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## Averaging is Key to Build and Use a Multidimensional Vulnerability Index

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In the general presentation of the criteria that the MVI should meet, we emphasized the importance of the way by which the three dimensions of the MVI are averaged in a single index and the need to limit the substitutability between them, so that the specific vulnerability of each country can be fairly reflected.



... /... For instance, the use of a quadratic average ( $MVI_q$ ) instead of the usual arithmetic average ( $MVI_a$ ) was proposed, what means, calling  $n$  the number of dimensions of the MVI, and  $V_i$  the subindex of vulnerability in the dimension<sup>1</sup>  $i$

$$MVI_q = \sqrt{\frac{1}{n} \sum_{i=1}^n V_i^2}$$

instead of

$$MVI_a = \frac{1}{n} \sum_{i=1}^n V_i$$

A step further, suggested in the footnote 2 of the note "Three criteria that a multidimensional vulnerability index should meet to be used effectively" would be to use what we called a *semi-geometric average* or a *reversed geometric average*, namely the complement to 100 (or one) of the geometric average of the complement to 100 (or one) of each dimension subindex<sup>2</sup> :

$$MVI_g = 100 - \sqrt[n]{\prod_{i=1}^n (100 - V_i)}$$

This averaging formula even more than the quadratic average enhances the impact of the most vulnerable dimension on the value of the composite index<sup>3</sup>.

It is still possible to move further in the same direction by designing "*critical thresholds*" for the three or  $n$  sub-indices i.e for the three or  $n$

dimensions, what means that a country where vulnerability in one dimension is above the critical threshold ( $V_i^*$ ) be considered as "highly vulnerable", with an index equal to 100, whatever its position in the other two dimensions<sup>4</sup> :

$$MVI_k = 100 - \sqrt[n]{\prod_{i=1}^n (V_i^* - V_i)}$$

The issue would then to choose the threshold levels. It could be for instance at the upper quintile or decile of the sub index value in each dimension for a set of developing countries<sup>5</sup>. It would mean that each country with a high level of vulnerability in one dimension would be considered as "highly vulnerable". In particular most of the SIDS, which are in the upper decile or quintile of the environmental vulnerability or the PVCCI (Physical Vulnerability Index to Climate Change), would be considered as "highly vulnerable" (probably as well as the most arid countries).

This last (truncated) averaging formula would be useful only for designing a *category* of "highly vulnerable countries", what would be also possible with the other three formulas, designed first to be used "continuously" without any threshold values.

Better is to focus on these 3 formulas and to compare the relative value of results obtained. It is well known that the quadratic average is higher than the arithmetic one. It also appears that generally the reversed geometric average is higher than the quadratic one, so that

$$MVI_a < MVI_q < MVI_g$$

1. As an example, let us compare the index value for two countries, supposing three dimensions, respectively with component indices of 90, 30, 30 for country A and 50, 50, 50 for country B: they have the same index of 50 with an arithmetic average, but they differ with the quadratic average, still 50 for country A, but 58 for country B, highly vulnerable in one dimension.  
2. We suggested and used this kind of averaging for the Economic Vulnerability Index (EVI) of the Committee for Development Policy (CDP) in Guillaumont P., *Caught in a Trap, Identifying the Least Developed Countries*, Economica, 2009, where it is called "semi-geometric", but better named "reversed geometric".  
3. With the previous two profiles of vulnerability the semi-geometric average would be about 62 for country B (and still 50 for country A), instead of 50 with the arithmetic average and 58 with the quadratic one.

4. Again, with the same two country profiles, and supposing a "critical threshold" of 85 or 90, the index would be at the maximum level of 100 for country B (and still 50 for country A).  
5. It has been the practice of the UN CDP from 1991 to 2015 to retain a threshold at the quartile level for using its EVI (and HAI as well) as a criterion for the identification of LDCs.

What here matters is that the difference between the 3 values is all the more important that a country has a high value in one dimension (see in annex a table showing the values for 4 virtual countries with the same arithmetic average). As a result, the share of SIDS, most of them with a high value of physical vulnerability to climate change, which are among the 40% or 33% highest vulnerable countries is higher with the quadratic average than with arithmetic average and higher with the reversed geometric average than with the quadratic average<sup>6</sup>.

In the choice of the averaging method, the expected use of the MVI should be kept in mind.

The last formula ( $MVI_k$ ) offers an answer to the question of classifying countries between those which are “highly vulnerable” and those which are not considered so. As such it may be politically attractive, although relying on arbitrary thresholds. But the identification of a specific

6. This could be illustrated for instance by using the data of the Commonwealth Secretariat UVI. Moreover, it would appear that the  $MVI_k$  evidences a group of countries reaching the maximum value (100) of the MVI, due to any dimension. This group would look like a category of “highly vulnerable countries” while only other countries would be differentiated by their level of vulnerability (below 100).

group of highly vulnerable countries can be used only for binary measures, such as the eligibility to special funds (or special preferences). Its use as a criterion for aid allocation would be debatable, because it would not allow to differentiate between the “highly vulnerable countries” according to their level of vulnerability, so that it would be unfair for the most vulnerable among the highly vulnerable countries.

In conclusion, averaging is key. Using an averaging method that enhances the specific vulnerability of each country in one or another dimension is a condition to make an MVI acceptable for the most vulnerable countries, in particular the SIDS. Once that agreed, it could be reasonable to propose a framework of calculation of the MVI with the 2 or 3 formulas for averaging the three dimensions, and to invite the users (or “donors”) to choose the method (and possible thresholds) the most appropriate with regard to the use they wish :  $MVI_g$  (or  $MVI_q$ ) for a continuous criterion of aid allocation,  $MVI_k$  for binary measures involving a classification between the highly vulnerable countries and the other ones, a classification that would unavoidably rely on arbitrary thresholds.

**Annex.** Value of the “MVI” and its 3 components for 4 countries (A, B, C, D) according the way by which the components are averaged, and with the same arithmetic average.

Countries	Component values			MVI Values		
	1	2	3	AR	QUA	RGEO
A	50	50	50	50	50	50
B	30	100	20	50	61,4	100
C	50	80	20	50	55,7	56,9
D	70	50	30	50	52,6	52,8

AR, QUA and RGEO mean respectively: Arithmetic, Quadratic and Reverse Geometric averages.



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