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A system framework for spatial allocation of soil management practices in river basins

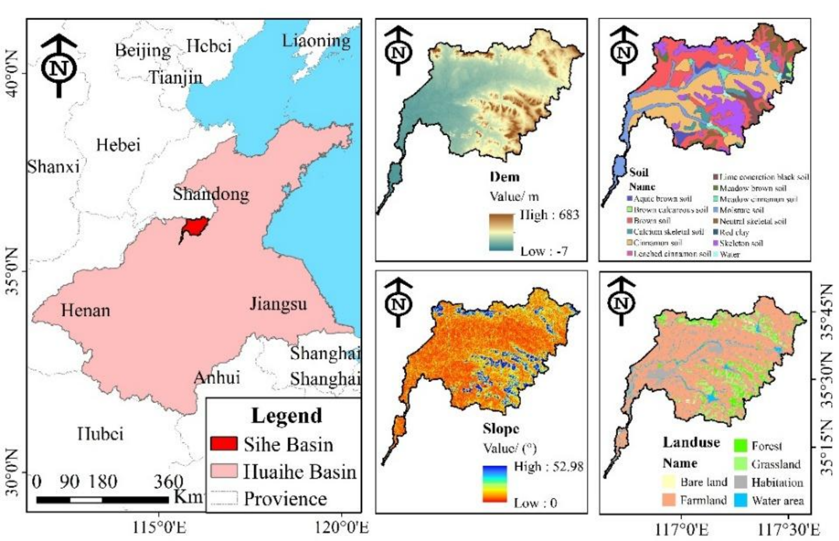
Zhenyu Lv, Tianling Qin, Hanjiang Nie, Jianwei Wang （*China Institute of Water Resources and Hydropower Research*）

Introduction

- Soil management practices (SMPs) such as conservation tillage (CT), straw mulching (SM), green manure (GM), contour ridge (CR) and terrace (TE) have been widely applied all over the world due to their enhancement of soil water storage capacity (WSC), thus improving the effective utilization of local precipitation. However, *the current implementation of SMPs* in the river basin was mostly *subject to smallholder production or problems*, resulting in random implementation and suffering from a lack of overall spatial planning. Relevant studies have focused on the mechanisms by which SMPs influence runoff and infiltration under the conditions of natural rainfall, simulated rainfall, and concentrated flow from upslope. *There is still a lack of information suitable for specifically guiding development of an effective method for optimizing the spatial allocation of SMPs across river basins.*
- To bridge these knowledge gaps, this study attempts to *establish a system framework for the spatial allocation of SMPs* across river basins through the evaluation of WSCs.

Study area

- The Sihe River Basin is between longitudes 116°40′ to 117°42′E, and latitudes 35°14′ to 35°50′N, with a drainage area of 2445.75 km^2
- The elevation ranges from -7 m to 683 m. Slopes vary from 0° to 49.5°. Farmland is the main land use, accounting for 71.1% of the total basin area.
- There are 13 soil types in the basin. Among these, cinnamon soil is the most widely distributed, accounting for 29.4%



Study area and its underlying surface characteristics

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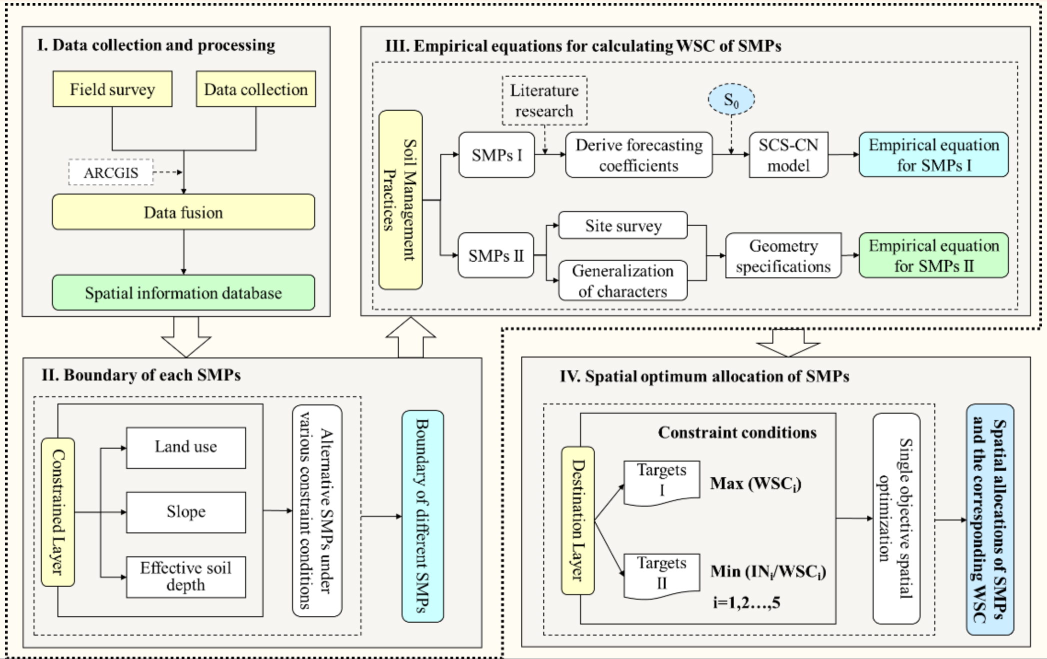
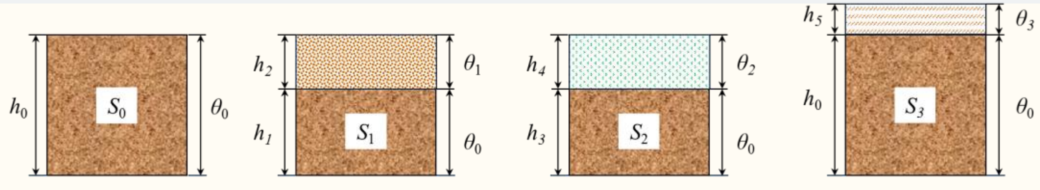
System framework

1. *Field surveys* were carried out to collect spatial information for the basin such as land-use and slope
2. *Alternative SMPs* for various evaluation units were confirmed using the constraints of *land-use*, *soil effective depth* and *slope of the unit*
3. Establishing the *empirical equations for calculating the WSC* of various SMPs
4. The spatial allocation of SMPs across the river basin were determined by using *single-objective spatial optimization.*



Methodology

- SMPs were divided into two categories according to their special functions.



CFT: $S_0 = \theta_0 \times h_0$, $\theta_0 = m_0 - \omega_0$

CT: $S_1 = \theta_0 \times h_1 + \theta_1 \times h_2$, $\theta_0 = m_0 - \omega_0$, $\theta_1 = m_1 - \omega_1$

GM: $S_2 = \theta_0 \times h_3 + \theta_2 \times h_4$, $\theta_0 = m_0 - \omega_0$, $\theta_2 = m_2 - \omega_2$

SM: $S_3 = \theta_0 \times h_0 + \theta_3 \times h_5$, $\theta_0 = m_0 - \omega_0$, $\theta_3 = m_3 - \omega_3$

Influence of SMP I on infiltration

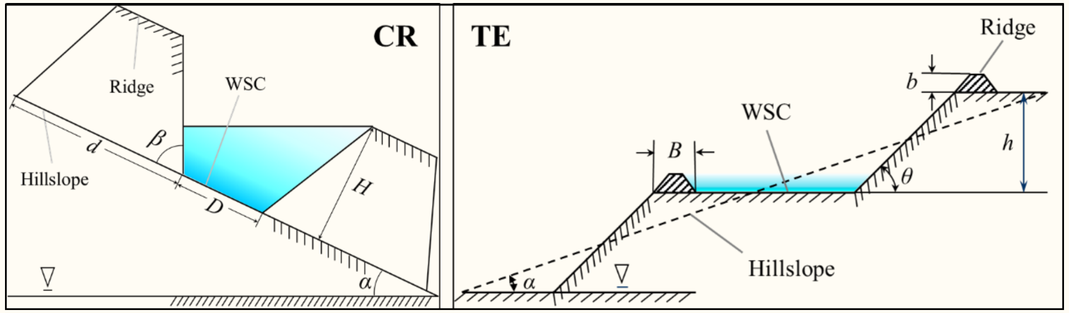
$$V_i = \frac{(\overline{C_0} - \overline{C_i})}{\overline{C_i} \times (1 - \overline{C_0})} \times (\overline{m_0} - \overline{\omega_0}) \times h_0 \times \frac{A}{100}$$

➢ Empirical equations for calculating WSC of SMP I

➢ Equations of SMP II

$$V_{CR} = \begin{cases} \dfrac{H^2 \sin(\beta - \alpha)}{200 \sin\alpha \sin\beta} \times \dfrac{A}{D+d} & D \ge \dfrac{H \sin(\beta-\alpha)}{\sin\alpha \sin\beta} \\ \dfrac{H^2 \sin(\beta-\alpha)\sin(\beta+\alpha) - [H\sin(\beta-\alpha) - D\sin\alpha\sin\beta]^2}{200 \sin\alpha \sin\beta \sin(\alpha+\beta)} \times \dfrac{A}{D+d} & D < \dfrac{H \sin(\beta-\alpha)}{\sin\alpha \sin\beta} \end{cases}$$

$$V_{TE} = [h \times (\cot\alpha - \cot\theta) - B] \times b \times \frac{A \sin\alpha}{h}$$



Influence of SMP II on infiltration

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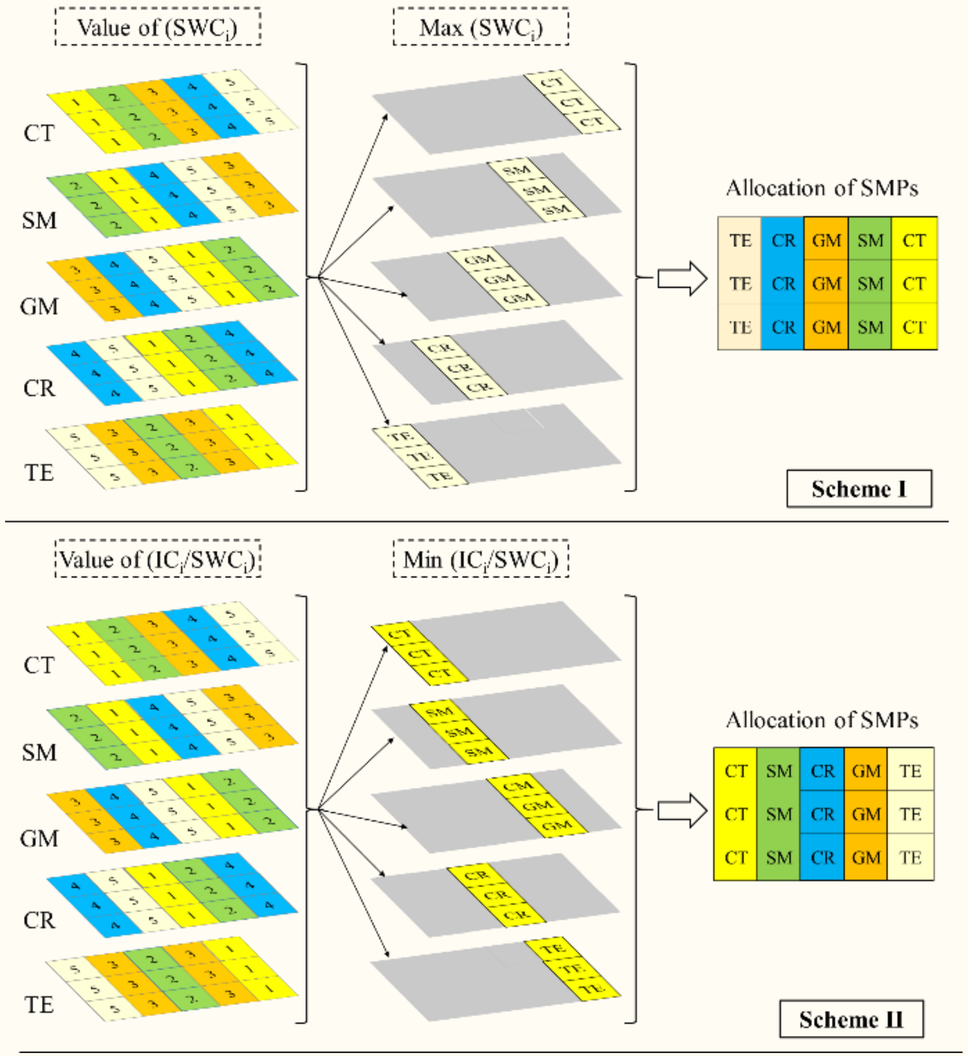
Methodology

➢ *Single-objective spatial optimization*

- The WSC and corresponding implementation cost (IC) to WSC (IC/WSC) of the alternative SMPs were quantified for each evaluation unit
- *the most appropriate SMPs* for the evaluation unit as well as the spatial allocation of individual SMPs were located by pairwise comparison and taking the maximum WSC and the minimum IC/WSC as target functions
- *Two different spatial allocation schemes* were developed by calculating and comparing the WSCs and IC/WSC of each SMP on evaluation units.



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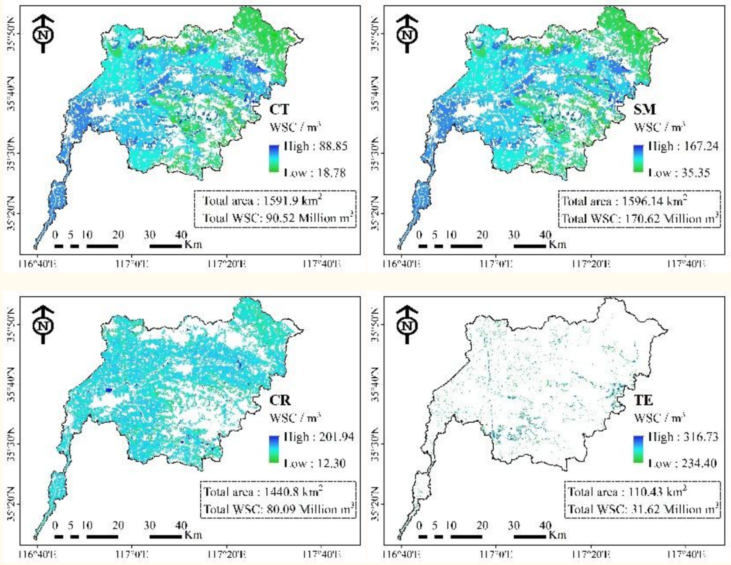
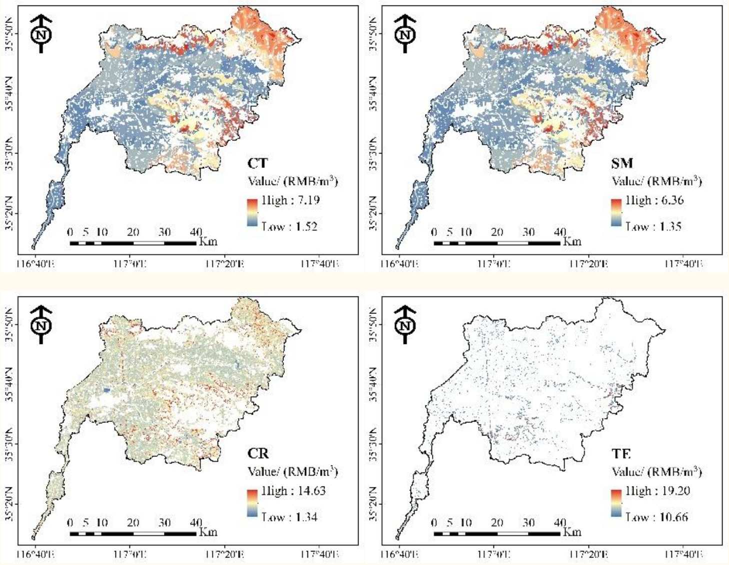
☐ Results

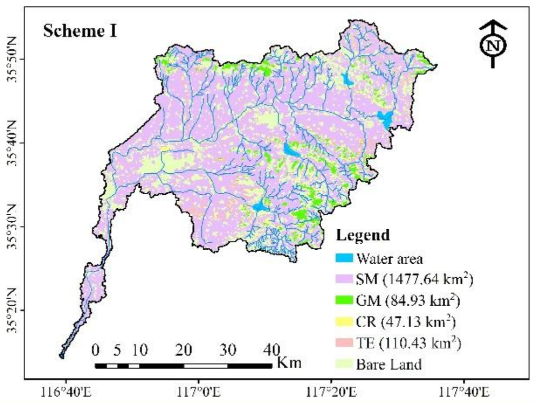


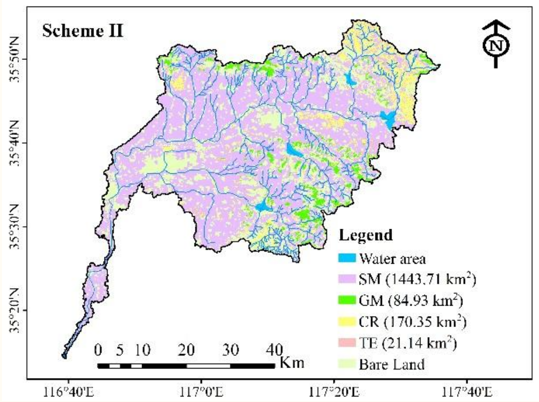
Alternative SMPs implementation on the river basin and the corresponding WSCs

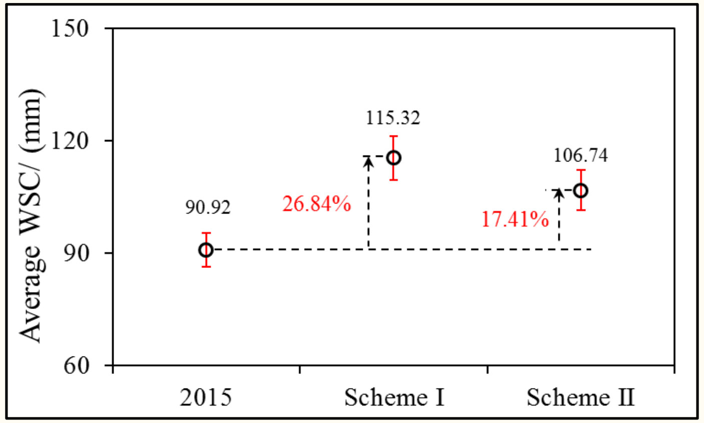


The IC/WSC for each SMP on the evaluation units

The implementation area and spatial allocation for various SMPs in design schemes.







Comparison of the average WSC of SMPs per unit area in 2015 and in two design schemes.