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Irrigation Suitability Report for 244 ha, near Griekwastad, Northern Cape Province

for

Hennie Stander

December 2017

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Executive summary

A soil survey was conducted for Hennie Stander on 244 ha near Griekwastad, Northern Cape Province, to assess the suitability of the area for the cultivation of potatoes under irrigation.

The soils of the study area are dominated by the Hutton soil form, an apedal red soil which is well drained. Most of the Hutton soils had loose stones in their deep subsoil, but as this material is also well drained, it was also regarded as suitable for irrigation. One observation, representing approximately 1 ha, was a Bloemdal soil observation. The Bloemdal soil form is insufficiently drained and poses a threat of water logging under irrigation conditions. The soil pH is acidic and lime should be applied before planting commences. Salinity is not a threat, as very low EC values were measured. Sodicity is on the threshold values, and should be managed. Liming and irrigation will control the ESP values. As the Bloemdal area is very small (1 ha) the entire site is regarded to comply with the irrigation guidelines of the Northern Cape Department of Agriculture(Figure A).

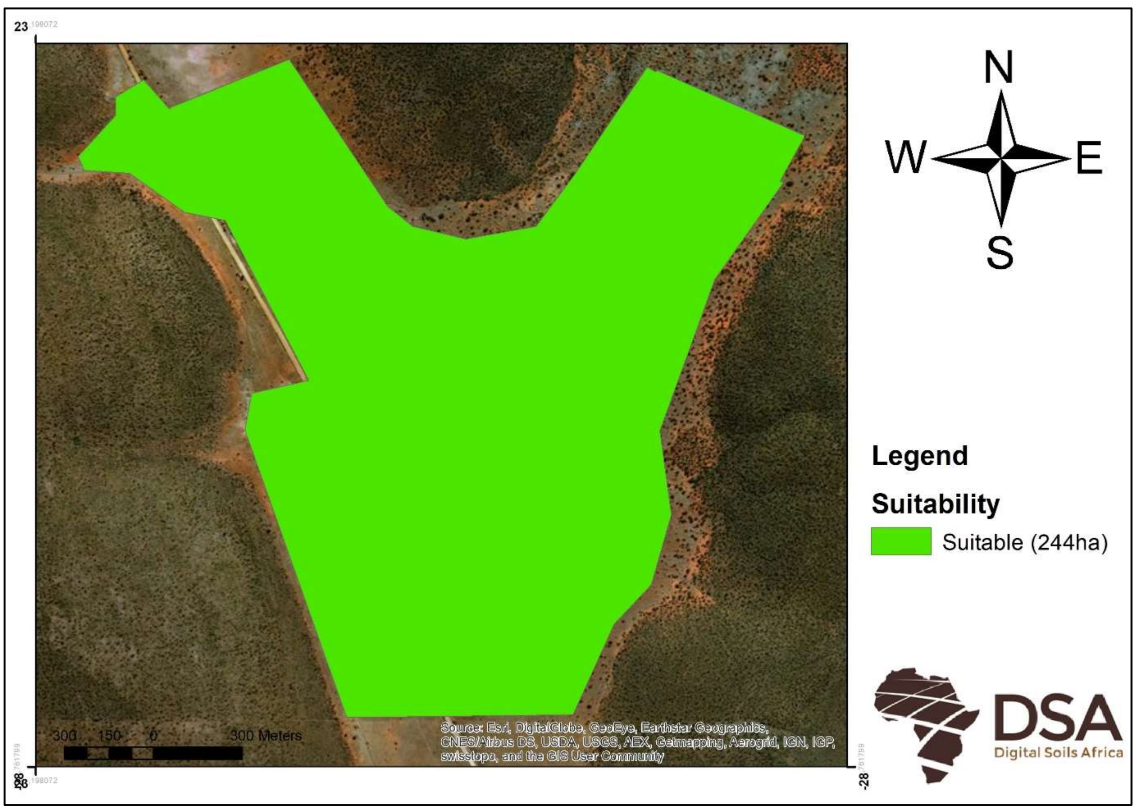

Figure A: The area suitable for irrigation at the site.

1. Introduction

Digital Soils Africa conducted a soil survey on a 244 ha piece of land near Griekwastad, in the Northern Cape Province. The aim of the survey was to determine the suitability of the soils for the cultivation of potatoes under irrigation. For sustainable irrigation of soil the risks of water logging, salinization and drainage 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 an extent that the soil cannot be vegetated anymore. These effects can be negated with proper management of soils with 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 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

The site is located approximately 12 km north of Griekwastad, on the gravel road heading to Metsimatala (Figure 1). The co-ordinates of the perimeter points of the surveyed area is shown in Table 1. The size of the surveyed area is 244 ha.

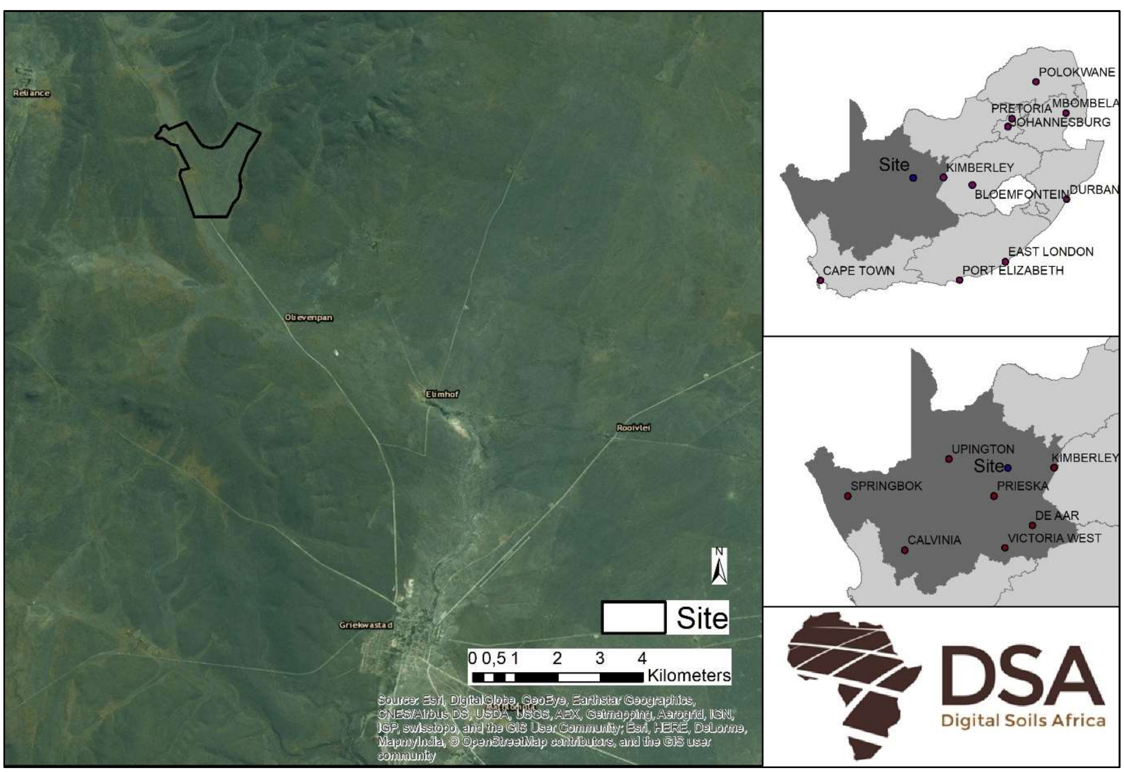

Figure 1: The location of the study site.

Table 1: Coordinates of the perimeter points of the site

Nr	X	Y
1	23.21667480470	-28.74047851560
2	23.22149658200	-28.74249267580
3	23.21447753910	-28.76019287110
4	23.20770263670	-28.76031494140
5	23.20452880860	-28.75158691410
6	23.20471191410	-28.75030517580
7	23.20629882810	-28.74987792970
8	23.20391845700	-28.74517822270
9	23.19952392580	-28.74340820310
10	23.20129394530	-28.74090576170
11	23.20208740230	-28.74169921880
12	23.20587158200	-28.74029541020
13	23.21130371090	-28.74572753910

3. Methodology

A field visit was conducted on the 9th of November 2017. Forty-six soil profiles were opened by the client to a depth of approximately 1500 mm or refusal using a TLB throughout the site. Soils were classified according to the Taxonomic Soil Classification System (Soil Classification Working Group, 1991). Soil depth and limiting material were noted and mapped. Fourteen samples of five modal profiles were taken for chemical and physical analysis, which included five topsoil samples (A horizons), five subsoil samples (B horizons) and four deep subsoil samples (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. Figure 2 shows the locations of the observation positions, while their GPS co-ordinates and information is given in Appendix 1.

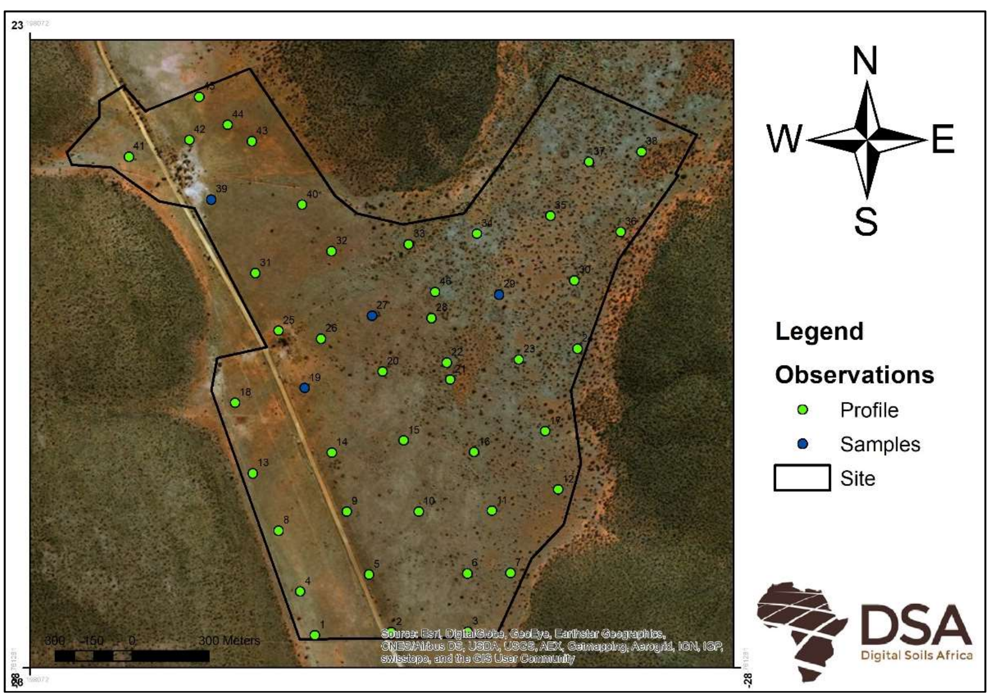

Figure 2: Soil observation locations for the study site.

4. Results

4.1. Soils forms

The most abundant soil form is the Hutton soil form, which was observed 45 times. However, a distinction could be made between Hutton soils with loose stones in the subsoil and Hutton soils without the loose stones, thus only being deep red sand for the full depth of the profile. Both types of Hutton soils will be conducive to irrigation, as their structure shows they are well drained to depths exceeding that of the soil profile. One Bloemdal soil observation was observed in a pan like area. The Bloemdal soil is not well drained, as it contains a horizon showing distinct signs of gleyed morphology, formed during saturation. However, this area is small and does not influence the irrigability of the entire site. Pictures of the two Hutton type soils are shown in Figure 3, while Figure 4 shows the abundance of plant roots within the loose stones. Table 2 shows the diagnostic horizons of the different observations, while Figure 5 shows the spatial extent of the different soil forms. Figure 6 shows where the different deep subsoil material occurs. An in-text description of the different diagnostic horizons is given.

Table 2: Diagnostic horizons of the different soil forms

Soil Form	A Horizon	B Horizon	B2/C Horizon	Nr of Obs
Hutton 1	Orthic A	Red Apedal B	Unspecified	11
Hutton 2	Orthic A	Red Apedal B	Stones	34
Bloemdal	Orthic A	Red Apedal B	Unspecified material with signs of wetness	1

Orthic A

The orthic A is sandy (approximately 15% 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 (approximately 15% 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 and the unspecified material with signs of wetness is abrupt.

Loose Stones

The loose stones commonly found under the red apedal 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.

Unspecified material with signs of wetness

This horizon exhibits gleyed morphology, indicative of it being waterlogged for extended periods of time. Thus, it shows an area where water will accumulate and is as such not conducive to irrigation.

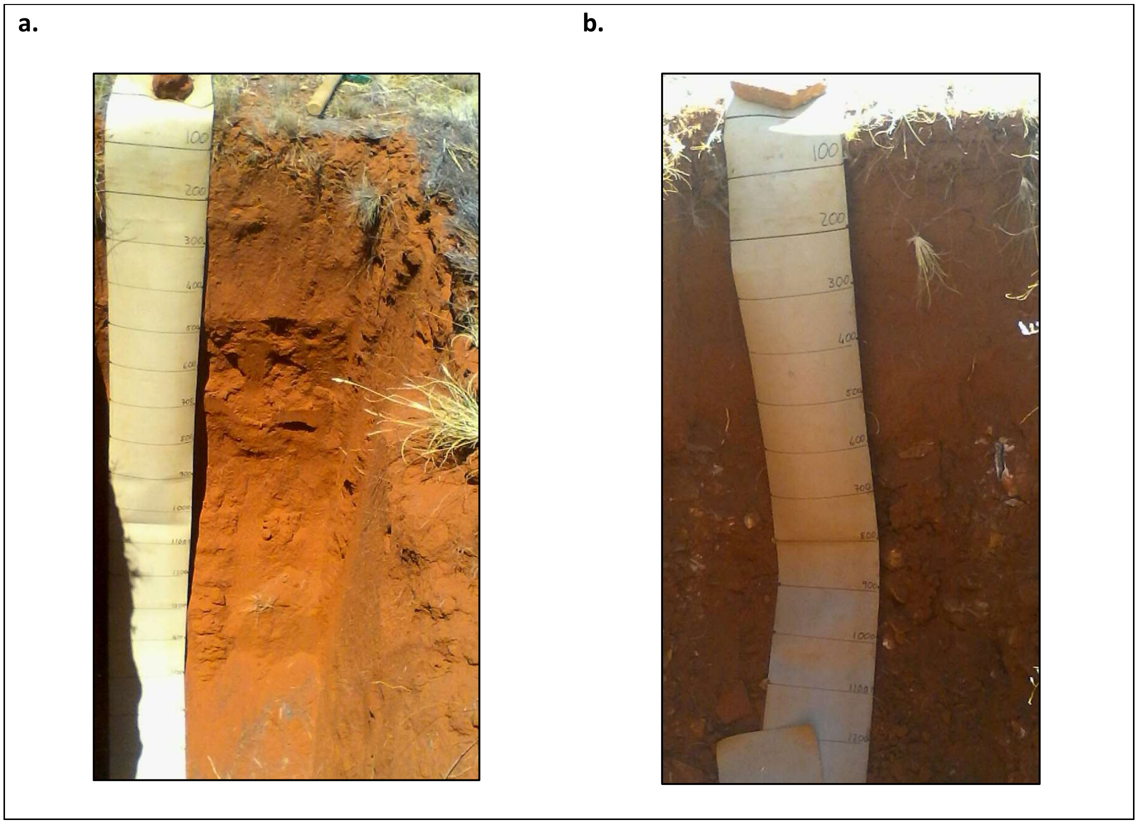

Figure 3: Examples of the two types of Hutton soils observed, with (b) and without (a) stones in the deep subsoil.

Figure 4: An example of the many plant roots growing within the loose stones layer.

4.2. Soil Depth

The soil distribution of the surveyed area is shown in Figure 5. Figure 6 shows the depth of the red soil before it reaches the loose stones, unspecified material with signs of wetness or the bottom of the profile pit, while Figure 7 shows the drainable depth, which is the observation depth in all cases except for the Bloemdal observation.

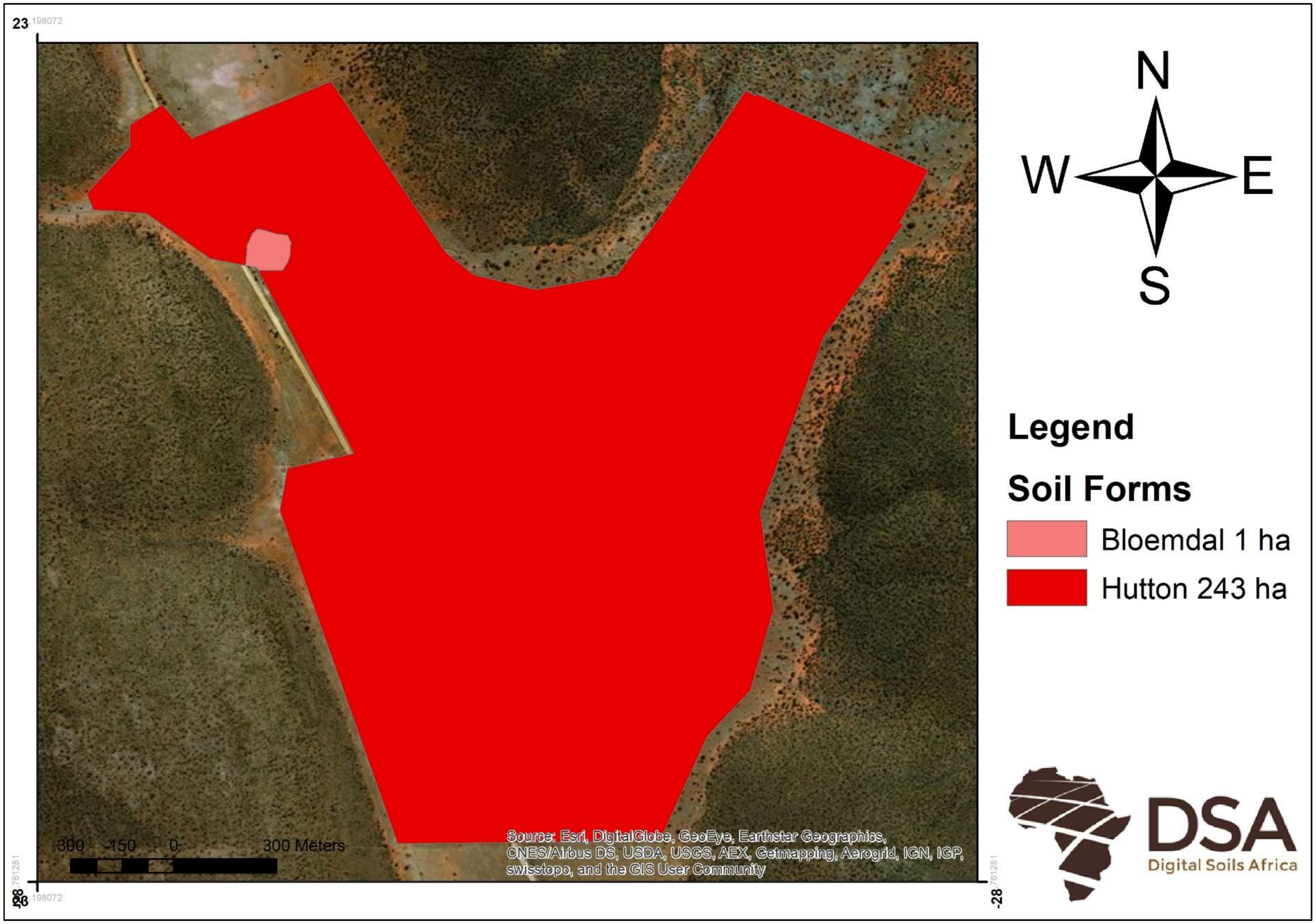

Figure 5: Distribution of the soil forms on the study site.

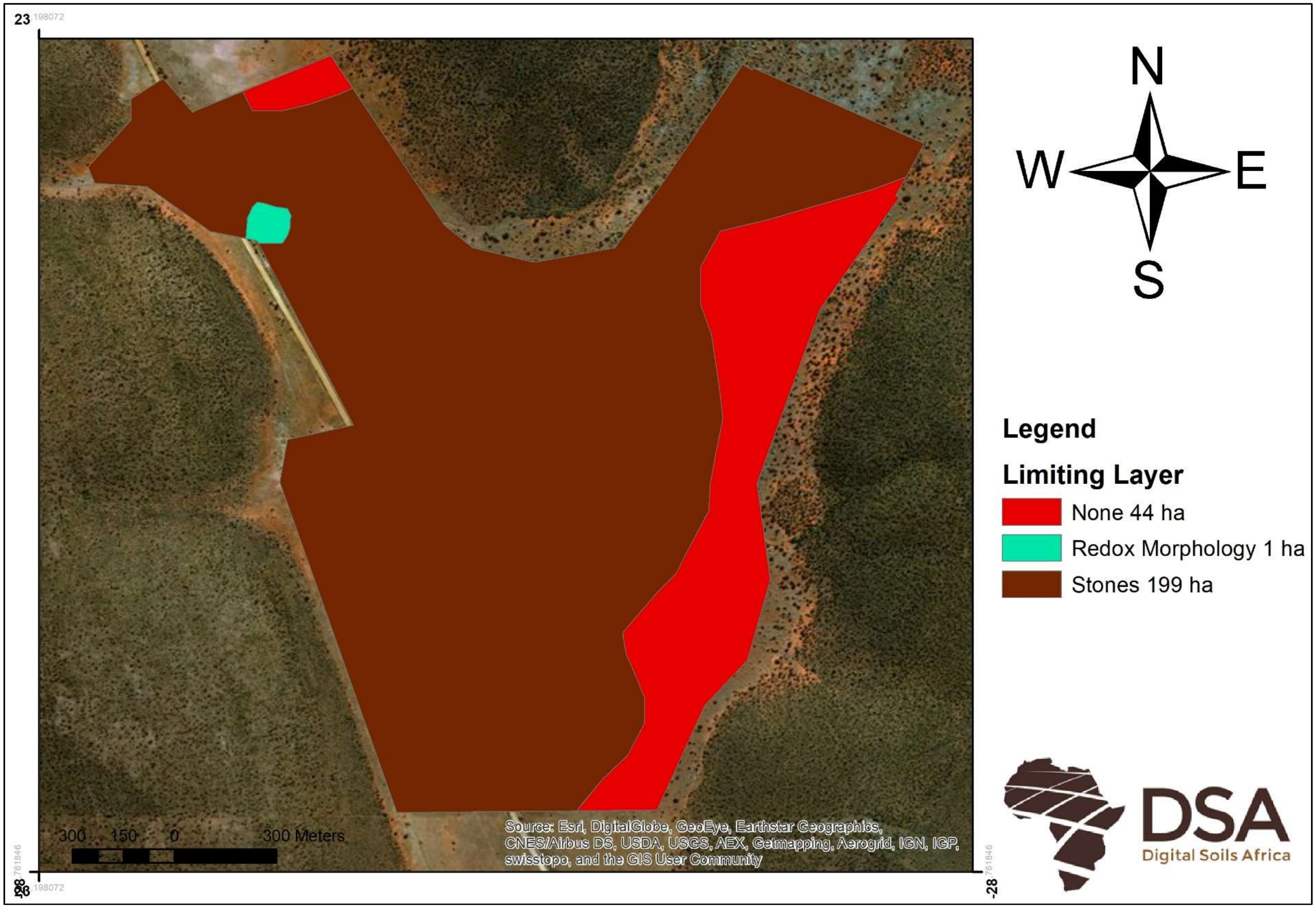

Figure 6: Depth limiting layers of the study site.

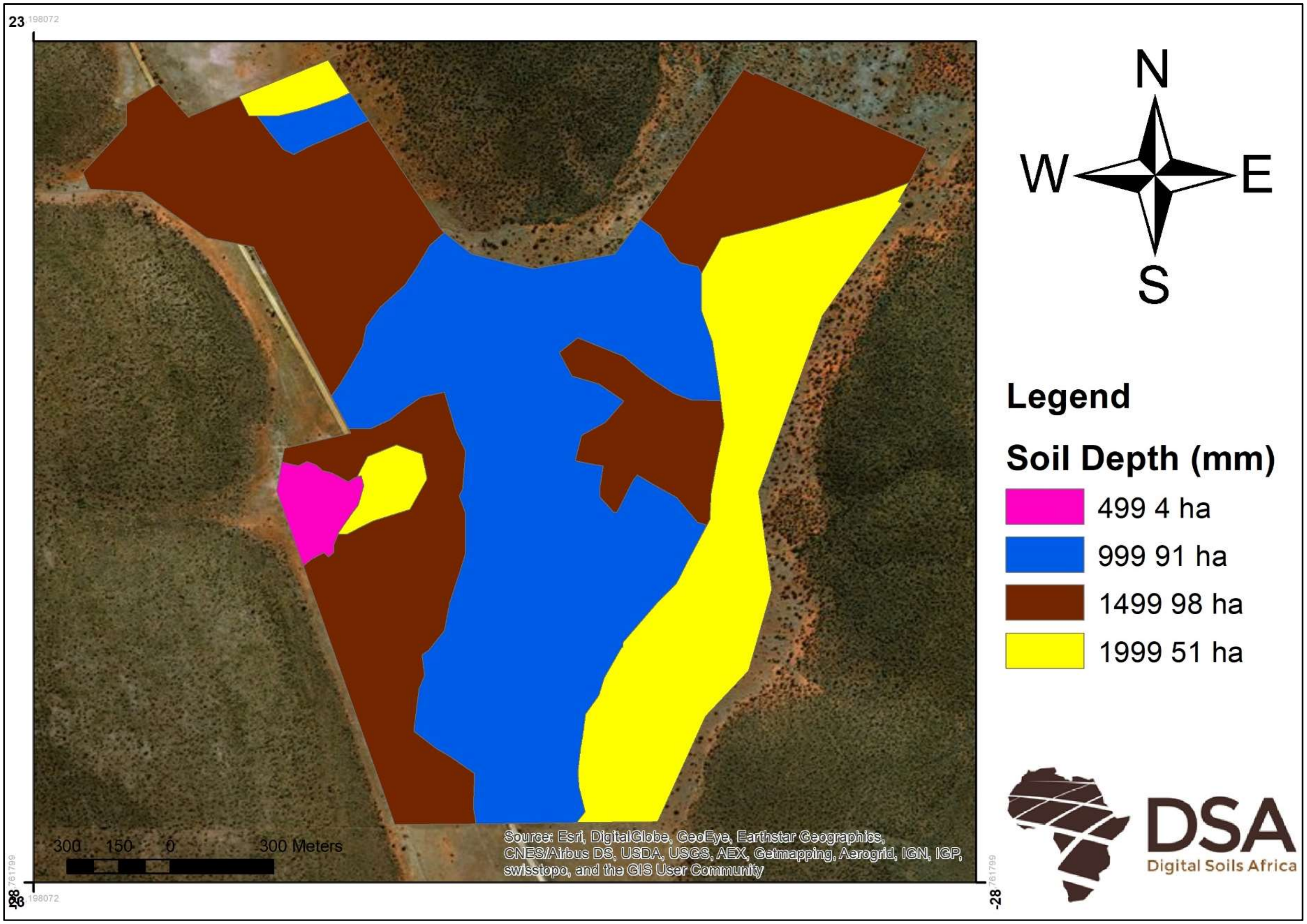

Figure 7: Depth of the red soil, before it reaches loose stone, unspecified material with signs of wetness or the bottom of the profile pit.

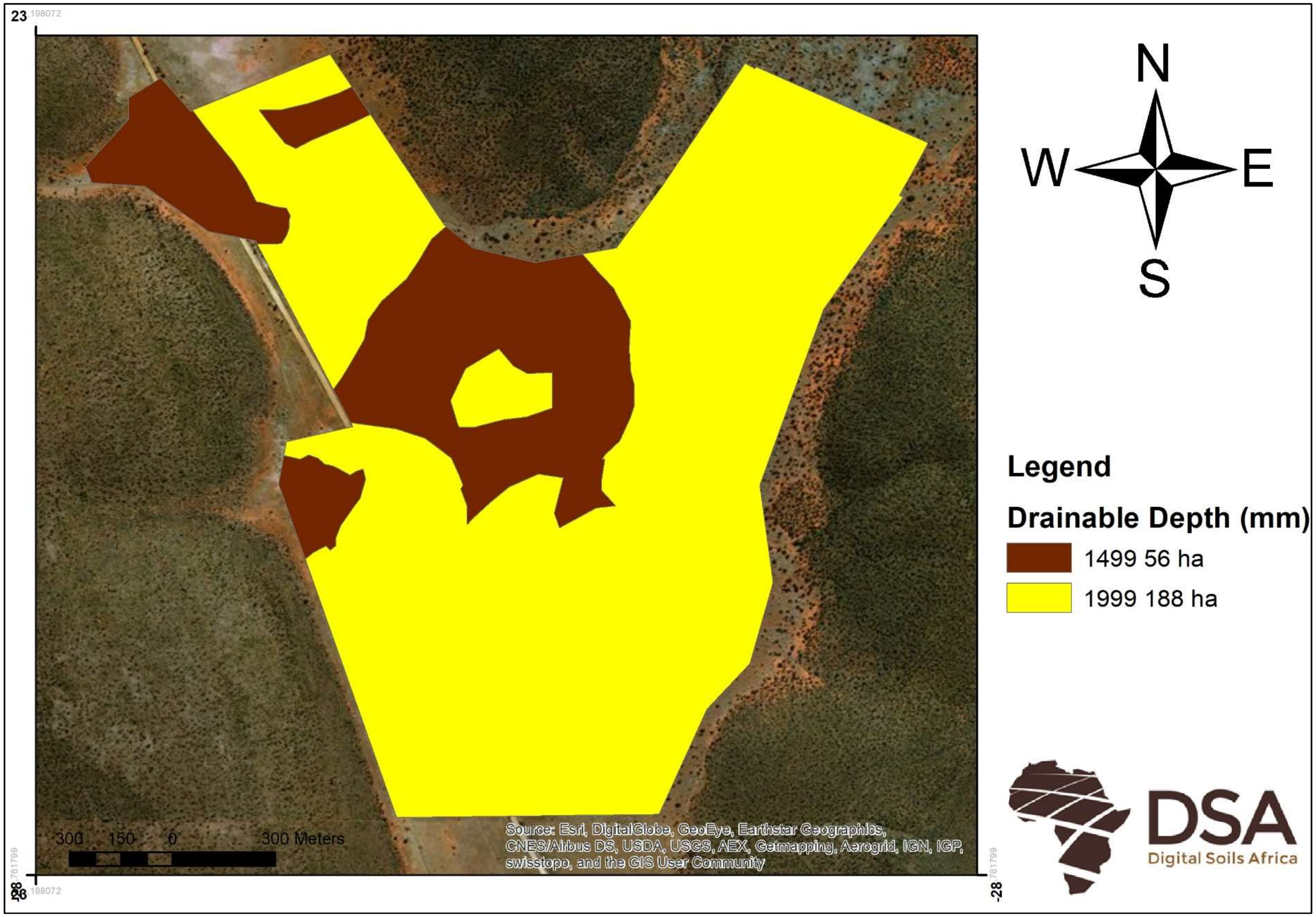

Figure 8: Drainable depth of the study site.

4.3. Laboratory analysis

Tables 3 (chemical) and 4 (texture) present selected soil properties of samples taken from modal profiles. Additionally, a laboratory infiltration test (Table 5) was done on one topsoil sample to assess the speed which water will infiltrate the soil.

The pH is acidic, varying between 4.38 and 5.67, way below the threshold value of 7.5. Liming is required for planting to ensure optimal production. The salt content of the soils is very low, as shown when the range of ECe values measured on the site (3.2 and 47.9 $mS.m^{-1}$) are compared to the norm value of 400 $mS.m^{-1}$. Interestingly, the unspecified material with signs of wetness, the only accumulating horizon observed, contained more salt than the other horizons measured, as indicated by the pronounced higher EC value than the second highest EC value of 18.3 $mS.m^{-1}$, thus confirming the morphological interpretation of the horizon. The ESP values ranges from moderate to high, between 1.88% and 5.25%. This is in the threshold value of 5%. However, sodium levels relative to other cations can be managed, and application of lime before planting commences will decrease the ESP, and contribute to leaching of sodium from the profile. Therefore, general management should prevent any sodicity problems which could appear. A monitoring program for sodicity should be incorporated into the fertility management program.

The textural analyses confirm the morphological indication that the soils are well drained. The clay percentages are generally below 10%, except two samples which has clay percentages of 20.1% and 34.4 % respectively. The sample with the 20.1% clay is understandable, as it is the unspecified with signs of wetness sample. However, this value is far below the threshold value of 35%. The sample with the 34.45% clay is from the stoney layer below the red apedal horizon. Even though the clay percentage is close to the threshold value, it will not reduce infiltration significantly, as the preferential flow paths around the stones will conduct water very quickly. In general, the clay contents correspond with the fertility, as the low clay contents show low CEC values. Irrigation scheduling and fertility management will be required to produce optimal yields. The laboratory infiltration test showed that the infiltration tempo is 152.7 mm/h, much higher than any irrigation rate will be.

Table 3: Selected chemical properties for modal soil profiles

Sample	Soil Form	Diagnostic horizon	pH KCl	EC ms/m	ESP %	CEC cmol(+)/kg
27A	Hutton	Orthic A	5.14	7.0	4.83	1.89
27B		Red Apedal B	4.56	7.0	5.15	1.76
27C		Stones	5.05	4.6	3.55	2.82
10A	Hutton	Orthic A	4.38	6.2	5.28	1.75
10B		Red Apedal B	5.38	3.2	5.15	1.94
10C		Stones	5.82	11.1	2.35	5.89
29A	Hutton	Orthic A	4.85	5.1	4.61	2.00
29B		Red Apedal B	5.29	5.8	4.36	2.25
29C		Stones	5.67	5.7	3.30	3.11
39A	Bloemdal	Orthic A	4.59	5.6	3.81	2.28
39B		Red Apedal B	5.51	6.3	2.26	3.73
39C		Unspecified material with signs of wetness	5.76	47.9	1.88	6.07
19A	Hutton	Orthic A	5.60	18.1	3.92	2.06
19B		Red Apedal B	5.50	5.0	3.40	2.63

Table 4: Texture analysis for modal soil profiles

Sample	**Soil Form**	**Diagnostic horizon**	**Clay %**	**Silt %**	**Sand %**
27A	Hutton	Orthic A	7.5	1.5	91.0
27B		Red Apedal B	5.5	5.0	89.6
27C		Stones	18.8	1.0	80.2
10A	Hutton	Orthic A	9.8	0.5	89.7
10B		Red Apedal B	9.6	1.4	89.0
10C		Stones	34.4	1.0	64.6
29A	Hutton	Orthic A	6.0	2.0	92.1
29B		Red Apedal B	7.0	2.5	90.5
29C		Stones	10.6	5.0	84.4
39A	Bloemdal	Orthic A	9.0	2.5	88.5
39B		Red Apedal B	10.0	5.5	84.5
39C		Unspecified material with signs of wetness	20.1	9.6	70.3
19A	Hutton	Orthic A	5.0	1.5	93.5
19B		Red Apedal B	7.5	2.0	90.5

Table 5: Laboratory infiltration values for one topsoil sample

Sample	**Soil Form**	**Diagnostic Horizon**	**Ksat mm/h**	**DUL ϕv**	**Saturation ϕv**	**Bulk density g/cm3**
19A	Hutton	Orthic A	152.72	0.04	0.45	1.46

5. Suitability

Based on the soil morphology and laboratory analysis, the areas shown in Figure 9 are suitable for irrigation according to the norms of the Department of Agriculture, Northern Cape. A simplified suitability map is shown in Figure 10, which comprises the entire site. Therefore, the perimeter points are the same as mentioned in Table 1.

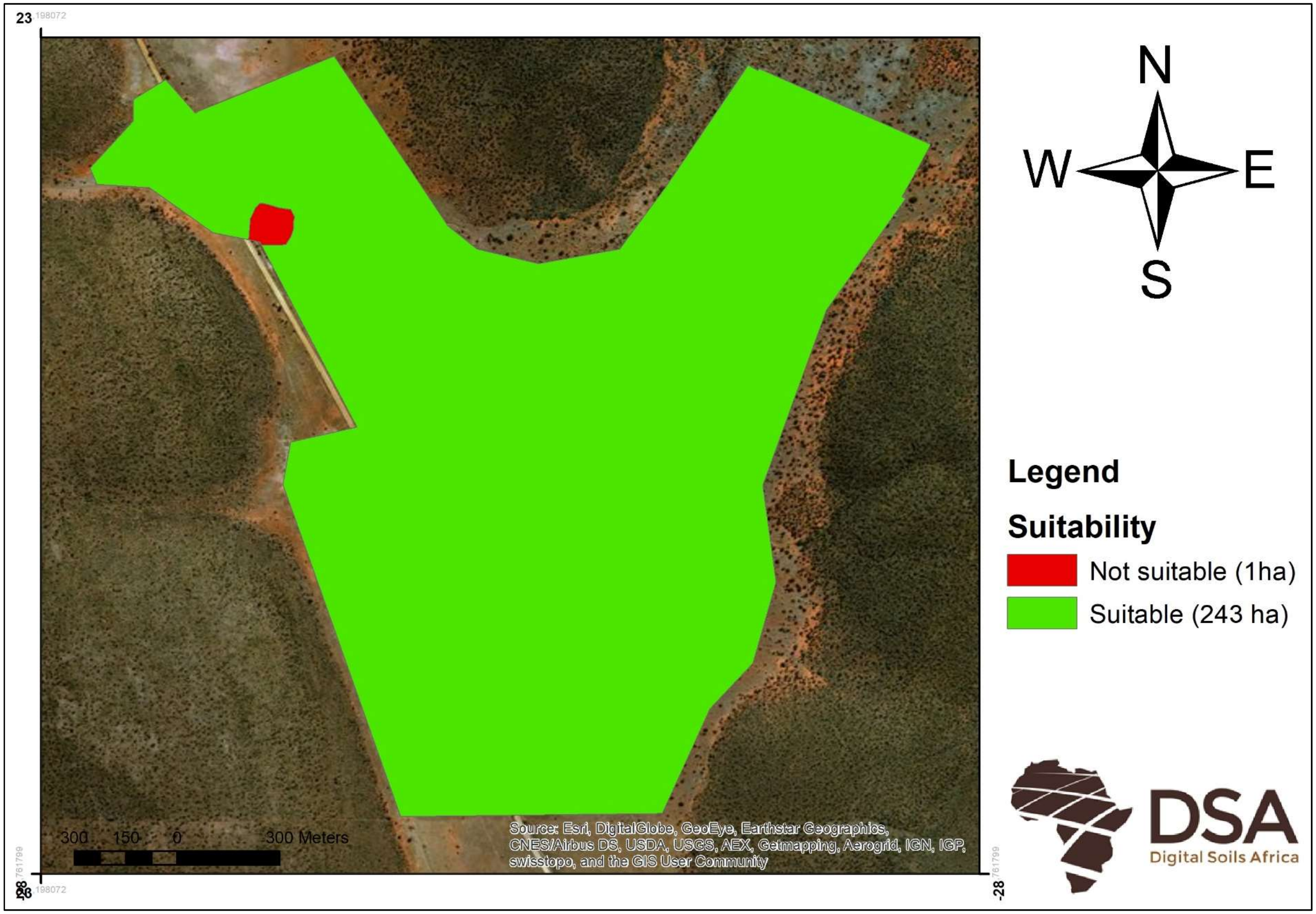

Figure 9: Suitability for potato cultivation and irrigation of the study site.

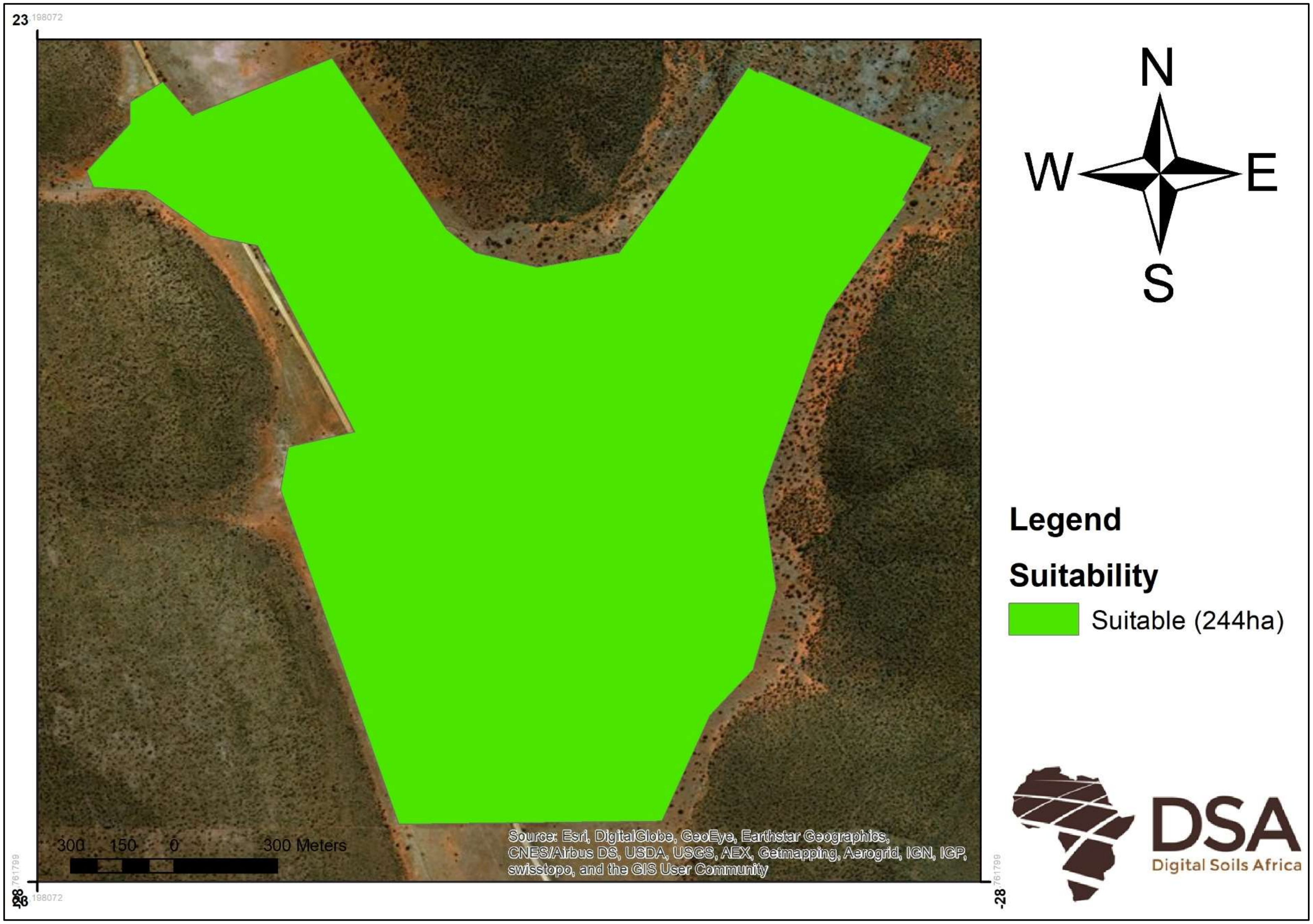

Figure 10: Simplified suitability for cultivation and irrigation of the study site.

6. Conclusion

Soil morphological indicators and laboratory analysis indicate that the entire site of 244 ha is conducive to irrigation. This is represented in Figure 10 as a map.

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: Observation locations of the study site

Nr	X	Y	Soil Form	Limiting Material	Soil Depth (mm)	Drainable Depth (mm)
1	23.20806091630	-28.76013666260	Hutton	Stones	1000	1500
2	23.21075166720	-28.76003166670	Hutton	Stones	900	1700
3	23.21343513980	-28.76001367040	Hutton	None	1600	1600
4	23.20755098900	-28.75860702640	Hutton	Stones	1000	1500
5	23.20997371220	-28.75800662730	Hutton	Stones	500	1500
6	23.21341500040	-28.75796500040	Hutton	Stones	1500	1500
7	23.21493519280	-28.75795134240	Hutton	None	1600	1600
8	23.20679597760	-28.75646334840	Hutton	Stones	1200	1500
9	23.20919833290	-28.75579666660	Hutton	Stones	900	1500
10	23.21170833270	-28.75580000040	Hutton	Stones	900	1500
11	23.21428414660	-28.75577074720	Hutton	None	1700	1700
12	23.21660259070	-28.75502239080	Hutton	None	1500	1500
13	23.20589019210	-28.75445276020	Hutton	Stones	1300	1500
14	23.20866049790	-28.75372927180	Hutton	Stones	1200	1600
15	23.21118166720	-28.75330666690	Hutton	Stones	550	1600
16	23.21365682000	-28.75371253180	Hutton	Stones	850	1500
17	23.21615251510	-28.75297653110	Hutton	None	1700	1700
18	23.20526730990	-28.75197429790	Hutton	Stones	400	1400
19	23.20770846030	-28.75146289840	Hutton	Stones	1600	1800
20	23.21044834560	-28.75088794830	Hutton	Stones	500	1400
21	23.21282206570	-28.75116626240	Hutton	Stones	900	1400
22	23.21269333310	-28.75057000020	Hutton	Stones	1000	1400
23	23.21523333340	-28.75046333340	Hutton	Stones	1100	1700
24	23.21728833280	-28.75007666720	Hutton	None	1700	1700
25	23.20680000020	-28.74945166720	Hutton	Stones	500	1400
26	23.20828999970	-28.74972499990	Hutton	Stones	1200	1400

Nr	X	Y	Soil Form	Limiting Material	Soil Depth (mm)	Drainable Depth (mm)
27	23.21006999990	-28.74892499990	Hutton	Stones	700	1500
28	23.21216999960	-28.74900333260	Hutton	Stones	600	1400
29	23.21453833280	-28.74817999970	Hutton	Stones	800	1800
30	23.21717775660	-28.74768026800	Hutton	None	1600	1600
31	23.20598333310	-28.74742666730	Hutton	Stones	1400	1700
32	23.20865143270	-28.74665985230	Hutton	Stones	850	1400
33	23.21136843030	-28.74641673220	Hutton	Stones	500	1400
34	23.21375833280	-28.74604833310	Hutton	Stones	900	1600
35	23.21633833300	-28.74541833280	Hutton	None	1600	1600
36	23.21880298990	-28.74598014560	Hutton	None	1500	1500
37	23.21769440640	-28.74353029880	Hutton	Stones	1100	1500
38	23.21953833310	-28.74317500000	Hutton	Stones	1300	1500
39	23.20443291170	-28.74484441780	Bloemdal	Redox Morphology	1000	1000
40	23.20762584860	-28.74503117290	Hutton	Stones	1000	1500
41	23.20153999960	-28.74334000040	Hutton	Stones	1200	1200
42	23.20366476570	-28.74275747810	Hutton	Stones	1300	1500
43	23.20585499980	-28.74280666740	Hutton	Stones	1300	1500
44	23.20500833310	-28.74222999960	Hutton	Stones	700	1400
45	23.20400461590	-28.74124198460	Hutton	None	2000	2000
46	23.21229500000	-28.74808666720	Hutton	None	1000	1000

Appendix 2: Modal soil profile descriptions

General Information							
Site:	Griekwastad					Soil form:	Hutton
Map/Photo example:	Figure 3a					Soil family:	3100
GPS Position:	23,217288; -28,750077					Colour	Red
Surface stones:	2%					Occurrence of flooding:	None
Altitude:	1386 m					Wind erosion potential:	Medium
Terrain unit:	Mid slope					Water erosion potential:	Medium
Slope:	2%					Vegetation/Land use:	Natural Veld
Slope shape:	Planform	Straight	Profile	Concave		Water table:	None
Aspect:	None						
Micro-relief:	None					Described by:	G van Zijl
Parent material solum:	Not reached					Date described:	2017-11-09
Geological group:	Asbestos Hill subgroup, Ghaap 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	None	Diffuse
B1700+	Red Apedal B	Red	Apedal	None	None	Gradual

General Information						
Site:	Griekwastad				Soil form:	Hutton
Map/Photo example:	Figure 3b				Soil family:	3100
GPS Position:	23,21217; -28,749003				Colour	Red
Surface stones:	2%				Occurrence of flooding:	None
Altitude:	1390 m				Wind erosion potential:	Medium
Terrain unit:	Mid slope				Water erosion potential:	Medium
Slope:	2%				Vegetation/Land use:	Natural Veld
Slope shape:	Planform	Straight	Profile	Concave	Water table:	None
Aspect:	None					
Micro-relief:	None				Described by:	G van Zijl
Parent material solum:	Ironstone				Date described:	2017-11-09
Geological group:	Asbestos Hill subgroup, Ghaap Group				Weathering of underlying material:	Stones

Profile Information

Horizon Depth (mm)	*Diagnostic Horizon*	*Colour*	*Structure*	*Redoximorphic features*	*Lime*	*Transition*
A 200	Orthic A	Red	Apedal	None	None	Diffuse
B 600	Red Apedal B	Red	Apedal	None	None	Abrupt
C 1400+	Loose stones	Red	Loose stones	None	None	None

Appendix 3: Selected chemical soil properties

Sample	Soil Form	Diagnostic horizon	Ca		Mg		Na		K	
			mg/kg	cmol(+)/kg	mg/kg	cmol(+)/kg	mg/kg	cmol(+)/kg	mg/kg	cmol(+)/kg
27A	Hutton	Orthic A	186	0.9	42	0.3	21	0.1	64	0.2
27B		Red Apedal B	198	1.0	32	0.3	21	0.1	67	0.2
27C		Stones	300	1.5	100	0.8	23	0.1	58	0.1
10A	Hutton	Orthic A	218	1.1	28	0.2	21	0.1	72	0.2
10B		Red Apedal B	188	0.9	49	0.4	23	0.1	80	0.2
10C		Stones	592	3.0	178	1.5	32	0.1	100	0.3
29A	Hutton	Orthic A	232	1.2	39	0.3	21	0.1	108	0.3
29B		Red Apedal B	235	1.2	52	0.4	23	0.1	80	0.2
29C		Stones	330	1.7	83	0.7	24	0.1	91	0.2
39A	Bloemdal	Orthic A	233	1.2	46	0.4	20	0.1	122	0.3
39B		Red Apedal B	422	2.1	101	0.8	19	0.1	147	0.4
39C		Unspecified material with signs of wetness	745	3.7	188	1.5	26	0.1	154	0.4
19A	Hutton	Orthic A	226	1.1	35	0.3	19	0.1	83	0.2
19B		Red Apedal B	193	1.0	44	0.4	21	0.1	105	0.3

Selected chemical soil properties continued

Sample	Soil Form	Diagnostic horizon	SO4 mg/l	S mg/kg	P mg/kg	pH KCl	US.KCl cmol(+)/kg	Acid Saturation	Ca:Mg	Mg:K
27A	Hutton	Orthic A	1.82	12.15	10.00	5.14	0.36	19.03	2.67	2.11
27B		Red Apedal B	2.10	14.02	10.00	4.56	0.24	13.66	3.73	1.55
27C		Stones	2.10	14.02	10.00	5.05	0.25	8.87	1.83	5.48
10A	Hutton	Orthic A	2.54	16.96	10.00	4.38	0.15	8.58	4.76	1.25
10B		Red Apedal B	1.78	11.88	10.00	5.38	0.3	15.46	2.35	1.96
10C		Stones	1.91	12.75	10.00	5.82	1.08	18.33	2.03	5.68
29A	Hutton	Orthic A	1.84	12.28	10.00	4.85	0.15	7.50	3.59	1.17
29B		Red Apedal B	1.82	12.15	10.00	5.29	0.35	15.54	2.78	2.07
29C		Stones	2.09	13.95	10.00	5.67	0.45	14.46	2.44	2.92
39A	Bloemdal	Orthic A	1.93	12.88	10.00	4.59	0.34	14.88	3.06	1.22
39B		Red Apedal B	1.53	10.21	10.00	5.51	0.33	8.85	2.55	2.20
39C		Unspecified material with signs of wetness	1.58	10.55	10.00	5.76	0.29	4.78	2.41	3.92
19A	Hutton	Orthic A	2.09	13.95	10.00	5.60	0.35	16.96	3.89	1.36
19B		Red Apedal B	2.12	14.15	10.00	5.50	0.95	36.11	2.69	1.34

Selected chemical soil properties continued

Sample	Soil Form	Diagnostic horizon	(Ca+Mg)/K	%Ca/BK	%Mg/BK	%Na/BK	%K/BK	Basic Cations cmol(+)/kg	CEC cmol(+)/kg	Saturated Paste Extract pH	Saturated Paste Extract EC ms/m
27A	Hutton	Orthic A	7.7	60.6	22.7	6.0	10.8	1.5	1.9	7.3	7.0
27B		Red Apedal B	7.3	65.3	17.5	6.0	11.3	1.5	1.8	6.7	7.0
27C		Stones	15.5	58.4	31.9	3.9	5.8	2.6	2.8	6.7	4.6
10A	Hutton	Orthic A	7.2	68.4	14.4	5.8	11.5	1.6	1.7	6.8	6.2
10B		Red Apedal B	6.6	57.2	24.3	6.1	12.4	1.6	1.9	6.7	3.2
10C		Stones	17.2	61.5	30.3	2.9	5.3	4.8	5.9	7.3	11.1
29A	Hutton	Orthic A	5.4	62.7	17.5	5.0	14.9	1.8	2.0	7.1	5.1
29B		Red Apedal B	7.8	61.8	22.2	5.2	10.8	1.9	2.3	6.9	5.8
29C		Stones	10.0	62.0	25.4	3.9	8.7	2.7	3.1	7.2	5.7
39A	Bloemdal	Orthic A	5.0	59.9	19.6	4.5	16.0	1.9	2.3	7.1	5.6
39B		Red Apedal B	7.8	62.1	24.4	2.5	11.1	3.4	3.7	7.5	6.3
39C		Unspecified material with signs of wetness	13.4	64.5	26.7	2.0	6.8	5.8	6.1	7.1	47.9
19A	Hutton	Orthic A	6.7	65.9	16.9	4.7	12.4	1.7	2.1	7.0	18.1
19B		Red Apedal B	4.9	57.4	21.4	5.3	15.9	1.7	2.6	7.1	5.0

Appendix 4: Agronomical Report

1. General soil requirements for potato production

Potatoes grows optimally in coarse textured soils, with less than 25% clay, which is more than a metre deep. Sand to Sandy-loam soils with a reasonable amount of organic carbon is especially productive. A pH of between 6 – 6.5 is optimal, although potatoes tolerate a wide range of pH values, from acidic to alkaline. Common scab could be suppressed in a soil with a pH value below 5.4. As potatoes grow well in sandy soils, the fertility of the soils need not be high, but fertilization is necessary for optimal production. Fertility corrections a year before planting is ideal, specifically for Calcium. Potatoes can be produced optimally in soils with an ECe value of below 170 $mS.m^{-1}$.

2. Specific Griekwastad situation.

2.1. Soil Depth

The freely drained soil depth of all the observations are more than 1 m deep, and thus suitable for potato production.

2.2. Soil texture

The soil samples tested have clay percentages of less than 15%, leading to freely drained and well aerated soils, ideal for potato production. The texture classifications are all within the classes Sand, Loamy Sand and Sandy Loam, which are the most ideal texture classes for potato production.

2.4. pH

The pH values generally are acidic, between 4.4 and 5.8, measured in KCl. This is too acidic for potatoes, but it can be corrected easily with lime application. Liming should be done before planting commences.

2.5. Fertility

The CEC values are low (1.8 – 6.1 cmol/kg), which means that fertilization management is critical for optimal production.

2.6. Salinity and sodicity

The EC values below 18 mS/m show that salt build-up is not close to detrimental levels for potatoes. The ESP values around 5% shows that sodicity could be a threat if not well managed. This could be done with liming and irrigation.

3. Conclusions

Based on morphological, physical and chemical observations and measurements, the soils for the entire site is suitable for potato production, with adequate management of irrigation, fertility and liming.