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A Composite Indicator Approach for the Water, Energy, and Food Nexus in Asia: The WEF Nexus Index

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Abstract The analysis of the Water, Energy, and Food Nexus (WEF nexus) gained importance as another opportunity to integrate management of natural resources. The inherent links among the three resources in the WEF system would purport integrative thinking. Although, these links are intertwined in a complex way, still they can lead to identifying the possibilities of interpreting new trade-offs and synergies. The efforts in this direction are severely constrained by the lack of available data. In this vein, this study aims to apply a quantitative approach namely- a composite indicator for indicating integrated resources management. The Asian geography is chosen to conduct the analysis since Asia is geopolitically and economically important. Furthermore, we analysed India's progress in realising the integrated management of the resources in comparison to the highest and lowest seven countries' scores on the Index. In doing so, it provides an opportunity to prescribe policy directions to progress in terms of sustainable development, allocation and access to the natural resources, and environmental protection. Coming to the methodology, we used the composite indicators and the scoreboards 'COIN' tool developed by the Joint Research Centre: Competence Centre on Composite Indicators and Scoreboards, Ispra, Italy. A conceptual framework is developed to select indicators arising from the dimensions of people, governance, and environment without jeopardising the dimensions of sustainability. The data sources are secondary. The raw dataset went under a series of treatment procedures such as missing values imputation, dealing with outliers, normalisation, and aggregation. The results are visualised through radial diagrams.

Keywords WEF Nexus, SDGs, Distributive Justice, Composite Indicator

1. Introduction

Water, Energy, and Food Nexus (WEF nexus) refer to the inextricable interlinks that span the production and consumption of these three resources. The current lack of access to these resources concomitant with the future expected demands would exacerbate the resource scarcity [1]. Provision of security to the WEF nexus in the light of climate change, rapid population growth, a rise of the middle-income group people, changing lifestyles, and urbanisation is becoming increasingly a policy priority for the nations across the globe [2]. The rise of the WEF nexus approach started in 2008 with the emphasis laid by [3]. However, its popularity is attributed to the Bonn 2011 conference. On top of this, with the onset of Sustainable Development Goals (SDGs), it became inclusive of the global development agenda of 2030. Simply put, the WEF nexus is formed from the three interrelated SDGs namely- goals 6, 7 and 2 respectively. Despite increased attention, the WEF nexus is also not immune to its critique. [4]

argued that the WEF nexus means different things to different people. This stems from the use of imprecise terminology. While [5] describe it as a buzzword. Besides, conceptual inadequacies, the WEF nexus has also been fraught with operational and financial challenges [6]. For instance, the WEF nexus is inconclusive about the scale of operation as opposed to Integrated Water Resources Management (IWRM) [7] and lack of data availability [8]. Against this backdrop, this study aims to pursue the WEF nexus as a paradigm to infer the progress towards integrated resources management, sustainable development, and equitable access. Following this introduction, this paper sets out Material and Methods in section 2, section 3 will discuss the processes embraced in constructing the index, section 4 spans over the results, section 5 outlines the limitations of the study and finally, section 6 concludes the study.

2. Material and Methods

The methodology utilised for this study is designed by the Joint Research Centre's Competence Centre on Composite Indicators and Scoreboards (JRC: COIN), Ispra, Italy. It has been widely used for building composite indicators in various fields across the globe. Composite indicators are a useful way of summarising the multi-dimensional data to a single measure without losing much information [9]. However, its construction must be dealt with the great care in that it must have a framework to guide the further processes involved. The framework acts as a precursor to guide the selection of indicators that are annexed to the composite indicator. It is the heart and soul of the context being assessed and measured. The framework resorted to in this study is presented in the following Figure 1.

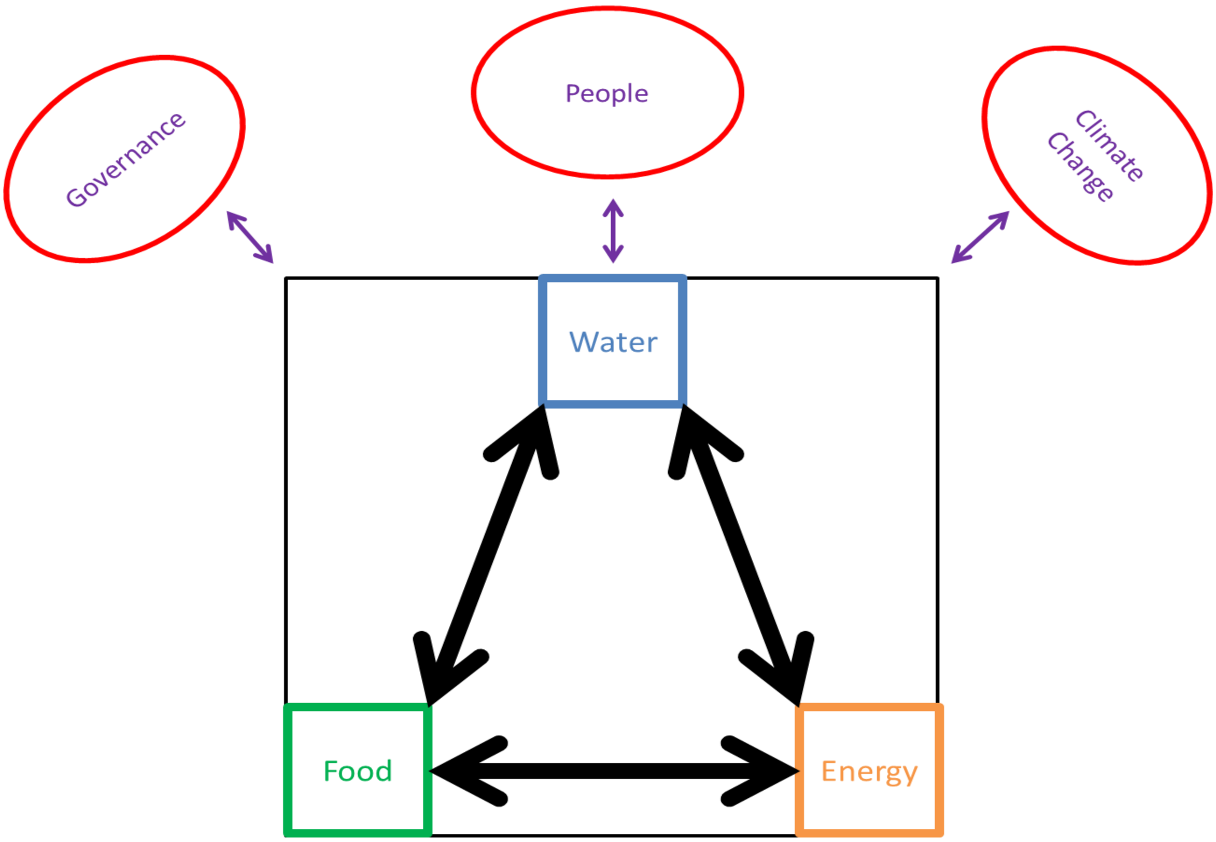

Figure 1. Conceptual framework of the study

The framework conveys that the three resources i.e., water, energy, and food are bidirectionally linked. These interlinks are further impacted by the factors such as governance, people, and climate change. The allocation and access to the WEF nexus by the people depends on how they are governed, extracted from and contributed to the environment [10]. Considering the inequity in the access to the WEF nexus globally, we tried to integrate the framework within the context of sustainable development. The SDGs aim for universal access to these three resources without jeopardising the environment. Building on this framework, the constituents of the proposed WEF nexus index are the three equal pillars representing Water, Energy, and Food pillars; each pillar is further bifurcated into two components representing its availability and access. Thus, we have a total of six sub-pillars. Availability and access dimensions are considered because they are key dimensions of the security concept related to any single resource. The indicators chosen for this study reflect the availability and access dimensions of the water, energy, and food. The meaning of access is confined to the minimum requirements of the people in tandem with the Rawlsian distributional justice. The further logic follows that the chosen indicators are aggregated to the respective sub-pillars. Coming to the selection of the indicators and their respective weights, we adopted them from the earlier study done by [11]. Among 87 globally applicable indicators to water, energy, and food sectors, 21 were selected for forming the WEF nexus Index. The above-described mechanism can be found in the following Table 1 in appendix A.

The data sources used in this study are secondary. The major sources from which the data is taken include World Bank development indicators, the Food and agriculture organisation of the United Nations (FAO) and the United Nations Environment Programme (UNEP). We then move to the description of the tool used for this study namely COIN. The COIN tool is a free Microsoft Excel-based tool designed to help users from research institutions, international organisations, European Union Institutions, national and local governments, among others, in the process of building and analysing composite indicators. It was developed by European Commission's Competence Centre on Composite Indicators and Scoreboards (COIN), at the Joint Centre, Ispra, Italy [12].

3. Discussion

As mentioned earlier, building a composite indicator involves a series of steps, this section dwells on them. After obtaining the raw data over the relevant and available indicators, we check it for the missing data values. Missing data values are handled through mean imputation i.e., substituting the missing values with the normalised mean of the other indicators in the aggregation group. The next step involves the Outlier treatment. The presence of outliers in the data generally distorts the descriptive summary statistics of the data such as mean, standard deviation and the correlation coefficients which may lead to wrongful conclusions. The COIN tool addresses this problem via a process of either winsorisation (if the number of outliers is five or fewer) or a Box-Cox transformation (if the number of outliers exceeds five) in the indicators dataset to bring the skewness and kurtosis to generally accepted levels i.e., |<2| and |<3.5| respectively [12]. Commonly, the selected indicators are measured in different units. To convert all the indicators data into a unitless value, we preferred the min-max method of normalisation. This method is widely applicable in the field of composite indicators. Through this method, the indicators data is brought on a [0:100] scale before compiling to the composite indicator. The next step involved the scheme of weighting the indicators and up to the aggregation levels till forming the index. The WEF nexus is conceived by many as either water-centric or energy as a cross-cutting theme; we deviated from such view by embracing the equal weights to the three pillars namely – water, energy and food pillars suggesting that all the resources are given equal importance. However, the weights and directions at the indicator level vary and are adopted from [11]. The final step involves the aggregation method. The aggregation method followed in this study is the weighted arithmetic mean irrespective of the aggregation level. Though the weighted arithmetic mean method is known for its limitation of being compensatory i.e., high score on one indicator can compensate the low score on another, still it is easier to understand and widely used.

4. Results

The results of the study are discussed under two subheads. One is the chosen Asian geography and another for India in particular. In Asia, the performance of 47 countries is assessed through the proposed WEF nexus index. The results suggest that among the highest-scoring seven countries, no individual country performs better in all three sectors than others. However, seen from an integrated resource management perspective i.e., the overall performance across three sectors reflected by the WEF nexus index reveals that in Asia, the highest-scoring seven countries are Bhutan, Laos, Brunei Darussalam, China, Malaysia, South Korea, and Kuwait. While the lowest-scoring countries are Bahrain, North Korea, Iraq, Lebanon, Syria, Pakistan, and Yemen. The visualisation through radar charts is shown below as Figures 2 and 3.

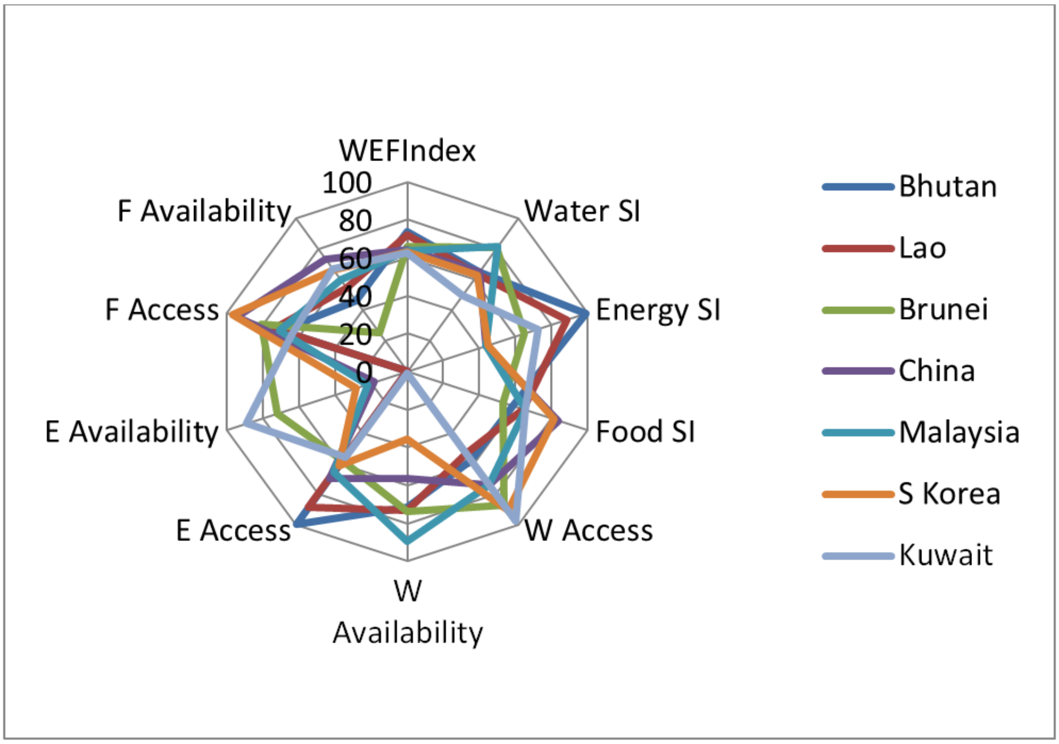

Figure 2. Showing highest scoring 7 countries

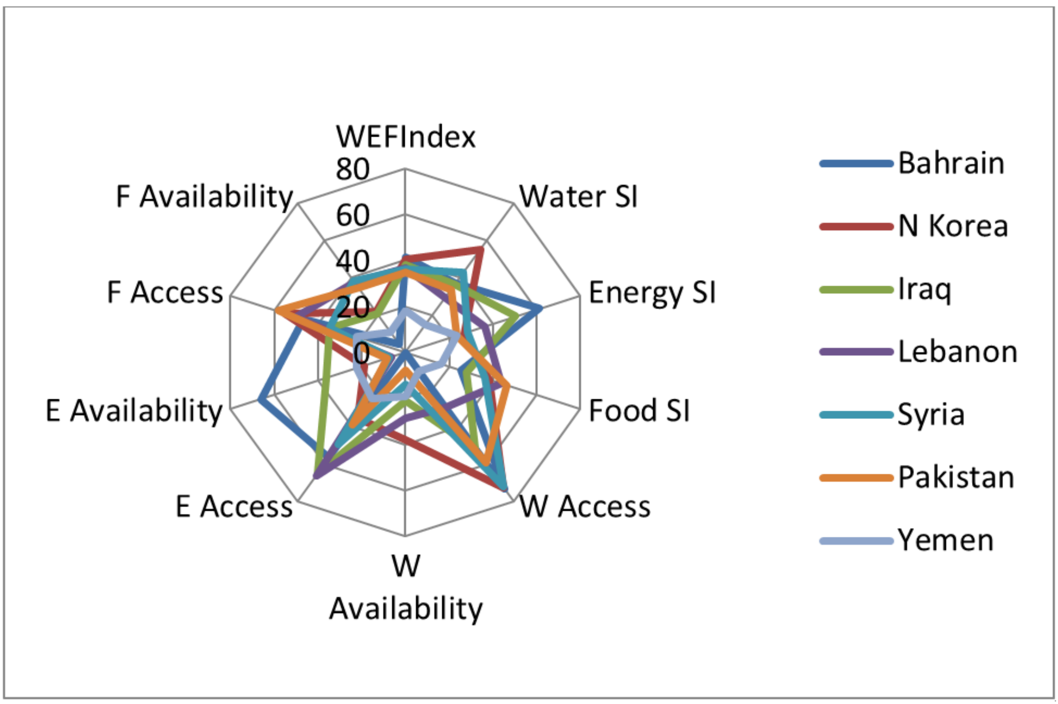

Figure 3. Showing low scoring seven countries

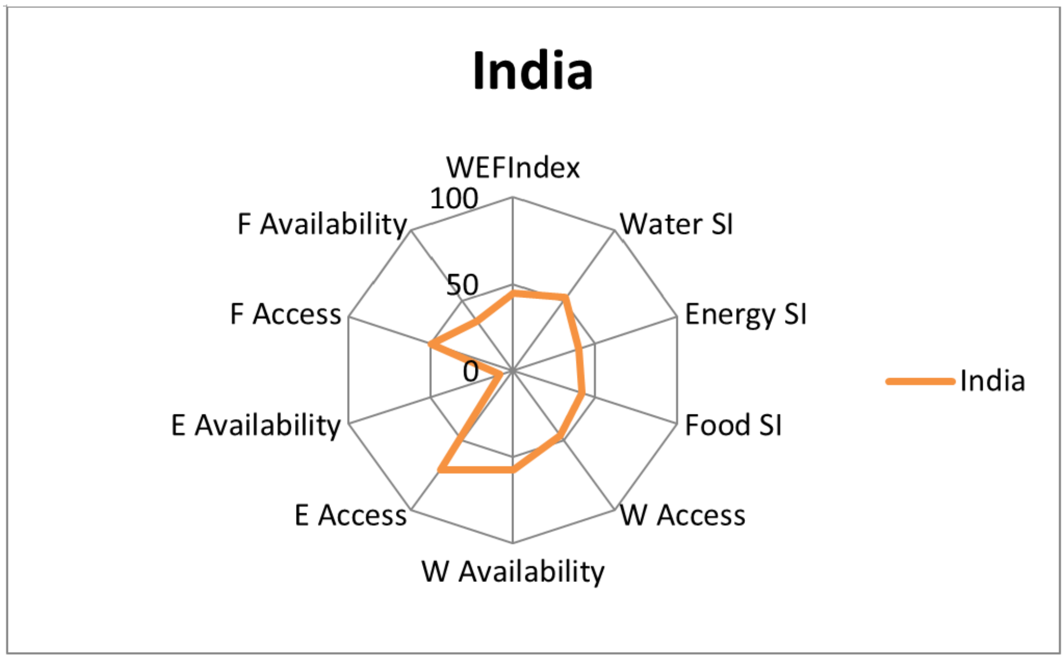

Figure 4. WEF index for India

Similarly, the scores of all the countries in Asia are presented in the heat map form provided in the appendix. The WEF nexus Index is useful for assessing the performance of the countries concerning integrated resource management but not to be conceived as a tool for positing determinants of WEF security. It depicts the level of security in the WEF nexus. For instance, Kuwait shares a similar kind of dry geography with the several lowest countries such as Iraq and Yemen but in contrast, Kuwait is enlisted among the highest-scoring countries in Asia. In sum, determinants of access and availability depend on several other factors over which the specific study may focus. However, it is beyond the scope of this study. Coming to the Indian context, it is the second most populous and expected to become most populous in near future, one of the biggest and largest economies of the world [13]. Its overall level of sustainable development and WEF security pose significant implications for the world economy. India secures a rank of 38 among the 47 countries assessed. Among its neighbours, only Pakistan leaves behind. India is a lower-middle-income country whose WEF security is facing myriad challenges. Its overall score on the WEF nexus index is 44.66. Its pillar scores namely- the water sub-index, the energy sub-index and the food sub-index hop at 52, 39.77 and 42.20 respectively. Following this are the scores attained by the six sub-pillars i.e., Water access, Water availability, Energy access, Energy availability, Food access and food availability. Their scores are 46.63, 57.38, 71.42, 8.13, 49.49 and 34.90 respectively. These results can be best viewed from the above radar chart Figure 4.

One key thing to be observed from the countries analysed in this study is the discrepancy between availability of and access to water, energy, and food resources. The literature establishes that availability is a precondition on which accessibility rests. The discrepancies may be altered through trade and technological solutions. It is easier to find scoring aspects for any country and emphasis can be laid on the sub pillars/pillars/indicators on which WEF Index score depends. Policies can better be framed for those which show a low score. In India, for the energy and food sectors, access dimensions are better compared to the availability. However, water access is less in comparison to availability. This suggests the need to enhance the access to Water, Sanitation and Hygiene (WASH) facilities. To delve deeper into, the three indicators that went into the calculation of water access sub-pillar indicates that people who have access to basic drinking water services perform relatively better, but the access sub-pillar is hurt by those whose sanitation services are not met. The third indicator is related to the governance of water resources i.e., the degree of IWRM implementation. The global dataset on this indicator shows it as 45, while [14] mentions that implementation of IWRM across the globe is unsatisfactory let alone India. Further, much research on the WEF nexus in India went in this direction. Succinctly put, much research on the WEF nexus highlighted India's groundwater problem. Groundwater abstraction requires more energy compared to the withdrawal of surface water [15] hence Irrigated area from groundwater is significantly correlated with the electricity consumed by food [16]. From an institutional perspective, decentralised governance within the IWRM i.e. Water Users Associations (WUAs) can be tried as a synergy [17]. From a legislative perspective, to address the groundwater conundrum, [18] expounds that delinking the water rights from the land rights is the key. Whilst from an economic point of view, the WEF nexus described in this manner puts Punjab state farmers in perplexing state [19]. From a technological perspective, the global solution towards it is the use of solar irrigated pumps which is decentralised [20] and renewable energy-based [21]. Whatsoever, the global paradigm percolated to the Indian policy sphere that made India tackle this problem via executive policy namely KUSUM (Kisan Urja Suraksha evam Utthan Mahabhiyan). KUSUM aims to support the installation of (i) stand-alone off-grid solar pumps to replace existing diesel pumps; (ii) decentralized ground or stilt-mounted, grid-connected solar power plants (~0.5–2.0 MW) by individual or group farmers, WUAs, cooperatives or *panchayats* (Local Self Governments) based on expressions of interest issued by distribution companies (DISCOMs) and available sub-station surplus capacity; and (iii) “solarizing” existing grid-connected pumps by outfitting them with solar panels, and allowing owners to sell excess electricity back to DISCOMs [22]. However, it may exhibit the ‘rebound effect’ in India [23]. Hence for effective resources management, integrated thinking would seek coordination from the technological, institutional, policy and business arenas.

5. Limitations of the Study

The study proceeded in the above manner does not reflect the trade-offs and synergies as intended by the vast and basic literature on the WEF nexus paradigm. The major barrier towards it is the lack of data availability on the interactions between the sectors. However, the approach envisaged in this study contributes to informing the national progress towards encapsulating the integrated nature of these three resources, equitable access to the WEF nexus and policy prescriptions for sustainable development of the nation of interest.

6. Conclusions

The WEF nexus is at the core of sustainable development. Since all these are quintessential for human survival, human security in procuring these is fundamental for the progress of any nation without jeopardising the environment. However, given the inequalities in accessing them globally, concomitant with their challenges in the face of population growth, climate change, rapid urbanisation and changing lifestyles, there may be a need to manage these three resources sustainably. To this end, this study attempted to assess the security level in the countries of Asia while incorporating the access and availability of each resource in connection with the environment too. The WEF nexus index adhered to in this study provides a nation’s level of integrated resources management. Due to the inherent links among these three resources in the production, the same cannot be concluded from the consumption point of view because the results show that having access to any one of the resources in the WEF nexus does not necessarily translate into having the access to the other two resources in the WEF nexus. Though availability may be a precondition on which the access rests but given the availability of the resources to turn it into access and security, it needs interventions from institutional, technological, policy, and business spheres. Data availability on the key interactions is necessary to convey trade-offs and synergies but is limited. Further research into these interlinks is demanding. Technology that harnesses renewable resources (solar energy in case of pumping groundwater for irrigation and electricity access for domestic purposes), promotes use efficiency in resources (drip irrigation and sprinkler irrigation) and circular economy (reducing food waste is the prime option but even if wasted bring it back into the system through the process of anaerobic digestion), are the potential solutions suggested in the WEF nexus literature so far. Institutions that regulate the overuse of conventional resources are inevitable for the effective and sustainable management of the WEF nexus and to reduce the rebound effects of the technology deployed. Ostensibly, all these may look like panaceas but must be dealt with necessary and sufficient conditions that ensure the access, availability, affordability dimensions of the security. Governance and policy towards sustainable development also need to be incorporated into the analysis. IWRM complements the WEF nexus; hence it is also to be seen as an integral part of the WEF nexus.

APPENDIX

The Raw Data set used for constructing the Index.

UnitName	UnitCode	ind.01	ind.02	ind.03	ind.04	ind.05	ind.06	ind.07	ind.08	ind.09	ind.10	ind.11	ind.12	ind.13	ind.14	ind.15	ind.16	ind.17	ind.18	ind.19	ind.20	ind.21
Afghanistan	AFG	75.1	50.5	12	43	1299	28.3	327	97.7	21.4	86	0.2	n/a	n/a	25.6	5.1	38.2	5.5	55.7	2164.9	106	33
Armenia	ARM	100	69.3	52	41.8	2329	2.8	562	100	11.1	28.3	1.9	1962	71	3.4	4.4	9.4	20.2	96	2623.6	124	134
Azerbaijan	AZE	96	21	57	157.5	824	12	447	100	2	7	3.22	2202	-310	2.5	3.2	17.8	19.9	92	3013.7	131	90
Bahrain	BHR	100	91.2	39	3877.5	3	n/a	83	100	0	0	19.6	19597	-62	n/a	6.6	13.6	29.8	n/a	n/a	n/a	9
Bangladesh	BGD	97.7	38.7	58	34.2	658	600.3	2666	92.2	30.7	1.2	0.5	320	17	9.7	9.8	28	3.6	59.7	4790.7	114	47
Bhutan	BTN	97.3	65.2	33	0.4	104619	54.1	2200	100	81	100	1.8	n/a	n/a	n/a	5.9	33.5	6.4	n/a	3466.9	n/a	93
Brunei Darussalam	BRN	100	96.3	70	1.1	20024	5.8	2722	100	0	0	16.6	10291	-357	2.5	2.9	19.7	14.1	30.6	2004	129	38
Cambodia	KHM	71.2	68.8	59	1.8	7533	265.4	1904	93	64.9	46.4	0.7	271	33	6.2	9.7	32.4	3.9	65.3	3623.5	120	94
China	CHN	94.3	69.7	80	21	2029	1471	645	100	13.1	23.9	7.4	3905	15	2.5	1.9	4.8	6.2	100.6	6081.4	137	127
Cyprus	CYP	99.8	77.1	93	27.7	661	0	498	100	12.1	8.8	6	3625	94	2.5	0.8	2.6	21.8	91.7	1955.3	120	87
Georgia	GEO	97.4	34.4	44	3.1	15593	32.63	1026	100	27.9	78	2.5	2694	69	8.7	0.6	5.8	21.7	75	2536.4	116	52
India	IND	90.5	45.9	45	44.8	1080	937.1	1083	97.8	31.7	15.3	1.8	805	34	15.3	17.3	34.7	3.9	62.3	3247.9	112	61
Indonesia	IDN	92.4	86.4	66	11	7629	1269	2702	98.8	20.9	10.6	2.2	812	-103	6.5	10.2	30.8	6.9	66.7	5226.7	126	80
Iran	IRN	97.5	90.2	40	72.3	1593	22.7	228	100	1	5.1	7.7	3022	-33	5.5	4	6.8	25.8	85.3	2298.8	127	104
Iraq	IRQ	98.4	42.9	38	109.5	937	18.66	216	100	0.5	3.7	4.9	1328	-229	37.5	3	12.6	30.4	64	2574.2	98	14
Israel	ISR	100	95	85	159.7	86	0.6	435	100	3.7	1.9	6.7	6601	67	2.5	0.8	2.6	26.1	125	3035.4	154	112
Japan	JPN	99.1	81.4	95	18.9	3391	212.5	1668	100	7.3	16	8.7	7820	94	2.5	2.3	7.1	4.3	86	5918.8	113	43
Jordan	JOR	98.9	82.3	64	132.5	70	0	111	100	7.2	1	2.5	1865	97	9.5	2.4	7.8	35.5	70	1506.4	116	48
Kazakhstan	KAZ	95.4	97.9	46	34.9	3567	36.3	250	100	1.9	8.9	12	5600	-117	2.5	3.1	8	21	91	1359.4	134	150
Kuwait	KWT	100	100	94	n/a	3	n/a	121	100	0	0	21.6	15591	-391	2.5	2.5	6.4	37.9	100.7	10482.2	140	29
Kyrgyzstan	KYR	91.7	92.5	31	15.8	7894	8.2	533	99.9	23.2	85.2	1.7	1941	50	7.2	2	11.8	16.6	83.3	3162.6	118	90
Laos	LAO	85.2	61.4	62	3.8	27384	180	1834	100	41.9	86.4	2.7	n/a	n/a	5.3	9	33.1	5.3	76.3	4504.2	119	120
Lebanon	LBN	92.6	16.3	25	37.8	704	1.4	661	100	4.7	2.6	4	2589	98	9.3	6.6	16.5	32	69.3	3155.6	119	52
Malaysia	MYS	97.1	77.5	63	1.2	18647	385	2875	100	5.3	10	7.6	4652	-6	3.2	9.7	21.8	15.6	77.3	4128	120	156
Maldives	MDL	99.5	99.2	42	15.7	60	n/a	1972	100	1.1	1.3	3.7	n/a	n/a	n/a	9.1	15.3	8.6	85.5	2661.7	90	5
Mongolia	MNG	85.5	55.5	45	1.3	11176	21.2	241	99.1	3.3	3.1	6.7	2006	-168	4.3	0.9	9.4	20.6	85	1236.3	125	103
Myanmar	MYN	83.7	60.7	33	3.3	18789	595	2091	68.3	60.1	58.9	0.6	215	-33	7.6	6.7	26.7	5.8	89.7	3604.5	123	107
Nepal	NPL	90.1	48.6	37	4.8	7173	95.9	1500	89.9	75	100	0.4	147	17	4.8	12	31.5	4.1	73	2896	128	71
North Korea	PRK	93.8	84.7	63	12.9	2635	45.9	1054	49.3	33.7	72.8	0.7	602	-75	42.4	2.5	19.1	6.7	53	3564.3	86	46
Oman	OMN	92.2	99.3	79	116.7	300	n/a	125	100	0	0	15.2	6446	-206	8.2	9.3	11.4	27	84.4	13350.5	117	35
Pakistan	PAK	90.2	68.3	56	363.6	264	83.79	494	74	41.7	31.4	1	448	24	13	7.1	37.6	8.6	65.7	3124.4	111	59
Philippines	PHL	94.1	60.7	56	19.4	4554	0.1	2348	95.6	23.2	25.4	1.3	696	46	9.4	5.6	30.3	6.4	62	3670.5	123	62
Qatar	QAT	99.6	97.2	81	447.9	21	151.9	74	100	0	0	32.4	14782	-399	n/a	0.8	2.6	35.1	n/a	8709.4	139	8
Saudi Arabia	SAU	100	59.1	57	883.3	72	n/a	59	100	0	0	15.3	9402	-192	3.9	11.8	9.3	35.4	88.3	5608.3	136	34
Singapore	SGP	100	100	100	82	107	n/a	2497	100	0.7	1.8	8.4	8845	98	n/a	3.6	4.4	6.1	n/a	n/a	n/a	2
South Korea	KOR	99.4	99.9	76	45	1263	35.4	1274	100	3.2	1.9	12.2	10497	82	2.5	1.2	2.5	4.7	98	6585	141	66
Srilanka	LKA	92.2	93.7	47	24.5	2462	38.5	1712	95.6	53	48.5	1	531	50	6.8	15.1	17.3	5.2	64.3	3761.6	120	40
Syria	SYR	93.9	89.7	56	195.8	417	5.6	252	89.3	0.9	2.3	1.6	975	48	n/a	11.5	27.9	27.8	n/a	1204.7	117	103
Tajikistan	TJK	81.9	96.8	46	16.4	7146	6.7	691	99.6	39.5	98.5	0.8	1500	36	n/a	5.6	17.5	14.2	53.3	3404.6	99	46
Thailand	THA	100	25.9	53	25.5	3244	189.6	1622	99.9	23.7	8.5	3.7	2539	42	8.2	7.7	13.4	10	62.3	3198.2	115	122
Timor Leste	TLS	85.5	56.8	14	14.2	6608	4	1500	94.7	18.4	0	0.5	n/a	n/a	22.6	9.9	51.7	3.8	58	2555.2	106	31
Turkey	TUR	97	78.4	72	26.4	2798	77	593	100	11.9	32	5	2847	74	2.5	1.7	6	32.1	109.3	3163.9	156	159
Turkmenistan	TKM	100	99.4	64	1983.3	244	5.3	161	99.9	0	0	12.3	2679	-192	4.1	4.1	7.2	18.6	89.3	1068.7	123	105
UAE	ARE	100	99.2	79	1708	16	n/a	78	100	0.2	0.2	20.8	11088	-184	3.7	0.8	2.6	31.7	111.7	27582.1	124	23
Uzbekistan	UZB	97.8	100	48	360.5	504	14	206	100	1.5	20.7	3.4	1645	-26	2.5	1.8	10.8	16.6	93.3	4055.9	136	105
Vietnam	VNM	96.9	89.2	52	22.8	3800	432.6	1821	99.4	23.5	36.7	2.7	1424	-15	6.7	5.8	23.8	2.1	96	5685.4	127	99
Yemen	YMN	60.7	18.8	36	169.8	75	n/a	167	72.8	4.2	0	0.3	220	-121	45.4	16.4	46.4	17.1	52	759.2	92	21

The Heat map of Scores

Rank	Unit	WEF Index	WEF Index	Water SI	Energy SI	Food SI	W Access	W Availability	E Access	E Availability	F Access	F Availability
1	BTN	73.92	73.92	64.45	99.17	58.15	57.64	71.26	99.17	n/a	70.28	46.01
2	LAO	71.82	71.82	63.06	88.38	64.03	53.10	73.02	88.38	n/a	73.60	54.45
3	BRN	66.11	66.11	80.50	64.99	52.85	87.16	73.84	58.14	71.85	80.70	25.00
4	CHN	64.20	64.20	65.04	43.80	83.75	73.76	56.31	69.59	18.01	94.11	73.39
5	MYS	63.46	63.46	81.46	43.80	65.13	73.67	89.26	65.56	22.04	70.63	59.63
6	KOR	63.09	63.09	62.97	44.80	81.49	90.17	35.76	61.39	28.22	96.98	66.00
7	KWT	62.32	62.32	49.41	72.22	65.31	97.73	1.10	55.55	88.90	63.48	67.15
8	VNM	61.55	61.55	67.89	45.00	71.76	73.93	61.86	75.36	14.65	80.61	62.90
9	JPN	61.51	61.51	70.37	43.26	70.88	89.66	51.09	66.40	20.13	94.69	47.07
10	IDN	61.15	61.15	77.58	45.86	60.01	72.91	82.26	69.78	21.93	69.70	50.31
11	MDL	59.41	59.41	65.90	65.26	47.05	77.13	54.67	65.26	n/a	71.68	22.43
12	QAT	58.13	58.13	48.85	68.79	56.74	91.22	6.48	49.95	87.62	53.63	59.85
13	ISR	57.55	57.55	54.91	42.03	75.70	92.33	17.50	64.34	19.71	77.44	73.96
14	TUR	56.91	56.91	55.98	40.65	74.11	77.32	34.65	71.94	9.36	69.81	78.40
15	KAZ	56.39	56.39	51.83	49.02	68.32	73.39	30.28	62.40	35.65	78.05	58.59
16	ARE	56.36	56.36	45.99	56.27	66.82	91.73	0.25	56.03	56.50	70.25	63.39
17	SGP	54.84	54.84	77.44	42.59	44.48	100.00	54.88	62.83	22.36	88.96	-
18	OMN	53.93	53.93	53.34	52.82	55.62	82.74	23.94	58.86	46.78	55.67	55.57
19	CYP	53.31	53.31	57.92	38.47	63.53	88.00	27.84	67.59	9.34	81.44	45.62
20	KYR	52.48	52.48	49.81	47.07	60.56	61.27	38.34	84.69	9.44	74.17	46.96
21	ARM	52.11	52.11	49.61	40.07	66.65	69.59	29.64	72.76	7.38	75.53	57.77
22	MYN	51.92	51.92	65.59	26.02	64.16	40.10	91.08	38.68	13.35	73.79	54.53
23	UZB	51.55	51.55	40.24	42.53	71.86	77.76	2.73	68.74	16.33	82.50	61.23
24	AZE	51.47	51.47	33.39	56.49	64.54	47.62	19.16	66.65	46.33	75.65	53.43

Table Continued

25	TKM	51.08	51.08	43.78	47.95	61.52	86.12	1.43	60.21	35.68	76.91	46.13
26	BGD	50.72	50.72	64.33	34.65	53.19	57.02	71.64	60.71	8.59	68.82	37.55
27	GEO	50.66	50.66	51.94	46.83	53.20	49.65	54.22	84.20	9.47	70.38	36.02
28	MNG	50.62	50.62	43.03	47.29	61.54	44.66	41.39	63.04	31.54	77.17	45.92
29	NPL	50.43	50.43	47.32	45.45	58.51	44.21	50.44	82.75	8.15	73.09	43.94
30	THA	50.41	50.41	50.89	41.37	58.97	52.69	49.09	70.96	11.78	72.41	45.53
31	LKA	50.37	50.37	55.54	42.05	53.51	68.39	42.69	78.29	5.82	70.47	36.56
32	KHM	50.28	50.28	50.22	41.66	58.97	38.71	61.74	76.45	6.86	72.95	44.99
33	IRN	49.61	49.61	47.48	42.19	59.17	70.48	24.48	63.80	20.57	68.13	50.21
34	PHL	49.29	49.29	55.28	37.39	55.19	60.85	49.70	68.15	6.64	70.13	40.24
35	TJK	48.33	48.33	48.01	49.99	46.99	57.32	38.71	90.26	9.72	68.00	25.98
36	SAU	47.67	47.67	33.77	55.89	53.34	67.42	0.11	58.81	52.97	53.20	53.48
37	AFG	46.50	46.50	22.69	81.76	35.03	18.13	27.24	81.76	n/a	46.92	23.15
38	IND	44.66	44.66	52.00	39.77	42.20	46.63	57.38	71.42	8.13	49.49	34.90
39	TLS	44.39	44.39	39.35	61.92	31.89	33.44	45.26	61.92	n/a	39.12	24.66
40	JOR	41.78	41.78	47.25	35.80	42.28	78.04	16.45	67.09	4.52	53.74	30.82
41	BHR	41.26	41.26	36.84	61.34	25.59	73.39	0.28	56.58	66.10	46.73	4.46
42	PRK	40.27	40.27	55.44	27.04	38.32	72.72	38.17	35.51	18.57	54.89	21.76
43	IRQ	38.15	38.15	36.38	50.43	27.65	51.92	20.83	64.92	35.93	34.55	20.75
44	LBN	36.41	36.41	29.20	36.17	43.85	29.69	28.70	66.07	6.28	50.17	37.53
45	SYR	35.99	35.99	43.09	28.39	36.48	72.17	14.01	49.62	7.16	34.89	38.07
46	PAK	34.54	34.54	33.52	23.65	46.44	59.37	7.68	39.08	8.22	58.14	34.74
47	YMN	18.16	18.16	14.64	23.40	16.44	10.09	19.18	24.59	22.22	22.05	10.84

Appendix A

Table 1. The description of components used in constructing the WEF nexus Index.

Item	Dimension/indicator	Supra-dimension	Weight	Aggregation	Direction	Name of dimension/indicator
Index	Index		1	Arithmetic	1	WEF Nexus Index
Sub-indices	si.01	Index	1	Arithmetic	1	WEF Nexus Index
Pillars	p.01	si.01	0.333	Arithmetic	1	Water Sub-Index
	p.02	si.01	0.333	Arithmetic	1	Energy Sub-Index
	p.03	si.01	0.333	Arithmetic	1	Food Sub-Index
Sub-pillars	sp.01	p.01	0.5	Arithmetic	1	Water Access
	sp.02	p.01	0.5	Arithmetic	1	Water Availability
	sp.03	p.02	0.5	Arithmetic	1	Energy Access
	sp.04	p.02	0.5	Arithmetic	1	Energy Availability
	sp.05	p.03	0.5	Arithmetic	1	Food Access
	sp.06	p.03	0.5	Arithmetic	1	Food Availability
Indicators	ind.01	sp.01	0.333	Arithmetic	1	The percentage of people using at least basic drinking water services
	ind.02	sp.01	0.333	Arithmetic	1	The percentage of people using safely managed sanitation services
	ind.03	sp.01	0.333	Arithmetic	1	Degree of IWRM implementation (1-100)
	ind.04	sp.02	0.25	Arithmetic	-1	Annual freshwater withdrawals, total (% of internal resources)
	ind.05	sp.02	0.25	Arithmetic	1	Renewable internal freshwater resources per capita (cubic meters)
	ind.06	sp.02	0.25	Arithmetic	1	Environmental flow requirements (10^9 m^3/annum)
	ind.07	sp.02	0.25	Arithmetic	1	Average precipitation in depth (mm per year)
	ind.08	sp.03	0.5	Arithmetic	1	Access to electricity (% of the population)
	ind.09	sp.03	0.167	Arithmetic	1	Renewable energy consumption (% of total final energy consumption)
	ind.10	sp.03	0.167	Arithmetic	1	Renewable electricity output (% of total electricity output)
	ind.11	sp.03	0.167	Arithmetic	-1	CO2 emissions (metric tons per capita)
	ind.12	sp.04	0.5	Arithmetic	1	Electric power consumption (KWh per capita)
	ind.13	sp.04	0.5	Arithmetic	-1	Energy imports, net (% of energy use)
	ind.14	sp.05	0.333	Arithmetic	-1	Prevalence of undernourishment (%)
	ind.15	sp.05	0.167	Arithmetic	-1	Percentage of children under 5 years of age affected by wasting
	ind.16	sp.05	0.167	Arithmetic	-1	Percentage of children under 5 years of age affected by stunting
	ind.17	sp.05	0.333	Arithmetic	-1	Prevalence of obesity in the adult population (18 years and older)
	ind.18	sp.06	0.25	Arithmetic	1	Average protein supply (gr/capita/day)
	ind.19	sp.06	0.25	Arithmetic	1	Cereal yield (Kg per hectare)
	ind.20	sp.06	0.25	Arithmetic	1	Average Dietary Energy Supply Adequacy (ADESA in %)
	ind.21	sp.06	0.25	Arithmetic	1	The average value of food production (I$ per capita)

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