A Fermatean Fuzzy Decision Support Framework for Wireless Technology Selection in Disaster Management

Karahan Kara, Galip Cihan Yalçın, Çağatay Korkuç, Yasin Genç, Vladimir Simic, Erkan Afacan, Hasan Dinçer, Serhat Yüksel, Dragan Pamucar

Supplementary Materials

Table S1. The notation

Indices and sets:	
$d = 1,2,\dots,D$	index of wireless technology,
$v = 1,2,\dots,V$	index of quantitative criteria,
$t = 1,2,\dots,T$	index of qualitative criteria,
$y = 1,2,\dots,Y$	index of overall criteria,
$k = 1,2,\dots,K$	index of experts,
$H = \{H_1, H_2, \dots, H_d, \dots, H_D\}$	set of wireless technology,
$P = \{P_1, P_2, \dots, P_t, \dots, P_T\}$	set of qualitative criteria,
$B = \{B_1, B_2, \dots, B_v, \dots, B_V\}$	set of quantitative criteria,
$Z = \{Z_1, Z_2, \dots, Z_y, \dots, Z_Y\}$	set of overall criteria,
$Z^- \subseteq Z$	set of cost-based criteria,
$Z^+ \subseteq Z$	set of benefit-based criteria,
$E = \{E_1, E_2, \dots, E_k, \dots, E_K\}$	set of experts.
Parameters:	
$D \geq 2$	number of wireless technologies,
$V \geq 2$	number of quantitative criteria,
$T \geq 2$	number of qualitative criteria,
$Y(V+T) \geq 4$	number of overall criteria,
$K \geq 2$	number of experts,
$\Theta[0,1]$	parameter of subjective criteria weight vector,
$\phi[0,1]$	parameter of first logarithmic normalization matrix.
Variables:	
$\widetilde{\mathfrak{B}}_k (k \in E)$	FF assessment for expertise of the expert E_k,
$\beta(\widetilde{\mathfrak{B}}_k)(k \in E)$	score function value of the expert E_k,
$\mathfrak{B}_k (k \in E)$	crisp expertise value of the expert E_k,
$\pi_k (k \in E)$	weight of the expert E_k,
$\widetilde{\mathfrak{Z}}_{yk} (y \in Z, k \in E)$	FF assessment of the overall criterion Z_y provided by the expert E_k,
$\widetilde{\mathfrak{T}}_y (y \in Z)$	aggregated assessment of the overall criterion Z_y,
$\beta(\widetilde{\mathfrak{T}}_y)(y \in Z)$	score function value of the overall criterion Z_y,
$\mathfrak{T}_y (y \in Z)$	crisp value of the overall criterion Z_y,
$\mathfrak{Y}_{yy'} (y, y' \in Z)$	comparison value for the overall criterion Z_y,, depending on the overall criterion $Z_{y'}$,
$\mathfrak{U}_y (y \in Z)$	pairwise comparison value for the overall criterion Z_y,
$\mu_y (y \in Z)$	subjective criteria weight of the overall criterion Z_y,
$\widetilde{\mathfrak{x}}_{dt}^{(E_k)} (k \in E, d \in H, t \in P)$	FF assessment of the wireless technology H_d depending on the qualitative criterion P_t provided by the expert E_k,
$\widetilde{\mathfrak{x}}_{dt} (d \in H, t \in P)$	aggregated assessment of the wireless technology H_d depending on the qualitative criterion P_t,
$\beta(\widetilde{\mathfrak{x}}_{dt})(d \in H, t \in P)$	score function value of the wireless technology H_d depending on the qualitative criterion P_t,
$\mathfrak{x}_{dt} (d \in H, t \in P)$	crisp expertise value of the wireless technology H_d depending on the qualitative criterion P_t,
$\mathfrak{W}_{dv} (d \in H, v \in B)$	alternative value for the wireless technology H_d depending on the quantitative criterion B_v,
$\mathfrak{A}_{dy} (d \in H, y \in Z)$	value for the wireless technology H_d depending on the overall criterion Z_y,
$\mathfrak{B}_{dy} (d \in H, y \in Z)$	normalized value for the wireless technology H_d depending on the overall criterion Z_y,
$\mathfrak{e}_y (y \in Z)$	entropy value for the overall criterion Z_y,
$\mathfrak{C}_y (y \in Z)$	differentiation value for the overall criterion Z_y,
$\wp_y (y \in Z)$	objective criteria weight value for the overall criterion Z_y,

$\lambda_y (y \in Z)$	final objective criteria weight value for the overall criterion Z_y,
$\delta_y (y \in Z)$	final aggregated criteria weight value for the overall criterion Z_y,
$\mathfrak{J}_{dy} (d \in H, y \in Z)$	initial value for the technology H_d depending on the overall criterion Z_y,
$\mathfrak{K}_{dy} (d \in H, y \in Z)$	first logarithmic normalization value for the wireless technology H_d depending on the overall criterion Z_y,
$\mathfrak{L}_{dy} (d \in H, y \in Z)$	second logarithmic normalization value for the wireless technology H_d depending on the overall criterion Z_y,
$\mathfrak{M}_{dy} (d \in H, y \in Z)$	final normalization value for the wireless technology H_d depending on the overall criterion Z_y,
$\mathfrak{O}_{dy} (d \in H, y \in Z)$	weighted value for the wireless technology H_d depending on the overall criterion Z_y,
$\mathfrak{R}_d^- (d \in H)$	total cost value for the wireless technology H_d,
$\mathfrak{R}_d^+ (d \in H)$	total benefit value for the wireless technology H_d,
$\Omega_d (d \in H)$	final ranking value for the wireless technology H_d.

Table S2. FF-expertise vector $\left(\widetilde{\mathfrak{V}} = [\widetilde{\mathfrak{V}}_k]_K\right)$ and the crisp-expertise vector $(\mathfrak{V} = [\mathfrak{V}_k]_K)$.

Experts	*Expertise level*	*FF sets* $\left(\lambda_{\widetilde{\mathfrak{V}}_k}(s), \beth_{\widetilde{\mathfrak{V}}_k}(s)\right)$	$\mathfrak{V}_k$
E_1 – First Expert	Medium (M)	(0.50, 0.50)	0.5000
E_2 – Second Expert	Medium (M)	(0.50, 0.50)	0.5000
E_3 – Third Expert	Very-good (VG)	(0.90, 0.10)	0.8640
E_4 – Fourth Expert	Good (G)	(0.70, 0.30)	0.6580
E_5 – Fifth Expert	Very-good (VG)	(0.90, 0.10)	0.8640
E_6 – Sixth Expert	Medium (M)	(0.50, 0.50)	0.5000
E_7 – Seventh Expert	Very-good (VG)	(0.90, 0.10)	0.8640
E_8 – Eight Expert	Good (G)	(0.70, 0.30)	0.6580
E_9 – Ninth Expert	Good (G)	(0.70, 0.30)	0.6580

Table S3. Linguistics-criteria evaluation matrix.

E_k	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8	Z_9	Z_{10}	Z_{11}	Z_{12}
E_1	EH	H	L	BA	VH	H	EH	BA	VH	BA	A	EH
E_2	H	EH	H	AA	BA	VH	BA	L	H	AA	L	EH
E_3	EH	VH	H	EH	A	L	BA	BA	AA	H	ExL	VL
E_4	EL	A	EL	EL	ExL	ExL	EL	EL	VL	VH	AA	ExL
E_5	VL	A	VL	EL	VL	EL	EL	EL	VL	EL	L	BA
E_6	BA	BA	ExL	ExL	ExL	EL	ExL	ExL	ExL	VL	BA	VH
E_7	VH	EH	VL	EL	A	BA	BA	BA	AA	A	VL	AA
E_8	VL	A	ExL	L	ExL	BA	ExL	EL	VL	L	L	VH
E_9	EL	VL	ExL	ExL	ExL	EL	VL	EL	EL	A	A	L

Table S4. FF-criteria evaluation matrix $\left(\widetilde{\mathfrak{Z}} = [\widetilde{\mathfrak{Z}}_{yk}]_{YK}\right)$.

E_k	Z_1		Z_2		Z_3		Z_4		Z_5		Z_6	
	ג	ב	ג	ב	ג	ב	ב	ג	ב	ג	ג	ב
E_1	0.90	0.10	0.70	0.30	0.30	0.70	0.40	0.60	0.80	0.20	0.70	0.30
E_2	0.70	0.30	0.90	0.10	0.70	0.30	0.60	0.40	0.40	0.60	0.80	0.20
E_3	0.90	0.10	0.80	0.20	0.70	0.30	0.90	0.10	0.50	0.50	0.30	0.70
E_4	0.10	0.90	0.50	0.50	0.10	0.90	0.10	0.90	0.05	0.95	0.05	0.95
E_5	0.20	0.80	0.50	0.50	0.20	0.80	0.10	0.90	0.20	0.80	0.10	0.90
E_6	0.40	0.60	0.40	0.60	0.05	0.95	0.05	0.95	0.05	0.95	0.10	0.90
E_7	0.80	0.20	0.90	0.10	0.20	0.80	0.10	0.90	0.50	0.50	0.40	0.60
E_8	0.20	0.80	0.50	0.50	0.05	0.95	0.30	0.70	0.05	0.95	0.40	0.60
E_9	0.10	0.90	0.20	0.80	0.05	0.95	0.05	0.95	0.05	0.95	0.10	0.90
E_k	Z_7		Z_8		Z_9		Z_{10}		Z_{11}		Z_{12}	
	ג	ב	ג	ב	ג	ב	ב	ג	ב	ג	ג	ב
E_1	0.90	0.10	0.40	0.60	0.80	0.20	0.40	0.60	0.50	0.50	0.90	0.10
E_2	0.40	0.60	0.30	0.70	0.70	0.30	0.60	0.40	0.30	0.70	0.90	0.10
E_3	0.40	0.60	0.40	0.60	0.60	0.40	0.70	0.30	0.05	0.95	0.20	0.80
E_4	0.10	0.90	0.10	0.90	0.20	0.80	0.80	0.20	0.60	0.40	0.05	0.95
E_5	0.10	0.90	0.10	0.90	0.20	0.80	0.10	0.90	0.30	0.70	0.40	0.60
E_6	0.05	0.95	0.05	0.95	0.05	0.95	0.20	0.80	0.40	0.60	0.80	0.20
E_7	0.40	0.60	0.40	0.60	0.60	0.40	0.50	0.50	0.20	0.80	0.60	0.40
E_8	0.05	0.95	0.10	0.90	0.20	0.80	0.30	0.70	0.30	0.70	0.80	0.20
E_9	0.20	0.80	0.10	0.90	0.10	0.90	0.50	0.50	0.50	0.50	0.30	0.70

Table S5. Aggregated FF-criteria vector $\left(\widetilde{\mathfrak{T}} = [\widetilde{\mathfrak{T}}_y]_Y\right)$ and crisp-criteria evaluation vector $\left(\mathfrak{T} = [\mathfrak{T}_y]_Y\right)$.

	Z_1		Z_2		Z_3		Z_4		Z_5		Z_6	
	ג	ב	ג	ב	ג	ב	ג	ב	ג	ב	ג	ב
$\widetilde{\mathfrak{T}}_y$	0.3497	0.4057	0.3639	0.3287	0.1789	0.7150	0.1807	0.6962	0.2054	0.6759	0.2236	0.6570
$\mathfrak{T}_y$	0.4880		0.5063		0.3201		0.3342		0.3500		0.3638	
	Z_7		Z_8		Z_9		Z_{10}		Z_{11}		Z_{12}	
	ג	ב	ג	ב	ג	ב	ג	ב	ג	ב	ג	ב
$\widetilde{\mathfrak{T}}_y$	0.2055	0.6859	0.1408	0.7701	0.2575	0.5701	0.2628	0.5152	0.1915	0.6556	0.3365	0.4041
$\mathfrak{T}_y$	0.3430		0.2731		0.4159		0.4407		0.3626		0.4861	

Table S6. The pairwise comparison matrix $\left(\mathfrak{Y} = [\mathfrak{Y}_{yy'}]_{YY}\right)$ and criterion comparison score vector $\left(\mathfrak{U} = [\mathfrak{U}_y]_Y\right)$.

	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8	Z_9	Z_{10}	Z_{11}	Z_{12}	$\mathfrak{U}_y$
Z_1	0.50	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	10.50
Z_2	1.00	0.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	11.50
Z_3	0.00	0.00	0.50	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.50
Z_4	0.00	0.00	1.00	0.50	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	2.50
Z_5	0.00	0.00	1.00	1.00	0.50	0.00	1.00	1.00	0.00	0.00	0.00	0.00	4.50
Z_6	0.00	0.00	1.00	1.00	1.00	0.50	1.00	1.00	0.00	0.00	1.00	0.00	6.50
Z_7	0.00	0.00	1.00	1.00	0.00	0.00	0.50	1.00	0.00	0.00	0.00	0.00	3.50
Z_8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.50
Z_9	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	1.00	0.00	7.50
Z_{10}	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	0.00	8.50
Z_{11}	0.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00	0.50	0.00	5.50
Z_{12}	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	9.50

Table S7. The Evaluation matrices.

E_k	H_d	P_1	P_2	P_3	P_4	P_5	P_6	P_7
E_1	H_1	VH	H	VH	H	VH	H	VH
	H_2	AA	H	AA	H	AA	H	A
	H_3	AA	H	H	H	H	H	H
	H_4	A	A	A	H	AA	AA	H
	H_5	A	BA	A	A	AA	AA	BA
	H_6	EH	VH	VH	EH	VH	VH	VH
	H_7	BA	BA	A	BA	BA	A	BA
	H_8	EH	EH	VH	EH	VH	EH	VH
E_k	H_d	P_1	P_2	P_3	P_4	P_5	P_6	P_7
E_2	H_1	H	H	VH	VH	H	VH	VH
	H_2	H	H	AA	AA	H	AA	A
	H_3	VH	H	H	H	AA	H	AA
	H_4	AA	A	AA	VH	AA	AA	H
	H_5	AA	AA	A	A	AA	A	BA
	H_6	VH	VH	H	EH	H	VH	H
	H_7	A	BA	AA	BA	AA	A	A
	H_8	EH	EH	EH	EH	EH	EH	VH
E_k	H_d	P_1	P_2	P_3	P_4	P_5	P_6	P_7
E_3	H_1	H	VH	VH	H	H	VH	VH
	H_2	A	H	AA	AA	AA	H	A
	H_3	H	AA	H	H	AA	H	AA
	H_4	H	A	H	AA	AA	AA	AA
	H_5	H	BA	A	A	AA	AA	AA
	H_6	VH	H	VH	EH	VH	VH	H
	H_7	BA	A	A	AA	BA	AA	BA
	H_8	VH	VH	VH	EH	VH	EH	VH
E_k	H_d	P_1	P_2	P_3	P_4	P_5	P_6	P_7
E_4	H_1	VH	VH	H	H	H	EH	H
	H_2	H	H	AA	VH	AA	EH	A
	H_3	H	VH	H	AA	AA	H	VH
	H_4	H	A	H	VH	AA	AA	H
	H_5	H	AA	H	A	A	A	AA
	H_6	VH	VH	H	H	H	VH	VH
	H_7	BA	A	A	AA	A	AA	BA
	H_8	VH	EH	VH	VH	VH	VH	VH
E_k	H_d	P_1	P_2	P_3	P_4	P_5	P_6	P_7
E_5	H_1	H	VH	H	H	H	H	EH
	H_2	A	H	AA	VH	H	H	A
	H_3	A	VH	H	H	VH	H	VH
	H_4	AA	A	AA	H	AA	AA	H
	H_5	AA	A	A	AA	A	A	BA
	H_6	H	VH	H	H	H	VH	VH
	H_7	A	BA	BA	BA	AA	BA	A
	H_8	VH	VH	EH	EH	EH	EH	VH
E_k	H_d	P_1	P_2	P_3	P_4	P_5	P_6	P_7
E_6	H_1	EH	VH	VH	H	EH	H	H
	H_2	AA	H	A	H	H	H	AA
	H_3	A	VH	AA	H	AA	H	VH
	H_4	AA	A	A	VH	A	AA	H
	H_5	A	AA	A	AA	AA	A	BA
	H_6	H	VH	H	EH	EH	EH	H
	H_7	A	BA	AA	A	A	A	AA
	H_8	VH	VH	VH	H	VH	H	H
E_k	H_d	P_1	P_2	P_3	P_4	P_5	P_6	P_7
E_7	H_1	H	AA	H	H	H	H	H
	H_2	A	H	A	H	A	H	AA
	H_3	A	AA	H	AA	H	H	AA
	H_4	AA	AA	A	VH	AA	A	H
	H_5	A	AA	A	A	AA	AA	BA
	H_6	H	H	VH	H	VH	AA	H
	H_7	AA	BA	A	AA	H	H	BA
	H_8	AA	AA	H	AA	VH	H	VH
E_k	H_d	P_1	P_2	P_3	P_4	P_5	P_6	P_7

E_8	H_1	H	VH	VH	VH	VH	VH	H
	H_2	H	AA	H	AA	AA	VH	VH
	H_3	H	VH	VH	H	VH	H	VH
	H_4	H	H	AA	H	H	AA	H
	H_5	AA	BA	H	A	H	AA	BA
	H_6	H	H	EH	H	H	VH	EH
	H_7	H	H	AA	BA	AA	A	BA
	H_8	EH	H	VH	EH	H	EH	VH
E_k	H_d	P_1	P_2	P_3	P_4	P_5	P_6	P_7
E_9	H_1	VH	VH	H	AA	VH	VH	VH
	H_2	H	VH	VH	H	AA	H	H
	H_3	H	H	VH	H	H	H	VH
	H_4	H	H	H	H	H	H	VH
	H_5	A	AA	A	AA	H	H	A
	H_6	VH	VH	VH	H	H	VH	H
	H_7	H	BA	AA	AA	H	AA	H
	H_8	H	VH	H	VH	H	H	H

Table S8. FF-evaluation matrices $\left(\widetilde{\mathfrak{X}}^{(E_k)} = \left[\widetilde{\mathfrak{X}}_{dt}^{(E_k)}\right]_{DT}\right)^{*}$.

E_k		P_1		P_2		P_3		P_4		P_5		P_6		P_7	
	H_d	ג	ב	ג	ב	ג	ב	ב	ג	ב	ג	ג	ב	ג	ב
E_1	H_1	0.80	0.20	0.70	0.30	0.80	0.20	0.70	0.30	0.80	0.20	0.70	0.30	0.80	0.20
	H_2	0.60	0.40	0.70	0.30	0.60	0.40	0.70	0.30	0.60	0.40	0.70	0.30	0.50	0.50
	H_3	0.60	0.40	0.70	0.30	0.70	0.30	0.70	0.30	0.70	0.30	0.70	0.30	0.70	0.30
	H_4	0.50	0.50	0.50	0.50	0.50	0.50	0.70	0.30	0.60	0.40	0.60	0.40	0.70	0.30
	H_5	0.50	0.50	0.40	0.60	0.50	0.50	0.50	0.50	0.60	0.40	0.60	0.40	0.40	0.60
	H_6	0.90	0.10	0.80	0.20	0.80	0.20	0.90	0.10	0.80	0.20	0.80	0.20	0.80	0.20
	H_7	0.40	0.60	0.40	0.60	0.50	0.50	0.40	0.60	0.40	0.60	0.50	0.50	0.40	0.60
	H_8	0.90	0.10	0.90	0.10	0.80	0.20	0.90	0.10	0.80	0.20	0.90	0.10	0.80	0.20

*The evaluation is presented only for the first expert. The assessments of the other experts are also converted into FF sets in the same manner.

Table S9. The aggregated FF-alternative evaluation matrix $\left(\widetilde{\mathfrak{X}} = \left[\widetilde{\mathfrak{X}}_{dt}\right]_{DT}\right)$.

H_d	P_1		P_2		P_3		P_4		P_5		P_6		P_7	
	ג	ב	ג	ב	ג	ב	ב	ג	ב	ג	ג	ב	ג	ב
H_1	0.3955	0.2445	0.3999	0.2379	0.3931	0.2462	0.3660	0.2879	0.3955	0.2445	0.4094	0.2244	0.4128	0.2201
H_2	0.3083	0.3916	0.3598	0.2974	0.3145	0.3802	0.3590	0.3014	0.3123	0.3796	0.3842	0.2633	0.2995	0.4108
H_3	0.3244	0.3626	0.3756	0.2753	0.3701	0.2819	0.3440	0.3232	0.3549	0.3086	0.3573	0.3000	0.3799	0.2697
H_4	0.3253	0.3568	0.2839	0.4353	0.3087	0.3883	0.3807	0.2663	0.3097	0.3833	0.2995	0.4010	0.3585	0.3000
H_5	0.2958	0.4111	0.2623	0.4759	0.2771	0.4489	0.2644	0.4653	0.3020	0.3990	0.2861	0.4271	0.2316	0.5347
H_6	0.4042	0.2313	0.4003	0.2355	0.4108	0.2222	0.4304	0.1991	0.3999	0.2380	0.4196	0.2105	0.4018	0.2355
H_7	0.2720	0.4648	0.2332	0.5354	0.2626	0.4722	0.2585	0.4851	0.2883	0.4301	0.2795	0.4437	0.2389	0.5222
H_8	0.4333	0.1942	0.4333	0.1942	0.4326	0.1927	0.4613	0.1602	0.4353	0.1889	0.4603	0.1600	0.4132	0.2167

Table S10. Crisp-alternative evaluation matrix ($\mathfrak{X} = [\mathfrak{X}_{dt}]_{DT}$).

H_d	P_1	P_2	P_3	P_4	P_5	P_6	P_7
H_1	0.5236	0.5252	0.5229	0.5126	0.5236	0.5287	0.5298
H_2	0.4846	0.5101	0.4881	0.5095	0.4879	0.5192	0.4788
H_3	0.4932	0.5161	0.5141	0.5035	0.5077	0.5093	0.5176
H_4	0.4945	0.4702	0.4854	0.5181	0.4867	0.4812	0.5095
H_5	0.4782	0.4551	0.4654	0.4589	0.4820	0.4727	0.4298
H_6	0.5268	0.5255	0.5292	0.5359	0.5252	0.5323	0.5259
H_7	0.4599	0.4296	0.4564	0.4515	0.4722	0.4672	0.4356
H_8	0.5370	0.5370	0.5369	0.5470	0.5379	0.5467	0.5302

Table S11. Initial matrix $\left(\mathfrak{A} = \left[\mathfrak{A}_{dy}\right]_{DY}\right)$.

H_d	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8	Z_9	Z_{10}	Z_{11}	Z_{12}
H_1	0.5236	0.5252	0.5229	0.5126	0.5236	0.5287	0.5298	1000	500,000	20,000	15,000	2000
H_2	0.4846	0.5101	0.4881	0.5095	0.4879	0.5192	0.4788	50,000	180,000	20,000	10,000	10,000
H_3	0.4932	0.5161	0.5141	0.5035	0.5077	0.5093	0.5176	32,767	2,000,000	1000	1000	10
H_4	0.4945	0.4702	0.4854	0.5181	0.4867	0.4812	0.5095	8191	16,000,000	1000	1000	300
H_5	0.4782	0.4551	0.4654	0.4589	0.4820	0.4727	0.4298	500,000	600	50,000	10,000	10,000
H_6	0.5268	0.5255	0.5292	0.5359	0.5252	0.5323	0.5259	50,000	1,400,000	20,000	5000	150
H_7	0.4599	0.4296	0.4564	0.4515	0.4722	0.4672	0.4356	65,000	5,000,000	100	100	100
H_8	0.5370	0.5370	0.5369	0.5470	0.5379	0.5467	0.5302	1,000,000	20,000,000	30,000	30,000	50

Table S12. The normalized matrix $\left(\mathfrak{B} = \left[\mathfrak{B}_{dy}\right]_{DY}\right)$ and entropy vector $\left(\mathfrak{e} = \left[\mathfrak{e}_y\right]_Y\right)$ and differentiation vector $\left(\mathfrak{C} = \left[\mathfrak{C}_y\right]_Y\right)$ and objective criteria weight vector $\left(\wp = \left[\wp_y\right]_Y\right)$.

H_d	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8	Z_9	Z_{10}	Z_{11}	Z_{12}
H_1	0.1310	0.1323	0.1308	0.1270	0.1302	0.1303	0.1339	0.0006	0.0111	0.1407	0.2080	0.0885
H_2	0.1212	0.1285	0.1221	0.1262	0.1213	0.1280	0.1210	0.0293	0.0040	0.1407	0.1387	0.4423
H_3	0.1234	0.1300	0.1286	0.1247	0.1262	0.1255	0.1308	0.0192	0.0444	0.0070	0.0139	0.0004
H_4	0.1237	0.1185	0.1214	0.1283	0.1210	0.1186	0.1288	0.0048	0.3549	0.0070	0.0139	0.0133
H_5	0.1196	0.1147	0.1164	0.1137	0.1198	0.1165	0.1086	0.2929	0.0000	0.3519	0.1387	0.4423
H_6	0.1318	0.1324	0.1323	0.1328	0.1305	0.1312	0.1329	0.0293	0.0311	0.1407	0.0693	0.0066
H_7	0.1150	0.1082	0.1141	0.1119	0.1174	0.1152	0.1101	0.0381	0.1109	0.0007	0.0014	0.0044
H_8	0.1343	0.1353	0.1343	0.1355	0.1337	0.1347	0.1340	0.5858	0.4436	0.2111	0.4161	0.0022
$\mathfrak{e}_y$	0.9994	0.9987	0.9992	0.9990	0.9995	0.9993	0.9985	0.5338	0.6205	0.7688	0.7465	0.5135
$\mathfrak{C}_y$	0.0006	0.0013	0.0008	0.0010	0.0005	0.0007	0.0015	0.4662	0.3795	0.2312	0.2535	0.4865
$\wp_y$	0.0947	0.2086	0.1205	0.1485	0.0748	0.1147	0.2383	0.2566	0.2089	0.1272	0.1395	0.2678

Table S13. Initial matrix $\left(\mathfrak{F} = \left[\mathfrak{F}_{dy}\right]_{DY}\right)$ for the ARLON method.

H_d	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8	Z_9	Z_{10}	Z_{11}	Z_{12}
H_1	52.36	52.52	52.29	51.26	52.36	52.87	52.98	100,000	500,000	20,000	15,000	2000
H_2	48.46	51.01	48.81	50.95	48.79	51.92	47.88	50,000	180,000	20,000	10,000	10,000
H_3	49.32	51.61	51.41	50.35	50.77	50.93	51.76	32,767	2,000,000	1000	1000	10
H_4	49.45	47.02	48.54	51.81	48.67	48.12	50.95	8191	16,000,000	1000	1000	300
H_5	47.82	45.51	46.54	45.89	48.20	47.27	42.98	500,000	600	50,000	10,000	10,000
H_6	52.68	52.55	52.92	53.59	52.52	53.23	52.59	50,000	1,400,000	20,000	5000	150
H_7	45.99	42.96	45.64	45.15	47.22	46.72	43.56	65,000	5,000,000	100	100	100
H_8	53.70	53.70	53.69	54.70	53.79	54.67	53.02	1,000,000	20,000,000	30,000	30,000	50

Table S14. First logarithmic normalization matrix $\left(\mathfrak{K}=\left[\mathfrak{K}_{dy}\right]_{DY}\right)$.

H_d	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8	Z_9	Z_{10}	Z_{11}	Z_{12}
H_1	0.1265	0.1269	0.1265	0.1256	0.1263	0.1248	0.1247	0.1271	0.1203	0.1430	0.1473	0.1200
H_2	0.1241	0.1260	0.1243	0.1254	0.1241	0.1249	0.1251	0.1194	0.1109	0.1430	0.1411	0.1152
H_3	0.1246	0.1264	0.1260	0.1250	0.1253	0.1250	0.1248	0.1148	0.1330	0.0997	0.1058	0.1359
H_4	0.1247	0.1234	0.1241	0.1259	0.1240	0.1252	0.1248	0.0995	0.1520	0.0997	0.1058	0.1257
H_5	0.1236	0.1223	0.1228	0.1220	0.1237	0.1253	0.1256	0.1449	0.0586	0.1562	0.1411	0.1152
H_6	0.1267	0.1269	0.1269	0.1270	0.1264	0.1248	0.1247	0.1194	0.1297	0.1430	0.1305	0.1278
H_7	0.1224	0.1205	0.1221	0.1215	0.1230	0.1254	0.1256	0.1223	0.1414	0.0665	0.0705	0.1290
H_8	0.1273	0.1276	0.1273	0.1276	0.1272	0.1247	0.1247	0.1525	0.1541	0.1488	0.1579	0.1311

Table S15. Second logarithmic normalization matrix $\left(\mathfrak{L}=\left[\mathfrak{L}_{dy}\right]_{DY}\right)$.

H_d	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8	Z_9	Z_{10}	Z_{11}	Z_{12}
H_1	0.1265	0.1269	0.1265	0.1256	0.1263	0.8736	0.8727	0.1271	0.1203	0.1430	0.1473	0.8402
H_2	0.1241	0.1260	0.1243	0.1254	0.1241	0.8742	0.8759	0.1194	0.1109	0.1430	0.1411	0.8063
H_3	0.1246	0.1264	0.1260	0.1250	0.1253	0.8748	0.8734	0.1148	0.1330	0.0997	0.1058	0.9516
H_4	0.1247	0.1234	0.1241	0.1259	0.1240	0.8766	0.8739	0.0995	0.1520	0.0997	0.1058	0.8801
H_5	0.1236	0.1223	0.1228	0.1220	0.1237	0.8772	0.8794	0.1449	0.0586	0.1562	0.1411	0.8063
H_6	0.1267	0.1269	0.1269	0.1270	0.1264	0.8734	0.8729	0.1194	0.1297	0.1430	0.1305	0.8946
H_7	0.1224	0.1205	0.1221	0.1215	0.1230	0.8776	0.8790	0.1223	0.1414	0.0665	0.0705	0.9032
H_8	0.1273	0.1276	0.1273	0.1276	0.1272	0.8726	0.8727	0.1525	0.1541	0.1488	0.1579	0.9177

Table S16. Final normalization matrix $\left(\mathfrak{M}=\left[\mathfrak{M}_{dy}\right]_{DY}\right)$.

H_d	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8	Z_9	Z_{10}	Z_{11}	Z_{12}
H_1	0.1265	0.1269	0.1265	0.1256	0.1263	0.4147	0.4143	0.1271	0.1203	0.1430	0.1473	0.3988
H_2	0.1241	0.1260	0.1243	0.1254	0.1241	0.4150	0.4158	0.1194	0.1109	0.1430	0.1411	0.3828
H_3	0.1246	0.1264	0.1260	0.1250	0.1253	0.4153	0.4146	0.1148	0.1330	0.0997	0.1058	0.4517
H_4	0.1247	0.1234	0.1241	0.1259	0.1240	0.4161	0.4149	0.0995	0.1520	0.0997	0.1058	0.4178
H_5	0.1236	0.1223	0.1228	0.1220	0.1237	0.4164	0.4174	0.1449	0.0586	0.1562	0.1411	0.3828
H_6	0.1267	0.1269	0.1269	0.1270	0.1264	0.4146	0.4144	0.1194	0.1297	0.1430	0.1305	0.4247
H_7	0.1224	0.1205	0.1221	0.1215	0.1230	0.4166	0.4172	0.1223	0.1414	0.0665	0.0705	0.4287
H_8	0.1273	0.1276	0.1273	0.1276	0.1272	0.4142	0.4143	0.1525	0.1541	0.1488	0.1579	0.4356

Table S17. Weighted matrix $\left(\mathfrak{O}=\left[\mathfrak{O}_{dy}\right]_{DY}\right)$.

H_d	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8	Z_9	Z_{10}	Z_{11}	Z_{12}
H_1	0.0122	0.0168	0.0051	0.0068	0.0063	0.0306	0.0347	0.0086	0.0125	0.0130	0.0108	0.0530
H_2	0.0120	0.0166	0.0050	0.0068	0.0062	0.0306	0.0349	0.0081	0.0116	0.0130	0.0103	0.0509
H_3	0.0120	0.0167	0.0051	0.0068	0.0063	0.0306	0.0348	0.0078	0.0139	0.0091	0.0077	0.0600
H_4	0.0120	0.0163	0.0050	0.0069	0.0062	0.0307	0.0348	0.0067	0.0159	0.0091	0.0077	0.0555
H_5	0.0119	0.0161	0.0050	0.0066	0.0062	0.0307	0.0350	0.0098	0.0061	0.0142	0.0103	0.0509
H_6	0.0122	0.0168	0.0051	0.0069	0.0063	0.0306	0.0348	0.0081	0.0135	0.0130	0.0095	0.0564
H_7	0.0118	0.0159	0.0050	0.0066	0.0061	0.0307	0.0350	0.0083	0.0147	0.0060	0.0052	0.0570
H_8	0.0123	0.0168	0.0052	0.0070	0.0064	0.0306	0.0347	0.0103	0.0161	0.0135	0.0115	0.0579

Table S18. Total cost vector ($\mathfrak{R}^-=[\mathfrak{R}_d^-]_D$) and total benefit vector ($\mathfrak{R}^+=[\mathfrak{R}_d^+]_D$).

	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8
$\mathfrak{R}_d^-$	0.1184	0.1164	0.1255	0.1210	0.1166	0.1218	0.1227	0.1232
$\mathfrak{R}_d^+$	0.0921	0.0896	0.0853	0.0858	0.0863	0.0915	0.0797	0.0991