A improved SCS-CN method incorporating slope, soil moisture and storm duration factors for runoff prediction

Wenhai Shi[1] and NI Wang[1]

[1]Chang'an University

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Abstract

Soil Conservation Service Curve Number (SCS-CN) is one of the widely used methods to estimate surface runoff because of its simplicity, convenience and widespread acceptance. However, the method still has several limitations such as ignorance of storm duration, lack of guidance on antecedent condition and absence of slope factor. In this study, an equation of the CN value combining with the original CN2 value and three introduced factors of slope, soil moisture and storm duration was developed to improve the SCS-CN method. The proposed method was calibrated and validated using a dataset of three experimental plots in the a watershed on the Loess Plateau. The results indicated that the proposed method, which boosted the model efficiencies to 80.58% and 80.44% in calibration and validation cases, respectively, performed better than the original SCS-CN, Huang et al. (2006) and Huang et al.(2007) methods which considered the single factor of slope and soil moisture in the SCS-CN method, respectively. Using the parameters derived from the initial three experimental plots, the proposed method was used to predict runoff from the remaining three experimental plots in another watershed.The root mean square error between the measured and predicted runoff values was improved from 5.53 mm to 2.01 mm. Furthermore, a sensitivity analysis of the parameters in the proposed method indicated that the parameters of soil moisture (b1 and b2) and storm duration equations (c) are more sensitive than those parameters of slope equation (a1 and a2) and λ. It can be concluded that the proposed method incorporating the three factors, may predict surface runoff more accurately in the Loess Plateau of China.

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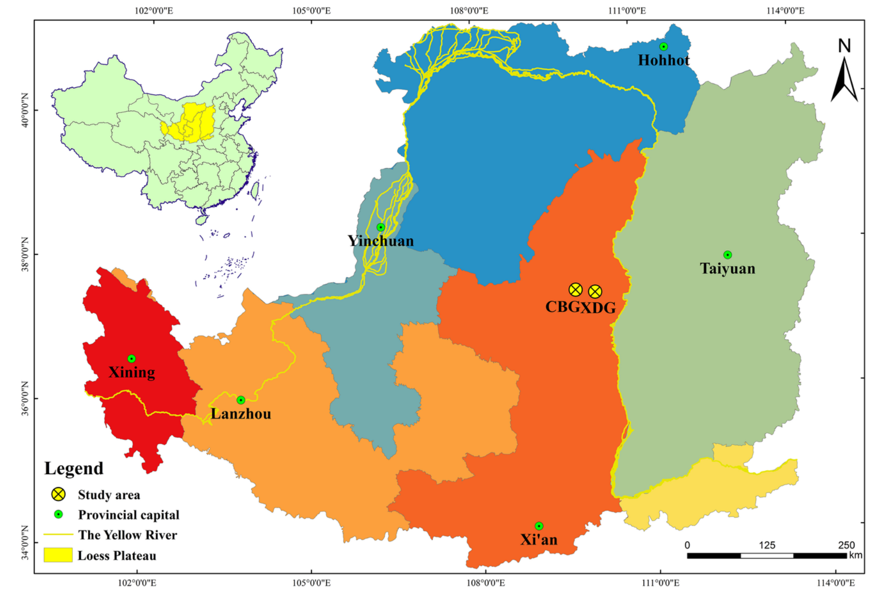
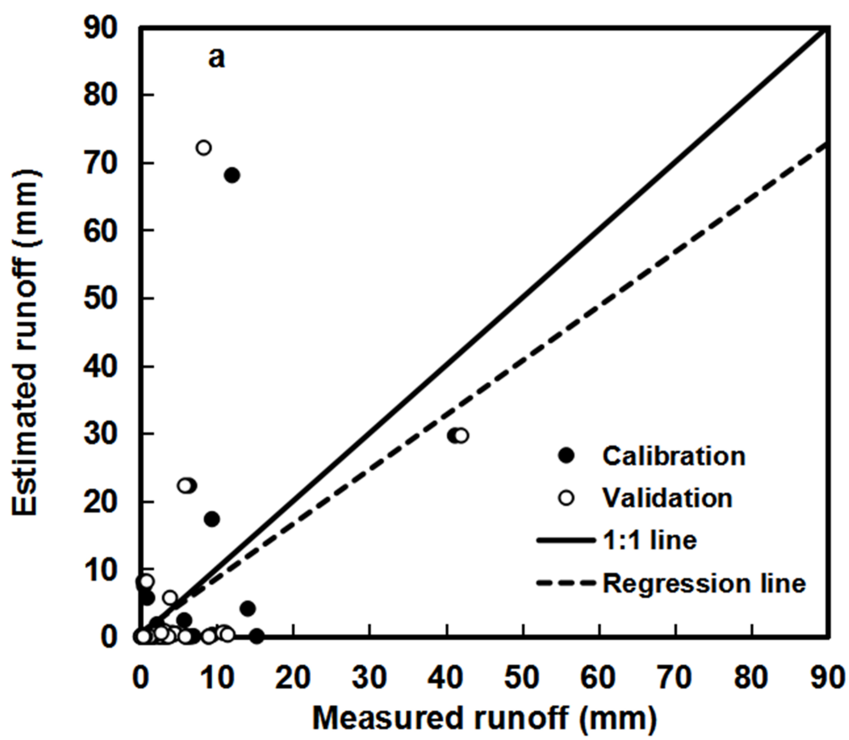
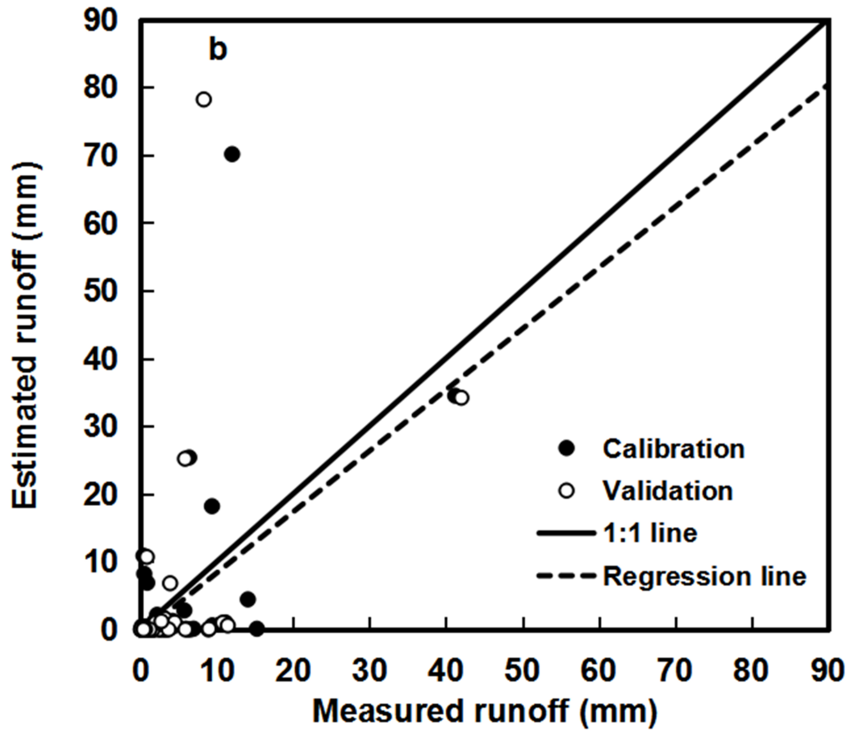


Fig. 1. Location of the two experimental watersheds of CBG and XDG.




b
Estimated runoff (mm)
Measured runoff (mm)
Calibration
Validation
1:1 line
Regression line

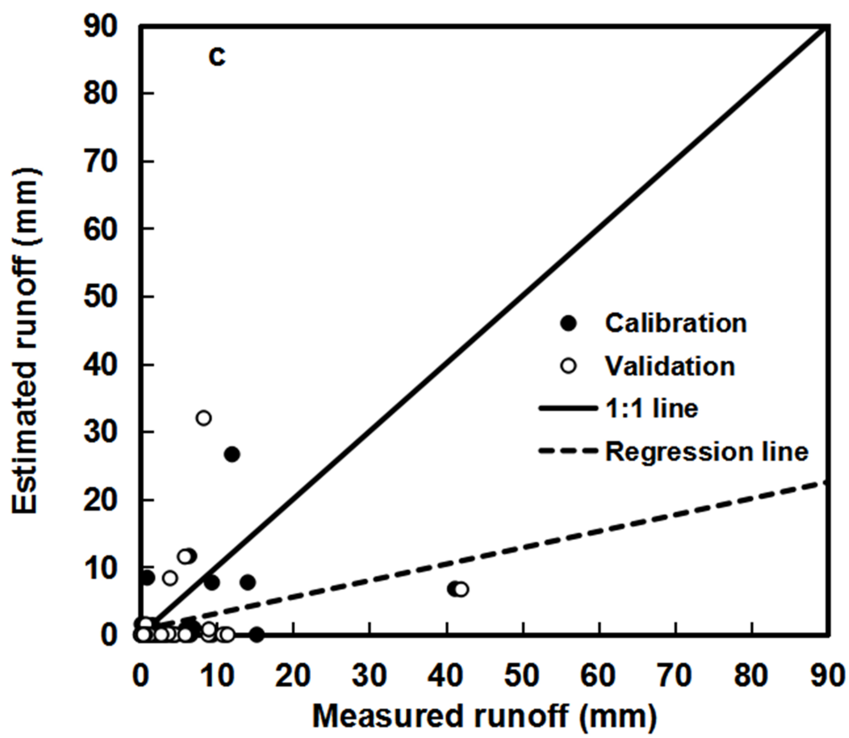
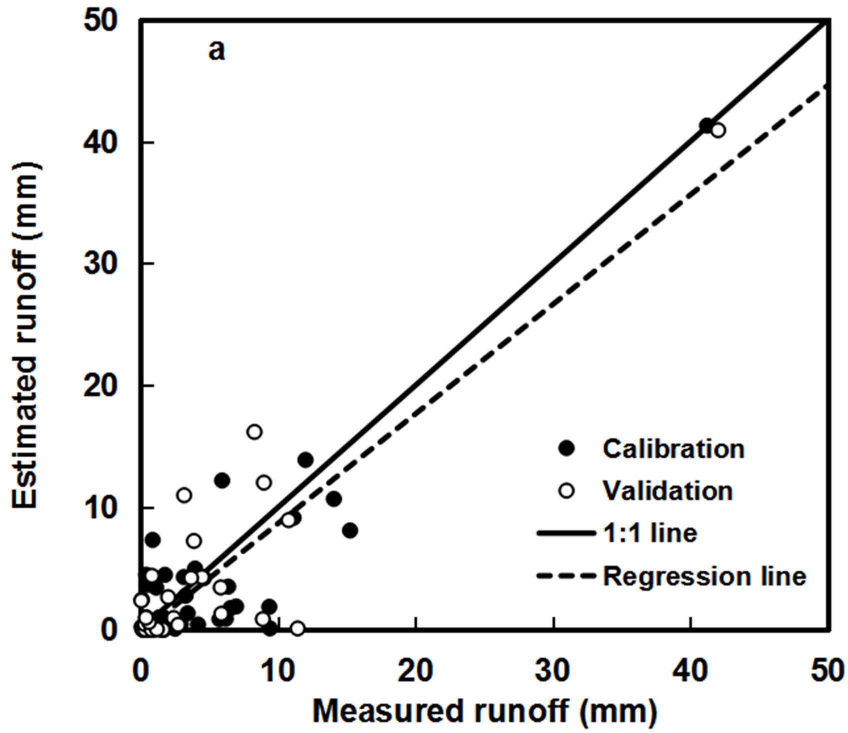
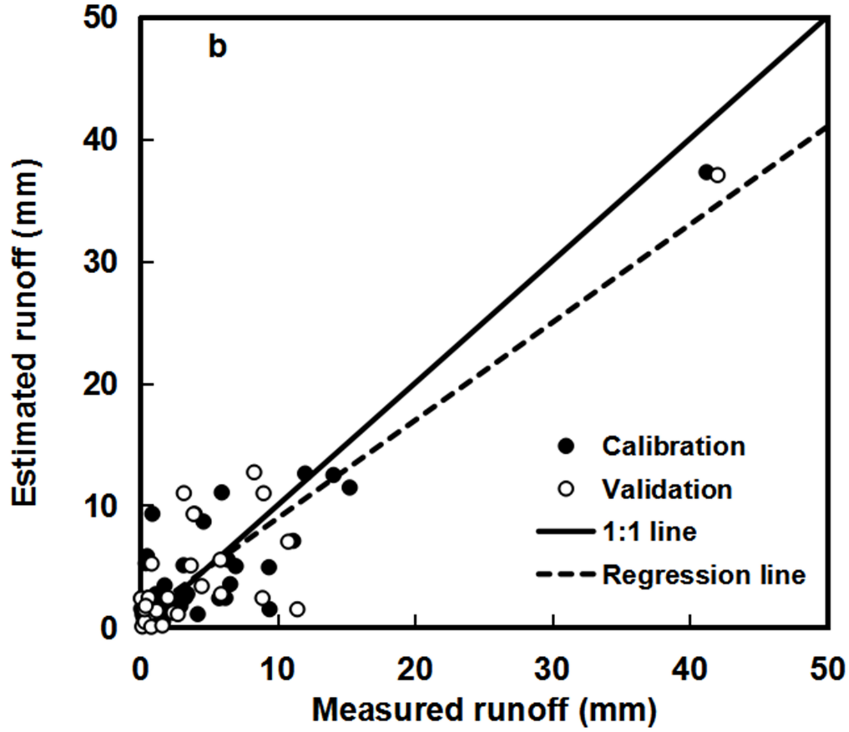

c
Estimated runoff (mm)
Measured runoff (mm)
Calibration
Validation
1:1 line
Regression line

Fig. 2. Measured versus estimated runoff depths for (a) the original SCS-CN method; (b) Huang et al.(2006) and (c) Huang et al.(2007) method for calibration and validation for three experimental plots located in the XDG watersheds..




b
Estimated runoff (mm)
Measured runoff (mm)
Calibration
Validation
1:1 line
Regression line
0
10
20
30
40
50

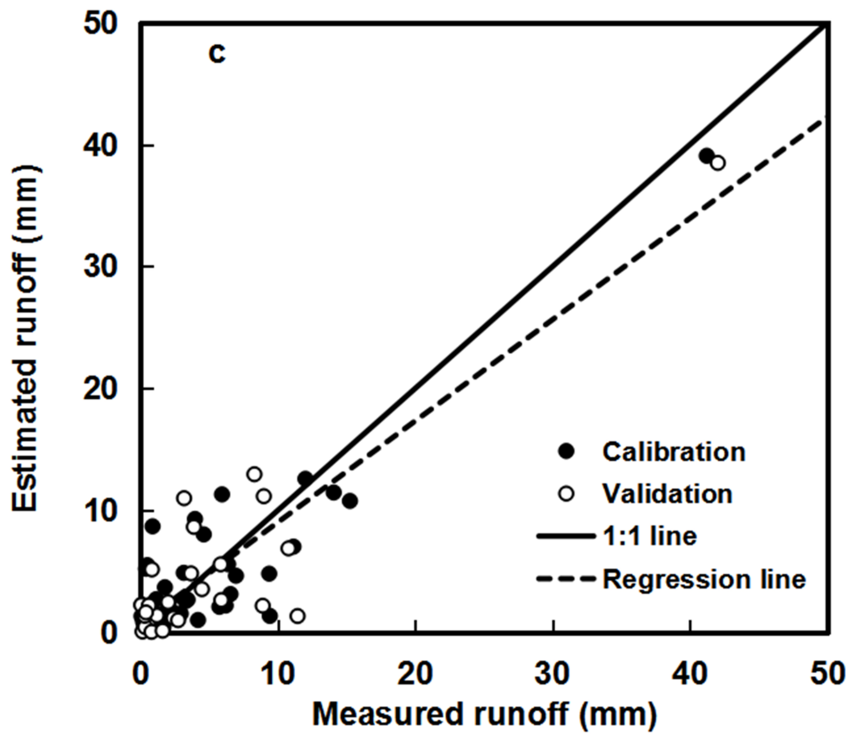
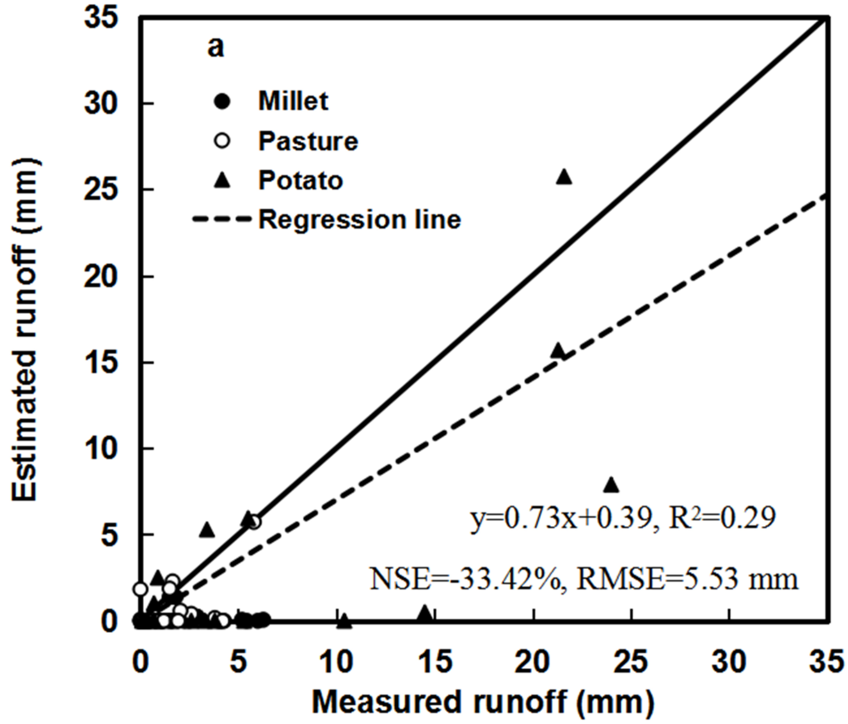
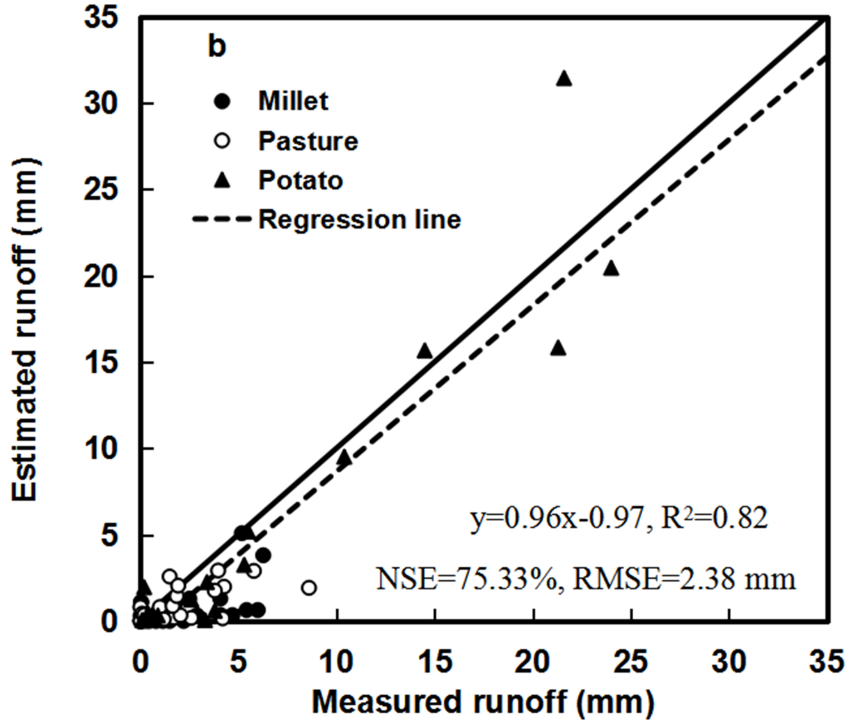
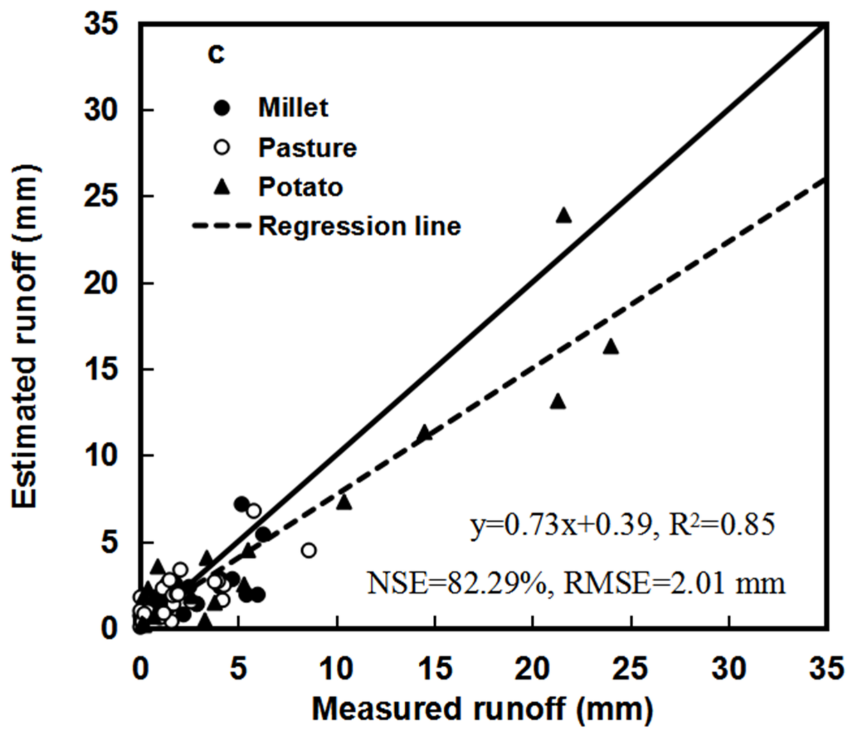

c
Estimated runoff (mm)
Measured runoff (mm)
Calibration
Validation
1:1 line
Regression line
0
10
20
30
40
50

Fig. 3. Measured versus estimated runoff depths for (a) Method 1; (b) Method 2 and (c) Method 3 for calibration and validation for three experimental plots located in the XDG watersheds.




b
Millet
Pasture
Potato
Regression line
y=0.96x-0.97, R2=0.82
NSE=75.33%, RMSE=2.38 mm
Estimated runoff (mm)
Measured runoff (mm)


c
Millet
Pasture
Potato
Regression line
y=0.73x+0.39, R2=0.85
NSE=82.29%, RMSE=2.01 mm
Estimated runoff (mm)
Measured runoff (mm)

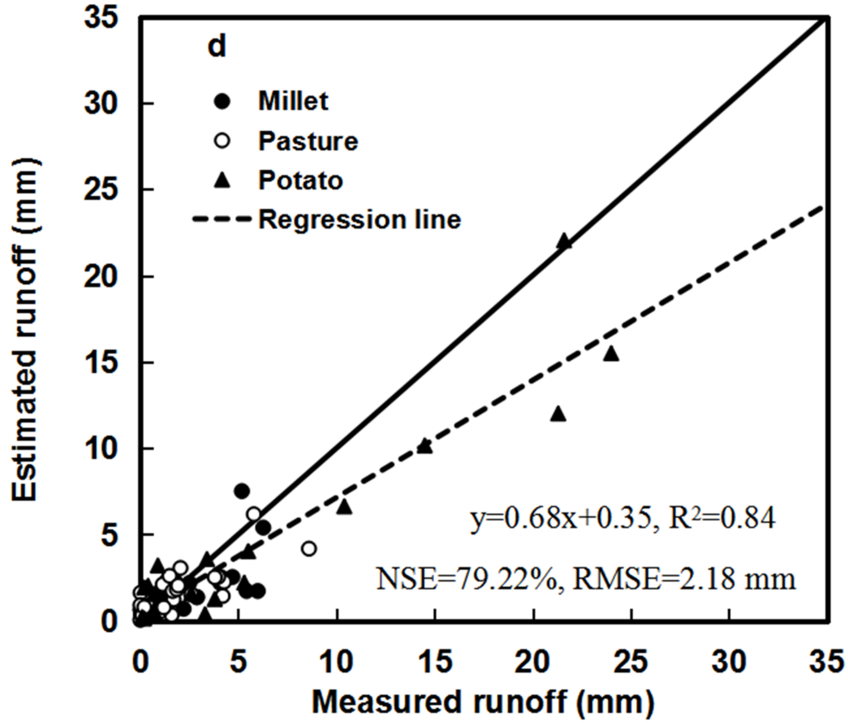


Fig. 4. Measured versus estimated runoff depths for (a) original SCS-CN method; (b) Method 1; (c) Method 2 and (d) Method 3 for the three experimental plots located in the CBG watershed.

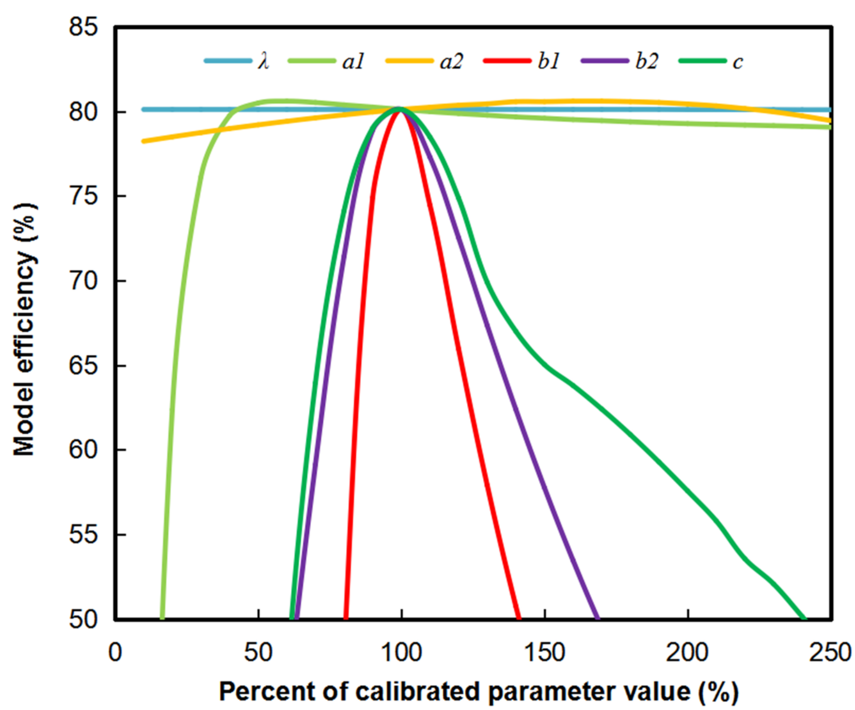
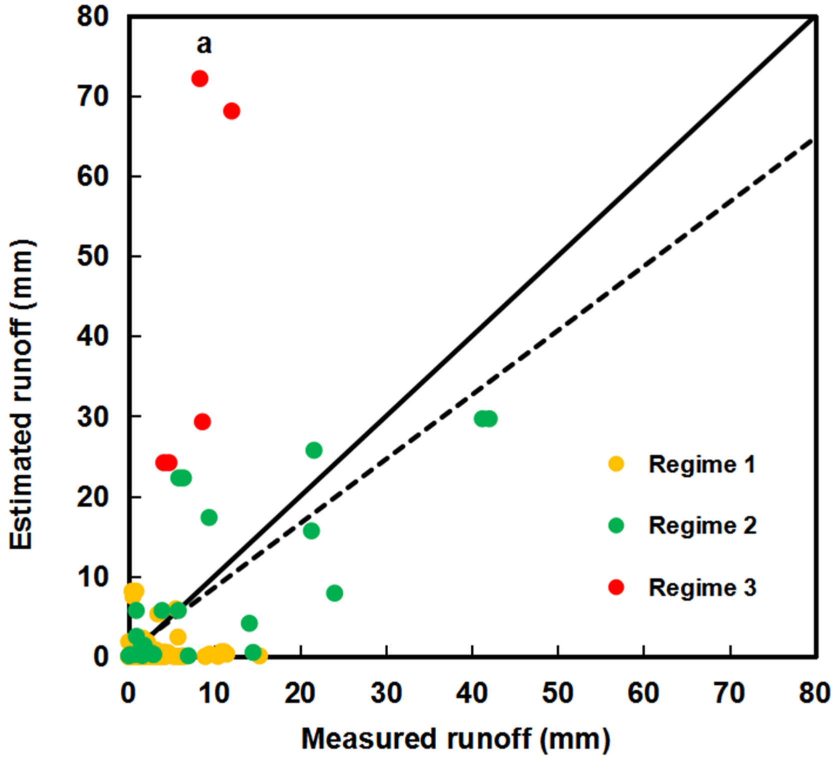


Fig. 5. Sensitivity analysis of the empirical parameters of the Method 2



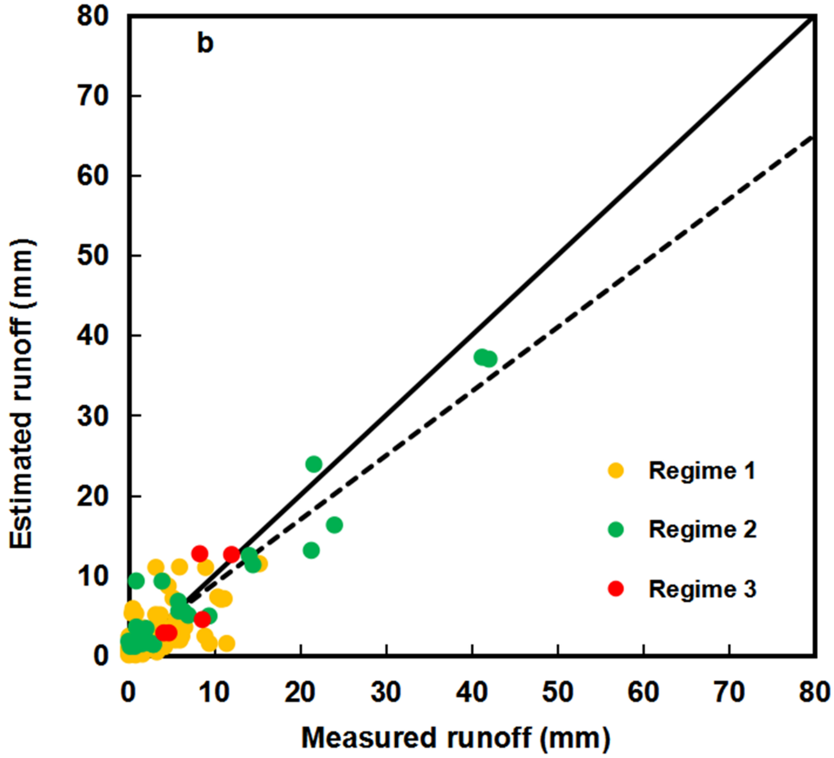


Fig. 6. Measured versus estimated runoff depths for (a) the original SCS-CN method and (b) Method 2 of the three rainfall regimes.