadically	792
19		PdJ: 1.5 tons/Ha	No soybeans/Unsuitable	0
20	Yes	MS: 3 tons/Ha	Sugar production region	17 387
21		E & A: Dry land 2 tons/Ha; Irrigation: 4 tons/Ha; MS: 3 - 4 tons/Ha	E & A: Low potential under dry land. Much preferable under irrigation	46
24	Yes	3.2 tons/Ha; MS concurs	Irrigation	4 159
25		PdJ: 1.5 tons/Ha; JB: 1.4 - 1.8 tons/Ha; MS: 2 - 2.5 tons/Ha	PdJ estimates surface area under soybeans at 1 700 Ha	2 685
26		JB: 1.7 -1.8 tons/Ha; MS: 1.7 - 2.5 tons/Ha		197 380
27		JB: 2.2 - 2.4 tons/Ha; MS: 2 - 2.5 tons/HA		549 478

28		MS: 1.5 -2 tons/Ha, JB: 1.2 tons/Ha	PdJ: Approximately 2 000 Ha soybeans	168 328
Table 2: Estimated existing dry land and irrigation surface areas suitable for soybean production under commercial conditions, 2008/09 (continued)				
29		Soybeans LTAY 3 - 4 tons/Ha	Sold out: Establishing small farming enterprises; high potential	0
30			Savannah; No soybeans/ Unsuitable	0
31		MS: 3 tons/Ha		9 914
36	Yes	STP: 3.5 tons/Ha	Soybeans in crop rotation with wheat	2 942
37	Yes	STP: 3.5 tons/Ha	Soybeans in crop rotation with wheat	7 222
38	Yes	STP: 3.5 tons/Ha	MS concurs with fixed outline	5 088
39	Yes	STP: 3.5 tons/Ha		2 808
40	Yes	3 tons/Ha; MS 1.8 -3 tons/Ha		3 279
41	Yes	SB: 3 tons/Ha		4 415
42	Yes	SB: >3 tons/Ha		13 608
43		1.5 -2 tons/Ha	Cultivation must go hand in hand with very good moisture retention techniques	76
44		1.5 - 2.8 tons/Ha	10-15% clay; Moisture retention techniques necessary	6 742
45		1.5 -2.8 tons/Ha	10 – 15% clay; Moisture retention techniques necessary	14 092
46		Shallow soil		16 727
48		MS: Dry land 1.2 tons/Ha, 2 – 3 tons/Ha if irrigated		19 499
49			MS: Sand south of Bothaville	0
50		1.2 -1.8 tons/Ha; MS: LTAY: 1.8 - 3 tons/Ha		11 059
51	Yes	JB: 1.2 tons/Ha; MS: 2 tons/Ha irrigation with good management	Drift-sand with danger of roundworm	4 939
52		JB: 1.5 - 1.7 tons/Ha; MS concurs	Area is unsuitable for soybean production based on heat units and rainfall	327 943
53		JB: 1.2 tons/Ha; MS: Too dry		149 457
54	Yes	DuPH: 5 tons/Ha; MS: 3 - 4 tons/Ha	Clay soils, danger of salt	3 266
55		DuPH: 5 tons/Ha; MS: 4 tons/ Ha	More clayey	6 603

59	Yes	DuPH: 5 tons/Ha; MS: 4 tons/ Ha	High potential with heavy clay with the danger of brackish water and drowning	10 562
64	Yes	DuPH: 5 tons/Ha; MS: 4 tons/ Ha	More clayey soil with water restrictions	2 606

Table 2: Estimated existing dry land and irrigation surface areas suitable for soybean production under commercial conditions, 2008/09 (continued)

73		Along West Coast; Temperatures above 35 degrees Celsius affect soybean yield	Crops: Predominantly lucerne, some maize, green chillies, sweet melon, watermelon, squash varieties	0
74		Along Orange River	No soybeans; Competing with grapes, peaches, cotton, dates, etc.	0
75		MS: 2 - 3 tons/Ha dry land	Crop rotation	883
82				65 752
83			JB: 1.2 tons/Ha; MS concurs	684
84		North: JB: 1.2 - 1.5 tons/Ha; Middle: JB: 1.2 - 1.5 tons/Ha; PdeJ: 1.5 - 2 tons/Ha; MS: 1.8 - 3 tons/Ha; South: JB: 1.2 - 1.5 tons/Ha; MS: 1.8 - 3 tons/Ha; PdeJ: 1.5 - 2 tons/Ha		21 739
85		North to South: LF: 1.2; JB & LF: 1.5; JB: 1.2, MS: 1.2 - 1.5; JB: 1.5; JB: 1.5 - 1.7; JH: 1.2; JH: 1.2; JB: 1.5 - 1.8; MS: 1.2; LF: 1.8; LF: 1.2; JB: 1.5 tons/Ha		467 295
86				73 287
88	Yes			1 455
			Total	2 610 346

Table 3: Estimated existing and potential dry land and irrigation surface areas suitable for soybean production under commercial conditions, 2008/09					
Area	**Irrigation**	**New**	**Soybean yield**	**Comments**	**Hectares**
1	Yes		3 tons/Ha	Soybeans in crop rotation with maize	13 674
3	Yes		3 tons/Ha; MS: 3 - 4 tons/Ha	Soybeans in crop rotation with wheat	1 132
4	Yes		3 tons/Ha; MS: 3 tons/Ha	Soybeans in crop rotation with wheat	883
6	Yes		3 - 3.5 tons/Ha	Crop rotation: Maize, wheat (winter), soybeans, limited potatoes	45 743
7	Yes		SCH: 3 tons/Ha; JB: 3 - 3.5 tons/Ha; MS concurs: 3- 3.5 tons/Ha	Crop rotation: Maize, wheat (winter), soybeans, limited potatoes	51
8				Rocky, no soybeans/Unsuitable	0
9			R Bosch: Marginal with high temperature	Informal settlements; No soybeans	0
10			JB: 1.3 - 1.5 tons/Ha; MS: < 2 tons/Ha		5 052
11	Yes		3 tons/Ha	Chris Burbridge	450
11	Yes		3 tons/Ha	Chris Burbridge	15 423
12			2 tons/Ha; MS: Note	Springbok Plains	129 408
13			MS: Doubtful about soybeans	Marginally dry and hot	23 405
14			MS: 2 - 3 tons/Ha		9 072
15			JB: 1.3 - 1.5 tons/Ha; MS: < 2 tons/Ha		15 523
16			MS: 1.8 - 2.5 tons/Ha		156 333
17			LTAY: 2 tons/Ha	Small lands, rocky, short contours, difficult to harvest	0
18			MS: 2 tons/Ha	Hail occurs sporadically	792
19			PdJ: 1.5 tons/Ha	No soybeans/Unsuitable	0
20	Yes		MS: 3 tons/Ha	Sugar production region	17 387
21			E & A: Dry land: 2 tons/Ha, Irrigation: 4 tons/Ha; MS: 3 - 4 tons/Ha	E & A: Low potential under dry land; Much preferable under irrigation	46
22	Yes	Yes	MS: 3 - 4 tons/Ha	Marginal sugar production region; Average/high	9 460
23	Yes	Yes	MS: 3 - 4 tons/Ha	Potential irrigation	360
24	Yes		3.2 tons/Ha; MS concurs	Irrigation	4 159
25			PdJ: 1.5 tons/Ha; JB: 1.4 - 1.8 tons/Ha; MS: 2 - 2.5 tons/Ha	PdJ estimates surface area under soybeans at 1 700 Ha	2 685

26			JB: 1.7 - 1.8 tons/Ha; MS: 1.7 - 2.5 tons/Ha		197 380
27			JB: 2.2 - 2.4 tons/Ha; MS: 2 - 2.5 tons/HA		549 478
Table 3: Estimated existing and potential dry land and irrigation surface areas suitable for soybean production under commercial conditions, 2008/09					
28			MS: 1.5 - 2 tons/Ha; JB: 1.2 tons/Ha	PdJ: Approximately 2 000 Ha soybeans	168 328
29			Soybeans LTAY 3 - 4 tons/Ha	Sold out: Establishing small farming enterprises; High potential	0
30				Savannah; No soybeans/ Unsuitable	0
31			MS: 3 tons/Ha		9 914
32		Yes	LK: 4 tons/Ha		9 703
33		Yes	LK: 4 tons/Ha		7 277
34		Yes	LK: 3 tons/Ha	LK: Good maize 6 tons/Ha	16 614
35		Yes	STP tons/Ha	Currently vegetables	10 489
36	Yes		STP: 3.5 tons/Ha	Soybeans in crop rotation with wheat	2 942
37	Yes		STP: 3.5 tons/Ha	Soybeans in crop rotation with wheat	7 222
38	Yes		STP: 3.5 tons/Ha	MS concurs with fixed outline.	5 088
39	Yes		STP: 3.5 tons/Ha		2 808
40	Yes		3 tons/Ha; MS: 1.8 - 3 tons/Ha		3 279
41	Yes		SB: 3 tons/Ha		4 415
42	Yes		SB: >3 tons/Ha		13 608
43			1.5 - 2 tons/Ha	Cultivation must go hand in hand with very good moisture retention techniques	76
44			1.5 - 2.8 tons/Ha	10-15% clay; Moisture retention techniques necessary	6 742
45			1.5 - 2.8 tons/Ha	10-15% clay; Moisture retention techniques necessary	14 092
46			Shallow soil		16 727
47		Yes	MS: 2 - 2.5 tons/Ha	Not sand; 10% clay	6 010
48			MS: Dry land 1.2 tons/Ha, 2 – 3 tons/Ha if irrigated		19 499
49				MS: Sand south of Bothaville	0
50			1.2 - 1.8 tons/Ha; MS: LTAY: 1.8 - 3 tons/Ha		11 059
51	Yes		JB: 1.2 tons/Ha; MS: 2 tons/Ha under irrigation with good management	Drift-sand with danger of roundworm	4 939

52			JB: 1.5 - 1.7 tons/Ha; MS concurs	Area is unsuitable for soybean production based on heat units and rainfall	327 943
53			JB: 1.2 tons/Ha; MS: Too dry		149 457
54	Yes		DuPH: 5 tons/Ha; MS: 3 - 4 tons/Ha	Clay soils, danger of salt	3 266
55			DuPH: 5 tons/Ha; MS: 4 tons/Ha	More clayey	6 603
Table 3: Estimated existing and potential dry land and irrigation surface areas suitable for soybean production under commercial conditions, 2008/09 (continued)					
56	Yes	Yes	DuPH: 4 tons/Ha; MS: 4 tons/Ha	Barren soils; Clovelly's; high Ca content; slightly cooler soils; not drained as high as Hutton's east of Douglas	8 299
57	Yes	Yes	DuPH: 4 tons/Ha; MS: 4 tons/Ha	Barren soils; Clovelly's; high Ca content; slightly cooler soils; not drained as high as Hutton's east of Douglas	1 457
58	Yes	Yes	SB: 4 tons/Ha; MS: 4 tons/Ha	Barren soils; Clovelly's; high Ca content; slightly cooler soils; not drained as high as Hutton's east of Douglas	6 151
59	Yes		DuPH: 5 tons/Ha; MS: 4 tons/Ha	High potential with heavy clay with the danger of brackish water and drowning	10 562
60	Yes	Yes	DuPH: 4 tons/Ha; MS: 4 tons/Ha	Barren soils; Clovelly's; high Ca content; slightly cooler soils; not drained as high as Hutton's east of Douglas	2 078
61	Yes	Yes	DuPH: 5 tons/Ha; MS: 3 - 4 tons/Ha	High potential	7 340
62	Yes	Yes	DuPH: 5 tons/Ha; MS: 4 tons/Ha		4 116
63	Yes	Yes	DuPH: 3 tons/Ha; A: 4 tons/Ha; MS: 4 tons/Ha	Red sand and warm soil. DuPH's surface area is 2 500 Ha. MS questions sustainability of irrigation water. If available, 4 tons/Ha.	9 354
64	Yes		DuPH: 5 tons/Ha; MS: 4 tons/Ha	More clayey soil with water restrictions	2 606
65	Yes	Yes	DuPH: 3 tons/Ha	Hutton soils, warm soils	6 199
66		Yes	LK:	Rainfall: 550 - 650 mm	276
69		Yes	LK:	Rainfall: 650 - 750 mm	125
70		Yes	LK:	Rainfall: 650 - 750 mm	92

73			Along West Coast. Temperatures above 35 degrees Celsius affect soybean yield	Crops: Predominantly lucerne, some maize, green chillies, sweet melon, watermelon, squash varieties	0
74			Along Orange River	No soybeans; Competing with grapes, peaches, cotton, dates, etc.	0
75			MS: 2 - 3 tons/Ha dry land	Crop rotation:	883
Table 3: Estimated existing and potential dry land and irrigation surface areas suitable for soybean production under commercial conditions, 2008/09 (continued)					
76	Yes	Yes	Unknown	Irrigation lands; In competition with permanent crops and vegetables	1 030
78	Yes	Yes	Unknown	Irrigation lands along Berg River; In competition with permanent crops	1 290
79		Yes	MS: Northern regions 3 - 4 tons/Ha; Southern regions 2 - 3 tons/Ha	KwaZulu-Natal sugar production region	42 791
80		Yes	SB: 3 tons/Ha	8 000 Ha maize - 6 tons/Ha	1 885
81		Yes			44 889
82					65 752
83				JB: 1.2 tons/Ha; MS concurs	684
84			North: JB: 1.2 - 1.5 tons/Ha; Middle: JB: 1.2 - 1.5 tons/Ha; PdeJ: 1.5 - 2 tons/Ha; MS: 1.8 - 3 tons/Ha; South: JB: 1.2 - 1.5 tons/Ha; MS: 1.8 - 3 tons/Ha; PdeJ: 1.5 - 2 tons/Ha		21 739
85			North to South: LF: 1.2; JB & LF: 1.5; JB:1.2; MS: 1.2 - 1.5; JB: 1.5; JB: 1.5 - 1.7, JH: 1.2; JH: 1.2, JB:1.5 - 1.8; MS: 1.2; LF: 1.8; LF: 1.2; JB: 1.5 tons/Ha		467 295
86					73 287
87		Yes			185 362
88	Yes				1 455
				Total	2 992 993

Table 4: Estimated existing and potential new surface area under irrigation that is suitable for soybean production under commercial conditions, 2008/09				
Area	**New**	**Soybean yield**	**Comments**	**Hectares**
1		3 tons/Ha	Soybeans in crop rotation with maize	13 674
3		3 tons/Ha; MS: 3 - 4 tons/Ha	Soybeans in crop rotation with wheat	1 132
4		3 tons/Ha; MS: 3 tons/Ha	Soybeans in crop rotation with wheat	883
6		3 - 3.5 tons/Ha	Crop rotation: Maize, wheat (winter), soybeans, limited potatoes	45 743
7		SCH: 3 tons/Ha; JB: 3 - 3.5 tons/Ha; MS concurs: 3- 3.5 tons/Ha	Crop rotation: Maize, wheat (winter), soybeans, limited potatoes	51
11		3 tons/Ha	Chris Burbridge	450
11		3 tons/Ha	Chris Burbridge	15 423
20		MS: 3 tons/Ha	Sugar production region	17 387
22	Yes	MS: 3 - 4 tons/Ha	Marginal sugar production region: average / high	9 460
23	Yes	MS: 3 -4 tons/Ha	Potential irrigation	360
24		3.2 tons/Ha; MS concurs	Irrigation	4 159
36		STP: 3.5 tons/Ha	Soybeans in crop rotation with wheat	2 942
37		STP: 3.5 tons/Ha	Soybeans in crop rotation with wheat	7 222
38		STP: 3.5 tons/Ha	MS concurs with fixed outline.	5 088
39		STP: 3.5 tons/Ha		2 808
40		3 tons/Ha; MS: 1.8 - 3 tons/Ha		3 279
41		SB: 3 tons/Ha		4 415
42		SB: >3 tons/Ha		13 608
51		JB: 1.2 tons/Ha; MS: 2 tons/Ha under irrigation with good management	Drift-sand with danger of roundworm	4 939
54		DuPH: 5 tons/Ha; MS: 3 - 4 tons/Ha	Clay soils, danger of salt	3 266
56	Yes	DuPH: 4 tons/Ha; MS: 4 tons/Ha	Barren soils; Clovelly's; high Ca content; slightly cooler soils; not drained as high as Hutton's east of Douglas	8 299
57	Yes	DuPH: 4 tons/Ha; MS: 4 tons/Ha	Barren soils; Clovelly's; high Ca content; slightly cooler soils; not drained as high as Hutton's east of Douglas	1 457

58	Yes	SB: 4 tons/Ha; MS: 4 tons/Ha	Barren soils; Clovelly’s; high Ca content; slightly cooler soils; not drained as high as Hutton's east of Douglas	6 151
Table 4: Estimated existing and potential new surface area under irrigation that is suitable for soybean production under commercial conditions, 2008/09 (continued)				
59		DuPH: 5 tons/Ha; MS: 4 tons/Ha	High potential with heavy clay with the danger of brackish water and drowning	10 562
60	Yes	DuPH: 4 tons/Ha; MS: 4 tons/Ha	Barren soils; Clovelly’s; high Ca content; slightly cooler soils; not drained as high as Hutton's east of Douglas	2 078
61	Yes	DuPH: 5 tons/Ha; MS: 3 - 4 tons/Ha	High potential	7 340
62	Yes	DuPH: 5 tons/Ha; MS: 4 tons/Ha		4 116
63	Yes	DuPH: 3 tons/Ha; A: 4 tons/Ha; MS: 4 tons/Ha	Red sand and warm soil. DuPH’s surface area is 2 500 Ha. MS questions sustainability of irrigation water. If available, 4 tons/Ha.	9 354
64		DuPH: 5 tons/Ha; MS: 4 tons/Ha	More clayey soil with water restrictions	2 606
65	Yes	DuPH: 3 tons/Ha	Hutton soils, warm soils	6 199
76	Yes	Unknown	Irrigation lands. In competition with permanent crops and vegetables	1 030
78	Yes	Unknown	Irrigation lands along Berg River. In competition with permanent crops.	1 290
88				1 455
			Total	218 226
			Total new	57 134
			Total existing	161 092
			Potential percentage increase in Ha in SPRs under irrigation	355%

Table 5: Estimated existing and potential new surface area under dry land that is suitable for soybean production under commercial conditions, 2008/09				
Area	**New**	**Soybean yield**	**Comments**	**Hectares**
8			Rocky, no soybeans/Unsuitable	0
9		R Bosch: Marginal with high temperature	Informal settlements; No soybeans	0
10		JB: 1.3 - 1.5 tons/Ha; MS: < 2 tons/Ha		5 052
12		2 tons/Ha; MS: Note	Springbok Plains	129 408
13		MS: Doubtful about soybeans	Marginally dry and hot	23 405
14		MS: 2 -3 tons/Ha		9 072
15		JB: 1.3 - 1.5 tons/Ha; MS: < 2 tons/Ha		15 523
16		MS: 1.8 -2.5 tons/Ha		156 333
17		LTAY: 2 tons/Ha	Small lands, rocky, short contours, difficult to harvest	0
18		MS: 2 tons/Ha	Hail occurs sporadically	792
19		PdJ: 1.5 tons/Ha	No soybeans/Unsuitable	0
21		E & A: Dry land: 2 tons/Ha, Irrigation: 4 tons/Ha; MS: 3 - 4 tons/Ha	E & A: Low potential under dry land. Much preferable under irrigation.	46
25		PdJ: 1.5 tons/Ha; JB: 1.4 - 1.8 tons/Ha; MS: 2 - 2.5 tons/Ha	PdJ estimates surface area under soybeans at 1 700 Ha	2 685
26		JB: 1.7 - 1.8 tons/Ha; MS: 1.7 - 2.5 tons/Ha		197 380
27		JB: 2.2 - 2.4 tons/Ha; MS: 2 - 2.5 tons/HA		549 478
28		MS: 1.5 - 2 tons/Ha; JB: 1.2 tons/Ha	PdJ: Approximately 2 000 Ha soybeans	168 328
29		Soybeans LTAY 3 - 4 tons/Ha	Sold out: Establishing small farming enterprises. High potential.	0
30			Savannah. No soybeans/Unsuitable	0
31		MS: 3 tons/Ha		9 914
32	Yes	LK: 4 tons/Ha		9 703
33	Yes	LK: 4 tons/Ha		7 277
34	Yes	LK: 3 tons/Ha	LK: Good maize 6 tons/Ha	16 614
35	Yes	STP 3 tons/Ha	Currently vegetables	10 489
43		1.5 - 2 tons/Ha	Cultivation must go hand in hand with very good moisture retention techniques	76
44		1.5 - 2.8 tons/Ha	10-15% clay. Moisture retention techniques necessary	6 742
45		1.5 - 2.8 tons/Ha	10-15% clay, Moisture retention techniques necessary	14 092
46		Shallow soil		16 727
47	Yes	MS: 2 - 2.5 tons/Ha	Not sand. 10% clay	6 010

Table 5: Estimated existing and potential new surface area under dry land that is suitable for soybean production under commercial conditions, 2008/09 (continued)

48		MS: Dry land 1.2 tons/Ha, 2 - 3 tons/Ha if irrigated		19 499
49			MS: Sand south of Bothaville	0
50		1.2 - 1.8 tons/Ha; MS: LTAY: 1.8 - 3 tons/Ha		11 059
52		JB: 1.5 - 1.7 tons/Ha; MS concurs	Area is unsuitable for soybean production based on heat units and rainfall	327 943
53		JB: 1.2 tons/Ha; MS: Too dry		149 457
55		DuPH: 5 tons/Ha; MS: 4 tons/Ha	More clayey	6 603
66	Yes	LK:	Rainfall: 550 - 650 mm	276
69	Yes	LK:	Rainfall: 650 - 750 mm	125
70	Yes	LK:	Rainfall: 650 - 750 mm	92
73		Along West Coast. Temperatures above 35 degrees Celsius affect soybean yield	Crops: Predominantly lucerne, some maize, green chillies, sweet melon, watermelon, squash varieties	0
74		Along Orange River	No soybeans. Competing with grapes, peaches, cotton, dates, etc.	0
75		MS: 2 - 3 tons/Ha dry land	Crop rotation:	883
79	Yes	MS: Northern regions: 3 - 4 tons/Ha; Southern regions: 2 - 3 tons/Ha	KwaZulu-Natal sugar production region	42 791
80	Yes	SB: 3 tons/Ha	8 000 Ha maize - 6 tons/Ha	1 885
81	Yes			44 889
82				65 752
83			JB: 1.2 tons/Ha; MS concurs	684
84		North: JB: 1.2 - 1.5 tons/Ha; Middle: JB: 1.2 - 1.5 tons/Ha; PdeJ: 1.5 - 2 tons/Ha; MS: 1.8 - 3 tons/Ha; South: JB: 1.2 - 1.5 tons/Ha; MS: 1.8 - 3 tons/Ha; PdeJ: 1.5 - 2 tons/Ha		21 739
85		North to South: LF: 1.2; JB & LF: 1.5; JB: 1.2; MS: 1.2 - 1.5; JB: 1.5; JB: 1.5 - 1.7, JH: 1.2; JH: 1.2; JB: 1.5 - 1.8; MS: 1.2; LF: 1.8; LF: 1.2; JB: 1.5 tons/Ha		467 295
86				73 287
87	Yes			185 362
			Total	2 774 767
			Total new	325 513
			Total existing	2 449 254
			Potential percentage increase in Ha in SPRs under dry land	11.73%

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Raath, J. 2004. *Sojaboonpotensiaal Oos-Kaap*. Cradock: Department of Agriculture.

Schoeman, J.L & Van der Walt, M. 2006. *Overview of land suitability for biofuel crops. Report Number GW/A/2006/17, March 2006.* Pretoria: ARC Institute for Soil, Climate and Water.

Smit, M.A. 2000. *Your guide to successful soybean production*. Potchefstroom: ARC, Grain Crop Institute.

Smit, M.A. 2008. Personal communication.

Van Wyk, W. 2009. Personal communication.

APPENDIX A: List of minutes, reports, papers and maps in respect of soybean production regions in the RSA

Armour, R.J. & Viljoen, M.F. 2003. *Financial interpretation of long-term soybean / maize crop rotation systems*. Protein Research Foundation Project, Final Additional Report, September 2003.

Botha, P. (Date unknown). *Area suitable for the production of dry land soybeans*. Senior Research Agriculturist, Grain South Africa, Bothaville.

IFPRI (International Food Policy Research Institute). 2007. *Global Hunger Index*.

Joubert, J.S.G. 2008. *Maart projeksies van proteïnbehoeftes vir diereverbruik vir 2010 en 2020*. PRF.

Lemmer, W.J.; Botha, P.J.; Van Zyl, I.C.J. & Louw, C.J. 2007. *Die potensiaal van sojaboonproduksie vir industriële doeleindes*. Bothaville: Grain SA.

Raath, J. 2004. *Sojaboonpotensiaal Oos-Kaap*. Cradock: Department of Agriculture.

Schoeman, J.L. &. Van der Walt, M. 2006. *Overview of land suitability for biofuel crops. Report Number GW/A/2006/17, March 2006*, Pretoria: ARC Institute for Soil, Climate and Water.

Smit, M.A. 1989. *Production potential for soybeans in South Africa*. Potchefstroom: Grain Crops Research Institute.

Smit, M.A. 2000. *Your guide to successful soybean production*. Potchefstroom: Grain Crops Research Institute.

APPENDIX B.

Soyabean potential for Eastern Cape per local municipality, 2004.

Local Municipality	Hectares per LM
	817
Amahlati Municipality	22,530
Buffalo City Municipality	7,235
Elundini Municipality	110,998
Emalahleni Municipality	3,157
Engcobo Municipality	34,984
Great Kei Municipality	4,951
Intsika Yethu Municipality	30,266
King Sabata Dalindyebo Municipality	6,575
Mbhashe Municipality	8,186
Mbizana Municipality	72,935
Mhlontlo Municipality	54,496
Mnquma Municipality	31,401
Nkonkobe Municipality	6,702
Ntabankulu Municipality	29,883
Nyandeni Municipality	7,571
Port St Johns Municipality	11,490
Qaukeni Municipality	38,084
Sakhisizwe Municipality	15,537
Umzimkulu Municipality	147,900
Umzimvubu Municipality	109,500
Grand Total:	755,199

APPENDIX C.

Procedure for the elimination of areas potentially unsuited to soybean production

Michael Taute, Senior GIS Specialist, AGIS, Department of Agriculture, Forestry and Fisheries (DAFF)

The shape-file soybean production areas of the Consortium (using PICES) were used as a mask to determine areas in South Africa where soybean production could occur (Map 2).

The land-use dataset of the DAFF was used to identify other areas unsuited to soybean production. These datasets were combined and used as a mask to eliminate certain other areas unsuited to soybean production (Map 6, Map 7, Map 9 and Map 10).

The sensitive areas dataset of DAFF was used to identify additional areas where soybeans could not be produced (Map 11).

The next step was to identify other areas where soybeans could not be planted or harvested within these particular regions.

The 1:50 000 topographical map "rivers and dams" dataset of the Department of Water and Mineral Affairs was used and buffered to 50 metres, and a raster was generated to indicate potential flood zones (Map 12).

The Digital Elevation Model[9] (DEM) of NASA was downloaded from NASA's website and used to generate an incline slope raster dataset for the RSA. The inclines were sub-selected to indicate those of 10 degrees and below. This raster was intersected to produce a raster of where harvesting machinery could be used within the existing and potential soybean production areas.

Lastly, the ARC's rainfall dataset (Map 13) and heat unit dataset (Map 14) were used to identify areas experiencing less than 500 mm of rainfall per year, as well as areas that might be too cold or too hot for the effective production of soybeans. These rasters were sub-selected to identify rainfall and temperature zones ideal for soybean production. This raster dataset was used as a mask to eliminate the remaining areas not suited to soybean production.

In the process, certain areas were eliminated after being identified as areas that are currently or potentially unsuitable for soybean production on the basis of rainfall and heat units, namely the irrigation schemes west of Kimberley in the vicinity of Delportshoop, Douglas, Prieska and Hopetown, as well as the remaining area by the Van der Kloof Dam. In the area north of Pretoria and also the area surrounding the Soutpansberg,

[9] DEM is a raster in which each cell of a pixel represents an elevation in metres above sea level. A specific cell, in conjunction with two other cells, is used to determine an elevation (slope). For this purpose, Pythagoras' theorem is used to determine the slope. This value is then written back to a new cell representing the grade or the percentage of the slope, forming a slopes grid.

soybean production is successfully carried out under irrigation. These areas were included in the final soybean production regions.

The total area on which soybeans can be cultivated, with all the above criteria eliminated, is represented in Map 16.

An ArcGis 9.3.1 spatial analyst model was developed to carry out the elimination process automatically and to generate raster datasets for use in the mapping. This model can also be rerun to test the procedure, to add new datasets, and to increase or decrease the areas of influence as required.

Adjusting the model as required by the additional development of the procedure is an option. As datasets improve over time, the model can be reintroduced to refine the process.

The introduction of changes in the parameters is possible as new raster datasets, representing the varied parameters and the results thereof, develop.

Datasets used in this exercise include the 90 m x 90 m DEM raster for the whole of Southern Africa, with only that of South Africa being used. The resolution was aggregated and resampled to represent 100 m x 100 m grid cells, representing one hectare each.

The DEM was used to generate a slopes raster in degrees to identify slopes less than 10 degrees, with slopes of more than 10 degrees being selected for elimination. This dataset's spatial resolution also consisted of 100 m x 100 m grid cells.

The land-cover dataset was used as a polygon shape file in vector format, as this represents the greatest quantity of the original dataset. This was rasterised to the 100 m x 100 m grid raster, as all the data sets need to be aggregated or split to the same spatial resolution. This does influence the vector data negatively, because the spatial resolution of the vector data is more refined, but this is not the case with all datasets. Some datasets have a lower spatial resolution, e.g. the rainfall dataset, and thus the fact that the resampling process uses 100 m x 100 m grid cells for all the datasets does not increase the spatial resolution of that dataset.

The model uses the vector dataset, converts it to a raster at 100 m x 100 m grid cells, and then reclasses the values using map algebra to develop a raster indicating a Boolean raster with 1s and 0s. The datasets are then multiplied to produce a results raster. This raster will represent the information to be included as a 1 and to be eliminated as a 0. As the result of one function is fed into the next function as an input, the process continues until all datasets have gone through the process. When the result of the final process is available, the model will add an item to the remaining raster and link the information of the original soybean production dataset. This last dataset contains the statistics and is used in the mapping to cartographically represent the soybean production areas.

APPENDIX D.

CLASSIFICATION OF CULTIVARS IN DIFFERENT CLIMATIC REGIONS

Wessel van Wyk and Gawie de Beer
Agricultural expertise contractors, PRF
January 2009

NOTE: Appendices D and E have been included, because the two authors are currently working further on this topic. CSB.

South Africa is divided into four climatic regions, namely cool, medium-cool, medium-hot and hot (see Appendix E). This classification was done on the basis of heat units and height above sea level. There are no direct lines demarcating the areas, and the mapping of the country's cultivation regions has been done "approximately" with the understanding that the districts that are divided by some of these demarcations can thus fall into both groups (see map in Appendix E: Growth-class grouping for different regions). In the USA, the land is divided into 10 climatic regions with lines that run almost in parallel, with soybeans being planted in climatic region 1 with a maturity grouping of 1 (which is very short), while climatic region 10 is suited to cultivars with a maturity grouping of 10 (which is very long).

The issue of "early" and "late" soybean cultivars now arises. "Late" cultivars cannot accumulate sufficient heat units in a region with low heat units and will consequently not perform optimally in such a region. The opposite is also true in that soybean cultivars with a low heat unit requirement, i.e. "early" cultivars, will not perform optimally in a region with high heat units. All these concepts must, however, be considered in combination with the growth class of the cultivar and its heat unit requirements. A soybean cultivar classified as "early" will not perform better in a warmer region than in a colder region – despite the presence of more heat. What this means is that energy derived from sunlight is wasted while it could have been better utilised elsewhere.

In South Africa, we only have cultivars with a maturity group ranging between 4 and 7 (list of cultivars with their maturity groups is attached). The largest seed companies producing soybean seed already group the cultivars into maturity groups by assigning them numbers, e.g.:

Link Seeds
Example: LS 6150 R
6 - Link Seeds' soybeans carry the number 6 in front.
1 – Indicates whether the soybeans are determined or undetermined. Even number means determined and uneven number means undetermined.
5 – Indicates the maturity group.
0 – Indicates whether the soybeans have a broad or narrow leaf. Uneven number means a narrow leaf and even number means a broad leaf.

PANNAR
Example: PAN 1454 RR
1 – PANNAR's soybeans carry the number 1 in front.
4 – Indicates the maturity group.
5 – Year of registration (in this case 2005).
4 – A line number assigned by PANNAR to the cultivar to indicate the parents of the cultivar.

With South Africa being divided into four climatic regions, the cultivars can also be divided into these regions, i.e.

Cold: Maturity groups 4 and 5
Cool: Maturity groups 5 and 6
Warm: Maturity group 6
Hot: Maturity groups 6 and 7

In South Africa, soybeans are only classified as groups 4 to 7. This differs from the USA, where the groups are more finely classified, e.g. 5.3 or 5.7. The 5.3 indicates that the cultivar is closer to maturity group 5 and the 5.7 indicates that the cultivar is closer to maturity group 6.

Antony Jarvie claims that it is possible to more finely classify the cultivars in South Africa, provided that more data is available on the cultivars over a number of years.

CULTIVAR GROUPING
Cultivars on the variety list

NOT ROUNDUP READY	Maturity group
Dundee	6
Egret	7
Ibis 2000	6
Heron	6
Amstel	
Bloekom	6
Dumela	6
Highveld Top	5
Jakaranda	
JF 91	7
Jimmy	6
Kiaat	6
Knap	5
Lightning	
LS 444	4
LS 555	5
LS 666	6
LS 669	

LS 677	6
LS 678	6
Marula	6
Maruti	6
Mopanie	
Mpimbo	
Mukwa	7
Nqutu	6
Octa	8/9
PAN 564	5
PAN 626	6
PAN 660	6
PAN 809	7
PAN 854	7
PAN 1652	6
Prima 2000	5
Prolific	
Snell	4
SNK 440	4
SNK 500	6
Solitaire	7/8
Sonata	7/8
Sonop	4
Spitfire	7/8
Stork	7
Tallboy	7/8
Tambotie	6
Wenner	4

ROUNDUP READY

A5409RG	5
AG5601	6
LS 6050 R	6
LS 6150 R	6
LS 6161 R	6
LS 6162 R	4 (this cultivar should actually have been 6142, but registered incorrectly)
LS 6164 R	6
PAN 520 R	5
PAN 522 R	7
PAN 535 RR	5
PAN 538 RR	7
PAN 737 RR	7
PAN 1454 RR	4
PAN 1643 RR	6
Phb 95B53 R	6

Phb 96B01 R	6
AG 6101	6
PAN 421 RR	4
PAN 1666 RR	6

NOTE: CULTIVARS PRINTED IN BLACK ARE THOSE CULTIVARS THAT ARE STILL BEING REPRODUCED AND ARE THUS AVAILABLE FROM COMPANIES.

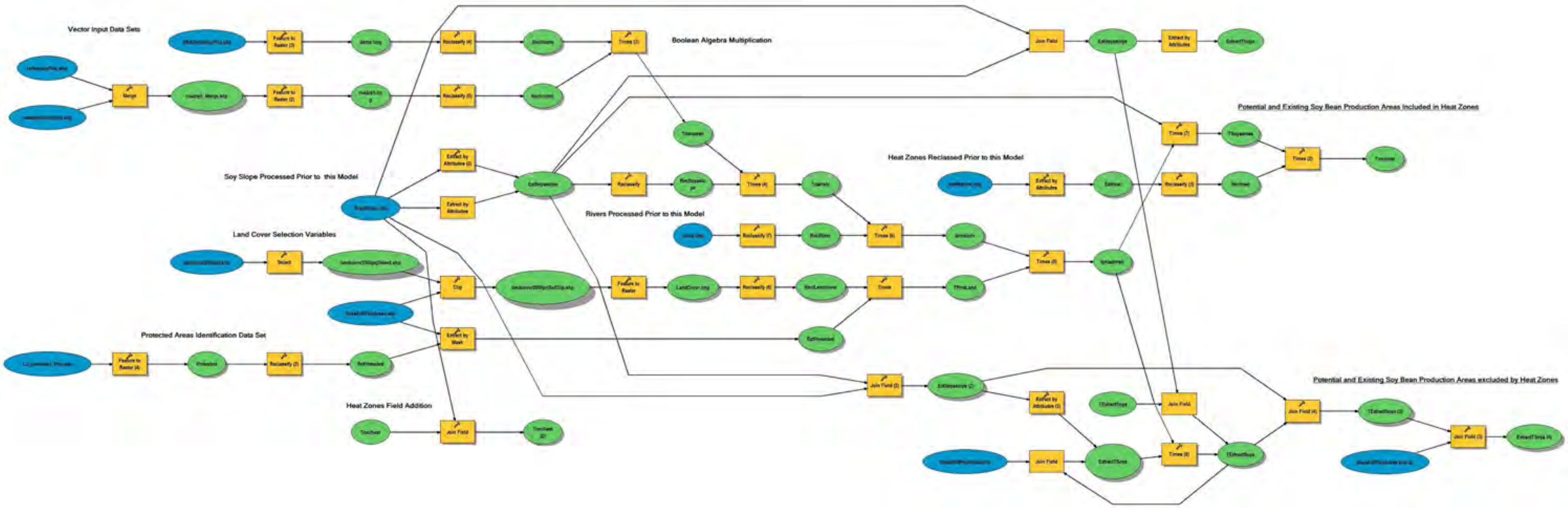
NEW CULTIVARS IN PHASE-1 TRIALS
Lex 1235
Lex 1233
Lex 2257
Lex 2685
PAN 1583 R
PAN 1867

It is clear from the above-mentioned cultivars that the classification according to maturity was only recently incorporated into the number of the cultivar. Where cultivars have been assigned names only, it is difficult to classify them unless this is monitored over a number of years.

APPENDIX E.
Growth-class grouping for different regions

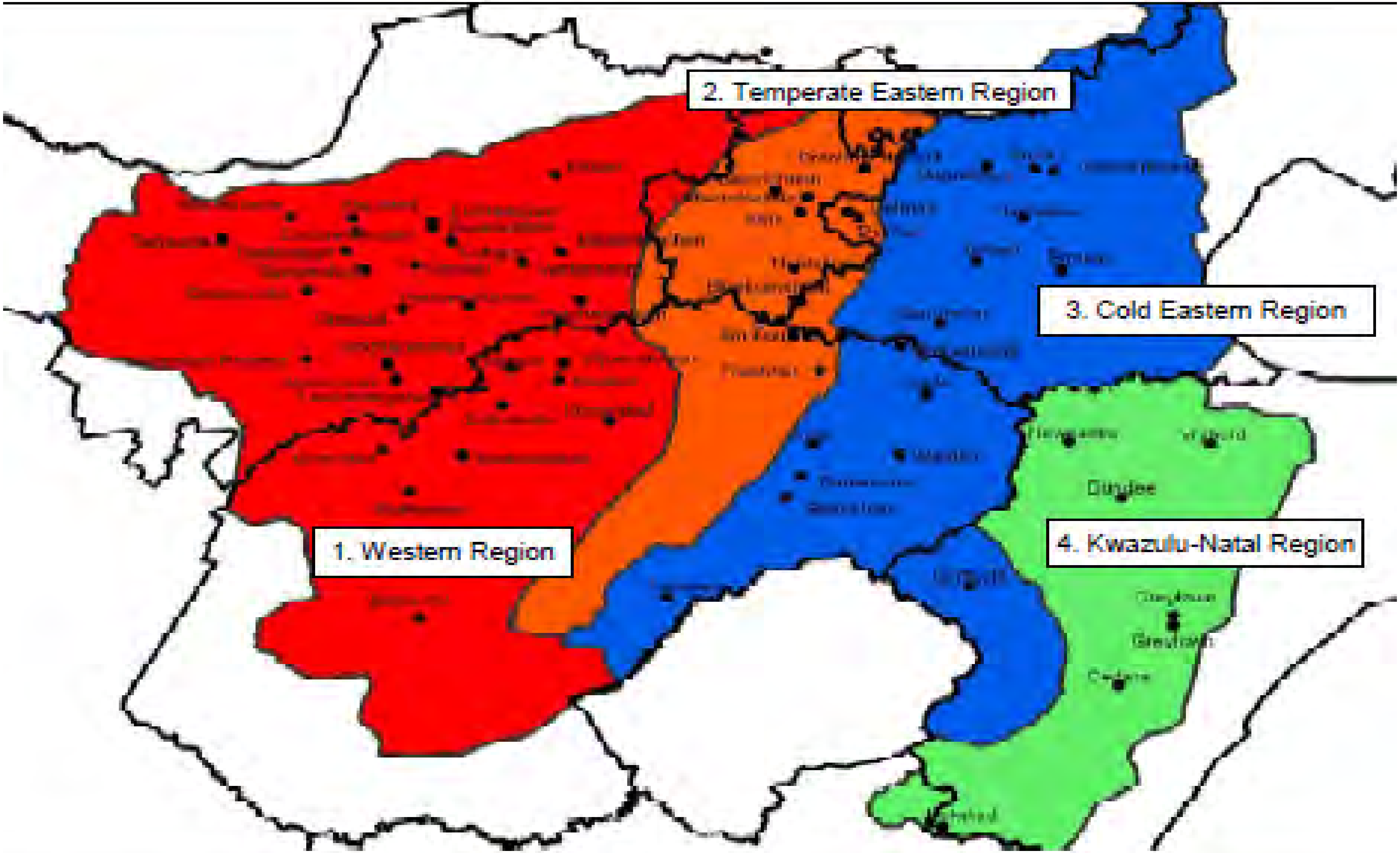
Model Process to Determine Soy Bean Production Area

Illimination Process by Use of Boolean Algebra and ArcGis 9.3.1



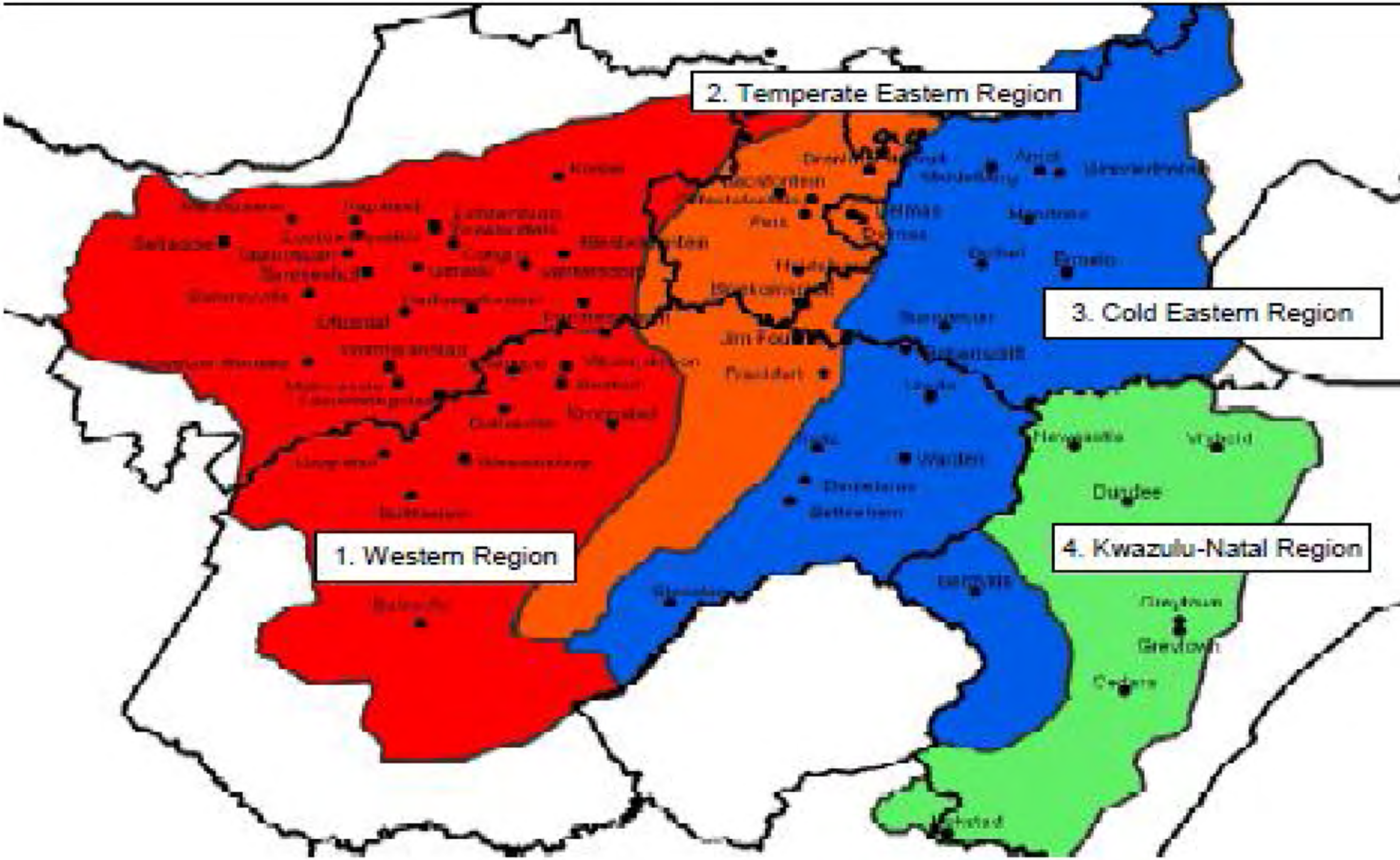
Climate zones of soybean production Map 1

Source: GrainSA



Climate zones of soybean production Map 1

Source: GrainSA



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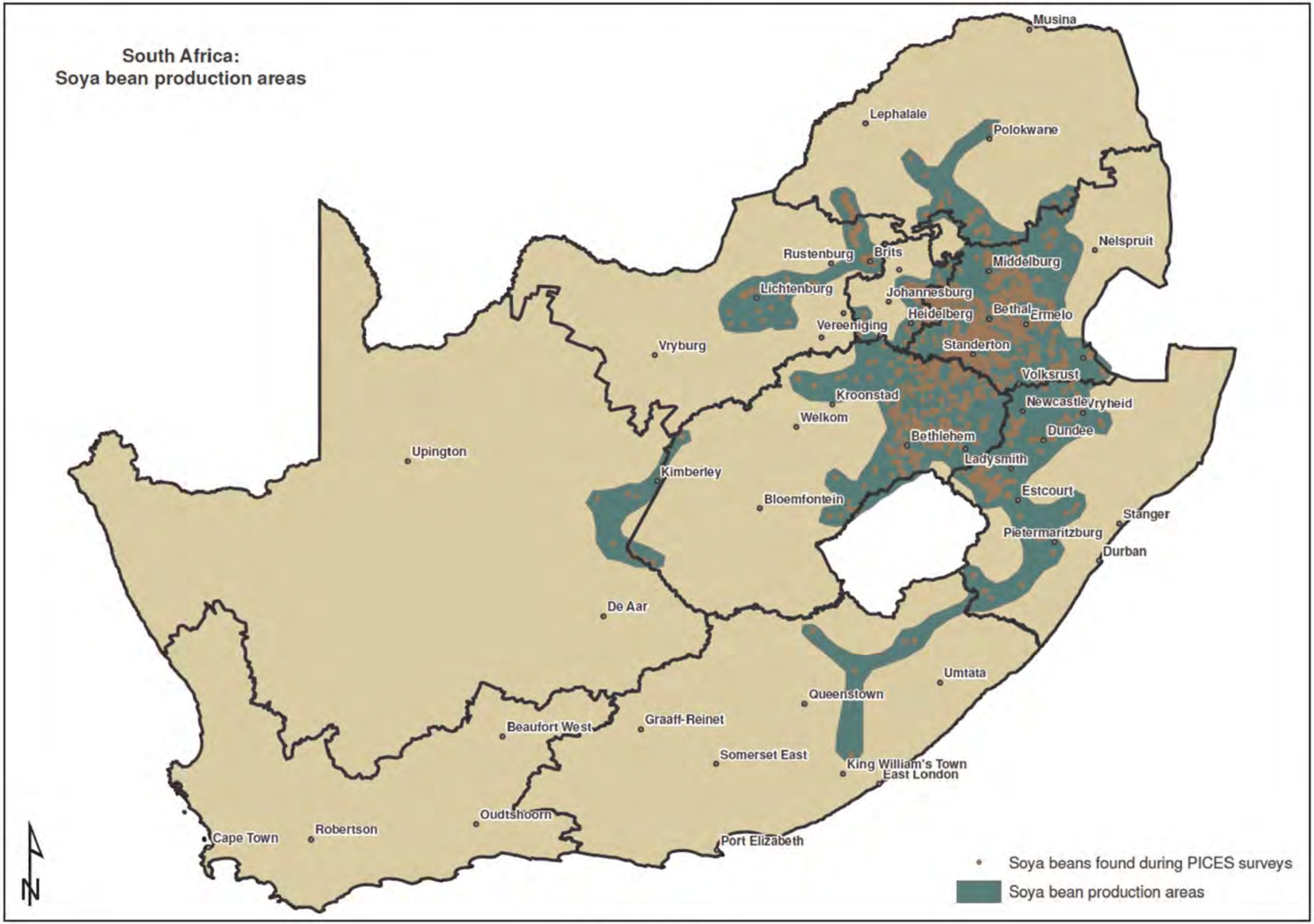
Consortium's soybean production regions

Map 2

Verification of Consortium's soybean production regions

Map 3



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ARC: Rainfall areas suitable for soybean production

Map 4

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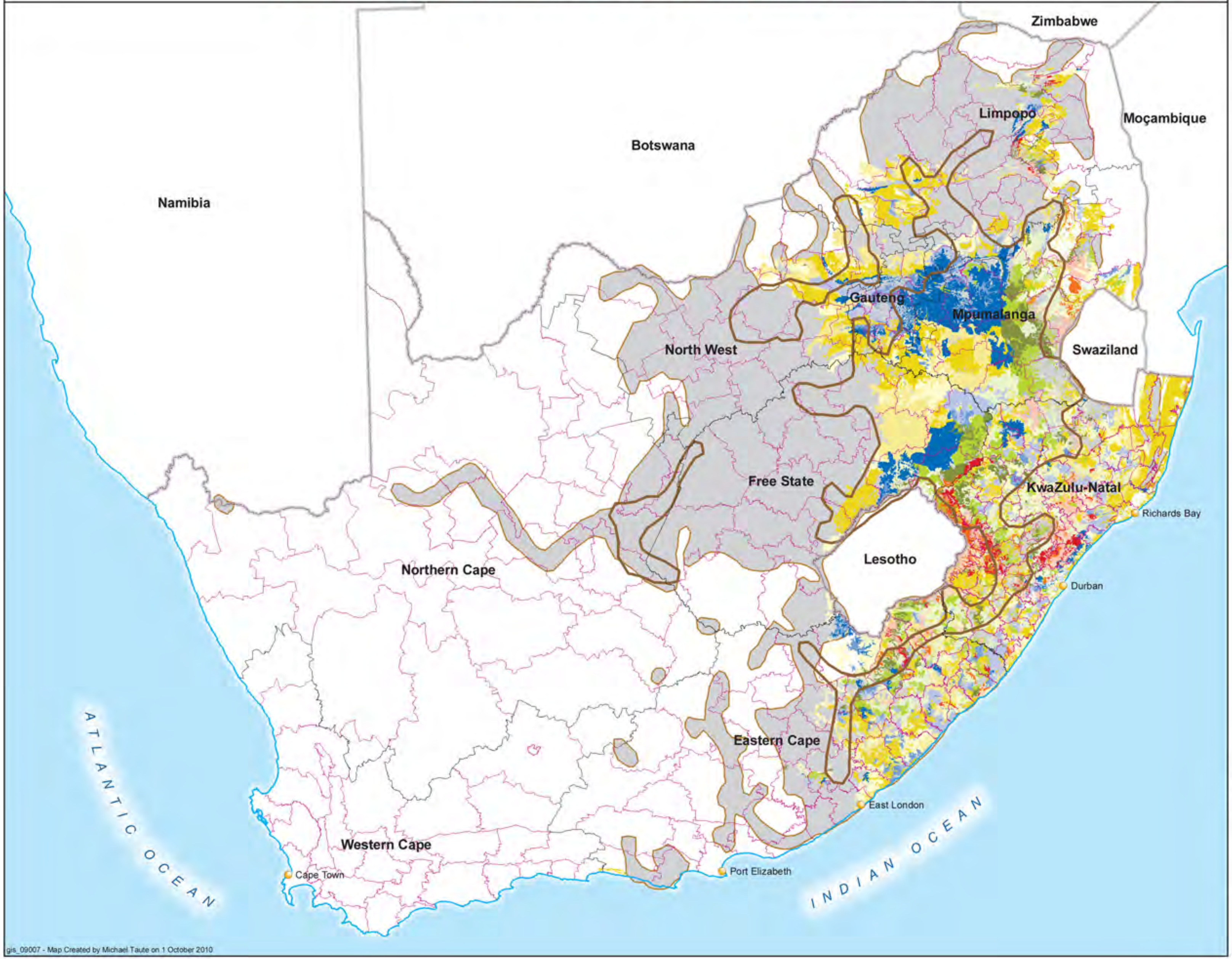

- Main Cities
- Provincial Boundaries
- Soya Areas
- Local Municipalities
- Mielie Areas

Soya Production / Potential Areas

- Marginal 10%
- Marginal 30%
- Marginal 50%
- Moderate 10%
- Moderate 30%
- Moderate 50%
- Suitable 10%
- Suitable 30%
- Suitable 50%
- High 10%
- High 30%
- High 50%

Bron : LNR
Source : ARC
Date: 1 October 2010

Directorate: ICT

Eastern Cape Province: Soybean production potential under dry land conditions. Map 5

Legend

- Dams
- MajorTowns
- Local Municipalities

Sojabean

- Suited

Criteria from ARC:
Rainfall Nov - March (mm): >= 400
Soil Categories: 1,2,3,5,6,11
Average Soil Depth (mm): >= 600
Average Slope (%): <=12
Average pH: >= 4.5
Frost start date: not before 15 April
Elevation (m): <= 1700

Date: June 2004

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Map Scale
1:3900000

Map produced by:
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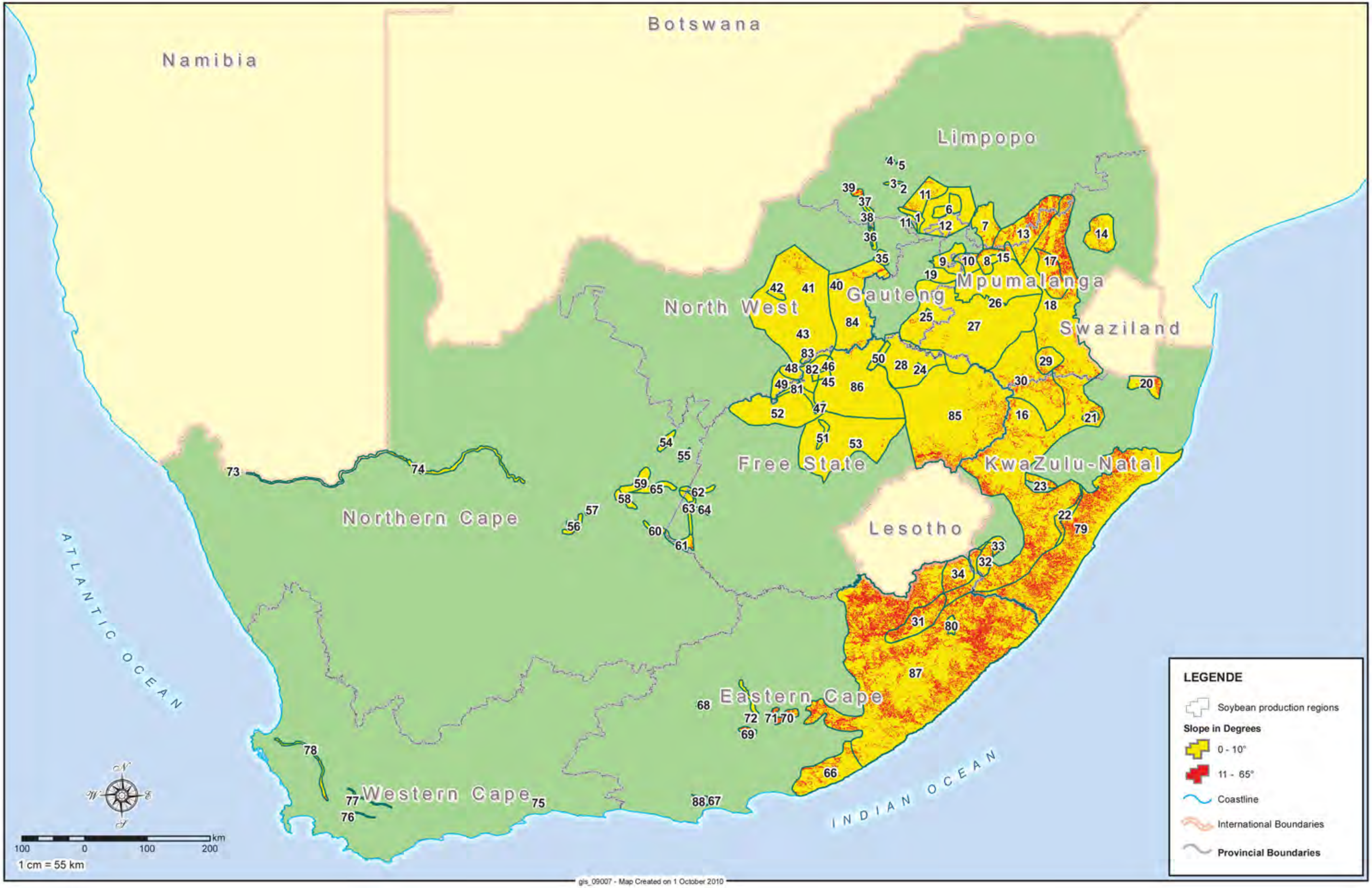
Identification of inclines greater than 10 degrees in soybean production regions Map 6



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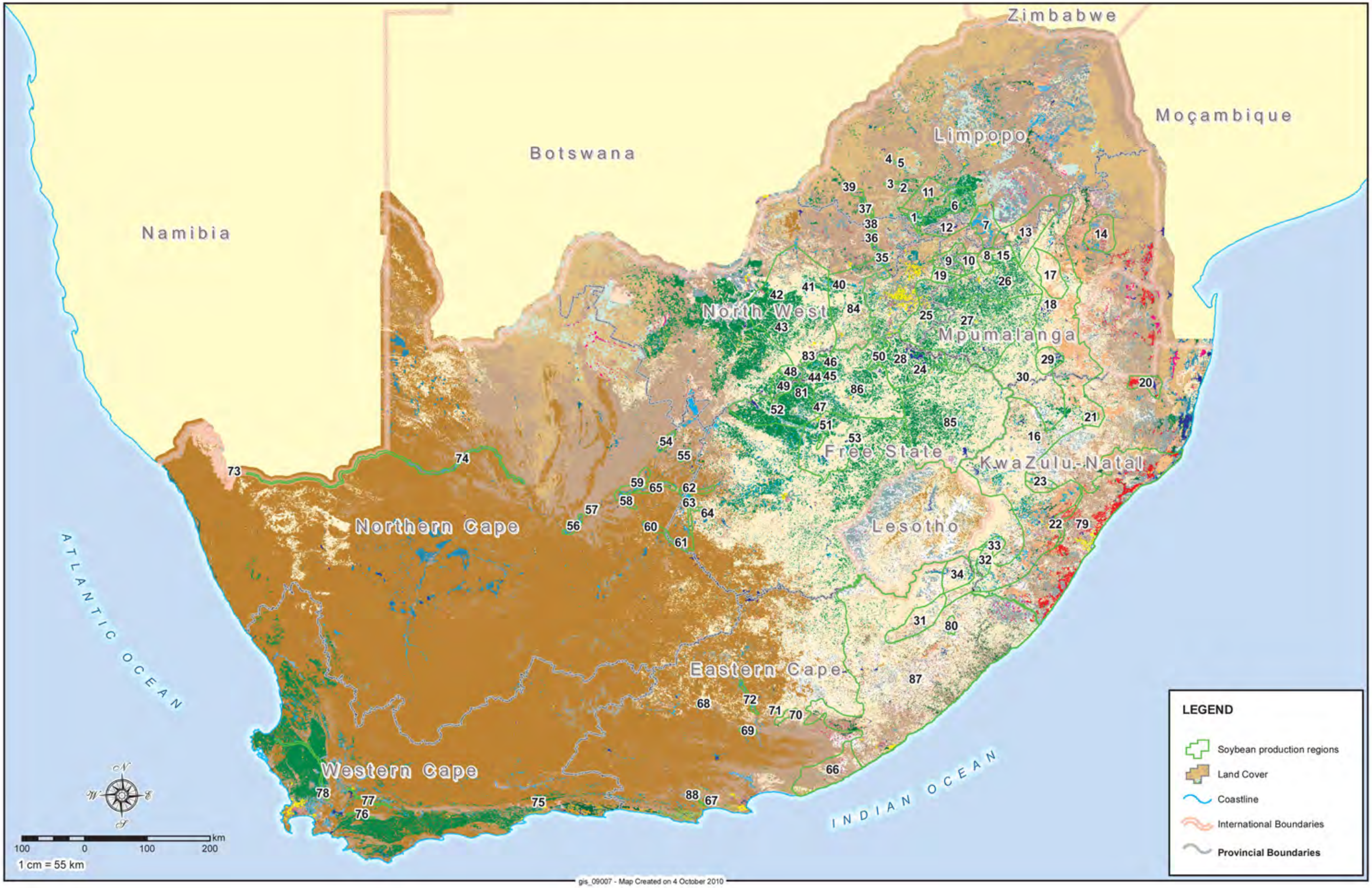
RSA: Land use redistribution and soybean production regions according to expert survey, 2009

Map 7



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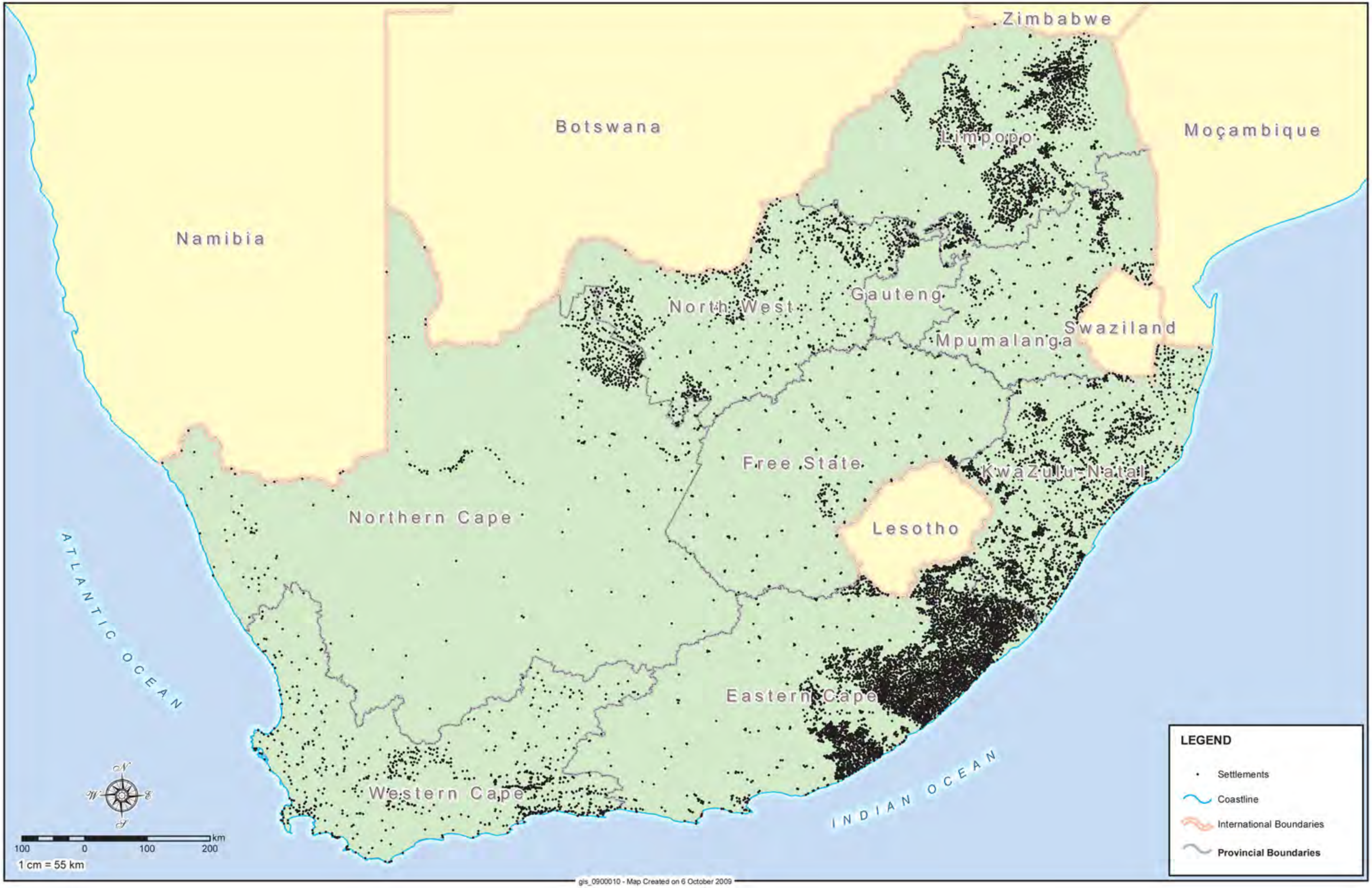
Residential areas in South Africa

Map 8



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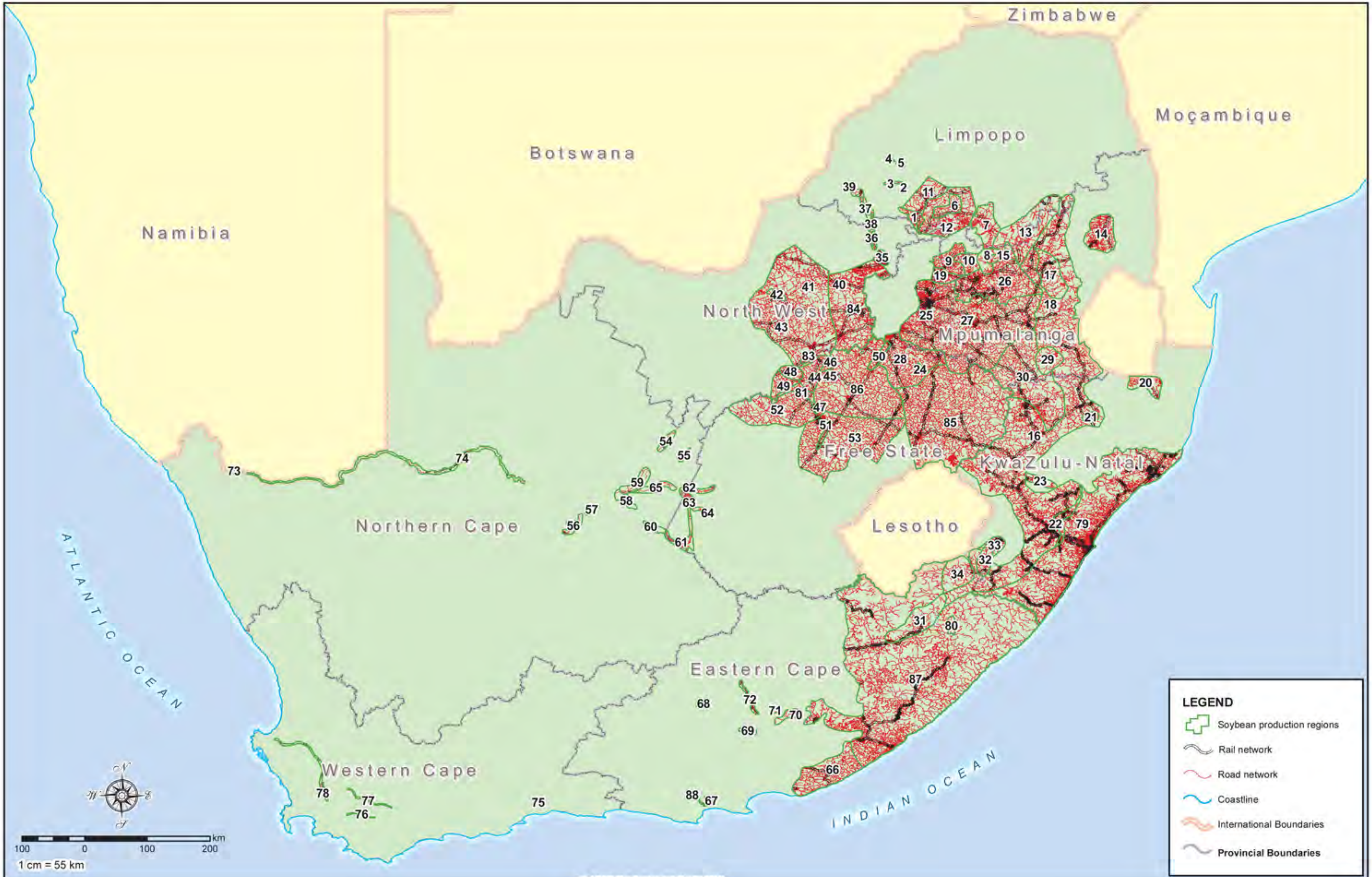
Rail and road networks in soybean production regions

Map 9



gis_09007 - Map Created on 2 October 2010

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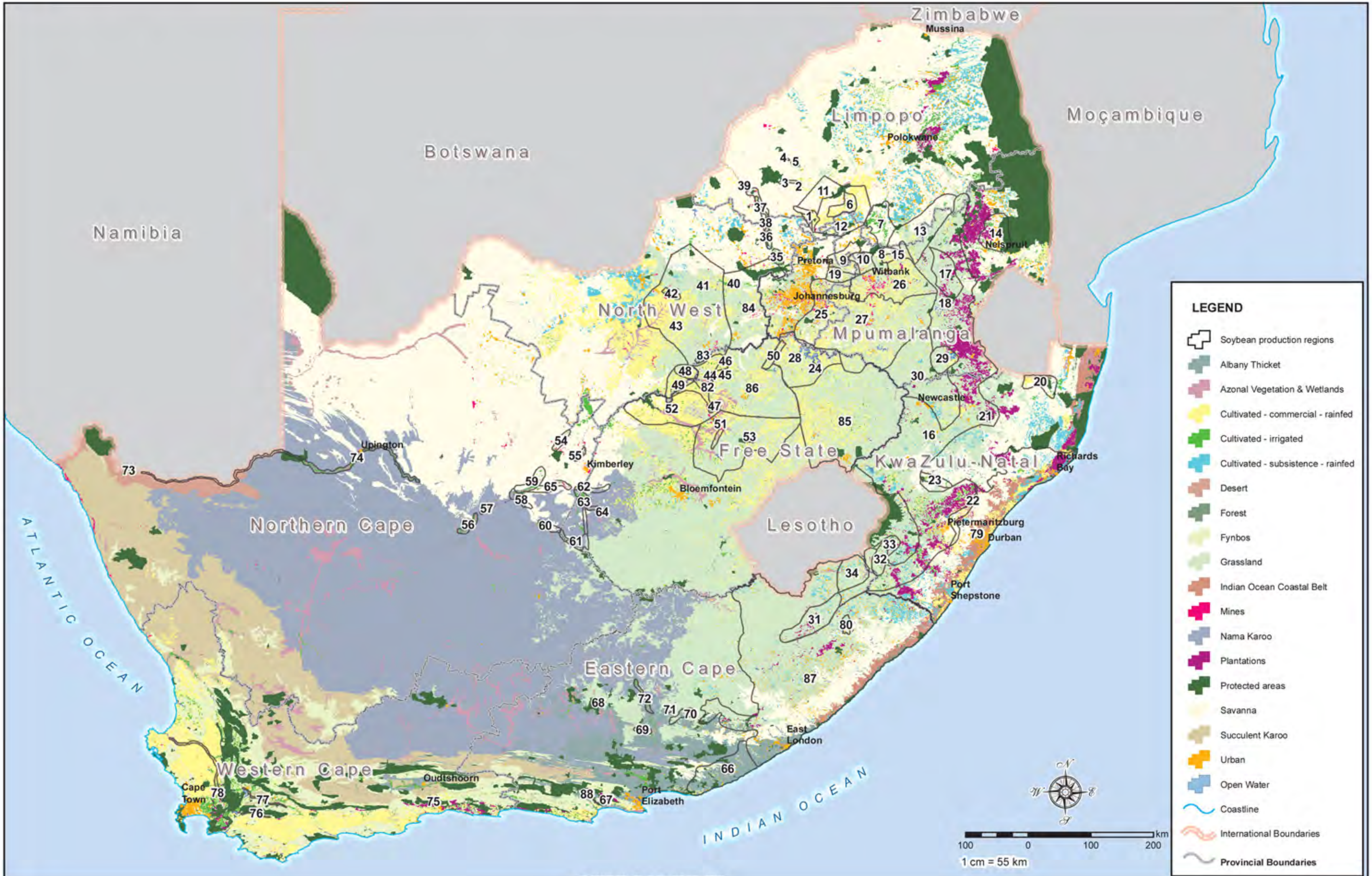
RSA : Environmental potential atlas: Overlall land usage

Map 10



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RSA: Protected areas

Map 11

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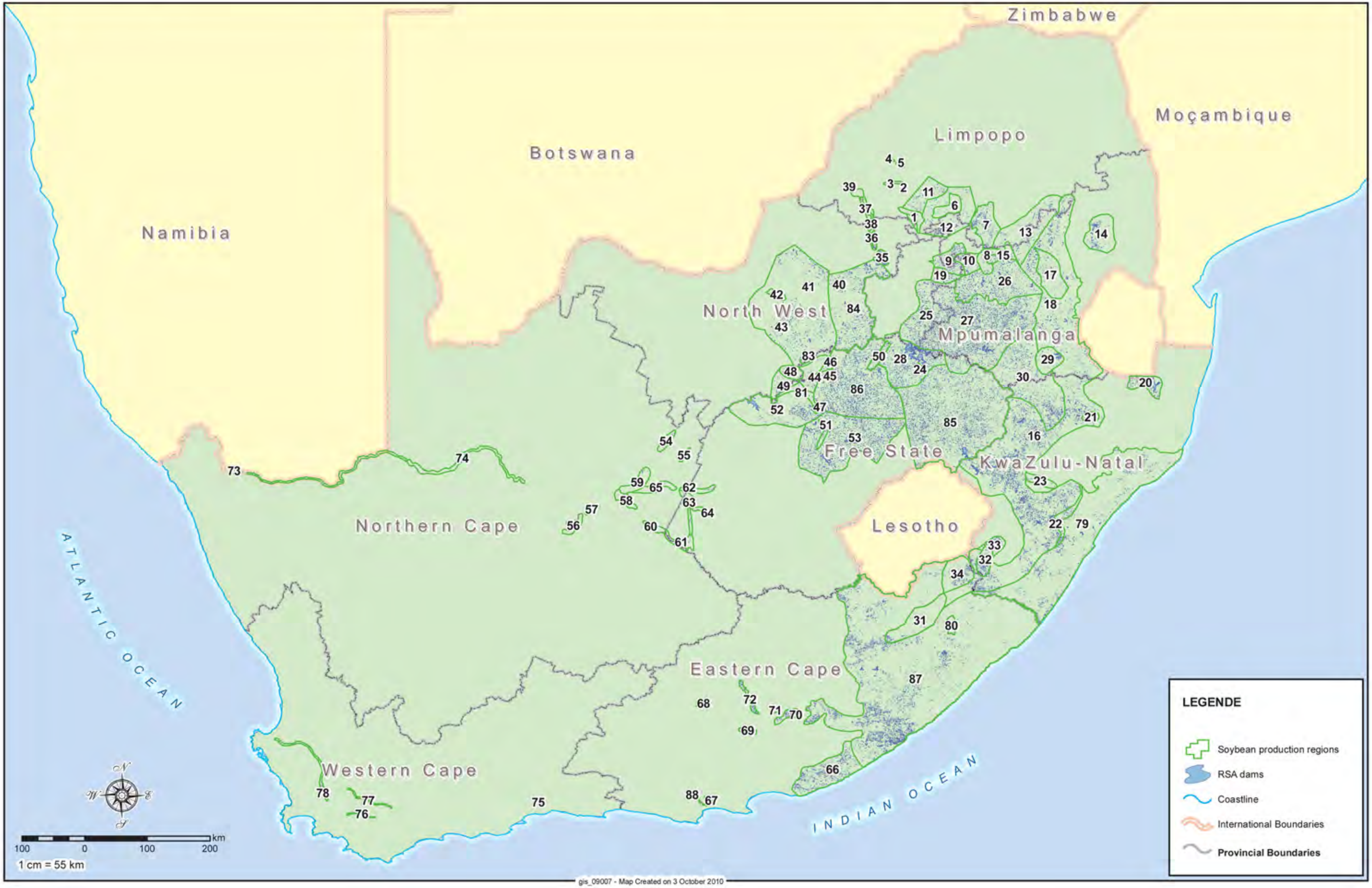
RSA: Dams of all sizes in soybean production regions

Map 12



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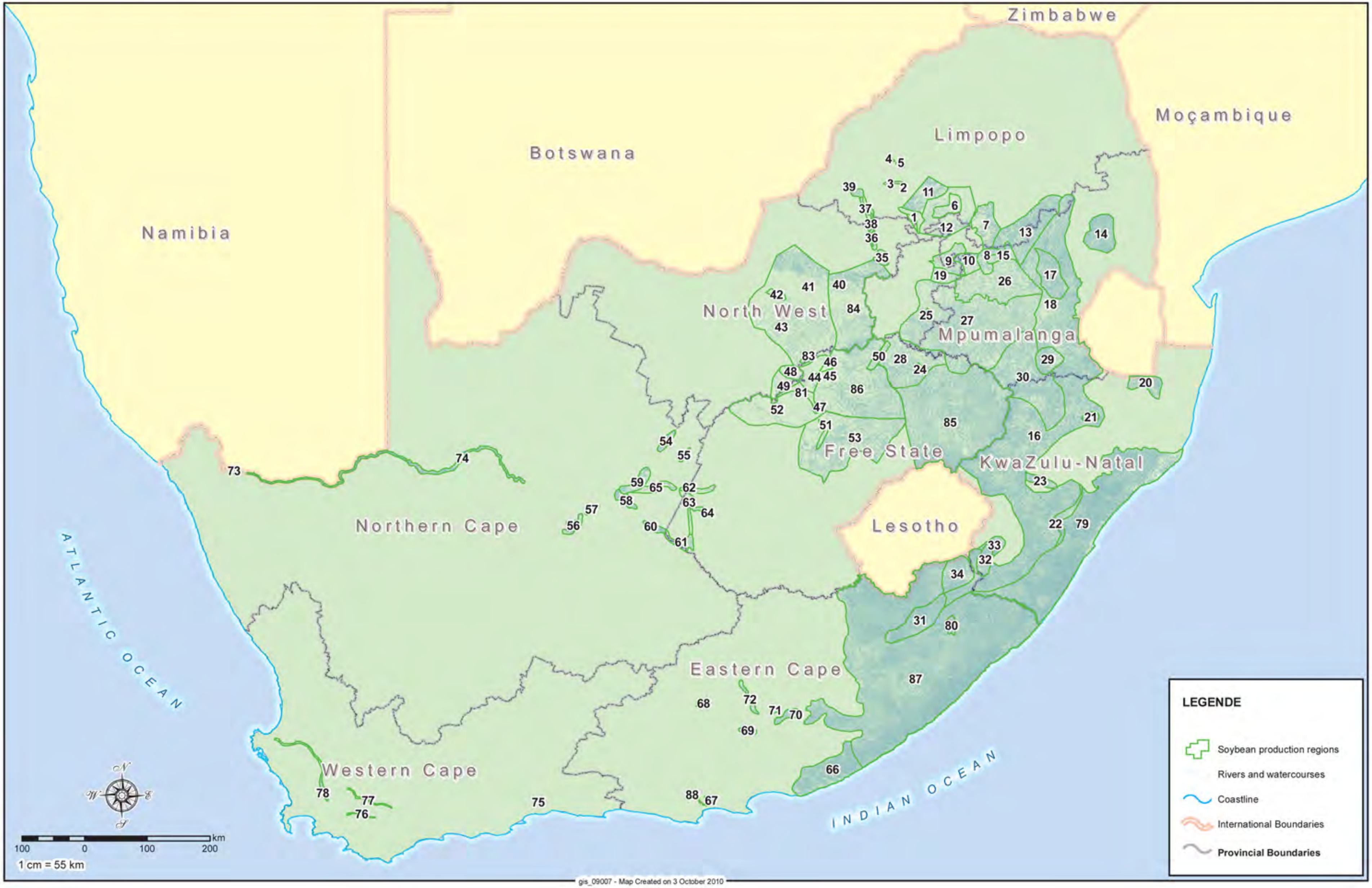
RSA: Rivers and watercourses in soybean production regions

Map 13



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RSA : Rainfall areas and soybean production regions

Map 14

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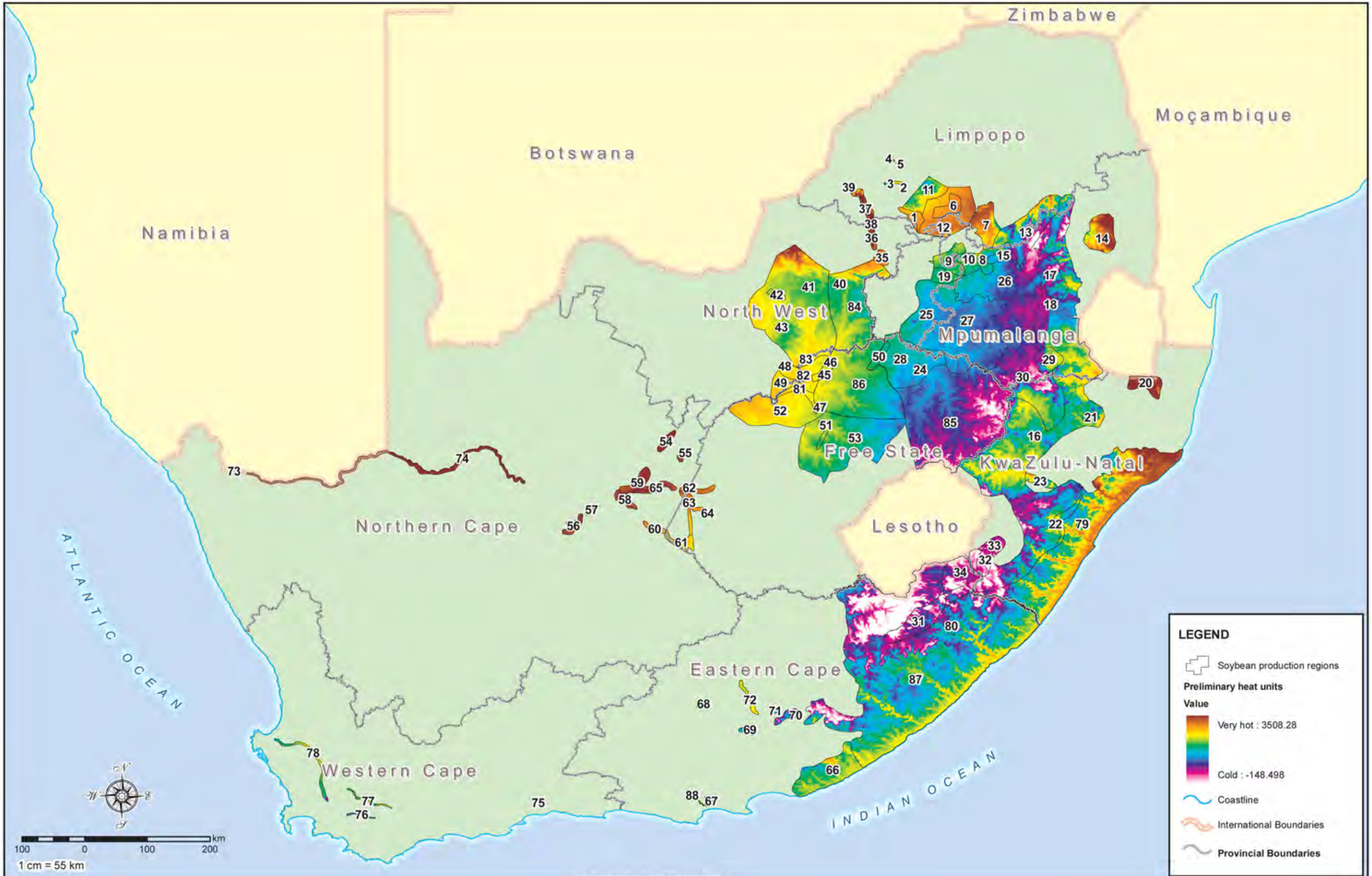
Preliminary heat units in soybean production regions

Map 15



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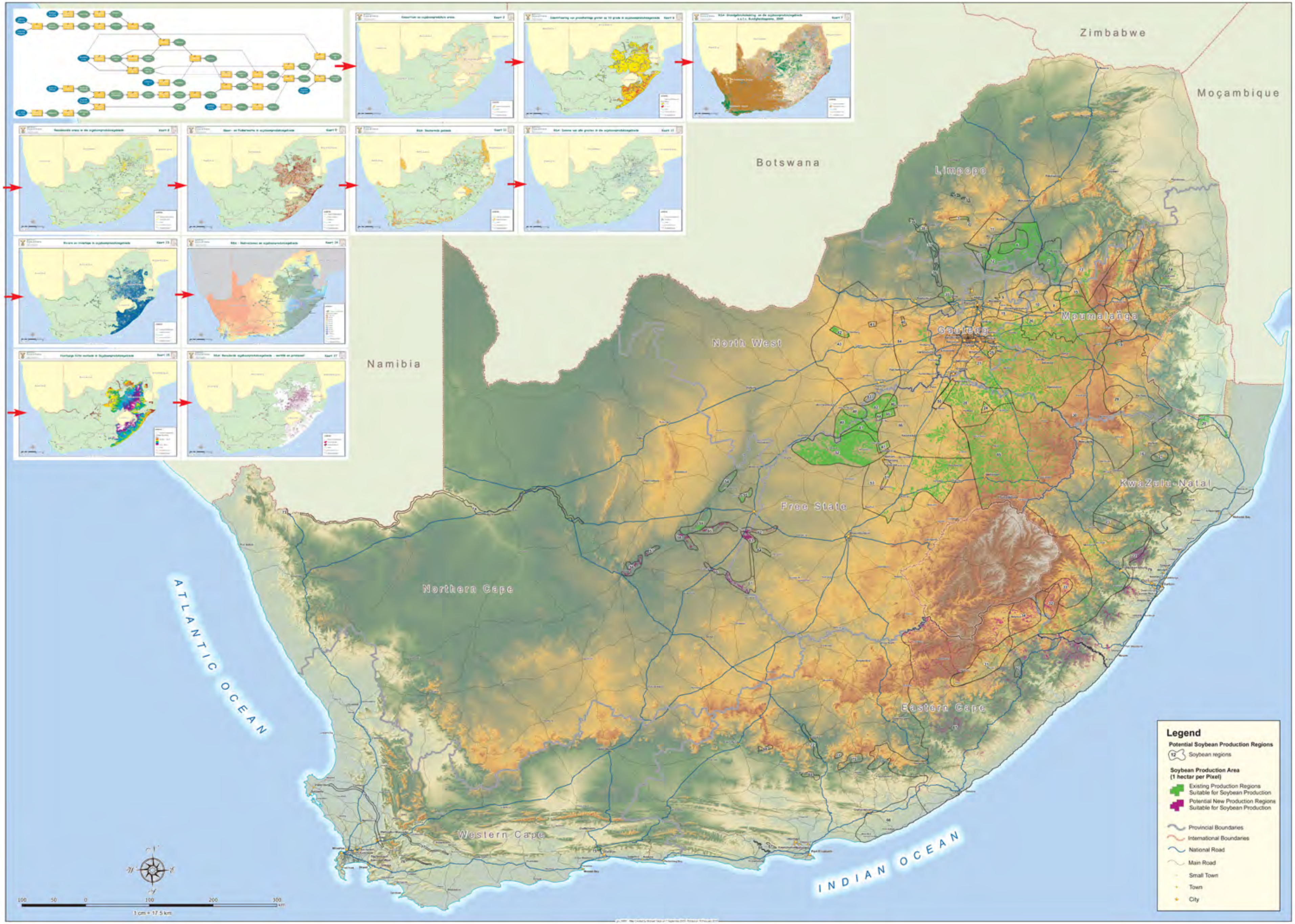
Cartographical representation of process used to identify soybean production regions

Map 16



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Cartographical representation map used to identify soybean production regions

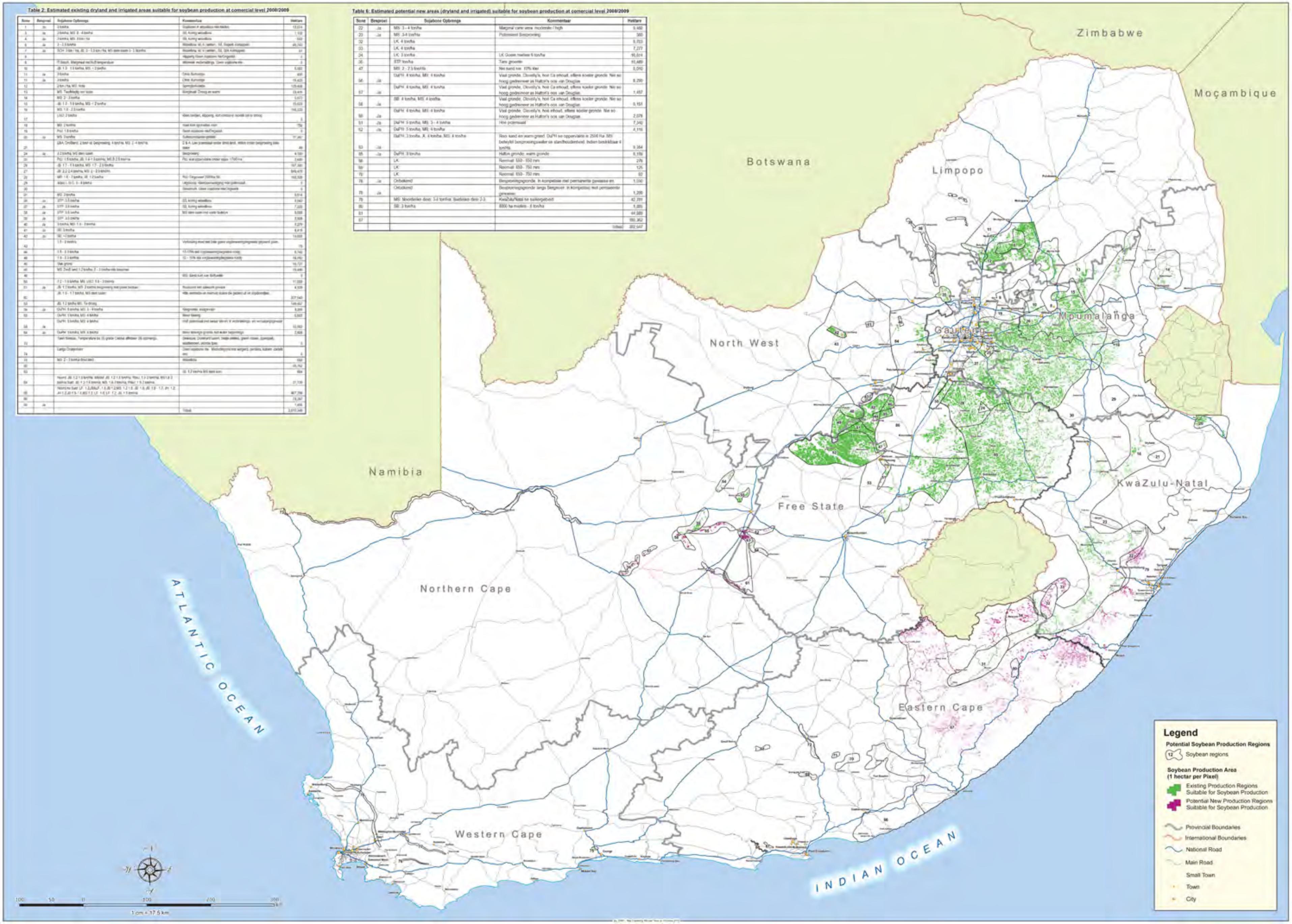
Map 17

Table 2: Estimated existing dryland and irrigated areas suitable for soybean production at comercial level 2008/2009

Sone	Besproei	Sojaboon Opbrengs	Kommentaar	Hektare
1	Ja	3 ton/ha	[illegible]	13,014
3	Ja	3 ton/ha, MS: 3 - 4 ton/ha	[illegible]	1,132
4	Ja	3 ton/ha, MS: [illegible]	[illegible]	322
6	Ja	3 - 3.5 ton/ha	[illegible]	45,743
7	Ja	[illegible]	[illegible]	51
8			[illegible]	3
9		[illegible]	[illegible]	3
10		[illegible]		5,082
11	Ja	3 ton/ha	[illegible]	400
11	Ja	3 ton/ha	[illegible]	15,423
12		2 ton / ha, MS: [illegible]	[illegible]	125,608
13		[illegible]	[illegible]	23,405
14		MS: 2 - 3 ton/ha		5,677
15		[illegible]		15,633
16		MS: 1.8 - 2.5 ton/ha		106,333
17		[illegible]	[illegible]	3
18		MS: 2 ton/ha	[illegible]	759
19		[illegible]	[illegible]	3
20	Ja	MS: 3 ton/ha	[illegible]	17,267
21		[illegible]	[illegible]	49
24	Ja	[illegible]	Besproeiing	4,100
25		[illegible]	[illegible]	2,600
26		[illegible]		157,360
27		[illegible]		549,475
28		[illegible]	[illegible]	168,328
29		[illegible]	[illegible]	3
30			[illegible]	3
31		MS: 2 ton/ha		5,514
36	Ja	STP: 3.5 ton/ha	[illegible]	3,942
37	Ja	STP: 3.5 ton/ha	[illegible]	7,333
38	Ja	STP: 3.5 ton/ha	[illegible]	5,558
39	Ja	STP: 3.5 ton/ha		7,508
40	Ja	3 ton/ha, MS: 1.5 - 2 ton/ha		3,279
41	Ja	SB: 3 ton/ha		8,419
42	Ja	SB: <3 ton/ha		14,858
43		1.5 - 2 ton/ha	[illegible]	75
44		1.5 - 2.3 ton/ha	[illegible]	6,742
45		1.5 - 2.3 ton/ha	[illegible]	16,782
46		Vlak grond		10,727
48		[illegible]		15,495
49			[illegible]	3
50		[illegible]		11,559
51	Ja	[illegible]	[illegible]	4,539
52		[illegible]	[illegible]	227,543
53		[illegible]		149,657
54	Ja	[illegible]	[illegible]	8,209
55		[illegible]	[illegible]	5,507
58	Ja	[illegible]	[illegible]	12,582
64	Ja	[illegible]	[illegible]	7,908
72		[illegible]	[illegible]	3
74		[illegible]	[illegible]	4
75		MS: 2 - 3 ton/ha [illegible]	[illegible]	332
82				25,752
83			[illegible]	884
84		[illegible]		21,739
85		[illegible]		467,799
86				73,387
88	Ja			1,655
			Totaal	2,011,348

Table 6: Estimated potential new areas (dryland and irrigated) suitable for soybean production at comercial level 2008/2009

Sone	Besproei	Sojaboon Opbrengs	Kommentaar	Hektare
22	Ja	MS: 3 - 4 ton/ha	Marginal care area: moderate / high	3,480
23	Ja	MS: 3-4 ton/ha	Potensieel Besproeiing	380
32		LK: 4 ton/ha		5,703
33		LK: 4 ton/ha		7,277
24		LK: 3 ton/ha	LK Goeie mielies 6 ton/ha	16,614
30		STP ton/ha	Tans groente	10,489
47		MS: 2 - 2.5 ton/ha	Nie sand nie. 10% klei	5,050
56	Ja	DuPH: 4 ton/ha, MS: 4 ton/ha	Vaal gronde, Clovelly's, hoë Ca inhoud, effens koeler gronde. Nie so hoog gedreineer as Hutton's oos van Douglas	8,290
57	Ja	DuPH: 4 ton/ha, MS: 4 ton/ha	Vaal gronde, Clovelly's, hoë Ca inhoud, effens koeler gronde. Nie so hoog gedreineer as Hutton's oos van Douglas	1,457
58	Ja	SB: 4 ton/ha, MS: 4 ton/ha	Vaal gronde, Clovelly's, hoë Ca inhoud, effens koeler gronde. Nie so hoog gedreineer as Hutton's oos van Douglas	5,151
60	Ja	DuPH: 4 ton/ha, MS: 4 ton/ha	Vaal gronde, Clovelly's, hoë inhoud, effens koeler gronde. Nie so hoog gedreineer as Hutton's oos van Douglas	2,078
61	Ja	DuPH: 5 ton/ha, MS: 3 - 4 ton/ha	Hoë potensiaal	7,340
62	Ja	DuPH: 5 ton/ha, MS: 4 ton/ha		4,116
63	Ja	DuPH: 3 ton/ha, JK: 4 ton/ha, MS: 4 ton/ha	Rooi sand en warm grond. DuPH se oppervlakte is 2500 ha. MS beteykel besproeiingswater se standhoudendheid. Indien beskikbaar 4 ton/ha	9,364
65	Ja	DuPH: 3 ton/ha	Hutton gronde; warm gronde	8,159
68		LK	Reënval: 550 - 650 mm	276
69		LK	Reënval: 650 - 750 mm	125
70		LK	Reënval: 650 - 750 mm	93
76	Ja	Onbekend	Besproeiingsgronde. In kompetisie met permanente gewasse en	1,030
78	Ja	Onbekend	Besproeiingsgronde langs Bergrivier. In kompetisie met permanente gewasse	1,208
79		MS: Noordelike dele: 3-4 ton/ha; Suidelike dele 2-3	KwaZulu/Natal se suikergebied	42,701
80		SB: 3 ton/ha	8000 ha mielies - 6 ton/ha	5,885
81				44,389
87				150,362
			Totaal	352,547



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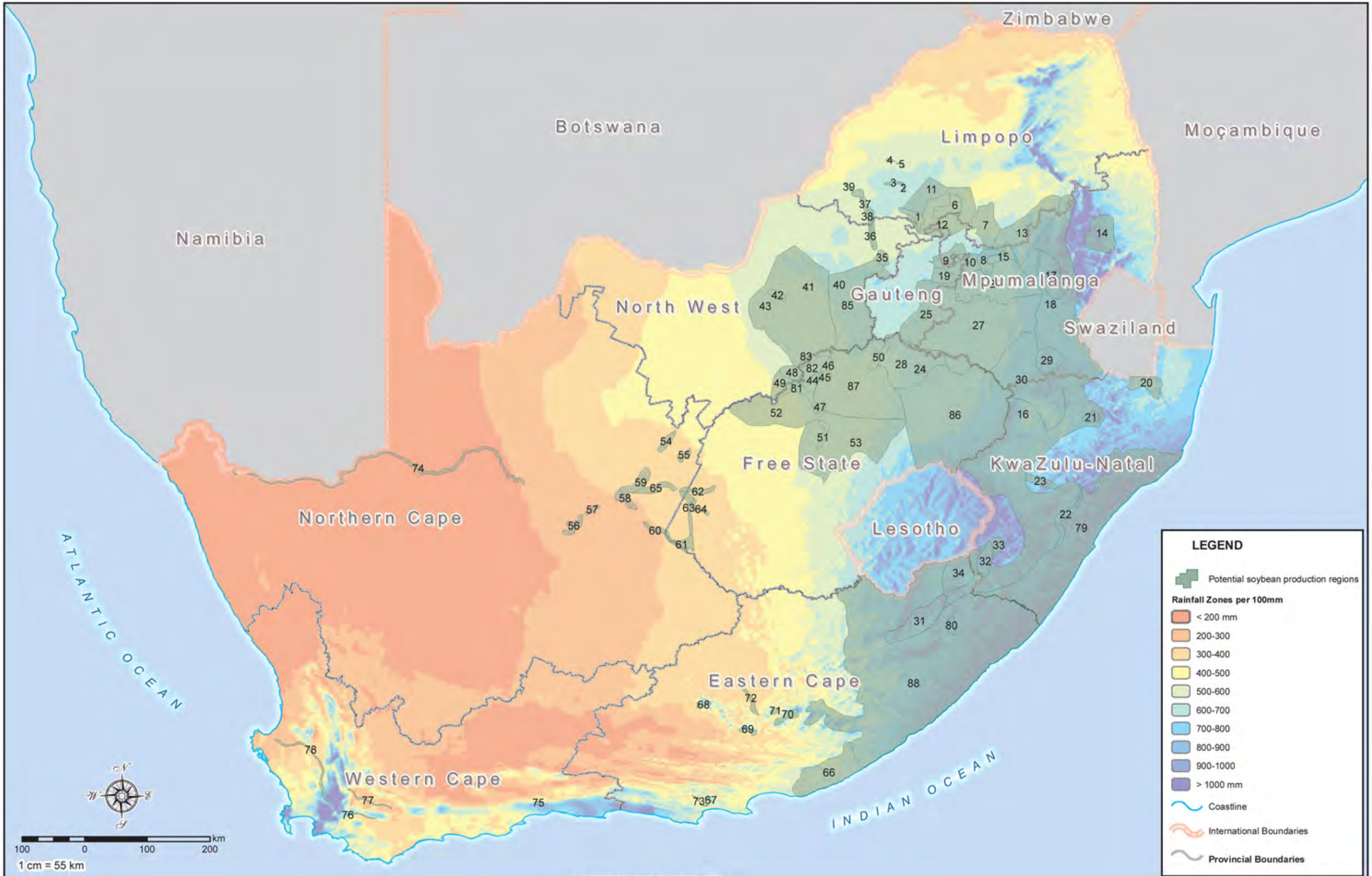
Rainfall zones in soybean production regions

Map 18



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