SOIL SUITABILITY FOR IRRIGATION ON THE FARM KLOOF NO 143

PREPARED FOR

ECO-CON ENVIRONMENTAL

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EXECUTIVE SUMMARY

A soil suitability survey was conducted on the farm, Kloof nr 143, near Niekerkshoop to assess the soil suitability for irrigation in support of an application for a ploughing certificate to allow irrigation. The lands were sparsely situated and therefore the area was divided into 3 areas. Area A with an existing irrigation and Area B, has not been irrigated for many years and Area C was under a centre pivot.

The soils are not typical windblown sands associated with the area. The Prieska soil form was the most frequently observed. The soils have a varying degree of free lime in the horizons. The Hutton and Bainsvlei soil forms are the exception as they overlie hard rock and soft plinthite rather than a carbonate horizon. The suitability of these three soil forms for irrigation is dependent on the depth of the B horizon.

The laboratory analyses show that the soils are suitable for irrigation if it possesses adequate drainage. In the Addo, the pH is somewhat neutral, and the ECe is values are adequately low (36, 65 $mS.m^{-1}$) but ESP is high ESP (7.9%). In the Hutton, the pH is neutral, and the ECe is values are very low (<20 $mS.m^{-1}$) but ESP is very high ESP (13%). However, the ESP is indicative of the low Ca and Mg values, rather than high Na values. Irrigation and fertilization should correct the ESP values.

The soils are generally suitable for irrigation with most of the soils classifying as unsuitable found in the north of Area A. (Figure A). Due to the presence of carbonates in varying degrees, drainage is problematic in general. Cross ripping of the area is advised to improve the drainage on the areas with shallow hardpan carbonate layers and highly weathered saprolite. Area C consists mostly of deep red soils with no carbonates and therefore the most suitable soils in the study area due to the depth and drainage.

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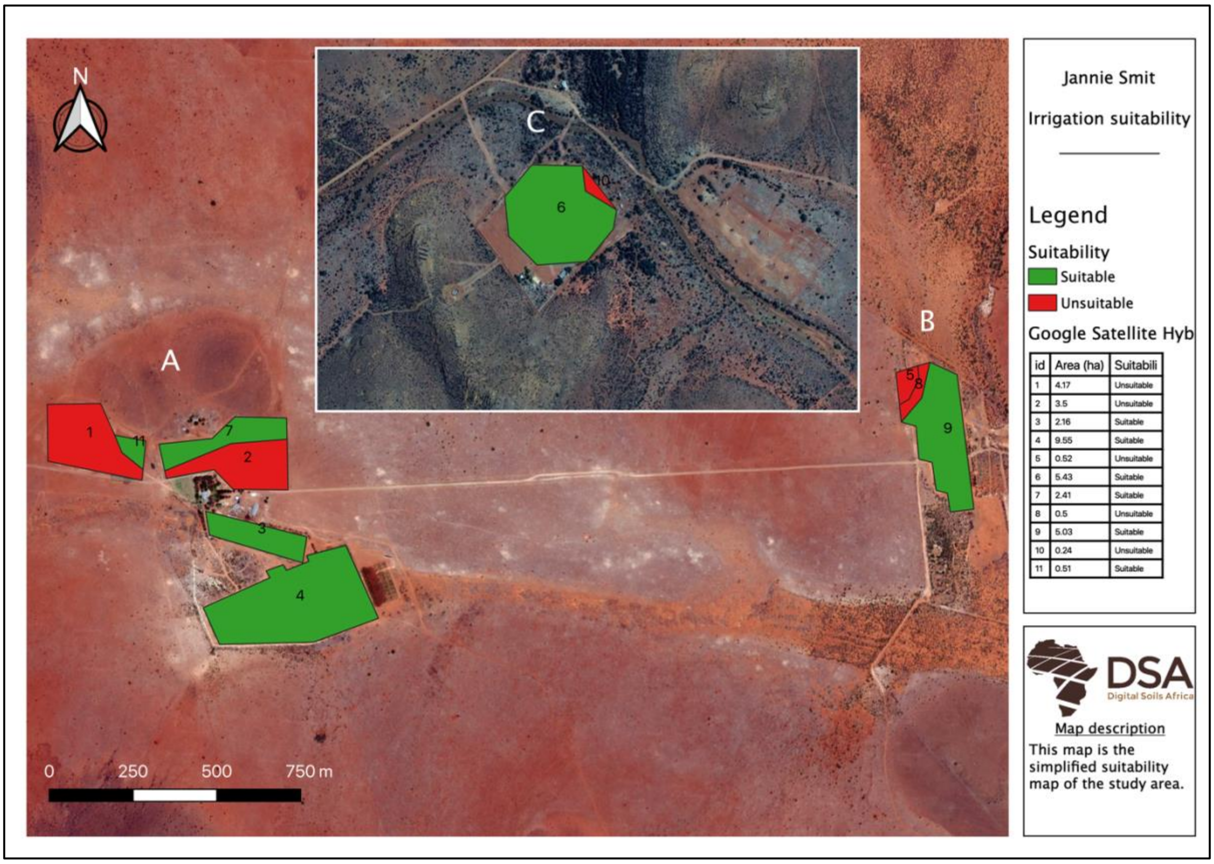

Figure A: Rectangular area suitable for irrigation.

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INTRODUCTION

Digital Soils Africa conducted an irrigation suitability survey on the farm, Kloof nr 143, near Niekerkshoop. 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 irrigation 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.

LOCATION AND OBSERVATIONS

The site is located near Niekerkshoop in the Northern Cape Province (Figure 1) and consists of 3 areas (Marked A, B and C). Most of the surveyed areas of the farm have existing centre pivot and lands, the perimeters of the study areas are shown in Table 1.

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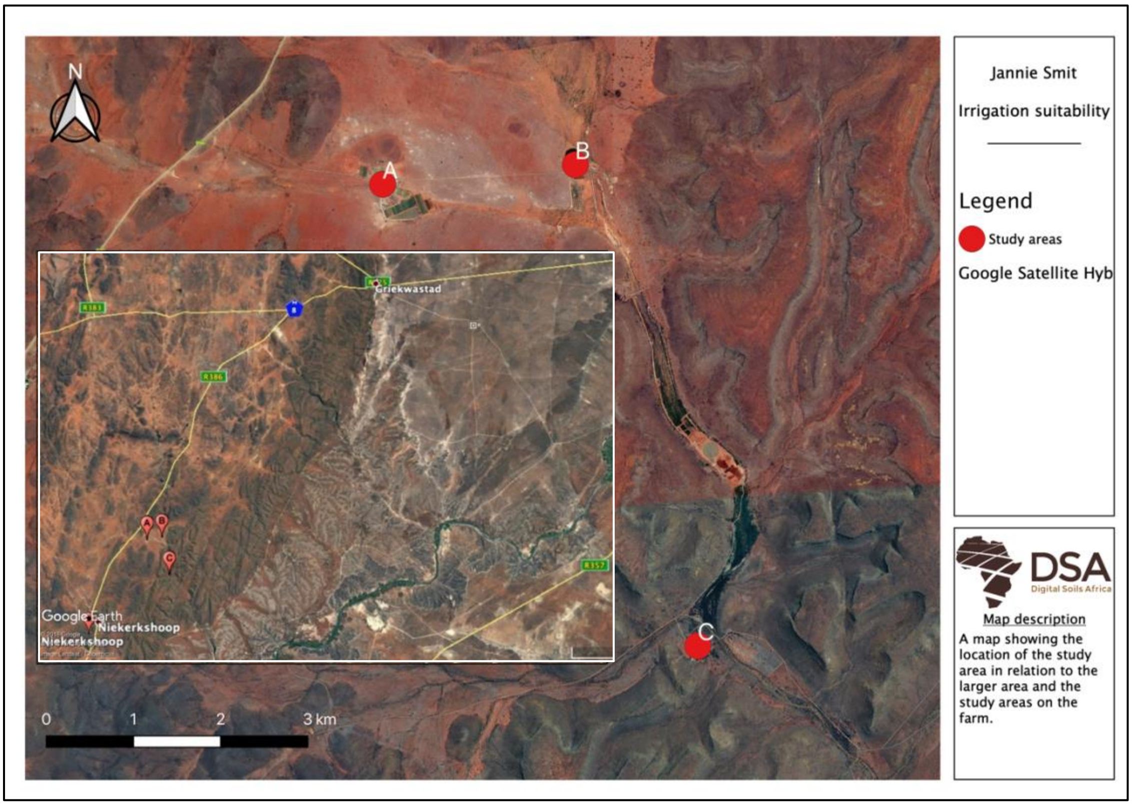

FIGURE 1: THE LOCATION OF THE STUDY SITES.

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

X	Y
Area A 1	
22.8953396	-29.215099
22.8969768	-29.215053
22.8974281	-29.215901
22.8983846	-29.216047
22.8982877	-29.217109
22.8953876	-29.21663
22.8953396	-29.215099
Area A 2	
22.9004193	-29.215948
22.901107	-29.215356
22.9026965	-29.215364
22.902776	-29.217301
22.9010907	-29.217309
22.900496	-29.216789
22.8990336	-29.217048
22.8987895	-29.216124
Area A 3	
22.9002547	-29.217911
22.9033756	-29.218556
22.9032236	-29.219309
22.9003888	-29.218553
22.9002547	-29.217911
Area A 4	
22.9056149	-29.22072
22.9036332	-29.221392
22.9007501	-29.221494
22.900228	-29.220511
22.9022632	-29.219674
22.9021382	-29.219493
22.9026564	-29.219318
22.9027634	-29.219469
22.9034539	-29.219215
22.9033816	-29.219063
22.9045753	-29.218772
22.9056149	-29.22072

Area B

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22.9056149	-29.22072
22.9036332	-29.221392
22.9007501	-29.221494
22.900228	-29.220511
22.9022632	-29.219674
22.9021382	-29.219493
22.9026564	-29.219318
22.9027634	-29.219469
22.9034539	-29.219215
22.9033816	-29.219063
22.9045753	-29.218772
22.9056149	-29.22072

Area C	
22.9373573	-29.263849
22.938693	-29.26385
22.9397816	-29.265037
22.938852	-29.266067
22.9375417	-29.266168
22.9367794	-29.265512
22.9366568	-29.264599
22.9373573	-29.263849

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.

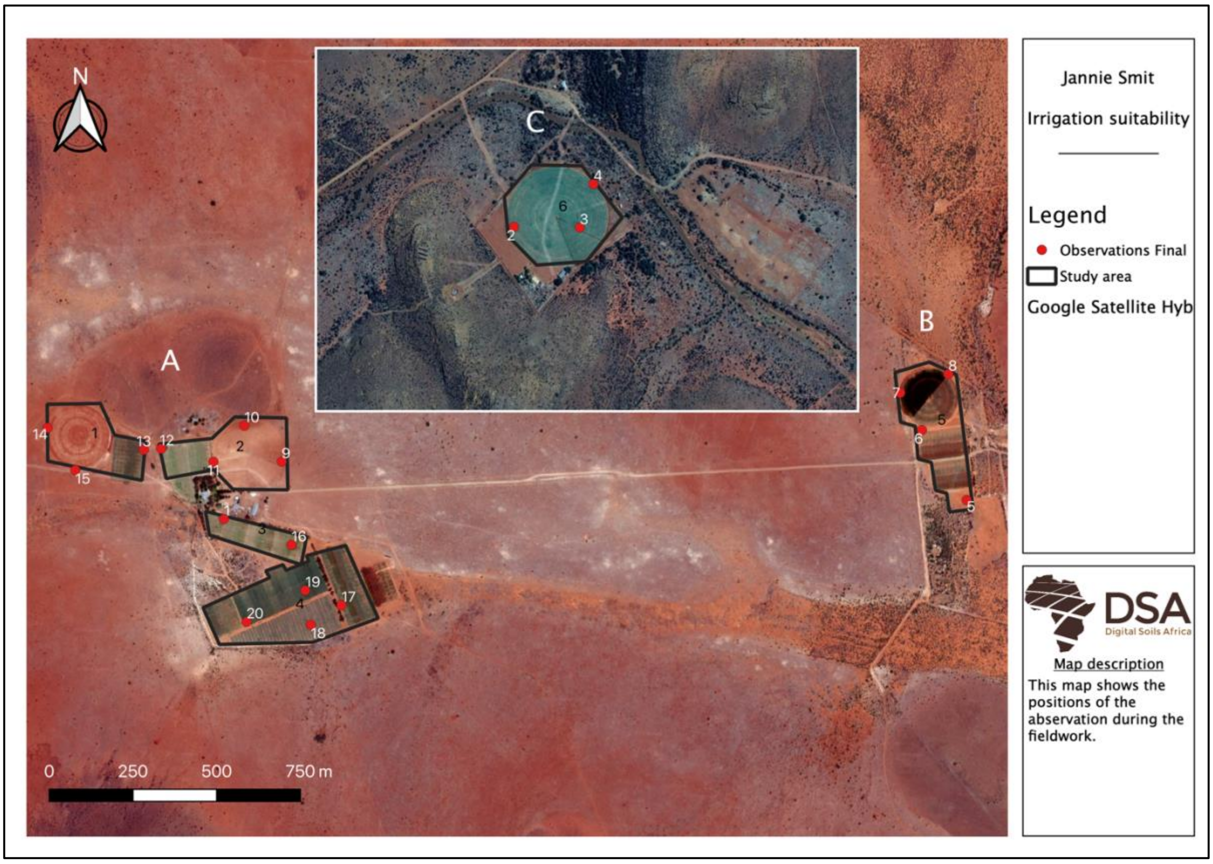

FIGURE 2: LOCATION OF OBSERVATIONS AND SAMPLE POINTS.

RESULTS

SOILS FORMS

The soil distribution is very varied on this site, as evidenced through the 7 soil forms present (Table 2, Figure 3). The soils are not typical windblown sands associated with the area. The Prieska soil form was the most frequently observed and is a red calcareous material overlying a carbonate layer which has precipitated and dominates the horizons. The Hutton and Bainsvlei soil forms, which were observed 3 times and once respectively, are the exception as they overlie hard rock and soft plinthite rather than a carbonate horizon. The suitability of these three soil forms for irrigation is dependent on the depth of the B horizon. The Addo and Brandvlei soil forms are similar in that they are largely calcareous and but differ due to the horizons directly under the topsoil doesn't display a morphology dominated by lime accumulation (i.e. you cannot see the lime), whereas this is the case with the Brandvlei soil form. The suitability for irrigation of the calcareous soil horizons is indicated by the laboratory analysis, as they often contain high amounts of salts, precipitated due to impermeability. Lastly,

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the Mispah and Coega soil forms are shallow soils, with the Mispah being underlain by hard rock, and the Coega with hardpan carbonate. Descriptions of the diagnostic soil horizons are given in the text, while Figures 4 and 5 show the spatial distribution of the soil forms and limiting layers respectively.

TABLE 2: THE PREVALENT SOIL FORMS IN THE STUDY AREA

Soil form	A Horizon	B Horizon	B2/C Horizon	Obs
Hutton	Orthic A	Red apedal B	Rock	3
Bainsvlei	Orthic A	Red apedal B	Soft Plinthic	1
Addo	Orthic A	Neocarbonate B	Soft Carbonate B	3
Brandvlei	Orthic A	Soft Carbonate B		2
Mispah	Orthic A	Rock		1
Coega	Orthic A	Hardpan Carbonate		1
Prieska	Orthic A	Neocarbonate B	Soft Carbonate B	9

HORIZON DESCRIPTIONS

ORTHIC A

The character of the Orthic A horizon is linked to the first subsoil horizon. When the first subsoil horizon is either soft carbonate or neocarbonate B, then the A horizon contains lime and is a lighter in colour. The A horizon of the Hutton soils are sandy

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. There is a high stone content.

NEOCARBONATE B

A neocarbonate B horizon is similar to the red apedal horizon, but lime has accumulated in it to the point that it will effervesce with 10% cold HCl. The lime does not dominate the morphology of the soil horizon. This horizon had a higher clay content to the red apedal B horizon.

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SOFT CARBONATE

In a soft carbonate horizon, lime has accumulated to the point where it dominates the morphology of the horizon. The lime accumulation is indicative of slow water infiltration, but this could also be due to the low natural leaching potential.

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.

SOIL DEPTH

Two maps are given to show the soil depth. Figure 6 shows the depth of the freely drained material, which is the depth to which water will naturally drain well. This includes the red apedal B and neocarbonate B horizons. Figure 7 shows the depth of the drainable material, which is the depth at which an effective drainage pipe could be installed. This is the depth above the pedocutanic B, hardpan carbonate, hard rock, unspecified material with signs of wetness and soft plinthic horizons.

Similar to the soil forms, the soil depth varies considerably throughout the three sites. Generally, the soils are shallow to moderately deep, with the deepest soils in Area C.

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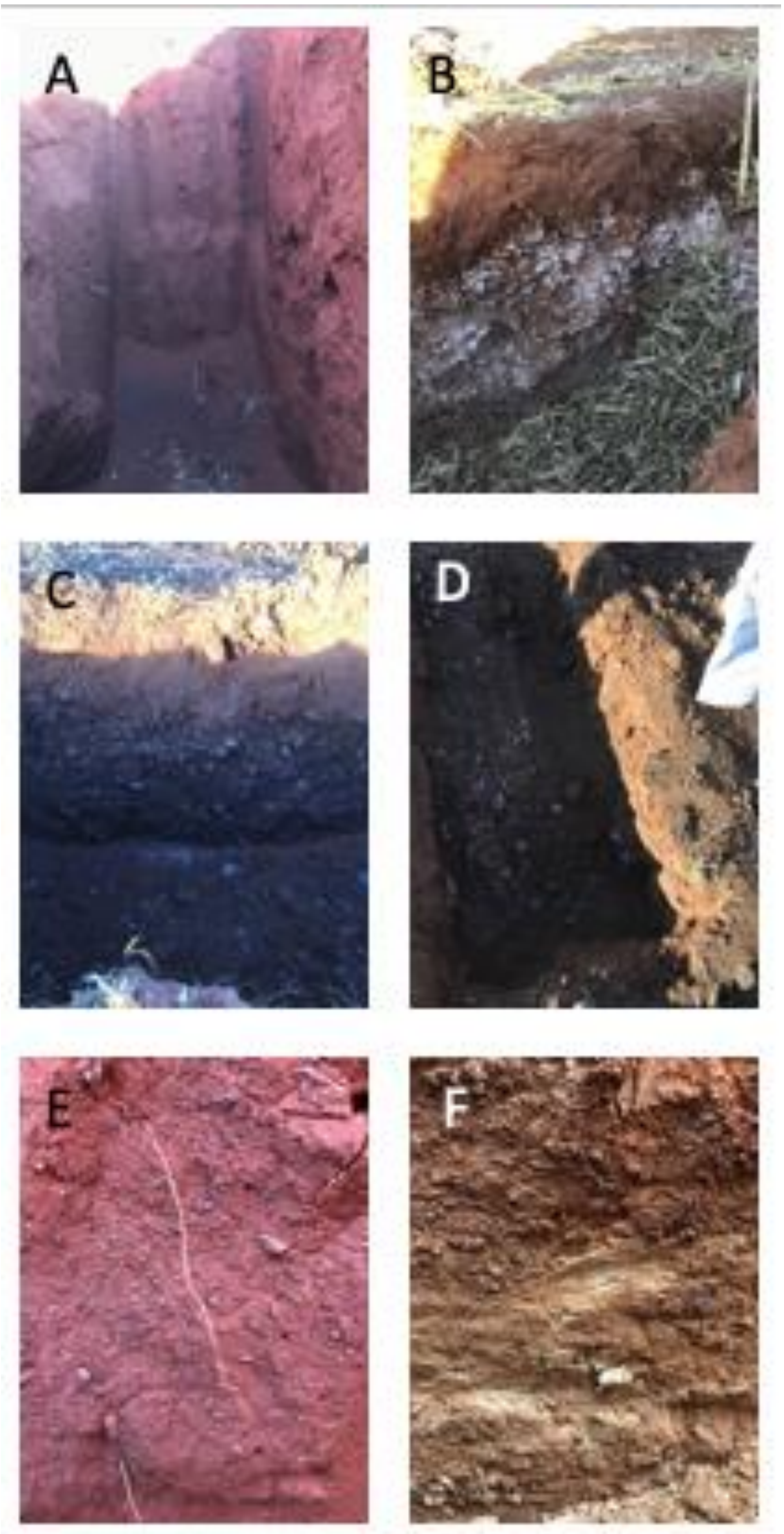

FIGURE 3: EXAMPLES OF THE SOILS FOUND ON THE STUDY SITE. A) HUTTON, B) BRANDVLEI, C) MISPAH ON VERY WEATHERED ROCK, D) SHALLOW COEGA, E) STONES IN THE HUTTON, AND F) SOFT PLINTHIC..

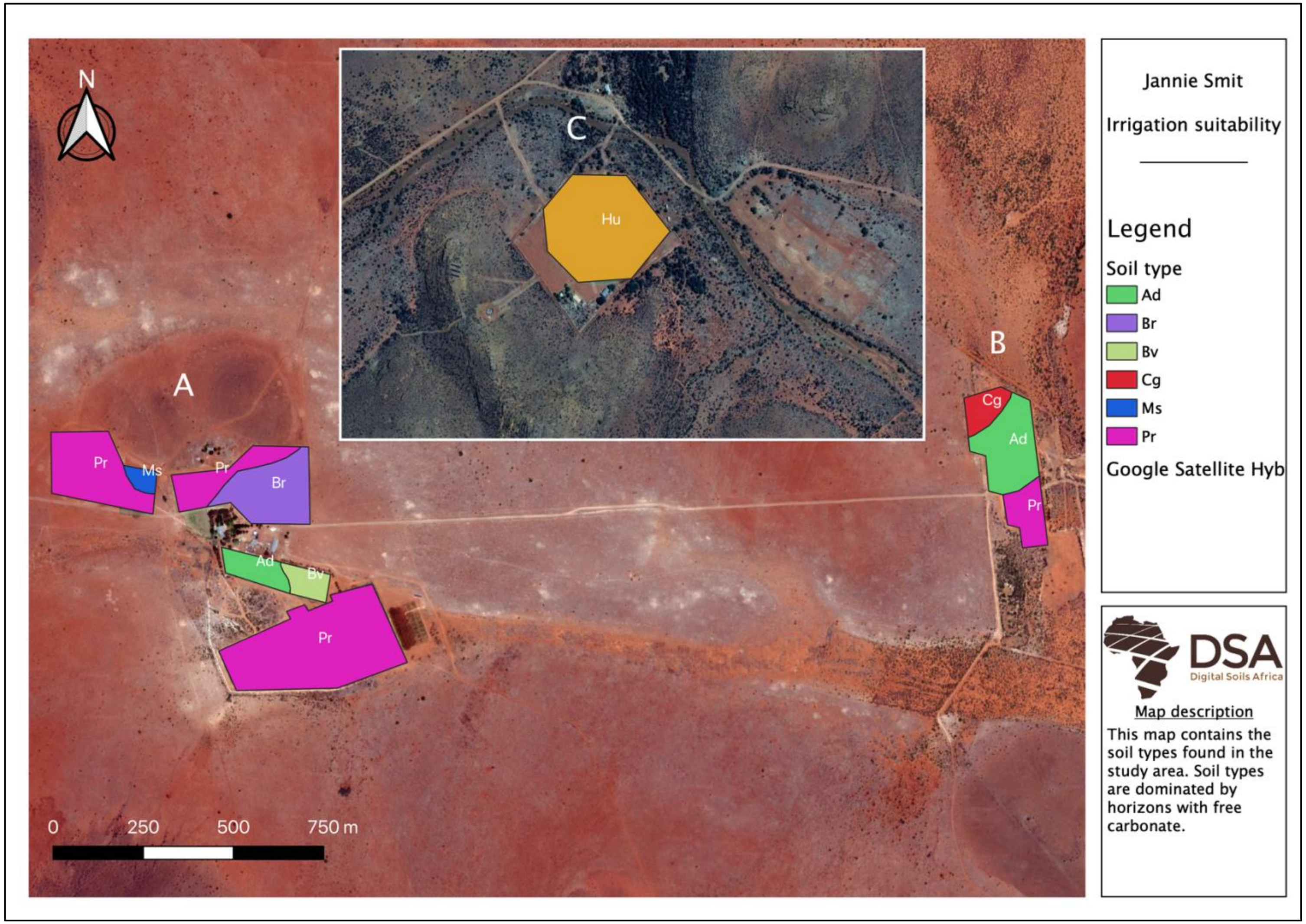

FIGURE 4: SOIL FORM DISTRIBUTION IN THE STUDY SITE.

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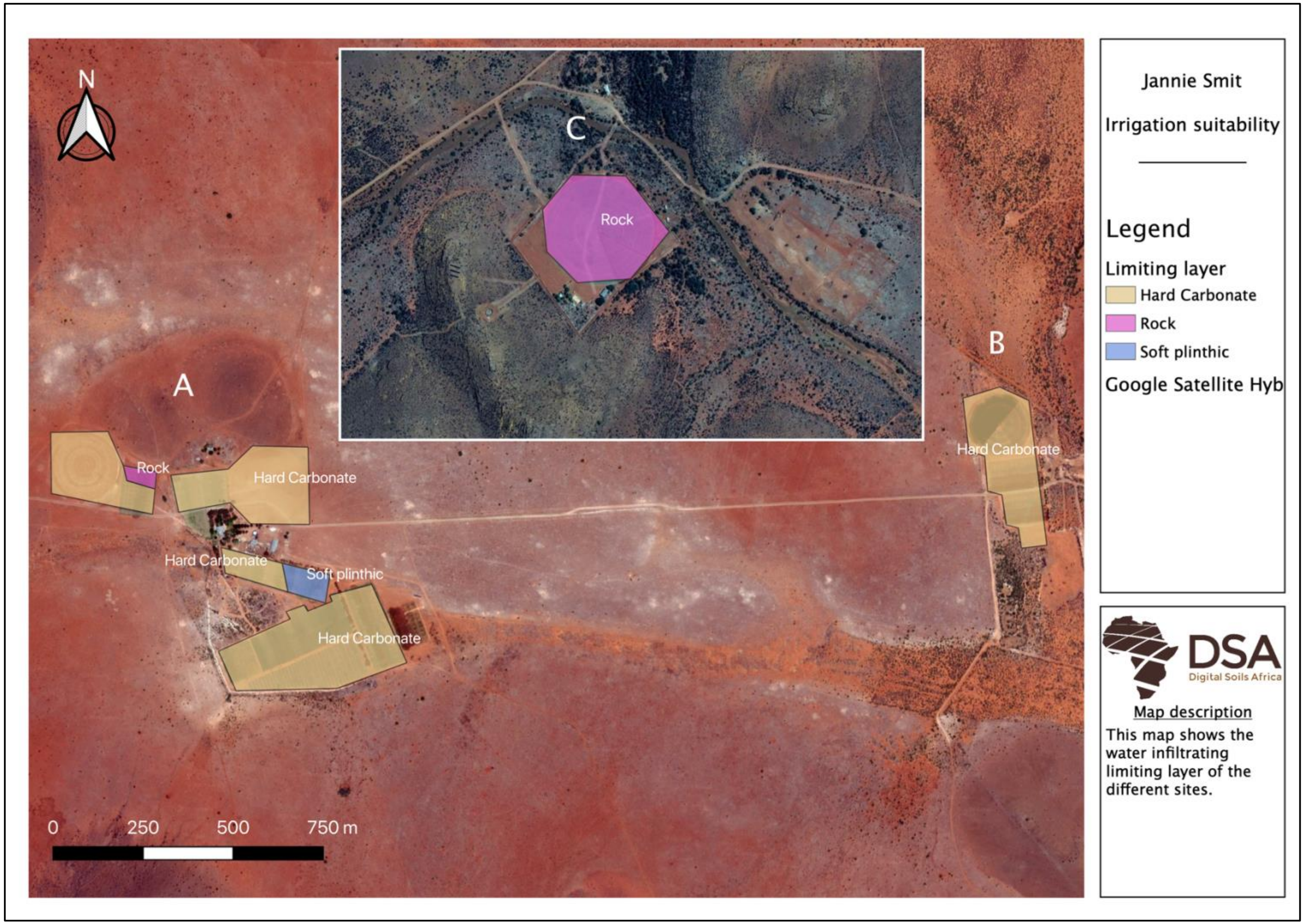

FIGURE 5: DEPTH LIMITING LAYER DISTRIBUTION IN THE STUDY SITE.

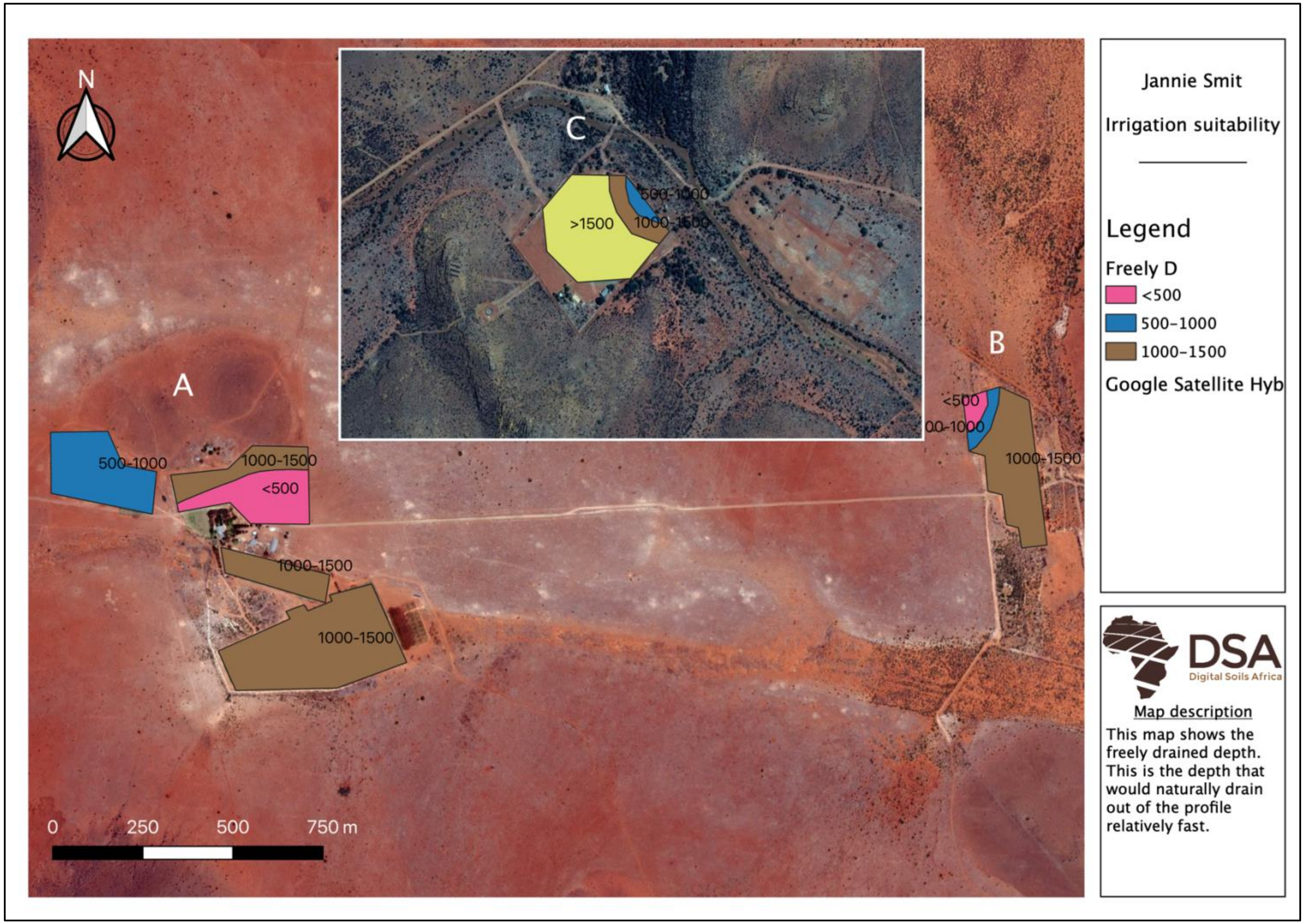

FIGURE 6: FREELY DRAINED DEPTH DISTRIBUTION IN THE STUDY SITE.

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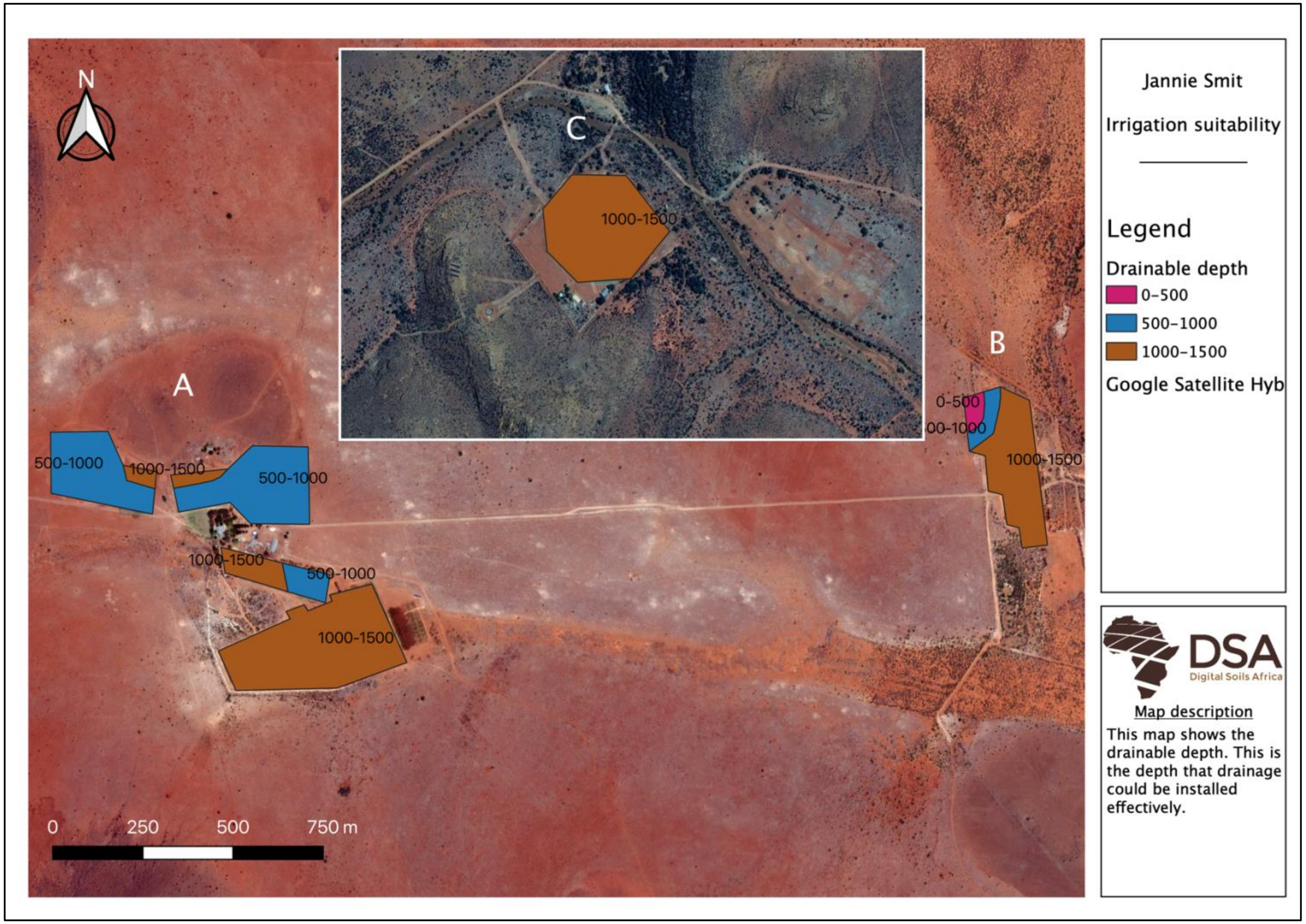

FIGURE 7: DRAINABLE DEPTH DISTRIBUTION IN THE STUDY SITE.

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CHEMICAL AND SOIL TEXTURE ANALYSIS

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

The pH values are relatively neutral, with values between 6.96 and 7.19. This indicates an accumulation of bases, which is expected due to the free lime within the soil profile. The pH values are below the 7.5 guidelines for irrigation suitability.

The CEC-values are low (11.79 cmol(+)/kg) to high (57 cmol(+)/kg), The 2A A horizons is relatively low and, thus fertility should be managed with an adequate fertilization plan to ensure optimal production.

The exchangeable sodium percentage (ESP) values fare high for all samples (2.66% - 13.76%). This indicates that sodicity is a general threat to irrigation on this site. The very high ESP of the Hutton soil is also due to the very low calcium content. Through irrigation and fertilization on soils with adequate drainage, the Na should leach out and be replaced with Ca, Ma and K, lowering the ESP and improving soil structure.

The Electrical Conductivity (ECe) values are all below 120 $mS.m^{-1}$, indicating non-saline conditions, well below the irrigation threshold of 400 $mS.m^{-1}$. This confirms that the High Na contents can be rectified in the soils.

The soils are not typical windblown sands common in the area, and higher clay contents are evident in most. The Hutton soils have a low clay content, but the high angular stone content suggests that soils could have formed in colluvial deposits from the high surrounding hills. Irrigation scheduling will be beneficial on both types of soil. The sandy soils will dry out relatively fast and the clay soils would require lower intensity irrigation over longer periods.

The laboratory results indicate that the chemical parameters are manageable, provided there are sufficient drainage. The texture results show that in general the soils does have sufficient drainage, except for the area with a soft plinthic horizon.

TABLE 3: SELECTED CHEMICAL RESULTS FOR THE MODAL SOIL PROFILES

Sample	Soil Form	Diagnostic Horizon	pH KCl	CEC cmol(+)/kg	ESP %	EC mS/m
1A	Addo	Orthic A	6.96	33.17	5.52	65.2
1B		Neocarbonate	6.96	22.47	7.93	36.5
2A	Hutton	Orthic A	7.19	11.89	13.65	19.11
2B		Red Apedal B	7.17	11.79	13.76	16.27
16C	Bainsvlei	Soft Plinthic	7.18	57.60	2.66	24.03

TABLE 4 SOIL TEXTURE RESULTS FOR THE MODAL SOIL PROFILES

Sample	Soil form	Diagnostic horizon	Clay %	Silt %	Sand %
1A	Addo	Orthic A	23.20	12.00	66.68
1B		Neocarbonate	21.60	14.60	65.23
2A	Hutton	Orthic A	8.60	3.20	89.64
2B		Red Apedal B	8.60	3.40	89.46
16C	Bainsvlei	Soft Plinthic	23.40	11.20	66.13

SUITABILITY

The soils are generally suitable for irrigation with most of the soils classifying as unsuitable found in the north of Area A. (Figure 8). Due to the presence of carbonates in varying degrees, drainage is problematic in general. Cross ripping of the area is advised to improve the drainage on the areas with shallow hardpan carbonate layers and highly weathered saprolite. Area C consists mostly of deep red soils with no carbonates and therefore the most suitable soils in the study area due to the depth and drainage. Figure 9 shows the area suitable for irrigation on a rectangular shape, while its perimeter points are given in Table 5.

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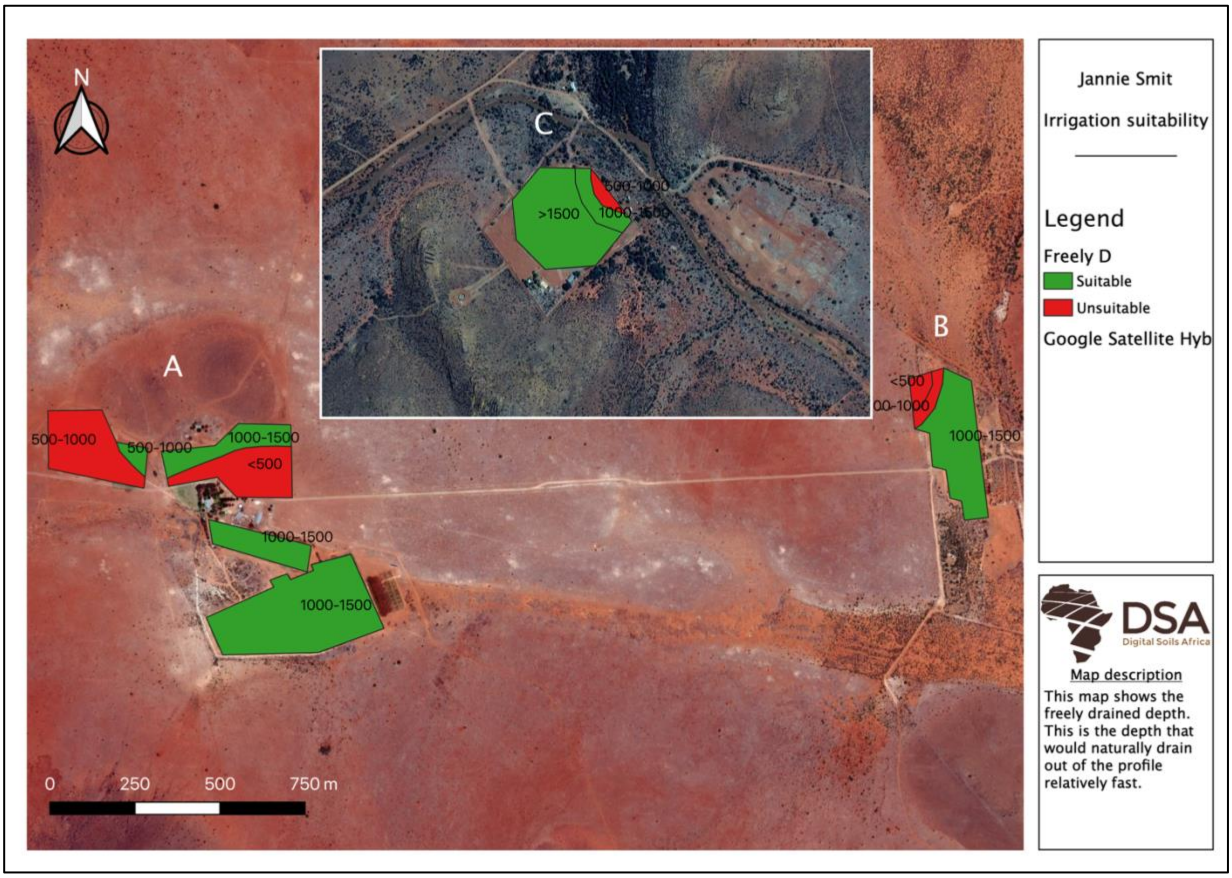

FIGURE 8: SUITABLE AREAS FOR IRRIGATION.

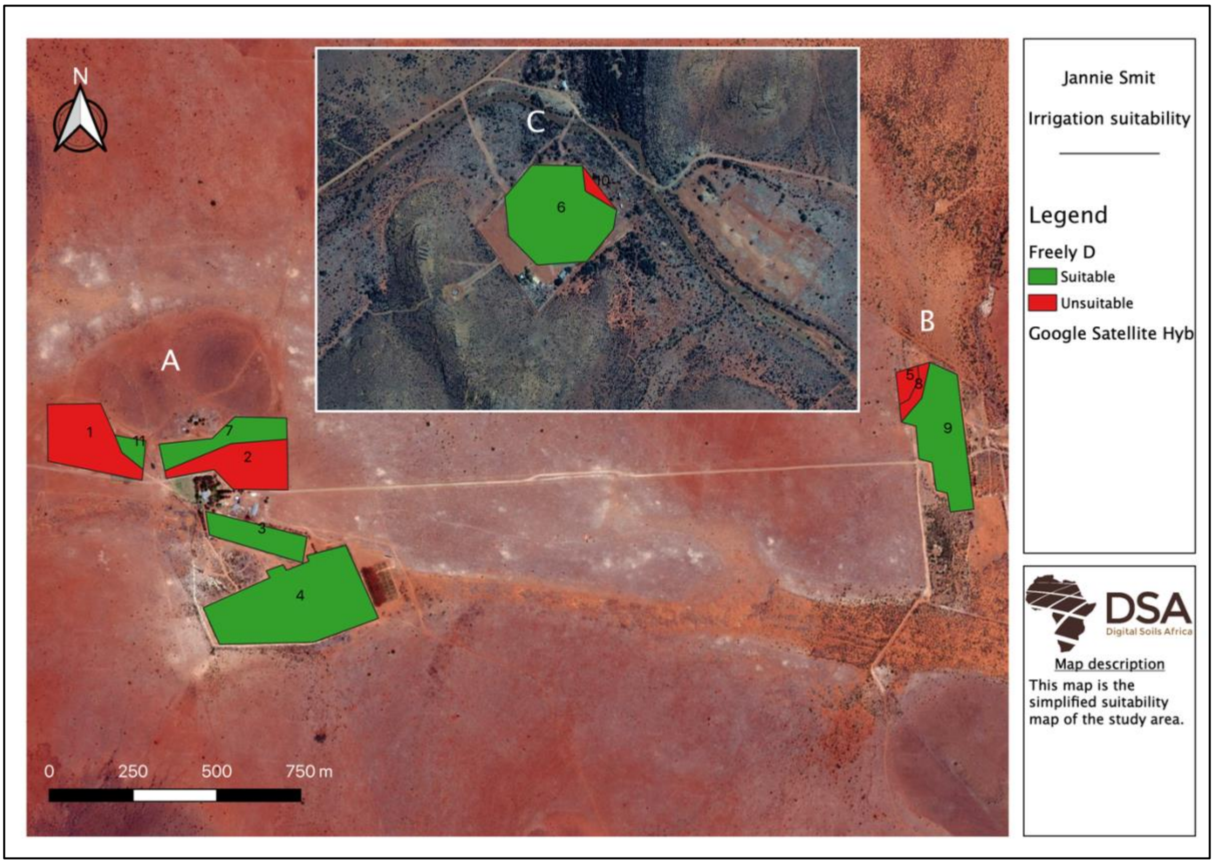

FIGURE 9: SUITABLE AREAS FOR IRRIGATION AT A RECTANGULAR SHAPE.

TABLE 5: THE COORDINATES OF THE CORNERS OF THE PERIMETER OF SUITABLE AREA NUMBERED ACCORING TO FIGURE 9

Area 3

X	Y
22.90025472	-29.2179112
22.9033756	-29.21855632
22.90326167	-29.21925976
22.90038883	-29.21855283
22.90025472	-29.2179112

Area 4

X	Y
22.90561488	-29.22072
22.90363318	-29.22139231
22.90075013	-29.2214943
22.90022798	-29.22051077
22.90226323	-29.21967384
22.90213823	-29.21949267
22.90265636	-29.2193176
22.90276342	-29.21946853
22.90345388	-29.21921478
22.90338156	-29.21906336
22.9045753	-29.21877195
22.90345388	-29.21921478
22.90338156	-29.21906336
22.9045753	-29.21877195
22.90561488	-29.22072

Area 6

X	Y
22.93735732	-29.26384921
22.93869301	-29.26385038
22.9387843	-29.26443419
22.9396188	-29.2648592
22.93953962	-29.26530485
22.93885201	-29.26606715
22.93754166	22.93754166
22.93677941	-29.26551162
22.93665676	-29.26459906
22.93735732	-29.26384921

Area 7

X	Y
22.90271999	-29.21593542
22.90100728	-29.2160753
22.89897882	-29.21684015
22.89878954	-29.21612401
22.90041933	-29.21594764
22.90110702	-29.21535563
22.90269654	-29.21536367
22.90271999	-29.21593542
22.90271999	-29.21593542
22.90100728	-29.2160753

Area 9

X	Y
22.9215652	-29.215203
22.9221809	-29.214545
22.9224128	-29.213575
22.9232541	-29.213902
22.9238356	-29.217519
22.9231091	-29.217605
22.923014	-29.217099
22.92267	-29.217029
22.9225275	-29.216279
22.922119	-29.216191
22.9220169	-29.21531
22.9215652	-29.215203

Area 11

X	Y
22.8983146	-29.216814
22.898313	-29.216814
22.8976538	-29.216362
22.8974281	-29.215901
22.8983846	-29.216047
22.8983146	-29.216814

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CONCLUSION

The absence of redox morphology (except for the one soft plinthic horizon) indicates that the soils are suitable for the irrigation. Depth was often the limiting factor in many of the soils deemed unsuitable. The clay percentage in the Prieska was slightly high, but still sufficient for irrigation. The chemical properties indicate that the samples taken were sufficient for irrigation.

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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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1. APPENDICES

APPENDIX 1: SOIL OBSERVATIONS

Obs nr	X	Y	Soil Type	Depth to Carbonate (mm)	Freely drained (mm)	Drainable (mm)	Limiting layer
1	22.9008278	-29.218114	Addo	1000	1000	1300	HC
2	22.936925	-29.265292	Hutton	na	1900	1900	R
3	22.9386667	-29.265283	Hutton	na	2000	2000	R
4	22.9390083	-29.264269	Hutton	na	600	1200	R
5	22.9236333	-29.217275	Prieska	na	1000	1000	Not reached
6	22.9222222	-29.215411	Addo	1400	1400	1600	HC
7	22.9215374	-29.214416	Coega	300	300	300	HC
8	22.9230083	-29.213892	Addo	1400	1400	1700	HC
9	22.9025722	-29.216542	Brandvlei	400	400	700	HC
10	22.9014047	-29.21559	Prieska	300	600	900	HC
11	22.9004749	-29.216575	Brandvlei	300	300	600	HC
12	22.8988697	-29.216244	Prieska	700	700	1000	HC
13	22.8983296	-29.216282	Mispah	na	300	1100	R
14	22.8953639	-29.215733	Prieska	600	600	600	HC
15	22.8962333	-29.216861	Prieska	600	600	600	HC
16	22.9029139	-29.218781	Bainsvlei	na	800	800	SP
17	22.9044826	-29.220385	Prieska	1100	1100	1100	HC
18	22.9035468	-29.220923	Prieska	1200	1200	1200	HC
19	22.9033611	-29.22	Prieska	1200	1200	1200	HC
20	22.901575	-29.220872	Prieska	1200	1200	1200	HC

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	Addo	Orthic A	4289.44	21.45	1044.90	8.56	421.50	1.83	518.10	1.33	84.40	6.96
1B		Neocarbonate	2444.32	12.22	922.30	7.56	410.00	1.78	353.62	0.90	52.40	6.96
2A	Hutton	Orthic A	1162.56	5.81	477.82	3.92	373.16	1.62	209.82	0.54	35.88	7.19
2B		Red Apedal B	1194.12	5.97	452.74	3.71	373.12	1.62	190.64	0.49	35.36	7.17
16C	Bainsvlei	Soft Plinthic	9854.56	49.27	710.16	5.82	352.44	1.53	381.38	0.98	23.68	7.18

Sample	Soil Form	Diagnostic Horizon	Exch Acidity (%)	Base Saturation	Ca:Mg	Mg:K	(Ca+Mg)/K	Ca/BK %	Mg/BK %	Na/BK %	K/BK	Basic Cations cmol(+)/kg	CEC cmol(+)/kg
1A	Addo	Orthic A	0.00	33.17	2.50	6.46	22.65	64.66	25.82	5.52	3.99	1.9	2.4
1B		Neocarbonate	0.00	22.47	1.62	8.36	21.87	54.39	33.65	7.93	4.03	8.0	9.0
2A	Hutton	Orthic A	0.00	11.89	1.48	7.30	18.13	48.89	32.94	13.65	4.51	1.3	1.8
2B		Red Apedal B	0.00	11.79	1.61	7.61	19.86	50.64	31.47	13.76	4.13	1.5	2.0
16C	Bainsvlei	Soft Plinthic	0.00	57.60	8.46	5.97	56.48	85.54	10.11	2.66	1.69	2.0	2.8

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