21 Falloden
Upper Dickens street
Port Elizabeth

0837033002
info@dsafrica.co.za
www.dsafrica.co.za

Irrigation Suitability Report for the farm Bultfontein, near Prieska, Northern Cape Province

For

The South African Farm Assured Meat Group cc

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Executive summary

A soil suitability survey was conducted on the farm Bultfontein near Prieska to assess the soils' suitability for irrigation in support of an application for a ploughing certificate to allow the irrigation on the land. Most of the area is occupied by deep sandy Hutton soils, with some shallow Glenrosa and Mispah soils scattered in between. In the south the Plooysburg soil form occurs, which has an impermeable hardpan carbonate layer. The laboratory analysis shows that the soils are suitable for irrigation as it possesses adequate drainage and a low salt and sodium contents. The texture measured is less than 10%, and the pH is acidic with a highest value measured of 6.1. The salt and sodium contents are low (highest ECe and ESP values measured are 72 $mS.m^{-1}$ and 2.25% respectively).

Areas with a drainable depth deeper than 1000 mm is considered to be suitable for irrigation. This covers a total area of 376 ha. Included in this is a 106 ha area which is slightly shallower than 1500 mm, which should be used to accommodate centre pivots. Forty-five hectares of shallow soils occur, which is mostly the Plooysburg soil form which occurs to the south of the site. Shallow areas within the area marked suitable should be avoided. Figures A and B shows the area marked as suitable in the natural and rectangular shapes.

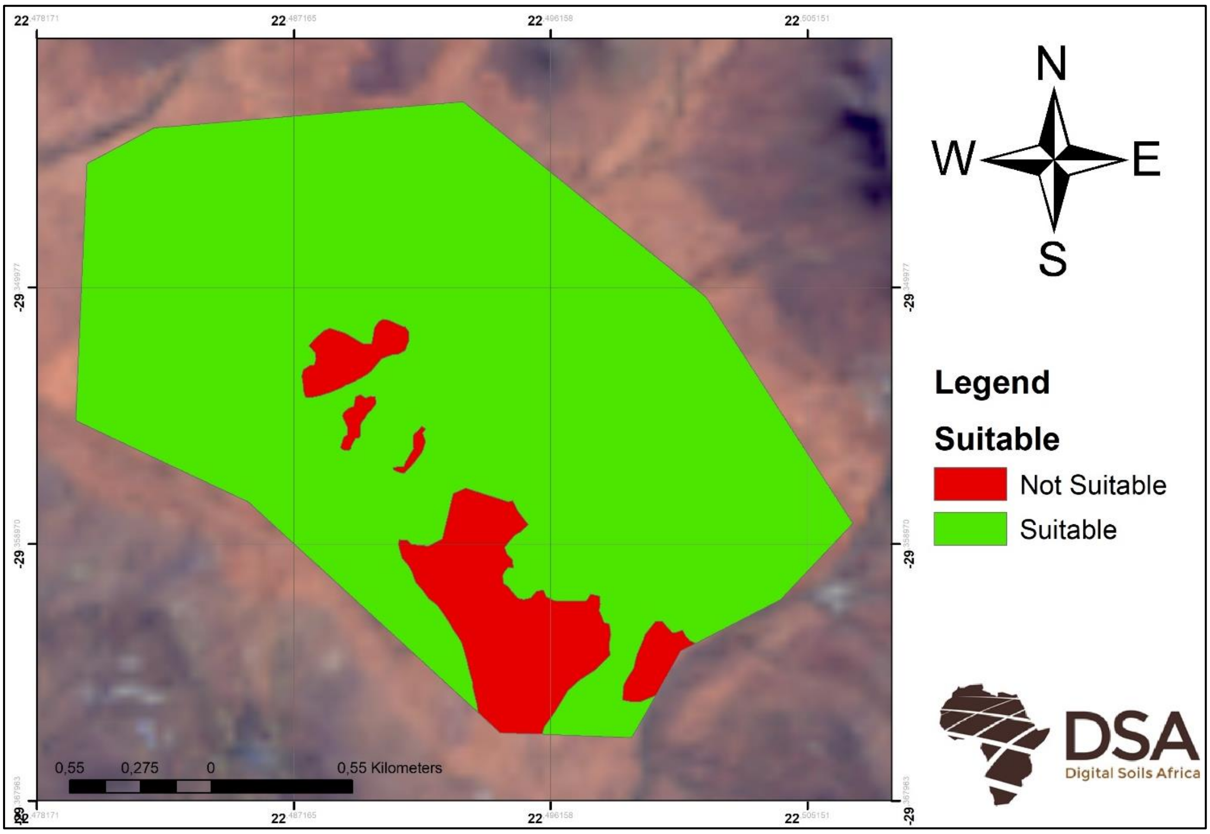


Figure A: Natural area suitable for irrigation.

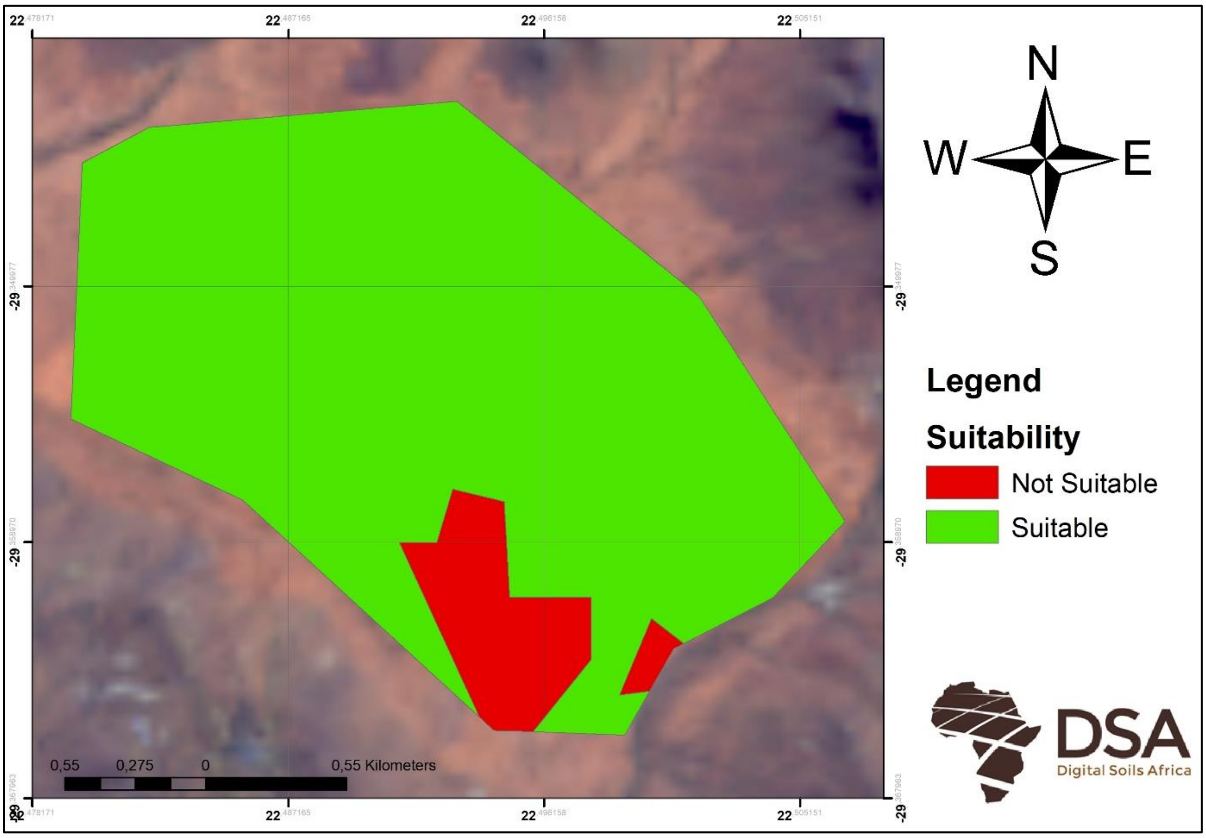


Figure B: Rectangular area suitable for irrigation.

1. Introduction

Digital Soils Africa conducted an irrigation suitability survey. To achieve the sustainable irrigation of soils, the appropriate soils need to be identified to prevent waterlogging and associated salinization. The soil must also be suitable for the crop earmarked for the land. During irrigation, a considerable amount of salts is applied with the water. When water is absorbed by plant roots through transpiration, the salts are precipitated in the soil and the long-term result is an increased amount of salts in the soil, which is called salinization. Salinization in the soil can hamper crop growth and in extreme cases, salinization will render the soil non-vegetative. These effects can be negated with proper management of soils, if the soils have certain properties. For this reason, the Department of Agriculture; Northern Cape, has provided guidelines to which soil properties must adhere to before a ploughing certificate can be issued. Therefore, soils with properties that enable good drainage and pose little threat of salinization are considered for irrigation.

2. Location and Observations

The site is located near Prieska in the Northern Cape Province, (Figure 1), and is approximately 400 ha in size. The perimeter of the study area is shown in Table 1.

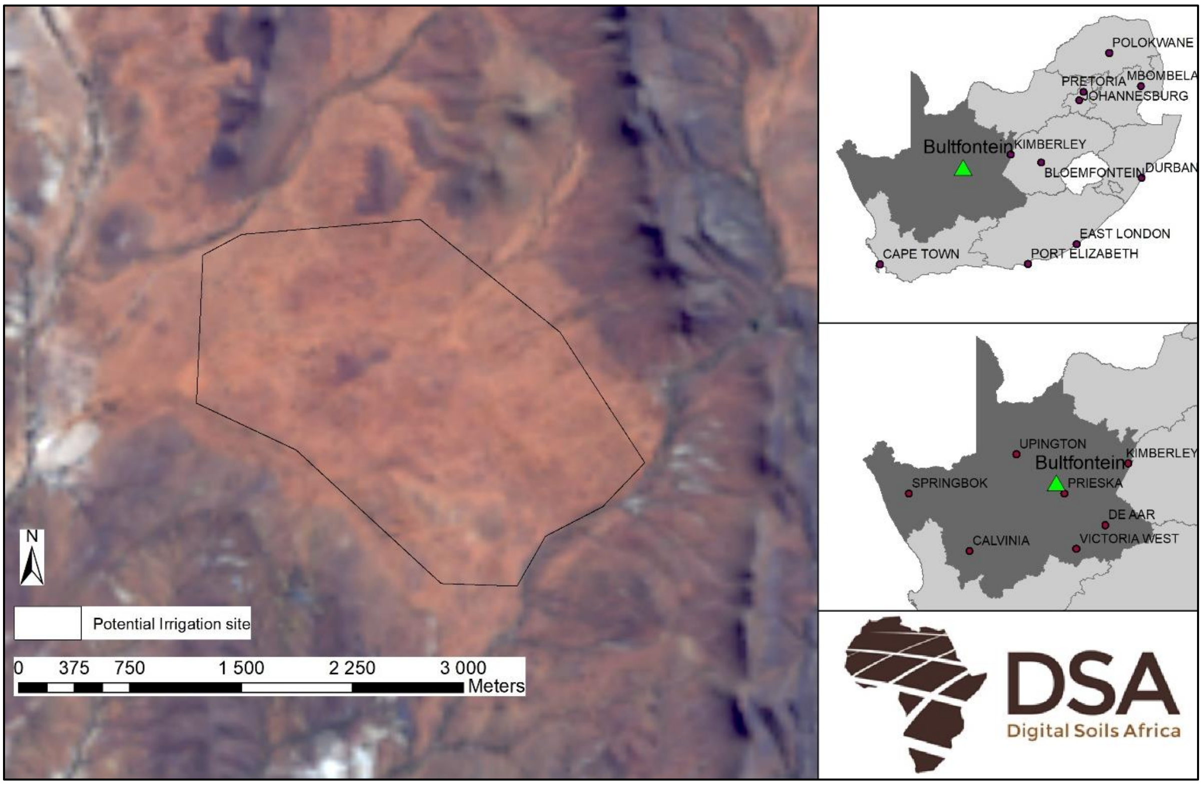


FIGURE 1: THE LOCATION OF THE BULTFONTEIN STUDY SITE.

TABLE 1: THE CO-ORDINATES OF THE PERIMETER OF AREA

Nr	X	Y
1	22.47981066160	-29.34553243390
2	22.48221190060	-29.34429543200
3	22.49305385850	-29.34342225410
4	22.50200393110	-29.35033491180
5	22.50666087940	-29.35812074740
6	22.50054863470	-29.36248663640
7	22.49909333840	-29.36561552360
8	22.49443639000	-29.36568828840
9	22.48577737670	-29.35761139360
10	22.47959236720	-29.35462803610

3. Methodology

Soil profile pits were dug to 1.5 m or to a limiting layer using a TLB. The soils were classified according to the Soil Classification Working Group (1991). Soil depth, freely drainable depth and limiting material were described and mapped. Samples of modal profiles were collected per horizon for analysis of selected chemical and textural properties. Figure 2 shows the location of the profile pits and where samples were taken. The coordinates of the observations are found in Appendix 1.

The basic cations were determined from a 1:10 NH_4OAc extract (White 2006) and soil pH was determined with a 1:2.5 KCl extract. The texture was measured using a pipette (Gee and Bauder, 1979). Electrical conductivity (ECe)was measured with the saturated paste extract.

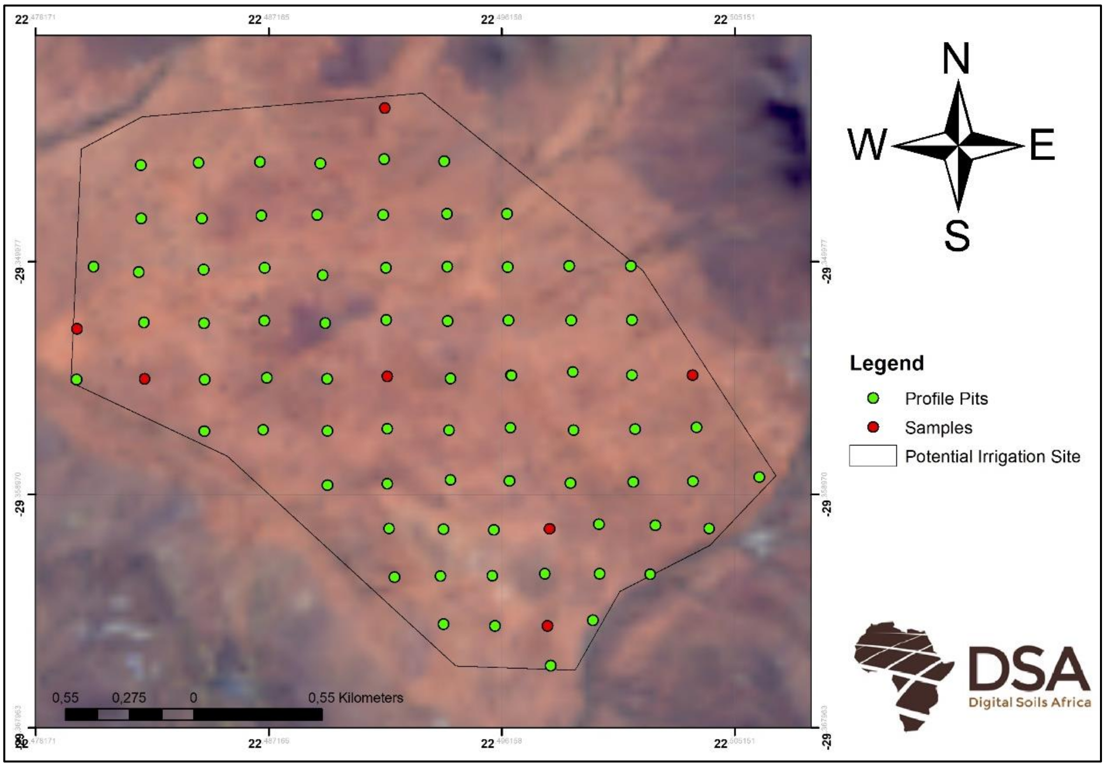


FIGURE 2: LOCATION OF OBSERVATIONS AND SAMPLE POINTS.

4. Results

4.1. Soils forms

Four soil forms were found in the area, Hutton, Glenrosa, Plooysburg and Mispah (Table 2, Figure 3). The Hutton soil is a red sandy soil on unspecified material, which in this case is either loose stones or hard rock. Generally, the underlying material was not reached. The Plooysburg soil form is similar to the Hutton soil from, except that the underlying material is specified as hardpan carbonate. Both the Glenrosa and Mispah soil forms are shallow, with the Glenrosa being formed on a lithocutanic B, which in this case is comprised of loose stones, while the Mispah soil form is a shallow topsoil on solid rock. Descriptions of the diagnostic horizons are given in the text, while Figures 4 and 5 shows the spatial distribution of the soil forms and depth limiting layers respectively.

TABLE 2: THE PREVALENT SOIL FORMS IN THE STUDY AREA

Soil Form	A horizon	B Horizon	B2/C Horizon	No of Observations
Hutton	Orthic A	Red Apedal B	Unspecified Material	60
Plooysburg	Orthic A	Red Apedal B	Hardpan Carbonate	8
Glenrosa	Orthic A	Lithocutanic B	Rock	11
Mispah	Orthic A	Rock		3

4.2. Horizon descriptions

Orthic A

The orthic A is sandy (less than 10% clay) red, apedal, and poorly developed, typical of arid environments. The transition to the red apedal B horizon is gradual.

Red Apedal B

Within this landscape this is a red, sandy (less than 10% clay), apedal horizon. It is freely drained with high water infiltration rates and generally low salinity, which makes it excellent for irrigation when it is deep enough. Transitions to the loose stones are clear. Often no deeper horizon was reached.

Lithocutanic B

The lithocutanic B horizon consists of fairly large loose stones with soil between them. Many plant roots were observed to grow within them, and they are regarded to have excellent drainage due to their loose nature. The loose stone material which occurs in the Glenrosa soil form, as well as in some of the Hutton observations, are shown in the limiting layer map (Figure 5). The lithocutanic B horizon often grades into hard rock, then the limiting layer will be shown as hard rock.

Hardpan Carbonate

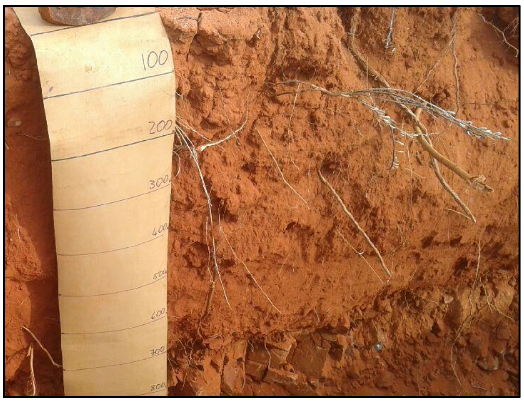
The hardpan carbonate occurs where lime has accumulated to the point where it has precipitated and hardened. This horizon is regarded as impermeable to water movement.

a. Hutton

c. Glenrosa

d. Mispah

b. Hutton on loose stones



e. Roots growing amidst loose stones

FIGURE 3: EXAMPLES OF THE SOILS FOUND ON THE STUDY SITE.

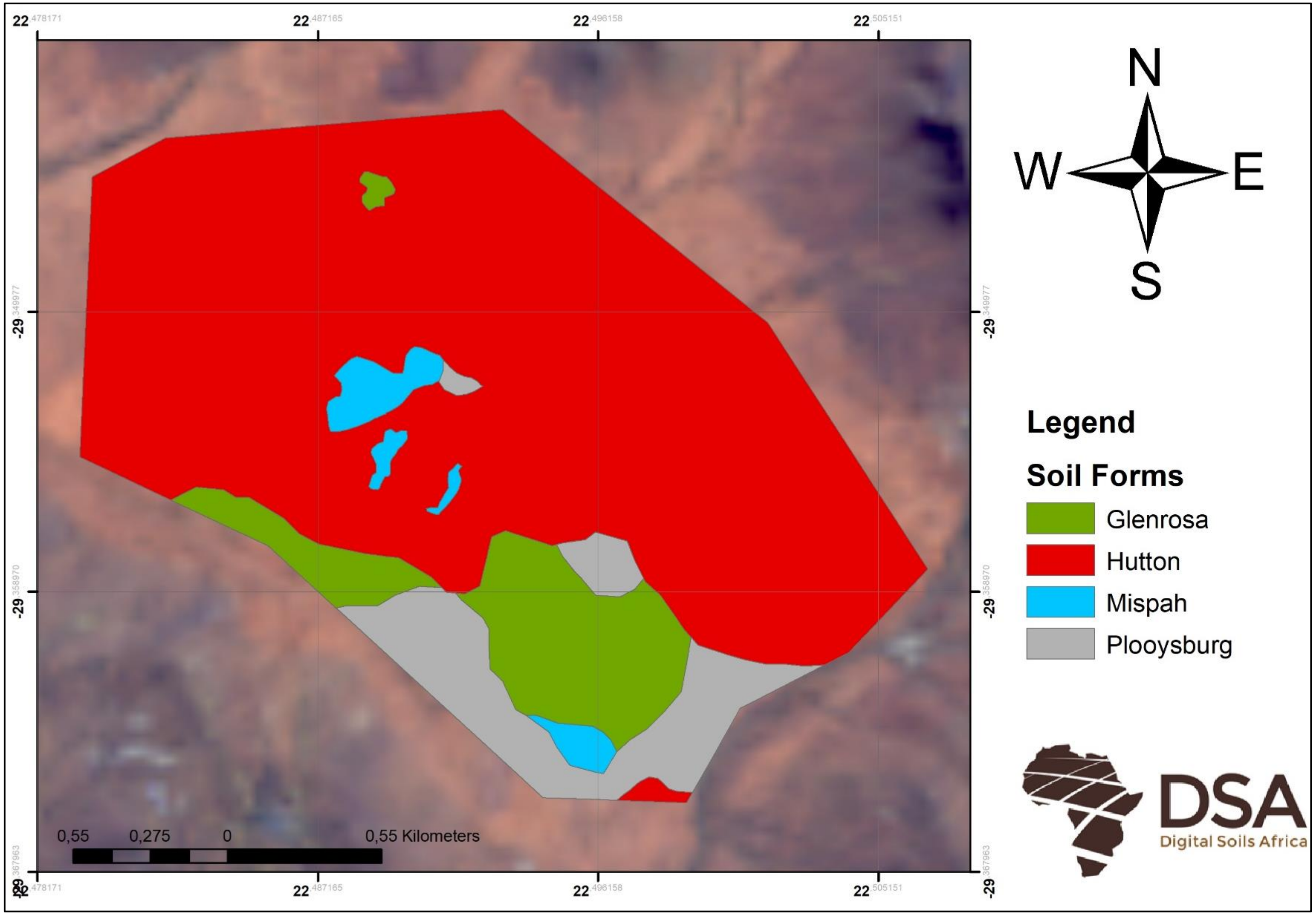


Figure 4: Soil form distribution in the study site.

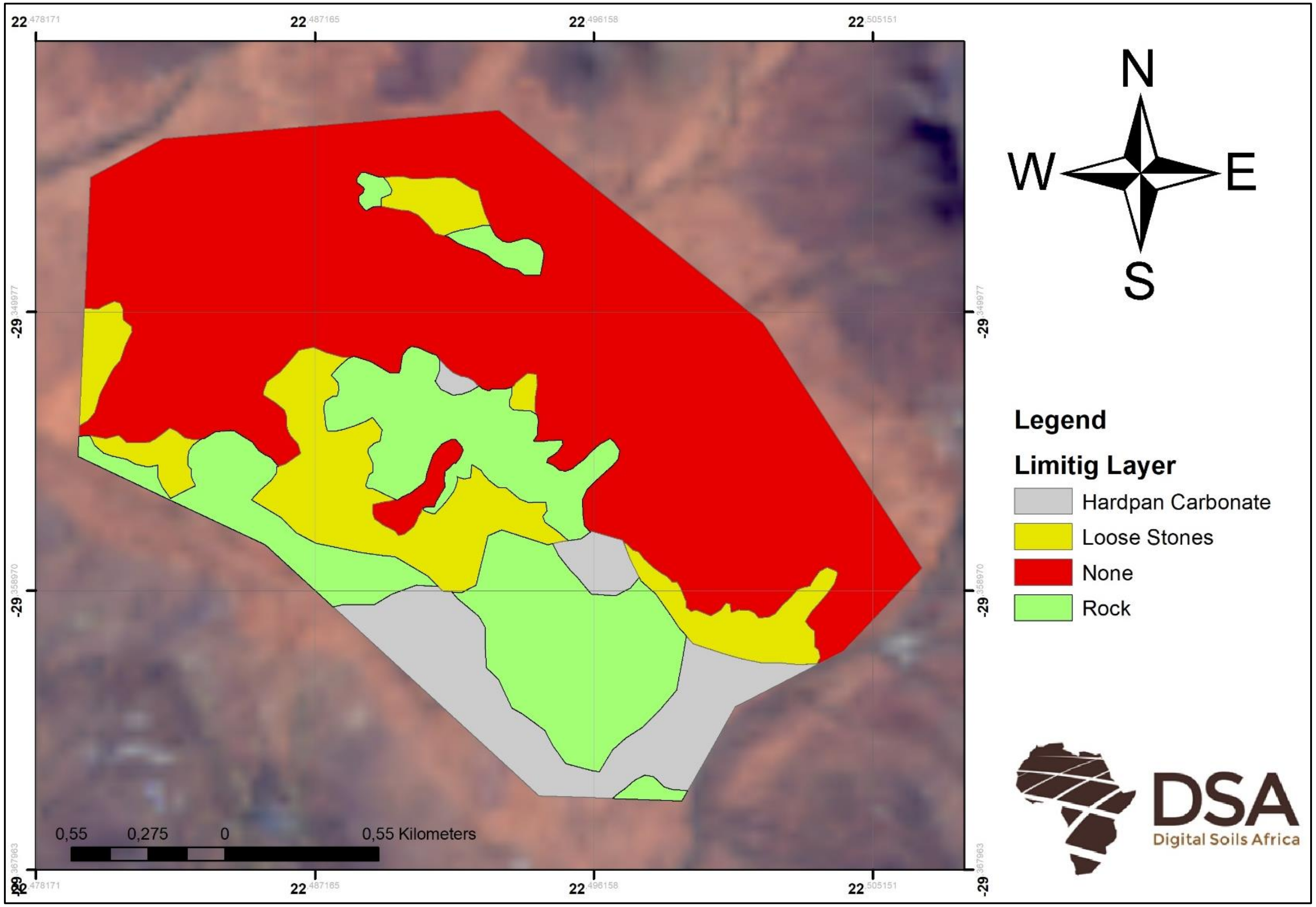


Figure 5: Depth limiting layer distribution in the study site.

4.3. Soil Depth

Three maps are given to show the soil depth. Figure 6 shows the depth of the soil, which is the depth of the limiting layer. Thus, it is basically the depth of the red sand up to either the lithocutanic B, hard rock or hardpan carbonate. Figure 7 shows the depth of the freely drained material, and this includes the depth of the lithocutanic B. The drainable depth shows the depth at which artificial drainage can be installed. For this 300 mm below the depth of the lithocutanic B was added, if hard rock was not yet encountered.

The soils of the site are generally deep, often no limiting layer was reached. Towards the south the soils are shallower, with hardpan carbonate accumulation. There are small areas, easily distinguishable in the field, where shallow soils occur, which must be omitted from irrigation.

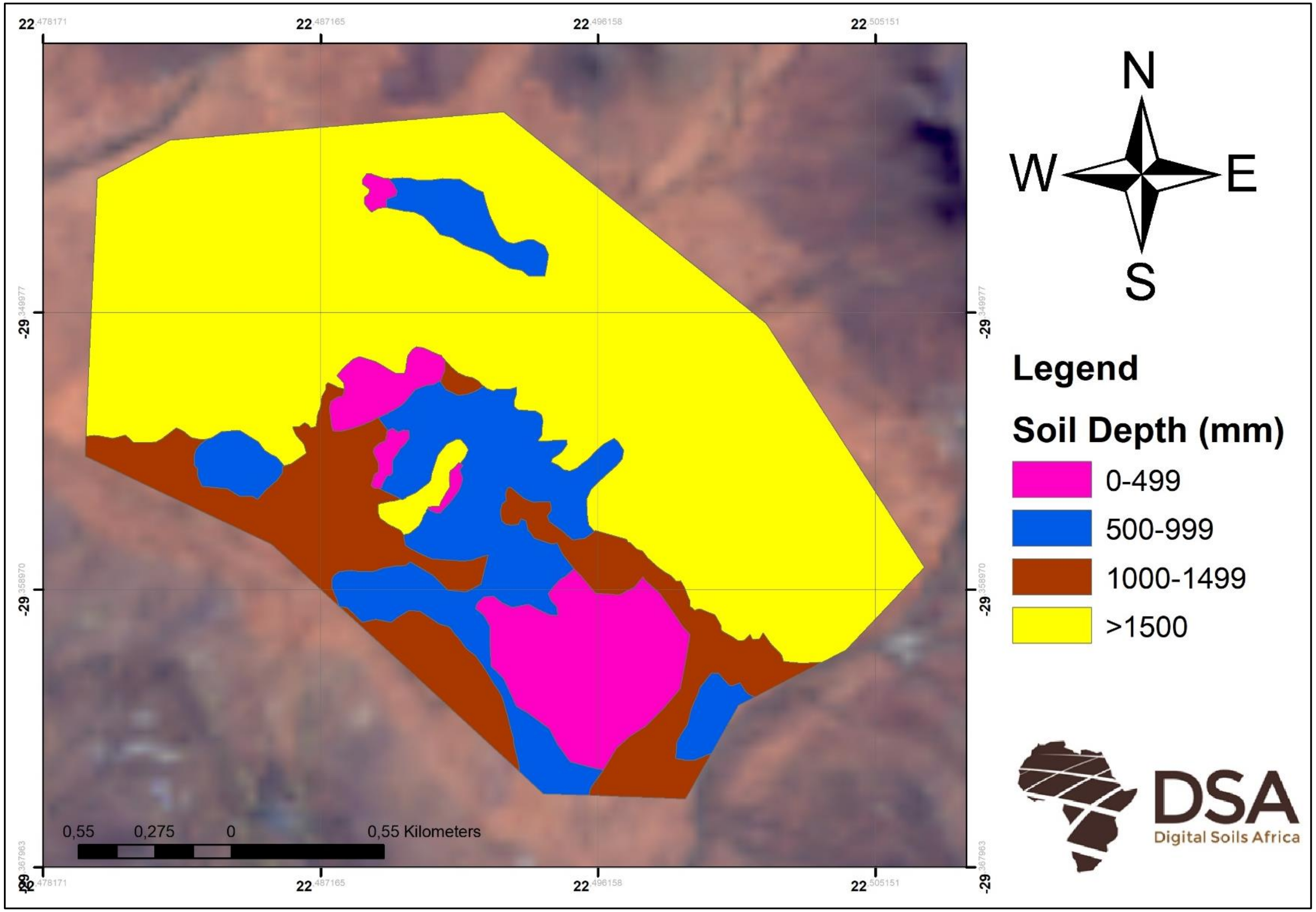


Figure 6: Soil depth distribution in the study site.

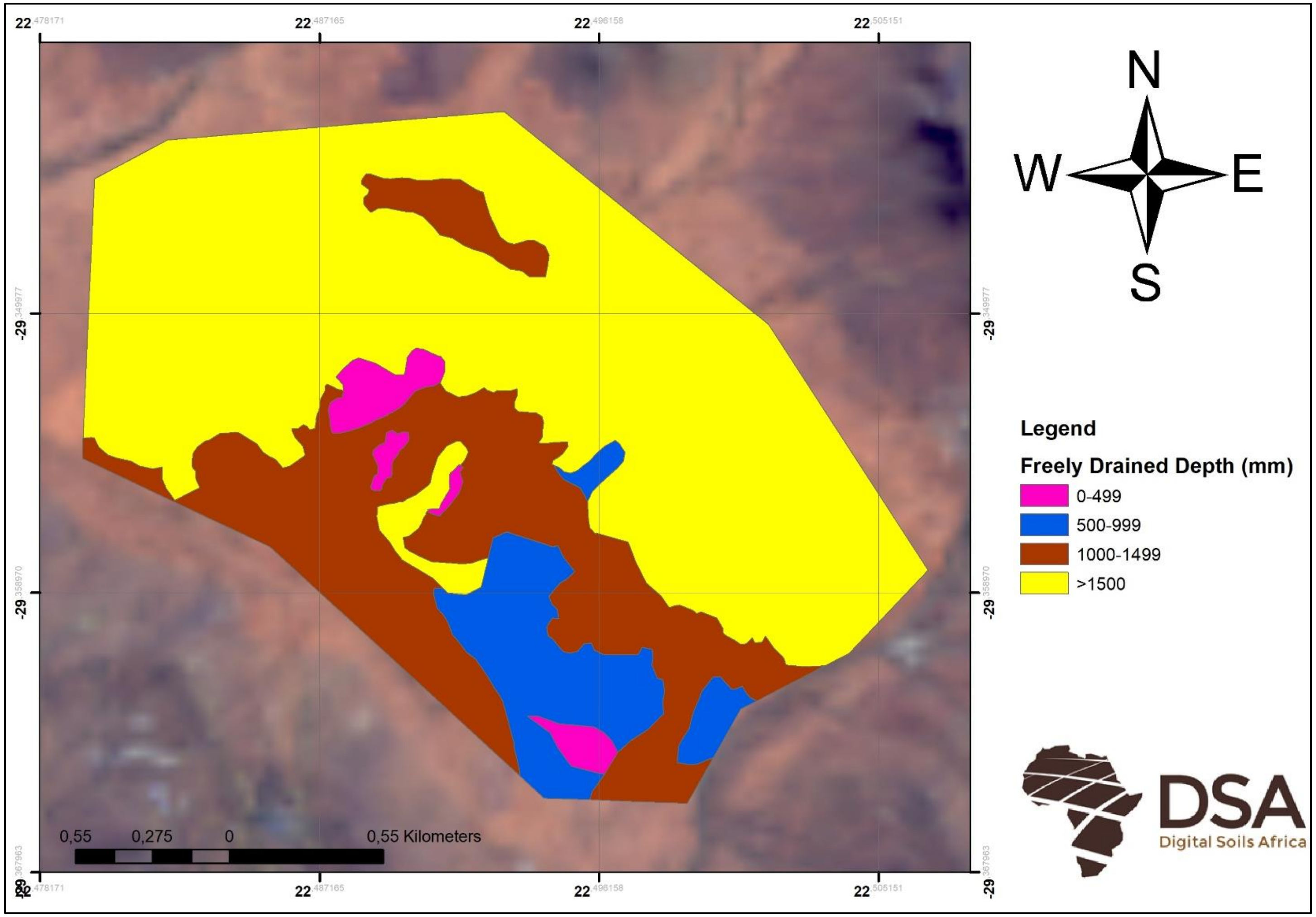


Figure 7: Freely drained depth distribution in the study site.

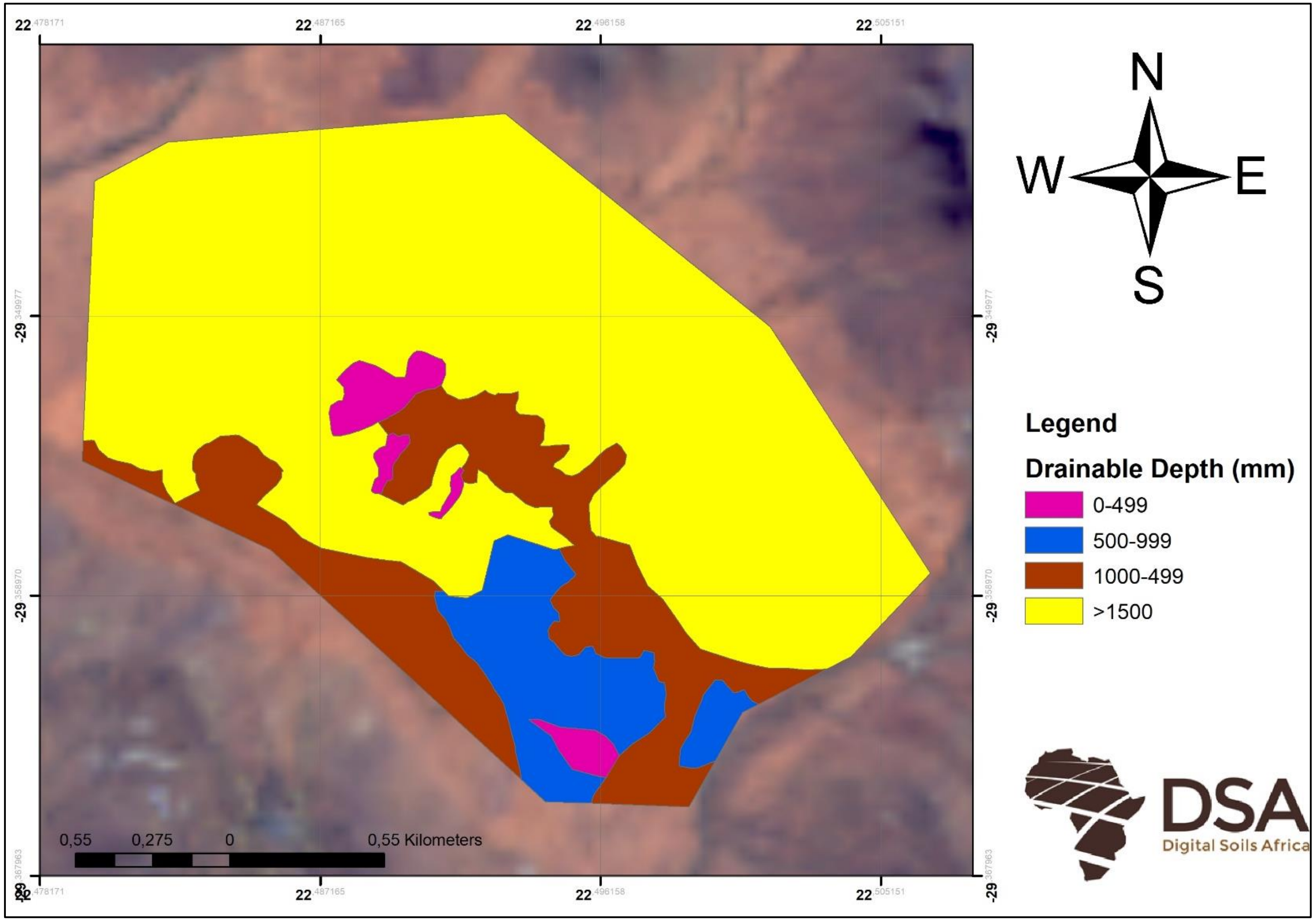


Figure 8: Drainable depth distribution in the study site.

5. Chemical and soil texture analysis

Tables 3 and 4 show selected soil chemical analysis and textural values respectively, while all the laboratory analysis are given in Appendix 2.

The pH values are very acidic to moderately acidic (4.69 – 6.09). This shows that salt accumulation within the soils is quite low, as cations have generally been leached from the profile. Liming will be required for the successful cultivation of crops on these soils.

The CEC-values are very low (< 6 cmol(+)/kg) to low (6 - 12 cmol(+)/kg), with three values in the moderate range (12 – 25 cmol)+)/kg). This corresponds with the acidic pH values. The low CEC values indicate a low fertility and the need for a fertilization plan.

The Electrical Conductivity (ECe) values are all below 75 mS.m^{-1}, indicating non-saline conditions. All values are well below the irrigation threshold of 400 mS.m^{-1}.

The exchangeable sodium percentage (ESP) values are relatively low, ranging from 0.66% to 2.25%, indicating non-sodic conditions. The sodicity threat therefore is minimal.

TABLE 3: SELECTED CHEMICAL RESULTS FOR THE MODAL SOIL PROFILES

Sample	Soil Form	Diagnostic horizon	pH KCl	ESP %	ECe mS/m	CEC cmol(+)/kg
1A	Hutton	Orthic A	6.08	1.56	0.06	3.54
1B		Red Apedal B	5.62	1.18	5.22	5.50
2A	Hutton	Orthic A	4.86	0.94	6.83	3.85
2B		Red Apedal B	5.40	1.94	12.51	5.66
3A	Hutton	Orthic A	4.69	1.58	12.81	3.48
3B		Red Apedal B	5.06	2.25	7.26	7.46
4A	Hutton	Orthic A	4.73	1.47	73.10	3.19
4B		Red Apedal B	5.50	1.41	11.68	5.29
5A	Hutton	Orthic A	5.56	1.43	8.86	4.98
5B		Red Apedal B	5.47	1.94	7.07	6.00
6A	Hutton	Orthic A	5.40	1.01	6.29	4.30
6B		Red Apedal B	5.43	0.76	8.39	5.87
7A	Plooysburg	Orthic A	5.40	1.12	7.80	7.98
7B		Red Apedal B	5.72	0.66	20.10	18.38
8A	Hutton	Orthic A	5.37	0.72	7.40	9.20
8B		Red Apedal B	5.49	1.04	72.50	15.24
8B2		Lithocutanic B	5.87	0.81	16.26	18.21

The chemical results are indicative of sandy to loamy sand soils, which are confirmed in Table 4. The highest clay percentage measured is 10%, which is very low. Therefore, the water holding capacity is very low, and water infiltration rates are high. Careful irrigation scheduling and fertilization will be required to successfully cultivate crops. However, the threats of salinization and sodicity are low.

TABLE 4 SOIL TEXTURE RESULTS FOR THE MODAL SOIL PROFILES

Sample	Soil Form	Diagnostic horizon	Clay %	Silt %	Sand %
1A	Hutton	Orthic A	4.55	0.60	95.67
1B		Red Apedal B	3.30	4.50	92.87
2A	Hutton	Orthic A	2.65	3.85	95.25
2B		Red Apedal B	2.30	3.80	93.93
3A	Hutton	Orthic A	4.95	2.40	93.99
3B		Red Apedal B	4.75	2.00	93.96
4A	Hutton	Orthic A	3.55	2.35	96.49
4B		Red Apedal B	7.30	0.90	93.53
5A	Hutton	Orthic A	2.35	3.70	93.85
5B		Red Apedal B	7.95	0.20	93.55
6A	Hutton	Orthic A	1.10	1.70	96.84
6B		Red Apedal B	6.90	2.20	91.75
7A	Plooysburg	Orthic A	9.95	4.60	87.98
7B		Red Apedal B	9.40	5.40	84.54
8A	Hutton	Orthic A	7.85	5.50	86.07
8B		Red Apedal B	7.65	5.35	88.57
8B2		Lithocutanic B	8.65	9.05	83.76

6. Natural drainage channels

Various natural drainage channels were witnessed during the survey, which should be avoided when setting out the centre pivots. In an arid area such as this, when it rains it is often as severe storms, leading to increased run-off, which causes these drainage channels. Infilling of the drainage lines will have a limited effect on the diversion of the natural drainage and it is predicted that storms occurring after infilling will wash open the natural drainage lines, leading to damage to the cultivation area. Figure 9 shows an example of such a drainage line, while Figure 10 is a map of the largest natural drainage channels, as derived from the SRTM 30m DEM.

Figure 9: An example of the natural drainage lines which occur on the site.

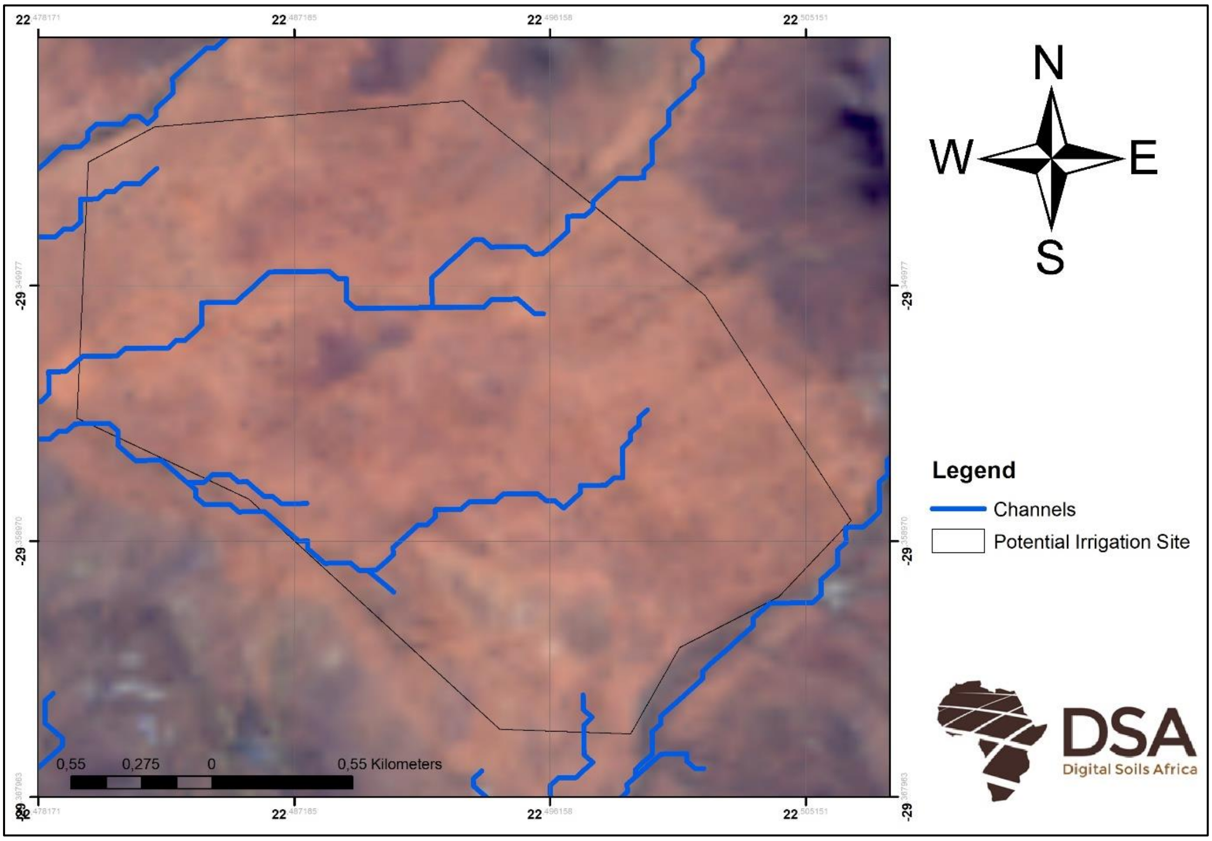


Figure 10: A map of the largest natural drainage channels, as derived from the SRTM 30 m DEM.

7. Suitability

Most the observations indicate that the soil is suitable for irrigation (Figure 11), as the profiles are deep with indications of good internal drainage. There are however some rock outcrops with shallow soils which should not be used, as well as an area in the south of the site where the soils are shallow, with either rock or hardpan carbonates prohibiting drainage. The area shown as suitable for irrigation is the area where the drainable depth is deeper than 1000 mm. This is shallower than normally considered suitable and was done to enable centre pivot layout, as the shallower soil area occurs on the fringes of the deeper soils. Excluding them, could cause entire centre pivots to not be used. The farmer will be well advised to use the areas shallower than 1500 mm as shown on Figure 8 only for the inclusion of centre pivots largely on the areas shown to be deeper than 1500 mm.

Figure 12 shows the area suitable for irrigation on a rectangular shape, while its perimeter points are given in Table 5. It is not possible to delineate the rock outcrops toward the centre of the site shown as not suitable in Figure 11. The farmer is advised to stay clear of this area when determining the location of the centre pivots.

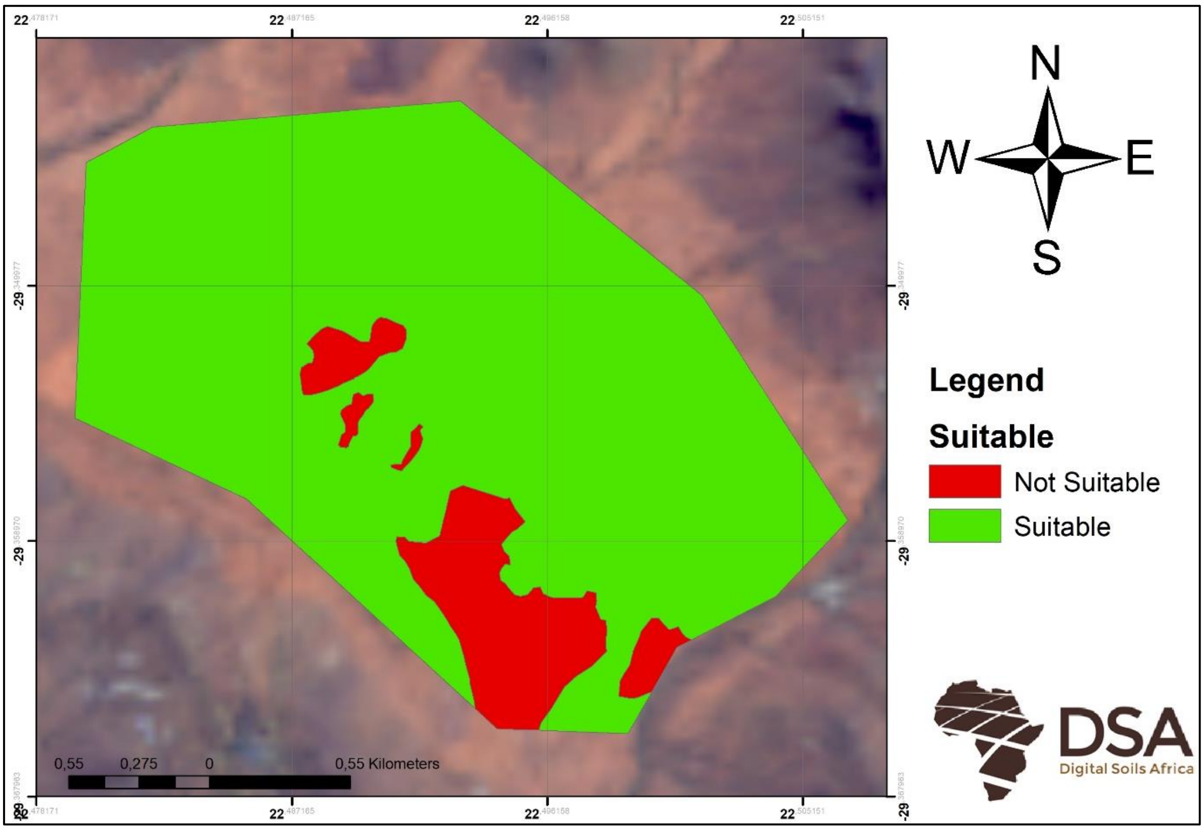


FIGURE 11: SUITABLE AREAS FOR IRRIGATION.

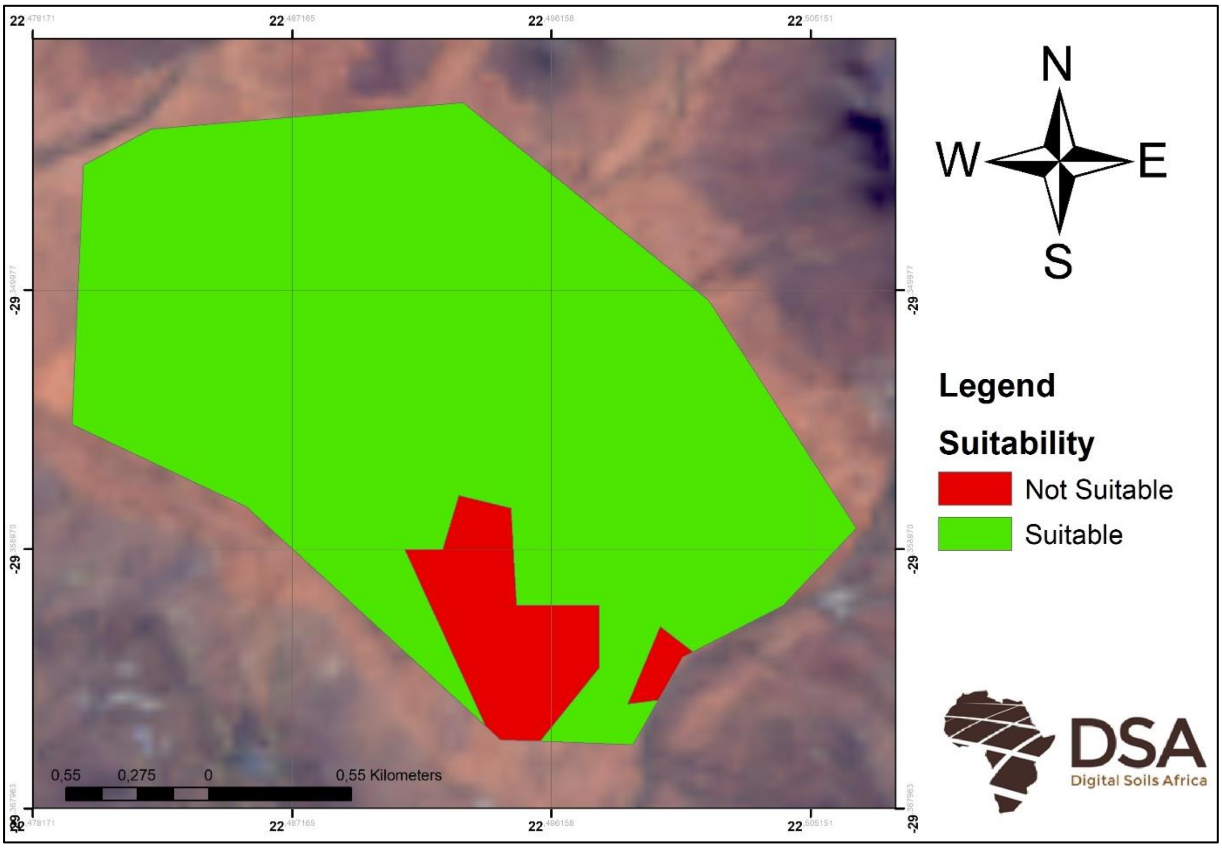


Figure 12: Suitable areas for irrigation at a rectangular shape.

Table 5: The coordinates of the corners of the perimeter of suitable area

Nr	X	Y	Nr	X	Y
1	22.4799462366	-29.3456227589	12	22.4959680413	-29.3656848447
2	22.4824075574	-29.3443688785	13	22.4978720819	-29.3630377640
3	22.4930887605	-29.3434865182	14	22.4978720819	-29.3609479634
4	22.5016337230	-29.3501738802	15	22.4949463610	-29.3608086433
5	22.5067885645	-29.3582080026	16	22.4947141610	-29.3576042824
6	22.5042808038	-29.3609015233	17	22.4930423205	-29.3570470022
7	22.5010300028	-29.3624340438	18	22.4924386003	-29.3589046028
8	22.5000083225	-29.3617838836	19	22.4912311599	-29.3589046028
9	22.4988937622	-29.3642452043	20	22.4939711207	-29.3652204446
10	22.4998225625	-29.3642452043	21	22.4857512383	-29.3575114023
11	22.4989866422	-29.3656848447	22	22.4796211566	-29.3547250015

8. Conclusion

The largest area is occupied by the Hutton soil form, which is sandy, apedal and well drained. Soils with inadequate drainage also occur, such as the shallower Glenrosa and Mispah soil forms, and the Plooysburg soil form, which has an accumulation of lime in the subsoil. The chemical and physical laboratory analysis indicate that the soils sampled are suitable for irrigation. In total 376 ha of the area is deemed suitable for irrigation. This includes an area of 106 ha which is slightly shallower and should only be used to fit centre pivots. Forty-five hectares of shallow soils also occur, which is mostly the Plooysburg soil form which occurs to the south of the site.

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.

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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: Soil Observations

Nr	X	Y	Soil Form	Soil Depth (mm)	Drainable Depth (mm)	Limiting Material
1	22.49800397100	-29.36029659680	Glenrosa	400	1200	Rock
2	22.49782100840	-29.36201745220	Glenrosa	300	700	Rock
3	22.49580510970	-29.36210707870	Glenrosa	300	700	Rock
4	22.49586075440	-29.36032887530	Glenrosa	300	1000	Rock
5	22.49390595830	-29.36031172160	Glenrosa	300	700	Rock
6	22.49379976270	-29.36211046370	Glenrosa	300	500	Rock
7	22.48915262490	-29.34619021610	Glenrosa	300	1300	Rock
8	22.49418718080	-29.35839717200	Glenrosa	800	800	Rock
9	22.48942711420	-29.35860898030	Glenrosa	300	1000	Rock
10	22.48467919920	-29.35652835110	Glenrosa	1000	1000	Rock
11	22.50353725220	-29.35845160530	Hutton	1600	2000	Loose Stones
12	22.50208260690	-29.36015300030	Hutton	2000	2200	Loose Stones
13	22.49990883130	-29.36011226190	Hutton	1300	1400	Loose Stones
14	22.47976146340	-29.35256300010	Hutton	1500	1600	Loose Stones
15	22.48039825180	-29.35017536480	Hutton	1500	1600	Loose Stones
16	22.49413160720	-29.35648648770	Hutton	1200	1300	Loose Stones
17	22.49174728770	-29.35642735090	Hutton	800	1300	Loose Stones
18	22.49174605200	-29.35855333840	Hutton	1300	1500	Loose Stones
19	22.48695734200	-29.35647431620	Hutton	1200	1300	Loose Stones
20	22.48237936560	-29.35450240790	Hutton	1100	1700	Loose Stones
21	22.50367747810	-29.35637103810	Hutton	2000	2000	None
22	22.50131067030	-29.35644521780	Hutton	2000	2000	None
23	22.50124222020	-29.35848561130	Hutton	2000	2000	None
24	22.50609609870	-29.35829242890	Hutton	1800	1800	None
25	22.50416122980	-29.36027691780	Hutton	2200	2200	None
26	22.49881182930	-29.35852551690	Hutton	2200	2200	None
27	22.48445389290	-29.34616146030	Hutton	1500	1500	None
28	22.48682403010	-29.34612971960	Hutton	1600	1600	None
29	22.48903444770	-29.34817500640	Hutton	1500	1500	None
30	22.48688623980	-29.34819692020	Hutton	1500	1500	None
31	22.48942553500	-29.35651620670	Hutton	1700	1700	None
32	22.49804825720	-29.36557190570	Hutton	1000	1200	Rock
33	22.49589874170	-29.36403871630	Mispah	400	400	Rock
34	22.50189063400	-29.36204370260	Plooysburg	1000	1000	Hardpan Carbonate
35	22.49967787910	-29.36381988700	Plooysburg	600	600	Hardpan Carbonate
36	22.49993694680	-29.36201559600	Plooysburg	600	600	Hardpan Carbonate
37	22.49646327230	-29.35844588470	Plooysburg	1000	1400	Hardpan Carbonate
38	22.49792538460	-29.36403502010	Plooysburg	1300	1300	Hardpan Carbonate
39	22.49391216540	-29.36396739830	Plooysburg	500	500	Hardpan Carbonate

Nr	X	Y	Soil Form	Soil Depth (mm)	Drainable Depth (mm)	Limiting Material
40	22.49201242130	-29.36216025740	Plooysburg	1000	1200	Hardpan Carbonate
41	22.49181974070	-29.36028399820	Plooysburg	600	600	Hardpan Carbonate
42	22.50352297010	-29.35435673660	Hutton	1700	1700	None
43	22.50117740690	-29.35435855590	Hutton	2000	2000	None
44	22.49883634210	-29.35224248620	Hutton	1600	1600	None
45	22.49639352440	-29.35018552890	Hutton	1700	1700	None
46	22.49875984400	-29.35013786850	Hutton	1800	1800	None
47	22.50114409150	-29.35014526270	Hutton	1800	1800	None
48	22.50118321740	-29.35222150590	Hutton	2000	2000	None
49	22.49635553620	-29.34813504860	Hutton	2000	2000	None
50	22.49393797780	-29.34610489830	Hutton	1800	1800	None
51	22.49165476190	-29.34405465000	Hutton	1900	1900	None
52	22.49404224520	-29.34813288120	Hutton	900	1200	Rock
53	22.49892984910	-29.35648857770	Hutton	2000	2000	None
54	22.49650282710	-29.35639596100	Hutton	1700	1700	None
55	22.49651489060	-29.35436471720	Hutton	700	900	Rock
56	22.49418156900	-29.35448387640	Hutton	900	1300	Rock
57	22.49371439730	-29.35391878380	Glenrosa	400	400	Rock
58	22.49174110040	-29.35440123590	Hutton	1600	1600	None
59	22.48941427810	-29.35450542510	Mispah	200	200	Rock
60	22.48934387110	-29.35234332630	Mispah	200	200	Rock
61	22.49170760240	-29.35223239040	Plooysburg	1400	1600	Hardpan Carbonate
62	22.49169367190	-29.35021598990	Hutton	1900	1900	None
63	22.49641606680	-29.35223348760	Hutton	1800	1800	None
64	22.49890479040	-29.35423294850	Hutton	1800	1800	None
65	22.49407589780	-29.35226331900	Hutton	1500	1700	Loose Stones
66	22.49406042320	-29.35017082770	Hutton	1600	1600	None
67	22.48925700380	-29.35050666870	Hutton	1400	1400	None
68	22.48698589460	-29.35225869470	Hutton	1500	1600	Loose Stones
69	22.48700367420	-29.35021164350	Hutton	1500	1500	None
70	22.48465246950	-29.35028222850	Hutton	1500	1500	None
71	22.48465845000	-29.35234361140	Hutton	1500	1500	None
72	22.48466363730	-29.35234336050	Hutton	1500	1500	None
73	22.48235078160	-29.35232506640	Hutton	1500	1500	None
74	22.49162221090	-29.34601455960	Hutton	800	1200	Loose Stones
75	22.49158372620	-29.34816496270	Hutton	1700	1700	None
76	22.48457530230	-29.34831257660	Hutton	1500	1500	None
77	22.48223222660	-29.34625640350	Hutton	1500	1500	None
78	22.48224302660	-29.34831341200	Hutton	1500	1500	None
79	22.48214952500	-29.35037508710	Hutton	1500	1500	None
80	22.47975184070	-29.35452872200	Hutton	1100	1250	Rock
81	22.48468645130	-29.35452834520	Hutton	500	1000	Rock
82	22.48709099030	-29.35446096170	Hutton	1200	1400	Loose Stones

Appendix 2: Chemical soil properties

Sample	Soil Form	Diagnostic horizon	Ca mg/kg	Ca cmol(+)/kg	Mg mg/kg	Mg cmol(+)/kg	Na mg/kg	Na cmol(+)/kg	K mg/kg	K cmol(+)/kg	P mg/kg	pH KCl
1A	Hutton	Orthic A	386.0	1.9	126.0	1.0	12.7	0.1	146.9	0.4	10.6	6.1
1B		Red Apedal B	532.0	2.7	279.2	2.3	15.0	0.1	93.6	0.2	3.6	5.6
2A	Hutton	Orthic A	453.4	2.3	103.0	0.8	8.4	0.0	165.4	0.4	16.0	4.9
2B		Red Apedal B	516.5	2.6	275.0	2.3	25.2	0.1	122.7	0.3	3.2	5.4
3A	Hutton	Orthic A	360.5	1.8	125.7	1.0	12.7	0.1	123.5	0.3	12.0	4.7
3B		Red Apedal B	839.2	4.2	306.3	2.5	38.6	0.2	112.0	0.3	3.0	5.1
4A	Hutton	Orthic A	326.2	1.6	99.2	0.8	10.8	0.0	184.8	0.5	14.0	4.7
4B		Red Apedal B	577.7	2.9	177.6	1.5	17.2	0.1	252.2	0.6	3.2	5.5
5A	Hutton	Orthic A	499.2	2.5	189.3	1.6	16.4	0.1	215.1	0.6	9.2	5.6
5B		Red Apedal B	480.3	2.4	358.3	2.9	26.8	0.1	99.5	0.3	2.0	5.5
6A	Hutton	Orthic A	396.3	2.0	124.1	1.0	10.0	0.0	121.4	0.3	8.6	5.4
6B		Red Apedal B	561.8	2.8	284.8	2.3	10.3	0.0	208.5	0.5	4.0	5.4
7A	Plooysburg	Orthic A	896.9	4.5	297.8	2.4	20.6	0.1	286.4	0.7	5.2	5.4
7B		Red Apedal B	2462.0	12.3	653.2	5.4	28.1	0.1	142.6	0.4	2.4	5.7
8A	Hutton	Orthic A	992.8	5.0	348.7	2.9	15.2	0.1	423.4	1.1	17.8	5.4
8B		Red Apedal B	1927.8	9.6	558.6	4.6	36.6	0.2	206.1	0.5	2.4	5.5
8B2		Lithocutanic B	2365.6	11.8	685.9	5.6	34.0	0.1	108.5	0.3	2.4	5.9

Sample	Soil Form	Diagnostic horizon	Exchangeable Acidity cmol(+)/kg	Base Sat (norm 5 - 30)	Ca:Mg (norm 1.5 - 4.5)	Mg:K (norm 3 - 4)	(Ca+Mg)/K (norm 10 - 20)	%Ca/BK (norm +-65)	%Mg/BK (norm +-25)
1A	Hutton	Orthic A	0.2	4.2	1.9	2.7	7.9	56.9	30.4
1B		Red Apedal B	0.3	4.5	1.2	9.6	20.7	50.6	43.6
2A	Hutton	Orthic A	0.3	7.3	2.7	2.0	7.4	63.5	23.6
2B		Red Apedal B	0.4	7.1	1.1	7.2	15.4	49.1	42.9
3A	Hutton	Orthic A	0.3	8.0	1.7	3.3	9.0	56.3	32.2
3B		Red Apedal B	0.3	4.0	1.7	8.8	23.4	58.6	35.1
4A	Hutton	Orthic A	0.2	7.2	2.0	1.7	5.2	55.0	27.4
4B		Red Apedal B	0.2	4.3	2.0	2.3	6.7	57.0	28.7
5A	Hutton	Orthic A	0.3	6.2	1.6	2.8	7.4	53.5	33.2
5B		Red Apedal B	0.3	4.8	0.8	11.5	21.0	42.1	51.4
6A	Hutton	Orthic A	1.0	22.1	1.9	3.3	9.7	59.1	30.3
6B		Red Apedal B	0.2	2.6	1.2	4.4	9.6	49.1	40.8
7A	Plooysburg	Orthic A	0.2	2.9	1.8	3.3	9.5	57.9	31.5
7B		Red Apedal B	0.2	1.3	2.3	14.7	48.5	67.8	29.5
8A	Hutton	Orthic A	0.2	2.5	1.7	2.6	7.2	55.3	31.9
8B		Red Apedal B	0.3	2.2	2.1	8.7	27.0	64.7	30.7
8B2		Lithocutanic B	0.3	1.8	2.1	20.3	62.9	66.2	31.5

Sample	Soil Form	Diagnostic horizon	%Na/BK (norm <2)	ESP %	%K/BK (norm +-10)	BC (basic Cations) cmol(+)/kg	CEC cmol(+)/kg
1A	Hutton	Orthic A	1.6	1.6	11.1	3.4	3.5
1B		Red Apedal B	1.2	1.2	4.6	5.3	5.5
2A	Hutton	Orthic A	1.0	0.9	11.8	3.6	3.9
2B		Red Apedal B	2.1	1.9	6.0	5.3	5.7
3A	Hutton	Orthic A	1.7	1.6	9.9	3.2	3.5
3B		Red Apedal B	2.3	2.3	4.0	7.2	7.5
4A	Hutton	Orthic A	1.6	1.5	15.9	3.0	3.2
4B		Red Apedal B	1.5	1.4	12.7	5.1	5.3
5A	Hutton	Orthic A	1.5	1.4	11.8	4.7	5.0
5B		Red Apedal B	2.0	1.9	4.5	5.7	6.0
6A	Hutton	Orthic A	1.3	1.0	9.3	3.4	4.3
6B		Red Apedal B	0.8	0.8	9.3	5.7	5.9
7A	Plooysburg	Orthic A	1.2	1.1	9.5	7.7	8.0
7B		Red Apedal B	0.7	0.7	2.0	18.2	18.4
8A	Hutton	Orthic A	0.7	0.7	12.1	9.0	9.2
8B		Red Apedal B	1.1	1.0	3.5	14.9	15.2
8B2		Lithocutanic B	0.8	0.8	1.6	17.9	18.2

Sample	**Soil Form**	**Diagnostic horizon**	**pH (extract)**	**Ece mS/m**
1A	Hutton	Orthic A	7.88	0.0618
1B		Red Apedal B	7.19	5.22
2A	Hutton	Orthic A	6.98	6.83
2B		Red Apedal B	6.97	12.51
3A	Hutton	Orthic A	7.04	12.81
3B		Red Apedal B	7.09	7.26
4A	Hutton	Orthic A	6.94	73.1
4B		Red Apedal B	7.2	11.68
5A	Hutton	Orthic A	7.22	8.86
5B		Red Apedal B	7.28	7.07
6A	Hutton	Orthic A	7.32	6.29
6B		Red Apedal B	7.18	8.39
7A	Plooysburg	Orthic A	7.28	7.8
7B		Red Apedal B	7.38	20.1
8A	Hutton	Orthic A	7.58	7.4
8B		Red Apedal B	7.29	72.5
8B2		Lithocutanic B	7.76	16.26

Appendix 3: Modal profiles

General Information

Profile no:	1				Soil form:	Hutton
Map/Photo example:	Figure 3a				Soil family:	
GPS Position:	22,491729; -29,354484				Colour	Red
Surface stones:	0%				Occurrence of flooding:	None
Altitude:	968 m				Wind erosion potential:	High
Terrain unit:	Mid slope				Water erosion potential:	Medium
Slope:	1%				Vegetation/Land use:	Natural Veld
Slope shape:	Planform	Straight	Profile	Straight	Water table:	None
Aspect:	None					
Micro-relief:	None				Described by:	George van Zijl
Parent material solum:	Aeolian sands				Date described:	2018-06-08
Geological group:	Koegas Subgroup, Ghaap 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	Single Grain Apedal	None	No	Diffuse
B1	1700+	Red Apedal B	Red	Single Grain Apedal	None	No	None

General Information							
Profile no:	2					Soil form:	Glenrosa
Map/Photo example:	Figure 3c					Soil family:	
GPS Position:	22,489168 -29,346112					Colour	Red
Surface stones:	10%					Occurrence of flooding:	None
Altitude:	966 m					Wind erosion potential:	Medium
Terrain unit:	Mid slope					Water erosion potential:	Low
Slope:	2%					Vegetation/Land use:	Natural Veld
Slope shape:	Planform	Straight	Profile	Straight		Water table:	None
Aspect:	None						
Micro-relief:	None					Described by:	Cassie du Plessis
Parent material solum:	Aeolian sands					Date described:	2018-06-08
Geological group:	Koegas Subgroup, Ghaap Group					Weathering of underlying material:	Physical

Profile Information

Horizon	*Depth (mm)*	*Diagnostic Horizon*	*Colour*	*Structure*	*Redoximorphic features*	*Lime*	*Transition*
A	300	Orthic A	Red	Single Grain Apedal	None	No	Clear
B	1 000	Lithocutanic B	Red	Single Grain Apedal	None	No	Gradual
R	1 300	Rock					

General Information						
Profile no:	3				Soil form:	Mispah
Map/Photo example:	Figure 3d				Soil family:	
GPS Position:	22,489355 -29,354484				Colour	Red
Surface stones:	20%				Occurrence of flooding:	None
Altitude:	966 m				Wind erosion potential:	Medium
Terrain unit:	Mid slope				Water erosion potential:	Low
Slope:	2%				Vegetation/Land use:	Natural Veld
Slope shape:	Planform	Straight	Profile	Straight	Water table:	None
Aspect:	None					
Micro-relief:	None				Described by:	George van Zijl
Parent material solum:	Aeolian sands				Date described:	2018-06-08
Geological group:	Koegas Subgroup, Ghaap Group				Weathering of underlying material:	Physical

Profile Information

Horizon	*Depth (mm)*	*Diagnostic Horizon*	*Colour*	*Structure*	*Redoximorphic features*	*Lime*	*Transition*
A	200	Orthic A	Red	Single Grain Apedal	None	No	Clear
R	200	Rock					

General Information							
Profile no:	4					Soil form:	Plooysburg
Map/Photo example:						Soil family:	
GPS Position:	22,491667 -29,352172					Colour	Red
Surface stones:	10%					Occurrence of flooding:	None
Altitude:	969 m					Wind erosion potential:	High
Terrain unit:	Mid slope					Water erosion potential:	Medium
Slope:	2%					Vegetation/Land use:	Natural Veld
Slope shape:	Planform	Straight	Profile	Straight		Water table:	None
Aspect:	None						
Micro-relief:	None					Described by:	George van Zijl
Parent material solum:	Aeolian sands					Date described:	2018-06-08
Geological group:	Koegas Subgroup, Ghaap Group					Weathering of underlying material:	Physical

Profile Information

Horizon Depth (mm)	*Diagnostic Horizon*	*Colour*	*Structure*	*Redoximorphic features*	*Lime*	*Transition*
A 300	Orthic A	Red	Single Grain Apedal	None	No	Diffuse
B 1 000	Red Apedal	Red	Single Gran Apedal	None	No	Clear
B 1 200	Lithocutanic B	Red	Single Grain Apedal	None	No	Clear
R 1 200	Hardpan Carbonate	White	Massive	Lime	Yes	None

Appendix 4: Agronomical Report: Lucerne

Agronomical report for the production of lucerne on the farm Bultfontein, near Prieska, Northern Cape

1. General soil requirements lucerne (*Medicago sativa*) production

The suitability of the farm Bultfontein site described in this report for lucerne production is based on the physical and chemical soil properties presented in this report. Lucerne (*Medicago sativa*) has a very strong root system and therefore can grow in a range of soil conditions. Lucerne prefers soils with light to medium texture (i.e. sandy to sandy loam), with a minimum of 600 mm of the soil being freely drained. The roots can penetrate up to 3 000 mm but the majority of the water is extracted from the first 1 200 mm. Lucerne can be cultivated on soils with a clay content that varies from less than 10% to more than 30%; with clay percentages of between 10% and 30% being preferred as a result of optimal air and water regimes. At clay percentages less than 10% the water management requires more care, but lucerne should still produce well when managed well.

In general, lucerne can be cultivated in a wide range of climates, but needs approximately 1 000 mm of water during growing season; about 75 mm of water for producing 1 ton of dry matter. Based on the climate (cold winters with approximately 750 mm rain) and management option (irrigation), the yield potential is approximately 15 $t.ha^{-1}$ dry matter. Lucerne can be produced on soils with a pH(H2O) of 5.5-8.0, but the optimum pH(H2O) range for lucerne is 6.5-7.5. Lucerne requires P, K, Ca and S as well as Gypsum; fertilizer requirements should however be based on soil analysis of soil samples which should preferably be taken in May – June on established crops or prior to establishment.

2. Specific Bultfontein situation

a. Soil depth

The soil on the site shown as suitable is generally deeper than 1200 mm, and is therefore suitable for lucerne production.

b. Soil texture

The texture of the soil profiles is extremely coarse, with clay percentages generally less than 7%. Thus, the soils will be well drained, but have a low water holding capacity. Special care should be taken with irrigation scheduling, but excellent yields are still possible when adequately managed. Wind erosion, surface encrustation after planting and soil compaction might however occur. These factors can and have to be managed by the producer in accordance to the selected tillage system.

c. pH

The pH $_{(KCl)}$ of the soil samples are between 4.7 and 6.1, which is acceptable for lucerne production, but lower than the optimal values. Liming should be considered and pH should be monitored as part of the fertilization regime. Soil pH values will drop once irrigation commences due to fertilization and leaching.

d. Salinity and sodicity

The highest Electrical Conductivity measurement (73 $mS.m^{-1}$) is within the norms and standards for lucerne production. The ESP values are also acceptable and should decline once irrigation commences. Even though there is no current threat for salinity or sodicity, irrigation does influence these factors and it should be managed continuously as part of a sustainable fertilization and irrigation program.

e. Other chemical elements

Lucerne requires P, K, Ca and S as well as Gypsum; fertilizer requirements should however be based on soil analysis of soil samples which should preferably be taken in May – June on established crops.

3. Conclusion

The available soil properties, soil depth, soil texture, soil pH and EC values are all within the required range for lucerne production under irrigation. The low clay percentage requires specific attention to water management. A good fertilizer regime will address any potential fertility issues. With adequate management, this area should produce very good lucerne crops. It is therefore recommended that the area be approved for lucerne cultivation under irrigation.