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BIODIVERSITY: SDGS AND AICHI TARGETS

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Abstract. The Aichi biodiversity targets were established by the UN convention of biological Diversity and consist of 20 specific targets to address and mitigate biodiversity loss across the globe. We determine how well OECD countries are achieving the Aichi targets. We use the Sustainable Development Goals to make the determination. The Biodiversity and Habitat issue category assesses countries' actions toward retaining natural ecosystems and protecting the full range of biodiversity within their borders. It consists of seven indicators: terrestorial biome protection (weighted for national and global rarity of biomes), marine protected areas, Protected Areas Representativeness Index, Species Habitat Index, Species Protection Index, and Biodiversiy Index, [4]. We determine the similarity between the rankings determined by the weighted average values and the Environmental Performance Index (EPI) scores.

Keywords: Sustainable development goals, Aichi targets, country rankings, similarity measures, habitat index.
2020 MSC: 03B52, 03E72.

1. Introduction

The following is taken from [1]. The 2030 Agenda for Sustainable Development, agreed by the 193 States Members of the United Nations, sets out an ambitious framework of universal and indivisible goals and targets to address a range of global societal challenges. Biodiversity and ecosystems feature prominently across many of the Sustainable Development Goals (SDGs) and associated targets. They contribute to human well-being development priorities. Biodiversity is at the center of many economic activities, particularly those related to crop and livestock, agriculture, forestry, and fisheries. Globally, nearly half of the human population is directly dependent on natural resources for its livelihood, and many of the most vulnerable people depend directly on biodiversity to fulfil their daily subsistence needs.

2. SDGs and Aichi Targets

The purpose of [1] was to develop a technical complement to the "Policy Brief on Biodiversity and the 2030 Agenda for Sustainable Development" The work

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in [1] is intended to help decision-makers such as government representatives and development professionals to understand more easily the contributions of biodiversity to achieving the SDGs. It presents a mapping of the linages between the SDGs, and the Strategic Plan for Biodiversity 2011-2020 and its 20 Aichi Biodiversity Targets. These targets are listed in the Appendix.

The Aichi biodiversity targets were established by the UN Convention of Biological Diversity and consists of 20 specific targets to address and mitigate biodiversity loss across the globe. A recent UN report stated that the current rate of species extermination is at historic levels and is accelerating. The purpose of this paper is to determine how well countries are achieving the 20 Aichi Biodiversity Targets. In this paper, we consider only the Organization for Economic Cooperation and Development (OECD) countries.

The table in [1, p. 2], provides a summary of linkages between the SDGs and Aichi Biodiversity Targets. The report in [5], provides a value that measures how well a country is achieving the 17 SDGs. We use these values to determine how well a country is achieving the Aichi targets by a formula involving the SDGs associated with a particular Target. This association is provided in the following Table 1 below which is determined from the table in [1, p.2]. We find that the countries which are achieving the Aichi Targets are the Czech Republic, Estonia, Denmark, Hungary, and Austria.

Table 1. SDGs Associated with Targets

Target	SDGs
T_1	$4, 12$
T_2	$1, 8, 9, 11, 13, 14, 15, 17$
T_3	14
T_4	$2, 8, 9, 11, 12, 14, 15$
T_5	$7, 13, 14, 15$
T_6	$1, 2, 8, 12, 14$
T_7	$1, 2, 7, 8, 12, 14, 15$
T_8	$3, 6, 9, 10, 11, 12, 13$
T_9	15
T_{10}	$13, 14$
T_{11}	$6, 11, 14, 15$
T_{12}	$14, 15$
T_{13}	$2, 3$
T_{14}	$1, 3, 5, 7, 8, 9, 11, 13, 14, 15$
T_{15}	$6, 7, 9, 10, 11, 13, 14, 15$
T_{16}	$3, 8, 15$
T_{17}	$5, 13, 14, 16, 17$
T_{18}	$2, 3, 5, 10$
T_{19}	$7, 9, 12, 14, 17$
T_{20}	$10, 17$

Tables 2 and 3 below provide new values for how well an OECD country is achieving the Aichi Targets. A country with the superscript * is one in which the SDG 14 was rated *na* and a country with a superscript # was one with *na* for SDG 10. How the values in Table 2 below are determined is illustrated in the following example. Consider Australia and Target T_5. The SDGs involved for T_5 are 7, 13, 14, and 15. We obtain $57.25 = \frac{1}{4}(91.0 + 33.9 + 56.3 + 47.8)$, where $91.0, 33.9, 56.3, 47.8$ are the values from [5] denoting how well Australia is achieving SDG 7, SDG 13, SDG14, SDG 15, respectively.

Table 2. Aichi Target Scores

Country	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
Australia	66.85	68.00	56.3	63.33	57.25	65.94	66.93	72.87	47.8	45.1
Austria	71.05	81.56*	*na*	72.75*	83.17*	74.58*	77.25*	81.89	71.4	84.30*
Belgium	65.30	74.99	30.6	67.44	72.60	65.68	72.19	79.23	85.0	56.75
Canada	75.00	74.01	59.5	67.04	71.00	70.60	72.71	75.85	60.7	64.00
Chile	82.65	76.14	66.2	67.41	77.80	76.32	75.99	72.51	59.3	80.45
Czech Rep.	83.55	81.10*	*na*	77.10*	90.63*	79.60*	83.53*	83.60	91.0	89.10*
Denmark	74.05	84.74	48.9	73.77	79.975	70.10	75.90	85.94	87.2	69.55
Estonia	77.00	81.08	81.3	75.06	86.425	76.56	80.31	78.03	90.5	83.15
Finland	73.80	79.61	55.5	71.29	76.25	68.94	74.74	82.63	82.1	63.25
France	75.40	80.08	64.2	71.29	81.075	72.24	76.41	81.17	76.7	75.30
Germany	68.2	81.46	40.5	70.70	76.625	68.12	73.77	82.36	82.6	65.35
Greece	64.75	70.70	59.4	61.67	77.75	63.94	69.87	69.33	78.7	70.80
Hungary	80.70	78.63*	*na*	73.38*	91.27*	79.05*	82.52*	78.87	87.3	94.90*
Iceland	74.00	71.81	35.9	61.71	64.60	66.36	66.53	84.01	34.5	62.25
Ireland	70.75	75.00	53.4	70.24	80.00	71.46	76.03	78.81	82.4	72.55
Israel	69.15	69.49	17.4	58.61	63.30	56.34	63.76	72.94	50.6	54.30
Italy	74.65	73.20	41.1	65.21	75.45	66.62	72.73	74.86	82.9	62.90
Japan	76.85	77.71	53.6	70.14	76.85	72.94	75.44	79.64	70.0	72.00
Korea Rep.	79.65	75.29	54.8	71.94	73.05	76.28	75.87	82.23	57.2	71.25
Latvia	81.80	74.86	50.9	70.04	80.525	72.24	77.80	77.33	92.2	69.35
Luxembourg	59.15	76.16*	*na*	63.73*	69.23*	64.02*	64.18*	77.31	62.3	78.70*
Mexico	85.70	68.24	69.5	63.01	73.55	72.70	71.09	66.07	47.6	80.05
Netherlands	69.10	77.81	41.2	70.04	76.075	66.66	72.59	84.20	83.2	64.75
New Zealand	74.80	75.69	57.0	66.24	72.885	71.94	71.81	80.87#	47.1	74.25
Norway	65.20	78.44	66.2	65.93	70.60	66.34	70.50	76.63	63.2	60.30
Poland	84.05	74.50	43.7	69.77	78.65	72.58	77.80	74.23	92.0	66.45
Portugal	75.15	74.74	51.8	65.54	77.825	68.72	74.14	74.74	73.4	71.65
Slovak Rep.	74.40	75.81*	*na*	72.18*	85.43*	78.18*	81.97*	75.69	86.9	77.20*
Slovenia	78.70	74.49	33.3	67.54	75.15	68.62	74.17	82.00	82.5	62.25
Spain	74.40	75.96	59.4	66.69	78.20	68.46	71.77	79.51	65.4	76.35
Sweden	75.75	83.42	42.3	71.21	75.85	68.06	73.46	87.53	75.2	64.75
Switzerland	59.90	81.60*	*na*	69.93*	81.10*	67.55*	70.77*	83.10	57.7	89.90*
Turkey	83.75	66.45	27.4	57.29	64.95	66.06	67.54	69.64	53.3	58.65
United Kingdom	71.15	77.44	57.5	70.80	77.20	69.88	73.73	80.10	73.7	71.05
United States	62.90	76.25	60.9	70.19	74.275	69.50	73.94	70.09	76.9	63.50

In table 4, we determine the rank of each country for each $T_i, i = 1, ..., 20$. We next determine a weighted average of the T_i values for each country, $i = 1, 2., , , .20$. We then rank the countries according to their weighted values. We

use the equation $WA = \sum_{i=1}^{20} w_i T_i$, where w_i is number of $SDGs$ associated with T_i divided by 89, the total of the SDGs involved with the T_i. For example, $w_2 = 8/89$. Thus

$$\begin{aligned} WA &= 0.022T_1 + 0.089T_2 + 0.011T_3 + 0.078T_4 + 0.044T_5 \\ &\quad +0.056T_6 + 0.078T_7 + 0.078T_8 + 0.11T_9 + 0.022T_{10} \\ &\quad +0.044T_{11} + 0.22T_{12} + 0.022T_{13} + 0.112T_{14} + 0.089T_{15} \\ &\quad +0.033T_{16} + 0.056T_{17} + 0.044T_{18} + 0.056T_{19} + 0.022T_{20}. \end{aligned}$$

For the countries with na for T_3, we determine a similar equation with T_3 deleted. Here the divisor becomes 88 rather than 89. The third column in Table 6 below is determined by taking the ordinary average of the $T_i, i = 1, ..., 20$.

Table 3. Aichi Target Scores

Country	T_{11}	T_{12}	T_{13}	T_{14}	T_{15}	T_{16}	T_{17}	T_{18}	T_{19}	T_{20}
Australia	70.425	52.05	74.45	74.93	70.98	75.13	63.18	76.20	66.70	69.05
Austria	84.03*	71.40*	83.25	85.63*	85.40*	82.77	80.85*	83.25	71.83*	77.70
Belgium	69.30	57.8	82.15	80.75	77.66	86.83	69.32	85.40	61.48	77.85
Canada	71.20	60.1	77.50	79.71	75.22	79.83	72.38	78.55	68.94	72.10
Chile	75.70	62.75	74.95	77.78	70.12	75.53	77.34	61.925	71.66	53.35
Czech Rep.	89.47*	91.00*	77.75	85.83*	86.40*	89.50	74.60*	79.725	70.32*	73.90
Denmark	79.25	68.05	82.20	86.26	86.68	89.07	81.26	86.425	74.04	93.15
Estonia	87.95	85.90	73.55	84.61	82.42	88.03	76.98	73.65	69.18	63.85
Finland	79.625	68.80	77.20	84.47	83.44	86.93	76.52	85.375	71.66	85.95
France	78.95	70.45	80.15	84.33	82.30	83.03	77.76	83.10	72.66	80.35
Germany	75.85	61.55	81.75	83.36	81.32	87.27	74.84	80.975	68.92	83.25
Greece	77.70	69.05	75.70	75.55	73.06	77.30	66.12	66.225	58.60	52.25
Hungary	87.47*	87.30*	75.05	82.28*	82.01*	85.10	70.98*	72.45	65.92*	63.55
Iceland	61.925	62.25	79.75	78.89	76.30	71.47	74.08	86.05	65.76	83.30
Ireland	75.575	67.90	82.70	82.74	79.81	88.43	68.40	80.825	58.56	59.10
Israel	55.60	34.00	77.20	76.60	66.91	77.13	62.46	69.95	57.06	52.55
Italy	70.70	62.00	79.70	78.19	74.29	85.57	67.06	75.125	62.56	66.50
Japan	70.875	61.80	81.45	80.36	76.75	84.47	71.54	74.55	69.48	70.85
Korea Rep.	68.45	56.00	85.15	79.77	78.02	78.60	67.04	80.175	69.58	69.95
Latvia	79.60	71.55	72.45	79.44	77.90	86.67	67.26	72.90	61.94	63.45
Luxembourg	82.27*	62.30*	79.40	70.16*	78.56*	76.20	75.48*	80.425	54.60*	73.35
Mexico	69.35	58.55	68.30	73.15	63.18	67.50	70.16	67.15	66.26	37.40
Netherlands	77.95	62.20	80.90	83.30	83.12	87.57	69.64	84.475	62.56	74.15
New Zealand	69.45	52.05	78.85	81.58	77.01#	76.60	78.14	80.76#	68.64	64.90#
Norway	75.75	64.70	77.45	81.21	79.50	79.87	78.56	85.65	74.98	99.80
Poland	74.05	67.85	74.40	79.10	72.96	88.00	67.76	68.40	63.08	53.55
Portugal	74.15	62.60	74.05	80.56	74.51	82.60	73.36	71.525	63.20	58.00
Slovak Rep.	84.43*	86.90*	78.40	80.53*	79.41*	85.20	78.05*	77.30	65.50*	69.30
Slovenia	71.025	57.90	78.65	79.99	78.75	86.63	69.1	83.15	61.26	78.80
Spain	75.50	62.40	75.80	82.14	78.41	78.67	75.02	75.875	66.94	64.15
Sweden	75.325	58.75	80.55	85.46	84.86	85.50	80.08	87.50	76.62	99.1
Switzerland	83.83*	57.70*	80.20	88.29*	87.20*	78.43	76.85*	80.65	67.80*	66.65
Turkey	58.30	40.35	69.70	67.91	62.49	70.23	60.30	56.475	61.54	56.00
United Kingdom	79.275	65.60	80.45	83.94	80.94	83.70	71.6	78.40	64.74	60.15
United States	76.325	68.90	77.75	80.99	74.45	83.87	66.54	69.15	66.02	51.95

Table 4. Aichi Target Scores

Country	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
Australia	29	34	12	30	35	31	32	30	32	35
Austria	24	4	*na*	5	5	7	7	11	21	4
Belgium	30	23	27	21	28	32	24	17	8	33
Canada	15	28	7	23	29	15	22	24	26	24
Chile	5	17	3.5	22	14	5	10	31	27	6
Czech Rep.	4	6	*na*	1	2	2	1	5	3	3
Denmark	20	1	19	4	10	16	11	2	6	19
Estonia	10	7	1	2	3	4	4	20	4	5
Finland	22	9	13	8.5	18	19	14	7	14	27
France	13	8	5	8.5	7	11.5	8	12	17	11
Germany	28	5	24	12	16	23	18	8	11	22
Greece	32	31	8.5	33	15	34	30	34	15	18
Hungary	7	10	*na*	3	1	1	2	19	5	1
Iceland	21	30	25	32	33	29	33	4	35	29.5
Ireland	25	22	16	13	9	14	9	18	13	13
Israel	26	32	29	34	34	35	35	29	31	34
Italy	17	29	23	28	22	27	21	26	10	28
Japan	11	13	15	14	19	8	13	15	22	14
Korea Rep.	8	21	14	7	26	6	12	9	29	16
Latvia	6	24	18	16.5	8	11.5	5.5	21	1	20
Luxembourg	35	16	*na*	29	31	33	34	22	25	8
Mexico	1	33	2	31	25	9	27	35	33	7
Netherlands	27	12	22	16.5	20	26	23	3	9	25
New Zealand	16	20	11	25	27	13	25	13	34	12
Norway	31	11	3.5	26	30	28	29	23	24	31
Poland	2	26	20	19	11	10	5.5	28	2	21
Portugal	14	15	17	27	13	20	16	27	20	15
Slovak Rep.	18.5	19	*na*	6	4	3	3	25	7	9
Slovenia	9	27	26	20	23	21	15	10	12	29.5
Spain	18.5	18	8.5	24	12	22	26	16	23	10
Sweden	12	2	21	10	21	24	20	1	18	23
Switzerland	34	3	*na*	18	6	25	28	6	28	2
Turkey	3	35	28	35	32	30	31	33	30	32
United Kingdom	23	14	10	11	17	17	19	14	19	17
United States	33	15	6	15	24	18	17	32	16	26

Table 5. Aichi Target Rankings

Country	T_{11}	T_{12}	T_{13}	T_{14}	T_{15}	T_{16}	T_{17}	T_{18}	T_{19}	T_{20}
Australia	28	32.5	29	32	31	32	34	21	17	18
Austria	5	6	2	4	4	20	2	8	5	10
Belgium	31	29	5	18	21	9	24	5	30	9
Canada	24	25	22	24	25	23	18	18	12	14
Chile	18	16	28	29	32	31	8	34	6.5	31
Czech Rep.	1	1	19.5	3	3	1	15	17	8	12
Denmark	11	11	4	2	2	2	1	2	3	3
Estonia	2	4	32	6	8	4	9	25	11	23
Finland	8	10	23.5	7	6	8	11	6	6.5	4
France	12	7	12	8	9	19	7	10	4	7
Germany	16	24	6	10	11	7	14	11	13	6
Greece	14	8	26	31	29	27	33	33	32	33
Hungary	3	2	27	13	10	15	21	27	20	24
Iceland	33	20	13	27	24	33	16	3	21	5
Ireland	19	12	3	12	13	3	26	12	33	27
Israel	35	35	23.5	30	33	28	28	29	34	32
Italy	27	22	14	28	28	12	30	23	26.5	20
Japan	26	23	7	21	23	16	20	24	10	15
Korea Rep.	32	31	1	29	19	25	31	16	9	16
Latvia	9	5	33	25	20	10	29	26	28	25
Luxembourg	7	19	15	34	17	30	12	15	35	23
Mexico	29	27	35	33	34	35	22	32	18	35
Netherlands	13	21	8	11	7	6	23	7	26.5	11
New Zealand	30	32.5	16	15	22	29	5	13	14	21
Norway	17	15	21	16	14	22	4	4	27	1
Poland	23	13	30	26	30	5	27	3	25	30
Portugal	22	17	31	19	26	21	17	28	24	28
Slovak Rep.	4	3	18	20	15	14	6	20	22	17
Slovenia	25	20	17	22	16	11	25	9	31	8
Spain	20	18	25	14	18	24	13	22	16	22
Sweden	21	26	9	5	5	13	3	1	1	2
Switzerland	6	30	11	1	18	26	10	14	15	19
Turkey	34	34	34	35	35	34	35	35	29	29
United Kingdom	10	14	10	9	12	18	19	19	23	26
United States	15	9	19.5	17	27	17	32	30	19	34

Table 6. Averages and Rank

Country	Weighted Average / Rank	Average / Rank
Australia	67.676 / 33	65.173 / 33
Austria	80.109 / 4	79.161 / 4
Belgium	73.116 / 24	70.916 / 27
Canada	73.038 / 25	71.297 / 22
Chile	73.135 / 23	71.791 / 21
Czech Rep.	82.504 / 1	83.037 / 1
Denmark	80.553 / 2	78.821 / 5
Estonia	80.171 / 3	79.777 / 3
Finland	77.939 / 9	76.409 / 9
France	78.464 / 7	77.347 / 7
Germany	76.652 / 11	74.438 / 12
Greece	69.336 / 31	66.923 / 32
Hungary	79.338 / 5	79.933 / 2
Iceland	71.345 / 30	68.072 / 30
Ireland	75.119 / 15	73.734 / 15
Israel	64.431 / 34	60.268 / 35
Italy	71.792 / 28	68.195 / 29
Japan	75.034 / 16	73.365 / 18
Korea Rep.	74.811 / 17	72.515 / 19
Latvia	74.735 / 18	74.010 / 14
Luxembourg	71.267 / 29	70.922 / 26
Mexico	67.979 / 32	66.926 / 31
Netherlands	75.791 / 12	73.594 / 16
New Zealand	73.953 / 21	71.028 / 25
Norway	75.263 / 14	74.040 / 13
Poland	73.224 / 22	72.144 / 20
Portugal	72.776 / 26	71.113 / 24
Slovak Rep.	78.056 / 8	78.567 / 6
Slovenia	74.066 / 20	71.199 / 23

Table 7. continued Averages and Rank

Country	Weighted Average / Rank	Average / Rank
Spain	74.380 / 19	75.552 / 10
Sweden	79.068 / 6	76.564 / 8
Switzerland	77.814 / 10	75.218 / 11
Turkey	63.369 / 35	60.911 / 34
United Kingdom	75.603 / 13	73.567 / 17
United States	72.389 / 27	70.720 / 28

We see that the countries that rank the highest are the Czech Republic, Estonia, Denmark, Hungary, and Austria.

3. Similarity Measures

Definition 3.1. Let S be a function of $\mathcal{FP}(X) \times \mathcal{FP}(X)$ into $[0,1]$. Then S is called a **fuzzy similarity measure** on $\mathcal{FP}(X)$ if the following properties hold for all $\mu, \nu, \rho \in \mathcal{FP}(X)$:

(1)$S(\mu,\nu) = S(\nu,\mu)$;
(2)$S(\mu.\nu) = 1$ if and only if $\mu = \nu$;
(3) If $\mu \subseteq \nu \subseteq \rho$, then $S(\mu,\rho) \leq S(\mu,\nu) \wedge S(\nu,\rho)$;
(4) If $S(\mu,\nu) = 0$, then $\forall x \in X, \mu(x) \wedge \nu(x) = 0$.

We apply fuzzy similarity measures to rankings of members of a finite set. Suppose that X is a finite set with n elements. Let A be a one-to-one function of X onto $\{1,2,...,n\}$. Then A is called a ranking of X. Define the fuzzy subset μ_A of X as follows: $\forall x \in X, \mu(x) = A(x)/n$. We wish to consider the similarity of two rankings of X by the use of fuzzy similarity measures.

Example 3.2. *Let μ_A, μ_B be the fuzzy subsets of X associated with two rankings A and B of X, respectively. Then M, L, and S are fuzzy similarity measures, where*

$$\begin{aligned} M(\mu_A,\mu_B) &= \frac{\sum_{x\in X} \mu_A(x) \wedge \mu_B(x)}{\sum_{x\in X} \mu_A(x) \vee \mu_B(x)}, \\ L(\mu_A,\mu_B) &= 1 - \vee_{x\in X} |\mu_A - \mu_B|, \\ S(\mu_A,\mu_B) &= \frac{\sum_{x\in X} |\mu_A(x) - \mu_B(x)|}{\sum_{x\in X} \mu_A(x) + \mu_B(x)}. \end{aligned}$$

Theorem 3.3. [2, 3] (1) *Suppose that n is even. Then the smallest value M can be is*

$$M = \frac{n+2}{3n+2}.$$

(2) *Suppose that n is odd. Then the smallest value M can be is*

$$M = \frac{n+1}{3n-1}.$$

Theorem 3.4. [2, 3] (1) *Suppose that n is even. Then the smallest value S can be is*

$$S = \frac{n/2+1}{n+1}.$$

(2) *Suppose that n is odd. Then the smallest value S can be is*

$$S = \frac{1}{2} + \frac{1}{2n}.$$

The equations in the above theorems give the smallest value $M(\mu,\nu)$ and $S(\mu,\nu)$ can take on, [5]. In general, $M(\mu,\nu)$ and $S(\mu,\nu)$ are bounded below by

$\frac{1}{3}$ and $\frac{1}{2}$, respectively. If we wish to calculate a value for $M(\mu,\nu)$ and $S(\mu,\nu)$ in which the values are bounded below by 0, we can use the following formulas:

$$\frac{M(\mu,\nu)-\frac{n+2}{3n+2}}{1-\frac{n+2}{3n+2}} \text{ and } \frac{S(\mu,\nu)-\frac{n/2+1}{n+1}}{1-\frac{n/2+1}{n+1}}$$

if n is even and

$$\frac{M(\mu,\nu)-\frac{n+1}{3n-1}}{1-\frac{n+1}{3n-21}} \text{ and } \frac{S(\mu,\nu)-(\frac{1}{2}+\frac{1}{2n})}{1-(\frac{1}{2}+\frac{1}{2n})}$$

if n is odd.

Describing fuzzy similarity values linguistically, one might say the similarity is very low if the value is between 0 and 0.2, low if the value is between 0.2 and 0.4, medium if the value is between 0.4 and 0.6, high if the value is between 0.6 and $0,8$, and very high if the value is between 0.8 and 1.

Let A denote the ranking of the countries using the weighted average and B the ranking using the ordinary average. Then

$$M(\mu_A,\mu_B)=\frac{597}{663}=0.900 \text{ and } S(\mu_A,\mu_B)=1-\frac{66}{1260}=0.948.$$

The following values provide the similarity measures converted to a value with a range from 0 to 1.We have

$$\begin{aligned}\frac{M(\mu_A,\mu_B)-\frac{n+1}{3n-1}}{1-\frac{n+1}{3n-1}} &= \frac{0.900-0.346}{1-0.346}=0.847 \text{ and}\\ \frac{S(\mu_A,\mu_B)-(\frac{1}{2}+\frac{1}{2n})}{1-(\frac{1}{2}+\frac{1}{2n})} &= \frac{0.948-0.514}{1-0.514}=0.893.\end{aligned}$$

We see that the similarity between μ_A and μ_B is very high.

Let A,B, and C be rankings of a set X. Suppose $S(\mu_A,\mu_C)$ and $S(\mu_A,\mu_B)$ are known. Then the inequalities in the following result provide a range of possible values for $S(\mu_B,\mu_C)$. For example, if $S(\mu_A,\mu_B)$ is very high, then $1-S(\mu_A\mu_B)$ is very small. The following result shows $S(\mu_B,\mu_C)$ is close to $S(\mu_A,\mu_C)$ as one would expect.

Proposition 3.5. *Let A,B, and C be rankings of a set X. Then $S(\mu_A,\mu_C)-(1-S(\mu_A,\mu_B))\le S(\mu_B,\mu_C)\le S(\mu_A,\mu_C)+(1-S(\mu_A,\mu_B))$.*

Proof. $|\mu_B(x)-\mu_C(x)|\le|\mu_B(x)-\mu_A(x)|+|\mu_A(x)-\mu_C(x)|$ and $|\mu_A(x)-\mu_C(x)|\le|\mu_A(x)-\mu_B(x)|+|\mu_B(x)-\mu_C(x)|$ and so $|\mu_A(x)-\mu_C(x)|-|\mu_A(x)-\mu_B(x)|\le|\mu_B(x)-\mu_C(x)|$. Thus

$$|\mu_A(x)-\mu_C(x)|-|\mu_A(x)-\mu_B(x)|\le|\mu_B(x)-\mu_C(x)|\le|\mu_B(x)-\mu_A(x)|+|\mu_A(x)-\mu_C(x)|.$$

Hence

$$\begin{aligned} & \sum_{x\in X} |\mu_A(x) - \mu_C(x)| - \sum_{x\in X} |\mu_A(x) - \mu_B(x)| \\ \leq & \sum_{x\in X} |\mu_B(x) - \mu_C(x)| \\ \leq & \sum_{x\in X} |\mu_B(x) - \mu_A(x)| + \sum_{x\in X} |\mu_A(x) - \mu_C(x)|. \end{aligned}$$

Thus

$$\begin{aligned} & \frac{\sum_{x\in X} |\mu_A(x) - \mu_C(x)|}{(n+1)n} - \frac{\sum_{x\in X} |\mu_A(x) - \mu_B(x)|}{(n+1)n} \\ \leq & \frac{\sum_{x\in X} |\mu_B(x) - \mu_C(x)|}{(n+1)n} \\ \leq & \frac{\sum_{x\in X} |\mu_B(x) - \mu_A(x)|}{(n+1)n} + \frac{\sum_{x\in X} |\mu_A(x) - \mu_C(x)|}{(n+1)n}. \end{aligned}$$

Hence

$$\begin{aligned} & -\frac{\sum_{x\in X} |\mu_A(x) - \mu_C(x)|}{(n+1)n} + \frac{\sum_{x\in X} |\mu_A(x) - \mu_B(x)|}{(n+1)n} \\ \geq & -\frac{\sum_{x\in X} |\mu_B(x) - \mu_C(x)|}{(n+1)n} \\ \geq & -\frac{\sum_{x\in X} |\mu_B(x) - \mu_A(x)|}{(n+1)n} - \frac{\sum_{x\in X} |\mu_A(x) - \mu_C(x)|}{(n+1)n}. \end{aligned}$$

Therefore,

$$\begin{aligned} & 1 - \frac{\sum_{x\in X} |\mu_A(x) - \mu_C(x)|}{(n+1)n} + \frac{\sum_{x\in X} |\mu_A(x) - \mu_B(x)|}{(n+1)n} \\ \geq & 1 - \frac{\sum_{x\in X} |\mu_B(x) - \mu_C(x)|}{(n+1)n} \\ \geq & -\frac{\sum_{x\in X} |\mu_B(x) - \mu_A(x)|}{(n+1)n} + 1 - \frac{\sum_{x\in X} |\mu_A(x) - \mu_C(x)|}{(n+1)n}. \end{aligned}$$

or

$$\begin{aligned} & S(\mu_A, \mu_C) + \frac{\sum_{x\in X} |\mu_A(x) - \mu_B(x)|}{(n+1)n} \\ \geq & S(\mu_B, \mu_C) \geq S(\mu_A, \mu_C) - \frac{\sum_{x\in X} |\mu_A(x) - \mu_B(x)|}{(n+1)n} \end{aligned}$$

That is,

$$S(\mu_A, \mu_C) + 1 - S(\mu_A, \mu_B) \geq S(\mu_B, \mu_C) \geq S(\mu_A, \mu_C) + S(\mu_A, \mu_B) - 1.$$

□

4. **Biodiversity and Habitat**

The Biodiversity and Habitat issue category assesses countries' actions toward retaining natural ecosystems and protecting the full range of biodiversity within their borders. It consists of seven indicators: terrestorial biome protection (weighted for national and global rarity of biomes), marine protected areas, Protected Areas Representativeness Index, Species Habitat Index, Species Protection Index, and Biodiversiy Index, [4].

In this section, we determine the similarity between the rankings determined by the weighted average values and the EPI scores are in the medium range.

Let X denote the set of 35 OECD countries. Let A be the ranking of X determined by the biodiversity weighted average and let B be the ranking of X using the EPI scores. Then $M(\mu_A, \mu_B) = \frac{503}{757} = 0.664$ and $S(\mu_A, \mu_B) = 1 - \frac{244}{1266} = 0.806$. Also,

$$\frac{M(\mu_A, \mu_B) - \frac{n+1}{3n-1}}{1 - \frac{3n+1}{sn-1}} = \frac{0.664 - 0.346}{1 - 0.346} = 0.486$$

and

$$\frac{S(\mu_A, \mu_B) - (\frac{1}{2} + \frac{1}{2n})}{1 - (\frac{1}{2} + \frac{1}{2n})} = \frac{0.806 - 0.514}{1 - 0.514} = 0.601.$$

In table 8, we see that the similarity between the rankings determined by the weighted average values and the EPI scores are in the medium range.

5. **Appendix**

Table 8. Aichi Targets

T_1 Awareness of biodiversity	T_2 Biodiversity values integrated
T_3 Incentives reformed	T_4 Sustainable production and consumption
T_5 Habitat loss halved or reduced	T_6 Sustainable management of aquatic living sources
T_7 Sustainable agriculture, aquaculture, and forestry	T_8 Pollution reduced
T_9 Invasive alien species prevented and controlled	T_{10} Ecosystems vulnerable to climate change
T_{11} Protected areas	T_{12} Reduced risk of extinction
T_{13} Safeguarding genetic diversity	T_{14} Ecosystem services
T_{15} Ecosystem restoration and resilience	T_{16} Access to and sharing benefits from genetic resources
T_{17} Biodiversity strategies and action plans	T_{18} Traditional knowledge
T_{19} Sharing information and knowledge	T_{20} Mobilizing resources from all sources

Table 8. EPI Scores

Country	EPI Score	Rank
Australia	60.10	15
Austria	66.50	7
Belgium	58.20	19
Canada	50.00	30
Chile	46.70	33
Czech Rep.	59.90	17
Denmark	77.90	1
Estonia	61.40	13
Finland	76.50	3
France	62.50	11
Germany	62.40	12
Greece	56.20	25
Hungary	55.10	26
Iceland	62.80	9
Ireland	57.40	21
Israel	48.20	31
Italy	57.70	20
Japan	57.20	22
Korea Rep.*	46.90	32
Latvia	61.10	14
Luxembourg	72.30	5
Mexico	45.50	34
Netherlands	62.60	10
New Zealand	56.70	23
Norway	59.30	18
Poland	50.60	28
Portugal	50.40	29
Slovak Rep.*	60.00	16
Slovenia	67.30	6
Spain	56.60	24
Sweden	72.70	4
Switzerland	65.90	8
Turkey	26.30	35
United Kingdom	77.70	2
United States	51.10	27

6. **Conclusion**

We determined how well OECD countries are achieving the Aichi targets. We used the Sustainable Development Goals to make the determination. The

Biodiversity and Habitat issue category assesses countries' actions toward retaining natural ecosystems and protecting the full range of biodiversity within their borders. We also determined the similarity between the rankings determined by the weighted average values and the Environmental Performance Index (EPI) scores.

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