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India's Progress in SDG3 – Good Health and Well-Being Some Insights

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Abstract

The Government of India has constructed and released a composite SDG India Index to monitor the progress in Sustainable Development Goals (SDGs) in the country and in its States and Union Territories since 2018. In this paper, we highlight some of the limitations of the SDG India Index released by the Government of India through a detailed exposition of the Index with reference to SDG3 – Good health and Well-being. In view of the limitations of the SDG3 India Index, we also suggest two alternative, data-driven, approaches to construct a composite index to measure the progress in SDG3. We also show that the rank of states/Union Territories vis-à-vis progress in SDG3 changes significantly when the alternative, data-driven approach is used for the construction of the composite index of progress in SDG3. The paper calls for adopting a more appropriate set of indicators and a more refined methodology for the construction of SDG3 India Index in particular and SDG India Index in general.

Introduction

The United Nations 2030 Agenda for Sustainable Development calls for safeguarding our future through economic growth, social inclusion, and social protection and to ensure that no one is left behind (United Nations, 2015). The core of the agenda is a set of 17 goals popularly known as Sustainable Development Goals (SDGs) to be achieved by the year 2030 – 1) No poverty; 2) Zero hunger; 3) Good health and well-being; 4) Quality education and lifelong learning; 5) Clean water and sanitation; 6) Gender equality; 7) Affordable and clean energy; 8) Decent work and economic growth; 9) Industry motivation and infrastructure; 10) Reduced inequalities; 11) Sustainable cities and communities; 12) Responsible consumption and production; 13) Climatic action; 14) Life below water; 15) Life on land; 16) Peace, justice and strong institutions; and 17) Partnerships for the Goals. These goals, apart from being ideal and multidimensional, also reinforce each other. India has endorsed the United Nations 2030 Agenda for Sustainable Development and is committed to achieving SDGs. This commitment is reflected in the country contextualization of SDGs and construction of the SDG India Index (SII) to monitor the progress towards SDGs in the country and in its states and Union Territories. The first SII was released by the Government of India in 2018 and served as the benchmark to chart the progress towards SDGs (Government of India, 2018).

Subsequently, SII has been released in 2019, 2020-2021 and 2023-2024 (Government of India, 2019; 2021; 2024). The change in SII reflects how the country and its states/Union Territories are progressing in terms of SDGs.

The SII for different years is, however, not strictly comparable because of data limitations including non-availability of data related to some indicators, quality of data, varied sources, some being schemes and not outcome indicators. The first SII, released in 2018, was based on 62 indictors and 39 targets related to 13 SDGs; the second SII, released in 2019, was based on 100 indicators and 54 targets related to 16 SDGs; the third SII, released in 2021, was based on 115 indicators and 70 targets related to 16 SDGs; and the fourth and the latest SII, released in 2024 is based on 113 indicators and 70 targets related to 16 goals (Government of India, 2024).

Given the many limitations of SII, there is a need to explore alternative approaches to construct an index to monitor the progress in different SDGs. In this paper, we propose alternative, data-driven approaches for the construction of a composite index to reflect the progress in SDG3 – good health and well-being. We have found that the rank of a state/Union Territory in terms of the progress in SDG3 based on alternative approaches proposed in this paper is different from the rank based on the SDG3 India Index (S3II) released by the Government of India. Since any index reflecting good health and well-being is essentially multidimensional in its construct, we also emphasise that there is a need for giving careful consideration to the indicators used for the construction of the composite index as different set of indicators may reflect different progress towards SDG3.

There are many limitations of the SII because of which it depicts a distorted picture of progress towards SDGs in the states and Union Territories of the country. These limitations are related to both data used and the methodology adopted. The time reference of different indicators used to construct the SII is not the same. For example, out of the 115 indicators used for the construction of SII 2021-2021, only 26 has the reference period 2020-2021 while 31 indicators date to the period 2019-2020; 34 to the period 2018-2019; and 24 to the period before 2018 (Government of India, 2021).

Another problem with the SII is the methodology adopted for computing goal of score for each of the first 16 SDGs. The goal score for SDG17 has not been computed. The goal score for each SDG has been obtained by working out the simple average of the normalised values of the indicators used in the construction of the index, implying equal weight to all indicators under each SDG. The goal scores in different SDGs are then averaged to obtain the SII (Government of India, 2022a). There are, however, many states and Union Territories for which data related to the indicators used in the construction of the composite index for different SDGs are not available. In such a situation, the average is computed for only those indicators for which the data are available or the 'non-null' indicators. This means that the goal scores for different states and Union Territories for the same SDG are not comparable as they are based on different set of indicators in different states and Union Territories. Since the goal scores of different states and Union Territories for the same SDG are not comparable, the rank of a state or Union Territory based on these goal scores is misleading.

Objectives

This paper has two objectives. The first is to highlight the limitations of the SDG3 India Index (S3II) in ranking the states and Union Territories of the country in terms of progress towards SDG3. These limitations are related to the indicators used in the construction of the index and to the methodology adopted for eliciting 'goal-scores' towards the assessment of progress or performance in SDG3. The second objective of the paper, on the other hand, is to rank states and Union Territories of the country using an alternative set of indicators and a different methodology. The study shows that if the indicators used and the methodology adopted for the construction of the index are changed, the rank of states and Union Territories also changes significantly. The paper, therefore, calls for adopting a more appropriate set of indicators and a more refined methodology for the construction of SII.

SDG3 India Index

The SDG3 aims at improving mother and child health, tackling HIV/AIDS, tuberculosis, malaria, and other communicable and non-communicable diseases in the quest towards good health and wellbeing of the people. The SDG India Index Report highlights complexities and interconnectedness between good health and well-being and stresses that achieving SDG3 will lead to reduction in burdens on family and public resources thereby strengthening societies (Government of India, 2022a). The report also mentions that several initiatives taken by the country like Ayushman Bharat Yojana, Pradhan Mantri Bhartiya Janaushdhi Pariyojana, Poshan and Amenia Mukt Bharat have contributed towards accelerating the progress in SDG3. The SDG3 India Index is based on a set of 10 indicators (Table 1). The SDG3 India Index (S3II) is the average of the normalised values of the indicators.

Table 1: The list of indicators used by the Government of India for the construction of SDG3 India Index (S3II).

SDG3 Indicator	Name	Definition of the Indicator
3.1	MMR	Maternal mortality ratio per 100 thousand live births
3.2	CMR	Under 5 mortality rate per 1000 live births
3.3	IMM	Children aged 1-2 years fully immunised
3.4	TBR	Tuberculosis infection rate per 100 thousand population
3.5	HIV	HIV infected persons per 1000 population
3.6	SUR	Suicide rate per 100 thousand population
3.7	DRT	Death rate due to road traffic accidents per 100 thousand population
3.8	IDL	Percentage of institutional deliveries out of total deliveries
3.9	OPE	Monthly per capita out-of-pocket expenditure on health as the proportion of monthly per capita consumption expenditure (MPCE)
3.10	PNM	Total number of physicians, nurses, and mid-wives per ten thousand population

Source: Government of India (2022b).

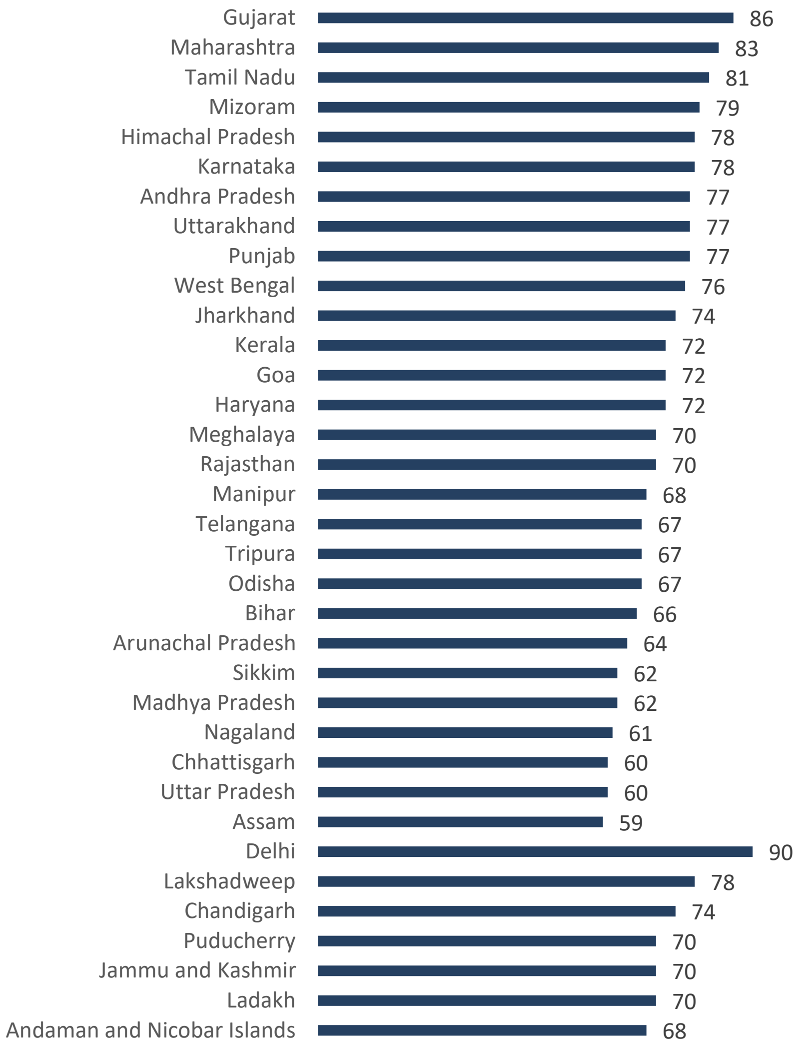

Figure 1: SDG3 India Index (S3II) for states and Union Territories of India, 2020-2021.
Source: Government of India (2022b)

The S3II for India is estimated to be 74 in 2023-2024 against the maximum possible value of 100. The Index varies widely across states and Union Territories. There are only 11 states and 2 Union Territories in which the S3II is higher than the national average (Figure 1). Gujarat ranks first among the 28 states while Assam ranks the last in S3II. Among Union Territories, Delhi ranks first while Andaman and Nicobar Islands ranks last. Combining states and Union Territories, Delhi ranks first while Assam ranks the last in S3II.

The ranking of states and Union Territories based on the S3II, however, is at odds with the ranking of states and Union Territories with respect to the life expectancy at birth, the most popularly used indicator of population health. Estimates available from the Global Data Lab suggest that the life expectancy at birth was the highest in Kerala in 2022 but the lowest in Uttar Pradesh. Kerala, however, ranks 14 in terms of S3II even lower than Jharkhand. Similarly, Delhi ranks first in terms of S3II but 18 in terms of the life expectancy at birth while Gujarat ranks second in terms of S3II but 21 in terms of the life expectancy at birth. In some states and Union Territories of the country, however, the rank in terms of S3II and the rank in terms of the life expectancy at birth is quite similar. For example, Uttar Pradesh ranks 32 in terms of S3II and 33 in terms of the life expectancy at birth while Madhya Pradesh ranks 29 in terms of S3II and 32 in terms of the life expectancy at birth. This raises concern about the relevance of S3II in monitoring progress towards SDG3 across states and Union Territories of the country.

There are many reasons why S3II depicts a distorted picture of the progress in good health and well-being across states and Union Territories of the country. These limitations are related to both data used and the methodology adopted. S3II is the average of the normalised values of 10 indicators (Table 1) but estimates of all the 10 indicators are available for only 19 states of the country only. In the remaining 18 states and Union Territories, the S3II is calculated as the average of the normalised values of only those indicators for which estimates are available. For example, S3II for Lakshadweep is the simple average of the normalised values of only 6 indicators whereas the S3II for Dadra & Nagar Haveli and Daman & Diu, Puducherry and Sikkim is the simple average of 7 indicators. This means that S3II is comparable for only those 19 states of the country for which estimates of all the 10 indicators are available. In 9 states and Union Territories, S3II is the simple average of 8 indicators whereas in 3 states and Union Territories, it is the simple average of 9 indicators.

Another problem with S3II is that it has been obtained by working out the simple average of the normalised values of the indicators, implying equal weight to all the indicators. The S3II, therefore, is associated with the problem of perfect substitutability which means that slow progress in terms of any one of the 10 indicators is fully compensated by the rapid progress in other indicators. In many states, the normalised values of some indicators is 1 which is associated with very low normalised values of other indicators but this inequality in progress in different indicators is not reflected in S3II. From policy and programme perspective, S3II should have given more weight to that indicator in which the progress is slow as compared to the indicator in which progress is fast so that more attention could be paid to that aspect of good health and well-being in which the progress is comparatively poor. There are many states and Union Territories in which the normalised values of some of the indicators has been set equal to 1 in the construction of S3II as these states and Union Territories have already achieved the target. This means that any further improvement in these indicators do not contribute at all to the improvement in the S3II.

There are data problems also. In Jammu & Kashmir and in Ladakh, the per centage of fully immunised children aged 9-11 months is estimated to be more than 100 per cent which is not possible. There is, however, no discussion on the quality of the data in the construction of S3II. Given all these limitations, we argue that S3II is not suitable to rank states and Union Territories of the country to reflect the progress towards SDG3–good health and well-being. There is a need of more refined methodology to construct a composite index that better reflects the progress towards SDG3 in the states and Union Territories of the country.

Alternative SDG3 India Index

For the sake of comparison, we have used the same set of 10 indicators and the same dataset that are used in the construction of S3II to construct an alternative SDG3 India Index ($S3II_A$). The approach followed by us to construct the alternative $S3II_A$ is summarised in the following steps:

1. The raw scores of the 10 indicators have been normalised by calculating the z-score. The z-score has been calculated different for indicators in which an increase reflects the progress and for indicators in which a decrease reflects the progress. If r_{kj} is the raw score of indicator k in state/Union Territory j, then the z-score for the indicator k in state/Union Territory j in which the increase reflects the progress is calculated as

   $$z_{kj} = \frac{r_{kj} - \overline{r_k}}{\sigma_k}$$

   where $\overline{r_k}$ is the arithmetic mean and σ_k is the standard deviation of r_{kj} over all j. On the other hand, the z-score for the indicator in which the decrease reflects the progress is calculated as

   $$z_{kj} = \frac{\overline{r_k} - r_{kj}}{\sigma_k}$$

   Using z-score for normalisation obviates the need of setting targets for the construction of goal scores.

2. The principal component analysis (Harman, 1960) has been used to calculate the weight for each of the 10 indicators to calculate the alternative SDG3 India Index. The $S3II_A$ is not the simple average of the normalised values of the indicators. Instead, it is the weighted sum of the 10 indicators with weights determined through the principal component analysis. The method proposed by Nicoletti et al (2000) has been used for the estimation of weights of different indicators.

3. If w_k is the weight for the indicator k, obtained through principal component analysis, then S3IIA for state/Union Territory j is calculated as

   $$S3II_A = \sum w_k \times z_{kj}$$

Results of the principal component analysis are presented in table 2. The K-M-O measure of sampling adequacy was found to be 0.592 while the Bartlett's test of sphericity was 85.220 which is statistically significant. This means that the principal component analysis was appropriate to group the 10 indicators into three components which accounted for almost 73 per cent of the variation in the original data set. The table also gives the weight assigned to each of the 10 indicators in the construction of S3IIA on the basis of the principal component analysis which have been used for the construction of the alternative $S3II_A$.

Table 2: Results of the principal component analysis of 10 indicators used in the construction of $S3II_A$.

Indicator	SDG target	Component 1	Component 2	Component 3	Communalities	Weight
MMR	3.1	0.809	0.117	-0.145	0.689	0.0994
CMR	3.2	0.806	0.347	0.006	0.770	0.0987
IMM	3.3	0.184	0.372	-0.832	0.863	0.1299
TBR	3.4	0.318	0.607	-0.097	0.479	0.0772
HIV	3.5	0.040	0.536	0.656	0.719	0.0807
SUR	3.6	-0.753	0.341	0.242	0.742	0.0861
DRR	3.7	-0.432	0.787	0.061	0.810	0.1300
IDL	3.8	0.821	-0.359	0.115	0.816	0.1023
OPE	3.9	0.025	-0.750	0.027	0.563	0.1179
PNM	3.10	-0.651	-0.007	0.282	0.832	0.0778
Eigen Values		3.382	2.368	1.534		

Extraction method: Principal component
Number of components extracted are based on Kaiser criterion (Harman, 1960)
Rotation Varimax
Source: Authors, based on data from Government of India (2022b)

The principal component analysis has revealed that the 10 indicators used to construct the S3II can be grouped into three components or factors. The first component or factor has high component loading in five indicators – maternal mortality ratio (MMR), child mortality rate (CMR), suicide rate (SUR), institutional deliveries as proportion to total deliveries (IDL) and physicians, nurses, and mid-wives per 10 thousand population (PNM). These five indicators are highly correlated. The second principal component, on the other hand, has high component loading in tuberculosis detection rate (TBR), death rate due to road traffic accidents (DRR) and share of per capita out-of-pocket expenditure on health (OPE) to the total per capita consumption expenditure which means that these three indicators are highly correlated. Finally, the third principal component has high loading in children aged 9-11 months fully immunised (IMM) and HIV infection rate (HIV) which suggests that the two indicators are highly correlated. Out of the total variation explained by the three principal components, the variation explained by the first principal component accounts for 46 per cent of the total variation, the second principal component accounts for 33 per cent of the total variation while the third principal component accounts for 21 per cent of the total variation explained by the three principal components.

Table 3 gives estimates of S3II and S3IIA for states and Union Territories along with their rank. $S3II_A$ could be computed for only 19 states for which data on all the 10 indicators are available. For the remaining states and Union Territories, $S3II_A$ could not be calculated whereas S3II has been calculated based on a reduced set of indicators so ranking does not make any sense.

Table 3: S3II and S3II$_A$ in states and Union Territories of India and rank of states/Union Territories in terms of S3II and S3II$_A$.

SN	State	S3II			S3II$_A$	
		Value	Rank1	Rank 2	Value	Rank
1	Andhra Pradesh	77	7	5	0.180	8
2	Arunachal Pradesh	64	22		na	na
3	Assam	59	28	19	-0.326	17
4	Bihar	66	21	15	-0.008	11
5	Chhattisgarh	60	26	17	-0.227	15
6	Goa	72	13		na	na
7	Gujarat	86	1	1	0.248	6
8	Haryana	72	14	11	-0.214	14
9	Himachal Pradesh	78	5		na	na
10	Jharkhand	74	11	9	0.230	7
11	Karnataka	78	6	4	0.266	4
12	Kerala	72	12	10	0.490	1
13	Madhya Pradesh	62	24	16	-0.432	19
14	Maharashtra	83	2	2	0.316	3
15	Manipur	68	17		na	na
16	Meghalaya	70	15		na	na
17	Mizoram	79	4		na	na
18	Nagaland	61	25		na	na
19	Odisha	67	20	13	-0.100	12
20	Punjab	77	9	5	0.054	9
21	Rajasthan	70	16	12	-0.276	16
22	Sikkim	62	23		na	na
23	Tamil Nadu	81	3	3	0.391	2
24	Telangana	67	18	13	-0.134	13
25	Tripura	67	19		na	na
26	Uttar Pradesh	60	27	17	-0.416	18
27	Uttarakhand	77	8	5	0.041	10
28	West Bengal	76	10	8	0.256	5
29	Andaman & Nicobar Islands	68	7		na	na
30	Chandigarh	74	3		na	na
31	Dadra & Nagar Haveli	74	14		na	na
32	Dam & Diu	80	5		na	na
33	Delhi	90	1		na	na
34	Jammu & Kashmir	70	5		na	na
35	Ladakh	70	6		na	na
36	Lakshadeep	78	2		na	na
37	Puducherry	70	4		na	na

Source: Estimates of S3II have been taken from the Government of India (2022b). The S3II has been calculated by the authors by using the same indicators and the same dataset that has been used for estimating S3II$_A$ but using different methodology as described in the text.

Perusal of table 3 reveals that rank of many states regarding progress in SDG3 is different when based on S3II as compared to the rank based on $S3II_A$. For example, Kerala ranks among 19 states in terms of $S3II_A$ whereas it ranks 8 in terms of $S3II_A$. Similarly, Gujarat ranks 1 among 19 states in terms of S3II but 6 in terms of $S3II_A$. Madhya Pradesh ranks the last among 19 states in terms of $S3II_A$, but its rank is better than the rank of Assam, Chhattisgarh and Uttar Pradesh in terms of S3II.

The $S3II_A$ is calculated using the same dataset that has been used for the calculation of S3II but with a different, more refined, methodology of construction of the composite index. The ranking of states/Union Territories based on $S3II_A$ shows that the ranking of states/Union Territories is influenced by the method used for the construction of the composite index. The S3II uses the simple arithmetic mean as to aggregate the normalised values of the indicators which have been termed as the goal score for SDG3. The limitations of the simple arithmetic mean as aggregation function in the construction of composite indexes is well-known and have been widely discussed and debated, especially, in the construction of the human development index. The main problem in using the simple arithmetic mean as the aggregation function is that the simple arithmetic mean is associated with the problem of perfect substitutability which means that a low normalised value of any one of the 10 indicators is compensated fully by high normalised value of other indicators. Another problem associated with the arithmetic mean is less reliable when the variation in the normalised values of the indicators is large. A third problem associated with the simple arithmetic mean as the aggregation function is that the interpretation of the simple arithmetic mean is difficult when the normalised values of the indicators are not statistically normally distributed across states and Union Territories of the country. variation in the goal scores across the 10 indicators is not statistically normally distributed and it is difficult to assume that the normalised values of the indicators across states and Union Territories of the country are statistically normally distributed. Moreover, if the normalised value of any one of the 10 indicators is exceptionally high relative to the normalised values of other indicators, then the simple arithmetic mean of the normalised values of the 10 indicators will be high even if goal scores of one or more of the remaining indicators is low which implies a high goal score. The geometric mean is recommended in place of the simple arithmetic mean as the aggregation function, but the geometric mean is biased towards indicators having low normalised values. In the extreme case, if the normalise value of any indicator is zero then the geometric mean of the 10 indicators is always zero irrespective of the normalised values of the other 9 indicators. When the normalisation is done using maximum and minimum values, then the normalised value of any indicator is zero for at least one state or Union Territory. This means that the geometric mean of 10 indicators will always be zero for that state/Union Territory.

New SDG3 India Index

It may be pointed out that the SDG3 of the United Nations 2030 Sustainable Development Agenda is directed towards promoting "good health and wellbeing" of the people. However, a perusal of the 10 indicators used by the Government of India in the construction of S3II suggests that all the 10 indicators are related to the health of the people only. There is no indicator which refers to the wellbeing dimension of SDG3. As such, the set of 10 indicators used by the Government of India for calculating S3II is incomplete and, for this reason, S3II may not be relevant to monitoring the progress in the wellbeing of the people. There is, therefore, a need to select a new set of indicators that reflect both health and wellbeing of the people and then calculating a new SDG3 India Index ($S3II_N$) following the alternative methodology used in this paper that more appropriately reflects the health and wellbeing of the people and that can be used for monitoring the progress towards SDG3 of the United Nations 2030 Sustainable Development Agenda.

Table 4 presents the new list of indicators that has been used to construct $S3II_N$ for India and its states and Union Territories. This new list of indicators includes indicators reflecting the health as well as wellbeing of the people. The selection of these 10 new indicators is based on scanning the correlation-matrix for all the 115 indicators of the national indicator framework adopted by the Government of India and preliminary factorial investigations. A justification of selecting the new set of indicators for the construction of $S3II_N$ is given below.

The United Nations 2030 Sustainable Development Agenda calls for reducing poverty by half of the proportions of men, women and children of all ages living in poverty in all its dimensions according to national definitions. Accordingly, the Government of India has targeted to reduce the proportion of population living below the national poverty line to around 10 per cent by the year 2030. According to the Tendulkar Committee Report, the population below the national poverty line was estimated to be around 28 per cent in 2011-12. According to the National Family Health Survey, the proportion of population living below the national poverty line was around 29 per cent in 2015-16 (Government of India, 2022a).

Table 4: List of new indicators for the calculation of $S3II_N$.

SDG goal	Indicator	Definition
3.1	MMR	Maternal mortality ratio per 100 thousand live births
3.2	CMR	Under 5 mortality rate per 1000 live births
1.1	BPL	Percentage of population living below national poverty line
1.2	MPI	Percentage of population multidimensionally poor
2.2	CUW	Percentage of children (< 5 years) low weight-for-age
4.3	GER	Gross enrolment ratio in higher secondary
6.7	GWA	Percentage of ground water withdrawal against availability
7.2	LPG	Percentage of household having LPG+PNG connection
9.6	MOB	Number of mobile connections per 100 persons
10.1	WQL	Percentage of population in the lowest two wealth quintiles

Source: Authors

Alleviation and eradication of poverty have always been the primary objective along with socioeconomic development and inequalities reduction in the Indian planning process. Methodologies for estimation of poverty line comprising of food and non-food baskets of essential items have undergone several modifications over the years. In the recent past, there has been an increase in the public expenditure on social services which has not been captured by the Consumer Expenditure Surveys conducted by the Government of India and, therefore, is neglected in the estimation of the poverty line. A detailed overview of methodological and data issues considered by various expert groups (Alagh Committee, 1979; Lakdawala Committee, 1993; Tendulkar Committee, 2005; Rangarajan Committee, 2014) constituted by the erstwhile Planning Commission for the estimation of the poverty line is given elsewhere (Naik and Tiwari, 2023). Obviating several limitations in the methodologies adopted by earlier expert groups, Rangarajan Committee Report recommended a per capita average monthly expenditure of Rs 972 for the rural areas and Rs 1407 for the urban areas as the poverty line (Government of India, 2014) taking into consideration the normative nutritional requirements of calories, proteins, fats and non-food essentials like clothing, rent, conveyance and education and other increasing government expenditures on social services. According to the Rangarajan Committee report, the population below the poverty line in the country has declined from 39.6 per cent in 2009-10 to 30.9 per cent in 2011-12 in the rural India and from 35.1 per cent to 26.4 per cent in the urban India so that the all-India poverty ratio fell from 38.2 per cent to 29.5 per cent. The Committee estimated that around 91.6 million people were lifted out of poverty during this period. On the other hand, according to the household expenditure survey 2022-2023, less than 5 per cent of the population of the country was living below the poverty line which suggests that around 248 million people have escaped poverty in last nine years.

The Government of India has also estimated the multidimensional poverty index (MPI) following the United Nations multidimensional poverty framework to drive policy reforms towards poverty reduction and improvements in wellbeing of the people. The national MPI retains all the ten indicators from the global MPI framework and incorporates two additional indicators – maternal health and bank accounts – in line with national priorities (Chand, 2023). The 10 indicators used to construct the global MPI are grouped into three equally weighted dimensions – health, education, and standard of living – following the approach adopted in the construction of the human development index (Government of India, 2022a). There are two indicators related to the health dimension, two indicators related to the education dimension and six indicators related to the standard of living dimension. The construction of MPI uses a nested weighting structure – equal weight to the three dimensions and equals weighting of the indicators related to different dimension. The MPI constructed by the Government of India, however, adjusts the MPI by the extent of deprivation (Chand, 2023).

Results of the principal component analysis based on the new set of indicators are presented in table 5. Perusal of the table reveals that 10 indicators can be grouped into two principal components which account for more than 80 per cent of the total variation in the data. The first principal has high loading in 8 indicators while the second principal component has high loading in two indicators. The K-M-O measure of sampling adequacy is found to be 0.593 whereas Bartlett's test of sphericity is found to be 193.03 which show the adequacy of the principal component model. The first principal component accounts for more than 55 per cent of the total variation explained by the two principal components whereas the second principal components accounts for about 44 per cent of the total variation explained.

Table 5: Principal component analysis of the new set of indicators adopted for the construction of $S3II_N$.

Indicator	SDG Goal	Component 1	Component 2	Communalities	Weight
MMR	3.1	0.068	0.944	0.896	0.2364
CMR	3.2	0.286	0.880	0.856	0.2056
BPL	1.1	0.786	0.537	0.907	0.0770
MPI	1.2	0.716	0.658	0.945	0.0638
CUW	2.2	0.701	0.408	0.658	0.0613
GER	4.3	0.600	0.584	0.702	0.0449
GWA	6.7	-0.799	0.074	0.643	0.0795
LPG	7.2	0.831	0.235	0.745	0.0860
MOB	9.6	0.753	0.585	0.909	0.0707
WQL	10.1	0.775	0.565	0.919	0.0748
Eigen Values		4.564	3.616		

Extraction Method: Principal Component
Number of Components Based on Kaiser Criterion (Harman, 1960)
Rotation Varimax
Source: Authors, based on data from Government of India (2022b).

Based on the results of the principal component analysis, $S3II_N$ that accounts for both good health and well-being for all states/Union Territories has been worked out and is presented table 6 for 18 states along with the rank of the state/Union Territory. The $S3II_N$ for the remaining states and Union Territories could not be calculated because of data gaps. We find that Kerala ranks first among the 18 states in terms of $S3II_N$ also while Madhya Pradesh ranks the last. Perusal of tables 3 and 6 reveals that the rank of states in terms of $S3II_A$ and in terms of $S3II_N$ is very similar. This comparison again shows that the methodology of the construction of the composite index reflecting the progress in SDG3 matters and different methodologies may depict different picture of progress. The S3II depicts a different picture of progress in SDG3 across states and Union Territories of the country compared to S3IIA and $S3II_N$ because the original SDG3 India Index is based on the methodology which has many limitations and weaknesses. When a more refined, data-driven methodology is used, the ranking of states is different even if different set of indicators is used for the construction of the index. Selection of the appropriate methodology for the construction of the composite index reflecting progress in SDGs is important. If the methodology of construction is imperfect, then the resulting composite index will depict a distorted picture.

Conclusions

This paper highlights the complexities involved in constructing a composite index to monitor the progress towards SDGs. The composite index of progress may change markedly depending upon the method used for normalising indicators and for aggregating normalised values of indicators even if the dataset used to construct the composite index remains the same.

Table 6: S3II and $S3II_N$ in the states and Union Territories of the country and rank of states/Union Territories in terms of S3II and $S3II_N$.

SN	State	S3II		$S3II_N$	
		Value	Rank	Value	Rank
1	Andhra Pradesh	77	5	0.317	5
2	Arunachal Pradesh	64		na	na
3	Assam	59	19	-1.057	14
4	Bihar	66	15	-1.101	15
5	Chhattisgarh	60	17	-1.110	17
6	Goa	72		na	na
7	Gujarat	86	1	0.127	9
8	Haryana	72	11	0.153	8
9	Himachal Pradesh	78		na	na
10	Jharkhand	74	9	-0.589	11
11	Karnataka	78	4	0.193	7
12	Kerala	72	10	1.176	1
13	Madhya Pradesh	62	16	-1.286	18
14	Maharashtra	83	2	0.602	3
15	Manipur	68		na	na
16	Meghalaya	70		na	na
17	Mizoram	79		na	na
18	Nagaland	61		na	na
19	Odisha	67	13	-0.868	13
20	Punjab	77	5	0.340	4
21	Rajasthan	70	12	-0.620	12
22	Sikkim	62		na	na
23	Tamil Nadu	81	3	0.790	2
24	Telangana	67	13	na	na
25	Tripura	67		na	na
26	Uttar Pradesh	60	17	-1.103	16
27	Uttarakhand	77	5	0.311	6
28	West Bengal	76	8	0.006	10
29	Andaman & Nicobar Islands	68		na	na
30	Chandigarh	74		na	na
31	Dadra & Nagar Haveli	74		na	na
32	Dam & Diu	80		na	na
33	Delhi	90		na	na
34	Jammu & Kashmir	70		na	na
35	Ladakh	70		na	na
36	Lakshadeep	78		na	na
37	Puducherry	70		na	na

Source: S3II is taken from the Government of India (2022b). The $S3II_N$ has been calculated by the authors by using a new set of indicators and different methodology used for the construction of the as discussed in the text. Estimates of $S3II_N$ are not available for some states and Union Territories.

There is no universally agreed method to construct a composite index out of a set of indicators for the purpose of monitoring the progress. The composite index is always a multidimensional construct. A description of different methods of construction of composite index and their strengths and weaknesses is given elsewhere (Narda et al, 2005). The selection of indicators for the construction of the composite index, although very important, is always arbitrary and depends primarily upon the availability of necessary data. There is no universally agreed protocol for the selection of indicators and different set of indicators by default lead to different composite indexes and, therefore, ranking of populations in terms of progress.

Dealing with missing values in the dataset is a major issue in the construction of composite indexes. There are different methods of data imputation. The most common one is to use the mean value of the indicator, but this may seriously distort the composite index. If the number of indicators used in the construction of the composite index is not the same for all populations, then the composite indexes are not comparable across population. Composite index must be based on those indicators only which are available for all the populations so as to ensure the comparability of the composite index across populations. This is a major limitation of the original SDG3 India Index as it is based on different number of indicators for different states and Union Territories.

Unlike the selection of indicators, there are different approaches for normalising the values of the indicators as the first step for the calculation of the composite index. The most common approach is the normalisation based on the variation of the indicator across populations as reflect through the range (maximum – minimum). Other approach of normalisation is calculation of the z-score based on the arithmetic mean and standard deviation of the distribution of the indicator values across populations. Both these approaches are based on the assumption that the distribution of the indicator values across populations are statistically normally distributed. If the distribution is not statistically normal, then the interpretation of the normalised values becomes difficult. One approach may be normalisation based on median of the distribution. Other approach may be normalisation based on some transformation of the indicator such as the logarithmic transformation. In any case, it is important to test the normality of the distribution of indicator values before normalisation.

Similarly, due considerations need to be given to the selection of the aggregation function for aggregating the normalised values of different indicators into a single composite index. The simple arithmetic mean is the most commonly used as has been used by the Government of India for the construction of SDG3 Index. The limitations of the arithmetic mean as the aggregation function are well-known particularly when there is wide variation in the normalised values of different indicators. The arithmetic mean gets influenced more by high or very high normalised values of some indicators at the cost of low to very low normalised values of other indicators as it is associated with the problem of perfect substitutability. The arithmetic mean is the most suited as the aggregation function when the underlying distribution is a statistically normal distribution. The reliability of the arithmetic mean decreases with the increase in variability. The geometric mean has been proposed as the alternative to the arithmetic mean in the construction of the composite index, but the geometric mean is influenced more by those indicators which have low or very low normalised values. In the extreme case when the normalised value of any one indicator is zero, the geometric mean is always zero irrespective of the normalised values of other indictors. Similarly, when the normalised value of any indicator is 1, then it has no impact on the geometric mean. Because of this reason, the geometric mean cannot be used as the aggregation function when the normalisation is done based on the range of the variation in the values of the indicators. A third alternative is to use the generalised mean or the power mean. The arithmetic mean and the geometric mean are the special cases of the generalised mean. The challenge with the use of generalised mean is that the selection of the power of the generalised mean is, at best, arbitrary and the value of the composite mean changes with the change in the power of the mean. However, by selecting a suitable value of the power of the mean, it is possible to give more weight to that indicator in which the progress lags as compared to that indicator in which the progress is advanced.

There are statistical approaches also to construct the composite index like SDG3 Index. In this paper, we have used the principal component analysis to construct a composite index. The advantage of the approach is that it is entirely data-driven and makes no assumption regarding normalisation and aggregation. The approach also takes into consideration the correlation among the indicators used for the construction of the composite index. This approach also gives different weights to different indicators used in the construction of the index. The limitation of this approach, however, is that the weights given to different indicators are data-dependency in the sense that they are changed when new dataset is used for the principal component analysis. They are not constant across datasets and, therefore, any composite index based on the principal component analysis is not strictly comparable over time and across populations.

Taking different issues associated with the construction of a composite index into consideration, we recommend that construction of any composite index for monitoring the progress towards SDGs should be based on the following approach:

1. Due considerations should be given to the selection of indicators to reflect for multidimensional wellbeing as ranking in terms of the progress depends upon the indicators selected for the construction of the index.
2. The normalisation of raw data or the values of the indicators should be done based on arithmetic mean and standard deviation rather than range (maximum – minimum) or a variation of it (target - minimum) or (minimum – target). Using arithmetic mean and standard deviation for normalisation will obviate the need of setting up the target for different indicators.
3. Goal scores for different SDGs should be elicited using the principal component analysis method which take into consideration the correlation that exists among the indicators used for the construction of the index.
4. The goal scores of different indicators should be aggregated into the composite index using the eigen values obtained through the principal component analysis. This approach of aggregation gives different weights to different indicators used in the construction of the composite index. The weight of the indicator depends upon the extent of variation of the indicator across the states and Union Territories of the country.

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Appendix table 1: Descriptive statistics of the 10 indicators used for constructing original SDG3 India Index.

SDG target		N	Minimum	Maximum	Mean	Standard deviation
3.1	MMR	19	43	215	112.58	51.43
3.2	CMR	23	10	56	31.61	11.04
3.3	IMM	37	54	109	86.11	13.39
3.4	TBR	37	23	606	189.86	113.97
3.5	HIV	36	0	1	0.12	0.22
3.6	SUR	37	0	46	12.54	9.95
3.7	DRT	37	0	19	10.25	4.78
3.8	IDL	37	60	100	94.69	7.54
3.9	OPE	36	5	19	11.89	3.57
3.10	PNM	32	1	115	35.06	25.89

Appendix table 2: Descriptive statistics of the 10 indicators used for constructing alternative SDG3 India Index.

SDG target		N	Minimum	Maximum	Mean	Standard deviation
3.1	MMR	19	43	215	112.58	51.43
3.2	CMR	23	10	56	31.61	11.04
3.3	IMM	37	54	100	85.62	12.69
3.4	TBR	37	23	606	189.86	113.97
3.5	HIV	36	0	1	0.12	0.22
3.6	SUR	37	0	46	12.54	9.95
3.7	DRT	37	0	19	10.25	4.78
3.8	IDL	37	60	100	94.69	7.54
3.9	OPE	36	5	19	11.89	3.57
3.10	PNM	32	1	115	35.06	25.89

Appendix table 3: Descriptive statistics of 10 indicators used for constructing new SDG3 India Index.

SDG target		N	Minimum	Maximum	Mean	Standard deviation
3.1	MMR	19	43	215	112.58	51.43
3.2	CMR	23	10	56	31.61	11.04
1.1	BPL	36	1	40	18.26	11.34
1.2	MPI	37	1	52	19.52	13.79
2.2	CUW	31	11	43	26.11	9.17
4.3	GER	37	5.5	54	28.17	11.60
6.7	GWA	37	0	100	46.05	31.12
7.2	LPG	37	48	100	92.33	11.93
9.6	MOB	37	51	100	85.34	14.87
10.1	WOL	37	1	75	30.73	21.14