

E2. RIVER DISCHARGE RECORDS

Station: Lirangwe RGS IC, Lirangwe Trading Centre

Grid Reference: YT164823

Catchment Area=198km²

Date	Gauge Height (m)	Discharge m ³ /sec	Date	Gauge Height (m)	Discharge m ³ /sec	Date	Gauge Height (m)	Discharge m ³ /sec
12/1/89	0.196	0.166	7/1/92	0.268	0.026	8/5/96	0.305	0.436
3/2/89	0.640	5.201	6/2/92	0.265	0.372	1/6/96	0.270	0.246
21/3/89	0.581	5.048	4/3/92	0.230	0.199	19/7/96	0.250	0.178
30/5/89	0.330	0.908	4/4/92	0.251	0.254	11/8/96	0.285	0.103
20/6/89	0.310	0.589	30/5/92	0.165	0.054	7/9/96	0.205	0.025
2/10/89	0.400	0.146	5/6/92	0.140	0.026	2/10/96	0.160	0.009
17/12/89	0.345	0.241	2/7/92	0.150	0.016	12/12/96	0.300	0.601
10/1/90	0.448	2.060	4/9/92	0.135	0.008	30/1/97	0.130	7.691
9/2/90	0.642	4.118	4/3/92	0.680	7.360	16/4/97	0.124	2.184
22/3/90	0.320	1.529	6/5/93	0.320	0.693	25/6/97	0.267	0.599
9/4/90	0.450	0.415	6/6/93	0.281	0.344	22/8/97	0.225	0.210
21/6/90	0.410	0.241	5/8/93	0.220	0.123	23/10/97	0.323	0.421
25/7/90	0.250	0.263	12/11/93	0.140	0.037	26/11/97	0.191	0.182
22/9/90	0.240	0.344	29/1/94	0.265	0.495	21/3/98	0.474	3.912
10/10/90	0.225	0.052	10/5/94	0.140	0.200	16/4/98	1.823	1.326
6/12/90	0.220	0.218	9/6/94	0.125	0.043	17/6/98	0.255	0.360
6/2/91	0.352	0.843	7/7/94	0.110	0.021	19/8/98	0.210	0.216
20/3/91	0.385	1.068	9/8/94	0.110	0.007	24/9/98	0.200	0.115
8/8/91	0.240	0.113	5/9/94	0.110	0.003	24/11/98	0.180	0.164
8/10/91	0.171	0.024	10/10/95	0.252	0.274	7/7/99	0.240	0.743
2/11/91	0.067	0.042	7/2/95	0.505	0.897	30/7/99	0.243	0.540
3/12/91	0.190	0.197	12/4/96	0.330	0.724			

Station: Lunzu RGS109, Village Name: Whaya

Grid Reference: YT121759

Catchment Area=163km²

Date	Gauge Height (m)	Discharge m ³ /sec	Date	Gauge Height (m)	Discharge m ³ /sec	Date	Gauge Height (m)	Discharge m ³ /sec
3/2/89	0.804	6.358	6/2/92	0.362	0.164	8/5/96	0.480	0.552
12/1/89	0.402	0.358	24/3/92	0.778	-	1/6/96	0.405	0.261
21/3/89	0.708	4.036	30/5/92	0.200	0.017	19/7/96	0.330	0.242
30/5/89	0.515	0.839	2/6/92	0.200	0.022	11/8/96	0.280	0.096
20/6/89	0.500	0.573	16/7/92	0.200	0.035	4/9/96	0.230	0.066
20/10/89	0.335	0.159	2/9/92	0.180	0.008	2/10/96	0.170	0.015
9/1/90	0.600	1.450	14/10/92	0.000	0.004	12/12/96	0.445	0.430
30/1/90	0.535	0.926	7/1/93	0.560	1.355	30/1/97	0.750	3.585
9/2/90	0.650	2.769	6/5/93	0.528	0.505	27/2/97	0.670	2.840
17/11/89	0.205	0.188	4/6/93	0.405	0.170	29/4/97	0.598	0.955
20/3/90	0.473	0.551	9/8/93	0.389	0.065	25/6/97	0.490	0.498
1/5/90	0.480	1.541	12/11/93	0.530	0.378	22/8/97	0.425	0.208
1/6/90	0.275	0.324	10/3/94	0.330	0.066	25/10/97	0.400	0.172
1/4/91	0.470	0.355	9/6/94	0.295	0.045	26/11/97	0.448	0.465
25/7/90	0.355	0.244	2/9/94	0.226	0.014	8/2/98		2.434
22/9/90	0.378	0.099	24/10/94	0.145	0.007	22/3/98	0.670	2.350
10/10/90	0.230	0.077	12/12/94	0.645	0.684	24/11/98	0.415	0.246
6/12/90	0.301	0.123	5/1/95	0.505	0.400	1/4/99	0.408	2.568
6/2/91	0.561	1.201	7/2/95	0.505	0.372	19/5/99	0.522	1.138
7/6/91	0.400	0.272	8/7/95	0.115	0.002	7/7/99	0.470	0.834
16/9/91	0.248	0.248	12/4/96	0.480	0.711	30/7/99		0.535
						30/7/99	0.450	0.535

E3. DAM REQUIRED TO REHABILITATE IN THE STUDY AREA

District	No.	Dam Name	Dimension Length(m) x Width(m)	Storage Capacity (m ³)	TA	EPA	Map Sheet	Grid Ref	Village	Status/Remarks
	1	Chilala(Chitunga)	100x150	30,000	Kape Lirangwe	1535 C1	213746	Chilala		Introducing of Fishing, Siltation Problem
	2	Ntenjela	50x150	15,000	Kapeni	1534 D2	118711	Ntenjela		Rehabilitation of Dike, Irrigation Facilities
	3	Ng'onga	20x30	1,200	Kapeni	1535 C1	161829	Sani		Introducing of Fishing, Siltation Problem
	4	Tnongande	100x100	20,000	Kapeni	1535 C1	175772	Malenle		Introducing of Fishing, Siltation Problem
	5	Mwanempeoha	50x30	3,000	Kapeni	1535 C1	152741	Jele		Introducing of Fishing, Siltation Problem
	6	Milala	200x200	80,000	Kuntaja	1534 D2	095735	Semu		Introducing of Fishing, Siltation Problem
	7	Pampando	50x70	7,000	Kuntaja	1534 D2	117711	Khungulu		Rehabilitation of Dike, Irrigation Facilities
	8	Pang'ond	50x50	5,000	Kuntaja	1534 D2	76736	Lenu		Rehabilitation of Dike, Irrigation Facilities
	9	Pankuyu	50x50	5,000	Kuntaja	1534 D2	93683	Chuna		Rehabilitation of Dike, Irrigation Facilities
	10	Namalindi	30x50	3,000	Kuntaja	1534 D2	85738	Lenu		Rehabilitation of Dike, Irrigation Facilities
	11	Mpando	50x50	3,750	Kuntaja	1534 D2	118718	Kamnkhata		Rehabilitation of Dike, Irrigation Facilities
Blantyre	12	Nkokozi	60x80	9,600	Kuntaja	1534 D2	90765	Kantumbiza		Rehabilitation of Dike, Irrigation Facilities
	13	Mkata	50x50	5,000	Kuntaja	1534 D2	105675	Mkata		Introducing of Fishing, Rehabilitation of Dike, Outlet
	14	Dziwi	30x50	3,000	Kuntaja	1534 D2	25788	Kachakwale		Introducing of Fishing, Rehabilitation of Dike, Outlet
	15	Chingwe	50x30	3,000	Kuntaja	1534 D2	108715	Kanmata		Introducing of Fishing, Rehabilitation of Dike, Outlet
	16	Nangonba	50x50	5,000	Kuntaja	1534 D2	88735	Len		Introducing of Fishing, Rehabilitation of Dike, Outlet
	17	Pankundi	30x50	3,000	Kuntaja	1534 D2	87689	Chuma		Introducing of Fishing, Rehabilitation of Dike, Outlet
	18	Mlongoti	30x50	45,000	Kuntembwe	1534 D2	23688	Mlongoti		Introducing of Fishing, Rehabilitation of Dike, Outlet
	19	Makina	100x50	150,000	Lundu	1535 C1	755177	Matengo		Out of Study Area
	20	Namikasi 1	50x70	7,000	Lundu	1535 C1	187822	Matengo		Introducing of Fishing, Siltation Problem
	21	Namikasi 2	50x70	7,000	Lundu	1535 C1	180825	Fes		Introducing of Fishing, Siltation Problem
	22	Mbvoniha	200x 300	120,000	Mak	1535 C1	255780	Fred		Siltation Problem, Rehabilitation of Dike and Outlet Facilities
	23	Chomba	300x400	240,000	Makata	1535 C1	243766	Ntolera		Siltation Problem, Rehabilitation of Dike and Outlet Facilities
	24	Mbendela	50x50	5,000	Makata	1535 C1	223738	Mili		Siltation Problem, Rehabilitation of Dike and Outlet Facilities
		Total		775,550						
				2						

Note:

Available water depth at each pond is estimat 1.5 m

E4. SMALL IRRIGATION PROJECT IN THE STUDY AREA

SITE	RDP	EPA	SECTION	TYPE OF IRRIGATION	NO OF PUMP	NAME/No.OF FARMER	TYPE OF PUMP	IRRIGATION AREA(ha)	CROP GROWN	REMARKS
Lirangwe	Bt/Sh	Lirangwe	Linjjidzi	Furrow	1	Mr. Phillip Hora	Treadel	0.3	Maize & vegetable	
Bangwe	Bt/Sh	Ntonda	Bargwe	Furrow	1	Pastor Malenga	Treadel	0.3	Maize & vegetable	
Chigumula	Bt/Sh	Ntonda	Chigumula	Furrow	1	Mr. Valera	Treadel	0.3	Flowers	
Chigumula	Bt/Sh	Ntonda	Chigumula South	Furrow	2	Mr. Njati	Treadel	0.6	Maize & vegetable	
Ntonda	Bt/Sh	Ntonda		Furrow	1	Mr. Naphiyo	Treadel	0.3	Maize & vegetable	
Chipande	Bt/Sh	Ntonda	Chipanda South	Furrow	1	Mrs. Phombeya	Treadel	0.3	Maize & vegetable	
Lirangwe	Bt/Sh	Ntonda	Chipanda South	Furrow	1	Mr.J. Lumbira	Treadel	0.3	Maize & vegetable	
Manyamba	Bt/Sh	Ntonda	Chipanda South	Furrow	1	Mr. Maria	Treadel	0.3	Maize & vegetable	
Milemani	Bt/Sh	Ntonda	Machinjili South	Furrow	1	Mr. Banda	Treadel	0.3	Maize & vegetable	
Chigumula	Bt/Sh	Ntonda	Chigumula South	Furrow	1	Mr. Mphele	Treadel	0.3	Maize & vegetable	
Lirangwe	Bt/Sh	Lirangwe	Lirangwe East	Furrow	1		Treadel	0.3	Maize & vegetable	
Mbvunguti	Bt/Sh	Lirangwe	Kunthembwe	Furrow	1	18 Farmers 2 Werner Pump		3.0	Maize & vegetable	Water Problem
Linjjidzi	Bt/Sh	Lirangwe	Linjjidzi	Furrow	1	30 Farmers	Pump	12.0	Maize & vegetable	Flood Damage
Lirangwe	Bt/Sh	Lirangwe	Matope Bridge	Furrow	1	Mr. Manjolo	Treadel	0.3	Maize & vegetable	
Lirangwe	Bt/Sh	Lirangwe	Linjjidzi	Furrow	1	Mr. Mirjale	Treadel	0.3	Maize & vegetable	
Lirangwe	Bt/Sh	Lirangwe	Linjjidzi	Furrow	1	Mr. Thycheyera	Treadel	0.3	Maize & vegetable	
Lirangwe	Bt/Sh	Lirangwe	Linjjidzi	Furrow	1		Treadel	0.3	Maize & vegetable	
Ndunde	Bt/Sh	Monbezi	Ndunde	Dam(MASF)						

Note: Bt/Sh Blantyre Shire Highlands Agricultural Dvelop

E5. EROSION HAZARD

1. Erosion Hazard

Erosion hazard is defined as an estimation of soil loss caused by run-off water when land use is converted by the inhabitants from forest, brush, grassland or fallow land into bare field. The hazard can be forecast from the following factors that induce soil erosion:

- 1) Erosion is more caused by torrential orographic rain with higher kinetic energy because rain-drops are larger and soil surface may soon saturated with moisture so that runoff quickly occurs. The more frequently orographic rainfall takes place, in other words the larger the annual precipitation becomes, the more soil may be taken off from bare ground. In the S.A., rainfall pattern shows mostly non-orographic type. Rain drops hit soil particles on the ground surface destroying aggregate structure and clogging soil pores that can allow water infiltrate into soil layers.
- 2) Erosion is often observed on slope, the steeper the slope, the severer erosion may develops. Similarly, the longer the slope extends, the larger erosion may result in. The velocity of run-off water on ground surface is accelerated with the slope gradient and when the gradient increases from 2° to 6° or 13° the water velocity augments to 1.8 or 2.46 times as much as that on the slope of 2° and capacity of washing or carrying soil particles becomes 8.1 times or 41.4 times as much as that on the slope of 2° . The speed of developing erosion behaves thus quadruple to the increase by the gradient rather than proportional.
- 3) The nature of soil surface is closely interrelated with development of soil erosion. As a rule, soils composed of the mixture of different size soil particles have higher rate of porosity that fosters water infiltration into soil layers, thus contributing to less run-off from ground surface. On the other hand, those consisted of relatively homogeneous size have less porosity to accommodate water, thus limiting water intrusion into soil layers and facilitating surface run-off. Humus containing in the soil surface layer allows to form aggregate particles thus increasing soil pores into which rain water can readily seeps.
- 4) Crop cover and surface mulching may attenuate the hitting energy of rain-drops because canopy and mulching materials intercept rain drops so that they don't strike soil surface directly. Cultivation with high ridges also can block run-off waterway running down the slope. Cassava, banana and other crops with longer growth period also serve as erosion barrier with

their developed canopy during the rainy season.

2. Erosion Hazard Map

Modified and simplified version of the Soil Loss Estimation Model for Southern Africa (SLEMSA), used by the Land Resources Evaluation Project (LREP) in the Ministry of Agriculture and Irrigation, is hereby adopted to provide the Erosion Hazard Map in the S.A. It consists of three submodels:

K : Mean annual soil loss (t/ha/year) from a standard tilled field (bare soil, without ridge, 4.5% slope, 30m long). K is a function of rainfall energy (E) and soil erodibility (F).

X : The ratio of soil loss from a plot length of L meters and slope gradient (in percent) S, to that lost from the standard plot.

C : The ratio of soil loss from a cropped plot, to that from the bare fallow.

The annual soil loss Z (in t/ha/yr) is calculated by multiplying K, C and X; $Z = KCX$

Calculation of each of the variables

K, the climate and soil factor, is a function of mean seasonal rainfall energy (E) and soil erodibility (F), and (E) was originally derived from annual rainfall but later replaced by the length of growing period of major crops (LGP), since a high correlation ($R^2 = 0.88$) was identified for 66 meteo-stations in Malawi. In the S.A., thunderstorms are predominant type of rainfall (orographic rain), for which the curve is proposed as Fig. 1.

X, the topographic factor, is a function of gradient (S) and slope length (L). In the modified model, four gradient ranges have been used, i.e., 0~2%, 2~6%, 6~13% and 13~20%. Since SLEMSA is not valid for slopes steeper than 20%, the fourth gradient range (13~20%) is different from the slope class of the corresponding FAO model (13~25%) as adopted by LREP. One standard slope length of 20m has been used, since ridging is assumed to reduce slope drastically. S and L compose a numerical equation and the corresponding X is read from Y axis.

C, the crop factor, is derived from the energy interception value (I), which is determined by crop type, yield and emergence date. The modified model primarily meant to predict erosion hazard. Therefore three standard I values were used to cover three widely different cropping situations: poor-cover annual crops (millet, sorghum, cotton, tobacco, cassava, pigeon pea etc.) with C-value of 0.13 or $i = 35\%$, good-cover annual crops (maize, groundnut, wheat, paddy, beans, cowpea, potato etc.) with C-value of 0.06 or $i = 50\%$,

and perennials (vegetables, banana etc.) or pasture, with C-value of 0.02 or $i = 70\%$, where i stands for interception rate of raindrops by plant canopy.

Calculation of Z : Predicted mean annual soil loss in t/ha/yr) is calculated by multiplication of K, X and C. For perennials, suitability of land slope class 25~55% has also been considered;/ these soil loss figures have been interpreted from known trends and from field knowledge and not calculated with SLEMSA.

Interpretations of results

Soil loss has been calculated both at the traditional management and the improved traditional management level. There are three possibilities to reflect the difference in management between the two levels in the model: in the crop factor, in the slope length factor and in the soil erodibility factor. Since no research data are available, the difference between the models has kept simple.

The crop factor (ground cover) has been unchanged, assuming that the presence of more weeds at the traditional management level compensate for the increased canopy cover at higher yields at the improved traditional management level. Slope length has been standardized at 20m for all situations. Only a different value for ridging in the management component of the soil erodibility factor has been assigned to the two levels. It is assumed that ridging on the contour is common practice at the improved management level (= basic soil erodibility factor plus one) and that ridging at the traditional level, although commonly practiced, is often not properly aligned on the contour (= basic soil erodibility factor only).

Finally, the tolerance to a decline in productivity of the eroding soil is considered. It is assumed that a shallow soil is in greater danger of losing its productivity than a deep soil. Therefore three different soil depth situations are considered:

- soils deeper than 100 cm are reasonably tolerant to soil loss (vertisols, entisols etc.)
- those between 50 and 100 cm deep are sensitive to soil loss (ferralitic or latosols)
- those between 30 and 50 cm deep are very sensitive to soil loss (mostly lithosols)

X Values by Slope length

slope	L = 20m	L = 30m
0 ~ 2%	0 ~ 0.3	0 ~ 0.4
2 ~ 6%	0.3 ~ 1.1	0.4 ~ 1.5
6 ~ 13%	1.1 ~ 3.5	1.5 ~ 4.2

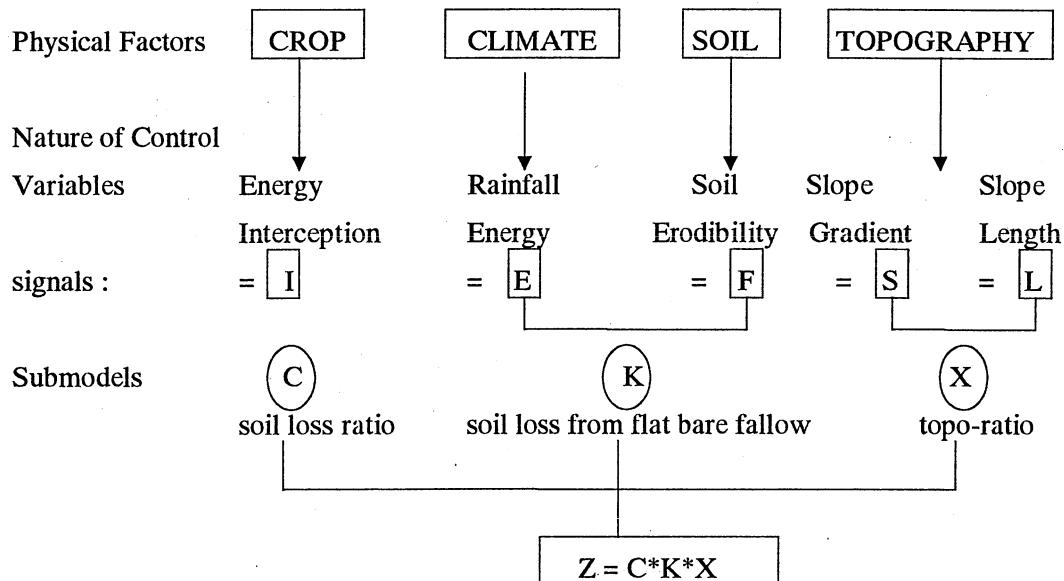
13 ~ 20%	3.5 ~ 7.2	4.2 ~ 9.0
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Relationship between Mean Seasonal Energy (E) or LGP, Soil Erodibility (F)
and Soil Loss from Bare Fallow Surface ($K = \text{ton/ha/yr}$)

j: joule

E	corresp.P	corresp.LGP	F = 3.0	F = 4.5	F = 5.5	F = 7.5
15,680 j/m ²	832mm	135days	190	74	35	8
17,450 j/m ²	926mm	150days	250	105	54	15
19,300 j/m ²	1,020mm	165days	-	152	82	27
20,970 j/m ²	1,207mm	195days	-	210	122	54
22,600 j/m ²	1,301mm	210days	-	270	170	65

Calibration procedures of hazard extent of a particular site are given below:



Equations:

$$C = \exp(-0.06 I)$$

$$C = \exp(2.3 - 0.01 I)/30$$

$$K = \exp\{(0.4681 + 0.7663F)\ln E + 2.884 - 8.1209F\}$$

where $F = F_{\text{bare}} + 1$ for contour ridge cultivation

where $E = 2,792 \sim 3,206 \text{ LGP}$ (length of growing period)

$$X = L^{0.8}(0.78 + 0.53S + 0.078S^2) / 25.65$$

Relationship between Mean Rainfall Energy and Length of Growth Period (LGP)

LGP	90 ~ 135	136 ~ 165	166 ~ 195	196 ~ 210 #	< 210 #
E value function	15,680	E=116.1LGP	E=58.7LPG + 9,540	E=107.6LGP	22,600

Note: $E = a * LGP$, unit of E; joule / m², # orographic rainfall pattern, rest are non-orographic

ones.

Class adopted for LGP (length of growth period), F_m (soil erodibility factor), slope gradient and soil depth

CLASS	LGP	F_m	Slope Gradient	Soil Depth	Crop Cover
1	< 134days	2.0	0 ~ 2	30 ~ 50cm	poor cover C=0.13
2	135~149days	3.5	2 ~ 6	50 ~ 100cm	good cover C=0.06
3	150~164days	4.5	6 ~ 13	> 100cm	perennials C=0.02
4	165~179days	6.5	13 ~ 20	-	and pasture C=0.02
5	180~195days	7.5	(13 ~ 25)	-	-
6	196~210days	-	-	-	-
7	> 210days	-	-	-	-

Note: C=0.13 equivalent to $i = 35\%$, C=0.06 corresponds to $i = 50\%$, C=0.02 to $I = 70\%$,

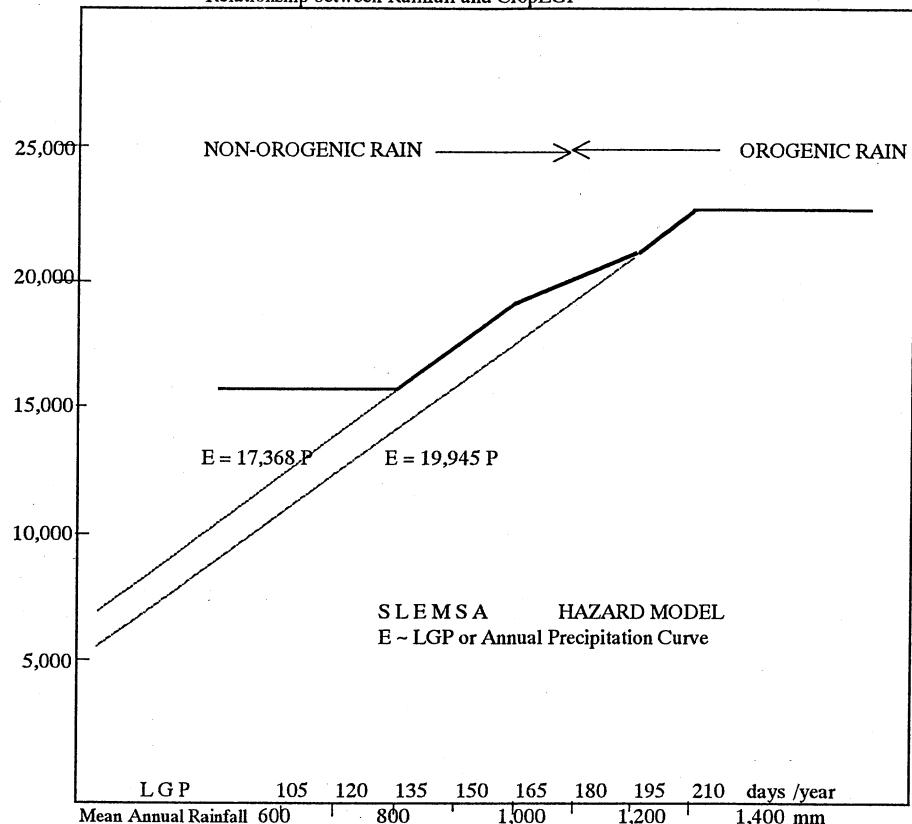
As to corresponding crop species, refer to the calculation of variable C as cited above.

Relationship between Soil Erodibility and Soil types

Soil Erodibility Factor		Soil Family and Texture	
case of traditional tillage	case of contour ridge	by USDA criteria	by FAO classification
2.0	3.0	Vertisol, sandy Lithosol	vertic with
3.5	4.5	Vertisol with coarse t.s.	salic, mopanic,
		Cambisol	vertic with coarse t.s.
4.5	5.5	Lithosol	lithic, paralithic, fulvic,
		Fulvisol, Arenosol	gleic, arenic, calcareic
		sandy Latosol	ferralic dystric or eutric*
		sandy Entisol	fersialic dystric or eutric**
6.5	7.5	Latosol	ferralic dystric or eutric**
		Entisol	fersialic dystric**

Note : * with coarse topsoil texture, ** with fine and medium topsoil texture

Relationship between Rainfall and CropLGP



Estimated Soil Loss under Improved Traditional Tillage by Various Environmental Conditions

Graphic Illustration of Factors related to SLEMSA Calibration

