NATIONAL UNIVERSITY OF LESOTHO

FACULTY OF AGRICULTURE

DEPARTMENT OF SOIL SCIENCE AND RESOURCE CONSERVATION

FINAL EXAMINATION PAPER

SSR413-3: SOIL SURVEY AND LAND EVALUATION

Bachelor of Science in Agriculture – Soil Science/Extension/Geography-Environmental Science

DECEMBER 2017 MARKS: 100 TIME : 3 HOURS

INSTRUCTIONS:

1. **ANSWER ALL FIVE (5) QUESTIONS.**
2. **ALL QUESTIONS CARRY EQUAL MARKS.**
3. ***MUST* COMMENCE EACH QUESTION ON A SEPARATE SHEET.**

Question 1: [20 marks]

Complete the analytical hierarchy process (AHP) decision making matrix, using **Table 1**, to evaluate development of irrigated agriculture, as follows:

Table 1: The experts' pairwise comparison matrix (pcm) of ranking the relative function of *each land quality factor* (objectives/parameters) at every selected *optional site* in planning land suitability for irrigated cropland use.

3	Final ideal AHP Relative Priority decision matrix								Final ideal AHP Relative Priority
Ideal optional site priority index $IPI_{os/qf}$	Priority indices for quality factor, PI_{QF}								
	Drz	**d_{PAW}**	**SOC**	**S**	**ER**	**EC_e**	**pH**	**Ksat**	**IRP**
	0.29	0.23	0.17	0.12	0.07	0.05	0.05	0.02	
1 Lesh	0.52	0.54	0.56	0.56	0.55	0.48	0.52	0.59	
2 Rako	0.30	0.28	0.28	0.24	0.26	0.26	0.28	0.30	
3 Masi	0.12	0.13	0.13	0.13	0.11	0.12	0.13	0.14	
4 Seak	0.05	0.06	0.06	0.08	0.06	0.06	0.07	0.07	

Drz = depth of plant rooting solum; cm; **d_{PAW}** =depth plant available water holding capacity, cm; **SOC** = soil organic carbon, g/Kg; **S** = slope gradient, %; **ER** = erosion risk, cm /yr; **EC_e** = Electrical conductivity in soil extract, dS/m; **pH** = Soil pH; **K_{sat}** = saturated hydraulic conductivity, cm/day; **GWM** = geometric weight mean; **PI** = priority index. . **Lesh =** Leshoele **; Rako =** Rakolo **; Masi =** Masianokeng **; Seak =** Seaka.

(i) Determine a normalized ideal AHP priority index by adjusting the optional site priority indices in regard to their quality factors, as follows: [5]

$$\mathbf{IPI\text{-}_{os:QFi} = PI\text{-}_{os:GFi} / max\ PI\text{-}_{os:QFi}}$$

(ii) Calculate the final ideal relative priority indices for option sites (**$RP_{\text{-}osi}$**), as follows: [5]

$$\mathbf{RPI_{OSi} = \sum_{i=1}^{n} (IPI_{OS:QFi} * PI_{QFi})_I}$$

(iii) Assign and briefly discuss the threshold values of ideal AHP relative priority indices (**RPI_{OSi}**) for optional sites to an appropriate potential land suitability

classes or groupings, based on the FAO – 1976: #56 – framework of land suitability evaluation. [10]

Question 2: [20 marks]

a) Identify the *master horizons*, as described where: (do not re-write the question) [**2 marks each**]

(i) Mineral surface layer mixed with humified organic materials by cultivation;

(ii) Undecomposed terrestrial organic litter accumulated on the soil surface;

(iii) Unconsolidated rocky or other parent material have traces or occasional deposits of organic carbon;

(iv) Mineral horizon has evidence of eluviation, has lost mainly the silicate clays, salts, SO_4^{2-}, CO_3^{2-}, Fe^{2+}, Al^{3+}; and has higher sand and silt content and with a lighter color than the overlying A-horizon and the underlying B-horizon;

(v) Mineral horizon has evidence of illuviation, has gained the silicate clays, salts, SO_4^{2-}, CO_3^{2-}, Fe^{2+}, Al^{3+}; and has increased reddish color that predominate gleying color; scares roots and microorganisms activity;

b) Assign the distinctive subordinate symbols to the subsurface master horizons that matches the following pedogenetic processes: [**2 marks each**]

(i) accumulation of illuviating or immigrating silicate clay;

(ii) accumulation of cemented oxides and residual sesquioxides of Fe^{2+}, Mn^{2+}, Al^{3+} and forming nodule;

(iii) gypsum accumulation ;

(iv) soluble salts accumulation ;

(v) exchangeable sodium accumulation

Question 3:

a) Air-dried potting soil mixture that weighed (3.5 kg $M_{ad\ soil}$) was packed inside a column of PVC pipe weighing (1.5 kg $M_{PVC\ pipe}$) having 320 mm diameter and 40 cm deep rooting zone. After wetting the soil column through capillary wicking-bed irrigation (Niranjani *et al*., 2016), the freely-drained weight (5.2 kg $M_{FDWC@gravitational\ water\ outflow\ ceased}$) of this soil column was measured immediately after the *freely outflowing drainage water* had ceased. **[15]**

(i) Estimate the volumetric water content at field condition ($\boldsymbol{\theta_{v@fc}}$) and depth of plant available water holding capacity ($\boldsymbol{d_{PAW}}$).

(ii) Determine the actual crop evapotranspiration ($\boldsymbol{ET_{crop}}$) from the soil column that was serving as a manual weighing lysimeter for monitoring and evaluating irrigated agriculture productivity.

b) Verify the following protocols, as the *true or false facts*: **[5]**

(i) The **capillary-rise** technique (*an actively rising mass of capillary pore water occurs when instantaneous water applied in small aliquots (volumes) at the base of the cylindrical* undisturbed *soil core samples*) has conveniently provided a low-bubbling pressure of flowing water with mild-disruptive slaking effect on soil aggregates;

(ii) Immediately after soil wetting front (a *rising mass flow of capillary water through soil pores*) has reached *end-point for maximum ascending water-film* at *glistened* surface of soil aggregates, the weight of maximum wetted-soil cores were recorded ($M_{MaxWet@glistened\ surface\ soil\ aggregates}$; under a transparent-PVC enclosure to limit water evaporation (*as optional*); and the volumetric maximum water holding capacity ($\boldsymbol{\theta_{v\text{-}MWHC}}$) was calculated.

(iii) The weight of freely-drained field soil-condition ($M_{FDWC@freely\ draining\ water\ cessation}$) was measured immediately after *freely outflowing drainage water* had ceased onto a funnel rack assembly; and the volumetric capillary-pore water-holding capacity ($\boldsymbol{\theta_{v\text{-}CPWC}}$) was calculated.

(iv) Attainment of end-point for constant (stable) mass of the *blotter-drained soil* was effectively facilitated by a ***water-blotting induced drainage*** technique (*i.e. paper-towel on a fine-sand bed*); and the weight of *blotter-drained soil* aggregates ($M_{CSWC@"-"charged\ colloidal\ soil\ bound\text{-}water}$) was determined;

(v) The limited flow rate (wettability) of capillary-rise of pore water into soils having high clay and SOC content could be chiefly attributed to some incremental input in available surface area and volumetric fractions of the colloidal soil particles;

Question 4:

a) State four fractions of active soil organic carbon input and which would be the most sequestered in soils. 6/

b) Discuss the biogeochemical reactions that can favor sequestration of soil organic carbon. 10/

c) Agree or Disagree: 4/

(i) The wide adoption of the weight loss on ignition (LOI) method in soil science reflects its versatility and it can produce strong relationship with the $\%OC_{LECO}$ ($R^2 = 0.96$, $P < 0.001$) than with the $\%OC_{WB}$ ($R^2 = 0.88$, $P > 0.001$) method for non-calcareous soils (Campos, 2010 Communications in Soil Science and Plant Analysis, 41:1454–1462, 2010).

(ii) In calcareous soils having a huge ”-negatively“-charged colloidal soil fractions with strong-mineral bound-water adsorption, the volumetric water content @-1500 kPa could be chiefly estimated by the apparent volumetric fraction of clays, carbonates and sulfates and organic carbon, as follows:

$$\%\theta_{v@-1500\ kPa} = (\%clay + \%SOC)/2.5$$

Question 5:

a) Briefly explain the type of soil survey that should be employed at the local site level that requires specific management practices for agriculture landuse suitability. **[5]**

b) Identify, *at least two*, main (**1º**) or secondary (**2º**) measurable land quality factors related to each objective (component) of the soil survey and land evaluation procedures (*listed below*): **[10]**

(i) Geology and soils
(ii) Topography
(iii) Climate
(iv) Environmental degradation
(v) Ecological protection
(vi) Social and economic livelihoods
(vii) natural resources and infrastructure

c) Highlight the kinds of *tools/instruments* that would be required for data acquisition at the local site level, based on any land quality factor. **[5]**

Good Luck.. Good Luck.. Good Luck.. Good Luck

Appendices

Table 1: The experts' pairwise comparison matrix (pcm) of ranking the relative function of *each land quality factor* (objectives/parameters) at every selected *optional site* in planning land suitability for irrigated cropland use.

3	Final ideal AHP Relative Priority decision matrix								Final ideal AHP Relative Priority
Ideal optional site priority index $IPI_{os/qf}$	Priority indices for quality factor, PI_{QF}								
	Drz	d_{PAW}	SOC	S	ER	EC_e	pH	Ksat	IRP
	0.29	0.23	0.17	0.12	0.07	0.05	0.05	0.02	
1 Lesh	0.52	0.54	0.56	0.56	0.55	0.48	0.52	0.59	
2 Rako	0.30	0.28	0.28	0.24	0.26	0.26	0.28	0.30	
3 Masi	0.12	0.13	0.13	0.13	0.11	0.12	0.13	0.14	
4 Seak	0.05	0.06	0.06	0.08	0.06	0.06	0.07	0.07	

Drz = depth of plant rooting solum; cm; $\mathbf{d_{PAW}}$ =depth plant available water holding capacity, cm; **SOC** = soil organic carbon, g/Kg; **S** = slope gradient, %; **ER** = erosion risk, cm /yr; $\mathbf{EC_e}$ = Electrical conductivity in soil extract, dS/m; **pH** = Soil pH; $\mathbf{K_{sat}}$ = saturated hydraulic conductivity, cm/day; **GWM** = geometric weight mean; **PI** = priority index. . **Lesh =** Leshoele **; Rako =** Rakolo **; Masi =** Masianokeng **; Seak =** Seaka.