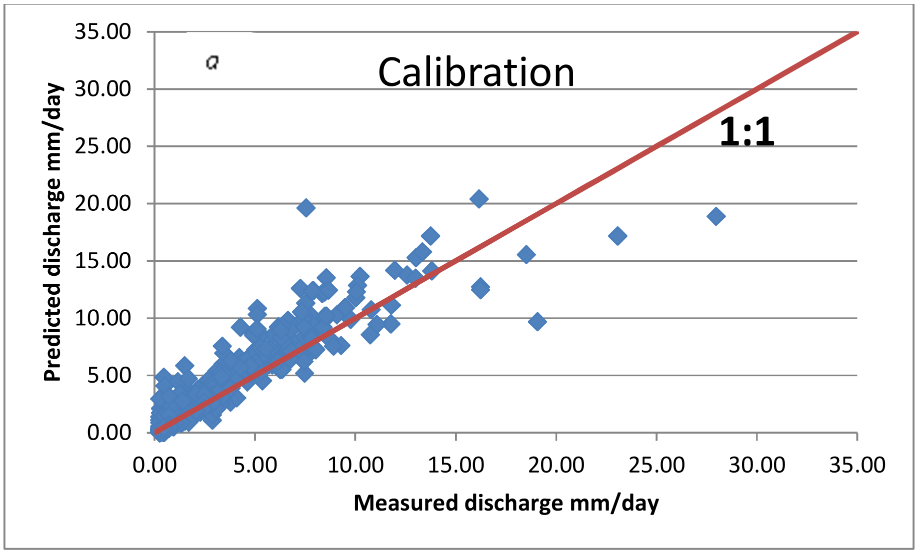
SUPPLEMENTARY MATERIAL

An efficient semi-distributed hillslope erosion model for the sub humid Ethiopian Highlands

S1. Scatter plot runoff and sediment concentration for Anjeni



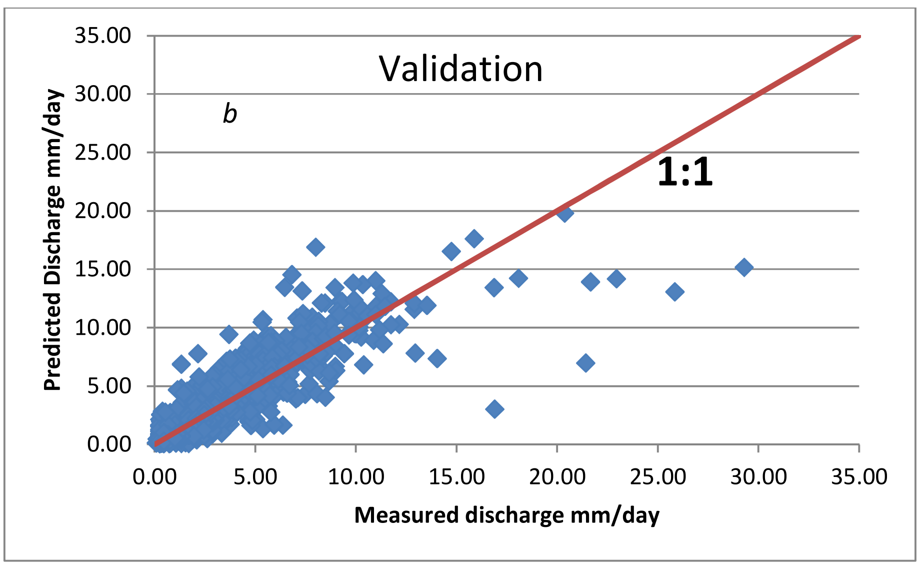


Fig. S1 Comparison of predicted and measured daily stream flow with the 1:1 line (a) for calibration period (b) for validation period

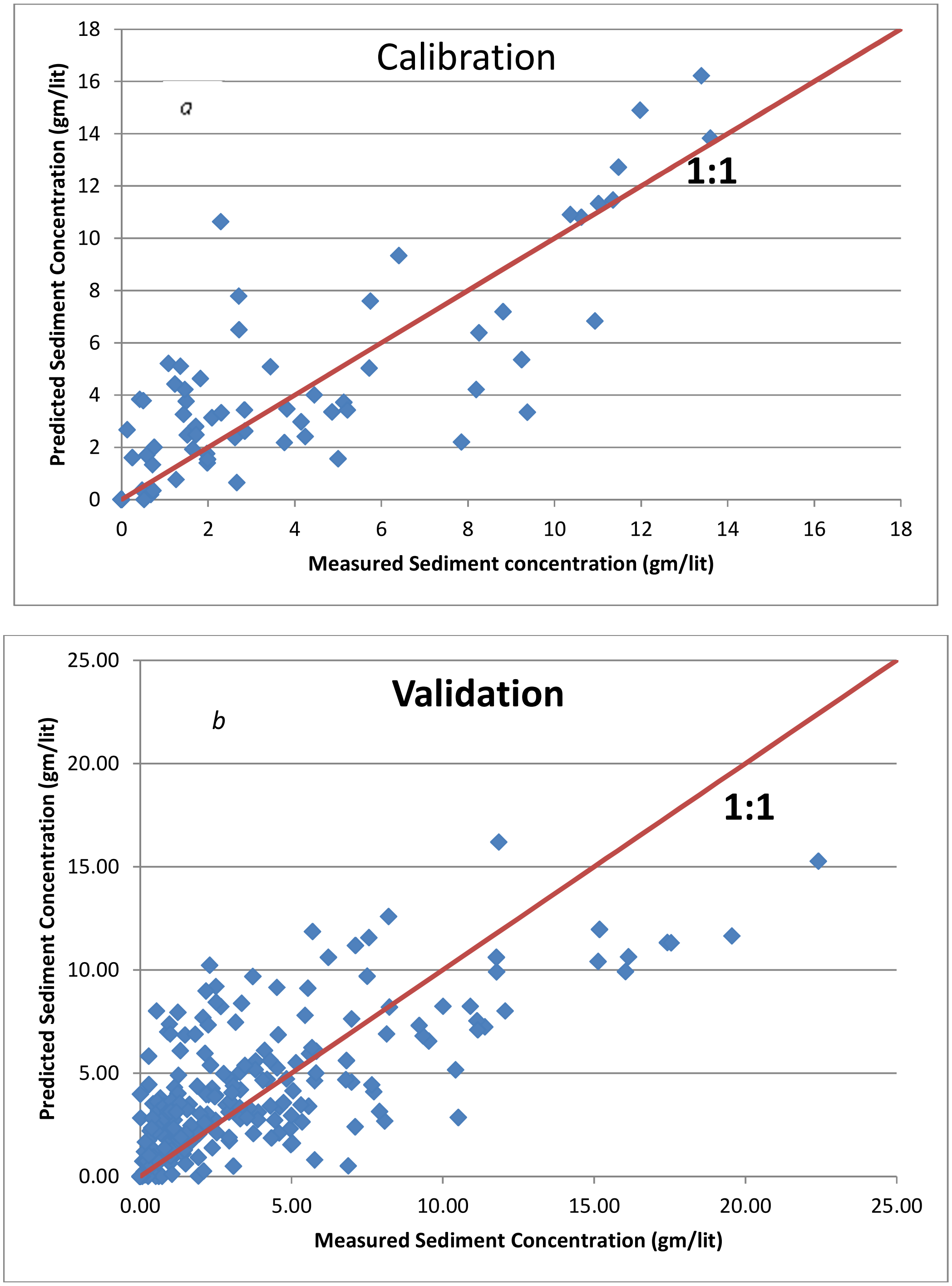


Fig. S2 Comparison of predicted and measured daily sediment concentration with the 1:1 line (a) for calibration period (b) for validation period

S2. Sensitivity analysis for Anjeni

The model was fitted visually and not according to any particular statistics. The most sensitive parameter is the fractional areas that produce runoff and recharge. Increasing the recharge area by 30% (or 15 % of the total area), the NS efficiency decreases from 0.8 to 0.63. For a 30% decrease of the recharge area, the NSE efficiency remained the same, i.e., 0.8. A 15% increase in saturated runoff area resulted in a NS efficiency of 0.46, and a 50% increase of degraded areas from the total area resulted in a NS efficiency of 0.07. The reason for the sensitivity is that the overall water balance is not met. Moreover changing recharge areas to runoff areas resulted in peak runoff occurring earlier (Tesemma et al., 2010). As expected the Nash Sutcliffe efficiency is insensitive to variation in the amount of water that can be stored in the root zone because the magnitude of the storage affects only the first runoff events after the rains have started. Since it rains often during the rainy season, the watershed soils remain near full capacity, and the total size of the storage affects the amount of recharge or runoff only minimally. This will not be the case for temperate climates where large storms are more infrequent. Finally, the model is not greatly dependent on the subsurface flow parameters. Testing has shown that when changing the parameters by a factor of two the baseflow tail is affected. Since the deviations are small the Nash Sutcliffe Efficiency (NSE) stays the same but the relative mean square error and the visual appearance is affected.

Table S1: Sensitivity analysis of hydrologic parameters in the validation

Parameters	Values	NSE	Parameters	Values	NSE
A1	0.02	0.8	Smax in A3	100	0.8
A1 +10%	0.022	0.8	Smax in A3 +10%	110	0.8
A1+20%	0.024	0.8	Smax in A3+20%	120	0.8
A1+30%	0.026	0.8	Smax in A3+30%	130	0.8
A1-10%	0.018	0.8	Smax in A3-10%	90.91	0.8
A1-20%	0.017	0.8	Smax in A3-20%	83.33	0.8
A1-30%	0.015	0.81	Smax in A3-30%	76.92	0.8
A2	0.14	0.8	IF	10	0.8
A2 +10%	0.154	0.8	τ* +10%	11	0.81
A2+20%	0.168	0.77	τ* +20%	12	0.81
A2+30%	0.182	0.76	τ* +30%	13	0.81
A2-10%	0.127	0.81	τ* -10%	9.091	0.8
A2-20%	0.117	0.81	τ* -20%	8.333	0.79
A2-30%	0.108	0.82	τ* -30%	7.692	0.78
A3	0.5	0.8	$t_{1/2}$	70	0.8
A3 +10%	0.55	0.77	t½ +10%	77	0.8
A3+20%	0.6	0.71	t½ +20%	84	0.8
A3+30%	0.65	0.63	t½ +30%	91	0.8
A3-10%	0.45	0.81	t½ -10%	63.64	0.8
A3-20%	0.42	0.81	t½ -20%	58.33	0.81
A3-30%	0.38	0.8	t½ -30%	53.85	0.81
Smax in A1	200	0.8	BSmax	100	0.8
Smax in A1 +10%	220	0.8	BSmax+10%	110	0.8
Smax in A1+20%	240	0.8	BSmax+20%	120	0.8
Smax in A1+30%	260	0.8	BSmax+30%	130	0.8
Smax in A1-10%	181.8	0.8	BSmax-10%	90.91	0.8
Smax in A1-20%	166.7	0.8	BSmax-20%	83.33	0.8
Smax in A1-30%	153.8	0.8	BSmax-30%	76.92	0.8
Smax in A2	10	0.8	a_2	3.4	0.64
Smax in A2 +10%	11	0.8	a_2 + 10%	3.74	0.63
Smax in A2+20%	12	0.8	a_2 + 20%	4.08	0.61
Smax in A2+30%	13	0.8	a_2 + 30%	4.42	0.57
Smax in A2-10%	9.09	0.8	a_2 – 10%	3.091	0.63
Smax in A2-20%	8.33	0.8	a_2 – 20%	2.833	0.62
Smax in A2-30%	7.69	0.8	a_2 – 30%	2.615	0.59

S3. Details for sediment model

The sediment model in this paper "closely" follows the Hairsine and Rose (1992a) model. As detailed below, it was showed that, for sheet flow, the sediment concentration (kg/m^3) at the transport limit, c_t, can be expressed in

$$C_t = \frac{F\sigma SV}{\left(\frac{\sigma}{\rho}-1\right)\varphi_e} \qquad 1$$

F is the fraction of the stream power effective in erosive processes, S (m/m) is the slope of the land surface, *V* (m/s) is mean overland flow velocity φ_e (m/s) is the effectiv depositability and σ (kg/m^3) and ρ (kg/m^3) are soil particle and water density, respectively.

The following derivation was derived first by Yu et al (1997). It is closely followed here with some minor modifications. In this derivation a sloping field of unit width and a length L and a rainfall rate R (m/s) is considered. The runoff at the end of the field is q (m^2/s).

$$q = hV = RL \qquad 2$$

Where h is the depth of the water at L Assuming kinematic flow approximation and flow to be turbulent we can write manning equation for a the cross section at L where the width is many time greater than the depth

$$V = \frac{1}{n} h^{\frac{2}{3}} S^{\frac{1}{2}} \qquad 3$$

Combining Eqs. 2 (i.e., q = hV) and 3 gives

$$q = kh^{5/3} \qquad 4$$

$$\text{Where, } k = 1/n * S^{1/2} \qquad 5$$

Using the relationship in Eq. 2 (i.e.,$h = \frac{RL}{V}$) and substituting this in Eqs 4 and 5 and rearranging we find that

$$V = \left(\frac{\sqrt{S}}{n}\right)^{\frac{3}{5}} L^{\frac{2}{5}} R^{\frac{2}{5}} \qquad 6$$

By substitution of Eq. 6 into Eq. 1 we find that

$$C_t = aQ^{0.4}$$

Where

$$a = \frac{F\sigma SL^{2/5}}{\left(\frac{\sigma}{\rho}-1\right)\varphi_e}\left(\frac{\sqrt{S}}{n}\right)^{3/5}$$

Therefore "***a***" is a function of both watershed and sediment characteristics.

For sediment load per unit area Y_t :

$$Y_t = C_t * Q = a * A * Q^{1.4}$$