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JRC Statistical Audit of the Individual Deprivation Measure

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Contents

Abstract

The Individual Deprivation Measure (IDM) is a gender-sensitive, multidimensional measure of poverty. The measure assesses deprivation at the individual level, in relation to 15 key dimensions of life, namely Food, Water, Shelter, Health, Education, Energy/fuel, Sanitation, Relationships, Clothing, Violence, Family planning, Environment, Voice, Time- Use and Work. It offers information additional to other national surveys, providing a high level summary of deprivation through an index while enabling users to gain further understanding through the decomposition and disaggregation of the scalar, gender-sensitive, individual-level data on which it is based.

European Commission's Competence Centre on Composite Indicators and Scoreboards (COIN) at the Joint Research Centre (JRC) was invited by the International Women's Development Agency (IWDA) to audit the IDM study concerning the Fiji (2014-17) dataset. In this dataset, composed by almost three thousands subjects, only 13 out of 15 key dimensions of the IDM are considered.

The statistical audit presented herein aims to contribute to ensuring the transparency of the IDM methodology and the reliability of the results. The report touches upon data quality issues, the conceptual and statistical coherence of the framework and the impact of modelling assumptions on the results.

1 Introduction

The Individual Deprivation Measure (IDM) framework defines a gender-sensitive, multidimensional measure of poverty. The measure assesses deprivation at the individual level, in relation to 15 key dimensions of life, namely Food, Water, Shelter, Health, Education, Energy/fuel, Sanitation, Relationships, Clothing, Violence, Family planning, Environment, Voice, Time- Use and Work.

It offers information additional to other national surveys, providing a high level summary of deprivation through an index while enabling users to gain further understanding through the decomposition and disaggregation of the scalar, gender-sensitive, individual-level data on which it is based.

The IDM was developed through an initial 4-year cross-disciplinary international research collaboration, led by the Australian National University (ANU), in partnership with International Women's Development Agency (IWDA) and the Philippine Health and Social Science Association, University of Colorado at Boulder, and Oxfam Great Britain (Southern Africa), with additional support from Oxfam America and Oslo University. The research sought to answer the question what is a just and justifiable measure of poverty that is gender sensitive and capable of revealing gender disparities. The first IDM study beyond the proof-of-concept trial was carried out in Fiji (2014–17) by IWDA working with Fiji Bureau of Statistics (FBoS) (Mcinerney, Fisk, & Crawford, 2019).

European Commission's Competence Centre on Composite Indicators and Scoreboards (COIN) at the Joint Research Centre (JRC) was invited by the International Women's Development Agency (IWDA) to audit the IDM study concerning the Fiji (2014-17) dataset. The JRC statistical audit is based on the recommendations of the Handbook on Composite Indicators (OECD and JRC, 2008) as well as on more recent research from the JRC. The Handbook offers a 10-step guidance on the process of building composite indicators. The statistical audit presented herein aims to contribute to ensuring the transparency of the IDM methodology and the reliability of the results, with the additional purpose of contributing to the improvements of the methodology and scoring that are under development by the current IDM program.

The audit of the IDM focuses on two main issues: the statistical coherence of the conceptual framework *(Section 3*) and the impact of key modelling assumptions on the IDM ranking *(Section 4, Section 5).* The audit follows three main steps: the first focuses on the main descriptive statistics and on the detection of missing values and potential outliers; the second on the analysis of the statistical coherence through an analysis of the correlations of the indicator, themes and dimensions; and the third, on the sensitivity analysis of the index and the testing of the impact of key modelling assumptions. The results are supported by a spreadsheet in Excel format shared with the IDM team.

The results of the audit presented herein aim at shedding light on the transparency and reliability of the IDM. It expects to contribute to enable policymakers and advocates to derive more accurate and meaningful conclusions as well as to guide choices on priority setting and policy formulation.

2 Conceptual framework

The Individual Deprivation Measure (IDM) is a tool meant to assess deprivation at the individual level and complement current approaches, which measure poverty at the household level. It takes into account 15 dimensions of individual deprivation, comprised of 23 themes, based on 34 individual indicators that are defined using responses to one or more survey questions (Table 1). The dimensions are categorised into three groups of importance and weighted accordingly; the 5 most important dimensions (dimensions 1-5, orange color) receive a total weighting of 50%, the 5 next-most important dimensions (dimensions 6-10, blue color) receive a total weighting of 33% and the remaining 5 (dimensions 11-15, light blue color) receive a total weighting of 17%.

In the case of Fiji to which this analysis is based, the themes of Violence and Family Planning are not being considered due to specific problems[1](Fisk, Crawford, & Slatter, 2015), resulting in 13 final dimensions instead of 15, 20 themes and 29 indicators.

The Fiji data have been collected between 2015 and 2016 on approximately 3000 individuals in 1125 households. The IDM index, obtained from the aggregation of the key dimensions, is meant to be representative at districts level. Further, the individual structure of the data allows for representation of Ethnic groups, Gender, and other meaningful subgroups. The developers aim at assessing the circumstances of individuals rather than households, in order to enable for a more accurate disaggregation of data.

Table 1. Conceptual framework of the Individual Deprivation Measure

No	Dimension	Theme	Indicator
1	Food	Security	Experience of hunger
2	Water	Quality	Source & treatment
		Accessibility	Distance
		Sufficiency	Frequency of sufficient
3	Shelter	Habitability	Housing materials
			Condition
		Homelessness	Homelessness
4	Health	Status	Status
			Exposure to fumes
		Health Care	Health Care
5	Education	Attainment	Schooling
			Literacy & numeracy
		Quality	Reading
			Writing
			Numeracy
6	Energy/ Fuel	Electricity	Access
			Reliability
		Cooking fuel	Cooking fuel
7	Sanitation	Quality	Toilet facilities
8	Relationships	Support	Ability to access support
9	Clothing	Clothing	Protection

[1] IDM report, Exploring multidimensional poverty in Fiji (2017), p.125, chapter 10.

No	Dimension	Theme	Indicator
			Presentation
10	Violence		
11	Family planning		
12	Environment	Hazards	Exposure to hazards
13	Voice	In the community	Raise opinion
			Bring about change
		In the household	Control over decisions
14	Time Use	Labour burden	Leisure time
15	Work	Paid work	Type of work
			Security and hazards
			Respect
		Unpaid work	Security and hazards
			Respect

The IDM hierarchical framework is conceptually well justified and its structure and themes cover the most relevant dimensions of deprivation.

Indicators and survey questions, designed to measure these aspects of each dimension were selected based on their validity, reliability, specificity, feasibility, and comparability, and an overall emphasis on parsimony.

3 Statistical assessment

The statistical assessment of the IDM framework was performed as follows:

- Assessment of missing data (section 3.1);
- Assessment of the weighting and aggregation methods (section 3.2)
- Identification of indicators with strong collinearity, "silent" indicators and indicators that point to the opposite direction and assessment of the statistical coherence of the dimensions (section 3.3);

3.1 Data quality and availability

The data analysis presented herein uses the indicators, themes, dimensions and the overall scores[2] provided by the developers.

[2] The IDM team provided the arithmetic mean (weighted, unweighted). The geometric ones are calculated by the JRC as an alternative

The IDM data are based on the IDM survey tool that was administered in Fiji and comprised two surveys: a household survey administered to the individual nominated as the most knowledgeable in the household and an individual survey administered to every adult member of the household. The survey aimed to measure the individual experience of deprivation for each of the 15 IDM dimensions.

Table 2 offers summary statistics for the indicators included in the IDM using the indicators' scores and highlights the cases in which specific issues were found in terms of missing variables.

Only six cases were identified with missing data above 10%. These are the following:

- Indicator 3.2.1 on Homelessness. In this case there are 13 individuals that had experienced homelessness and were assigned a score of 0 (most deprived).
- Indicator 5.1.2 on Literacy and numeracy.
- Indicator 6.1.2 on Reliability of electricity. This question is a follow up to the access to electricity. Obviously, the individuals that replied no in the access were not questioned, thus the sample population for this should be considered 478 individuals (that had access to electricity).
- Indicator 15.1.2 on Paid work - Security and hazards. This is a follow up question asked only to the persons that had a paid work.
- Indicator 15.1.3 on Paid work - Respect. This is a follow up question, asked only to the persons that had a paid work.
- Indicator 15.2.2 on Unpaid work - This is a follow up question, asked only to the persons that had an unpaid work.

JRC signalled these cases in previous communications with the IDM team and after bilateral discussions, possible ways to move forwards were found.

Since the indicators are based on the specific surveys[3], there are not missing data per individual, apart from the questions that were omitted due to the structure of the questionnaire/ design of the survey. To this respect, changes have been made to future iterations of the survey tool for improvement.

Table 2. Summary statistics of the indicators (normalised data) included in the 2020 IDM.

Code	Individuals	% Missing data	Mean	Standard Deviation	Median	Min. value	Max. value	Range
1.1.1	2966	0	2.64	0.89	3	0	3	3
2.1.1	2966	0	2.90	0.51	3	0	3	3
2.2.1	2966	0	2.81	0.54	3	0	3	3
2.3.1	2966	0	2.09	1.12	3	0	3	3
3.1.1	2966	0	1.69	0.99	1	0	3	3
3.1.2	2966	0	1.96	1.18	3	0	3	3
3.2.1	**13**	**99.6**	0.00	0.00	0	0	0	0
4.1.1	2966	0	2.42	0.92	3	0	3	3
4.1.2	2966	0	2.51	0.89	3	0	3	3
4.2.1	2966	0	1.63	1.28	2	0	3	3
5.1.1	2966	0	2.46	0.77	3	0	3	3

[3] IDM survey tool

Code	Individuals	% Missing data	Mean	Standard Deviation	Median	Min. value	Max. value	Range
5.1.2	**266**	**91.0**	0.32	0.50	0	0	2	2
6.1.1	2966	0	2.52	1.10	3	0	3	3
6.1.2	**2488**	**16.1**	2.79	0.49	3	1	3	2
6.2.1	2966	0	0.96	1.40	0	0	3	3
7.1.1	2966	0	2.72	0.56	3	0	3	3
8.1.1	2966	0	2.04	1.07	2	0	3	3
9.1.1	2966	0	2.28	0.94	3	0	3	3
9.1.2	2966	0	2.36	0.89	3	0	3	3
12.1.1	2966	0	2.23	0.83	2	0	3	3
13.1.1	2798	5.7	1.87	1.09	2	0	3	3
13.1.2	2711	8.6	1.83	1.07	2	0	3	3
13.2.1	2966	0	1.97	0.98	2	0	3	3
14.1.1	2966	0	2.40	0.80	3	0	3	3
15.1.1	2965	0.0	1.43	1.40	2	0	3	3
15.1.2	**1559**	**47.4**	2.53	1.01	3	0	3	3
15.1.3	**118**	**96.0**	1.00	0.00	1	1	1	0
15.2.1	2965	0.0	2.78	0.74	3	0	3	3
15.2.2	**127**	**95.7**	1.00	0.00	1	1	1	0

Note: Indicators highlighted in red have data coverage below 85%.

Source: European Commission's Joint Research Centre, 2020.

3.2 Weighting and aggregation

The hierarchical structure of the IDM is designed to allow the user to disaggregate the index and gain more detail on how individuals (and groups of individuals with similar characteristics) are deprived[4](Individual Deprivation Measure Study in Fiji). To assign indicator scores, combinations of responses to one or more survey questions are ranked on an interval scale from 0 (most deprived) to 3 (least deprived), reflecting individual experience of deprivation. An individual's score for each theme is the simple arithmetic mean of all non-missing indicator scores within that theme, and the individual's score for each dimension is the simple arithmetic mean of all non-missing theme scores within that dimension.

The final IDM score for an individual is the weighted arithmetic mean of all dimension scores. Weighting is applied when aggregating the dimension scores to the overall score and are based on participatory work. The dimensions are categorised into three groups of importance and weighted accordingly; the 5 most important dimensions (dimensions 1-5) receive a total weighting of 50%, the 5 next-most important dimensions (dimensions 6-10) receive a total weighting of 33% and the remaining 5 (dimensions 11-15) receive a total weighting of 17%.

However, it is important to notice that, since in the Fiji dataset the two dimensions of Violence and Family Planning are missing, the weights of the dimensions in the second and third group are higher than they would be if all dimensions were present. It is significant to understand whether the three groups need to maintain this difference in weights irrespectively to the number of dimension each group actually contains; or the individual dimensions should maintain the assigned difference between them. In the first case, we notice that having less dimensions in the second or third group increases the risk for these dimensions to account for more (or similar) weight that the ones of the first group. As an example, an extreme case scenario would be to miss dimensions 9 and 10. In this

[4] Individual Deprivation Measure Study in Fiji (2014-17): Technical Guide, October 2019, p11

case, the assigned weight to dimensions 6, 7 and 8 would be 11.1% for each- more than the 10% assigned to the first five dimensions. Table 3 shows the theoretical weight when all dimensions are present, the actual weight that the Fiji data dimensions get and what the weight in each dimension should be, in order to maintain the initial difference between them. A specific analysis of this issue and its effects is presented in Section 5.1.

Table 3. Weights assigned to each dimension

Dimension	Theoretical weight	Actual weight	Weight to keep initial difference
Group1	***Total – 50%***	***Total – 50%***	***Total – 55%***
Food	10%	10%	11.1%
Water	10%	10%	11.1%
Shelter	10%	10%	11.1%
Health	10%	10%	11.1%
Education	10%	10%	11.1%
Group2	***Total – 33%***	***Total – 33%***	***Total – 30%***
Energy/ Fuel	6.7%	8.3%	7.4%
Sanitation	6.7%	8.3%	7.4%
Relationships	6.7%	8.3%	7.4%
Clothing	6.7%	8.3%	7.4%
Violence	6.7%	-	-
Group3	***Total – 17%***	***Total – 17%***	***Total – 15%***
Family planning	3.3%	-	-
Environment	3.3%	4.2%	3.7%
Voice	3.3%	4.2%	3.7%
Time Use	3.3%	4.2%	3.7%
Work	3.3%	4.2%	3.7%

Source: European Commission's Joint Research Centre, 2020.

Regarding the aggregation formula, the arithmetic average is used at all levels to build the IDM; while arithmetic averages are easy to interpret, they also allow perfect compensability between the variables, whereby a high score on one variable can fully offset low scores in other variables. This may not necessarily fit with the concept of individual deprivation. For this reason, in the following analysis the geometric average (weighted and unweighted) of the dimensions is also calculated, as an alternative aggregation method which is less compensatory and fits with the view that scores in different dimensions should not compensate one another. Another, non-compensatory method that could fit well with the IDM data is the Copeland's aggregation method that is based on pairwise comparisons (see Section 5.2). The impacts of the aggregation formula as well as of the weighting scheme in the index results are discussed thoroughly in Section 4.

3.3 Correlation analysis

The statistical coherence should be considered a necessary but not a sufficient condition for a sound composite measure. Given that the statistical analysis is mostly based on correlations, the correspondence of the IDM to a real world phenomenon needs to be critically addressed because "correlations do not necessarily represent the real influence of the individual indicators on the phenomenon being measured" (OECD & JRC, 2008). This relies on the interplay between both conceptual and statistical soundness. The correlation analysis is used to address to what extent the data support the conceptual framework. In the ideal case, there should be positive significant correlations within every level of the index, i.e. each indicator positively correlated with its theme, each theme with its dimension and each dimension with the overall IDM. This effectively ensures that the overall scores adequately reflect the underlying indicator values.

Table 4 shows the correlation coefficients between dimensions and the IDM. Overall, correlations are significant and positive, except for the Time use dimension (dim14) that does not correlate with the overall index and most of the other dimensions, and even shows negative correlation with a few of them (Education-5, Energy/Fuel-6 and Environment-12). It is worth mentioning that considering the alternative equally weighted methods even this dimension is significantly correlated to the index. Nevertheless, since the developers and the conceptual framework identify the first dimensions as of higher importance, JRC initially recommended to consider excluding or modifying the Time Use dimension. Responding to that, the developers indicated their intention to modify the scoring method of the indicators within the Time Use dimension as it is considered to be an important conceptual element of a gender sensitive measure of deprivation.

Table 4. Pearson correlation coefficients between dimensions and IDM

	IDM Weighted Arithmetic Mean	IDM Arithmetic Mean	IDM Weighted Geometric Mean	IDM Geometric Mean	Food (dim1)	Water (dim2)	Shelter (dim3)	Health (dim4)	Education (dim5)	Energy/ Fuel (dim6)	Sanitation (dim7)	Relationships (dim8)	Clothing (dim9)	Environment (dim12)	Voice (dim13)	Time Use (dim14)	Work (dim15)
Food	**0.54**	0.51	0.53	0.51	1.00												
Water	**0.40**	0.38	0.37	0.36	0.10	1.00											
Shelter	**0.61**	0.56	0.62	0.56	0.22	0.15	1.00										
Health	**0.26**	0.23	0.24	0.21	0.07	0.01	0.08	1.00									
Education	**0.35**	0.28	0.35	0.29	0.06	0.06	0.12	-0.07	1.00								
Energy/ Fuel	**0.51**	0.45	0.51	0.45	0.10	0.22	0.32	0.06	0.16	1.00							
Sanitation	**0.51**	0.48	0.49	0.47	0.16	0.26	0.30	0.03	0.15	0.37	1.00						
Relationships	**0.51**	0.52	0.52	0.53	0.16	0.11	0.17	0.02	0.02	0.04	0.11	1.00					
Clothing	**0.56**	0.55	0.55	0.54	0.23	0.13	0.27	0.04	0.09	0.17	0.20	0.33	1.00				
Environment	**0.27**	0.37	0.27	0.36	0.24	0.08	0.13	0.05	-0.07	-0.09	0.06	0.15	0.10	1.00			
Voice	**0.23**	0.35	0.23	0.35	0.12	0.12	0.03	-0.01	-0.03	-0.07	0.03	0.14	0.15	0.14	1.00		
Time Use	**0.02**	0.10	0.01	0.09	0.00	0.01	0.00	0.00	-0.17	-0.06	0.00	0.05	-0.06	0.03	0.01	1.00	
Work	**0.28**	0.36	0.28	0.36	0.09	0.07	0.05	0.07	0.16	0.07	0.08	0.10	0.15	0.03	0.19	-0.26	1.00

Note: Numbers represent the Pearson correlation coefficients between dimensions and overall IDM, using different aggregation methods. Correlations that are not significant (significance level α = 0.01) are in grey and negative ones in red. Source: European Commission's Joint Research Centre, 2020.

Table 5. Pearson correlation coefficients between themes, dimensions and the IDM.

	Food	Water	Shelter	Health	Education	Energy/Fuel	Sanitation	Relationships	Clothing	Environment	Voice	Time Use	Work	Overall IDM			
Theme	dim1	dim2	dim3	dim4	dim5	dim6	dim7	dim8	dim9	dim12	dim13	dim14	dim15	Weighted Arithmetic Mean	Arithmetic Mean	Weighted Geometric Mean	Geometric Mean
thm1.1	1.00	0.10	0.22	0.07	0.06	0.10	0.16	0.16	0.23	0.24	0.12	0.00	0.09	0.54	0.51	0.53	0.51
thm2.1	0.05	0.57	0.09	-0.02	0.06	0.16	0.23	0.04	0.03	-0.08	0.04	-0.01	0.03	0.22	0.19	0.21	0.19
thm2.2	0.06	0.60	0.06	-0.01	0.12	0.22	0.22	0.06	0.03	-0.03	0.03	-0.01	0.05	0.25	0.23	0.24	0.22
thm2.3	0.09	0.80	0.12	0.02	0.00	0.11	0.14	0.11	0.15	0.16	0.13	-0.01	0.05	0.32	0.31	0.29	0.29
thm3.1	0.22	0.14	1.00	0.08	0.12	0.32	0.30	0.17	0.27	0.13	0.03	0.00	0.05	0.61	0.56	0.61	0.56
thm3.2																	
thm4.1	0.20	0.03	0.07	0.30	0.05	0.08	0.05	0.14	0.14	0.15	0.05	-0.02	0.20	0.27	0.28	0.26	0.28
thm4.2	-0.04	-0.01	0.05	0.87	-0.10	0.02	0.00	-0.05	-0.03	-0.03	-0.04	0.01	-0.04	0.12	0.08	0.11	0.08
thm5.1	0.06	0.06	0.12	-0.07	1.00	0.16	0.15	0.02	0.09	-0.07	-0.03	-0.17	0.16	0.35	0.28	0.35	0.29
thm6.1	0.14	0.21	0.35	0.03	0.06	0.69	0.35	0.11	0.19	0.05	0.00	-0.02	0.05	0.46	0.43	0.49	0.46
thm6.2	0.03	0.14	0.17	0.05	0.17	0.83	0.24	-0.03	0.08	-0.16	-0.10	-0.07	0.06	0.33	0.28	0.32	0.26
thm7.1	0.16	0.26	0.30	0.03	0.15	0.37	1.00	0.11	0.20	0.06	0.03	0.00	0.08	0.51	0.48	0.49	0.47
thm8.1	0.16	0.11	0.17	0.02	0.02	0.04	0.11	1.00	0.33	0.15	0.14	0.05	0.10	0.51	0.52	0.52	0.53
thm9.1	0.23	0.13	0.27	0.04	0.09	0.17	0.20	0.33	1.00	0.10	0.15	-0.06	0.15	0.56	0.55	0.55	0.54
thm12.1	0.24	0.08	0.13	0.05	-0.07	-0.09	0.06	0.15	0.10	1.00	0.14	0.03	0.03	0.27	0.37	0.27	0.36
thm13.1	0.09	0.08	-0.01	-0.02	-0.01	-0.12	0.01	0.05	0.01	0.12	0.77	0.01	0.08	0.11	0.20	0.12	0.20
thm13.2	0.09	0.11	0.06	0.00	-0.03	0.00	0.03	0.18	0.23	0.09	0.74	0.01	0.21	0.24	0.33	0.24	0.33
thm14.1	0.00	-0.01	0.00	0.00	-0.17	-0.06	0.00	0.05	-0.06	0.03	0.01	1.00	-0.26	0.02	0.10	0.01	0.09
thm15.1	0.05	0.05	0.04	0.05	0.17	0.05	0.04	0.08	0.11	-0.01	0.18	-0.30	0.90	0.22	0.28	0.21	0.27
thm15.2	0.11	0.07	0.05	0.06	0.06	0.07	0.10	0.08	0.13	0.09	0.10	-0.03	0.60	0.23	0.29	0.24	0.31

Note: Numbers represent the Pearson correlation coefficients between themes, dimensions and overall IDM, using different aggregation methods. Correlations that are not significant (significance level a = 0.01) are in grey and negative ones in red.

Theme 3.2 (Homelessness) remains empty as it consists 99% of missing values, the correlation coefficient cannot be calculated

Source: European Commission's Joint Research Centre, 2020.

Table 6. Pearson correlation coefficients between themes

Themes	1.1	2.1	2.2	2.3	3.1	3.2	4.1	4.2	5.1	6.1	6.2	7.1	8.1	9.1	12.1	13.1	13.2	14.1	15.1	15.2
1.1	1	0.05	0.06	0.09	0.22		0.20	-0.04	0.06	0.14	0.03	0.16	0.16	0.23	0.24	0.09	0.09	0.00	0.05	0.11
2.1	0.05	1	0.49	0.08	0.10		-0.02	-0.01	0.06	0.17	0.10	0.23	0.04	0.03	-0.08	0.02	0.04	-0.01	0.03	0.03
2.2	0.06	0.49	1	0.11	0.06		-0.01	-0.01	0.12	0.19	0.15	0.22	0.06	0.03	-0.03	0.02	0.02	-0.01	0.05	0.02
2.3	0.09	0.08	0.11	1	0.12		0.06	-0.01	0.00	0.11	0.07	0.14	0.11	0.15	0.16	0.09	0.12	-0.01	0.03	0.07
3.1	0.22	0.10	0.06	0.12	1		0.07	0.05	0.12	0.34	0.17	0.30	0.17	0.27	0.13	-0.01	0.06	0.00	0.04	0.04
3.2																				
4.1	0.20	-0.02	-0.01	0.06	0.07		1	-0.22	0.05	0.04	0.07	0.05	0.14	0.14	0.15	0.01	0.08	-0.02	0.12	0.23
4.2	-0.04	-0.01	-0.01	-0.01	0.05		-0.22	1	-0.10	0.01	0.02	0.00	-0.05	-0.03	-0.03	-0.02	-0.04	0.01	-0.01	-0.06
5.1	0.06	0.06	0.12	0.00	0.12		0.05	-0.10	1	0.06	0.17	0.15	0.02	0.09	-0.07	-0.01	-0.03	-0.17	0.17	0.06
6.1	0.14	0.17	0.19	0.11	0.34		0.04	0.01	0.06	1	0.17	0.35	0.11	0.19	0.05	-0.01	0.01	-0.02	0.03	0.05
6.2	0.03	0.10	0.15	0.07	0.17		0.07	0.02	0.17	0.17	1	0.24	-0.03	0.08	-0.16	-0.15	0.00	-0.07	0.05	0.05
7.1	0.16	0.23	0.22	0.14	0.30		0.05	0.00	0.15	0.35	0.24	1	0.11	0.20	0.06	0.01	0.03	0.00	0.04	0.10
8.1	0.16	0.04	0.06	0.11	0.17		0.14	-0.05	0.02	0.11	-0.03	0.11	1	0.33	0.15	0.05	0.18	0.05	0.08	0.08
9.1	0.23	0.03	0.03	0.15	0.27		0.14	-0.03	0.09	0.19	0.08	0.20	0.33	1	0.10	0.01	0.23	-0.06	0.11	0.13
12.1	0.24	-0.08	-0.03	0.16	0.13		0.15	-0.03	-0.07	0.05	-0.16	0.06	0.15	0.10	1	0.12	0.09	0.03	-0.01	0.09
13.1	0.09	0.02	0.02	0.09	-0.01		0.01	-0.02	-0.01	-0.01	-0.15	0.01	0.05	0.01	0.12	1	0.13	0.01	0.08	0.04
13.2	0.09	0.04	0.02	0.12	0.06		0.08	-0.04	-0.03	0.01	0.00	0.03	0.18	0.23	0.09	0.13	1	0.01	0.19	0.11
14.1	0.00	-0.01	-0.01	-0.01	0.00		-0.02	0.01	-0.17	-0.02	-0.07	0.00	0.05	-0.06	0.03	0.01	0.01	1	-0.30	-0.03
15.1	0.05	0.03	0.05	0.03	0.04		0.12	-0.01	0.17	0.03	0.05	0.04	0.08	0.11	-0.01	0.08	0.19	-0.30	1	0.19
15.2	0.11	0.03	0.02	0.07	0.04		0.23	-0.06	0.06	0.05	0.05	0.10	0.08	0.13	0.09	0.04	0.11	-0.03	0.19	1

Similarly, all themes are correlated with their dimensions and the overall IDM, as it can be seen in Table 5. The correlation between the themes and the IDM is positive but often not very strong (lower than 0.3 for ten themes,), but this is to be expected for such a measure. All the relationships are statistically significant, with the exception of theme 14.1.

Similarly, themes within dimensions are positively correlated with the exception of the themes in dimension 4 – Health. In Table 6 we can notice that theme 4.1 (Health Status) and theme 4.2 (Health care) are negatively correlated with each other. The JRC team suggests focusing on this fundamental aspect (considering the importance of Health). Often, when two variables are negatively correlated they may be describing something different from what is assumed in the conceptual framework. The exclusion or modification of theme 4.2 may be needed in order to improve the coherence of the Health dimension and its influence in the IDM.

The cross-correlation analysis confirms that all the indicators are more correlated with their own theme than with any other theme (see table in accompanying excel) and their own dimension than any other dimension. As shown in Table 7, there are significant correlations between indicators and their corresponding theme, dimension and the overall index, thus suggesting that the indicators provide meaningful information on the variation of the category scores. The only critical results are shown within the Health dimension where indicators 4.1.1 seems to be uncorrelated with the IDM as well as 4.2.1.

Table 7. Kendall correlation coefficients between indicators and their corresponding theme, dimension and the overall IDM.

Dimension	Theme	Indicator	Corresponding theme	Corresponding dimension	IDM Weighted Arithmetic Mean	IDM Arithmetic Mean	IDM Weighted Geometric Mean	IDM Geometric Mean
Food	Security	1.1.1	1.00	1.00	0.37	0.36	0.37	0.35
Water	Quality	2.1.1	1.00	0.32	0.16	0.14	0.16	0.14
	Accessibility	2.2.1	1.00	0.43	0.21	0.19	0.20	0.19
	Sufficiency	2.3.1	1.00	0.86	0.25	0.24	0.22	0.22
Shelter	Habitability	3.1.1	0.68	0.68	0.35	0.32	0.35	0.31
		3.1.2	0.78	0.78	0.44	0.39	0.44	0.39
	Homelessness	3.2.1						
Health	Status	4.1.1	0.69	0.08	0.08	0.08	0.08	0.08
		4.1.2	0.64	0.25	0.22	0.23	0.21	0.22
	Health Care	4.2.1	1.00	0.77	0.10	0.07	0.09	0.06
Education	Attainment	5.1.1	1.00	1.00	0.27	0.22	0.26	0.21
		5.1.2	0.77	0.77	0.10	0.09	0.16	0.14
Energy/ Fuel	Electricity	6.1.1	0.75	0.54	0.34	0.32	0.36	0.35
		6.1.2	1.00	0.56	0.14	0.10	0.13	0.10
	Cooking fuel	6.2.1	1.00	0.75	0.28	0.23	0.26	0.21
Sanitation	Quality	7.1.1	1.00	1.00	0.40	0.38	0.39	0.37
Relationships	Support	8.1.1	1.00	1.00	0.38	0.40	0.39	0.40
Clothing	Clothing	9.1.1	0.85	0.85	0.41	0.40	0.39	0.38
		9.1.2	0.82	0.82	0.38	0.38	0.36	0.36
Environment	Hazards	12.1.1	1.00	1.00	0.19	0.27	0.19	0.26
Voice	In the community	13.1.1	0.95	0.66	0.09	0.16	0.10	0.16
		13.1.2	0.96	0.65	0.09	0.16	0.10	0.16
	In the household	13.2.1	1.00	0.63	0.18	0.25	0.18	0.24
Time Use	Labour burden	14.1.1	1.00	1.00	0.00	0.06	0.00	0.05
Work	Paid work	15.1.1	0.89	0.80	0.17	0.21	0.16	0.20
		15.1.2	0.70	0.63	0.12	0.15	0.12	0.14
		15.1.3						
	Unpaid work	15.2.1	0.85	0.41	0.16	0.20	0.16	0.21
		15.2.2						

Note: Numbers represent the Kendall's tau rank correlation coefficients between each indicator and the corresponding theme, between each indicator and the corresponding dimension and between each indicator and the overall IDM, using different aggregation methods. Correlations that are not significant at the significance level of a = 0.05 are in grey.

Source: European Commission's Joint Research Centre, 2020.

4 Impact of modelling assumptions on the IDM results

A fundamental step of the statistical analysis of a composite indicator is to assess the effect of different modelling assumptions among reasonable alternatives. Despite the efforts given in the building process, there is an unavoidable subjectivity (or uncertainty) in the resulting choices. This subjectivity can be explored comparing the results of different – alternative – choices.

The literature on the topic, and the usual JRC approach, suggests assessing the robustness basing on Monte Carlo simulations and multi-modelling approach, assuming 'error free' data as eventual errors have been corrected in the preliminary stages of the construction of the composite indicator (M Saisana, Tarantola, & Saltelli, 2005; Michaela Saisana, D'Hombres, & Saltelli, 2011).

Nevertheless, the IDM presents a completely different setting with respect to the traditional indicators considered in the literature. The main two reasons of its uniqueness are: the micro level variables observed directly on subjects and the presence of a vast majority of non-quantitative indicators in the framework. These two reasons motivated the JRC team to avoid the step of the Monte Carlo simulations, mainly because the perturbation of weights on thousands of individual observation would not have the same meaning and interpretation of the same procedure applied on stable entities (e.g. countries, regions).

The modelling issues considered in the assessment of the IDM were the aggregation formula the inclusion/exclusion of the Time-use dimension (dim 14) and the dimension weights.

Aggregation formula. Regarding the aggregation formula, the IDM team opted for the arithmetic average of the fifteen dimensions which implies a strong compensability that allows outstanding performance in some aspects to balance for weaknesses in others and vice-versa. This approach means that subjects with high and low scores at the indicator, theme or dimension level are considered similarly deprived as those with average scores.

To assess the impact of this choice, a comparison with the geometric mean is included in the analysis. The comparison of the two aggregation approaches should be able to highlight the individuals with unbalanced profiles because the geometric mean tends to penalize the existence of a low value, even when the other values are not so low.

Weights. The weighting system of the IDM is particularly strong, with the 5 most important dimensions (dimensions 1-5) receiving a total weighting of 50% (10% each), the 5 next-most important dimensions (dimensions 6-10) receiving a total weighting of 33% (6.6% each) and the remaining 5 (dimensions 11-15) receiving a total weighting of 17% (3.4% each). In order to evaluate the effect of this choice, the scores and rank of subjects are compared with those that would be obtained using equal weighting.

Inclusion of dimension 14 (Time Use). The Time Use dimension has been proven to be poorly correlated with the rest of the framework. For this reason, the effect of its exclusion from the final aggregation is evaluated.

To compare the three alternative options on aggregation formula, structure and weights with the proposed one, four models were considered and they can be seen in Table 8.

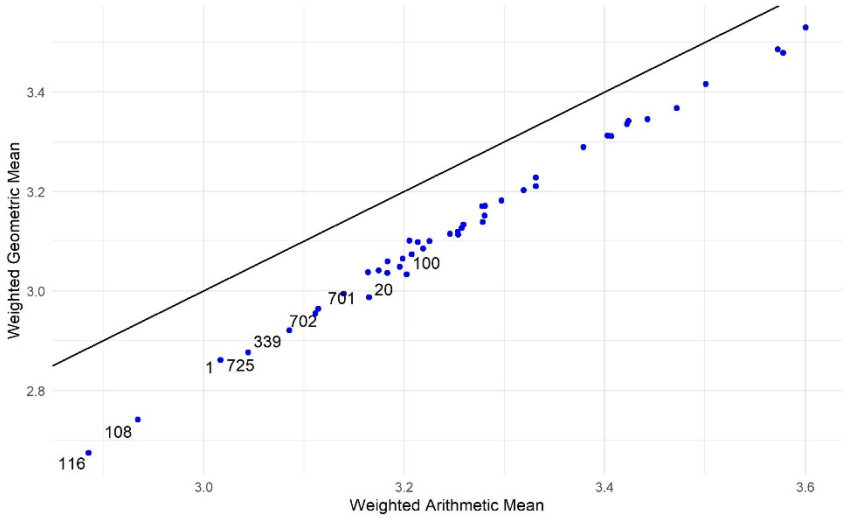
It is important to mention that the results of the analysis are shown only for the values of the 45 areas of Fiji, since the representation of all the individuals does not seem to be informative in this context.

Table 8. Alternative assumptions considered in the analysis.

	Reference	Alternative
I. Aggregation formula	Arithmetic average	Geometric average
II. Weighting system	50% / 33% / 17%	Equal weights
III. Presence of Time Use dimension	Presence	Absence

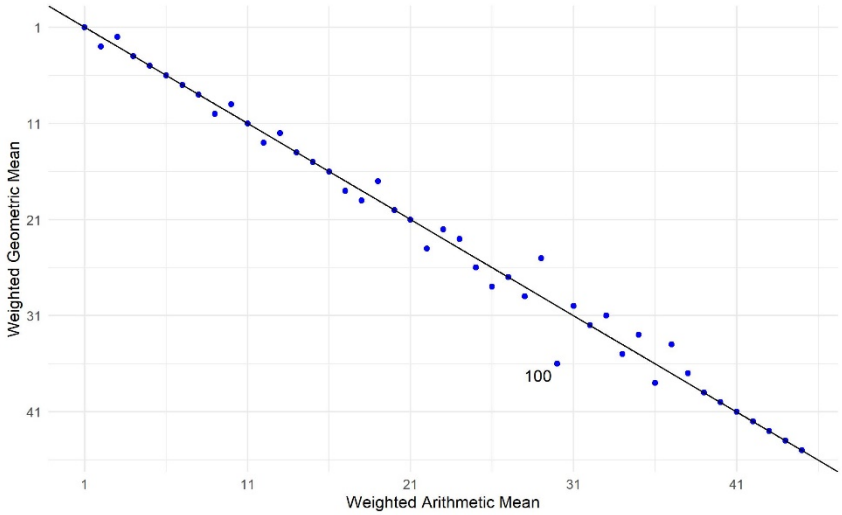
The single effect of every choice can be investigated with sensitivity analysis. In Figure 1 and 2, it is possible to compare the scores and ranks of the 45 Fiji areas considering the arithmetic and the geometric aggregation. The results of scores show that in every area the **average score is definitely lower when computed with the geometric mean**. This is a normal result, because the geometric mean is mathematically lower than the arithmetic unless the averaged numbers are perfectly equal. It is interesting to see that the negative effect of the geometric mean is generally the same for all the areas, but is slightly stronger when the scores are smaller (see Figure 1). That means that subjects in areas with low results have more unbalanced scores on different dimensions. Despite the common effect on the scores, the use of geometric average does not influence the ranks sensibly. For this reason, Figure 2 shows very stable comparison of ranks, where only region 100 faces a change of more than 5 ranks between the two aggregation methods.

Figure 1. Sensitivity analysis on Aggregation (comparison of Scores)



Note: Only Areas with a difference larger than 0.15 are labelled.
Source: European Commission, Joint Research Centre, 2020.

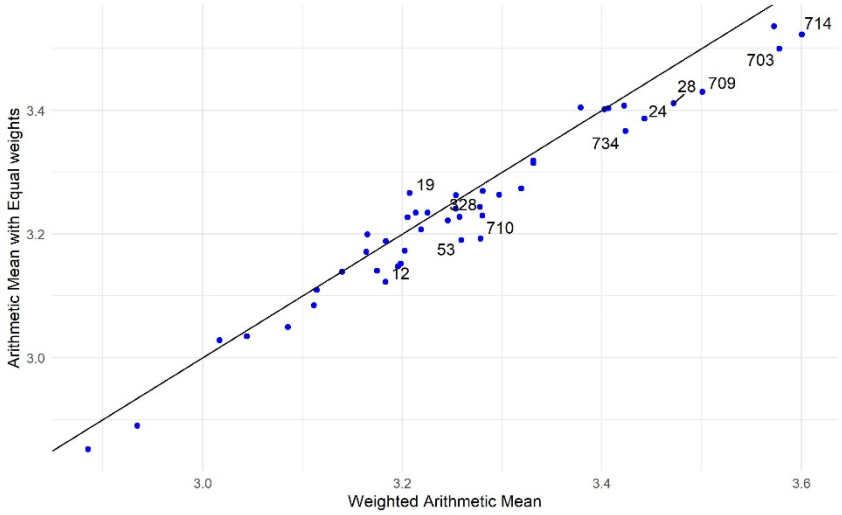
Figure 2. Sensitivity analysis on Aggregation (comparison of Ranks)



Note: Only Areas with a shift larger than 5 ranks are labelled.
Source: European Commission, Joint Research Centre, 2020.

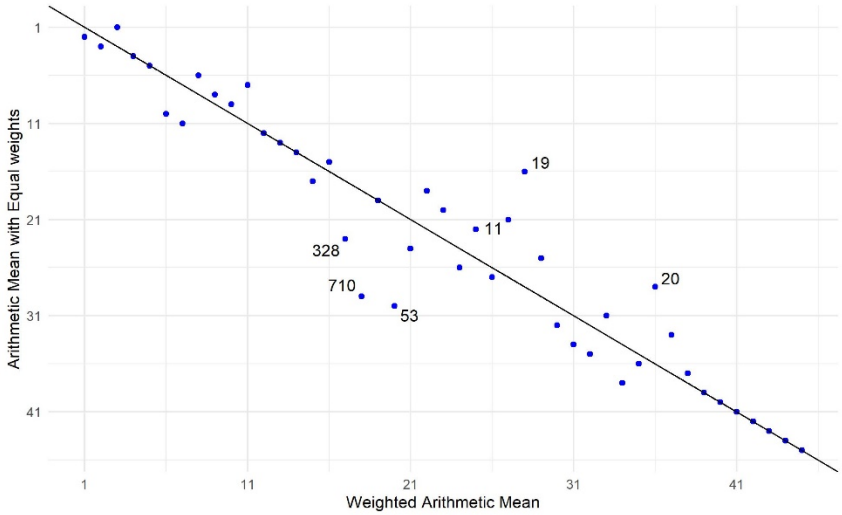
The comparison between the two weighting schemes gives different results. The largest differences in the scores are observed mainly in the best performing areas (Figure 3). Most of the areas are located under the diagonal line, meaning they have a higher value when the formula contemplates a strong system of weights (namely 50%/ 33%/ 17% for each block). Hence, most of the areas, and especially the best performers, are stronger in the first five dimensions than the others. The only meaningful exception is area 19, which performs better with equal weights (more than 0.05 average improvement). The average performing areas are influenced by the two weighting schemes in different ways, some are penalised, some are rewarded and some are not affected. Figure 4 gives an idea of this heterogeneity. Five areas show more than 5 ranks of shift in this comparison, with the strong result of area 19, which gains 11 positions when Equal Weights are used.

Figure 3. Sensitivity analysis on Weights (comparison of Scores)



Note: Only Areas with a difference larger than 0.05 are labelled.
Source: European Commission, Joint Research Centre, 2020.

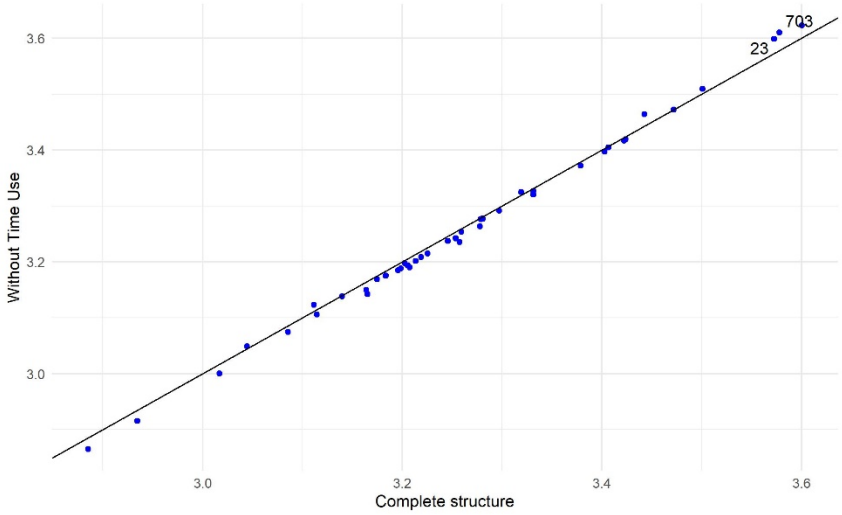
Figure 4. Sensitivity analysis on Weights (comparison of Ranks)



Note: Only Areas with a shift larger than 5 ranks are labelled.
Source: European Commission, Joint Research Centre, 2020.

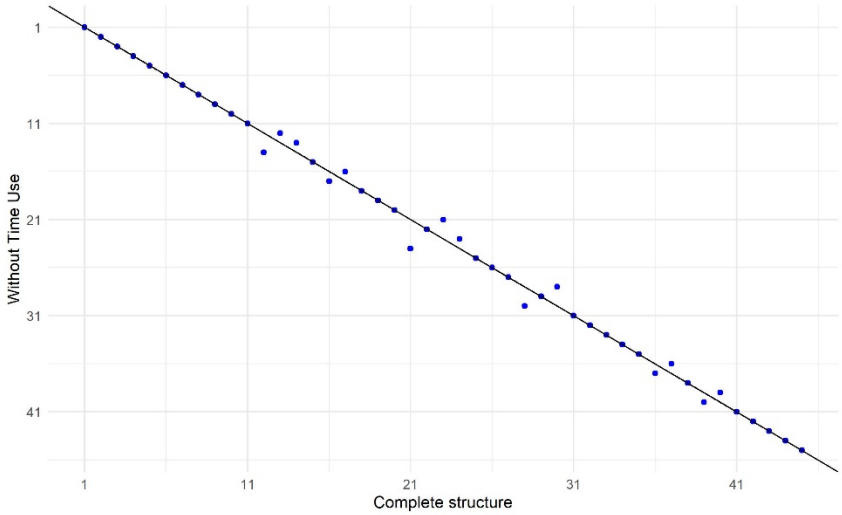
The last comparison is based on the exclusion of dimension 14 (Time Use) from the framework. The dimension has been already proven to be weakly correlated with the other dimensions and the overall index, as discussed in section 3.3. Consequently, we expect to see no effect of its exclusion and the results confirm the expectations. The presence/absence of dimension 14 has almost no effect on the final score (only two areas improve their average score by approximately 0.025 as shown in Figure 5). The ranks are basically the same, with irrelevant differences due to comparisons between extremely similar areas (Figure 6).

Figure 5. Sensitivity analysis on Structure (comparison of Scores)



Note: Only Areas with a difference larger than 0.025 are labelled
Source: European Commission, Joint Research Centre, 2020.

Figure 6. Sensitivity analysis on Structure (comparison of Ranks)



Note: Only Areas with a shift larger than 5 ranks are labelled.
Source: European Commission, Joint Research Centre, 2020.

5 Special focus

5.1 Impact of the missing dimensions on the weights

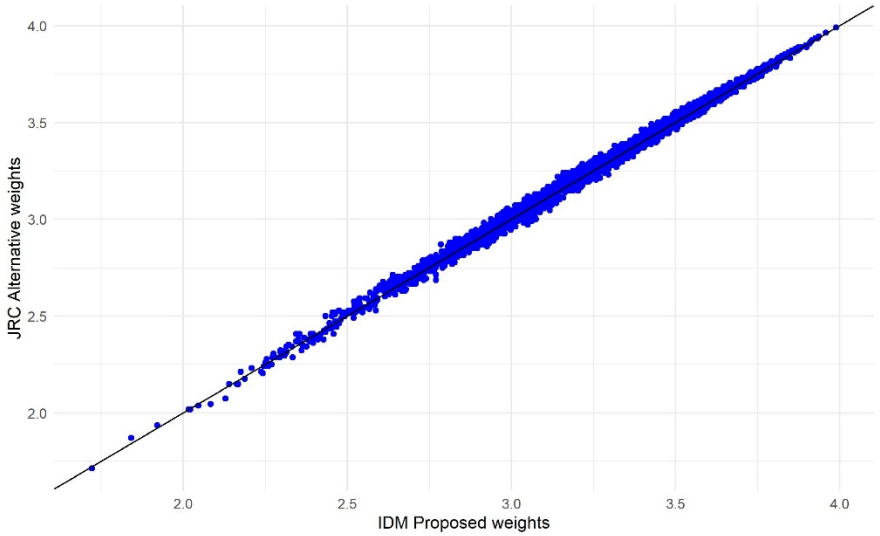
In the methodological report, the developers describe the system of weighting of the 15 dimensions with three levels (50% for dimensions 1-5, 33% for 6-10 and 17% for 11-15). This structure is clear and intuitive. However, the framework of the IDM is meant to be generic and adaptable to different countries. In particular, as discussed in section 3.2, IDM Fiji is not taking into account dimensions 10 and 11, which leads to a different scheme where the 33% and the 17% weights of the last two groups, are shared among 4 dimensions instead of 5. Consequently, the respective distribution of dimensions' weights is 10%, 8.3% and 4.2% for the first five, middle four and last four. This means that the relative impact of the dimensions from 6th to 15th is improved and it looks like the 4 remaining dimensions in each group act as substitutes for the removed one.

An alternative would be keeping the original weights to each dimension (10%/6.6%/3.4%) for the thirteen remaining ones and then adjust them to sum to unity. The resulting set of weights would then be (11%/7.4%/3.7%)[5], as shown in Table 3. This approach distributes the weight of the removed dimensions to all the other dimensions, proportionally to their nominal weight.

Figure 7 compares the scores resulting from the IDM weights and those resulting from the suggestion of the JRC. While Figure 8 represents the ranks of the same scores.

[5] To adjust the weights to have sum one, it is sufficient to divide each weight by the sum of the weights. The original weights with 15 dimensions are: (0.10, 0.10, 0.10, 0.10, 0.10, 0.066, 0.066, 0.066, 0.066, 0.066, 0.033, 0.033, 0.033, 0.033, 0.033). When 10 and 11 are removed, at the moment they become (0.10, 0.10, 0.10, 0.10, 0.10, 0.083, 0.083, 0.083, 0.083, 0.044, 0.044, 0.044, 0.044). Alternatively, we suggest to take the original weights only for the thirteen dimensions, and divide by their sum, that is 0.9. Obtaining the following set of weights: (0.11, 0.11, 0.11, 0.11, 0.11, 0.074, 0.074, 0.074, 0.074, 0.037, 0.037, 0.037, 0.037).

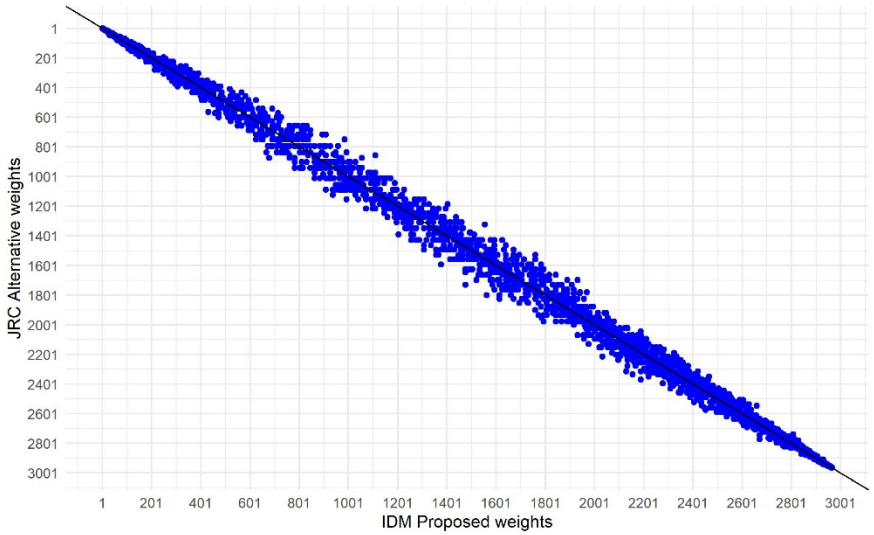
Figure 7. Scores of individuals (with different weights)



Source: European Commission, Joint Research Centre, 2020.

The two graphs show very little changes in ranking, the maximum score and rank changes are respectively 0.086 and 257, with only 2.8% of the subjects showing a rank change of more than 150. These results confirm that this choice on the weights is not influencing the final results too much. However, the effect of missing dimensions on the weighting scheme should be considered further as this may have a significant influence on scores when more than one dimension is missing from the same group.

Figure 8. Ranks of individuals (with different weights)



Source: European Commission, Joint Research Centre, 2020.

5.2 Alternative paradigm of aggregation

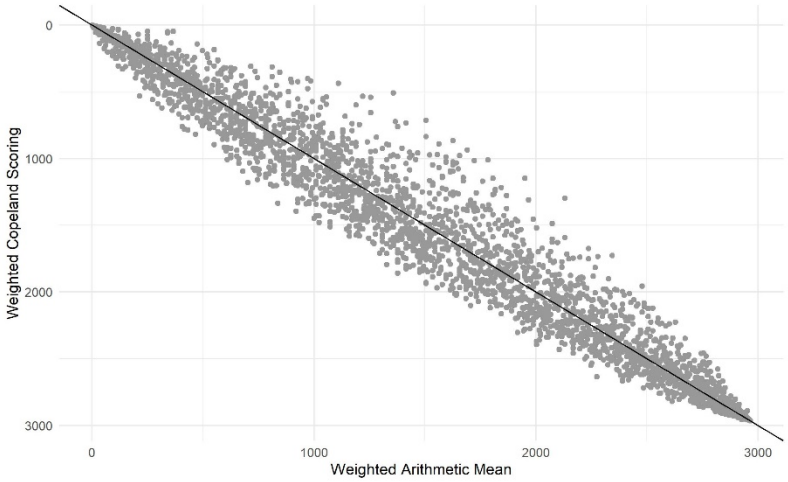
The kind of data used in the IDM is inherently different from the traditional quantitative data used in composite indicators. For this reason, the IDM team developed a system of classes and scores to transform the data into manageable scores that can be averaged and summarised. This practice is the more intuitive and common in the field. Here an alternative approach is proposed, together with some simple results to visualise its effects.

The approach proposed here is called Copeland scoring[6], and is considered one of the least compensatory aggregation methods (Munda, 2008). It means that, differently from the arithmetic mean, no high scores in one dimension can compensate for low scores in others.

The comparison of a compensatory and a non-compensatory method can highlight specific patterns in data. In particular, the presence of strongly unbalanced subjects. In fact, when a subject is rewarded by the Copeland approach with respect to the average, it means the observed values on the subject are very unbalanced. For example, a very low value in one dimension can "drag down" the average of many high (but not strongly high) values.

In Figure 9, the ranks of the Arithmetic average and the Copeland scores are compared. It is possible to see that there is an unavoidable effect on the ranks, with many subjects improving their ranks in the context of the non-compensatory method. In this situation a relevant 38.3% of the individuals are facing a difference of ranks greater than 150 (the maximum is 849). This result suggest that the aggregation of the 13 dimensions of the IDM is influenced by the degree of compensability of the aggregation function. Although deprivation scores will no longer be comparable across countries or time, the developers may want to consider this method in future developments, as well as for aggregating scores at the lower levels of the framework, namely themes and dimensions.

Figure 9. Ranks of individuals (with Arithmetic mean and Copeland scoring)



Source: European Commission, Joint Research Centre, 2020.

[6] In this approach, the score is given by the comparison of every pair of subjects. Whenever a subject outperform another on the majority of dimensions (considering the weights), it gets one point, it lose one point in the opposite case. After every subject has been compared with all the others, all the points are sums to obtain the Copeland score. In this document, the final score has been scaled to a (0,1) interval, to make it more readable.

6 Conclusions

The JRC statistical audit delves into the extensive work carried out by the developers of the IDM with the aim of suggesting improvements in terms of data characteristics, structure and methods used. The analysis aims to ensure the transparency of the IDM methodology and the reliability of the results. This report focuses on the assessment of the statistical coherence of the Individual Deprivation Measure, for the Fiji 2017 dataset, by carrying out a multilevel analysis of the correlations within and across the indicators and dimensions as well as by an assessment of the impact of key modelling assumptions on the IDM scores and ranking.

The analysis suggests that the IDM is statistically well balanced with respect to the 13 dimensions used in the specific dataset, with the exception of the Time –Use dimension (dim 14). For most dimensions, the correlations are significant and positive and the indicators are more correlated with their own dimension than with any other, thus suggesting that they provide meaningful information on the variation of the scores. Similarly, all themes are correlated with their dimensions and the overall IDM, with positive, though often not very strong correlations.

However, two issues were identified: First, the Time use dimension does not correlate with the overall index and most of the other dimensions and even shows a negative relationship with some of them. JRC recommends to consider modifying or even excluding the Time Use dimension from the framework. The same dimension or its components can still be used for further analysis, in relation with the IDM. Second, the themes within the Health dimension are negatively correlated with each other, which often implies that they are describing a different concept than the one assumed in the conceptual framework. JRC would suggest special attention to this aspect, given the importance of Health. The revision or exclusion of indicators 4.1.1 and 4.2.1 could be considered, in order to improve the coherence of the Health dimension and its influence in the overall score. The developers consider Time Use to be an important conceptual element of a gender sensitive measure of deprivation and so have indicated their intention to modify the scoring method of the indicators within both the Time Use and Health dimensions to improve statistical coherence.

The conceptual framework of the IDM categorises the 15 dimensions into three groups of importance and weights those accordingly. However, as in the Fiji dataset the two dimensions of Violence and Family Planning are missing, the weights of the dimensions in the second and third group are higher than they would be if all dimensions were present. The JRC analysis showed that in the specific dataset this choice of weighting is not influencing the final results too much. However, it is important to consider if the three groups need to maintain this difference in weights irrespective of the number of dimension each group contains; or the individual dimensions should maintain the assigned difference between them. In the first case, having less dimensions in the second or third group increases the risk for these dimensions to account for more (or similar) than those in the first group. The suggestion is to seriously consider the influence of missing dimensions on the weighting scheme when implementing the IDM in other countries, particularly where multiple dimensions are missing from the same group.

The sensitivity analysis presented in the report, shows a comparison between the arithmetic mean of the dimensions, which is the aggregation method chosen by the developers, and the geometric mean. The first implies a strong compensability that allows outstanding performance in some aspects to balance for weaknesses in others while the second penalizes the existence of a low value, even when the other values are not so low. The analysis shows no major differences in the final ranking for the two methods, suggesting a satisfying robustness of the index in respect to this methodological choice. As the nature of the data allows for that, JRC suggests considering also an alternative aggregation method, the Copeland scoring, which is one of the least compensatory aggregation methods. The comparison of this method with the arithmetic average showed that indeed the aggregation of the 13 dimensions of the IDM is influenced by the degree of compensability of the aggregation function. A downside of this method in the specific dataset is that although it offers great advantages for the between individuals comparisons, it would not allow for comparisons between different countries or over time.

In general, the present audit confirms that the IDM Fiji dataset meets the quality standards for statistical soundness and acknowledges the important efforts of the developers' team in the definition of a composite indicator for individuals. The IDM can serve as a tool to provide insights for individual deprivation and poverty.

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