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Stormwater Runoff Allocation and Basin-Wide Flood Mitigation Mechanism From the Perspectives of Efficiency and Equity

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In the two-stage DEA model, the formula for calculating economic efficiency is provided in Eq. (S1), the formula for runoff management efficiency is given in Eq. (S2). In both equations, the part preceding "*s.t.*" represents the objective function, and the part following it represents the constraints. The formula for the division model is shown in Eq. (S3), and the formula for the dynamic stormwater runoff allocation mechanism is presented in Eq. (S4). Definitions of all symbols used in the equations are provided in Supplementary Table 1.

$$
\begin{aligned}
&E_0^s = Max\sum_{i=1}^{n}\pi_i g_i + \sum_{i=1}^{n}\tau_i \bar{z}_i \\
&s.t. \\
&\sum_{i=1}^{n}\pi_i g_i + \sum_{i=1}^{n}\tau_i \bar{z}_i - \sum_{i=1}^{n}\omega_i x_{ij} \le 0, \\
&\sum_{i=1}^{m}\omega_i x_{ij} = 1, \\
&\pi_i, \tau_i, \omega_i \ge 0, i = 1,2,\ldots,n, j = 1,2,3
\end{aligned}
\tag{S1}
$$

$$
\begin{aligned}
&E_0^m = Max\sum_{i=1}^{n}\delta_i y_i \\
&s.t. \\
&\sum_{i=1}^{n}\delta_i y_i - (\sum_{i=1}^{n} w_{1i}\bar{z}_i + \sum_{i=1}^{n}\gamma_i b_i) \le 1, \\
&E_0^{s^*} = \pi_i y_i + \tau_i \bar{z}_i, \\
&w_{1i} = w_{2i}, \\
&\delta_i, \tau_i, \rho_i, \pi_i \ge 0, j = 1,2,\ldots,n
\end{aligned}
\quad , \qquad \text{(S2)}
$$

$$
E_0 = E_i^s / E_i^m = Max\frac{\sum_{i=1}^{n}\varphi_i g_i + \sum_{i=1}^{n} w_{1i}\bar{z}_i}{\sum_{i=1}^{n} v_i x_{ij}} / Max\frac{\sum_{i=1}^{n}\mu_i y_i}{\sum_{i=1}^{n} w_{1i}\bar{z}_i + \sum_{i=1}^{n}\gamma_i b_i}, \qquad \text{(S3)}
$$

$$
\begin{aligned}
&\min\sum_{i=1}^{n}(\Delta g_i + \Delta y_i) \\
&\max\sum_{i=1,j=1}^{n}(\Delta x_{ij} + \Delta b_i) \\
&s.t. \\
&\Delta x_{ij} \le \eta_i x_{ij}, i = 1,2\ldots n, j = 1,2,3 \\
&\Delta g_i \ge \eta_i g_i, \Delta z_i \le \eta_i z_i, \Delta s_i \le \rho_i z_i, \Delta b_i \le \rho_i b_i, \Delta y_i \ge y_i b_i, i = 1,2\ldots n. \\
&x_{ij} - \Delta x_{ij} \ge \alpha_i X, i = 1,2\ldots n, j = 1,2,3. \\
&g_i - \Delta g_i \le \alpha_i G, z_i - \Delta z_i \ge \alpha_i Z, z_i - \Delta s_i \ge \beta_i Z, b_i - \Delta b_i \ge \beta_i B, y_i - \Delta y_i \ge \beta_i Y, i = 1,2\ldots n. \\
&\sum_{i=1}^{n}\Delta s_i = \sigma\sum_{i=1}^{n} z_i, i = 1,2\ldots n(1). \\
&\varsigma z_i \le \Delta s_i \le \psi z_i, i = 1,2\ldots n(2). \\
&\delta, \psi, \varsigma \ge 0.
\end{aligned}
\quad , \qquad \text{(S4)}
$$

Supplementary Table 1: Definitions of symbols used in the equations

Symbol	Definition	Unit
$\boldsymbol{E_0^s}$	Economic efficiency	—
$\boldsymbol{\delta_i, \tau_i, \rho_i, \pi_i, y_i, \mu_i, \nu_i, \phi_i}$	Weights of each indicator	—
$\boldsymbol{x_{ij}}$	Input indicators	—
$\boldsymbol{y_{ij}}$	Output indicators	—
$\boldsymbol{i}$	Number of decision-making units	—
$\boldsymbol{E_0^m}$	Runoff management efficiency	—
$\boldsymbol{w_{1i}, w_{2i}}$	Common weight set of the economic efficiency subsystem and the runoff management efficiency subsystem	—

z_i	Stormwater runoff allocation in the intermediate stage across various management units	m^3
$\Delta g_i, \Delta y_i, \Delta x_{ij}, \Delta b_i, \Delta z_i$	Total reduction of various resources	m^3
ψ	Lower limit of stormwater runoff allocation in the intermediate stage across various management units	%
ς	Upper limit of stormwater runoff allocation in the intermediate stage across various management units	%
j	Number of indicators	—
g	Expected output	Yuan (NT$)
z	Unexpected output, i.e., stormwater runoff	m^3
b	External inputs	Yuan (NT$)
n	Number of decision-making units	—
E_0	Overall efficiency value of two-stage DEA output	—
Δs_i	Amount of stormwater runoff reduction by each management unit	m^3
σ	The percentage reduction in total stormwater runoff	%