

# 1 Discussion on “GIS Based Distributed 2 Model for Soil Erosion and Rate of 3 Sediment Outflow from Catchments” 4 by Manoj K. Jain, Umesh C. Kothiyari, 5 and Kittur G. Ranga Raju

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13 The authors present a model of soil erosion for application in  
14 grid-cell representations of catchments. The model includes sub-  
15 models for detachment by raindrop impact, detachment by flow  
16 and transport capacity of flow to determine the discharge of sedi-  
17 ment from each grid cell. Following an examination of the litera-  
18 ture, the authors have used the following equation to compute  $D_i$ ,  
19 the amount of material detached by raindrop impact per unit area  
20

$$21 \quad D_i = \omega F_W C_F K_F I^a (2.96 S_0^{0.79} + 0.56) \quad (1)$$

22 where  $\omega$ =coefficient of rainfall detachment,  $F_W$ =water depth cor-  
23 rection factor,  $C_F$ =cover management factor of the Universal Soil  
24 Loss Equation (USLE),  $K_F$ =soil erodibility factor of the USLE,  
25  $I$ =rainfall intensity and  $a=2$ , and

$$26 \quad F_W = 1.0, \quad h \leq D_m \quad (2)$$

27 where  $h$ =flow depth and  $D_m$ =median raindrop diameter.

28 While the  $I^2$  term in Eq. (1) is attributed by the authors to  
29 Foster (1982), it was used in the WEPP interrill erosion model  
30 described by Nearing et al. (1989)

$$31 \quad D_i = K_i I_e^2 C_g C_c S_f \quad (3)$$

32 where  $K_i$ =interrill erodibility;  $I_e$ =effective rainfall intensity dur-  
33 ing the period of rainfall excess;  $C_g$ =ground cover effect adjust-  
34 ment factor;  $C_c$ =canopy cover effect adjustment factor; and  
35  $S_f$ =function of the interrill slope. However, rather than using soil  
36 and cover factors as used in WEPP, Eq. (1) uses the soil and cover  
37 factors as in the USLE. This approach is inappropriate. As noted  
38 by the authors,  $K_F$  has units of  $\text{kg h/Nm}^2$ . This is because the soil  
39 erodibility factor is essentially an empirical coefficient in the em-  
40 pirical relationship between the USLE erosivity factor and soil  
41 loss from a bare fallow runoff and soil loss plot. Similarly,  $K_i$  in  
42 Eq. (3) is essentially an empirical coefficient in the empirical  
43 relationship between the  $I_e^2$  interrill erosivity factor and soil loss  
44 from a bare soil surface being subjected to erosion by rain-  
45 impacted flow and consequently, has units of soil loss per unit of  
46  $I_e^2$ . The soil factor used in Eq. (1) needs to have those same units.  
47  $K_F$  does not meet this criterion. Also,  $K_F$ , the soil factor for soil  
48 erosion, is associated with both sheet and rill erosion, a situation  
49 which includes detachment by both raindrop impact and flow;  
50 while Eq. (1) applies to erosion caused by raindrop detachment  
51 alone. The application of the USLE cover factor ( $C_F$ ) within Eq.  
52 (1) and the use of the USLE soil and cover factors in the equation  
53 for detachment by flow are also inappropriate for the same rea-  
54 sons.

55 It should be noted that Eq. (3) is no longer used in WEPP.  
56 Following observations by Kinnell (1990, 1991, 1993a,b) that the  
57 rate at which sediment is transported across a unit width of any

boundary covered by shallow rain-impacted flow of uniform 58  
depth and velocity varies directly with  $I$  rather than  $I^2$ , and that 59  
the  $I^2$  term is simply an approximation of  $q_w I$  (where  $q_w$  is runoff 60  
rate in the same units as rainfall intensity), particularly when the 61  
soil surface is impermeable or nearly so 62

$$D_i = K_i I_e I_x C_g C_c S_f \quad (4) \quad 63$$

$I_x$ , the excess rainfall rate (surrogate for  $q_w$ ), was adopted later in 64  
WEPP (Flanagan and Nearing, 1995). Because the product of  $I_e$  65  
and  $I_x$  is less than  $I_e^2$ , the value for  $K_i$  in Eq. (4) differs from the 66  
value for  $K_i$  in Eq. (3), even though the units are the same. 67

While models such as WEPP refer to  $D_i$  as detachment in areas 68  
where detachment is driven by raindrop impact, the term “detach- 69  
ment” needs to be defined.  $D_i$  is the mass of sediment discharged 70  
by rain-impacted flow across a boundary divided by the area con- 71  
tributing to that flow. To be discharged, the sediment detached by 72  
raindrop impact has to be transported across that boundary. Small, 73  
low density material remains suspended in the flow and moves 74  
freely with the flow but coarse more dense material falls back on 75  
the bed awaiting a subsequent drop impact before continuing the 76  
travel downstream (Kinnell 2005). As a result of this, the non- 77  
suspended load material produces a lag deposit and consequently, 78  
the actual rate at which the material is being detached by drop 79  
impact is not measured until the mass of the lag deposit reaches a 80  
steady state. Also, the transport capacity of shallow rain-impacted 81  
flow exceeds the transport capacity of unimpacted flow having the 82  
same depth and velocity. Thus, if the transport capacity of flow as 83  
proposed by Beasley et al. in 1980 is used to provide an overrid- 84  
ing control on sediment discharge from a cell, this will underes- 85  
timate sediment discharge for shallow overland flow. 86

Despite the issues discussed above, the validation data pre- 87  
sented by the authors indicate their model performed well in sev- 88  
eral catchments in varying climates. In each of the equations they 89  
presented for detachment by raindrop impact ( $D_i$ ), detachment by 90  
flow ( $D_{RC}$ ) and transport by flow ( $T_R$ ), a coefficient existed and 91  
values for these coefficients were determined by calibration be- 92  
fore the validation exercise was performed. That approach mini- 93  
mized the effects of model failures associated with the inappro- 94  
priate use of factors such as the USLE soil and cover factors. 95  
Validation after calibration does not necessarily show that a 96  
model is properly formulated given current understanding of the 97  
rainfall erosion process. However, if a model can be effective in 98  
predicting erosion despite such shortcomings, its utility should 99  
not be ignored. 100

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