UNIVERSITY OF SWAZILAND
FINAL EXAMINATION PAPER

PROGRAMME: BSC AGRIC (LWM)

COURSE CODE: LUM 412

TITLE OF PAPER: SOIL AND WATER CONSERVATION

TIME ALLOWED: TWO (2) HOURS

SPECIAL MATERIAL REQUIRED: NONE

INSTRUCTIONS: ANSWER QUESTION ONE AND ANY TWO OTHER QUESTIONS.

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QUESTION 1

(a) Gully erosion is a major ecological problem in Swaziland. Discuss the following:

(i) The factors responsible for gully formation; (10 Marks)
(ii) The process of gully formation; and (5 Marks)
(iii) Gully reclamation. (5 Marks)

(b) Estimate the mean annual soil loss, using the Soil Loss Estimator for Southern Africa (SLEMSA), on a 120 m long slope of 5° on a sandy loam soil under maize at Luyengo with a mean annual precipitation of 953 mm. The crop was planted on ridges up and down the slope.

(20 Marks)

QUESTION 2

It has been established that soil detachment and transport are influenced by the kinetic energy of a storm. Many researchers developed emperical relationships between kinetic energy and rainfall intensity and amount of rainfall as shown below:

$$E = 210.3 + 89\log I \quad \text{(Wischmeier and Smith, 1958; - USA)}$$

Here E is in tonnes per hectare per centimetre of rain and I is rainfall intensity in centimetres per hour. This equation is valid for I values of up to 76mm/h.

$$E = 0.273 + 0.217e^{-0.048I} - 0.413e^{-0.072I} \quad \text{(Mutchler and Murphee, 1985)}$$

Here E is the kinetic energy per millimetre depth of rain for the corresponding intensity and I is measured in millimetres per hour for short time increments. This equation is valid for intensities exceeding 100mm/h.

$$E = 18.846R_a \quad \text{(Elwell, 1979 – Zimbabwe)}$$

Where E is in joules per square metre, R_a is amount of rainfall in millimetres.

Discuss the practical applications of the above equations in Swaziland.

(30 Marks)

QUESTION 3

(a) The implementation and adoption of soil and conservation measures by governments and farmers respectively are dependent on many factors. Discuss the following as they affect the implementation and adoption of soil conservation measures:

(i) Social-economic setting; (10 Marks)
(ii) Political context; (5 Marks)

(b) Discuss the following approaches to soil and water conservation:

(i) Agronomic measures; (5 Marks)
(ii) Soil management; and (5 Marks)
(iii) Mechanical measures. (5 Marks)

QUESTION 4

(a) Discuss **THREE** of the following approaches to soil and water conservation:

(i) Strip cropping;
(ii) Terraces;
(iii) Waterways;
(iv) Contour bunds; and
(v) Tillage practices. (15 Marks)

(b) Discuss how the following catchment factors affect both the volumes and rates of runoff:

(i) Size; (5 Marks)
(ii) Shape; and (5 Marks)
(iii) Orientation. (5 Marks)

APPENDIX

The Soil Loss Estimator for Southern Africa (SLEMSA):

$$Z = K.X.C$$

Where Z is mean annual soil loss (t/ha)
K is mean annual soil loss (t/ha) from a standard field plot, 30m long, 10m wide, at 2.5° slope for a known soil of known erodibility (F) under weed free bare fallow
X is a combined slope length and steepness factor
C is a crop management factor

The value of K is determined by relating mean annual soil loss to mean annual rainfall (P in mm) energy (E) using the exponential relationship:

$$\ln K = b \ln E + a$$
$$E = 18.846 R_a \text{ (Elwell, 1979 – Zimbabwe)}$$

where E is in J/m^2, R_a is the mean annual rainfall and the values of a and b are functions of the soil erodibility factor (F):

$$a = 2.884 - 8.2109F$$
$$b = 0.4681 + 0/7663F$$
$$X = L^{1/2}(0.76 + 0.53s + 0.076s^2)/25.65$$

Where L is the slope length (m)
s is the percentage slope

Input values for soil erodibility and crop cover for use in SLEMSA

Soil erodibility (F factor)		
Soil texture	Soil Type	F Value
Light	Sands Loamy sands Sandy loams	4
Medium	Sandy clay loam Clay loam Sandy clay	5
Heavy	Clay Heavy clay	6

Subtract the following from the F value:

1 for light-textured soils consisting mainly of sands and silts

1 for restricted vertical permeability within one metre of the surface or for severe soil crusting.

1 for ridging up-and-down the slope.

1 for deterioration in soil structure due to excessive soil loss in the previous year (>20t/ha) or for poor management.

0.5 for slight to moderate surface crusting or for soil losses of 10 – 20t/ha in the previous year.

Add the following to the F value:

2 for deep (>2m) well-drained, light-textured soils.

1 for tillage techniques which encourage maximum retention of water on the surface, e.g. ridging on the contour.

1 for tillage techniques which encourage high surface infiltration and maximum water storage in the profile, e.g. ripping, wheel-track planting.

1 for first season of no tillage.

2 for subsequent seasons of no tillage.

Crop cover ratings (C)	
Crop	Average percentage cover
Cotton	40 – 65
Cowpeas	40 – 55
Tobacco	11 – 54
Sorghum	50 – 70
Sunflower	20 – 59
Groundnuts	55 – 65
Velvet beans	46 – 70
Coffee	60 – 80
Maize	42 – 80
Rotational grass	80 – 98
Soya beans	40 – 65
Rice	70 – 78
Weed fallow	100

After Elwell and Wendelaar (1977); Elwell (1978)

Maximum safe velocities in channels (maximum velocity on cover expected after two seasons

Material	Bare m/s	Medium grass cover m/s	Very good grass cover m/s
Very light silty sand	0.3	0.75	1.5
Light loose sand	0.5	0.9	1.5
Coarse sand	0.75	1.25	1.7
Sandy soil	0.75	1.5	2.0
Firm clay loam	1.0	1.7	2.3
Stiff clay or stiff gravelly soil	1.5	1.8	2.5
Coarse gravels	1.5	1.8	unlikely to form very
Shale, hardpan, soft rock, etc.	1.8	2.1	good grass cover
Hard cemented conglomerates	2.5	-	-