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Irrigation Suitability Report for a portion of land identified by Mahoebe Eiendomme, Prieska, Northern Cape Province

For

Henry Coetzee

August 2016

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Executive summary

A soil survey was done for a 149 ha field on Mahoebe Farm for Henry Coetzee, to assess the suitability of the area for drip irrigation for vineyards. The soils of the study site are very shallow (200 mm) to deep (1600 mm). Soil forms encountered include Addo, Brandvlei, Coega and Prieska. The topography is uniform flat with a maximum slope gradient of 3%. Infiltration limiting materials were either soft or hard carbonate. An area of 91 ha is preferred for vineyard production under drip or micro irrigation, which will require deep ripping of neocarbonate and soft carbonate horizons. The additional 58 ha could be cultivated for vineyards as well, but will require deep ripping of hard carbonate, which will be more expensive than the initial 91 ha.

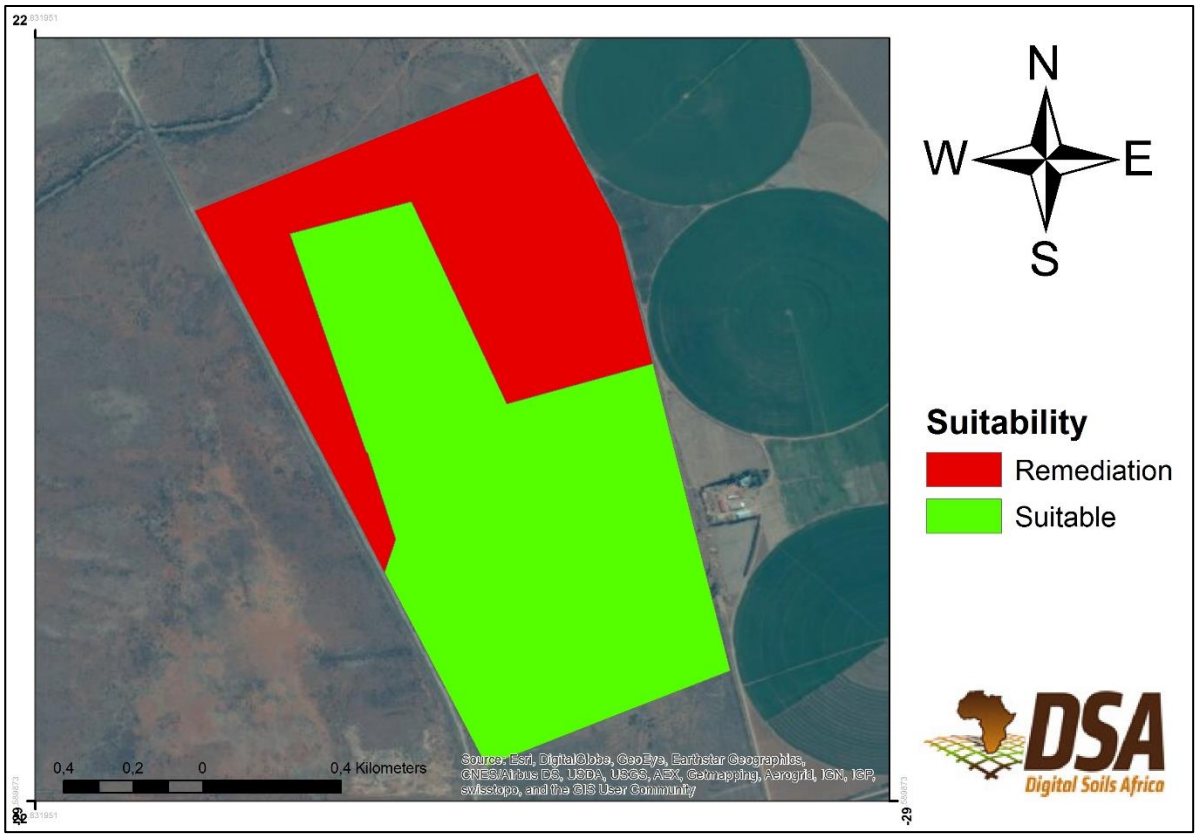

Figure A: The area suitable for the proposed drip irrigation scheme.

1. Introduction

Digital Soils Africa conducted an irrigation potential soil survey on land indicated by Henry Coetzee in order to determine which area on a 149 ha portion of the farm is suitable for vineyard production under drip irrigation.

2. Location

The site is located between Prieska and Niekerkshoop in the Northern Cape Province, within one km from the Orange River (Figure 1). The site has a slope ranging between 0 and 3%. Table 1 gives the co-ordinates of the perimeter of the 149 ha study site.

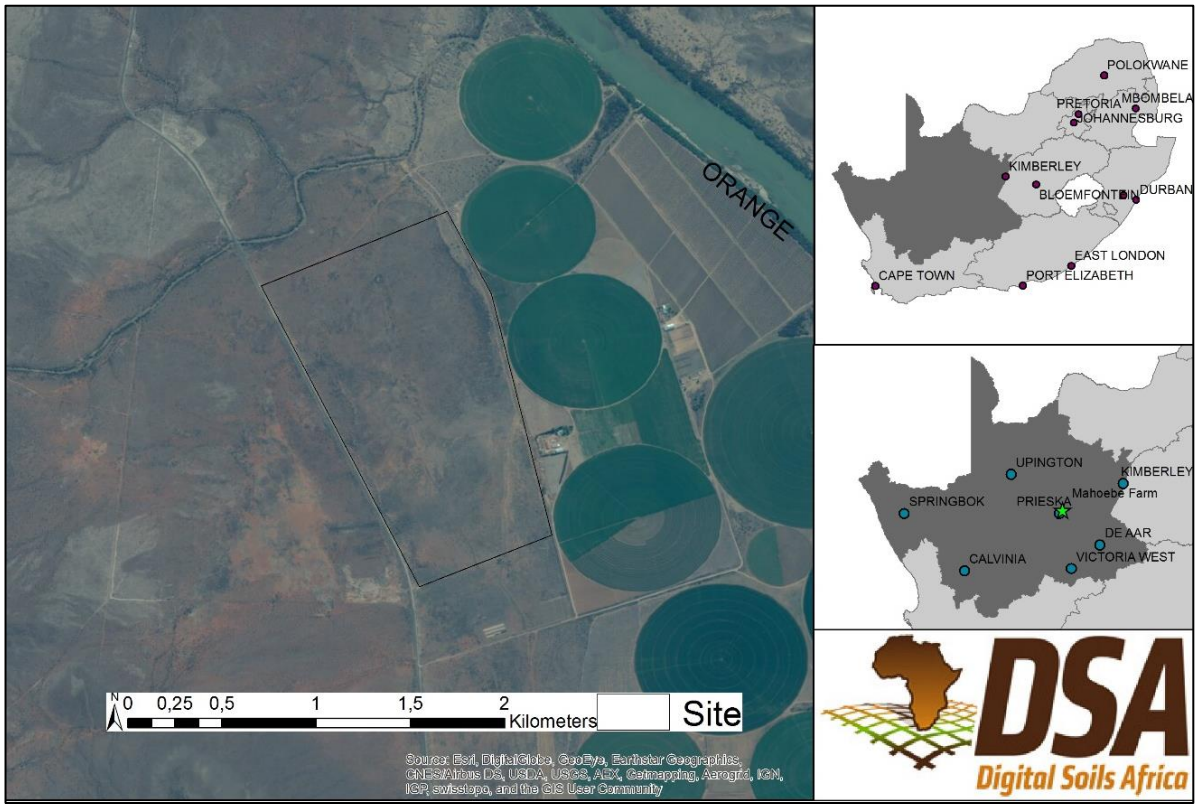

Figure 1: The location of the study site.

Table 1: The perimeter points of the study site

X	Y
22.84500	-29.57108
22.84719	-29.57504
22.85002	-29.58651
22.84368	-29.58898
22.83614	-29.57459

3. Methodology

Soil profile pits were dug to 1.8 m or to hard carbonate on a 200 m grid using a TLB. Soils were classified according to Taxonomic Soil Classification System (Soil Classification Working Group, 1991). Soil depth, freely drainable depth and limiting material were noted and mapped. Samples of modal profiles were taken for chemical and physical analysis. Texture was measured with the hydrometer method (Gee and Bauder, 1979), basic cations from a 1:10 NH4OAc extract (White 2006) and soil pH in a 1:2.5 water and KCl extract. Figure 3 shows the locations of the soil observations, while Table 2 gives the GPS coordinates of the observations.

As the drainage ability of the soft carbonates were doubted an informal experiment was set up. The profiles were filled with water to about 350 mm and left overnight. By the next morning the free water in the profiles had drained, showing that the soft carbonate horizon drains well.

Figure 2: Soil observation locations.

Table 2: Soil observation positions

Observation	X	Y	Observation	X	Y
01	22.8476	-29.5867	17	22.8441	-29.5839
02	22.8469	-29.5851	18	22.8449	-29.5854
03	22.8462	-29.5833	19	22.8457	-29.5873
04	22.8455	-29.5817	20	22.8437	-29.5884
05	22.8454	-29.5808	21	22.8432	-29.5875
06	22.8458	-29.5797	22	22.8430	-29.5861
07	22.8454	-29.5784	23	22.8421	-29.5854
08	22.8443	-29.5769	24	22.8415	-29.5844
09	22.8434	-29.5753	25	22.8409	-29.5833
10	22.8418	-29.5740	26	22.8402	-29.5822
11	22.8419	-29.5761	27	22.8394	-29.5804
12	22.8409	-29.5764	28	22.8388	-29.5787
13	22.8416	-29.5780	29	22.8382	-29.5770
14	22.8423	-29.5797	30	22.8372	-29.5753
15	22.8426	-29.5805	31	22.8369	-29.5747
16	22.8434	-29.5823			

4. Results

4.1. Soils forms

The soils encountered during the survey are shown in Table 3, while descriptions of the various diagnostic horizons follow in the text. Examples of the soil forms are shown in Figure 3-6 and the soil form distribution is shown in Figure 7. Figure 8 shows the distribution of the water infiltration impeding layers. Modal profile descriptions are shown in Appendix 1.

Table 3: Soil forms encountered

Soil Form	A Horizon	B Horizon	B2/C Horizon	Nr of Profiles
Addo	Orthic A	Neocarbonate	Soft carbonate	16
Brandvlei	Orthic A	Soft carbonate	Soft carbonate	6
Prieska	Orthic A	Neocarbonate	Hard carbonate	6
Coega	Orthic A	Hard carbonate		3

4.2. Horizon descriptions

Orthic A Horizon:

The orthic A is apedal, yellow-brown and poorly developed, typical of arid environments. Transitions to the neocarbonate, soft carbonate and hard carbonate horizons are clear.

Neocarbonate B:

This soil horizon contains enough dispersed free carbonates to effervesce with cold 10% HCl, but the morphology is not dominated by lime. The colour is reddish brown.

Soft Carbonate:

Within this horizon lime has accumulated to the extent that it dominates the morphology of the horizon, but it has not hardened to the point where it cannot be cut with a spade. Soft carbonate horizons are products of carbonate rich water that evaporates and the lime remain. Standing water is an indication of an impermeable layer. The depth to the impermeable layer was not observed within observation depth. The hydraulic conductivity of the soft carbonates are therefore determined by the permeability and depth of the underlying horizon. The informal experiment shoed that these soft carbonate horizons drain well.

Hard Carbonate:

Within this horizon lime has accumulated to the point that it hardened to the point that it impedes water movement.

Figure 3: Addo soil form.

Figure 4: Brandvlei soil form.

Figure 5: Prieska soil form.

Figure 6: Coega soil form.

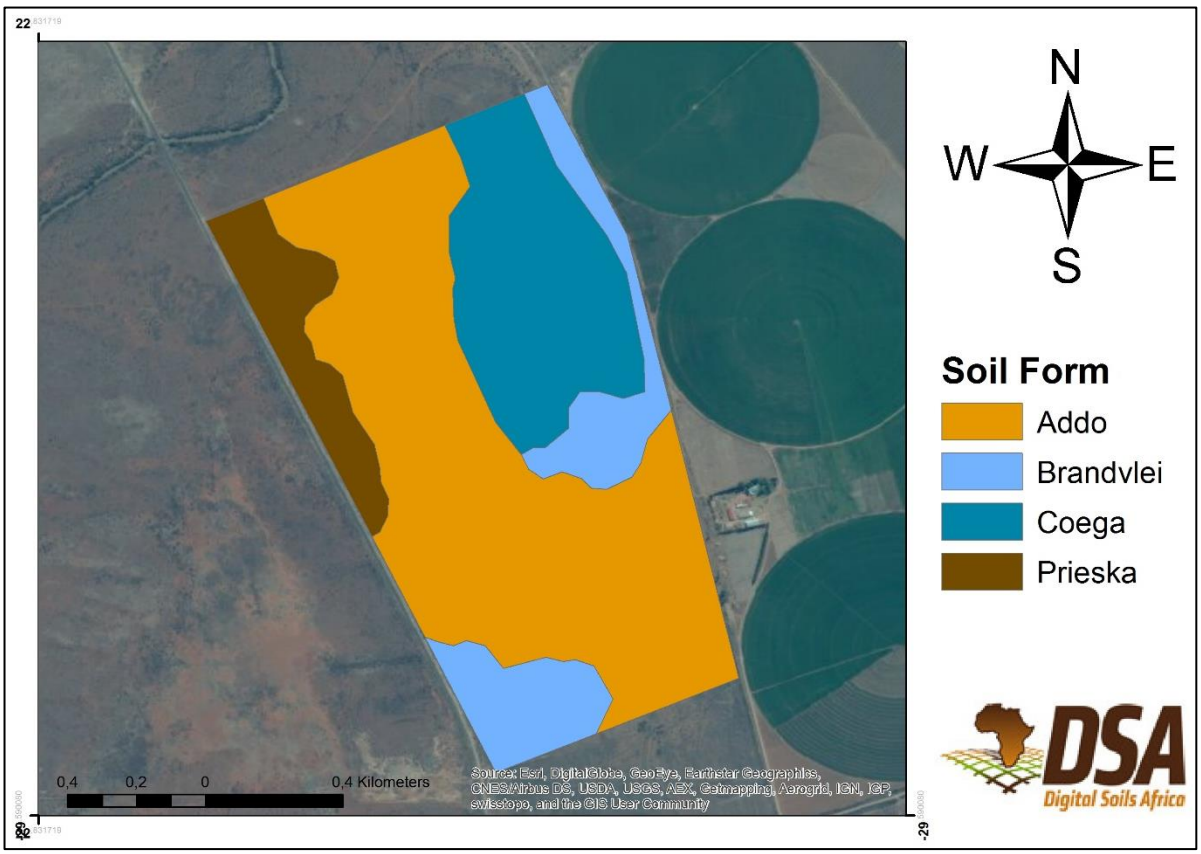

Figure 7: Soil form distribution of the study site.

Figure 8: Water infiltration limiting material distribution.

All the soils are calcareous. In the Addo soil form lime is dispersed in the upper B and concentrated in the lower B horizon. The Prieska soil form is an equivalent but the lower B horizons is petrified. The Brandvlei soil form is a shallow version of the Addo and the Coega a shallow version of the Prieska.

5. Soil Depth

The freely drainable depth is the depth where the water will freely drain, and includes the depth of the orthic A and neocarbonate B horizons. The drainable depth includes the depth of the soft carbonate as the informal experiment showed that it is also drainable. The freely drained depth (Figure 9) reaches 1000 mm in places, while the drainable depth is much deeper, with most of the study site being deeper than 1000 mm, with a maximum encountered of 1800 mm (Figure 10). Vineyards require a drainable depth of 800 mm (Appendix 4: Agronomical Report), which means that a large part of the field is suitable for vineyard irrigation cultivation.

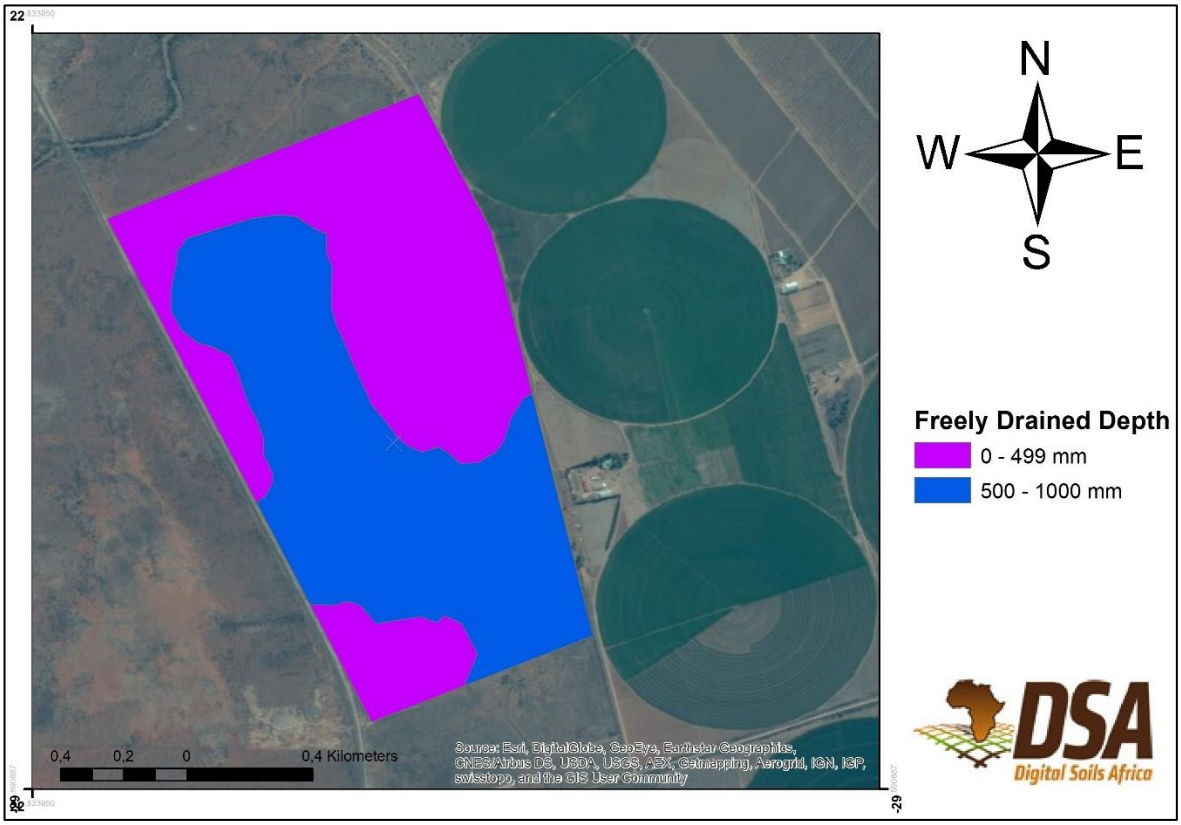

Figure 9: Soil depth including the orthic A and neocarbonate B horizons only.

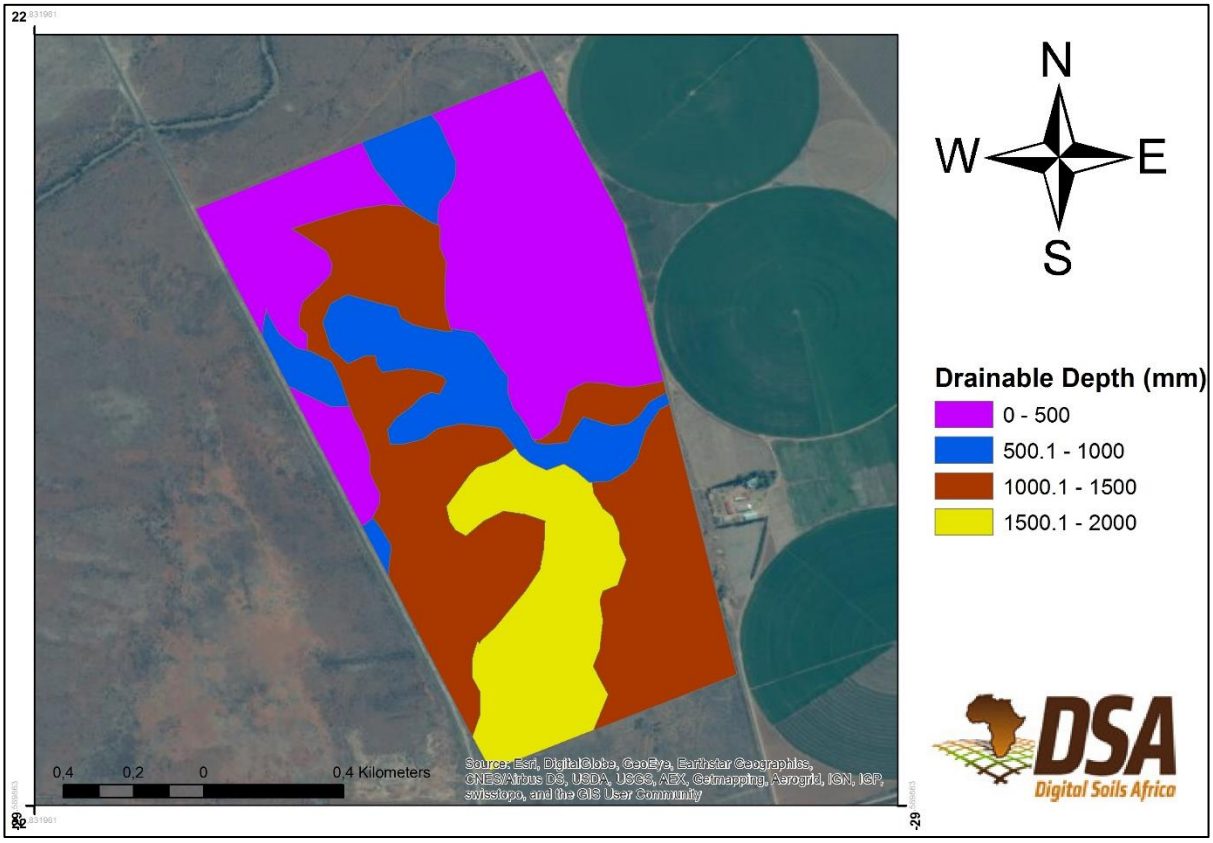

Figure 10: Soil depth including the orthic A horizon, neocarbonate B horizon and the soft carbonate B horizon.

6. Chemical and soil texture analysis

Tables 4 and 5 show selected soil properties. Table 4 shows chemical properties for the samples taken at the locations shown in Figure 2. Unfortunately, the first texture results seemed dubious and had to be redone. As there was no sample left, new samples were taken at random within the field, which is regarded as representative of the field, due to the uniformity of the soil texture predictions made during the field work. These results are reported in Table 5.

The pH values of the soils are neutral, being found on both sides of the 7 value depending if it is measured in KCl or water. This is of little consequence to vineyard production, as vineyards can grow under all natural occurring pH conditions (Appendix 4: Agronomical Report). Exchangeable Sodium Percentage (ESP) is very low, which means that the salts are dominated by Ca and or Mg. There is thus a very low risk of dispersion of the clay fraction and the resultant negative effects on the soil physics. The S value is quite high for coarsely textured soils, but this is expected as the S-value incorporates both salts found on exchange sites and free salts in the soil. The presence of free carbonates show that the S-value is inaccurate and should be neglected. The low ECe values show that the salinity is not high enough to impact negatively on vineyard production. The threshold ECe value where vineyards would be negatively impacted is 150 mS/m. All the texture samples have a clay percentage of less than 30%, which makes it conducive to irrigation.

Table 4: Selected chemical results for the soil samples collected at locations shown in Figure 2

Sample Nr.	Soil Form	Horizon	pH (KCl)	pH(H2O)	S-Value cmol(+)/kg	ESP %	ECe mS/m
P17A	Addo	Orthic A	6.89	7.75	N/A	N/A	24.2
P17B		Neocarbonate B	6.41	7.20	28.20	0.31	17.2
P18A	Addo	Orthic A	7.14	7.92	28.70	0.27	33.5
P18B		Neocarbonate B	6.65	7.50	24.59	0.27	19.8
P27A	Coega	Ortic A	6.35	7.20	12.55	0.42	25.2

Table 5: Soil texture results for the soil samples collected at random in the field

Sample Nr	Soil Form	Horizon	Clay %	Silt %	Sand %
P1A		Orthic A	28	39	33
P2A	Addo	Orthic A	20	41	39
P2B		Neocarbonate B	28	30	42
P3A	Addo	Orthic A	16	37	47
P3B		Neocarbonate B	10	44	46

7. Suitability

The suitability of Addo, Coega and Prieska soils for crop production under irrigation is controlled by the crop. Vineyards grow and produces quite well on these soils and the drip irrigation controls salinity. Soils with a drainable depth deeper than 800 mm was considered to be suitable for vineyard cultivation under drip or micro irrigation. This makes 91 ha of the land surveyed preferable for irrigation of vines (Figure 11). Table 6 shows the perimeter points of this area. However, with deep ripping of the hard carbonate horizon, the rest of the area could also be cultivated to be suitable for vineyard production (Appendix 4: Agronomical Report). The deep ripping of hard carbonate is more expensive than the deep ripping of the softer material found in the initial 91 ha.

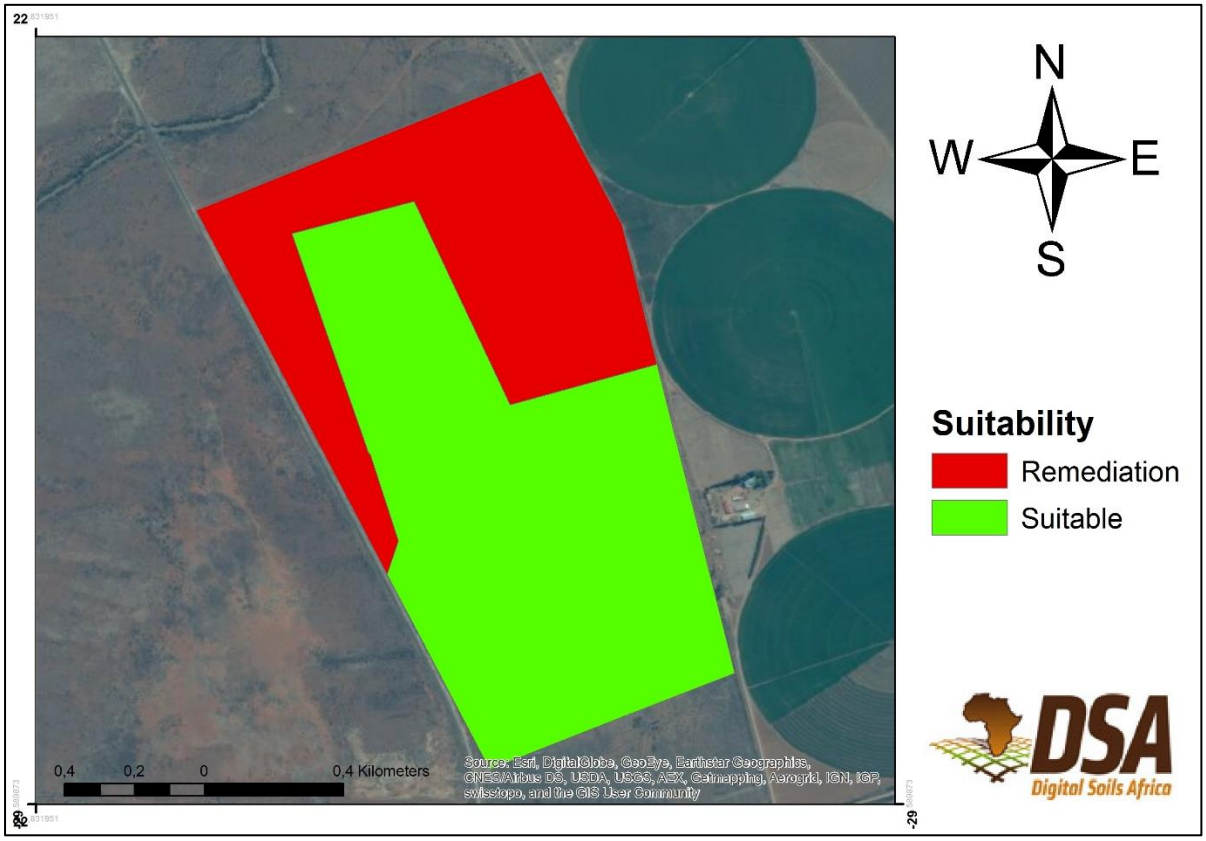

Figure 11: Suitable areas for drip irrigation of vineyards.

Table 6: Perimeter points of the suggested area considered for irrigation

X	Y
22.83856	-29.57518
22.84173	-29.57432
22.85001	-29.58648
22.84429	-29.57956
22.84798	-29.57855
22.84136	-29.58309
22.84101	-29.58388
22.84363	-29.58901

8. Conclusion

Pedological results indicate that 91 of the 149 ha is preferable for vineyard cultivation under drip and micro irrigation, with deep ripping of soft material needed as amelioration. Deep ripping of hard carbonate could ameliorate the remaining 58 ha, but would cost more than the deep ripping of the initial 91 ha. Maps showing these areas are given in the report.

9. References

Gee GW and Bauder JW, 1979. Particle size analysis by hydrometer: a simplified method for routine textural analysis and a sensitivity test of measured parameters. Soil Science Society of America Journal 43:1004-1007.

Soil Classification Working Group, 1991. Soil classification – a taxonimial system for South Africa. Department of Agriculture, Pretoria.

White R E, 2006. Principles and Practice of Soil Science: The soil as a Natural Resource. 4th ed. Blackwell Science, Oxford, UK.

10. Appendices

Appendix 1: Modal soil profile descriptions

General Information						
Profile no:	3				Soil form:	Addo
Map/Photo example:	Figure 3				Soil family:	
GPS Position:	22.8462 -29.5833				Colour	Red
Surface stones:	20%				Occurrence of flooding:	None
Altitude:	941 m				Wind erosion potential:	None
Terrain unit:	Foot slope				Water erosion potential:	None
Slope:	0%				Vegetation/Land use:	Natural Veld
Slope shape:	Planform	Straight	Profile	Convex	Water table:	None
Aspect:	East					
Micro-relief:	None				Described by:	PA Le Roux
Parent material solum:	Aeolian sands				Date described:	2016
Geological group:	Karoo Super group				Weathering of underlying material:	Not reached

Profile Information						
Horizon Depth (mm)	*Diagnostic Horizon*	*Colour*	*Structure*	*Redoximorphic features*	*Lime*	*Transition*
A 300	Orthic A	Red	apedal	None	Present	Clear
B1 600	Neocarbonate B	Red	apedal	None	Present	Clear
B2 1600	Soft carbonate B	Yellow	apedal	None	Present	None

General Information						
Profile no:	20				Soil form:	Brandvlei
Map/Photo example:	Figure 4				Soil family:	
GPS Position:	22.8437 -29.5884				Colour	Red
Surface stones:	5%				Occurrence of flooding:	None
Altitude:	946				Wind erosion potential:	None
Terrain unit:	Foot slope				Water erosion potential:	None
Slope:	1%				Vegetation/Land use:	Natural Veld
Slope shape:	Planform	Straight	Profile	Concave	Water table:	None
Aspect:	East					
Micro-relief:	None				Described by:	PA Le Roux
Parent material solum:	Aeolian Sands				Date described:	2016
Geological group:	Karoo Super group				Weathering of underlying material:	Not reached

Profile Information						
Horizon Depth (mm)	*Diagnostic Horizon*	*Colour*	*Structure*	*Redoximorphic features*	*Lime*	*Transition*
A 300	Orthic A	Red	apedal	None	Present	Clear
B1 600	Soft carbonate	Yellow	apedal	None	Present	Diffuse
B2 1600	Soft carbonate	Yellow	apedal	None	Present	none

General Information						
Profile no:	30				Soil form:	Prieska
Map/Photo example:	Figure 5				Soil family:	
GPS Position:	22.8372 -29.5753				Colour	Red
Surface stones:	40%				Occurrence of flooding:	None
Altitude:	948 m				Wind erosion potential:	
Terrain unit:	Foot slope				Water erosion potential:	None
Slope:	1,50%				Vegetation/Land use:	Natural Veld
Slope shape:	Planform	Straight	Profile	Concave	Water table:	None
Aspect:	South-East					
Micro-relief:	None				Described by:	PA Le Roux
Parent material solum:	Aeolian sands				Date described:	2016
Geological group:	Karoo Super group				Weathering of underlying material:	Not reached

Profile Information

Horizon Depth (mm)	*Diagnostic Horizon*	*Colour*	*Structure*	*Redoximorphic features*	*Lime*	*Transition*
A 100	Orthic A	Red	Apedal	None	Absent	Clear
B1 300	Neocarbonate	Red	Apedal	None	Present	Abrupt
C 400	Hard carbonate	White	Massive	None	Present	none

General Information						
Profile no:	8				Soil form:	Coega
Map/Photo example:	Figure 6				Soil family:	
GPS Position:	22.8443 -29.5769				Colour	Red
Surface stones:	60%				Occurrence of flooding:	None
Altitude:	947 m				Wind erosion potential:	None
Terrain unit:	Foot slope				Water erosion potential:	None
Slope:	3%				Vegetation/Land use:	Natural Veld
Slope shape:	Planform	Straight	Profile	Convex	Water table:	None
Aspect:	South-East					
Micro-relief:	None				Described by:	PA Le Roux
Parent material solum:	Aeolian sands				Date described:	2016/
Geological group:	Karoo Super group				Weathering of underlying material:	Not reached

Profile Information

Horizon Depth (mm)	*Diagnostic Horizon*	*Colour*	*Structure*	*Redoximorphic features*	*Lime*	*Transition*
A 200	Orthic A	Red	Apedal	None	Absent	Abrupt
B N/A	Hard carbonate	White	Massive	None	Present	None

Appendix 2: Chemical soil properties

Sample Nr	Soil Form	Horizon	pH (KCl)	pH(H2O)	P Olsen mg/kg	PBray1 mg/kg	Ammon Acetate K mg/kg	Ammon Acetate Na mg/kg	Ammon Acetate Ca mg/kg	Ammon Acetate Mg mg/kg	EA.KCl cmol(c)/kg
P17A	Addo	Orthic A	6.89	7.75	9	5	NA	NA	NA	NA	0.00
P17B		Nepcarbonate B	6.41	7.20	5	3	206	20	4464	643	0.00
P18A	Addo	Orthic A	7.14	7.92	17	8	792	18	4753	346	0.00
P18B		Neocarbonate B	6.65	7.50	7	3	336	16	4379	216	0.00
P27A	Coega	Orthic A	6.35	7.20	16	10	143	12	2073	215	0.00

Appendix 2: Chemical soil properties continued

Sample Nr	Soil Form	Horizon	%Ca %	%Mg %	%K %	%Na %	ACID SAT %	Ca:Mg 1.5-4.5	(Ca+Mg)/K 10.0-20.0	Mg:K 3.0-4.0	S-Value cmol(+)/kg
P17A	Addo	Orthic A	NA	NA	NA	NA	0.00	NA	NA	NA	NA
P17B		Nepcarbonate B	79.14	18.68	1.87	0.31	0.00	4.24	52.38	10.00	28.20
P18A	Addo	Orthic A	82.79	9.88	7.06	0.27	0.00	8.38	13.13	1.40	28.70
P18B		Neocarbonate B	89.03	7.20	3.50	0.27	0.00	12.37	27.51	2.06	24.59
P27A	Coega	Orthic A	82.58	14.07	2.92	0.42	0.00	5.87	33.06	4.81	12.55

Appendix 2: Chemical soil properties continued

Sample Nr	Soil Form	Horizon	Na:K	T cmol(c)/kg	Density g/cm3	S AmAc mg/kg	ECe ms/m
P17A	Addo	Orthic A	Na:K	NA	1.16	3.27	24.2
P17B		Nepcarbonate B	0.17	28.20	1.10	0.64	17.18
P18A	Addo	Orthic A	0.04	28.70	1.11	3.30	33.5
P18B		Neocarbonate B	0.08	24.59	1.13	4.28	19.8
P27A	Coega	Orthic A	0.14	12.55	1.35	0.06	25.2

Appendix 3: Textural analysis

Sample Nr	Soil Form	Horizon	Clay %	Silt %	Sand %
P1A		Orthic A	28	39	33
P2A	Addo	Orthic A	20	41	39
P2B		Neocarbonate B	28	30	42
P3A	Addo	Orthic A	16	37	47
P3B		Neocarbonate B	10	44	46

Appendix 4: Agronomical Report

Vineyard development in the upper Orange River Area (Prieska)

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Viticulturalist: GWK

1. Soil requirements

Vineyard is generally not sensitive to soil properties for four reasons. Firstly the crop naturally tolerates a wide variety of soil conditions, secondly a variety of rootstocks favouring different soil types are available, thirdly the production system is intensive and soils are manipulated to suit the crop requirements and fourthly irrigation improves soil conditions.

1.1. Soil depth

The soil must be deeper than 800mm. Deeper soils have slightly lower preparation costs but due to the improvement in growth conditions they are deep ripped to prevent possible limitations irrespective of soil properties. Soils with an Orthic A horizon 300 mm deep on fractured rock (Mispah) or hardpan carbonate (Coega) that can be ripped, may be suitable for cropping but as they require more intensive remediation and management they are not preferred.

The soil depth conditions tolerated by vineyards include variation in water contents. The water contents of soils with low water holding capacity (shallow or rocky soils) is manipulated with deep ripping (increased water holding capacity) and controlled with intensive irrigation systems and lastly optimised with selection of a rootstock adapted to conditions.

1.2. Soil texture

The crops are resistant to soil water conditions controlled by texture and application rates is controlled to avoid runoff. Soil surface treatments like mulching is part of intensive vineyard cropping.

1.3. Soil chemistry

Vineyard is insensitive to alkalinity. The crops are cultivated successfully in calcareous soils. Salinization is a hazard but the risk is low as the irrigation water is low in salts and leaching should be part of irrigation scheduling depending on drainage.

1.4. Soil fertility

Soil fertility are successfully adjusted with intensive cropping procedure and therefore not a prerequisite for land suitability. The crop is insensitive to the limitation of the availability of micronutrients affecting for example peaches.

1.5. Drainage

Soil drainage is critical in vineyard production, especially as the crop is irrigated.

2. Soil-crop matching

Soil depth

The Addo, Prieska and Brandvlei soils meet this parameter. All the soils should be ripped to 800mm depth. The Coega soil could also be made suitable with deep ripping, which will be expensive, because of the hard carbonate layer which needs to be ripped.

Soil texture

The range of textures are acceptable and no restrictions are foreseen.

Soil chemistry

The pH is acceptable.

Drainage

The drainage of the soils is acceptable. The high calcium content increase drainage due to flocculation and micro-aggregate stability.

Crop selection

It is recommended that the best cultivar is selected e.g. Colombard on Ramsey as Ramsey is well-suited to low fertility, coarse-textured sandy/stony soils. It performs well on a wide range of soils ranging from deep dry sandy soils to rocky and stony soils with low organic matter content, highly compactable soils, heavy clay soils, as well as poorly weathered granitic soils on the higher mountain slopes. Soil forms include Fernwood, Glenrosa, Swartland, Estcourt, Westleigh, Longlands, Vilafontes, Dundee and Cartref.