Methods supplement

for

Sediment accumulation expectations for growing desert cities: a realistic desired outcome to be used in constructing appropriately sized sediment storage of flood control structures

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3.1. Model 1: sediment yield prediction under without urban sprawl condition

An inverse relation exists between SSY and drainage area (Dendy and Bolton 1976, Milliman and Syvitski 1992, Lahlou 1996, Einsele and Hinderer 1997), and Milliman and Syvitski (1992) confirmed a clear negative relation between SSY and drainage basin area based on 280 global data points. Thus, using this relationship has the benefit that the measurement of basin area is relatively simple, and hence it is frequently used for prediction of SSY in ungauged basins (De Vente et al 2007). The negative relation is generally explained by widely-used concept of the sediment delivery ratio (Walling 1983); as basin area increases, the relative portion of flat and gentle slopes increases and act as sediment sinks rather than sources (Verstraeten et al 2003). The negative relation also exists between SSV and drainage area because sediment delivery ratios decline in the downstream direction (Graf et al 2010). In model 1, the SSV of FCS is best approximated by a power function.

The problem with this model is that other local environmental conditions could also influence the SSY. For example, scholarship reveals several factors thought to influence erosion rates, that could restrict use of this model: rock type in the Indian arid zone (Sharma and Chatterji 1982, Ferreira et al 2017); sediment remobilization in valleys (Church and Slaymaker 1989); and prominent channel erosion over hillslope erosion in highly vegetated areas (Dedkov and Mozzherin 1992, Church et al 1999, Prosser et al 2001, Dedkov 2004). Therefore, similar environmental settings should be compared when predicting SSV with Model 1.

3.2. Model 2: sediment yield prediction under with urban sprawl condition

Housing and commercial real-estate development in the PMR led to a lot of bare ground exposure that led to as much as a 3.4-fold increase in sediment yield above and beyond the effects of grazing (Jeong and Dorn 2019). An individual case exemplifies the Wolman (1967) model for the RUDC of Phoenix, USA. The SSV of the watershed supplying sediment to a cattle stock tank called “Peralta tank” was 42 m$^3$ km$^{-2}$ yr$^{-1}$ during the period of grazing. Sediment yield then rapidly increased to 70 m$^3$ km$^{-2}$ yr$^{-1}$ during the time of active subdivision construction, and decreased to 8 m$^3$ km$^{-2}$ yr$^{-1}$ when sediment sources were sealed by a lot of concrete and pavement (supplemental table 1 and figure 3). Based on the Wolman model, the key land use parameters impacting SSV were annual urban growth and annual imperviousness. The goal of Model 2 is to estimate SSV for FCS in PMR.
3.2.2 Sediment delivery ratio

As described in the development of Model 1, a negative relation exists between SSV and drainage area \((A_D)\). The regression model based on LULCC-related parameters-sedimentation volume, however, does not consider the negative relation between SSV and \(A_D\). Thus, unreasonably high SSV could be estimated when the regression equation is used for extrapolation, because drainage areas of FCS are much bigger than stock ponds drainage areas (table 1; supplemental table 2). Therefore, the concept of sediment delivery ratio (SDR) related to \(A_D\) is adopted for Model 2. The latest FCDMC Hydraulics manual (FCDMC 2015a) provides an equation to calculate SDR based on the SDR curve as a function of drainage area (USDA 1972) with modification using data from southwest semiarid regions. FCDMC shifted the original USDA curve using data from Walnut Gulch watersheds near Tucson, AZ that the sediment delivery ratio is 0.41 for a drainage area of 57.53 square miles (Lane et al 2000). The SDR equation provided by FCDMC is (FCDMC 2015a):

\[
SDR = -14.08(\log_{10} A_D) + 2.44(\log_{10} A_D)^2 \\
- 0.45(\log_{10} A_D)^3 + 60.85
\]

where the unit of SDR is percent and \(A_D\) is mile\(^2\). Stock pond SSV were then converted to eroded volume (EV) from the watersheds, using this equation:

\[
EV = \frac{SSV}{(SDR*0.01)}
\]

Then for the larger drainage basins of FCS, the SSV was calculated based on the predicted EV based on regression equation from stock ponds data, using this equation:

\[
SSV = EV*SDR*0.01
\]

The following subsections describe the regression model between EV (m\(^3\) km\(^{-2}\) yr\(^{-1}\)) and annual urban growth, as well as between EV and annual imperviousness (figure 4).

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