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Irrigation Suitability Report for four centre pivots on the farm Amanzi, near Hopetown, Northern Cape Province

for

Piet Louw

October 2017

Table of Contents

Executive summary

A soil survey was conducted for Piet Louw on four existing centre pivots comprising 100 ha on the farm Amanzi near Hopetown, Northern Cape, to assess the suitability of the area for irrigation.

The soils of the study area are dominated by the Glenrosa/Coega soil form, a rocky soil with a hardpan carbonate ayers which formed within the lithocutanic horizon. Other soil forms present include the Coega, Plooysburg, Prieska, Addo, Brandvlei and Augrabies soil forms. The soils of Site A (the two centre pivots to the north), complies with the guidelines of the Northern Cape Department of Agriculture, while only the western centre pivot of Site B (the 2 centre pivots to the south) complies with those guidelines. These centre pivots are suitable for irrigation. Only about half of the fourth centre pivot complies with the guidelines. There are however site-specific reasons as to why this centre pivot could be retained for planted pastures. These include:

- The limiting layer is loose boulders which would not limit the drainage.
- The hard carbonate which has formed on top of these boulders has been shown to have extremely high saturated hydraulic conductivity under cultivation.
- The surface drainage from this centre pivot leads back to the river, and will not influence other irrigable soils.

Based on these considerations, it is advised that all four centre pivots are retained for irrigation, with the understanding that the half of the south eastern pivot will be used for planted pasture.

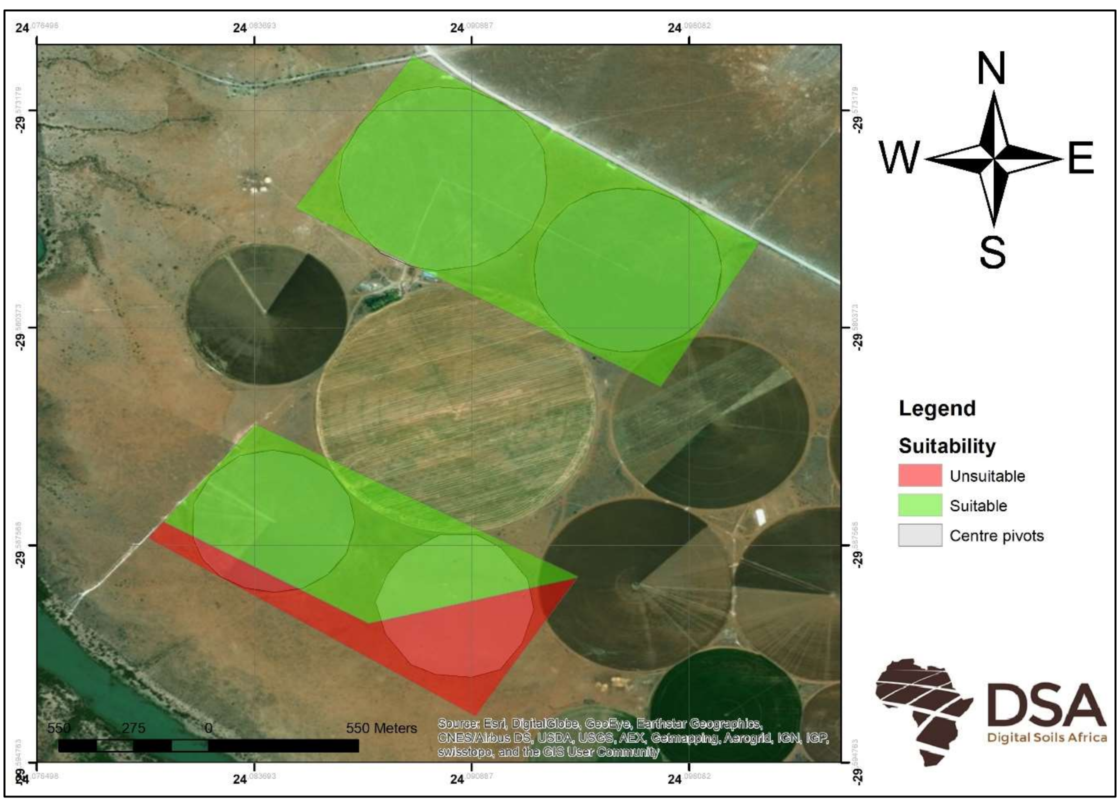

Figure A: Area suitable for irrigation at the Amanzi site.

1. Introduction

Digital Soils Africa conducted a soil survey on four existing centre pivots of approximately 100 ha on the farm Amanzi, near Hopetown in the Northern Cape Province. The aim of the survey was to determine the suitability of the soils for cultivation under irrigation. For sustainable irrigation of soil the risks of water logging and salinization need to be established. When irrigation water is applied, dissolved salts are applied with the water, but plants mainly remove water through transpiration resulting in the accumulation of salts in the soils, which may result in yield decreases and crop losses. In extreme cases, salinization will reach the extent that the soil cannot be vegetated anymore. These effects can be negated with proper management on soils with certain properties. For this reason, the Department of Agriculture, Northern Cape, has provided guidelines to which soil properties must adhere before a ploughing certificate can be granted. These properties are related to the water infiltration of the soil, as well as salt and sodium build-up. On this site the properties of the soils and the distribution thereof were investigated and areas where irrigation can be managed sustainable identified.

2. Location

Amanzi is located approximately 6 km north of Hopetown between the R385 and the Orange River (Figure 1). The co-ordinates of the perimeter points of the two surveyed areas are shown in Tables 1 and 2 respectively.

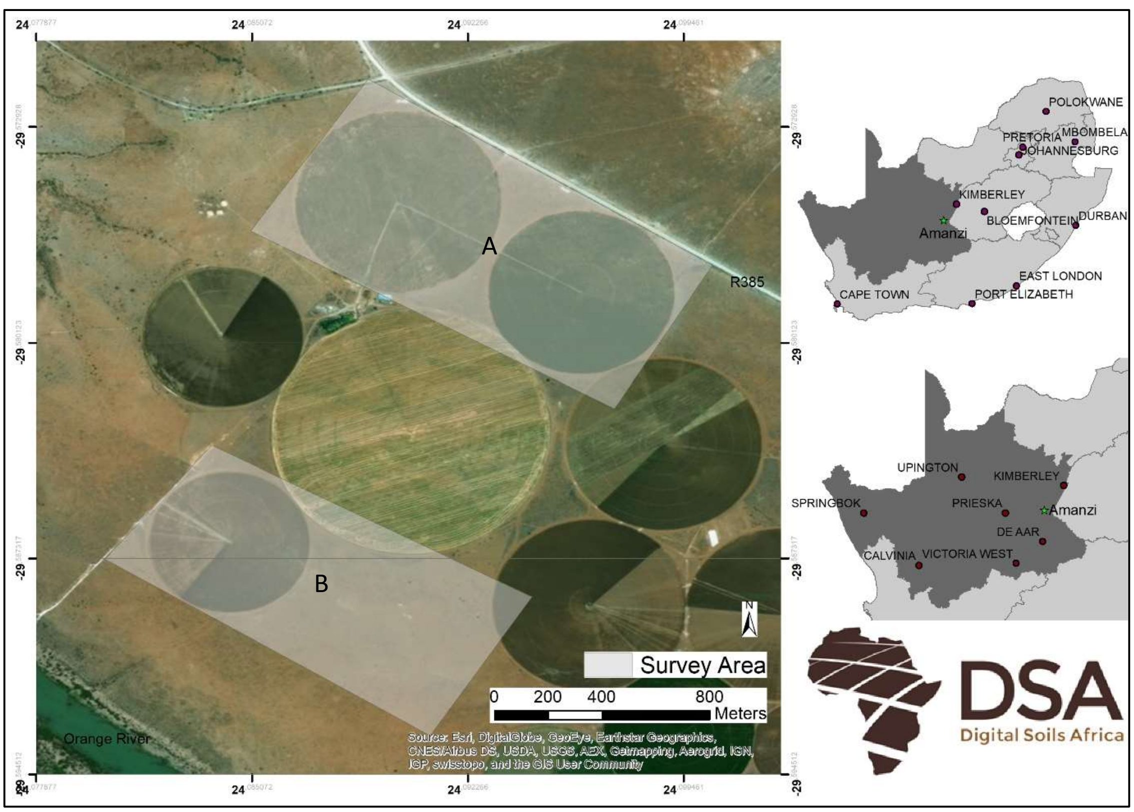

Figure 1: The location of the Amanzi farm as well as the survey areas.

Table 1: Coordinates of the perimeter points of the surveyed area marked A in Figure 1

Nr	X	Y
1	24.08901060120	-29.57141766160
2	24.08507992070	-29.57638748750
3	24.10044120100	-29.57751699350
4	24.09718822400	-29.58235127870

Table 2: Coordinates of the perimeter points of the surveyed area marked B in Figure 1

Nr	X	Y
1	24.08375732420	-29.58356424590
2	24.08020329440	-29.58734040250
3	24.09437498800	-29.58862873830
4	24.09090980900	-29.59316012620

3. Methodology

Field visits were conducted on the 14th and 20th of September 2017. Forty-nine soil profiles were opened by the client to a depth of approximately 1300 mm or refusal using a TLB around the centre pivots and inside the two larger centre pivots. (Figure 2 and Table 3). Observation depths were increased by augering into the profile pits to refusal. Two additional soil auger observations were made inside the smaller centre pivots. Soils were classified according to the Taxonomic Soil Classification System (Soil Classification Working Group, 1991). Soil depth, freely drainable depth and limiting material were noted and mapped. Fourteen samples of modal profiles were taken for chemical and physical analysis, which included five topsoil samples (A horizons) and five subsoil samples (B horizons) and 4 deep subsoil horizons (C horizons). Texture was measured with the pipette method, basic cations from a 1:10 NH4OAc extract (White 2006) and soil pH in a 1:2.5 KCl extract. Additionally, three water infiltration tests were conducted to measure the conductivity of the soil horizons.

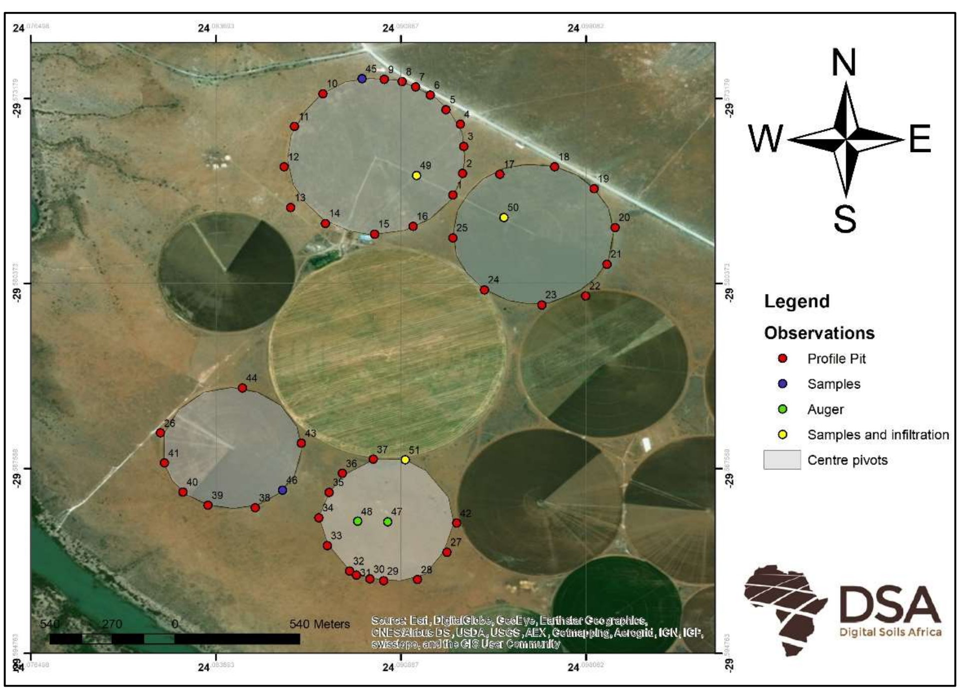

Figure 2: Soil observation locations for the Amanzi study site.

Table 3: Observation locations of the Amanzi study site

Nr	Soil Form	Limiting Layer	Freely drained Depth (mm)	Drainable Depth (mm)	X	Y
1	Glenrosa/Coega	Rock	1300	1300	24.092912	-29.576935
2	Glenrosa/Coega	Rock	1300	1300	24.093295	-29.576100
3	Glenrosa/Coega	Rock	1700	1700	24.093343	-29.575042
4	Glenrosa/Coega	Rock	1500	1500	24.093205	-29.574183
5	Glenrosa/Coega	Rock	1200	1200	24.092650	-29.573618
6	Glenrosa/Coega	Rock	1000	1000	24.092033	-29.573050
7	Glenrosa/Coega	Rock	1400	1400	24.091458	-29.572727
8	Glenrosa/Coega	Rock	1500	1500	24.090942	-29.572527
9	Glenrosa/Coega	Rock	1200	1200	24.090248	-29.572443
10	Glenrosa/Coega	Rock	1400	1400	24.087853	-29.572995
11	Glenrosa/Coega	Rock	1300	1300	24.086747	-29.574268
12	Glenrosa/Coega	Rock	1500	1500	24.086342	-29.575843
13	Glenrosa/Coega	Rock	1200	1200	24.086600	-29.577427
14	Glenrosa/Coega	Rock	1300	1300	24.087948	-29.578038
15	Glenrosa/Coega	Rock	1500	1500	24.089870	-29.578453
16	Glenrosa/Coega	Rock	1450	1450	24.091367	-29.578150
17	Glenrosa/Coega	Rock	1300	1300	24.094740	-29.576132
18	Glenrosa/Coega	Rock	1400	1400	24.096877	-29.575842
19	Glenrosa/Coega	Rock	1400	1400	24.098412	-29.576687
20	Glenrosa/Coega	Rock	600	600	24.099228	-29.578198
21	Prieska	Hardpan Carbonate	700	700	24.098902	-29.579625
22	Glenrosa/Coega	Rock	1500	1500	24.098077	-29.580862
23	Glenrosa/Coega	Rock	1300	1300	24.096375	-29.581212
24	Plooysburg	Hardpan Carbonate	1300	1300	24.094148	-29.580622
25	Glenrosa/Coega	Rock	1300	1300	24.092913	-29.578600
26	Glenrosa/Coega	Rock	1200	1200	24.081533	-29.586188
27	Coega	Hardpan Carbonate	200	200	24.092680	-29.590822
28	Coega	Boulders	200	200	24.091533	-29.591890
29	Prieska	Boulders	700	700	24.090215	-29.591937
30	Glenrosa/Coega	Boulders	900	900	24.089678	-29.591867
31	Coega	Hardpan Carbonate	300	300	24.089153	-29.591713
32	Coega	Hardpan Carbonate	400	400	24.088885	-29.591553
33	Coega	Hardpan Carbonate	300	300	24.088030	-29.590570
34	Glenrosa/Coega	Rock	1100	1100	24.087695	-29.589482
35	Glenrosa/Coega	Rock	1600	1600	24.088093	-29.588495
36	Plooysburg	Hardpan Carbonate	900	900	24.088608	-29.587758
37	Plooysburg	Hardpan Carbonate	1600	1600	24.089817	-29.587210
38	Prieska	Hardpan Carbonate	600	600	24.085218	-29.589093
39	Coega	Hardpan Carbonate	300	300	24.083378	-29.588995
40	Coega	Hardpan Carbonate	700	700	24.082405	-29.588483
41	Coega	Hardpan Carbonate	400	400	24.081685	-29.587358
42	Coega	Hardpan Carbonate	350	350	24.093063	-29.589696
43	Glenrosa/Coega	Rock	1500	1500	24.087012	-29.586585
44	Glenrosa/Coega	Rock	1200	1200	24.084722	-29.584436
45	Glenrosa/Coega	Rock	1800	1800	24.089377	-29.572418
46	Addo	Rock	1300	1300	24.086278	-29.588412
47	Coega	Hardpan Carbonate	350	350	24.090373	-29.589640
48	Coega	Hardpan Carbonate	350	350	24.089204	-29.589624
49	Glenrosa/Coega	Rock	1300	1300	24.091498	-29.576176
50	Glenrosa/Coega	Rock	1300	1300	24.094896	-29.577807
51	Plooysburg	Hardpan Carbonate	1500	1500	24.091065	-29.587233

4. Results

4.1. Soils forms

The most abundant soil form is the Glenrosa/Coega soil form, which occurs throughout the A survey site and to the north of the B survey site. To the south of the B survey area a shallow Coega soil form occurs. Jotted between these observations on the B survey site are soils depicting a range of depths. The shallower soils (Prieska) occur more to the south, while in the north deeper soils (Addo, Brandvlei, Plooysburg) were observed. Table 4 shows the diagnostic horizons of the different observations, while Figure 3 shows the spatial extent of the different soil forms and Figure 4 shows examples of the most abundant soil forms. An in-text description of the different diagnostic horizons as well as the Glenrosa/Coega soil form is given.

Table 4: Diagnostic horizons of the different soil forms

Soil Form	A Horizon	B Horizon	B2/C Horizon	Nr of Obs
Glenrosa/ Coega	Orthic A	Hardpan Carbonate within Lithocutanic B	Lithocutanic B	32
Coega	Orthic A	Hardpan Carbonate		9
Plooysburg	Orthic A	Red Apedal	Hardpan Carbonate	3
Prieska	Orthic A	Neocarbonate B	Hardpan Carbonate	3
Brandvlei	Orthic A	Soft Carbonate		2
Augrabies	Orthic A	Neocarbonate B	Lithocutanic B	1
Addo	Orthic A	Neocarbonate B	Soft Carbonate	1

Orthic A

The orthic A is sandy (approximately 10% clay) apedal, and poorly developed, typical of arid environments. Transitions to the hardpan carbonate, soft carbonate and rock are abrupt, while it is diffuse to the red apedal B and neocarbonate B horizons. It may or may not contain free lime, depending on the nature of the underlying horizons.

Lithocutanic B

The lithocutanic B horizon at Amanzi is a fractured rock horizon with sufficient fractures to allow for water infiltration and root growth within the horizon. It typically contains between 60% to 80% rock, which increases with depth, eventually grading into solid rock.

Hardpan Carbonate

Within this horizon carbonates have accumulated to the point that it has hardened and impedes water movement. The transition from the above lying horizon is often abrupt, indicating the natural leaching depth. At Amanzi, hardpan carbonate horizons occur within the top parts of the lithocutanic horizons, or on loose boulders, or deeper below neocarbonate B or red apedal horizons. Hardpan carbonate horizons impedes both water movement and root growth, but if it occurs shallow enough to be broken up with mechanical action, it will have excellent drainage.

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 carbonates precipitate. This is associated with inadequate leaching due to impermeable layers restricting deep drainage. The hydraulic conductivity of the soft carbonates are determined by the permeability and depth of the underlying horizon. In both cases where soft carbonates were observed they transitioned into solid rock, which was deemed to be impermeable to water.

Neocarbonate B

Neocarbonate B horizons contain enough dispersed free carbonates to effervesce with cold 10% HCl, but the morphology is not dominated by lime. The colour is reddish brown and the clay content around 10%. The carbonate accumulation indicates that some salts do wash into this horizon, which could be attributed to a water impenetrable deeper layer or natural accumulation of salts in this area, due to the low natural leaching factor. This horizon is regarded to drain fairly well, and the excess carbonates could leach out with irrigation.

Red Apedal B

Within this landscape this is a red, sandy (approximately 10% clay), apedal horizon. It is freely drainable with high water infiltration rates and generally low salinity, which makes it excellent for irrigation, provided this horizon is deep enough. It does not cover a large area though, being found only in 3 profiles.

Glenrosa/Coega soil form

The Glenrosa/Coega soil form indicates an unique situation where a hardpan carbonate horizon has formed within the top parts of the lithocutanic B horizon. As the hardpan carbonate horizon is shallow enough that it can be broken with mechanical action, precedence was given in naming the soil form the acknowledging the lithocutanic character. These soils are good irrigation soils with sufficient drainage and depth, provided that the hardpan carbonate layer is broken.

4.1. **Soil Depth**

The depth limiting layer are presented in Figure 6. On much of the site it is hard rock, while shale also appears in a small portion. Hardpan carbonate is regarded as depth limiting if an impenetrable layer appears underneath, but not if it occurs within a shallow depth (where it can be ripped) on drainable soils (such as with the Glenrosa/Coega soil form). To the south of site B loose boulders limit the depth. These boulders are not drainage limiting, as water could move around them, but the TLB did not dig

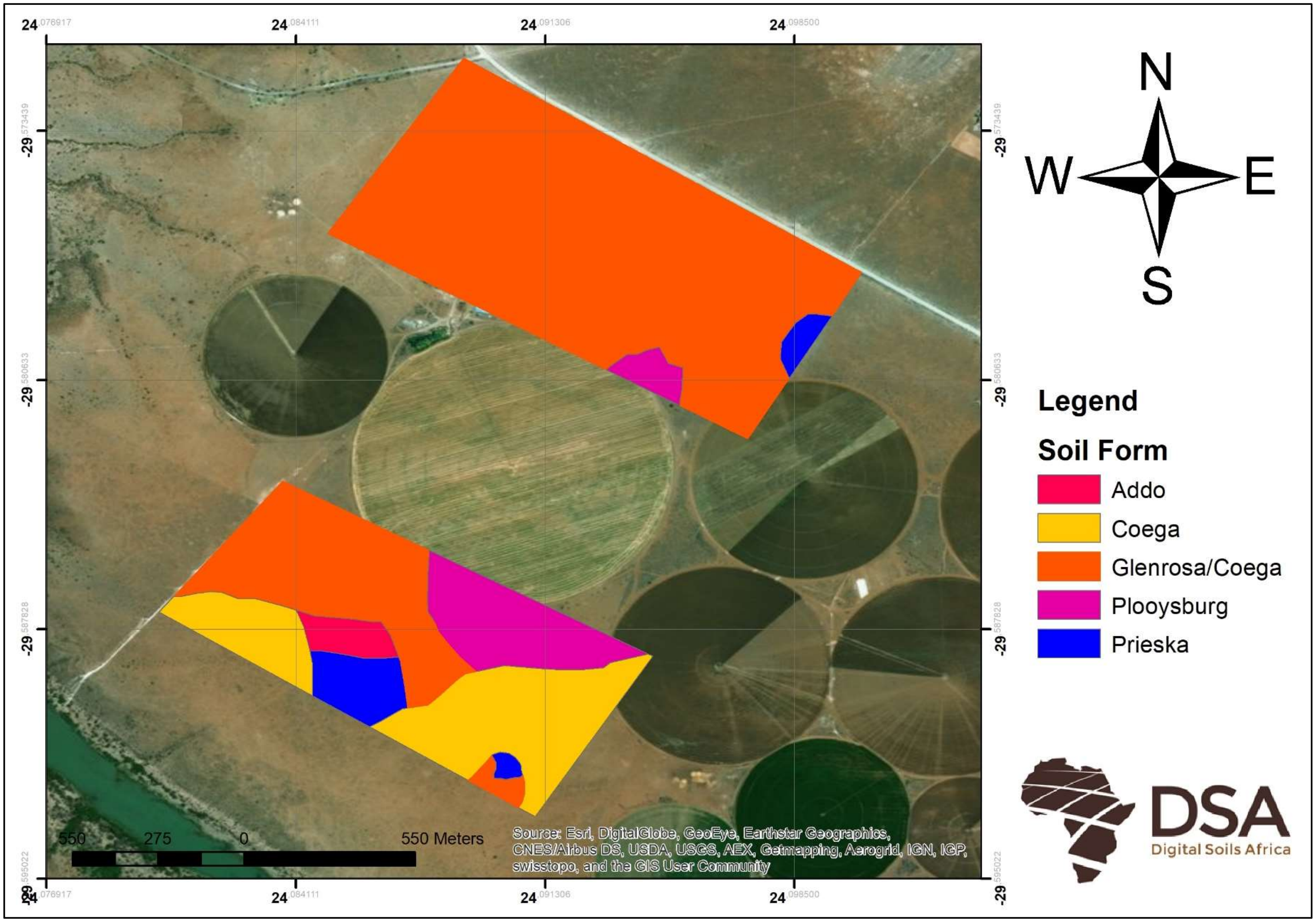

Figure 3: Distribution of the soil forms on the Amanzi site.

a. Glenrosa/Coega

b. Coega

c. Plooysburg

d. Prieska

Figure 4: The most abundant soil forms encountered.

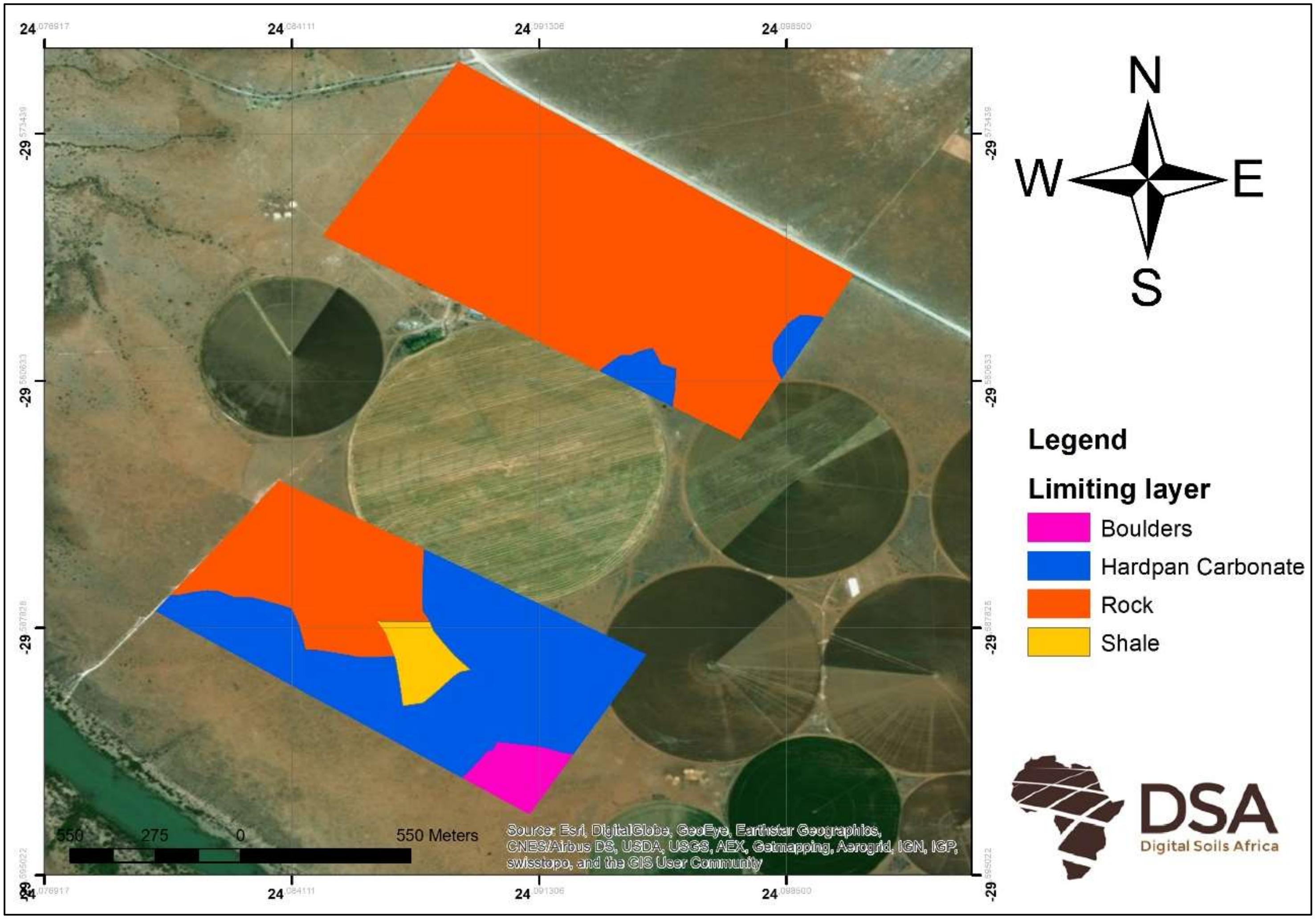

Figure 6: Depth limiting layers of the Amazi site.

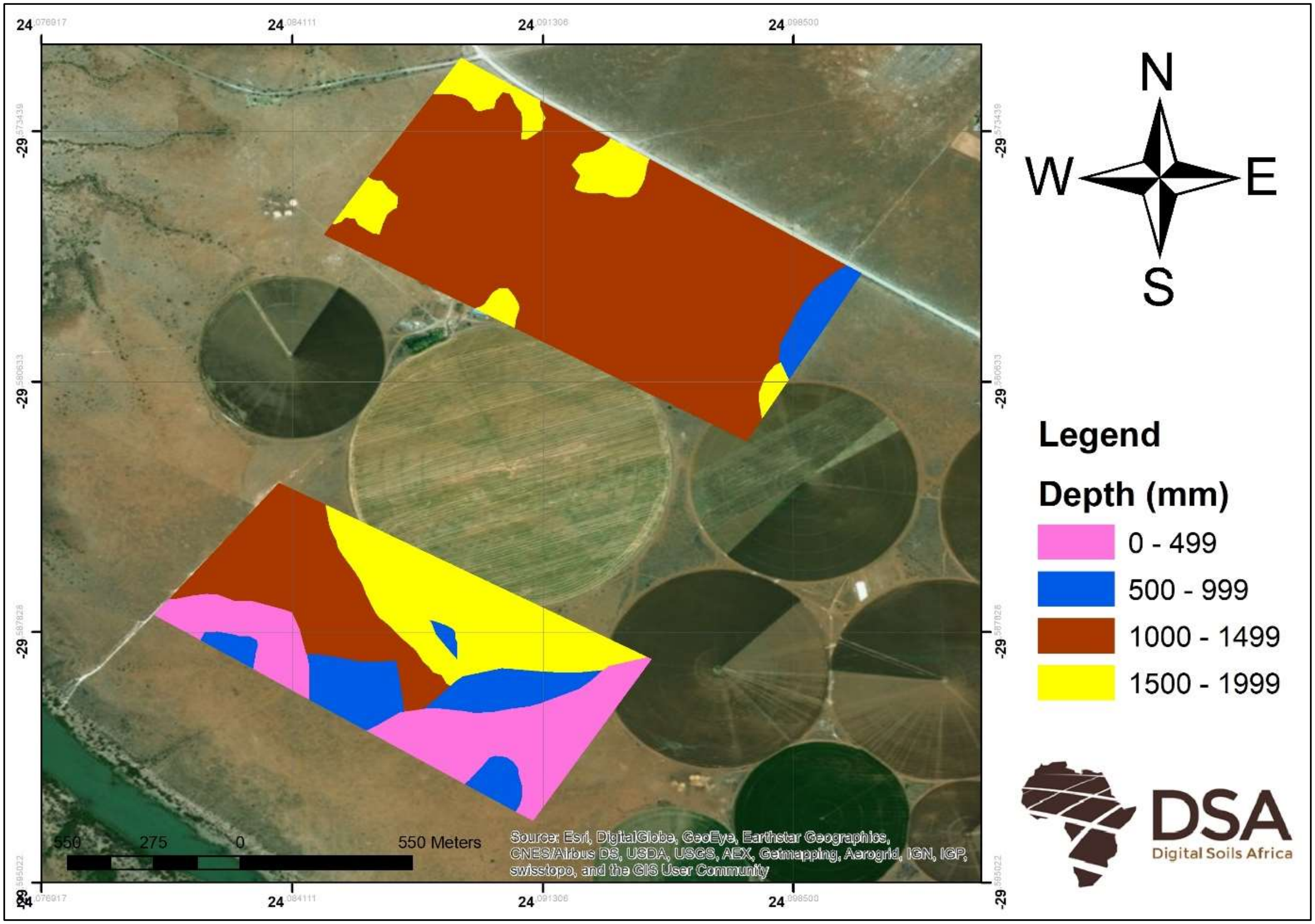

Figure 7: Freely drained depth of the Amanzi site.

Into them. At Amanzi, the freely drained depth is the same as the drainable depth as the limiting layers do not allow for drainage. The exception is the boulders, but the depth of the boulders could not be measured. Figure 7 shows the freely drained depth.

4.2. Chemical and soil texture analysis

Tables 5 (chemical) and 6 (texture) present selected soil properties of samples taken from modal profiles. As expected, the pH is high for an environment with abundant carbonates present. The pH ranges between 7.5 and 8, and all the samples are above the norms of 7.5. However, the EC values range between 4.1 and 321 mS.m^{-1}, which is lower than the norm value of 400 mS.m^{-1}, and all the ESP levels are below the threshold value of 5. Thus, salinity and sodicity are not a threat, provided that the soils have adequate drainage. This is confirmed by the textural analysis. All the samples have clay percentages of 12% or less, and drainage will not be impeded. The drainage was confirmed with single ring drainage tests conducted at three sites (it is important to note that the test does not provide for lateral flow). The saturated hydraulic conductivity (K_{sat}) of the measurements are shown in Table 5. The measurements vary considerably, due to the fractured nature of the specific horizon. However, all the values are much higher than what irrigation rates are (approximately 10 mm/hr), and thus will allow for adequate drainage.

Table 5: Selected chemical properties for modal soil profiles

Sample	Soil Form	Horizon	pH KCl	EC ms/m	ESP %	CEC cmol(+)/kg
1A	Glenrosa/Coega	Orthic A	7.5	71.2	0.8	23.6
1B		Hardpan Carbonate	7.7	97.5	1.4	23.3
1C		Lithocutanic B	7.8	78.3	1.2	17.7
2A	Glenrosa/Coega	Orthic A	7.7	133.6	0.9	19.8
2B		Hardpan Carbonate	7.8	321.0	3.5	24.3
2C		Lithocutanic B	7.9	127.4	3.6	25.1
3A	Glenrosa/Coega	Orthic A	7.9	89.2	1.2	17.7
3B		Hardpan Carbonate	8.0	47.3	1.2	20.2
3C		Lithocutanic B	8.0	47.7	1.0	26.4
4A	Plooysburg	Orthic A	7.8	76.2	1.8	5.5
4B		Red apedal B	7.6	147.4	2.0	6.4
4C		Hardpan Carbonate	7.8	24.0	0.6	23.3
5A	Addo	Orthic A	7.8	50.7	0.8	25.6
5B		Neocarbonate B	7.9	4.1	3.7	29.3

Table 6: Texture analysis for modal soil profiles

Sample	Soil Form	Horizon	Clay %	Silt %	Sand %
1A	Glenrosa/Coega	Orthic A	12.0	7.7	79.4
1B		Hardpan Carbonate	4.3	16.7	78.7
1C		Lithocutanic B	0.7	8.7	89.9
2A	Glenrosa/Coega	Orthic A	3.3	15.3	80.4
2B		Hardpan Carbonate	1.0	13.7	84.3
2C		Lithocutanic B	1.7	12.0	87.1
3A	Glenrosa/Coega	Orthic A	3.3	7.3	88.9
3B		Hardpan Carbonate	2.7	19.3	77.2
3C		Lithocutanic B	3.3	7.0	90.2
4A	Plooysburg	Orthic A	0.3	5.7	93.1
4B		Red apedal B	2.3	5.0	91.8
4C		Hardpan Carbonate	2.7	13.0	83.9
5A	Addo	Orthic A	3.0	13.3	84.5
5B		Neocarbonate B	11.7	15.0	73.2

Table 7: Saturated hydraulic conductivity for selected soil horizons

Sample	Horizon	K_{sat} mm/hr	K_{sat} cm/min
1B	Hardpan Carbonate	260	0.43
3B	Hardpan Carbonate	68	0.11
4C	Hardpan Carbonate	301	0.50

5. Suitability

Based on the soil morphology and laboratory analysis, the area shown in Figure 8 is suitable for irrigation according to the norms of the Department of Agriculture, Northern Cape. A simplified suitability map is shown in Figure 9, with the perimeter points for the suitable area in Figure 9 given in Table 8. According to these suitability maps, three of the existing centre pivots could be retained, while only about a half of the fourth centre pivot is suitable for cash crop cultivation under irrigation.

Table 8: Perimeter points of the suitable area from Figure 9 for the Amanzi sites

Site A

Nr	X	Y
1	24.08899255790	-29.57133184220
2	24.10045437220	-29.57752509270
3	24.09720721650	-29.58234206530
4	24.08505726330	-29.57636385830

Site B

Nr	X	Y
1	24.08377490570	-29.58354367550
2	24.09439758320	-29.58859847370
3	24.08749949380	-29.59013771680
4	24.08073442550	-29.58671717660

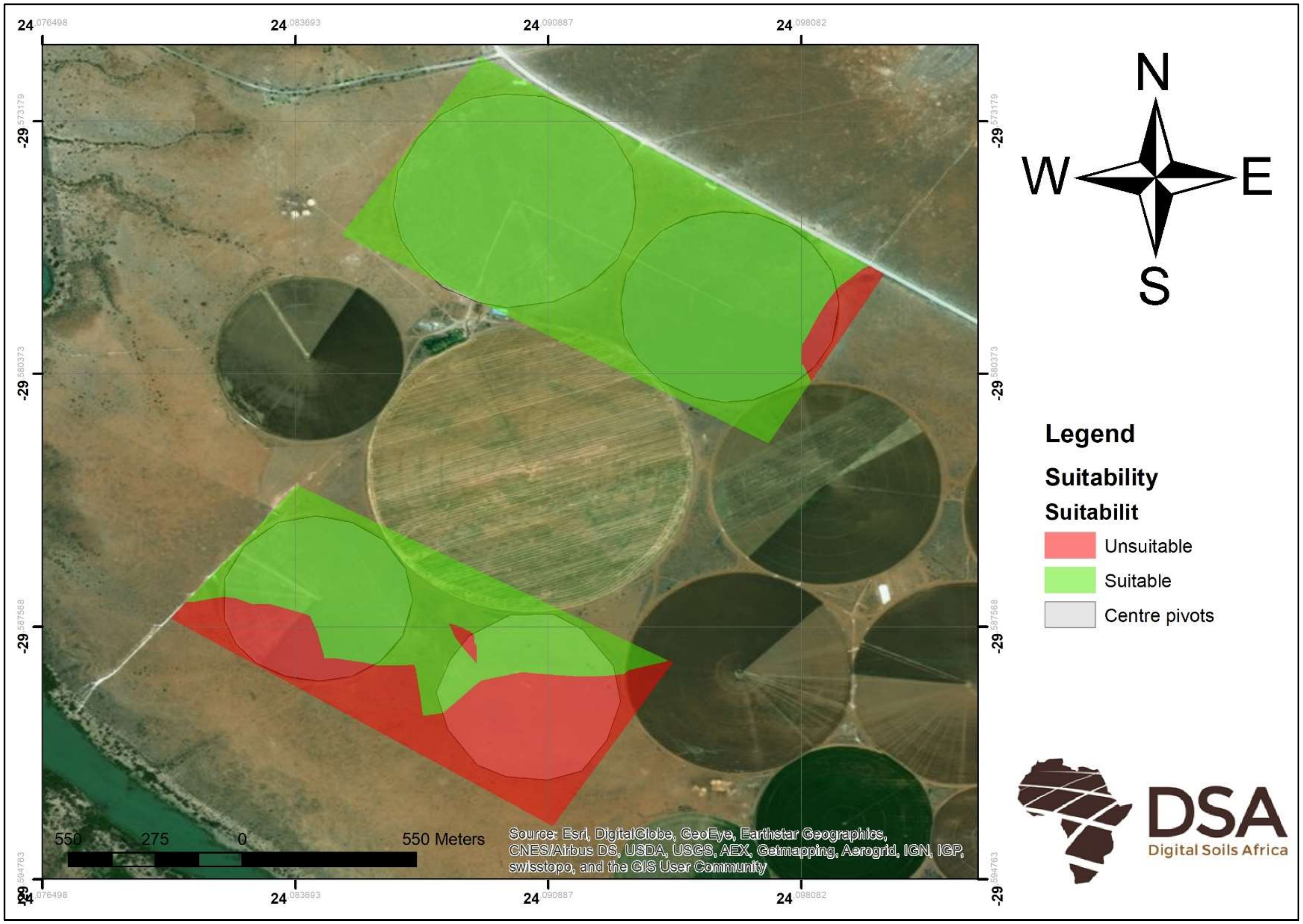

Figure 8: Suitability for cultivation and irrigation of the Amanzi site.

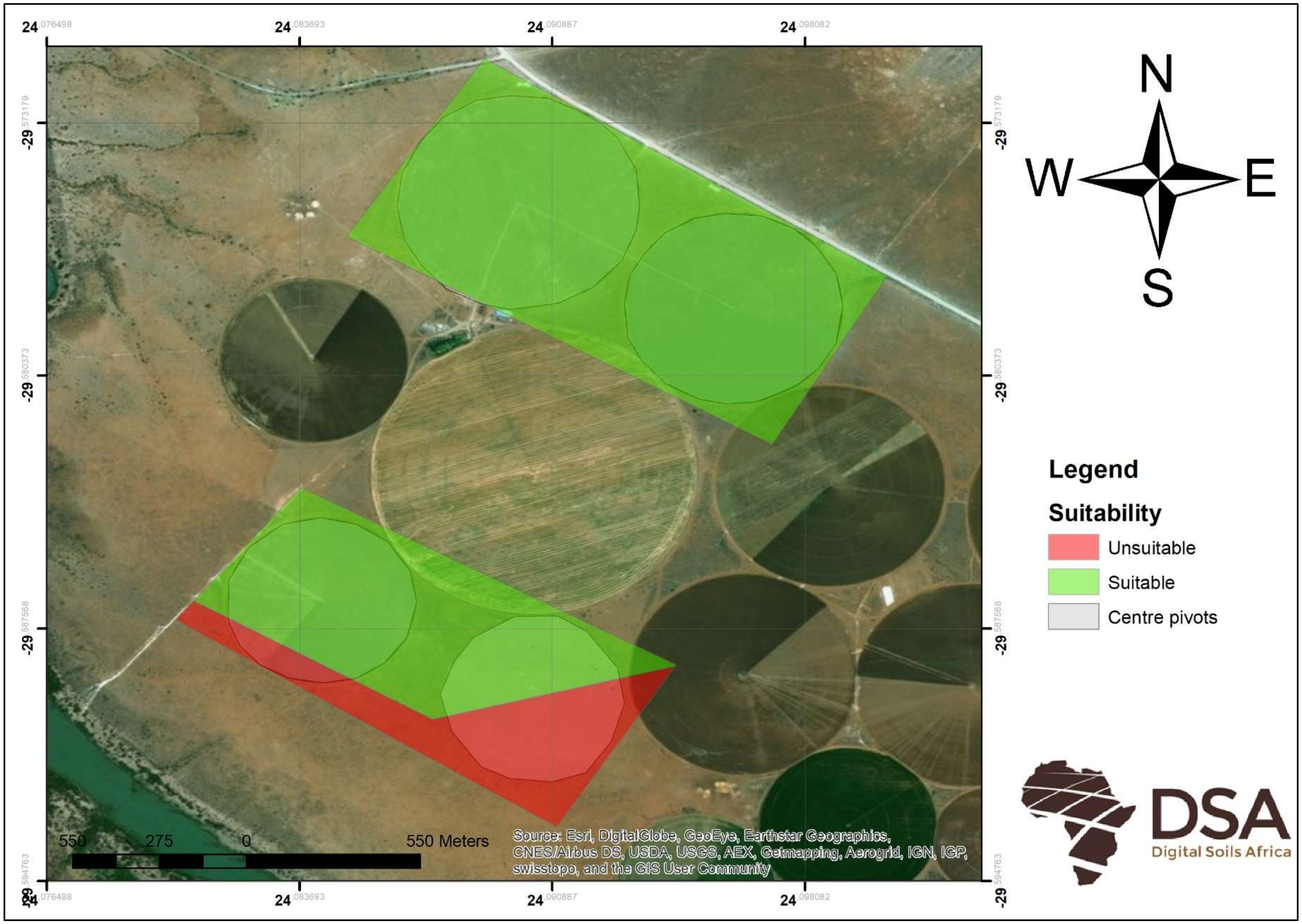

Figure 9: Simplified suitability for cultivation and irrigation of the Amanzi site.

There are however, based on the specific situation, some arguments as to why this centre pivot could be retained for planted pastures.

1. In the south of the centre pivot, where the soil is too shallow according to the Department of Agriculture's guidelines, the limiting layer is loose boulders (Figure 10) which would not limit the drainage.

Figure 10: Loose boulders which is the limiting layer in the shallow southern area.

2. The hard carbonate which has formed on top of these boulders has been shown to have extremely high saturated hydraulic conductivity (Table 7) under cultivation, due to the mechanical disturbance and leaching of the carbonates, leading to a fractured layer. This process will be slower with the boulders directly underneath the hardpan carbonate, but will still continue.
3. The surface drainage from this centre pivot leads back to the river, and will not influence other irrigable soils (Figure 11).

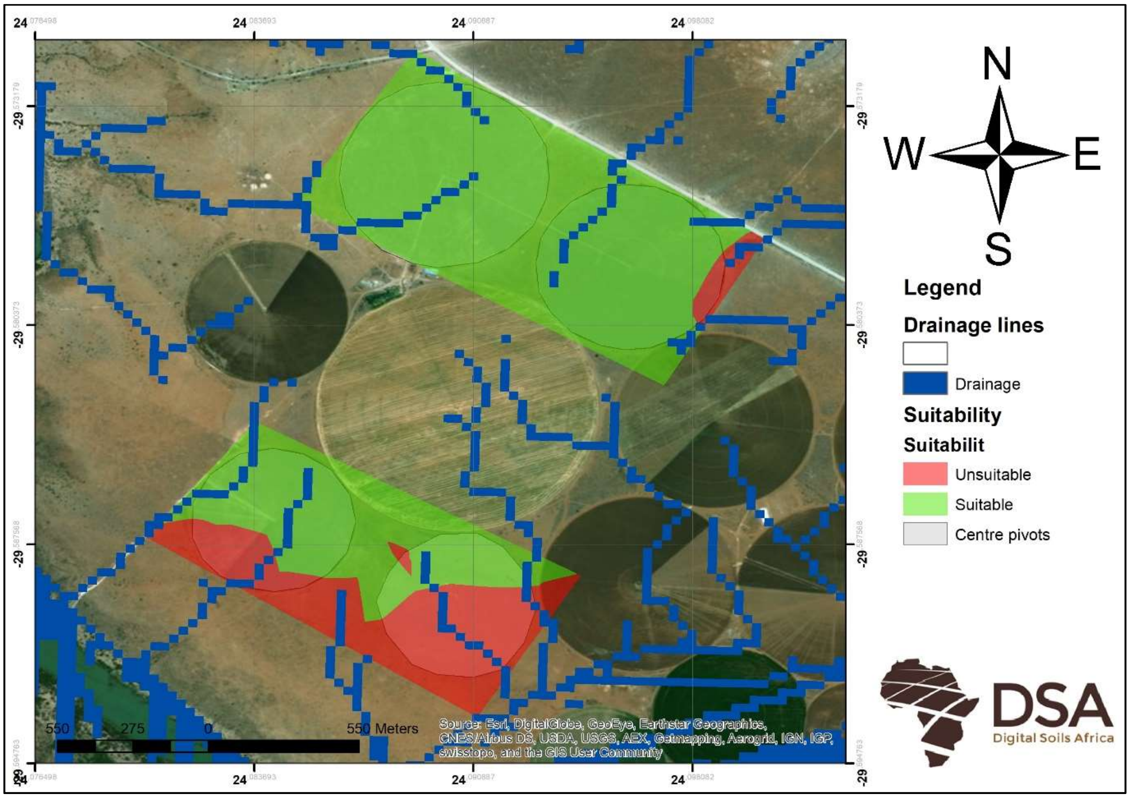

Figure 11: Topographic drainage lines from the four existing centre pivots under investigation. Surface drainage from the centre pivot in question will run to the Orange River.

6. Conclusion

The soil survey and accompanying analysis of soil properties indicate that most the two areas investigated are suitable for irrigation. Site A is suitable for irrigation, while Site B is suitable in the north and west. It the south, about halfway across the fourth centre pivot, the soils are unsuitable for irrigation of cash crops according to the guidelines of the Northern Cape Department of Agriculture. However, due to the arguments considered in the text, it is advised that the unsuitable half of the fourth centre pivot could be retained for planted pastures.

7. References

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8. Disclaimer

Digital Soils Africa cannot be held responsible for any advice given based on incorrect laboratory analysis given by our providers. Although all care is taken to ensure that the results reported are correct, we are dependent on services from other companies.

9. Appendices

Appendix 1: Modal soil profile descriptions

General Information							
Site:	Amanzi					Soil form:	Glenrosa/Coega
Map/Photo example:	Figure 4a					Soil family:	1212
GPS Position:	24,08987; -29,578453					Colour	Brown
Surface stones:	5%					Occurrence of flooding:	None
Altitude:	1082 m					Wind erosion potential:	Low
Terrain unit:	Ridge					Water erosion potential:	Low
Slope:	1%					Vegetation/Land use:	Irrigation
Slope shape:	Planform	Straight	Profile	Straight		Water table:	None
Aspect:	None						
Micro-relief:	None					Described by:	G van Zijl
Parent material solum:	Tillite					Date described:	2017-09-14
Geological group:	Dwyka group					Weathering of underlying material:	Fractured

Profile Information

Horizon Depth (mm)	*Diagnostic Horizon*	*Colour*	*Structure*	*Redoximorphic features*	*Lime*	*Transition*
A 200	Orthic A	Brown	Weak, Fine, SANBL	None	Present	Clear
B 500	Hardpan Carbonate B	White	Massive / granular	None	Present	Clear
B 1450	Lithocutanic B	Bluegrey	Platy	None	Present	Clear
1450+	Rock					

General Information						
Site:	Amanzi				Soil form:	Coega
Map/Photo example:	Figure 4b				Soil family:	2000
GPS Position:	24,09268; -29,590822				Colour	Red
Surface stones:	5%				Occurrence of flooding:	None
Altitude:	1058 m				Wind erosion potential:	Low
Terrain unit:	Toe slope				Water erosion potential:	Low
Slope:	2%				Vegetation/Land use:	Irrigation
Slope shape:	Planform	Straight	Profile	Convex	Water table:	None
Aspect:	South					
Micro-relief:	None				Described by:	G van Zijl
Parent material solum:	Tillite				Date described:	2017-09-20
Geological group:	Dwyka group				Weathering of underlying material:	Fractured

Profile Information

Horizon Depth (mm)	*Diagnostic Horizon*	*Colour*	*Structure*	*Redoximorphic features*	*Lime*	*Transition*
A 200	Orthic A	Red	Weak, Fine, SANBL	None	Present	Clear
B 200+	Hardpan Carbonate	White	Massive	None	Present	Not reached

General Information						
Site:	Amanzi				Soil form:	Plooysburg
Map/Photo example:	Figure 4c				Soil family:	1000
GPS Position:	24,088608; -29,587758				Colour	Red
Surface stones:	0%				Occurrence of flooding:	None
Altitude:	1060 m				Wind erosion potential:	Low
Terrain unit:	Mid slope				Water erosion potential:	Medium
Slope:	4%				Vegetation/Land use:	Irrigation
Slope shape:	Planform	Concave	Profile	Convex	Water table:	None
Aspect:	South					
Micro-relief:	None				Described by:	G van Zijl
Parent material solum:	Tillite				Date described:	2017-09-20
Geological group:	Dwyka 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	None	Diffuse
B 900	Red apedal B	Red	Apedal	None	None	Aprupt
B 1500	Hardpan Carbonate	White	Massive and Granular	None	Present	Clear
C 1500+	Lithocutanic B	Blue Grey	Platy	None	Present	None

General Information							
Site:	Amanzi					Soil form:	Prieska
Map/Photo example:	Figure 4d					Soil family:	1210
GPS Position:	24,090215; -29,591937					Colour	Red
Surface stones:	2%					Occurrence of flooding:	None
Altitude:	1051 m					Wind erosion potential:	Low
Terrain unit:	Toe slope					Water erosion potential:	Medium
Slope:	2%					Vegetation/Land use:	Irrigation
Slope shape:	Planform	Straight	Profile	Concave		Water table:	None
Aspect:	South						
Micro-relief:	None					Described by:	G van Zijl
Parent material solum:	Not reached					Date described:	2017-09-20
Geological group:	Dwyka group					Weathering of underlying material:	Fractured

Profile Information

Horizon Depth (mm)	*Diagnostic Horizon*	*Colour*	*Structure*	*Redoximorphic features*	*Lime*	*Transition*
A 200	Orthic A	Red	Apedal	None	Present	Gradual
B 600	Neocarbonate B	Red	Apedal	None	Present	Abrupt
C 700	Hardpan Carbonate	White	Massive	None	Present	Clear
C 700+	Hard Rock					None

Appendix 2: Selected chemical soil properties

Sample	Lab	Ca		Mg		Na		K		SO4	S		pH
	Number	mg/kg	cmol(+)/kg	mg/kg	cmol(+)/kg	mg/kg	cmol(+)/kg	mg/kg	cmol(+)/kg	mg/l	mg/l	mg/kg	KCl
1A	2142	4193.65	20.97	183.14	1.5	44.88	0.2	159.35	0.41	3.73	1.25	24.93	7.5
1B	2143	4260.14	21.3	129.01	1.06	75.71	0.33	41.5	0.11	6.46	2.16	43.11	7.7
1C	2144	3029.57	15.15	200.77	1.65	49.4	0.21	29.77	0.08	2.76	0.92	18.45	7.8
2A	2145	3520.89	17.6	115.56	0.95	40.22	0.17	195.75	0.5	4.12	1.37	27.49	7.7
2B	2146	4390.19	21.95	117.09	0.96	196.69	0.86	57.7	0.15	7.54	2.52	50.33	7.8
2C	2147	4371.49	21.86	215.79	1.77	207.71	0.9	24.63	0.06	5.33	1.78	35.58	7.9
3A	2148	3082.31	15.41	165.82	1.36	47.97	0.21	96.45	0.25	4.09	1.36	27.29	7.9
3B	2149	3542.95	17.71	173.2	1.42	54.76	0.24	28.22	0.07	3.37	1.12	22.47	8.0
3C	2150	4787.6	23.94	169.01	1.39	61.77	0.27	56.46	0.14	3.89	1.3	25.98	8.0
4A	2151	732.45	3.66	133.53	1.09	23.28	0.1	154.9	0.4	1.07	0.36	7.17	7.8
4B	2152	932.92	4.66	147.11	1.21	28.98	0.13	36.31	0.09	2.02	0.68	13.51	7.6
4C	2153	4078.51	20.39	266.15	2.18	32.46	0.14	58.02	0.15	2.56	0.85	17.07	7.8
5A	2154	4667.51	23.34	149.19	1.22	48.82	0.21	95.43	0.24	3.58	1.19	23.87	7.8
5B	2155	4843.76	24.22	396.11	3.25	248.41	1.08	59.69	0.15	8.85	2.95	59.09	7.9

Selected chemical soil properties continued

Sample	Lab Nr	P mg/kg	US.KCl cmol(+)/kg	Acid Sat %	Ca:Mg	Mg:K	(Ca+Mg)/K	%Ca/BK	%Mg/BK	%Na/BK	%K/BK	BK cmol(+)/kg	CEC cmol(+)/kg
1A	2142	28.6	0.525	2.22	13.97	3.68	55.13	90.88	6.51	0.85	1.77	23.07	23.6
1B	2143	10	0.4625	1.99	20.14	9.96	210.67	93.45	4.64	1.44	0.47	22.79	23.26
1C	2144	10	0.6125	3.46	9.2	21.62	220.57	88.66	9.63	1.26	0.45	17.08	17.7
2A	2145	31.4	0.525	2.66	18.59	1.89	37.06	91.56	4.93	0.91	2.6	19.23	19.75
2B	2146	10	0.4	1.65	22.87	6.5	155.26	91.79	4.01	3.58	0.62	23.91	24.31
2C	2147	10	0.5	1.99	12.36	28.07	375	88.88	7.19	3.67	0.26	24.59	25.09
3A	2148	63.8	0.45	2.55	11.34	5.51	67.99	89.47	7.89	1.21	1.43	17.23	17.68
3B	2149	10	0.75	3.71	12.48	19.67	265.12	91.1	7.3	1.22	0.37	19.44	20.19
3C	2150	10	0.625	2.37	17.28	9.59	175.38	93.01	5.38	1.04	0.56	25.74	26.36
4A	2151	31.2	0.25	4.54	3.35	2.76	12.01	69.7	20.83	1.93	7.54	5.25	5.5
4B	2152	10	0.325	5.07	3.87	12.99	63.22	76.6	19.8	2.07	1.52	6.09	6.41
4C	2153	10	0.4	1.72	9.35	14.7	152.14	89.19	9.54	0.62	0.65	22.86	23.26
5A	2154	10	0.55	2.15	19.08	5.01	100.63	93.29	4.89	0.85	0.98	25.02	25.57
5B	2155	10	0.6125	2.09	7.46	21.27	179.93	84.39	11.31	3.76	0.53	28.7	29.31

Saturated Paste extract

Sample	Lab nr	Sample weight	Volume water	pH (extract)	EC ms/m
1A	2142	250	100	7.59	71.2
1B	2143	101.93	80	7.46	97.5
1C	2144	102.79	80	6.72	78.3
2A	2145	250	100	7.58	133.6
2B	2146	141.54	90	7.42	321
2C	2147	198.5	100	7.61	127.4
3A	2148	250	110	7.22	89.2
3B	2149	248.95	120	7.39	47.3
3C	2150	250	130	7.38	47.7
4A	2151	250	100	7.2	76.2
4B	2152	250	100	6.98	147.4
4C	2153	250	120	7.61	24
5A	2154	250	100	7.38	50.7
5B	2155	250	130	7.34	4.12

Appendix 3: Agronomical Report

1. General soil requirements for Maize

Maize requires a well drained and well aerated loamy soil that retains water and which fertility levels optimal and well balanced. Maize roots can extend, if root growth is not restricted, laterally approximately 1.5 m and downward to a depth of 2 to 3 m if not restricted. Maize will grow in a variety of soil textures, but the optimal clay content lies between 10% and 30%, due to water-air regimes. Lower clay percentages will require better management of irrigation, but can still produce very good yields. The optimal pH(KCl) range for maize is 5-7.5, but it can be grown in ranges between 4 and 7.5. Maize is moderately sensitive to salinity and starts to have crop losses ECe values of 170 $mS.m^{-1}$.

2. Specific Amanzi situation

a. *Soil depth*

The areas shown as suitable has sufficient freely drainable depth for maize roots to develop, and is suitable for production. On the fourth centre pivot, maize roots will be restricted and the available water and nutrient store is smaller, thus requiring a higher level of management to produce economical yields.

b. *Soil texture*

The soil texture is generally very course, with clay percentages under 10%. Maize could grow very well in such a medium, provided that the water management regime is adequate, which will require irrigation scheduling.

Wind erosion, surface encrustation after planting and soil compaction might however occur. These factors can and has to be managed by the producer in accordance to the selected tillage system.

c. *pH*

The $pH_{(KCl)}$ of the soil samples are between 7.5 and 8, which is a bit higher than the optimal level. Liming is not required at this stage and it is anticipated that the pH will lower with continued cultivation and irrigation. Regular soil sampling will inform the farmer of best management practices concerning alkalinity/acidity.

d. *Salinity*

The highest Electrical Conductivity and Resistance measurements are lower than the 170 $mS.m^{-1}$ at which maize crop losses start to occur. In terms of soil salinity this area is therefore conducive to maize production.

3. Conclusion

The soils indicated as suitable in Figure 9 are generally suitable for maize production. The pH is a bit high, but is expected to drop with continued cultivation. The texture is course, which necessitates irrigation scheduling for optimal production. In the fourth centre pivot, the area indicated as unsuitable in Figure 9, will have limited yields due to the shallow depth. Excellent management is required to farm economically on such shallow soils.