



Sustainable Development Goals: A cluster analysis of worldwide countries

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Abstract

In 2015, the United Nations introduced the 2030 Agenda, which sets out Sustainable Development Goals (SDGs) for building a sustainable future. The main objective of this study is to classify worldwide countries in terms of Sustainable Development Goals progress in order to understand key implementation challenges, define the gaps between countries and identify priorities for action. 110 countries were included in the analysis. The SDG progress data used in the data analysis phase were gathered from the Sustainable Development Report 2019. To classify countries, the K-Means method, which is a non-hierarchical cluster analysis technique, was used. After constructing homogeneous groups of countries, each cluster was examined based on the socioeconomic and politico-cultural structure of the countries. The results of the cluster analysis show that the countries can be classified into 5 clusters. The countries in each cluster have substantially similar characteristics, not only in terms of progress on the SDGs, but also in terms of socioeconomic and politico-cultural structure. In general, the clusters with a more advanced socioeconomic structure and a better politico-cultural structure tend to have superior SDGs progress. Socioeconomic and politico-cultural indicators are positively related to most of the SDGs indices. This study provides crucial guidance to identify each country's achievements, challenges, needs, strengths and weaknesses in terms of progress on the SDGs. In addition, the empirical results of the study also show the importance of the superior socioeconomic and politico-cultural structure in reaching SDGs.

Keywords Sustainable development · Sustainable Development Goals · Cluster analysis · Socioeconomic structure · Politico-cultural structure

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1 Introduction

There have been some calls and warnings from scientists with broad participation to humanity to conserve nature and ensure sustainable life on Earth (Ripple et al., 2017, 2020; Union of Concerned Scientists, 1992). These calls and warnings urge humanity to make fundamental changes and take urgent actions to avoid harming nature. Therefore, while maintaining economic development, nations should avoid harming the environment and develop strategies for sustainable development. The urgency of sustainable development is growing day by day for the entire world (Sachs, 2012). Some international organizations like European Union and United Nations (UN) have been taking actions to ensure sustainable development of nations. Within the scope of Europe 2020 strategies, European Commission has identified three main growth priorities, one of which is "Sustainable growth-promoting a more resource efficient, greener and more competitive economy" (European Commission, 2010). A broader action was taken by the United Nations (UN). The UN set Millennium Development Goals (MDGs) in 2000 and expanded these goals as Sustainable Development Goals (SDGs) in 2015. The SDGs are considered to be the most comprehensive action for nations to achieve sustainable development. These goals are also financially supported by The World Bank Group (2017) and International Monetary Fund (IMF, 2020). In September 2015, the UN adopted 17 SDGs as core components of the 2030 Agenda for Sustainable Development. These SDGs are expanded versions of the MDGs, which expired at the end of 2015. By adopting the SDGs, all members of the UN agreed to take action to build a sustainable future including all three dimensions of sustainable development: environmental, social and economic development (United Nations, 2015).

Each country has different characteristics and needs (Jabbari et al., 2019) and faces specific challenges in implementing the SDGs (Sarvajayakesavalu, 2015). Monitoring the progress of nations toward the SDGs is a crucial process to identify each country's achievements, needs, strengths and weaknesses. Progress monitoring has the ability to provide guidance for policymaking. To this end, the United Nations (2016, 2017, 2018, 2019, 2020) and the European Commission (2017, 2018, 2019, 2020) have published several reports on the implementation and monitoring of progress on the SDGs. In addition, Sustainable Development Solutions Network (SDSN) and Bertelsmann Stiftung created Sustainable Development Index and Dashboard for measuring the progress of the countries based on the SDGs (Sachs et al., 2019a).

Prioritizing the SDGs and related targets based on national circumstances is very critical for countries (Allen et al., 2018). Prioritization of the SDGs can be done by identifying country-specific levels of progress and country-specific qualities and needs. From this perspective, this study aims to classify countries based on their SDGs progress in order to understand the key implementation challenges, define the gaps between countries and identify priorities for action. To classify countries, the K-means method was used. The K-means method is a widely used non-hierarchical cluster analysis technique. The purpose of classifying countries is to identify which countries are similar and which are different in terms of SDGs performance. Socioeconomic and politico-cultural factors are assumed to be related to sustainable development (Kurniawan & Managi, 2018a, 2018b; Mukherjee & Chakraborty, 2013). To clarify this, we examined each cluster using the socioeconomic and politico-cultural structures of the cluster's member countries. There are only few studies in which researchers classified countries according to their sustainable development performance. Most of these studies are limited to selected indicators for a few selected countries and none of them examined the socioeconomic and politico-cultural structures of

the countries in the clusters. In this study, we examined 110 countries using data from the Sustainable Development Index and Dashboard (Sachs et al., 2019a).

This study provides a comprehensive examination of countries by classifying them in terms of progress on the SDGs. In addition to classifying the countries, this study examines each of the clusters based on the socioeconomic and politico-cultural structures of the countries. The main contribution of this study is to provide insights into the state of the art in SDGs progress, socioeconomic and politico-cultural structures of countries around the world simultaneously. This comprehensive study provides deeper insight into homogeneous groups of countries in SDGs progress by defining the gaps between countries with different structures and identifying priorities for action. This study covers 110 countries with 17 SDGs progress indices, 6 socioeconomic structure indicators and 8 politico-cultural structure indicators. Thus, this study covers an extensive range of indicators and a large sample of countries from around the world. Compared to previous literature (Adamišin et al., 2015; Allievi, 2011; Drastichová, 2020; Drastichová & Filzmoser, 2019; Jabbari et al., 2019; Petrov et al., 2018), this work is one of the pioneers with a comprehensive examination of countries in terms of SDGs progress.

The structure of the paper is constructed as follows. In the next section, the SDGs set by the UN are presented. Later, theoretical foundations of the study and related literature are briefly explained. Then, in the methodology section, the research design, scope of the study, data and the method used in this study are explained. Finally, the results of the analysis are presented, and these results are discussed.

2 Sustainable Development Goals set by the United Nations

The UN considered to be an international organization with a unique span of influence was founded in 1945 and currently has 193 members. The UN provides a forum to discuss and take actions for challenges that humanity and member countries face (Bebbington & Unerman, 2018). One of the biggest challenges of today's world is sustainability of environment, human well-being, and economic development. To overcome these challenges, the UN set MDGs in 2000. The UN set 8 MDGs for the period of 2000–2015. At the end of this period, UN expanded MDGs' thematic and geographic scope and adapted a more comprehensive, holistic and universal version of these as SDGs (Biermann et al., 2017; Eisenmenger et al., 2020; Hickel, 2019; Le Blanc, 2015). In 2015, all UN Member States adopted "The 2030 Agenda for Sustainable Development." The core of this agenda is SDGs, which were set by the member countries (United Nations, 2015). MDGs were applicable for developing countries to help poor countries; however, SDGs pose goals and targets for all countries (Eisenmenger et al., 2020; Le Blanc, 2015; Sachs, 2012). SDGs are defined as calls for universal action to eradicate poverty, protect our planet and ensure that all people live in peace and prosperity (United Nations, 2015). The SDGs were set to take actions for ensuring environmental protection, human well-being and economic prosperity simultaneously (Pradhan et al., 2017). There are total of 17 SDGs with 169 targets related to these goals. SDGs and their descriptions are given in Table 1.

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Table 1 Sustainable Development Goals and descriptions

Sustainable Development Goals	Goal description
Goal 1: No poverty	End poverty in all its forms everywhere
Goal 2: Zero hunger	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Goal 3: Good health and well-being	Ensure healthy lives and promote well-being for all at all ages
Goal 4: Quality education	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5: Gender equality	Achieve gender equality and empower all women and girls
Goal 6: Clean water and sanitation	Ensure availability and sustainable management of water and sanitation for all
Goal 7: Affordable and clean energy	Ensure access to affordable, reliable, sustainable and modern energy for all
Goal 8: Decent work and economic growth	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal 9: Industry, innovation and infrastructure	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Goal 10: Reduced inequality	Reduce inequality within and among countries
Goal 11: Sustainable cities and communities	Make cities and human settlements inclusive, safe, resilient and sustainable
Goal 12: Responsible consumption and production	Ensure sustainable consumption and production patterns
Goal 13: Climate action	Take urgent action to combat climate change and its impacts
Goal 14: Life below water	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15: Life on land	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 16: Peace, justice and strong institutions	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal 17: Partnership for the goals	Strengthen the means of implementation and revitalize the global partnership for sustainable development

Source: United Nations (2015, October 21: 14)

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The SDGs are defined as a call for universal action to eradicate poverty, protect our planet, and ensure that all people live in peace and prosperity (United Nations, 2015). The SDGs were set to take action to simultaneously ensure environmental protection, human well-being, and economic prosperity (Pradhan et al., 2017). There are total of 17 SDGs with 169 targets related to these goals. The SDGs and their descriptions are listed in Table 1.

3 Theoretical foundations and literature review

Practitioners, organizations and researchers have long been interested in the concept of sustainable development. The measurement and determinants of sustainable development are among the most important research interests. How to achieve sustainable development is one of the crucial questions that are attempted to be answered. Sustainable development has three aspects/dimensions: environmental, social and economic development. In order to achieve overall sustainable development, these dimensions must be handled together. In other words, countries must simultaneously harmonize profit, social protection, and respect for the environment to achieve sustainable development (Di Vaio et al., 2020a).

Economic growth which helps in value creation for the economy and fosters sustainable development (Di Vaio et al., 2020b) is one of the goals in the SDGs (Goal 8: Decent Work and Economic Growth). Economic growth, which is assumed to be essential for human development, is also linked to several SDGs such as Goal 1, 2, 3 and 4 (Hickel, 2019). As indicated in a report published by the United Nations (2019), "sustained and inclusive economic growth can drive progress, create decent jobs for all and improve living standards." Specifically, economic growth provides prosperity for households to increase their well-being (Ranis et al., 2000). For countries, economic growth provides capital investment to increase their level of development. However, economic growth alone is not sufficient to achieve sustainable development and social well-being (Brad et al., 2016; Eisenmenger et al., 2020). For example, high economic growth and high-income level foster overconsumption and neglect of efficient resource use (Coscieme et al., 2020; Eisenmenger et al., 2020). Furthermore, income inequality needs to be reduced as much as possible to ensure sustainable development (Chancel et al., 2018; Wilkinson & Pickett, 2010). Income inequality leads to increased defensive spending, higher violence rates, and worse health conditions and social relations (Wilkinson & Pickett, 2009, 2018). Another important point is that the dimensions of sustainable development depend on good governance (Sachs, 2012). While good governance promotes sustainable development (Dartey-Baah, 2014), poor governance (Nwankwo & Richards, 2001) and institutional and structural weaknesses (Killick et al., 2001; Yeats et al., 1996) make it difficult to achieve Sustainable Development Goals. In this regard, governments and institutions that act as catalysts for global priorities play an important role in achieving sustainable development (Alvino et al., 2020). Human capital is also needed and is very important in achieving sustainable development (Goodwin, 2003). Because of the knowledge they possess, people are considered as one of the drivers of growth (Alvino et al., 2020). The most important measure of human capital is education (Sachs et al., 2019b). Better education promotes human capital and foster economic growth (Barro & Sala-i-Martin, 2003; Becker, 2009; Hanushek & Woessmann, 2012; Kc et al., 2010), eliminate extreme poverty and overcome inequality (Bengtsson, et al., 2018; Lutz et al., 2008). Thus, education is a very important driver of development (Lutz & Samir, 2011).

Since the adoption of the 2030 Agenda for Sustainable Development, practitioners, researchers and organizations have focused on the SDGs. Various aspects of the SDGs and their implementation have long been discussed by many researchers. For example, attempts have been made to define and explain linkages between the SDGs and related goals (Collste et al., 2017; Coopman et al., 2016; International Council for Science, 2015, 2017; Le Blanc, 2015; Nilsson et al., 2018; Pradhan et al., 2017). Some researchers focused on specific SDGs and targets (Chancel et al., 2018; Coopman et al., 2016; Giupponi et al., 2018; Guppy, 2017) and some aspects of the SDGs such as human development (Moyer & Hedden, 2020) and environment (Jayaraman et al., 2015). These studies mainly discuss and try to explain the SDGs and targets. Some researchers and organizations have attempted to examine nations' SDGs progress and implementations for specific countries and regions. Country- and region-specific discussions and planning are accepted as key to achieving the SDGs (Aust et al., 2020). There are some studies that measure, examine and/or discuss countries' progress in sustainable development based on regions such as OECD (OECD, 2019; Shinwell & Cohen, 2020), Europe (Adamiřin et al., 2015; Huttmanov , 2016; Iřljamovi  et al., 2015; Jankovi  et al., 2016; Stanujkic et al., 2020; Vorontsova et al., 2020), BRICS (Ali et al., 2018), Arab Region (Allen et al., 2017) and G20 (Schmidt-Traub et al., 2017).

A number of studies have classified countries in terms of sustainable development using cluster analysis (Adamiřin et al., 2015; Allievi, 2011; Drastichov , 2020; Drastichov  & Filzmoser, 2019; Jabbari et al., 2019; Petrov et al., 2018). Allievi (2011) applied cluster analysis to classify the EU-27 countries. In his study, Allievi (2011) selected and used a total of 19 indicators as social, environmental and economic dimensions of sustainable development from Eurostat Sustainable Development Indicators (SDIs). Petrov et al. (2018) used 15 selected sustainable development indicators to cluster Southeast European countries. Drastichov  and Filzmoser (2019) used selected 12 SDGs indicators gathered from Eurostat to cluster EU-27 countries. Drastichov  (2020) clustered 29 European countries based on 9 indicators for selected SDGs. Jabbari et al. (2019) clustered 74 countries using the Sustainable Development Index developed by Sustainable Development Solutions Network (SDSN) and Bertelsmann Stiftung. Compared to the other studies, Jabbari et al. (2019) examined more countries and used a broader scale of indicators. In their study, Jabbari et al. (2019) also decomposed the SDGs and created aggregated development index and environmental index.

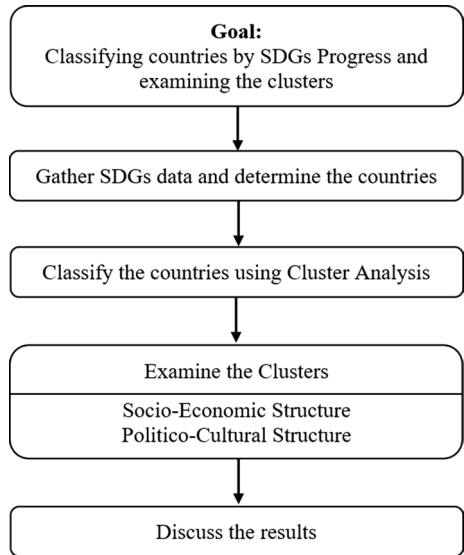
There are not many studies in the literature that use cluster analysis to classify countries in terms of the SDGs. The abovementioned researchers except Jabbari et al. (2019) used some selected indicators which may not be sufficient to cover all aspects and indicators of sustainable development. Moreover, none of these researchers considers the socioeconomic and politico-cultural structures of the countries.

4 Methodology

4.1 Research design, sample and data

Several research steps were carried out in this study. The research design of the study is shown in Fig. 1.

First of all, in order to classify countries, the data on SDGs progress of countries were obtained. In line with the SDGs, and independent expert teams at the Sustainable

Fig. 1 Research design

Development Solutions Network (SDSN) and Bertelsmann Stiftung have been calculating countries' Sustainable Development Index and publishing the results as Sustainable Development Report since 2016. In this report, country performances on 17 SDGs are tracked. Each of the 17 SDGs indices is equally weighted to calculate the global Sustainable Development Goal Index. The index values range from 0 to 100, with 0 representing the worst performance and 100 representing the best performance. The SDGs progress data used in the data analysis stage were obtained from the Sustainable Development Report 2019 (Sachs et al., 2019a). This report covers 162 countries. After subtracting the countries whose indicator values are missing, a total of 110 countries and 17 SDG indices of these countries were included in the analysis. In the cluster analysis stage, the K-means method was used. K-means method is one of the non-hierarchical cluster analysis techniques. After obtaining the clusters, each of the cluster were examined by the member countries' socioeconomic and politico-cultural structures using descriptive statistics and correlation analysis. Indicators for socioeconomic and politico-cultural structure of the countries used in this study are as follows:

- *Socioeconomic structure* GDP per capita, Income level classification and Human Capital
- *Politico-cultural structure* Governance, Institutions and Human Freedom

Data on GDP per capita were gathered from World Development Indicators (The World Bank, 2019), and income level classification was gathered from The World Bank (n.d.). Data on human capital and institutions indicators were gathered from The Global Competitiveness Report 2019 (Schwab, 2019). Indicators for the governance were obtained from the Worldwide Governance Indicators (Kaufman et al., 2011; Kaufmann & Kraay, n.d.), and the data of human freedom indicator were obtained from the Human Freedom Index (Cato Institute & the Fraser Institute, 2020). While the human freedom indicator is for the year 2020, the remaining indicators are for 2019.

4.2 K-Means method

K-means was first published in 1955. Although 65 years have passed since its first publication, K-means is still very popular and is often used for clustering. The key reasons for its popularity are its ease of use, simplicity, efficiency and empirical success (Jain, 2010). The K-means algorithm attempts to assign each point that is closest to the cluster center, also called centroid. A cluster center is the average of all points assigned to the corresponding cluster (Madhulatha, 2012). K-means tries to minimize the sum of squared distance between each point and the cluster center (Ray & Turi, 1999). Besides the mentioned features, one of the most important limitations is that it depends too much on the number of clusters (k). For this reason, k must be fixed, and the results depend on the initial cluster centers (Žalik, 2008). K-means' steps as follows (Tou & Gonzalez, 1974):

- 1) Choose k initial cluster centers $z_1(1), z_2(1), \dots, z_k(1)$.
- 2) At the k -th iterative step distribute the samples $\{x\}$ among the K clusters, using the relation,

$$x \in C_j(k) \text{ if } \|x - z_j(k)\| < \|x - z_i(k)\|$$

for all $i = 1, 2, \dots, K; i \neq j$; where $C_j(k)$ denotes the set of samples whose cluster center is $z_j(k)$.

- 3) Compute the new cluster centers $z_j(k+1), j = 1, 2, \dots, K$ such that the sum of the squared distances from all points in $C_j(k)$ to the new cluster center is minimized. In other words, the new cluster center $z_j(k+1)$ is computed so that the performance index is minimized. The $z_j(k+1)$ which minimizes this performance index is simply the sample mean of $C_j(k)$. Therefore, the new cluster center is given by

$$z_j(k+1) = \frac{1}{N_j} \sum_{x \in C_j(k)} x, j = 1, 2, \dots, K$$

where N_j is the number of samples in $C_j(k)$.

- 4) If $z_j(k+1) = z_j(k)$ for $j = 1, 2, \dots, K$ the algorithm has converged, and the procedure is terminated. Otherwise go to Step 2.

As mentioned earlier, the success of the k-means algorithm depends heavily on the number of clusters (k) and the initial cluster centers. Considering step 4, the final clusters depend on the initial cluster centers and on k . To define k , there are some methods such as Elbow, Silhouette and Gap statistics. Elbow method uses the percentage of variance explained to determine the number of clusters. The Elbow method plots the percentage of variance explained against the number of clusters. The first clusters will add much information, but the marginal benefit will drop significantly at some stage and give the graph an angle. At this point, the number of clusters is chosen (Bholowalia & Kumar, 2014). Silhouette is actually a validation method that calculates the silhouette width for each point, the average silhouette width for each cluster, and the overall average silhouette width for the entire dataset. Based on the average silhouette width, k can be decided (Thilagamani & Shanthi, 1999). Gap statistic uses the output of the clustering algorithm to compare the change in within the cluster dispersion under the null distribution (Tibshiran et al., 2001). Silhouette and Gap statistic methods decide the optimal k themselves. On the other hand, the Elbow method allows the decision-maker to choose the appropriate k .

5 Results

Before clustering countries, regional SDGs progresses are examined. This examination will provide regional differences, needs and qualifications in relation to sustainable development. Regional classifications were obtained from the World Bank (n.d.). Mean SDGs index scores by region are given in Table 2.

The average SDG index of 162 countries is calculated as 65.99. The highest mean SDG index belongs to North America ($\bar{x}=72.60$). It should be known that there are only 2 countries in North America: The USA and Canada. These countries have high-income levels. Europe and Central Asia has the second highest mean SDG index ($\bar{x}=75.23$). Most of the countries in this region are developed countries. 28 and 14 of these countries in Europe and Central Asia are high-income and upper middle income countries, respectively. The lowest mean SDG index belongs to Sub-Saharan Africa ($\bar{x}=53.84$). There are 42 countries in this region. 23 of these countries are low income, and 14 of these countries are lower middle income countries. Sub-Saharan Africa region has the lowest mean score on 10 out of 17 SDGs. The lowest progress of the Sub-Saharan Africa region is on SDG 9: Industry, Innovation and Infrastructure ($\bar{x}=14.36$). On the other hand, this region has the highest mean score on SDG 13: Responsible Consumption and Production ($\bar{x}=92.02$).

The highest mean score belongs to SDG 13: Climate Actions ($\bar{x}=86.61$). This shows that members of UN are very good at taking urgent action to combat climate change and its impacts. The lowest mean scores belong to SDG 9: Industry, Innovation and Infrastructure ($\bar{x}=35.06$), SDG 14: Life Below Water ($\bar{x}=50.51$) and SDG 2: Zero Hunger ($\bar{x}=53.56$). The mean score of the Industry, Innovation and Infrastructure goal is very low compared to the other goals. Countries should put much more efforts to achieve this goal.

5.1 Clustering Countries in terms of Sustainable Development Goals progress

Since the K-Means method is a non-hierarchical clustering method, the number of clusters must be determined before applying it. To determine the number of clusters, the elbow method was used. According to the elbow method, the optimal number of clusters was determined as 5. Therefore, the number of clusters is set to 5 and the K-Means method was applied. The results of the elbow method (Fig. 2a) and the k-means method (Fig. 2b) are shown below.

Countries belonging to each cluster is given in Table 3.

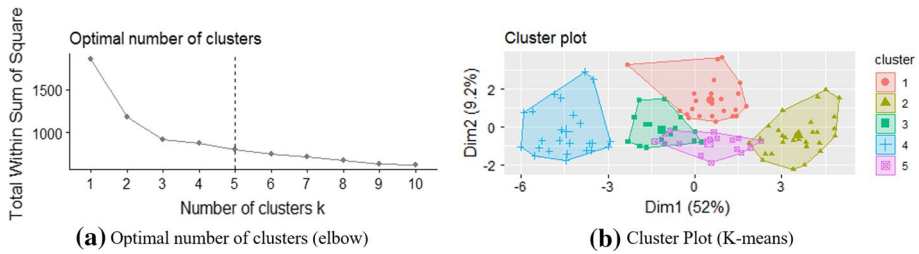
The number of countries in each cluster is 24, 29, 16, 24 and 17, respectively. To identify the characteristics of the clusters, the average scores of the Global Sustainable Development Goal Index are calculated. The income levels of the countries in each cluster are also examined. The World Bank's, 2019 income classification is used in this study (The World Bank, n.d.). Mean SDG Index and country classification by income group of each cluster are given in Table 4.

The mean SDG index of the countries is 67 and the mean SDG indices of the clusters are 69.12, 77.80, 63.91, 52.12 and 69.74, respectively. Thus, cluster 2 has the highest mean SDG index and cluster 4 has the lowest mean SDG index. Cluster 2 comprises a total of 29 countries. Out of these countries, 28 are high-income countries and only 1 country (China) is a upper middle income country. There are a total of 33 high-income countries in the sample and 28 of them are in cluster 2. Cluster 4 has a total of 24 countries out of which 13 are low-income countries and 11 are lower middle income countries. All of the low-income

Table 2 SDGs index by region

Regions	East Asia and Pacific	Europe and Central Asia	Latin America and Caribbean	Middle East and North Africa	North America	South Asia	Sub-Saharan Africa	Worldwide
# of country	18	48	25	19	2	8	42	162
SDG Index	68.25	75.23	67.48	65.95	76.20 ^H	62.08	53.84 ^L	65.99
SDG 1	85.20	97.27	82.30	91.17	99.07 ^H	77.10	32.11 ^L	74.40
SDG 2	56.95	59.97	53.76	50.55	63.12 ^H	47.00	46.80 ^L	53.56
SDG 3	73.75	86.38	74.70	76.47	92.16 ^H	63.16	44.34 ^L	70.04
SDG 4	86.95	93.76	81.57	77.96	94.63 ^H	72.48	50.08 ^L	76.90
SDG 5	63.16	70.06	68.79	46.19	76.88 ^H	40.94 ^L	51.63	60.17
SDG 6	72.89	81.63	74.05	57.57	84.60 ^H	59.02	50.97 ^L	67.64
SDG 7	69.42	90.48	83.59	85.65	94.25 ^H	68.81	35.09 ^L	71.13
SDG 8	77.60	76.63	74.06	67.09	84.61 ^H	71.94	63.28 ^L	71.63
SDG 9	44.01	52.82	27.09	39.25	78.89 ^H	21.00	14.36 ^L	35.06
SDG 10	66.52	74.24	35.49 ^L	69.14 ^H	63.25	62.92	46.46	59.12
SDG 11	77.18	82.85 ^H	78.21	62.85	81.43	61.55	58.64 ^L	71.81
SDG 12	77.02	64.32	81.61	71.41	43.35 ^L	90.19	92.02 ^H	77.43
SDG 13	82.70	85.96	87.12	80.24	67.31	94.17 ^H	91.09	86.61
SDG 14	47.74	46.09 ^L	54.99	46.18	60.17 ^H	51.77	55.98	50.51
SDG 15	52.07 ^L	72.59	60.82	57.02	68.84 ^H	57.49	68.47	64.81
SDG 16	71.78	77.57	58.28	68.93	82.13 ^H	60.53	53.89 ^L	66.01
SDG 17	55.23	66.73	70.57	72.30 ^H	60.78	55.13 ^L	60.58	64.46

^HHighest among the clusters; ^LLowest among the clusters

**Fig. 2** Results of cluster analysis**Table 3** Cluster membership of the countries

Cluster 1 ($n=24$)	Cluster 2 ($n=29$)	Cluster 3 ($n=16$)	Cluster 4 ($n=24$)	Cluster 5 ($n=17$)
Albania	Australia	Bangladesh	Angola	Brazil
Algeria	Belgium	Cabo Verde	Benin	Bulgaria
Argentina	Canada	Cambodia	Cameroon	Chile
Azerbaijan	China	Egypt	Comoros	Colombia
Bosnia and Herzegovina	Cyprus	Gabon	Congo	Costa Rica
El Salvador	Denmark	Ghana	Congo, Rep	Croatia
Fiji	Estonia	Guatemala	Cote d'Ivoire	Dominican Republic
Georgia	Finland	India	Djibouti	Ecuador
Iraq	France	Indonesia	Gambia	Honduras
Jamaica	Germany	Iran	Guinea	Mexico
Jordan	Greece	Myanmar	Haiti	Namibia
Kazakhstan	Iceland	Panama	Kenya	Nicaragua
Lebanon	Ireland	Philippines	Liberia	Peru
Malaysia	Israel	Sao Tome and Principe	Madagascar	Romania
Maldives	Italy	Sri Lanka	Mauritania	South Africa
Mauritius	Japan	Vanuatu	Mozambique	Thailand
Montenegro	Korea, Rep		Nigeria	Venezuela
Morocco	Latvia		Pakistan	
Russia	Lithuania		Papua New Guinea	
Tunisia	Malta		Senegal	
Turkey	Netherlands		Sierra Leone	
Ukraine	Norway		Sudan	
Uruguay	Poland		Tanzania	
Vietnam	Portugal		Togo	
	Slovenia			
	Spain			
	Sweden			
	UK			
	USA			

Table 4 Mean SDG index and income level classification of the clusters

Clusters			Income group			
Cluster	# of countries	Mean SDG index	Low	Lower middle	Upper middle	High
Cluster 1	24	69.12		6	16	2
Cluster 2	29	77.80			1	28
Cluster 3	16	63.91		12	3	1
Cluster 4	24	52.12	13	11		
Cluster 5	17	69.78		2	13	2
Total	110	67.0	13	31	33	33

countries in the sample are in cluster 4. Cluster 1 includes 6 lower middle income countries (El Salvador, Georgia, Morocco, Tunisia, Ukraine, Vietnam), 16 upper middle income countries and 2 high-income countries (Argentina, Uruguay). Cluster 3 includes 12 lower middle income countries, 3 upper middle income countries (Gabon, Guatemala, Iran), and 1 high-income country (Panama). Cluster 5 includes 2 lower middle (Honduras, Nicaragua), 13 upper middle, and 2 high-income (Chile, Croatia) countries. The average scores of each SDG by cluster are shown in Table 5.

Cluster 1 has the lowest mean score on SDG 14 and SDG 15 and the highest mean score on SDG 17. Cluster 2 has the highest performance on SDG 1–11, SDG 15 and SDG 16 and the lowest performance on SDG 12 and SDG 13. This cluster consists mainly of high-income countries. Here, we can see that these countries have good performance in achieving most of the SDGs. However, they have the lowest performance in achieving Responsible Consumption and Production (SDG 12) and Climate Action (SDG 13). Cluster 3 has the lowest performance in achieving SDG 17. Cluster 4 is the worst cluster in achieving SDGs with a mean global SDG Index of 52.12. Cluster 4 has the lowest performance in achieving SDG 1–11 and SDG 16, and the highest performance in achieving SDG 12 and SDG 13. Cluster 5 is the best performing cluster in achieving SDG 14. Among the clusters, Cluster 2 seems to be the best performing cluster and Cluster 4 seems to be the worst cluster in achieving most of the SDGs. Cluster 2 consists mainly of high-income countries and all of the low-income countries are in cluster 4. On the other hand, cluster 2 is the worst performing cluster and cluster 4 is the best performing cluster in achieving the goals for responsible consumption and production and climate change mitigation.

5.2 SDGs progress and socioeconomic structure

The main socioeconomic indicators for countries are economic growth and human capital. In this study, GDP per capita is used as an indicator of economic growth. The corresponding data were obtained from the World Development Indicators (The World Bank, 2019). The human capital indicators were gathered from The Global Competitiveness Report 2019. The human capital indicators and their explanations are as follows (Schwab, 2019):

- *Human capital* Healthy life expectancy, general skill level and quantity and quality of education.
- *Skills* General level of skills of the workforce and the quantity and quality of education.
- *Current workforce* General level of skills and education of the current workforce.

Table 5 Average values of each SDG by cluster

SDGs and description	Overall mean	Cluster 1 (<i>n</i> = 24)	Cluster 2 (<i>n</i> = 29)	Cluster 3 (<i>n</i> = 16)	Cluster 4 (<i>n</i> = 24)	Cluster 5 (<i>n</i> = 17)
SDG Index: global SDG index	67.0	69.12	77.80	63.91	52.12	69.74
SDG 1: No poverty	77.91	95.43	99.10 ^H	74.86	33.40 ^L	82.70
SDG 2: Zero hunger	53.52	51.71	62.86 ^H	52.62	43.94 ^L	54.47
SDG 3: Good health and well-being	71.74	77.67	92.96 ^H	65.01	42.40 ^L	74.91
SDG 4: Quality education	78.48	87.67	96.20 ^H	80.44	43.41 ^L	82.98
SDG 5: Gender equality	61.02	56.35	76.47 ^H	51.62	45.18 ^L	72.46
SDG 6: Clean water and sanitation	69.47	71.56	85.93 ^H	64.19	46.47 ^L	75.87
SDG 7: Affordable and clean energy	73.57	88.13	92.64 ^H	65.77	33.46 ^L	84.46
SDG 8: Decent work and economic growth	73.21	70.93	82.25 ^H	72.59	63.75 ^L	74.96
SDG 9: Industry, innovation and infrastructure	37.46	33.93	70.08 ^H	25.20	11.66 ^L	34.76
SDG 10: Reduced inequality	58.13	61.44	77.74 ^H	52.86	52.73 ^L	32.56
SDG 11: Sustainable cities and communities	73.47	78.39	84.15 ^H	70.02	53.61 ^L	79.59
SDG 12: Responsible consumption and production	76.87	79.66	51.74 ^L	89.44	94.53 ^H	79.05
SDG 13: Climate action	88.61	85.99	82.68 ^L	92.20	94.87 ^H	90.22
SDG 14: Life below water	50.66	38.38 ^L	49.70	54.20	51.87	64.63 ^H
SDG 15: Life on land	65.36	56.32 ^L	74.06 ^H	58.42	65.49	69.66
SDG 16: Peace, justice and strong institution	66.84	68.63	82.49 ^H	63.92	51.70 ^L	61.75
SDG 17: Partnership for the goals	63.39	72.80 ^H	61.49	53.05 ^L	57.55	71.31

^HHighest among the clusters; ^LLowest among the clusters

- *Future workforce* General level of skills and education of the future workforce.

SocioEconomic Structure of the clusters is shown in Fig. 3.

The highest mean GDP per capita (\$41,038) belongs to cluster 2, and the lowest mean GDP per capita (\$1,370) belongs to cluster 4. In terms of human capital, cluster 2 has the highest mean scores of all human capital indicators and cluster 4 has the lowest mean scores of all human capital indicators. In general, the clusters differ from each other in terms of socioeconomic indicators. The ranking of the clusters from the highest mean SDG

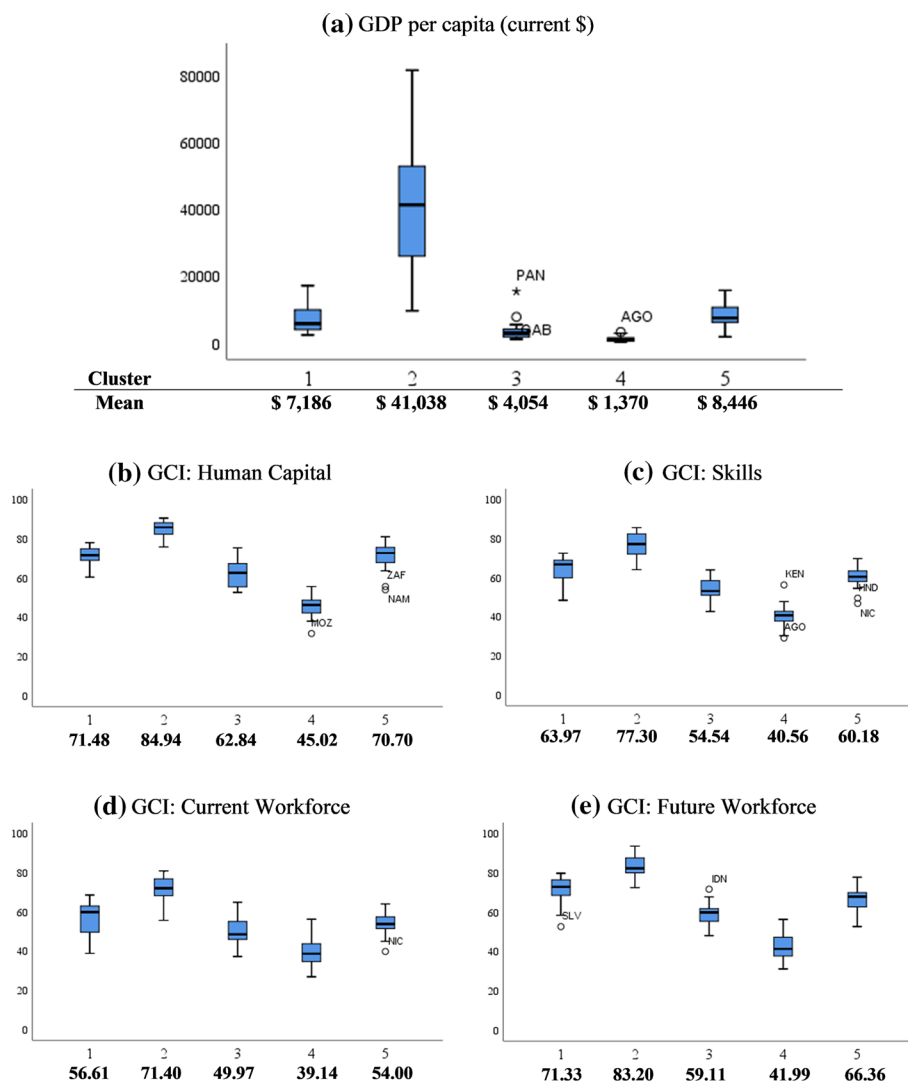


Fig. 3 Distribution of socioeconomic indicators by cluster

index to the lowest is cluster 2 (77.80), cluster 5 (69.78), cluster 1 (69.12), cluster 3 (63.91) and cluster 4 (52.12). This ranking is also identical for GDP per capita. The ranking of clusters from highest to lowest mean human capital is cluster 2 (84.94), cluster 1 (71.48), cluster 5 (70.70), cluster 3 (62.84) and cluster 4 (45.02). This ranking is the same for all human capital indicators. The differences between cluster 1 and cluster 5 are very low. The mean score by clusters and the ranking of the clusters in terms of indicators show that there may be a relationship between progress on the SDGs and the socioeconomic indicators. To find out whether there is a relationship between countries' economic growth, human capital and SDGs performance, a correlation analysis was conducted. The relationship between GDP per capita, human capital indicators and SDGs indices was determined using Pearson correlation coefficient. The results of the correlation analysis are presented in Table 6.

The relationship between GDP per capita and the Global Sustainable Development Goal Index is significant and positive ($r=0.691$, $p<0.01$). As the GDP per capita increases, the overall performance in achieving the Sustainable Development Goals also increases and vice versa. When we examine the relationships between GDP per capita and each of the SDGs, only two of the correlations are not significant: SDG 14: Life Below Water and SDG 17: Partnership for the Goals. This result shows that there is no relationship between economic growth and SDG 14 and SDG 17. SDG 17 is about partnership for sustainable development. Therefore, not only developed countries are striving for partnership, but also developing and underdeveloped countries are taking action to revive the global partnership for sustainable development. The relationship between GDP per capita and SDG 12: Responsible Consumption and Production ($r=-0.879$, $p<0.01$) and SDG 13: Climate Action ($r=-0.469$, $p<0.01$) are negative. These results show that as economic growth increases, performance in achieving these goals decreases and vice versa. The relationships between GDP per capita and SDG 1–11, SDG 15 and SDG 16 are positive. These results show that as economic growth increases, performance in achieving these goals increases and vice versa.

The relationships between all of the human capital indicators and the Global Sustainable Development Goal Index are significant and positive. Human Capital is positively correlated with SDG 1–11, SDG 16 and SDG 17, and negatively correlated with SDG 12: Responsible Consumption and Production ($r=-0.813$, $p<0.01$) and SDG 13: Climate Action ($r=-0.380$, $p<0.01$). The relationships between human capital and SDG 14 and 15 are not significant.

Socioeconomic indicators are correlated with most of the SDGs progresses. Moreover, as can be seen in Fig. 3, the clusters differ from each other in terms of socioeconomic indicators. When we examine the clusters, there are huge differences between them in terms of GDP per capita. The correlation matrix (Table 6) shows that 13 of the SDGs are positively correlated and 2 of the SDGs are negatively correlated with GDP per capita, namely economic growth. That is, most of the achievements in attaining the SDGs are correlated with economic growth. Since economic growth leads to large differences in the achievement of the SDGs, we examined SDG performance by income level of countries. The classification by income level was from The World Bank (n.d.). Mean performance score for each SDG by income level is shown in Fig. 4.

The mean score of the Global Sustainable Development Goal Index is 51.4 in low-income countries, 61.6 in lower middle income countries, 68.8 in upper middle income countries, and 76.2 in high-income countries. As mentioned earlier, economic growth is positively correlated with the SDG Index (Table 6). Thus, as the income levels increase, so does the SDG index. The highest average SDG scores in low-income countries are SDG 12: Responsible Consumption and Production ($\bar{x}=94.8$) and SDG 13: Climate

Table 6 Relationship between SDG indexes and socioeconomic structure indicators

SDGs and description	GDP per capita (current \$)	GCI: Human capital	GCI: Skills	GCI: Current workforce	GCI: Future workforce
SDG Index: Global SDG index	0.691**	0.926**	0.894**	0.826**	0.906**
SDG 1: No poverty	0.483**	0.809**	0.734**	0.646**	0.771**
SDG 2: Zero hunger	0.563**	0.645**	0.641**	0.599**	0.644**
SDG 3: Good health and well-being	0.689**	0.971**	0.884**	0.801**	0.910**
SDG 4: Quality education	0.506**	0.862**	0.847**	0.764**	0.875**
SDG 5: Gender equality	0.621**	0.645**	0.652**	0.627**	0.640**
SDG 6: Clean water and sanitation	0.646**	0.880**	0.855**	0.781**	0.875**
SDG 7: Affordable and clean energy	0.517**	0.849**	0.789**	0.706**	0.821**
SDG 8: Decent work and economic growth	0.598**	0.700**	0.701**	0.704**	0.662**
SDG 9: Industry, innovation and infrastructure	0.866**	0.845**	0.879**	0.866**	0.844**
SDG 10: Reduced inequality	0.480**	0.394**	0.406**	0.393**	0.396**
SDG 11: Sustainable cities and communities	0.483**	0.763**	0.730**	0.671**	0.742**
SDG 12: Responsible consumption and production	-0.876**	-0.813**	-0.839**	-0.815**	-0.817**
SDG 13: Climate action	-0.469**	-0.380**	-0.420**	-0.407**	-0.410**
SDG 14: Life below water	-0.016	-0.080	-0.113	-0.086	-0.131
SDG 15: Life on land	0.197*	0.100	0.161	0.194	0.125
SDG 16: Peace, justice and strong institution	0.707**	0.814**	0.834**	0.795**	0.825**
SDG 17: Partnership for the goals	0.125	0.225*	0.235*	0.164	0.284*

Correlation is significant at the **0.01 level and *0.05 level (2-tailed)

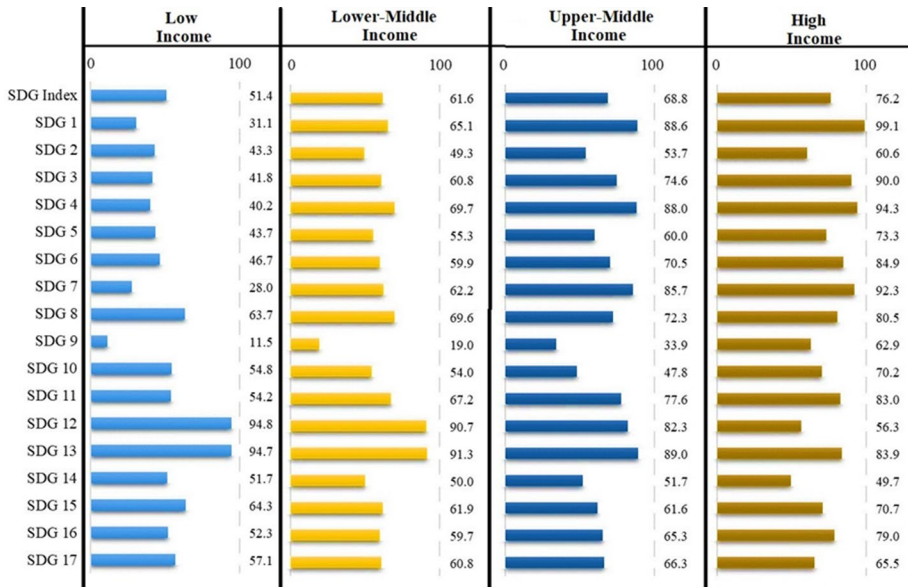


Fig. 4 Average values of each SDG by income level

Action ($\bar{x}=94.7$). As can be seen in Table 6, the relationship between performance on these goals and economic growth is negative. The lowest mean scores on the SDGs in low-income countries are SDG 9: Industry, Innovation and Infrastructure ($\bar{x}=11.5$), SDG 7: Affordable and Clean Energy ($\bar{x}=28.0$) and SDG 1: No Poverty ($\bar{x}=31.1$), respectively. Low-income countries have challenges especially in these SDGs. The highest mean scores of SDGs in lower middle income countries are SDG 12: Responsible Consumption and Production ($\bar{x}=90.7$) and SDG 13: Climate Action ($\bar{x}=91.3$) as in low-income countries. The lowest mean scores of the SDGs in lower middle income countries are SDG 9: Industry, Innovation and Infrastructure ($\bar{x}=19.0$), SDG 2: Zero Hunger ($\bar{x}=49.3$) and SDG 14: Life Below Water ($\bar{x}=50.0$). As mentioned earlier (Table 6), there is no correlation between economic growth and SDG 14. The main challenges faced by lower middle income countries are SDG 9 and SDG 2 to achieve sustainable development.

The highest mean scores of the SDGs in upper middle income countries are SDG 13: Climate Action ($\bar{x}=89.0$), SDG 1: No Poverty ($\bar{x}=88.6$), SDG 4: Quality Education ($\bar{x}=88.0$), and SDG 7: Affordable and Clean Energy ($\bar{x}=85.07$), respectively. On the other hand, the lowest mean scores of SDGs in upper middle income countries are SDG 9: Industry, Innovation and Infrastructure ($\bar{x}=33.9$) and SDG 10: Reduced Inequality ($\bar{x}=47.8$). The highest mean scores of the SDGs in high-income countries are SDG 1: No Poverty ($\bar{x}=99.1$), SDG 4: Quality Education ($\bar{x}=94.3$), SDG 7: Affordable and Clean Energy ($\bar{x}=92.3$), and SDG 3: Good Health and Well-being ($\bar{x}=90.0$), respectively. On the other hand, the lowest mean scores of the SDGs in high-income countries are SDG 14: Life Below Water ($\bar{x}=49.7$) and SDG 12: Responsible Consumption and Production ($\bar{x}=56.3$).

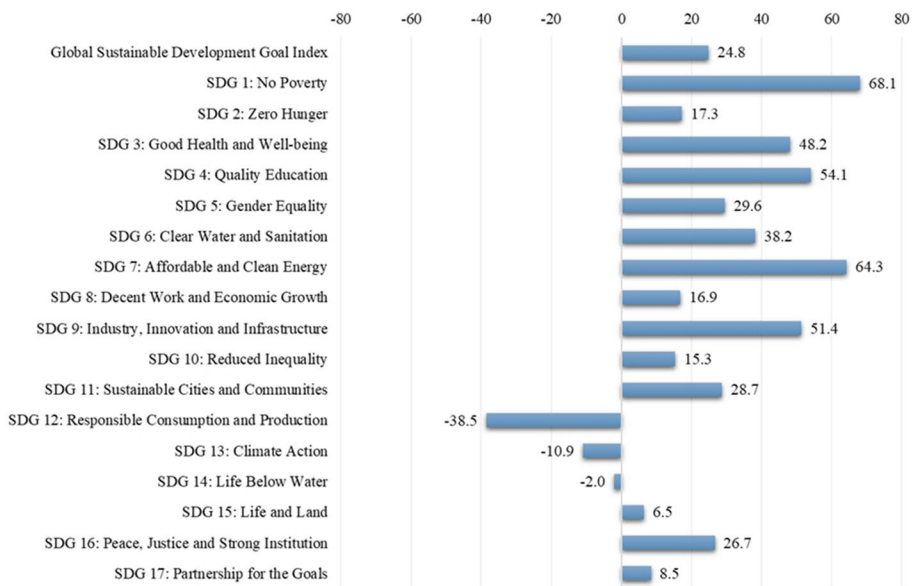


Fig. 5 SDG performance difference of high-income and low-income countries

It can be seen that countries with different income levels have different performance on the SDGs. To identify these differences, the differences between the mean SDG scores of high-income and low-income countries were calculated. The results are shown in Fig. 5.

The highest differences among mean SDGs are belong to SDG 1: No Poverty (68.1), SDG 7: Affordable and Clean Energy (64.3), SDG 4: Quality Education (54.1), SDG 9: Industry, Innovation and Infrastructure (51.4) and SDG 3: Good Health and Well-being (48.2), respectively. High-income countries have a much better performance in achieving these goals compared to low-income countries. Low-income countries need to make more efforts toward these goals. On the other hand, the differences are negative for SDG 12: Responsible Consumption and Production (−38.5) and SDG 13: Climate Action (−10.9). This means that the performance in achieving these goals is higher for low-income countries than for high-income countries. Therefore, high-income countries need to improve their performance on these goals.

5.3 SDGs progress and politico-cultural structure

In this study, governance indicators, institutions and level of human freedom of the countries are selected as politico-cultural indicators of the countries. The explanations of the Worldwide Governance Indicators (Kaufman et al., 2011; Kaufmann & Kraay, n.d.), institutions (Schwab, 2019) and Human Freedom Index (Cato Institute & the Fraser Institute, 2020) are as follows:

- *Voice and accountability* Reflects perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.

- *Political stability and absence of violence/terrorism* Reflects perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism.
- *Government effectiveness* Reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.
- *Regulatory quality* Reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.
- *Rule of law* Reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.
- *Control of corruption* Reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.
- *Institutions* Assessment of security, property rights, social capital, checks and balances, transparency and ethics, public-sector performance, future orientation of government, and corporate governance.
- *Human freedom index* Measurement of economic freedoms such as the freedom to trade or to use sound money, and the degree to which people are free to enjoy the major freedoms often referred to as civil liberties in the countries.

Mean politico-cultural indicators of each cluster are shown in Table 7.

The distributions of politico-cultural indicators by cluster are shown in Fig. 6.

As can be seen in Table 7 and Fig. 6, Cluster 2 has the highest mean scores of all politico-cultural indicators. On the other hand, Cluster 4 has the lowest mean scores of all politico-cultural indicators. Cluster 2 is the best and cluster 4 is the worst performing clusters in terms of SDG progress as well (Table 5). Among the other indicators, the highest difference between Cluster 2 and Cluster 4 occurs in "Government Effectiveness." While the mean score for government effectiveness in cluster 2 is 86.36, the mean score for government effectiveness in cluster 4 is 19.57. The rankings of the other clusters differ depending on the indicator. There are also outlier countries in the clusters. For example, the mean score of the "Voice and Accountability" indicator in cluster 2 is 84.15, but China, which is in the cluster 2, has a score of 6.40 on this indicator. Politico-cultural structures of the clusters generally differ from each other. The rankings of the clusters on the politico-cultural indicators largely overlap with the rankings of the clusters on SDG progress. To clarify whether there is a relationship between countries' politico-cultural structures and their SDG performance, a correlation analysis was conducted. The relationships between politico-cultural indicators and SDGs indices are shown in Table 8.

The relationships between the global SDG index and the politico-cultural indicators are all significant and positive. This result shows that as countries' politico-cultural structure improves, their progress in sustainable development increases and vice versa. While the relationships between SDG 1-11, SDG 16 and politico-cultural indicators are all significant and positive, the relationships between SDG 11-12 and politico-cultural indicators are all significant and negative. On the other hand, the relationships between SDG 14, SDG 17 and politico-cultural indicators are not significant. The correlation results show differences in SDG 15, so the progress of SDGs is not only related to socioeconomic structure but also to politico-cultural structure of countries.

Table 7 Mean governance, institutions and human freedom scores by cluster

Clusters	SDG index	Worldwide Governance Indicators					Institutions	Human free-dom index	
		Voice and accountability	Political stability and absence of violence / terrorism	Government effectiveness	Regulatory quality	Rule of law			Control of corruption
Cluster 1	69.12	40.99	38.12	51.24	49.46	43.67	44.31	53.81	6.78
Cluster 2	77.80	84.15	70.62	86.36	86.32	84.91	82.36	68.18	8.22
Cluster 3	63.91	42.80	37.41	39.00	35.34	37.71	35.40	49.12	6.45
Cluster 4	52.12	30.48	24.70	19.57	22.64	21.21	22.70	43.18	6.04
Cluster 5	69.78	52.39	40.81	49.29	53.76	44.23	43.24	50.59	7.09
Mean	67.0	52.10	44.07	51.51	51.94	48.86	48.16	55.17	7.03

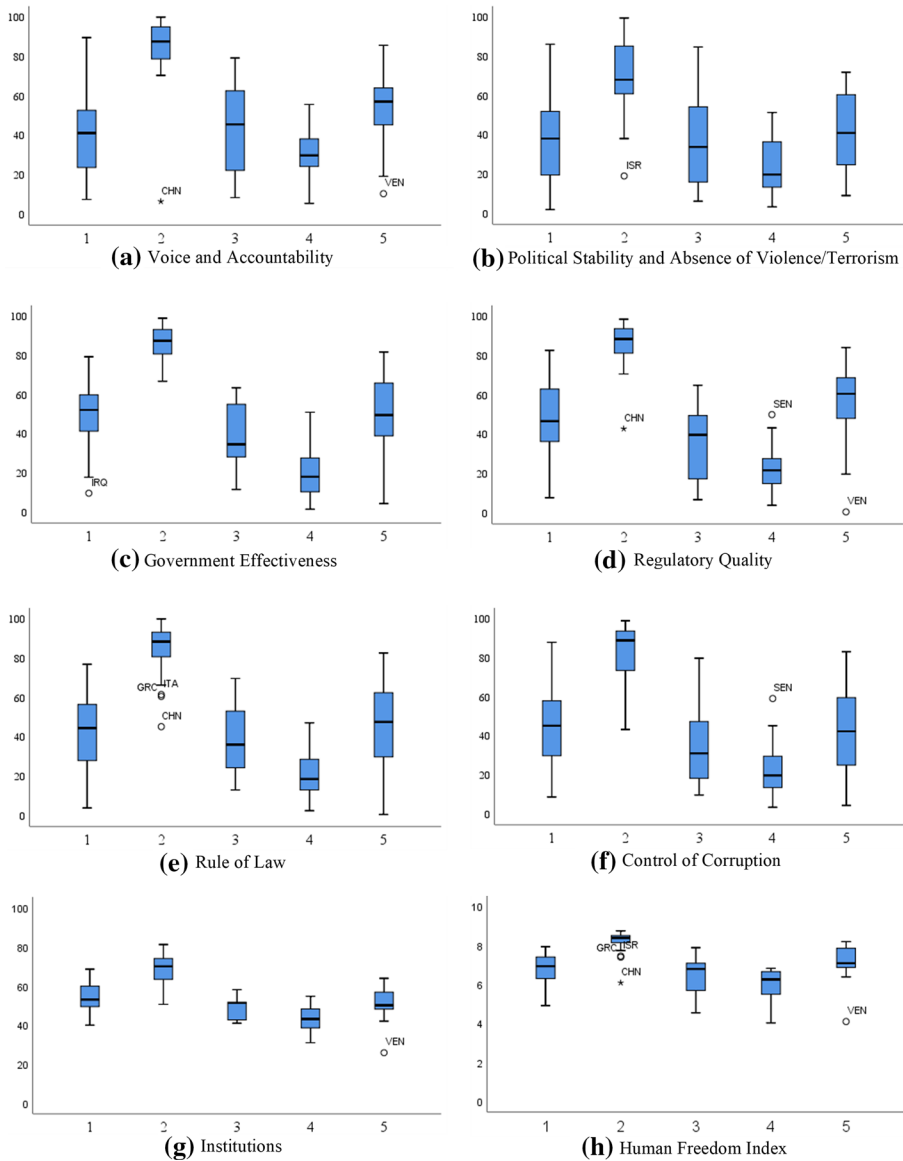


Fig. 6 Distribution of politico-cultural indicators by cluster

6 Discussion

This study first examines regional SDGs progress to highlight regional differences, needs and qualifications in terms of Sustainable Development Goals. This is because region-based discussion and planning is accepted as a key to achieving the SDGs (Aust et al., 2020). The results of this study show the regional differences in the progress of SDGs for each SDG. The results show that the Sub-Saharan Africa region is lagging behind the other

Table 8 Relationship between SDG indexes and politico-cultural indicators

SDG Index	Voice and account-ability	Political stability and absence of violence / terrorism	Government effectiveness	Regulatory quality	Rule of law	Control of corruption	Institutions	Human freedom index
SDG	0.655**	0.611**	0.843**	0.793**	0.786**	0.753**	0.764**	0.697**
SDG 1	0.424**	0.428**	0.692**	0.650**	0.614**	0.530**	0.573**	0.513**
SDG 2	0.531**	0.492**	0.646**	0.616**	0.631**	0.621**	0.595**	0.573**
SDG 3	0.636**	0.597**	0.814**	0.785**	0.761**	0.712**	0.720**	0.692**
SDG 4	0.501**	0.466**	0.730**	0.667**	0.653**	0.604**	0.624**	0.583**
SDG 5	0.624**	0.550**	0.683**	0.679**	0.610**	0.634**	0.579**	0.653**
SDG 6	0.660**	0.618**	0.778**	0.768**	0.724**	0.698**	0.659**	0.716**
SDG 7	0.450**	0.363**	0.690**	0.643**	0.595**	0.535**	0.568**	0.485**
SDG 8	0.612**	0.560**	0.735**	0.715**	0.704**	0.676**	0.687**	0.659**
SDG 9	0.705**	0.600**	0.880**	0.835**	0.854**	0.817**	0.863**	0.703**
SDG 10	0.255**	0.353**	0.287**	0.233**	0.335**	0.326**	0.433**	0.226*
SDG 11	0.558**	0.589**	0.688**	0.668**	0.600**	0.617**	0.620**	0.681**
SDG 12	-0.735**	-0.656**	-0.817**	-0.818**	-0.819**	-0.775**	-0.792**	-0.715**
SDG 13	-0.398**	-0.468**	-0.436**	-0.426**	-0.452**	-0.433**	-0.410**	-0.399**
SDG 14	0.143	0.092	0.016	0.009	0.035	0.058	0.013	0.013
SDG 15	0.213*	0.126	0.174	0.222*	0.213*	0.201*	0.149	0.173
SDG 16	0.715**	0.719**	0.803**	0.765**	0.840**	0.842**	0.877**	0.734**
SDG 17	0.121	0.126	0.133	0.081	0.142	0.173	0.133	0.083

Correlation is significant at the **0.01 level and *0.05 level (2-tailed)

regions and the most developed regions based on progress on the SDGs are North America and Europe and Central Asia. Sub-Saharan Africa region needs to take urgent actions on many of the Sustainable Development Goals, such as poverty, health, education, clean water, clean energy and infrastructure. However, these issues are directly related to economic development and this region is mainly composed of low and lower middle income countries. North America and Europe and Central Asia need to take actions to increase responsible consumption and production (Goal 12). Among the SDGs, all regions except North America have the worst progress in achieving Goal 9: Industry, Innovation and Infrastructure (Table 2). This SDG requires urgent action worldwide, as institutional and structural weaknesses make it difficult to achieve sustainable development (Killick et al., 2001; Yeats et al., 1996).

The results of the cluster analysis show that countries can be classified into 5 homogeneous clusters in terms of progress on the SDGs. The countries in each cluster can be seen on the world map in Fig. 7.

These clusters show different performances in achieving the SDGs. In particular, two of these clusters (Cluster 2 and Cluster 4) have very distinctive characteristics compared to the other clusters. 28 out of 29 countries in cluster 2 are high-income countries. All of the low-income countries in the sample (13) are in cluster 4, and the other countries in this cluster are lower middle income countries. While cluster 2 has the highest mean overall SDG index (77.8), cluster 4 has the lowest mean overall SDG index (52.12). Moreover, cluster 2 has the highest mean score on 13 SDGs and cluster 4 has the lowest mean score on 12 SDGs (Table 4 and Table 5). The clusters also have different socioeconomic and politico-cultural structure (Fig. 3 and 6). In general, the clusters with better socioeconomic and politico-cultural structure also have a high global SDG index.

Socioeconomic and politico-cultural factors are accepted to be related to sustainable development of countries (Kurniawan & Managi, 2018a, 2018b; Mukherjee & Chakraborty, 2013). The results of this study confirm that socioeconomic and politico-cultural factors are positively correlated with the overall progress of the SDGs. Our results further indicate that the relationships between SDGs performance and socioeconomic and

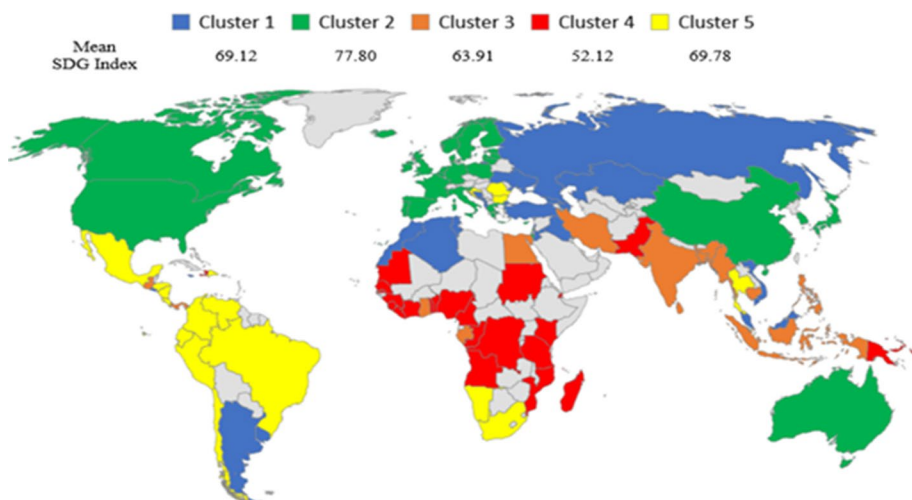


Fig. 7 Countries by Cluster on a World map

politico-cultural indicators vary by goal and indicator. The relationships between economic growth and progress for SDG 14 and SDG 17 are not significant. On the other hand, although there are negative relationships between economic growth and progress in SDG 12: Responsible Consumption and Production and SDG 13: Climate Action, the relationships between economic growth and progress in the other SDGs are positive (Table 6). GDP per capita, which is the total monetary value of all the finished goods and services produced within a country in a specific time period per person, is considered as the indicator of economic growth. As production and consumption of goods and services increases, so does the consumption of resources and fossil fuels, as well as CO₂ emissions. Therefore, developing countries face challenges in achieving SDG 12. Our findings support the argument that "high economic growth and high-income level foster overconsumption and neglect of efficient resource use" (Coscieme et al., 2020; Eisenmenger et al., 2020). Some studies also argue that higher levels of GDP lead to food waste (Costa et al., 2011; Hiç et al., 2016; Stoll-Kleemann & O'Riordan, 2015). The main challenges to achieve sustainable consumption and production are resource use, available technologies, product design and consumer demand (Nash, 2009). Some researchers emphasize the importance of R and D investment to achieve sustainable consumption and production (Adedoyin et al., 2020; Stevens, 2010). Countries with high GDP per capita and income should promote practices such as eco-design, repair, reuse, refurbishment, remanufacture, product sharing, waste prevention and waste recycling to increase resource productivity and recycling to achieve sustainable consumption and production (EEA, 2016; Pineiro-Villaverde & García-Álvarez, 2020).

Progress on climate action (SDG 13) is also negatively correlated with economic growth. Low-income countries have better performance on climate action than high-income countries. However, the relatively good performance of low-income countries in achieving SDG 13 cannot be directly seen as an achievement and commitment to the environment. This higher performance of poor countries is mainly due to lower emission of pollutants due to their level of development (Jabbari et al., 2019). Greenhouse gas (GHG) emission is the main cause of global warming. The relationship between GHG emissions and economic growth is extensively debated in the literature (Zaman, K., & Abd-el Moeen, 2017). Environmental Kuznets Curve (EKC) hypothesis attempts to explain the relationship between economic growth and various pollutants through an inverted U-shaped relationship. The EKC hypothesis states that in the early stages of development, pollution increases as per capita income increases, while in the later stages, pollution decreases over time (Dinda, 2004; Gara, 2019; Kahuthu, 2006). Therefore, countries will pollute and damage the environment more as they grow. However, countries should promote economic growth while taking necessary measures to ensure environmental sustainability (Munier, 2006). The performance of countries in taking urgent action to combat climate change and its impacts (SDG 13) is the highest among the SDGs, but high-income countries need to put more efforts in climate action for sustainable development.

Countries' performance in building resilient infrastructure, promoting inclusive and sustainable industrialization and fostering innovation (SDG 9) is the lowest among the SDGs. Low-income countries in particular struggle to achieve this goal (Table 6 and Fig. 4). According to the results, not only developed countries, but also developing and underdeveloped countries are striving for the global partnership for sustainable development (SDG 17). This shows that all UN member countries are reviving the partnership for sustainable development. However, the differences in SDGs performance between high-income and low-income countries are high in many goals. Low-income countries lag behind other income groups on many SDGs (SDG 1-9, SDG 11, SDG 16, SDG 17) and are ahead on

SDG 12 and SDG 13 (Fig. 4). Due to the nature of the SDGs and the insufficient infrastructure and financial resources in low-income countries, it is difficult to achieve some SDGs.

This study also shows the importance of human capital in achieving the SDGs (Fig. 3 and Table 6). The clusters have the same pattern of human capital as SDGs progress. The clusters with more advanced human capital tend to have superior SDG progress (Fig. 3). Besides, human capital indicators are positively related to most SDG progress indices (Table 6). These results confirm the importance of human capital in achieving sustainable development (Goodwin, 2003).

This study also examined the politico-cultural structure of the clusters. Just like the socioeconomic indicators, politico-cultural indicators in the clusters also show a similar pattern to the progress of the SDGs. The clusters with better politico-cultural structure tend to have superior SDG progress (Table 7). Politico-cultural indicators are positively related to most SDGs indices (Table 8). These results support the argument that to reach sustainable development good governance (Dartey-Baah, 2014; Nwankwo & Richards, 2001; Sachs, 2012), strong institutions (Killick et al., 2001; Yeats et al., 1996) and freedom (Dartey-Baah, 2014) are needed.

6.1 Theoretical and practical implications and policy recommendation

The SDGs were set to achieve and ensure sustainability for humanity and nature. These goals cover all dimension of sustainable development: environmental, social and economic development. UN member countries have been trying to achieve sustainable development through environmental, social and economic development simultaneously by adopting the SDGs. Measurement and monitoring each countries' achievement on SDGs are crucial for defining the current progress and developing future plans. First step of developing effective sustainable development plans is to measure and monitor the progress of nations in SDGs and define the characteristics of the countries accordingly. This study presents a novel attempt to define characteristics of the countries in terms of SDGs progress and socioeconomic and politico-cultural structure. In terms of SDGs progress of countries in 2019, there are 5 homogenous groups of countries. These clusters may change in time as the countries show different performance. In any case, each cluster has different achievements, challenges, needs, strengths and weaknesses in terms of SDGs progress. Policymakers can develop more effective sustainable development plans and prioritize actions for sustainable development in accordance with the characteristics of countries and clusters. Furthermore, governments, institutions and other policymakers should prioritize Sustainable Development Goals and related targets on a country, region and cluster basis. Because different countries, regions and clusters show different performances in achieving the SDGs, and also they have diverse socioeconomic and politico-cultural structure.

The socioeconomic and politico-cultural structure of countries are among the crucial drivers and determinants of sustainable development. This study proves that socioeconomic and politico-cultural indicators are correlated with most of the SDGs. This indicates that sustainable development cannot be separated from socioeconomic and politico-cultural structure but are highly dependent on each other. Policymakers should take into consideration of socioeconomic and politico-cultural structure of countries while developing sustainable development plans. Briefly stated, to promote sustainable development and achieve the SDGs, the socioeconomic structure and the politico-cultural structure of countries need to be improved. In other words, human capital should be developed, effective,

stable and accountable governance should be structured, institutions should be strengthened, and human freedom should be ensured to achieve the SDGs.

Poor performances on some SDGs are not always result from poor effort. Some countries have major challenges, needs and weaknesses in reaching some SDGs. Due to the nature of some SDGs, insufficient infrastructure and low financial resources constitute as weaknesses and challenges for some countries. Insufficient infrastructure and low financial resources appear to be the main gaps between low-income and high-income countries in achieving the SDGs. Practitioners, academicians and policymakers should take this into consideration while monitoring and measuring countries' progress on SDGs and developing sustainable development plans. Besides weaknesses and challenges, structural characteristics of countries should be kept in view.

7 Conclusions

The 2030 Agenda for Sustainable Development is a comprehensive and universal policy adopted by the UN. This agenda sets 17 Sustainable Development Goals with 169 targets. Achieving these goals is mandatory for all countries to ensure economic, social and environmental sustainability. The main aim of this study is to classify countries in terms of SDGs progress. The data for SDGs progress were obtained from the Sustainable Development Report 2019 (Sachs et al., 2019a). The K-Means method is used to classify the countries. The results of the cluster analysis show that the countries can be classified into 5 homogeneous clusters. Each of the clusters was examined based on the socioeconomic and politico-cultural structures of the countries. The literature lacks such study in which classifying worldwide countries based on their SDGs progress. There is only one study for the global domain and a few studies for some regions. Moreover, most of these studies lack a wide range of sustainable development indicators and none of them examined the clusters in terms of socioeconomic and politico-cultural structure.

The results of this study show that the countries in each cluster have broadly similar characteristics, not only in terms of progress on the SDGs, but also in terms of socioeconomic and politico-cultural structure. In general, the clusters with more advanced socioeconomic and better politico-cultural structure tend to have superior progress on most SDGs. This study presents the current status of progress of countries worldwide on the SDGs. The results mainly show that the progress of countries and clusters on the SDGs varies by region, goals, socioeconomic indicators and politico-cultural indicators. In order to achieve and maintain sustainable development and sustainability for humanity, these variations can provide important guidance for prioritizing actions. By defining the current status and variations, policymakers can make more effective plans for the future and develop strategies. This study provides important guidance for identifying each country's and cluster's achievements, needs, strengths and weaknesses in terms of progress on the SDGs. In addition, the empirical results of the study also show the importance of the superior socioeconomic and politico-cultural structure in achieving the SDGs.

This study has some limitations. This study only examined 2019 data from Sustainable Development Report. Because the 2019 data are not comparable to previous years (Sachs et al., 2019a), we could not examine countries' progress on the SDGs over time. Future studies could examine countries' progress on the SDGs over time by using different data sources. In the future studies, each of the SDGs can be examined separately for different countries, regions and income levels. To identify the relationship between SDGs progress

and socioeconomic and politico-cultural indicators, we could only use a cross-sectional data for 2019. The drivers and determinants of SDGs progress can be explored by building more advanced models. In addition, the determinant of the SDGs progress gap between countries with different income levels could be explored.

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Code availability Used R packages and codes are freely available.

Declarations

Conflicts of interest The authors declare no conflict of interest and competing interest.

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