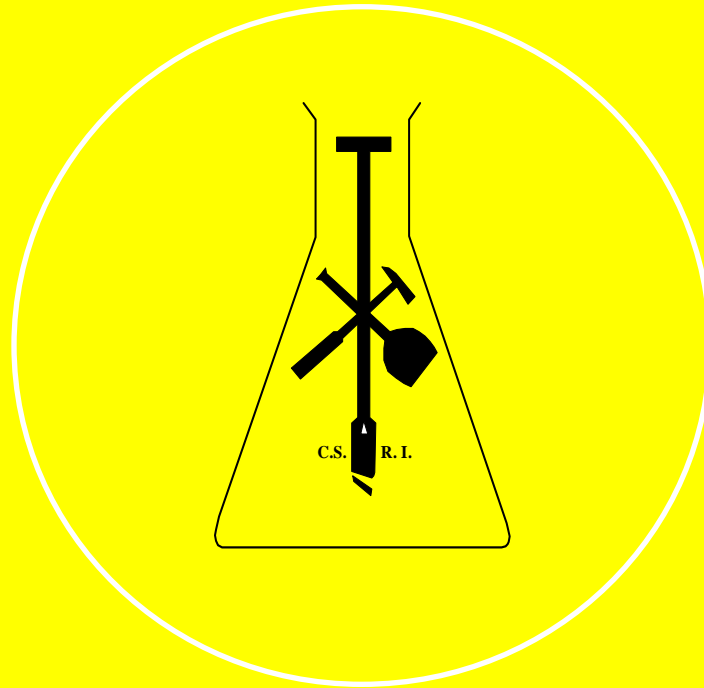


Reference No. **FS/3/2/130**

ZIMBABWE



*Chemistry and Soil Research Institute*

Soils Draft Report No: A 707

**SOILS OF  
SENGWA IRRIGATION SCHEME AND THE  
PROPOSED EXTENSION**

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September 2019

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## SUMMARY

Sengwa irrigation scheme is located in Gokwe, Midlands Province. At the request of International Fund for Agricultural Development (IFAD) under the Smallholder Irrigation Revitalization Programme (SIRP), a detailed soil survey was carried out on approximately 57 ha (21 hectares within the existing scheme but nonfunctional and 37 hectares proposed extension site). Irrigability classes were assigned as outlined in Appendix 7.2. The proportions of Irrigability Classes in terms of hactorage are shown in Table 1.

Table 1: Different soil categories: Irrigability Classes and sizes.

Category	Irrigability Class	Approximate area (ha)	Limitations/Remarks	Recommendations
E1	B	4.5	Expansive clays	Most crops such as maize, wheat, sugar beans, tomatoes, cabbage
E2	B	14.2	Moderately shallow depth	Most crops such as maize, wheat, sugar beans, tomatoes, cabbage
E3	B	1.5	Surface stones	Most crops such as maize, wheat, sugar beans, tomatoes, cabbage
E4	C	10.3	Very shallow depth	Shallow rooted crops such garlic and onions
E5	D	22	Extremely shallow depth	Shallow rooted crops such garlic and onions

The existing scheme and proposed extension area have soils derived from mafic rock with mostly reddish medium textured sandy loam overlying sandy clay loam sub soils. Clays are found in soil unit E1.

### Major limitations to irrigation include:

- i) Very shallow to shallow soil depth
- ii) Surface stones in parts of the existing nonfunctional scheme and most of the proposed extension site.

A greater part of the proposed extension area is not suitable for irrigation development due to many surface stones and extremely shallow soil depth. The same problems apply for category E5 while E3 is shallow but has surface stones. The stones can significantly hinder germination hence all those which are movable should be removed. Soils in Units E1 to E3 are the most suitable for irrigation development as they have appreciable

amounts of clay to retain moisture and nutrients and are deep enough to sustain most plant rooting depths.

## **1.0 INTRODUCTION**

The existing Sengwa irrigation scheme with 21 hectares was developed with canals and a water storage tank being in place but was reported not to have ever been functional. At the request of the International Fund for Agricultural Development (IFAD), a detailed soil survey was carried out on approximately 57 ha (21 ha existing scheme and 37 ha proposed extension site) by one Pedologist over a 4 day period. A total of 35 auger observations were made and 2 pits were dug, fully described and sampled. Currently the scheme is non-functional and the canals previously put in place have been vandalized. The irrigation scheme is proposed to draw water from Mukwichila dam.

Two Google Earth images dated July 2019 were used as base maps for the soil survey. During the survey process, pre-generated auger observations were made and where necessary new points were generated. Soils were demarcated and categorized according to similar morphological properties such as soil depth, texture, surface stoniness and soil colour. The objective of the survey was to assess the suitability for irrigation development.

## **2.0 GENERAL DESCRIPTION OF AREA**

### **2.1 INTRODUCTION**

Sengwa irrigation scheme is found in Rumhumha village approximately 18 km north-west of Gokwe Centre, Gokwe North District, Midlands province. The area lies in Natural Region III at an altitude between 1180-1193 m above sea level with mean annual rainfall of 600-750 mm. The existing scheme and proposed extension site covers 21 and 37 ha respectively.

### **2.2 GEOLOGY AND LANDFORM**

Soils of the both the existing scheme and proposed extension are underlain predominantly by mafic (E) rock, dolerite rock outcrops being visible especially in proposed extension site. The topography of the existing scheme is almost flat with 2% slopes while the proposed scheme ranges from almost flat to gently undulating with 2-3% slopes and hilly with up to 5-8% slopes.

### **2.3 NATURAL VEGETATION**

Within the existing scheme, secondary vegetation of *Dichrostachy cinerea* is the woody specie found while in the proposed extension area the following trees are found *Julbernardia globiflora*, *Xeroderis stuhlmannii* *Parinari curatelifolia* and scattered *Terminalia sericea*.

## 2.4 SOILS AND SOIL CLASSIFICATION

A total of five soil units were observed within the survey area. Most of the soils of the existing scheme are mostly brown, dark to reddish medium to fine grained sandy loam overlying dark brown to reddish fine sandy clay loams. A portion of the southernmost part of the proposed extension site has sandy clay soils.

## 3.0 SOIL CATEGORIES

Soil categories were based on texture, soil depth, soil drainage, permeability and surface features, like stones.

### 3.1 CATEGORY E1

Soils in this category are found only in the northern part of the proposed extension area and are moderately shallow (50-100cm). Many large surface cracks are found across the unit. *Dictrostachy cinerea* vegetation is common in this area. The soils found in the area brown fine sand clay over sandy clay with good permeability and are well drained.

#### Summary of Morphological Properties

Depth	: shallow (50-100cm)
Texture	: clay
Colour	: brown (7.5YR4/3m)
Drainage	: well drained
Permeability	: good

#### Summary of subsoil Chemical properties

Cation exchange capacity	: 23.9
Base saturation	: 100
pH	: 6.2
S/C	: 56.0
EC	: 56.0
ESP	: 4
Typical profiles	: 25/AM/19
Approximate Available Water Holding Capacity (AWC)	: 13 %
Zimbabwe classification	: 4E
Irrigable value	: Mainly 2
Irrigability class	: B
FAO classification	: Eutric Cambisols (Clayic)

PROFILE NUMBER : 25/AM/19 GOOGLE EARTH IMAGE; 4/07/19  
 CO-ORDINATES : 18°17'19.9"S 28°53'53.2"E  
 AUTHOR : Manyanga M. A DATE: 25-09-19

LOCATION : Sengwa-Gokwe  
 ELEVATION : 1180 m  
 RAINFALL : 600-750mm  
 LANDSCAPE (SHAPE) : Almost flat  
 SLOPE (%) : 2  
 NATURAL REGION : 3  
 PARENT MATERIAL : Basalt (B)  
 ZIMBABWEAN CLASSIFICATION  
 GROUP : 4  
 FAMILY : E  
 DESCRIPTION:



0 - 30cm Brown (7.5 YR4/3m); fine clay; hard dry; friable moist: plastic and sticky wet consistence; strongly developed coarse sub-angular blocky structure; good permeability; well drained; fairly numerous fine and coarse roots; interstitial pores; diffuse transition to:

30 - 66cm Brown 7.5YR4/3m); clay; hard dry; friable moist; sticky plastic and sticky wet consistence; strongly developed coarse angular blocky structure; good permeability; well drained; few very fine and occasional coarse roots; common medium interstitial pores; clear smooth transition to:

66- 100cm C1 Weathering material

100+ C2 Weathering material

**SOIL CHEMICAL DATA: PROFILE 25/AM/19**

REFERENCE	S1	S2
DEPTH(cm)	0 -30	30 -66
LAB NO	E1908	E1909
DM %	100.0	100.0
TEXTURE	C	C
CLAY %	49	43
SILT %	18	24

FiNE SAND %	20	23
MEDIUM SAND %	10	8
COARSE SAND %	2	
pH (CaCl <sub>2</sub> )	5.9	6.2
EX Ca (me %)	4.3	34.5
EX Mg (me %)	.6	5.7
EX Na (me %)	.11	.95
EX K (me %)	.11	.05
TEB (me %)	5.1	23.9
CEC (me %)	5.6	23.9
BASE SAT %	91	100
E/C	11.3	56.0
S/C	10.3	56.0
ESP	2.0	4.0
EKP	2.0	.2

### 3.2 CATEGORY E2

This unit is found on mid slope positions of 2-3% in the existing scheme and its soils are mostly moderately shallow (50-100 cm). These soils are dark brown to dark yellowish brown medium grained sandy loams over yellowish red coarse sandy clay loams. Soils have good permeability and are well drained. The soils in this category are weakly sodic. *Dicrostachy cinerea* secondary vegetation is found throughout the soil category in the existing scheme while *Julbernardia globiflora* and *Xeroderis stuhlmannii* being found mainly in the proposed extension area.

#### Summary of morphological properties

Depth	: moderately shallow (50-100 cm deep)
Texture	: medium grained sandy loam over coarse grained sandy clay loam.
Colour	: dark brown (7.5YR3/4m) to dark yellowish brown (10YR3/4m) over yellowish red (5YR4/6m) to dark reddish brown (2.5YR 3/4)
Drainage	: well drained
Permeability	: good

#### Summary of subsoil chemical properties

Cation exchange capacity	: 5.1- 10.4
Base saturation	: 77 - 92
pH	: 3.9-4.3
S/C	: 15.6 - 32
EC	: 17 – 41.9
Typical auger	: 28/AG/19
Approximate Available Water Holding Capacity (AWC):	13.5 %
Zimbabwe classification	: 4GE
Irrigable value	: Mainly 2

Irrigability class : B  
 FAO classification : Eutric Lixisols (Loamic)

SOIL CHEMICAL DATA: AUGER 28/AG/19

REFERENCE	S1	S2	S3
DEPTH(cm)	0-20	20-50	50-80
LAB NO	E1914	E1915	E1916
DM %	100.0	100.0	100.0
TEXTURE	mSaL	cSaCL	cSaCL
CLAY %	13	30	25
SILT %	11	12	20
FINE SAND %	38	25	27
MEDIUM SAND %	24	16	11
COARSE SAND %	14	17	17
pH (CaCl <sub>2</sub> )	5.2	4.3	3.9
EX Ca (me %)	4.5	2.8	4.4
EX Mg (me %)	1.5	1.3	2.9
EX Na (me %)	.51	.58	.61
EX K (me %)	.05	.05	.05
TEB (me %)	6.6	4.7	8.0
CEC (me %)	7.4	5.1	10.4
BASE SAT %	89	92	77
E/C	55.0	17.0	41.9
S/C	49.1	15.6	32.2
ESP	6.8	11.2	5.9
EKP	.7	1.0	.5

### 3.3 CATEGORY E3

Soils in this unit are moderately shallow (50-100 cm) and are found on lower slope positions of 2-3 %. Many small surface loose stones are found across the category. These soils are dark brown to dark reddish brown medium grained sandy loam over dark brown to reddish brown coarse grained sandy clay loams. The soils have good permeability and are well drained. Throughout the soil unit, *Dicrostachy cinerea* secondary vegetation is found. Top soils in this category are weakly sodic therefore pose a risk of sodicity.

#### Summary of morphological properties

Depth : moderately shallow (50-100 cm)  
 Texture : medium sandy loam over coarse grained sandy clay loams  
 Colour : dark brown (7.5YR3/4m) to dark reddish brown (5YR3/3m) over dark brown (7.5YR3/4m) to reddish brown (5YR4/3m).  
 Drainage : well drained  
 Permeability : good



### Summary of subsoil chemical properties

Cation exchange capacity	: 9.5
Base saturation	: 90
pH	: 5.4
S/C	: 27.5
EC	: 30.5
ESP	: 6.8
Typical auger	: 27/AG/19
Approximate Available Water Holding Capacity (AWC):	13.2 %
Zimbabwe classification	: 4GE
Irrigable value	: Mainly 2
Irrigability class	: Downgraded to class C due to surface stones
FAO classification	: Eutric Lixisols (loamic)

### SOIL CHEMICAL DATA: AUGER 27/AG/19

REFERENCE	S1	S2
DEPTH(cm)	0-20	20-50
LAB NO	E1912	E1913
DM %	100.0	100.0
TEXTURE	fSaL	mSaCL
CLAY %	18	31
SILT %	15	15
FINE SAND %	45	25
MEDIUM SAND %	11	18
COARSE SAND %	11	11
pH (CaCl <sub>2</sub> )	5.8	5.4
EX Ca (me %)	1.8	4.0
EX Mg (me %)	2.1	3.9
EX Na (me %)	.63	.65
EX K (me %)	.06	.03
TEB (me %)	4.5	8.6
CEC (me %)	5.8	9.5
BASE SAT %	78	90
E/C	32.6	30.5
S/C	25.3	27.5
ESP	10.7	6.8
EKP	1.0.3	.3

### 3.4 CATEGORY E4

This category is found on all slope positions of 2-3 %. Soils in this unit are very shallow (25-40cm) with parent material stones limiting depth. The soils in this category are weakly sodic. They are dark reddish brown fine-grained sandy clay loams to sandy clay

loams over reddish brown sandy clay loams. Category is part of the existing scheme and secondary *Dicrostachy cinerea* vegetation is found throughout.

### Summary of morphological properties

Depth : very shallow (25-40cm)  
Texture : fine grained sandy loam over medium sandy clay  
Colour : brown (7.5YR 4/4m) over dark brown (7.5YR3/3m)  
Structure : moderately developed medium sub angular blocky  
Drainage : well drained  
Permeability : good

### Summary of subsoil Chemical properties

Cation exchange capacity : 6.5  
Base saturation : 100  
pH : 5.4  
S/C : 17  
EC : 17  
ESP : 10.7  
Typical profiles : 26/AM/19  
Approximate Available Water Holding Capacity (AWC) : 13 %  
Zimbabwe classification : 4GE  
Irrigable value : Mainly 3  
Irrigability class : C  
FAO classification : Leptic Luvisols

PROFILE NUMBER : 26/AM/19 GOOGLE EARTH IMAGE; 7/07/19  
CO-ORDINATES : 18°16'56.4"S 28°52'53.7"E  
AUTHOR : Manyanga M. A DATE: 26-09-19  
LOCATION : Sengwa-Gokwe  
ELEVATION : 1193 m  
RAINFALL : 600-750mm  
LANDSCAPE (SHAPE) : Gently undulating  
SLOPE (%) : 2-3%  
NATURAL REGION : 3  
PARENT MATERIAL : Maffic (E)  
ZIMBABWEAN CLASSIFICATION  
GROUP : 4  
FAMILY : E

DESCRIPTION:



0 - 13cm Dark reddish brown (5YR3/3m); fine sandy loam; slightly hard dry; very friable moist; plastic and sticky wet consistence; moderately developed medium sub angular blocky structure; good permeability; very well drained; fairly numerous very fine and occasional medium roots; few fine and very fine tubular pores; few coarse gravel and small stones clear smooth transition to:

13 - 28cm Reddish brown (5YR4/4m); medium sandy clay; slightly hard dry; friable moist; plastic and sticky wet consistence; good permeability; well drained; fairly numerous very fine and occasional medium roots; common to many angular many small stones, clear irregular transition to:

28- 40cm Very many small sub-rounded and angular stones clear irregular transition to:

40+ C Material.

SOIL CHEMICAL DATA: AUGER 26/AM/19

REFERENCE	S1	S2
DEPTH(cm)	0 -13	13-28
LAB NO	E1910	E1911
DM %	100.0	100.0
TEXTURE	fSaL	mSaC
CLAY %	18	38
SILT %	21	14
FINE SAND %	37	27
MEDIUM SAND %	16	12
COARSE SAND %	8	9
pH (CaCl <sub>2</sub> )	5.7	5.4
EX Ca (me %)	7.5	2.3
EX Mg (me %)	7.4	4.3
EX Na (me %)	.61	.70
EX K (me %)	.05	.03
TEB (me %)	14.9	6.5
CEC (me %)	14.9	6.5
BASE SAT %	100	100

E/C	80.9	17.0
S/C	80.9	17.0
ESP	4.1	10.7
EKP	.3	.5

### 3.5 CATEGORY E5

This category is mostly found in the proposed extension area and has many surface small stones. These soils in this area are extremely shallow (<25cm) deep. *Dictrostachy cinerea* in the major woody species found within this unit with *Julbernardia globiflora* and *Xeroderis stuhlmannii* being found in the proposed extension site. Topography is gently undulating with 2-3 % slopes. Soils are dark reddish brown sandy clay loam. Permeability is rapid and drainage is good.

#### Summary of Morphological Properties

Depth	: extremely shallow (<25cm)
Texture	: sandy clay loam.
Colour	: reddish brown (5YR4/4m)
Structure	: moderately developed medium sub angular blocky
Drainage	: well drained
Permeability	: good

#### Summary of subsoil Chemical properties

Cation exchange capacity	:
Base saturation	:
pH	:
S/C	:
EC	:

Approximate Available Water Holding Capacity (AWC)	: 11 %
Zimbabwe classification	: 2G
FAO classification	: Hyperskeletal Leptsols

### 4.0 DISCUSSION

Most of the soils in the existing scheme are suitable for irrigation. However, shallow soil depth in (E4 and E5) and presence of surface stones in E4 are major limitations. Soils in category E1 have shrink-swell characteristics as shown by surface cracks and this can negatively impact roots of crops as they may break under dry conditions. Greater part of the proposed extension site is either rocky with rock outcrops or extremely shallow <25cm (E5) deep making it difficult to establish irrigation in these areas. Soils in categories E4 and E2 are weakly sodic which may create problems under poor crop production management practices. Sodidity can result in poor root penetration and water infiltration, poor structure further increasing soil erodibility. There is potential of sodicity of soils in category E3 if there are poor crop production management practices. Soils in categories E2 and E4 have an acidic pH of 3.9 – 4.3. Units E1, E2 and E3 with a total of 20 hectare are the most suitable for irrigation.

## **5.0 RECOMMENDATIONS**

Any proposed extension must concentrate on areas under soil unit E1, and E2 where there is moderately shallow soil depth. Soil unit E4 can be developed though it has serious depth limitation which reduces water storage capacity. No landscaping should be done especially on units E4 and E5 since depth is a major limitation. Sprinkler or center pivot irrigation methods are recommended to minimize the need for land scaping which expose subsurface soils. There is need for good irrigation scheduling especially given the relatively shallow soil depths which may require more frequent irrigation cycles. There is need for lime application at 1300kg/ha in soils of categories E2 and E4 to correct the acidic pH. Sodicity can be reclaimed by flashing out sodium from the exchange sites through addition of (lime or gypsum) or adding sulfur followed by lime then leaching with irrigation suitable water. With good soil management practices the following crops can be grown sugar beans as well as horticultural crops such as cabbage, onion and garlic can be grown especially in soil units E4 and E5.

## **6.0 BIBLIOGRAPHY**

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## **7.0 APPENDICES**

### **7.1 LAND SUITABILITY CLASSIFICATION FOR IRRIGATION**

The irrigability classes assigned to mapping units have been based on factors related to land characteristics, such as slope and soil properties, such as water holding capacity, permeability and levels of exchange sodium percentage.

The irrigability classes are defined as follows.

**Class A:** Suitable for irrigation without special precautions or practices and capable of sustained productivity.

**Class B:** Suitable for irrigation with special precautions or practices. Sustained productivity is attainable with good management and maximum efficiency in the use of irrigation water, but risks are greater than with class A owing to moderate soil and/or topographic limitations and special care is necessary. Corrective measures may be recommended according to the nature of limitations.

**Class C:** Of very restricted suitability for irrigation; confined to specific types of crops and practices owing to severe soil and/or topographic limitations.

**Class D:** Unsuitable for normal irrigation.

**Class S:** Excessively pervious sands of restricted suitability owing to inadequate water holding capacity, unavoidable high water losses and low inherent fertility.

**N.B.** It should be noted that these Irrigability Classes and the criteria used to assess the suitability of soils are intended for normal full-scale irrigation i.e. all-the-year- round irrigation for rotation of intensively grown crops as distinct from supplementary irrigation of summer crops grown mainly under normal rainfall. It also assumed that the water used for irrigation is of good quality.

## 7.2 GLOSSARY OF TECHNICAL TERMS

### Soil Depth

Extremely shallow	<25cm
Very shallow	25-40cm
Shallow	40-50cm
Moderately shallow	50-100cm
Moderately deep	100-150cm
Deep	>150cm

### Soil Texture class

<b>C</b>	clay
<b>CL</b>	clay loam
<b>L</b>	loam
<b>SiC</b>	silty clay
<b>SiCL</b>	silty clay loam
<b>Si</b>	silt
<b>SaC</b>	sandy clay
<b>SaCL</b>	sandy clay loam
<b>SaL</b>	sandy loam
<b>LS</b>	loamy sand
<b>Sa</b>	sand

### Texture classification-coarse(c), medium (m) and fine (f).

Express each sand fraction as a % of the total sand fraction in the sample.

- If the coarse sand is  $\geq 25\%$  the texture will be prefixed with a 'c'.
- If the fine sand is  $\geq 60\%$  the texture will be prefixed with 'f'.
- If the coarse sand,  $< 25\%$  and the fine sand is  $< 60\%$  the texture will be prefixed with 'm'.
- If the total sand fraction is  $< 45$  there is no prefix.

### Particle size grades

Coarse sand	2, 0mm (2000um)-0.5mm (500um)
Medium sand	0,5mm (500um) - 0,2mm (200um)
Fine sand	0, 2mm (200um)-0, 02(20um)
Silt	0, 02(20um) - 0,002(2um)
Clay	$< 0,002(2um)$

### Other Abbreviations

**d**-Dry **m**-Moist **K**-Potassium **Ca**-Calcium **Mg**-Magnesium **Fe**-Iron

**CEC**-Cation Exchange Capacity **TEB**-Total Exchangeable Bases

**me%**-Milli-equivalents percent or per 100grams of soil.

**Base Saturation%**- $100 * \text{TEB} (\text{cmol}_c\text{kg}^{-1}) / \text{CEC} (\text{cmol}_c\text{kg}^{-1})$

**ESP**-Exchangeable sodium percentage **EKP**-Exchangeable potassium percentage

### 7.3 A SIMPLIFIED OUTLINE OF THE SOIL CLASSIFICATION SYSTEM OF ZIMBABWE

ORDER	DESCRIPTION	GROUP	TYPICAL SOIL FAMILIES
1.AMORMIC	Little or no horizon development	1.Regosol Deep sands  2.Lithosol Extremely shallow	1K(Dep sands derived from Kalahari deposits) 2E(derived from mafic rocks)
CALCIMOPHIC	Unleached soils generally with large reserves of weatherable minerals: high base saturation.	3. Vertisols Very acidic clay  4.Siallitic Active clay	3B(derived from basalt)  4PE(derived from mafic gneiss)
KAOLINITIC	Moderately to strongly leached soils; appreciable amounts of free sesquioxides of iron and aluminum.	5.Fersiallitic mixed clay  6.Paraferrallitic Inert clay 7.Orthoferrallitic	5G(coarse grained sandy soils derived from granite) 6G 7G
NATRIC	Dominated by appreciable amounts of sodium as the exchangeable ion	8.Sodic Weakly sodic Strongly sodic Saline sodic	8n 8N 8h