Soil loss calculations with WEPP and USLE models on sloping arable land near Isaszeg, Hungary

Krisztina Demény[A,C], Csaba Centeri[A] and Gergely Jakab[B]

[A]Department of Nature Conservation and Landscape Ecology, Institute of Environmental and Landscape Management, Faculty of Agricultural and Environmental Sciences, Szent István University, 2103-Gödöllő, Páter K. u. 1, Hungary, Email Centeri.Csaba@kti.szie.hu
[B]Research Institute of Geography, Hungarian Academy of Sciences, H-1112-Budapest, XI. Budaörsi ut 45, Hungary, Email jakab@sparc.core.hu
[C]Budapest Tech Polytechnical Institute Rejtő Sándor, Faculty of Light Industry and Environmental Protection Engineering, H-1034 Budapest, Doberdó út 6, Hungary, E-mail demeny.krisztina@rkk.bmf.hu

Abstract
The global economical crisis forced all farmers to increase cost effectiveness on their farms. Soil loss calculations provide important information because losing soil means losing nutrients that are expensive not only to buy but also to spread and work into the soil. The examined area has a loessy sand parent material. Intensive arable farming, high compaction and small infiltration rate result in high erodibility. WEPP and USLE model were chosen to be used to provide information from various sources and also to compare the efficiency of the models on a slope of intensive arable farmland. The results show that on the upper and middle slope sections WEPP calculates more soil loss than USLE while at the bottom of the slopes WEPP calculates much more than USLE. On-site investigations proved that the lower part of the slope is sedimented, so USLE is closer to reality at the bottom of the slope.

Key Words
Soil erosion, modelling, soil loss, WEPP, USLE, intensive farming.

Introduction
Soil loss reaches smaller extents in Hungary than in tropical countries, but still remains an ongoing problem on agricultural fields of Hungary. The phenomenon is examined mainly in hilly areas or in medium size mountainous outskirts of Hungary, where precipitation is reaching 800 mm /year. In the Isaszeg area the amount of precipitation (600mm/y) and its intensity is not extremely high but the determining parent material (sand mixed with loess) resulted in high erodibility and on arable farms soil loss can reach higher proportion that is causing economical loss for the farmers and for local communities through cleaning up off site effects. Around Isaszeg gullies are wide spread, covering 11.19ha of the outskirts of the settlement. The crop rotation contains a high percentage of of sunflower and maize and thus does not support soil protection measures (Centeri 2002, Szilassi *et al.* 2006). Better management needs to be achieved for a more sound nature and environmental protection (Jordan *et al.* 2005). Soil and nutrient loss are calculated in erosion models all over the world (Gournellos *et al.* 2004, Pimentel *et al.* 1995, Renwick *et al.* 2008, Gordon *et al.* 2008, Rhoton et al 2008, Montgomery 2007, Vanacker *et al.* 2007), especially in connection with arable cultivation.

Methods
The well-known USLE (Wischmeier and Smith 1978) and WEPP (Flanagan models were used for the analyses. The Water Erosion Prediction Project (WEPP) was started in 1985. Its purpose was to develop new-generation water erosion prediction technology, originally (as well as the USLE) for use in the USA. The WEPP model was developed by the USDA-ARS to replace empirically based erosion prediction technologies, such as USLE, RUSLE, MUSLE. The WEPP model simulates many of the formerly missing physical processes important in soil erosion (e.g. infiltration, runoff, raindrop and flow detachment, sediment transport, deposition, plant growth, and residue decomposition) as input parameters. The WEPP project is similar to USLE because it was constructed based on extensive field experimental program (on cropland, rangeland and disturbed forest sites). The model can be used with Microsoft Windows operating system graphical interfaces, web-based interfaces, and integration with Geographic Information Systems since 1995. Watershed channel and impoundment components, CLIGEN weather generator, the daily water balance and evapotranspiration routines, and the prediction of subsurface lateral flow along low-permeability soil layers was developed and continuously improved (Chaves and Nearing 1991; Risse *et al.* 1994; Flanagan *et al.* 2007; Deer-Ascough *et al.* 1995; Grismer 2007; Moffet *et al.* 2007; Kim *et al.* 2007; Bonilla *et al.* 2007; Moore *et al.* 2007, Shen *et al.* 2009). Input parameters for the WEPP model: rainfall (amount 16.50 mm,

duration 48 min), normalized peak intensity (2.73), normalized time to peak (0.15). Land use was tilled fallow. Slope length and slope angle was calculated based on the topography map of the area and on in situ check with GPS. Input parameters for the USLE model were as it is detailed in Table 1 with the results of soil loss calculations.

Results

The results of soil loss calculations with USLE model for the selected slope section of the Isaszeg arable field can be found in Table 1.

Table 1. Input parameters and results of the simulation with the USLE model, Isaszeg, Hungary.

Slope section	R[A]	K	L	S	A (t/ha)	A (kg/ha)	A (kg/m^2)
Upper_01	12,12882	0.38	0.52	0.57	1.37	1366.09	0.136609
Upper_02		0.28	1.27	1.33	5.74	5736.30	0.573630
Middle		0.009	1.515	1.95	0.32	322.48	0.032248
Lower		0.0001	1.41	0.57	0.00	0.97	0.000097

[A]in this special case, since the calculation is for one rainfall event, this is erosivity index, C and P factors = 1

The results of soil loss calculations with WEPP model can be found in Tables 2-5.

Table 2. Results of the simulation with the WEPP model for the upper slope third No.1, Isaszeg, Hungary.

PD[A] (m) (m)	SOL (kg/m^2)	PD (m) (m)	SOL (kg/m^2)	PD (m) (m)	SOL (kg/m^2)	PD (m) (m)	SOL (kg/m^2)	PD (m) (m)	SOL (kg/m^2)
0.06	0.012	1.39	0.012	2.73	0.012	4.06	0.037	2.60	0.012
0.12	0.012	1.45	0.012	2.79	0.012	4.12	0.039	2.66	0.012
0.18	0.012	1.51	0.012	2.85	0.012	4.18	0.041	3.94	0.033
0.24	0.012	1.57	0.012	2.91	0.012	4.24	0.043	4.00	0.035
0.30	0.012	1.64	0.012	2.97	0.012	4.30	0.045	5.27	0.076
0.36	0.012	1.70	0.012	3.03	0.012	4.36	0.047	5.33	0.078
0.42	0.012	1.76	0.012	3.09	0.012	4.42	0.049	5.39	0.080
0.48	0.012	1.82	0.012	3.15	0.012	4.48	0.051	5.45	0.081
0.55	0.012	1.88	0.012	3.21	0.012	4.54	0.053	5.51	0.083
0.73	0.012	1.94	0.012	3.27	0.012	4.60	0.055	5.57	0.085
0.79	0.012	2.00	0.012	3.33	0.012	4.66	0.057	5.63	0.087
0.85	0.012	2.06	0.012	3.39	0.014	4.72	0.059	5.69	0.089
0.91	0.012	2.12	0.012	3.45	0.016	4.78	0.061	5.75	0.090
0.97	0.012	2.18	0.012	3.51	0.018	4.84	0.063	5.81	0.092
1.03	0.012	2.24	0.012	3.57	0.020	4.91	0.065	5.87	0.094
1.09	0.012	2.30	0.012	3.63	0.023	4.97	0.067	5.94	0.096
1.15	0.012	2.36	0.012	3.69	0.025	5.03	0.069	6.00	0.097
1.21	0.012	2.42	0.012	3.75	0.027	5.09	0.070	6.06	0.099
1.27	0.012	2.48	0.012	3.82	0.029	5.15	0.072		
1.33	0.012	2.54	0.012	3.88	0.031	5.21	0.074		

[A]PD = Profile distances are from top to bottom of hillslope, SOL = Soil loss

Table 3. Results of the simulation with the WEPP model for the upper slope third No.2., Isaszeg, Hungary.

PD[A] (m) (m)	SOL (kg/m^2)	PD (m) (m)	SOL (kg/m^2)	PD (m) (m)	SOL (kg/m^2)	PD (m) (m)	SOL (kg/m^2)	PD (m) (m)	SOL (kg/m^2)
6.42	0.107	13.62	0.201	20.82	0.280	28.02	0.350	35.22	0.283
6.78	0.112	13.98	0.205	21.18	0.284	28.38	0.349	35.58	0.278
7.14	0.117	14.34	0.209	21.54	0.288	28.74	0.346	35.94	0.275
7.50	0.122	14.70	0.213	21.90	0.291	29.10	0.344	36.30	0.277
7.86	0.127	15.06	0.218	22.26	0.295	29.46	0.341	36.66	0.279
8.22	0.132	15.42	0.222	22.62	0.298	29.82	0.339	37.02	0.282
8.58	0.137	15.78	0.226	22.98	0.302	30.18	0.336	37.38	0.284
8.94	0.142	16.14	0.230	23.34	0.306	30.54	0.333	37.74	0.286
9.30	0.147	16.50	0.234	23.70	0.309	30.90	0.330	38.10	0.288
9.66	0.151	16.86	0.238	24.06	0.313	31.26	0.327	38.46	0.291
10.02	0.156	17.22	0.242	24.42	0.316	31.62	0.323	38.82	0.293
10.38	0.161	17.58	0.246	24.78	0.320	31.98	0.320	39.18	0.295
10.74	0.165	17.94	0.250	25.14	0.323	32.34	0.316	39.55	0.297
11.10	0.170	18.30	0.254	25.50	0.326	32.70	0.313	39.91	0.299
11.46	0.174	18.66	0.258	25.86	0.330	33.06	0.309	40.27	0.301
11.82	0.179	19.02	0.261	26.22	0.333	33.42	0.305	40.63	0.304
12.18	0.183	19.38	0.265	26.58	0.337	33.78	0.301	40.99	0.306
12.54	0.188	19.74	0.269	26.94	0.340	34.14	0.297	41.35	0.308
12.90	0.192	20.10	0.273	27.30	0.343	34.50	0.292	41.71	0.310
13.26	0.196	20.46	0.276	27.66	0.347	34.86	0.288	42.07	0.312

[A]PD = Profile distances are from top to bottom of hillslope, SOL = Soil loss

Table 4. Results of the simulation with the WEPP model for the middle slope third, Isaszeg, Hungary.

PD[A] (m) (m)	SOL (kg/m^2)	PD (m) (m)	SOL (kg/m^2)	PD (m) (m)	SOL (kg/m^2)	PD (m) (m)	SOL (kg/m^2)	PD (m) (m)	SOL (kg/m^2)
42.57	0.189	52.76	0.177	62.94	0.165	73.12	0.153	83.30	0.198
43.08	0.189	53.26	0.176	63.45	0.165	73.63	0.154	83.81	0.197
43.59	0.188	53.77	0.176	63.95	0.164	74.14	0.158	84.32	0.196
44.10	0.187	54.28	0.175	64.46	0.163	74.64	0.162	84.83	0.195
44.61	0.187	54.79	0.175	64.97	0.163	75.15	0.166	85.33	0.195
45.12	0.186	55.30	0.174	65.48	0.162	75.66	0.170	85.84	0.194
45.63	0.185	55.81	0.173	65.99	0.162	76.17	0.174	86.35	0.193
46.14	0.185	56.32	0.173	66.50	0.161	76.68	0.178	86.86	0.192
46.65	0.184	56.83	0.172	67.01	0.160	77.19	0.181	87.37	0.192
47.16	0.184	57.34	0.172	67.52	0.160	77.70	0.185	87.88	0.191
47.67	0.183	57.85	0.171	68.03	0.159	78.21	0.189	88.39	0.190
48.17	0.182	58.36	0.170	68.54	0.159	78.72	0.193	88.90	0.190
48.68	0.182	58.86	0.170	69.05	0.158	79.23	0.196	89.41	0.189
49.19	0.181	59.37	0.169	69.55	0.157	79.73	0.200	89.92	0.188
49.70	0.181	59.88	0.169	70.06	0.157	80.24	0.202	90.42	0.187
50.21	0.180	60.39	0.168	70.57	0.156	80.75	0.201	90.93	0.187
50.72	0.179	60.90	0.167	71.08	0.156	81.26	0.200	91.44	0.186
51.23	0.179	61.41	0.167	71.59	0.155	81.77	0.200	91.95	0.185
51.74	0.178	61.92	0.166	72.10	0.155	82.28	0.199	92.46	0.185
52.25	0.178	62.43	0.166	72.61	0.154	82.79	0.198	92.97	0.184

[A]PD = Profile distances are from top to bottom of hillslope, SOL = Soil loss

Table 4. Results of the simulation with the WEPP model for the lower slope third, Isaszeg, Hungary.

PD[A] (m) (m)	SOL (kg/m^2)	PD (m) (m)	SOL (kg/m^2)	PD (m) (m)	SOL (kg/m^2)	PD (m) (m)	SOL (kg/m^2)	PD (m) (m)	SOL (kg/m^2)
93.41	0.109	102.22	0.025	111.02	0.023	119.83	0.020	128.63	0.017
93.85	0.109	102.66	0.025	111.46	0.022	120.27	0.020	129.07	0.017
94.29	0.108	103.10	0.025	111.90	0.022	120.71	0.019	129.51	0.017
94.73	0.104	103.54	0.025	112.34	0.022	121.15	0.019	129.96	0.016
95.17	0.098	103.98	0.025	112.78	0.022	121.59	0.019	130.40	0.016
95.61	0.092	104.42	0.025	113.22	0.022	122.03	0.019	130.84	0.016
96.05	0.086	104.86	0.024	113.66	0.022	122.47	0.019	131.28	0.016
96.49	0.080	105.30	0.024	114.10	0.022	122.91	0.019	131.72	0.016
96.93	0.074	105.74	0.024	114.54	0.021	123.35	0.019	132.16	0.016
97.37	0.068	106.18	0.024	114.99	0.021	123.79	0.018	132.60	0.016
97.81	0.062	106.62	0.024	115.43	0.021	124.23	0.018	133.04	0.015
98.25	0.055	107.06	0.024	115.87	0.021	124.67	0.018	133.48	0.015
98.69	0.049	107.50	0.024	116.31	0.021	125.11	0.018	133.92	0.015
99.13	0.043	107.94	0.023	116.75	0.021	125.55	0.018	134.36	0.015
99.57	0.036	108.38	0.023	117.19	0.021	125.99	0.018	134.80	0.015
100.01	0.030	108.82	0.023	117.63	0.020	126.43	0.018	135.24	0.015
100.46	0.026	109.26	0.023	118.07	0.020	126.87	0.017	135.68	0.015
100.90	0.026	109.70	0.023	118.51	0.020	127.31	0.017	136.12	0.014
101.34	0.026	110.14	0.023	118.95	0.020	127.75	0.017	136.56	0.014
101.78	0.025	110.58	0.023	119.39	0.020	128.19	0.017	137.00	0.014

[A]PD = Profile distances are from top to bottom of hillslope, SOL = Soil loss

Comparing the results of USLE (Table 1) and WEPP (Tables 2-5) we can see that USLE calculates more soil loss for the upper third No.1. and No.2. (and No.2. values are closer), while WEPP calculates higher values for the middle slope section. Each model calculates almost no erosion for the lower slope third.

Conclusion

We can conclude that in the present situation (with the given input parameters) USLE and WEPP calculated different soil loss values for the upper and middle slope thirds. The importance of local measurements in order to make these models more appropriate is evident in order to provide more precise input parameters

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