



Research article

The state of the ‘Prosperity’ pillar by 2022: A partial ordering-based analysis of the sustainable development goals 7–11

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Abstract: Based on the data provided in the 2022 Sustainable Development Report the so-called Prosperity pillar, i.e., the Sustainable Development Goals (SDGs) 7–11 is studied to elucidate the state of compliance as well as the trends in development for the 193 countries included in the report. To the extent that data for all five SDGs were available partial ordering methodology was applied to rank the countries according to their compliance as well as their trend toward compliance. The analyses took simultaneously data for all five SDGs into account to get an overall picture of the prosperity midway through the 15 years period for the 17 UN SDGs. It was disclosed that the ten top countries, i.e., presently best comply with the prosperity goals were Denmark > Austria = Finland = Sweden = Norway > Slovenia > Germany > Portugal > Japan > Iceland, respectively. In the case of the trends, the top ten countries were found to be Germany > Netherlands > Ecuador > Bhutan = Finland = Ireland = Slovak Republic > Czech Republic = Maldives = Malta, respectively. It was further disclosed that SDG 10 (Reduced inequalities) appeared as the most important indicator for the ranking, whereas SDG 9 (Industry, innovation, and infrastructure) appeared as the least important. A similar set of analyses was carried out for country regions. The top regions both in the case of states and trends were the OECD and the high-income countries whereas the bottom of the list was the low-income countries and Africa. The study unambiguously points to SDG 10 (reduced inequalities) as the main focus for the remaining period.

Keywords: SDG; sustainable development goals; prosperity; state; trends; partial ordering; average ranking

JEL Codes: C02, C18, C63, C65, C88

1. Introduction

The 17 Sustainable Development Goals (SDGs) were unanimously adopted by the United Nations General Assembly in September 2015 and went into force by January 1st, 2016. Thus, today - we are close to the end of 2022 it is appropriate to estimate the state of the goals being midway in their 15 years lifespan. This paper reports some reflections or more concrete: how are we doing?

The goals, with their 169 sub-goals and more than 231 unique indicators are virtually focusing on every aspect of the global society and constitute, or should constitute the framework, i.e., the ‘compass directions’, for countries, regions, districts, companies, organizations, and single persons to operate within to secure the progress, prosperity and eventually the survival of the planet.

Sustainability is based on three main criteria, i.e., social, financial, and environmental (Future Learn, 2021). Based on these criteria the seventeen goals can be grouped into five so-called pillars (SEG, 2021; Whatcanyou do, 2021) (Table 1). It should here be noted that the last two goals – peace (SDG 16) and partnership (SDG 17), respectively - constitute separate groups as they are of utmost importance for all the other goals.

Table 1. The 5 P’s of the SDGs (SEG, 2021; Whatcanyou do, 2021).

Pillar	Description	SDGs
People	End poverty in all forms and ensure dignity and equality	1, 2, 3, 4, 5
Planet	Protect our planet’s natural resources and climate for future generations	6, 12, 13, 14, 15
Prosperity	Ensure prosperous and fulfilling lives in harmony with nature	7, 8, 9, 10, 11
Peace	Foster a peaceful, just and inclusive society	16
Partnership	Implement the agenda through a solid global partnership	17

The present study focuses on the financial criteria of sustainability; in other words, the focus is on the pillar ‘Prosperity’, i.e., the SDGs 7 (Affordable and clean energy), 8 (Decent work and economic growth), 9 (Industry, innovation and infrastructure), 10 (Reduced inequality) and 11 (Sustainable cities and communities).

It is emphasized that the present study has adopted the concept of the five pillars (SEG, 2021; Whatcanyou do, 2021), whereas other studies have used the SDGs SDG 7, SDG 8, SDG 9, SDG 11 and SDG 12 as the group is related to economic issues (D’Adamo et al, 2022).

The pillar prosperity SDGs have links to other goals, e.g., SDG 12 (Responsible consumption and production). However, in the pillar system (Table 1) SDG 12 is assigned to the pillar ‘Planet’. The analyses of SDG 12 have previously been reported by Carlsen (2021).

It is further emphasized that the present study does not take into account the possible influence of SDG 17 that appears to be probably the most important SDG in order eventually to be successful meeting the goals

Based on the data for 193 countries available through the 2022 version of the “Sustainable Development Report (Sachs et al., 2022), the present study elucidates the actual state of the five SDGs of the pillar prosperity as well as the development trends for the individual countries as well as for twelve groups of countries (cf. Table 2) (Sachs et al., 2022). The single countries are denoted by their ISO3 Country code (Appendix A).

Table 2. Grouping of countries.

East and South Asia	E_S_Asia	focus-economics.com/ESA_Sample_Report
Eastern Europe and Central Asia	E_Euro_Asia	ilo.org/moscow/countries/lang--en/index.htm
Latin America and the Caribbean	LAC	worldometers.info/geography/how-many-countries-in-latin-america/
Middle East and North Africa	MENA	en.wikipedia.org/wiki/MENA
Oceania	Oceania	worldometers.info/geography/how-many-countries-in-oceania/
OECD members	OECD	oecd.org/about/
Small Island Developing States	SIDS	un.org/ohrlls/content/list-sids
Sub-Saharan Africa	Africa	https://www.loc.gov/rr/amed/guide/afr-countrylist.html
Low-income Countries	LIC	g2lm-lic.iza.org/call-phase-iv/list-of-lic/
Lower-middle-income Countries	LMIC	worldpopulationreview.com/country-rankings/middle-income-countries
Upper-middle-income Countries	UMIC	worldpopulationreview.com/country-rankings/middle-income-countries
High-income Countries	HIC	worldeconomics.com/Regions/High-Income-Countries/

The basic ranking of the countries and groups of countries has been performed by applying partial ordering methodology, a methodology that allows simultaneously to take account into account several indicators (here the five SDGs in pillar prosperity) without any pretreatment like, e.g., the individual weighting of the single SDGs and subsequent aggregation like the study of D'Adamo et al. (2022).

It is well-known that the SDGs are interlinked, i.e., making changes to one SDG may have implications to several other SDGs. This linkage approach has been studied by Kostetckaia and Hametner (2022) leading to interesting results. However, the present study does not take such interlinks into account but treats the five SDGs composing the pillar prosperity as individuals.

2. Method

2.1. Data

Within the data material associated with the Sustainable Development Report (Sachs et al., 2022) the single states are color coded as green, yellow, orange, red, and grey which signalizes 'Goal Achievement', 'Challenges remain', 'Significant challenges', 'Major challenges' and 'Insufficient data', respectively. The trends are visualized by arrows. Thus \uparrow , \nearrow , \rightarrow and \downarrow that refer to 'On track or maintaining achievement', 'Moderately Increasing', 'Stagnating' and 'Decreasing', respectively.

For both the state as well as for the trends the color/arrow coding was transferred into numbers: green = 3, yellow = 2, orange = 1, red = 0 and grey = -1, respectively. Likewise, the arrow codes were transferred into $\uparrow = 3$, $\nearrow = 2$, $\rightarrow = 1$, and $\downarrow = 0$, respectively.

In the case of states two sets of calculations were performed, i.e., 1: excluding countries/groups where data were not available and 2: including all countries/groups associating the lack of data by the value -1. In the case of trends, countries/groups with no data available were excluded from the study.

2.2. Partial ordering methodology

Partial ordering is a relation among the objects to be ordered. In mathematical terms, the only relation is " \leq " (Bruggemann and Patil, 2011; Carlsen, 2018; Carlsen and Bruggemann, 2013, Carlsen

and Bruggemann, 2018). Hence, the “ \leq ” relation is the basis for a comparison of objects and constitutes a graph, the so-called Hasse diagram (see below). Two objects are connected if and only if the relation “ $x \leq y$ ” holds. A given object, x , is characterized by a set of indicators $r_j(x)$, $j = 1, \dots, m$ and can thus be compared to another object y , characterized by an identical set of indicators $r_j(y)$, if

$$r_i(x) \leq r_i(y) \text{ for all } i = 1, \dots, m \quad (1)$$

It is obvious that Equation 1 is a rather strict requirement for having a comparison as at least one indicator value of object x must be lower (the remaining lower or at least equal) to those of object y . In technical terms: Let X be the group of objects studied, i.e., $X = \{O_1, O_2, O_3, \dots, O_n\}$, then object O_y will be ranked higher than object O_x , i.e., $O_x < O_y$ if at least one of the indicator values for O_y is higher than the corresponding indicator value for O_x and no indicator for O_y is lower than the corresponding indicator value for O_x . On the other hand, if $r_j(O_y) > r_j(O_x)$ for some indicator j and $r_i(O_y) < r_i(O_x)$ for some other indicator i , O_y and O_x will be called incomparable (notation: $O_y \parallel O_x$) due to the mathematical contradiction expressed by the conflicting indicator values. A set of comparable objects are called a chain, whereas a set of mutually incomparable objects is called an antichain. In cases where all indicator values for two objects, O_y and O_x , are equal, i.e., $r_j(O_y) = r_j(O_x)$ for all j , the two objects will be considered as equivalent, i.e., $O_x = O_y$, which in terms of ranking means that they will have the same rank.

2.2.1. The Hasse diagram

Equation 1 is the basis for the so-called Hasse diagram technique (HDT) (Bruggemann and Patil, 2011; Bruggemann and Carlsen, 2006a, b). Hasse diagrams are visual representations of partial orders. In a Hasse diagram, comparable objects are connected by a sequence of lines (Bruggemann and Patil, 2011; Bruggemann and Münzer, 1993). Thus, sets of comparable objects, i.e., fulfilling Equation 1 are called chains that in the diagram are connected with lines, whereas sets of mutually incomparable objects, i.e., not fulfilling Equation 1 are called antichains.

In the diagram, the single objects are positioned in levels, typically arranged from low to high (bottom to top in the diagram). It is a general rule that objects are located as high in the diagram as possible. Thus, isolated objects will, by default be located at the top level of the diagram. It is important to make sure that the orientation of the single indicators is identical, e.g., that high values correspond to ‘good’ whereas low values correspond to ‘bad’. In practice, this is done by multiplying indicator values by -1 in cases where high and low values correspond to ‘bad’ and ‘good’, respectively (cf. 2.5). In the present study the highest located object/country will be assigned rank 1 indicating the ‘best’.

The module `mHDC17_1` of the PyHasse software (vide infra) was used for the basic partial ordering calculations and the associated construction of the Hasse diagrams.

2.2.2. Sensitivity—indicator importance

The relative importance of the single indicators in play can be determined through a sensitivity analysis (Bruggemann et al., 2001). The basic idea is to construct partially ordered sets (posets) excluding the single indicators one at a time. Subsequently, the distances from these posets to the original poset are determined. The indicator, whose elimination from the original poset leads to the

maximal distance to the original one, in other words causing the highest degree of changes in the Hasse diagram is most important for the structure of the original partial order. As the effect of elimination of single indicators is studied, this kind of sensitivity analysis can be called ‘indicator-related sensitivity’.

The sensitivity values were calculated by the sensitivity24_5 module (Bruggemann and Patil, 2011) of the PyHasse software (vide infra).

2.2.3. Average ranking

Looking at the Hasse diagram, the level structure constitutes a first approximation to an ordering. However, as all objects in a level automatically will be assigned identical orders such an ordering will cause many tied orders. It is desirable with a degree of tiedness as low as possible. Hence, ultimately a linear ordering of the single objects is desirable. However, when incomparable objects are included in the ordering, this is not immediately obtainable. Partial order methodology provides a weak order, where tied orders are not excluded, which is obtained by calculating the average order of the single objects as, e.g., described by Bruggemann and Carlsen (2011) and Bruggemann and Annoni (2014).

The average rankings were calculated by applying a local partial order approach by the LPOMext9_1 (Bruggemann and Carlsen, 2011) of the PyHasse software (vide infra).

The peculiar elements were calculated by applying the incomposet9_3 (Bruggemann and Carlsen, 2014) of the PyHasse software (vide infra).

2.2.4. Software

All partial-order analyses were conducted using the PyHasse software (Bruggemann et al., 2014). PyHasse is programmed using the interpreter language Python (version 2.6). Today, the software package contains around 140 more or less specialized modules.

3. Results and discussion

An initial look at the color-coded summary of the five SDGs included in the current study leaves a confused impression with an overall of 32, 166, 334, 372, and 61 “Green” (3), “yellow” (2), “orange” (1), “red” (0) and “grey” (−1) colors, respectively (cf. Appendix B and C). In Table 3 the distribution of the five colors for the single SDGs can be found, i.e., giving a complete picture of to what extent the 193 countries included in the data material (Sachs et al., 2022) comply with the five SDGs. It is immediately noted that a clear minority of the countries today comply with the five SDGs whereas a considerable number are still in “red figures” halfway through the SDG period. For quite a few countries (the “grey”) the data material is simply missing (cf. table 3).

The initial partial order analyses of the state of compliance of the countries have been carried out excluding countries where data are missing for one or more SDGs, i.e., looking at a multi-indicator system (MIS) with values only 0, 1, 2 and 3. A subsequent set of analyses included countries with missing data assigning an indicator value of −1 where data are missing.

Table 3. Compliance with the SDGs 7, 8, 9,10 and 11 for the 193 countries (cf. Appendix C).

	“green”	“yellow”	“orange”	“red”	“grey”
SDG 7 - Affordable and clean energy	18	42	54	78	1
SDG 8 - Decent work and economic growth	2	25	60	90	16
SDG 9 - Industry, innovation and infrastructure	2	21	85	85	0
SDG 10 - Reduced inequality	9	29	62	61	32
SDG 11 - Sustainable cities and communities	1	49	73	58	12

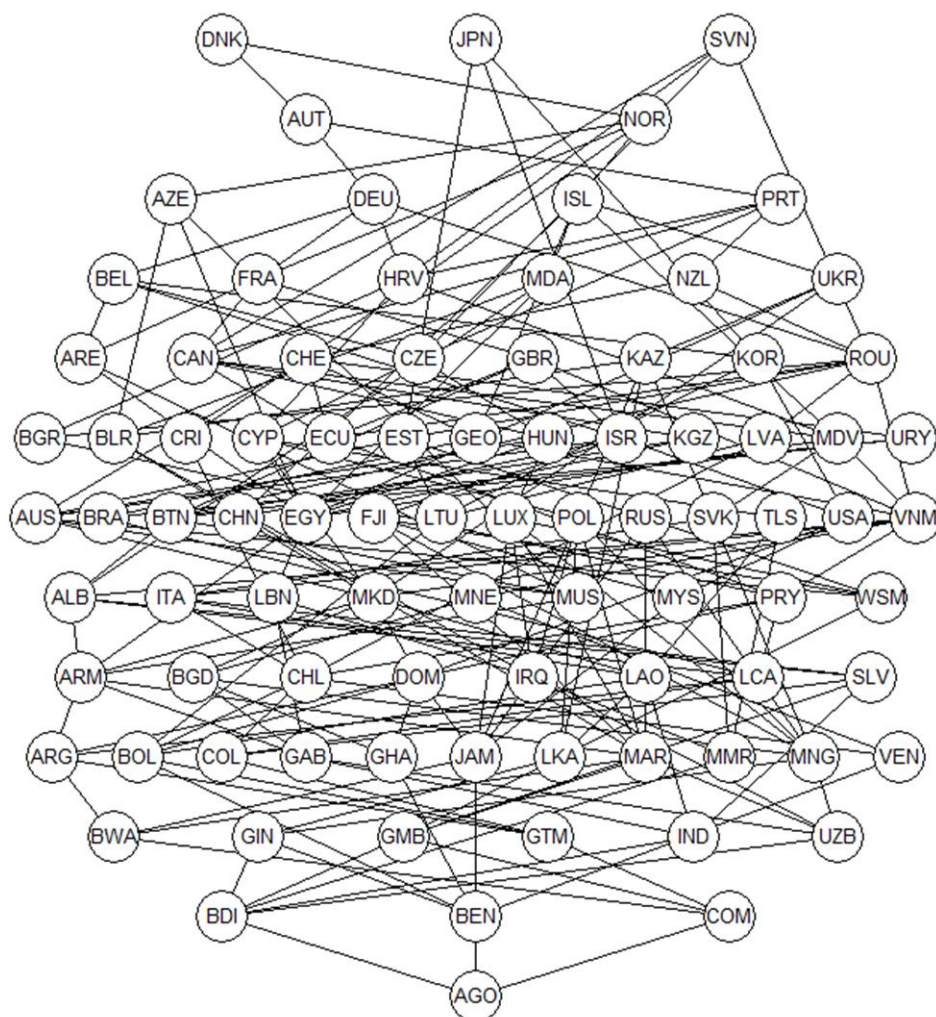
3.1. Excluding countries with missing data

Excluding countries with missing data for one or more of the five SDGs leaves 154 countries with a complete set of data (Appendix B). In Figure 1 the resulting Hasse diagram is shown. It should be emphasized that the diagram display only representatives for the single countries as several countries have identical indicator profiles and thus will appear in identical locations in the diagram, which leads to a simplified diagram. In Table 4 the equivalent, i.e., having identical indicator profiles countries are listed.

Table 4. Equivalent countries due to identical indicator profiles.

The first country in each group is the one displayed in the diagram (Figure 1)

AGO, CAF, CMR, COD, COG, DJI, HTI, LSO, MDG, NAM, RWA, SEN, SSD, STP, TCD, TGO, TZA, UGA, ZMB, ZWE,
ARG, CPV,
ARM, JOR,
AUT, FIN, SWE,
BDI, BFA, ETH, LBR, MLI, MRT, NER, NGA, PAK, SDN, SLE, SOM, SYR, YEM,
BEL, IRL, NLD,
BEN, CIV, GNB, KEN,
BGD, BIH, IDN,
BLR, DZA,
BTN, ESP,
BWA, IRN, ZAF,
COL, TUR,
COM, MOZ, MWI, PNG,
EGY, GRC,
GAB, TUN,
GIN, NPL,
GTM, HND, MEX, NIC, PHL, SWZ,
HUN, MLT,
ITA, TJK,
LCA, PAN, PER,
MKD, SRB, THA,
RUS, VUT,



where data for all countries for all 5 SDGs are available.

Figure 1. Hasse diagram displaying the partial ordering of the 154 countries.

The diagram has 1759 comparabilities and 2069 incomparabilities and thirteen levels. The level structure gives a first indicator of the ranking. Thus, Denmark (DNK), Japan (JPN) and Slovenia (SVN) appear as the countries that to the highest extent comply with the pillar 'Prosperity' SDGs whereas the group of countries represented by Angola (AGO) is those with the lowest compliance, the countries being in "red figures" on all parameters.

Due to the high number of incomparabilities, several rankings that all will be consistent with the overall partial ordering (cf. Figure 1) exist, and with the number of countries included in the present study, the number of so-called linear extensions will be overwhelming. However, partial order methodology offers the possibility to calculate the average ranking of the countries, i.e., a ranking where the single countries rank is calculated as an average of all possible ranks (cf. sect. 2.2.3). In Table 5 the top ten countries are summarized. It is immediately noted that AUT, FIN, and SWE were found to have identical average ranks (cf. also Table 4). Hence, they are all three assigned the rank 3. At the bottom of the list, we find Angola (AGO) and the nineteen equivalent countries (cf. Table 4)

Table 5. The average rank of the top ten countries.

Country	Country code	Average ranking	Rank
Denmark	DNK	87.945	1
Austria	AUT	86.696	3
Finland	FIN	86.696	3
Sweden	SWE	86.696	3
Norway	NOR	86.261	5
Slovenia	SVN	85.209	6
Germany	DEU	85.106	7
Portugal	PRT	84.832	8
Japan	JPN	83.013	9
Iceland	ISL	82.772	10

Returning to the Hasse diagram (Figure 1) DNK, JPN and SVN occupy the top level because of the drawing rules for such diagrams. Looking at the data in Table 5 there are differences between the three countries. A calculation of the mutual probability of these three countries shows that the probability that DNK is ranked above JPN and SVN is 70.5% and 58.9%, respectively and that SVN is ranked above JPN is 62.5%, i.e., a mutual ranking of $DNK > SVN > JPN$ as shown in the data in Table 5.

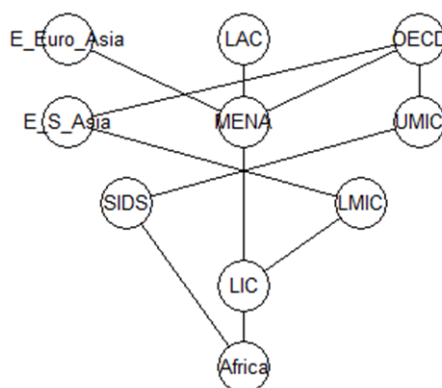
Turning to the indicators, it is worthwhile to further elucidate the relative importance of the five SDGs for the ordering of the 154 countries. This is done through a sensitivity study (cf. sect. 2.2.2). The importance of SDG 10 (Reduced inequalities) is striking, the relative importance is calculated to be 0.365 followed by SDG 7 (Affordable and clean energy) with a relative importance of 0.239. The least important, surprisingly in a prosperity context appeared to be SDG 9 (industry, innovation, and infrastructure) with a relative importance of 0.089. It is in this connection surprising that Kostetckaia and Hametner (2020) do not find linkages between SDG 10 and other SDGs. In fact, SDG 10 is not mentioned in their study.

In addition to the above-discussed mutual ordering of single countries, it is of obvious interest to look at the mutual ordering of the regions (cf. Table 2). In Table 6 the MIS for eleven out of the twelve regions is shown. Oceania is not included due to missing data for SDG 8 (Decent work and economic growth). From Table 6 it can be seen that the OECD and HIC regions are equivalent.

Table 6. MIS for the regions excluding countries with missing data.
(green = 3, yellow = 2, orange = 1, red = 0)

ID	SDG7	SDG8	SDG9	SDG10	SDG11
E_S_Asia	1	1	1	1	0
E_Euro_Asia	0	1	1	2	1
LAC	2	0	1	0	1
MENA	0	0	1	1	1
OECD	1	2	3	1	2
SIDS	1	1	1	0	1
Africa	0	0	0	0	0
LIC	0	0	0	1	0
LMIC	1	0	0	1	0
UMIC	1	1	2	0	1
HIC	1	2	3	1	2

The ranking of the eleven regions is displayed by the Hasse diagram in Figure 2.



(Note: OECD and HIC are equivalent, thus only OECD is shown as a representative)

Figure 2. Hasse diagram displaying the partial ordering of the eleven regions where all data are available.

As by the partial ordering of the single countries, the relative importance of the SDGs for the ordering shows that $SDG\ 10\ (0.516) > SDG\ 7\ (0.355) > SDG\ 11\ (0.065) > SDG\ 7 = SDG8\ (0.032)$. The average ranking of the regions was found to be $OECD = HIC > E_Euro_Asia > E_S_Asia > UMIC > LAC > MENA > LMIC > SIDS > LIC > Africa$, a ranking that does not reveal great surprises, as we found the high-income countries (HIC) and the OECD countries on the top ranks with a decreasing income level downwards to Africa at the bottom of the list, the latter being in “red figures” on all parameters.

3.2. Including countries with missing data

Including countries with missing data for one or more of the five SDGs obviously will lead to an MIS with 193 entries corresponding to the 193 countries included in the original data material (Sachs et al., 2022) (Appendix C).

The top ten countries as obviously identical to the above-shown list (Table 5), whereas some changes are noticed at the bottom of the list due to several countries now displaying missing data for one or more SDGs. Hence, the bottom is still the twenty-two countries represented by AGO, but they are, including missing data, being overtaken by Micronesia, Fed. Sts. (FSM, No 191), Dominica (DMA, No 192) and at the very bottom Afghanistan (AFG) is “red” on SDG 7, SDG 8, SDG 9, and SDG 11 and are maybe not surprisingly missing data on SDG 10 (Appendix C).

It was further noted that including countries with data missing did not change the fact that SDG 10 (Reduced inequalities) followed by SDG 7 (Affordable and clean energy) by far are the most important indicators for the ranking.

Also, in the case of the regions, a quite similar picture as that above developed. In addition to the above 11 regions (Table 6), Oceania is now included in the analysis with data of 0, -1, 0, 0, and 1 for SDGs 7, 8, 9, 10, and 11, respectively, i.e., data are missing for SDG 8 (Decent work and economic growth). Hence, an identical ordering is seen (cf. Figure 2), now including Oceania the latter being covered by LAC, MENA, and SIDS, respectively. In the average ranking Oceania is found at the 11th rank measured from the top, i.e., placed between LIC and Africa.

3.3. Trend analyses

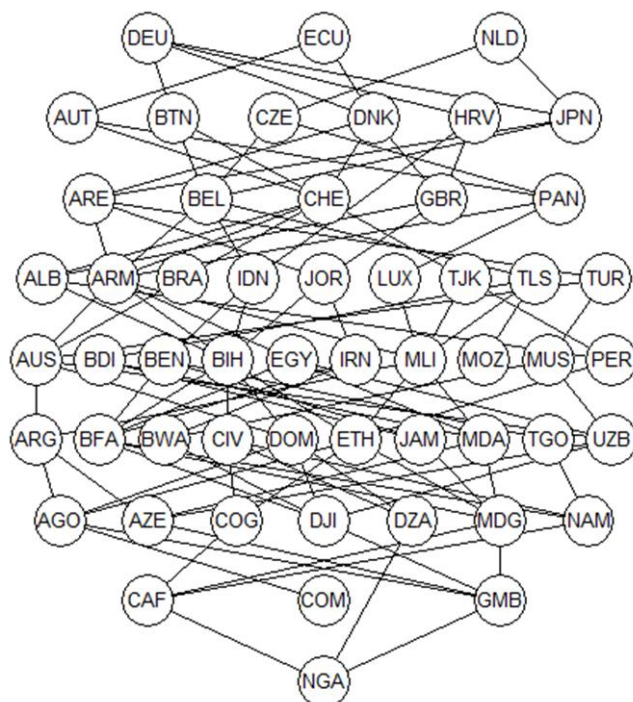
In the case of analyzing the trends of development in the prosperity pillar SDGs, countries with missing data are for obvious reasons excluded as trends simply could not be established. Thus, for 121 out of 193 countries and eight out of twelve regions, no trend data were reported. Especially data for SDG 10 (Reduced inequalities) are missing. Hence, excluding SDG 10 as well as countries with missing data for one or more of the remaining four SDGs leaves 154 countries and eleven regions (again Oceania is missing due to missing data for SDG 8 and 10) for the trend analyses (Appendix D).

The partial ordering of the 154 countries is illustrated by the Hasse diagram in Figure 3. As above it should, by inspecting the diagram, be remembered that only representatives for equivalent countries are shown. The equivalences are shown in Table 7.

Table 7. Equivalent countries due to identical trend profiles.

The first country in each group is the one displayed in the diagram (Figure 3).

AGO, STP, SWZ, ZMB,
ALB, GAB,
ARE, CAN, CHN, FRA, HUN, ISR, USA,
ARG, MEX, SLV,
ARM, BGD, BGR, BLR, EST, KGZ, KOR, LCA, RUS, SEN,
AUS, CPV, HND, LKA, PRY,
AUT, CHL, NOR, URY,
BEL, CYP, ESP, FJI, GRC, LAO, LTU, MYS,
BEN, VUT,
BFA, KAZ, MNG, NPL, ROU,
BIH, BOL, CMR, COD, COL, GHA, IRQ, MMR, MNE, PHL, UGA, UKR,
BRA, CRI,
BTN, FIN, IRL, SVK, SWE,
CAF, HTI, LBR, TCD,
CHE, GEO, ISL, LVA, NZL,
CIV, IND,
COG, GIN, ZWE,
CZE, MDV, MLT,
DJI, MRT, WSM,
DNK, ITA, PRT,
DOM, KEN, MAR, NIC, SDN, TUN,
DZA, LBN,
EGY, SRB, VNM,
ETH, GTM,
GMB, GNB, LSO, SLE, SOM, SSD, SYR,
IDN, RWA,
IRN, POL,
JAM, MKD, PNG,
JOR, THA,
JPN, SVN,
MDA, TZA,
MDG, MWI, NER, PAK, YEM,
PER, VEN,
UZB, ZAF,



where trend data for all countries for SDGs 7, 8, 9 and 11 are available.

Figure 3. Hasse diagram displaying the partial ordering of the 154 countries.

The average ranking of the countries based on their respective trend data leads to a picture significantly different from the picture for the actual status (Table 5). Thus, we find the 10 ten countries to be $DEU > NLD > ECU > BTN = FIN = IRL = SVK = SWE > CZE = MDV = MLT$. At the bottom of the list, we find a group represented by $GMB > NGA$. It is noteworthy that all the countries, apart from Syria (SYR) are African countries. Looking at the trends for the regions (Table 2) we find OECD = HIC countries at the top rank followed by $E_S_Asia = MENA = LMIC > LAC > E_Euro_Asia > UMIC$ and with the $LIC = Africa > SIDS$ countries at the lowest ranks.

The trend ranking is reasonably well correlated, especially looking at the regions, with the economic capacity of the included countries.

It is striking that for a significant number of countries, 122, data on the development in SDG 10 (Reduced inequalities) are missing, a fact that points to SDG 10 as an area of specific attention for the second half of the SDG period, especially considering the LIC, African and SIDS countries also occupy the three lowest ranks in the status analysis (Figure 2 plus the subsequent text).

4. Conclusions and outlook

Looking at the status as well as the trend in development for the pillar prosperity comprising the Sustainable Development Goals 7, 8, 9, 10 and 11 in 2022, i.e., corresponding to the midterm of the foreseen period for the 17 UN Sustainable Development Goals it can be concluded that the majority of the 193 countries have significant challenges for the remaining period. For quite a few countries data are simply missing or not assessable and only a relatively small fraction of countries apparently are on the right track although for several countries positive trends are noted but still quite a long way to go in order to comply with the goals.

Looking at the overall status for pillar prosperity we find the top ten countries, i.e., those best complying with the five SDGs to be Denmark > Austria = Finland = Sweden = Norway > Slovenia > Germany > Portugal > Japan > Iceland, respectively. Turning to the regions we find The average ranking of the regions was found to be OECD = HIC > E_Euro_Asia > E_S_Asia > UMIC > LAC > MENA > LMIC > SIDS > LIC > Africa (cf. Table 2 for abbreviations), i.e., the top regions, OECD and the high-income countries are at the top whereas the low-income countries and Africa are found in the bottom of the ranking list, which taken the economic capacities of the regions into account is not unexpected.

The trends of development show a somewhat different picture on a country basis. Here, we find the top ten countries to be Germany > Netherlands > Ecuador > Bhutan = Finland = Ireland = Slovak Republic > Czech Republic = Maldives = Malta, respectively, whereas the trend analysis displayed an identical picture as above, i.e., the top of the list was OECD countries and the high-income countries whereas the low-income countries and Africa occupy the lowest positions.

The relative importance of the five SDGs included in the study is based on the data available without attaching any weights to the single SDGs. However, the influence of different various stakeholders constitutes an interesting subject for future studies (cf. e.g., Tanaka and Tanaka, 2022). Partial order methodology offers a tool for such analyses (Carlsen and Bruggemann, 2022a,b)

Especially in the trend analysis, the absence of data for SDG 10 (Reduced inequalities) for 122 out of the 193 countries included in the study is striking – a topic that constitutes a major challenge for a wide variety of countries around the globe and should have top priority in the years to come.

Acknowledgment

In memoriam Rainer Bruggemann (☆28. Oct., 1943 – †4. Dec., 2022).

Conflict of interest

All authors declare no conflicts of interest in this paper.

References

- Bruggemann R, Carlsen L (2006a) *Partial Order in Environmental Sciences and Chemistry*, Springer, Berlin. Available from: <https://www.springer.com/gp/book/9783540339687>.
- Bruggemann R, Carlsen L (2006b) Introduction to partial order theory exemplified by the evaluation of sampling sites, In Bruggemann R and Carlsen L (Eds.), *Partial Order in Environmental Sciences and Chemistry*, Springer, Berlin, 61–110.
- Bruggemann R, Carlsen L (2011) An improved estimation of averaged ranks of partial orders. *Match-Commun Math Co* 65: 383–414.
- Bruggemann R, L Carlsen (2014) Incomparable-What now? *Match-Commun Math Co* 71:699–714
- Bruggemann R, Carlsen L, Voigt K, et al. (2014) PyHasse Software for Partial Order Analysis: Scientific Background and Description of Selected Modules, In: Bruggemann R, Carlsen L, and Wittmann J (Eds), *Multi-indicator Systems and Modelling in Partial Order*, Springer, New York, 389–423.

- Bruggemann R, Münzer B (1993) A Graph-Theoretical Tool for Priority Setting of Chemicals. *Chemosphere* 27: 1729–1736. [https://doi.org/10.1016/0045-6535\(93\)90153-V](https://doi.org/10.1016/0045-6535(93)90153-V)
- Bruggemann R, Patil GP (2011) *Ranking and Prioritization for Multi-indicator Systems—Introduction to Partial Order Applications*, Springer, New York.
- Bruggemann R, Halfon E, Welzl G, et al. (2001) Applying the Concept of Partially Ordered Sets on the Ranking of Near-Shore Sediments by a Battery of Tests. *J Chem Inf Comp Sci* 41: 918–925. <https://doi.org/10.1021/ci000055k>
- Carlsen L (2018) Happiness as a sustainability factor. The World Happiness Index. A Posetic Based Data Analysis. *Sustain Sci* 13: 549–571. <https://doi.org/10.1007/s11625-017-0482-9>
- Carlsen L (2021) Responsible consumption and production in the European Union. A partial order analysis of Eurostat SDG 12 data, *Green Financ* 3: 28–45. <https://doi.org/10.3934/GF.2021003>
- Carlsen L, Bruggemann R (2013) Partial order methodology a valuable tool in chemometrics. *J Chemometrics* 28: 226–234. <https://doi.org/10.1002/cem.2569>
- Carlsen L, Bruggemann R (2018) Environmental perception in 33 European countries an analysis based on partial order. *Environ Dev Sustain* 22: 1873–1896. <https://doi.org/10.1007/s10668-018-0267-z>
- Carlsen L, Bruggemann R (2022a) Partial Order as Decision Support Between Statistics and Multi-criteria Decision Analyses. *Standards* 2: 306–328. <https://doi.org/10.3390/standards2030022>
- Carlsen L, Bruggemann R (2022b) Combining different stakeholders' opinions in multi-criteria decision analyses applying partial order methodology. *Standards* 2: 503–521. <https://doi.org/10.3390/standards2040035>
- D'Adamo I, Gastaldi M, Morone P (2022) Economic sustainable development goals: Assessments and perspectives in Europe. *J Clean Prod* 354: 131730. <https://doi.org/10.1016/j.jclepro.2022.131730>
- Di Vaio A, Varriale L, Lekakou M (2023) SDGs disclosure: evidence from cruise corporations' sustainability reporting. *Corp Gov-Int J Bus S*. <https://doi.org/10.1108/CG-04-2022-0174>
- Future Learn (2021) The three pillars of sustainability. Available from: <https://www.futurelearn.com/info/courses/sustainabilitysociety-and-you/0/steps/4618>.
- Kostetckaia M, Hametner M (2022) How Sustainable Development Goals interlinkages influence European Union countries' progress towards the 2030 Agenda. *Sustaaain Dev* 30: 916–926. <https://doi.org/10.1002/sd.2290>
- Sachs JD, Lafortune G, Kroll C, et al. (2022) *From Crisis to Sustainable Development: the SDGs as Roadmap to 2030 and Beyond*. Sustainable Development Report 2022. Cambridge: Cambridge University Press. <https://doi.org/10.1017/9781009210058>
- SEG (2021) 5 pillars of Sustainable Development Goals (SDGs), Social Enterprise Guide. Available from: <http://socialenterpriseguide.com/5-pillars-of-sustainable-development-goals-sdgs/>.
- Tanaka H, Tanaka C (2022) Sustainable investment strategies and a theoretical approach of multi-stakeholder communities. *Green Financ* 4: 329–346. <https://doi.org/10.3934/GF.2022016>
- Whatcanyou do (2021) What can you do? The 5p's. Available from: <https://whatcanyou do.earth/selecting-the-sdg-for-youraction/the-5-ps/>.

