Estimating vulnerability to income and multidimensional poverty: a new methodological approach

Andualem Goshu Mekonnen
Department of Development, Addis Ababa University, Addis Ababa, Ethiopia and Gender, Poverty and Social Policy Division (GPSPD), United Nations Economic Commission for Africa, Addis Ababa, Ethiopia

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Abstract

Purpose – The purpose of this paper is to propose a new vulnerability to income and multidimensional poverty estimation index (VIMPI). This index is designed to measure the likelihood of individuals falling into and remaining in poverty.

Design/methodology/approach – The paper introduces a new methodology that integrates the concepts of the well-being gap, individual and indicator-specific weighting, and vulnerability. This approach is simple to apply and accurately measures vulnerability with less susceptibility to measurement error and outliers. The index satisfies all poverty and vulnerability axioms, including transferability and monotonicity. The newly proposed method has been applied to Namibian and Ghanaian data and compared with similar techniques.

Findings – The results showed that Ghana's vulnerability to income and multidimensional poverty was 37.9% and 56%, respectively. Of the 37.9% of vulnerable individuals, 23.4% were at risk of falling into poverty, while 14.57% were at risk of remaining in poverty. These findings demonstrate the effectiveness of VIMPI in accurately estimating vulnerability to poverty and its potential to inform targeted policies to alleviate poverty.

Originality/value – This paper proposes a new methodology to estimate vulnerability to income and multidimensional poverty.

Keywords Vulnerability to income poverty, vulnerability to multidimensional poverty, well-being gap

Paper type Research paper

1. Introduction

Empirically, poverty has been proven to be dynamic in most developing countries (Alkire and Foster, 2019). Due to country-specific and global risks, thousands of people are vulnerable to falling into poverty. According to an estimate by The United Nations Economic Commission for Africa (2022), 53 million people experience poverty due to COVID-19. This implies that various risks significantly impact the number of people living

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in poverty. Hence, the concept of vulnerability to poverty should be integrated into the estimation of poverty to understand the dynamic nature of poverty clearly.

From a policy perspective, in addition to knowing the number of poor people, knowing the number of people at risk of falling into poverty is required. There is a significant distinction between the ideas of vulnerability and poverty. Poverty is a stochastic process that indicates a lower level of well-being by comparing it against a specific threshold. Hence, assessing poverty means assessing the actual well-being of an individual. The uncertainty of people's welfare levels to such poverty thresholds is what vulnerability means. Thus, vulnerability differs from poverty because it entails the risk of becoming or staying poor. Hence, for the sake of public policy, it is critical to recognize not only multidimensionally poor individuals but also those at risk of becoming or staying multidimensionally poor (Gallardo, 2013).

Henceforth, many scholars have started developing a vulnerability measure that captures the probability of falling into poverty (Alkire and Foster, 2019), while others define it broadly by including the probability of remaining poor and the likelihood of falling into poverty (The World Bank, 2000; Gallardo, 2013; Chaudhuri *et al.,* 2002; Christopher Connor, 2022; United Nations. Economic Commission for Africa, 2022). Despite several vulnerability measures proposed in the past decades, this literature has significant challenges discouraging the empirical use of these conceptually attractive measures. The criticism of vulnerability to poverty measures will undoubtedly continue. However, these measures will continue to develop since it is now universally agreed that poverty is dynamic. Generally, existing methods have the following limitations:

First, most of the estimation methods require panel data (Chaudhuri *et al.,* 2002; Calvo, 2008; The World Bank, 2000). Second, some approaches consider only income poverty and are less applicable in the multidimensional poverty context (The World Bank, 2000). Third, most of the measures account only for the number of people who are vulnerable to falling into poverty and ignore the risk of staying poor (Alkire and Foster, 2019). Fourth, even though vulnerability is supposed to be estimated using full endowment entitlements, vulnerability to falling into poverty is underestimated due to the dimension's initial censoring (Alkire and Foster, 2019). Fifth, some estimates use the full endowment entitlements but are highly susceptible to outliers due to the vulnerability threshold (Assa and Meddeb, 2021). Sixth, there are controversial issues regarding the cutoff to select vulnerable people, and some estimates are highly susceptible to measurement errors (Christopher Connor, 2022; Gallardo, 2013).

This paper introduces a new vulnerability to income and multidimensional poverty index (VIMPI) measure that addresses some substantive issues related to the estimation of vulnerability to income and multidimensional poverty. The estimate uses the complete information set of dimensional achievements. The proposed estimation broadens the information about an individual's well-being and allows one to estimate the probability of staying in and falling into poverty. This estimation method has the following strengths: first, it estimates the severity and extent of poverty by giving more weight to a person whose endowment is far below the poverty threshold. Second, it estimates the welfare gap by considering the complete set of dimensional achievements. Third, it estimates the vulnerability to staying in poverty and the risk of falling into poverty. Fourth, it avoids overestimation or underestimation of the estimate due to outliers. Fifth, it satisfies the two most crucial poverty axiomatic principles: monotonicity and transferability. Finally, it can apply to continuous, ratio, or ordinal variables with numerous categories.

The paper is organized as follows: the first part reviews existing vulnerability to income and multidimensional poverty estimation methods. The second part discusses the proposed VIMPI estimation method. Finally, the proposed estimation will be illustrated using data from Ghana and Namibia.

2. Current vulnerability to poverty estimation methods

The unidimensional paradigm continues to predominate in most newly published studies when analyzing vulnerability to poverty (Dutta, 2011; Chiwaula, 2011; Calvo, 2013; Gallardo, 2013; Klasen, 2013; Celidoni, 2013). Recently, there have also been studies on vulnerability to poverty with a multidimensional framework (Gallardo, 2018; Hohberg, 2018) and a decomposition of vulnerability to poverty (Celidoni, 2015; Günther, 2014; Povel, 2015).

To the best of the author's knowledge, eight proposals regarding vulnerability to poverty have been made. Two of these (Calvo, 2008; Abraham, 2008) use the fuzzy poverty indicator (Cerioli, 1990) and the multidimensional poverty index (MPI) put forth by Bourguignon and Chakravarty (2003) as reference indicators. The other two (Feeny and McDonald, 2016; OPHI, 2018) use the MPI, which was developed with Alkire and Foster's (2011) counting methodology (AF) as the reference indicator of poverty. The fifth, known as the vulnerability to multidimensional poverty index (VMPI), uses a mean-risk behavior approach that includes downside risk as an essential feature of vulnerability (Gallardo, 2013) and the median downside risk method by Christopher Connor (2022). The last approach, UNECA (2021), used the World Bank thresholds to identify vulnerable people. The details of the methods are explained hereafter.

Calvo (2008) put forth the first strategy, which extends Calvo and Dercon's approach of unidimensional vulnerability to multidimensional space. Considering both the possibility of experiencing poverty in the future and the severity of poverty in such a circumstance, Calvo (2008) defines vulnerability as "the threat of future poverty." However, the model works only in the panel data framework, which limits its applicability.

Abraham and Kavi proposed a fuzzy method to assess vulnerability to multidimensional poverty (VMP) (Abraham, 2008). These researchers developed a fuzzy measure of vulnerability based on the Cerioli and Zani membership function (1990). The estimates created by the authors only apply to income poverty and continuous variables, in addition to the fundamental limitations of utilizing fuzzy approaches to evaluate vulnerability.

Feeny and McDonald (2016) introduced a third method to assess VMP in their work. This method identified those individuals who are multidimensionally poor by utilizing the MPI cross-dimensional cutoff as the reference threshold and gave a measure of VMP as the probability of being multidimensionally poor in the future. The measure estimates vulnerability only for nonpoor people and uses a counting approach.

The fourth approach (Alkire and Foster, 2016) uses a framework like the unidimensional idea of vulnerability as an extended poverty line to assess exposure to multidimensional poverty. According to the Global MPI's cross-deprivation threshold k, set at 1 / 3, every individual with a deprivation score of at least 1 / 3 is multidimensionally poor. In contrast, those with scores of between 1 / 5 and 1 / 3 are categorized as vulnerable to multidimensional poverty. This estimate defines vulnerability only for nonpoor people. In addition, the estimate of vulnerability is derived from the aggregate score of multidimensional poverty, which surely underestimates the level of vulnerability. The AF vulnerability estimate also failed to satisfy the transferability axiom. In general, the challenges and limitations of the AF methodology are also the limitations of the AF vulnerability estimate (Andualem, 2024).

The fifth method, the VMPI, is part of Alkire and Foster's multidimensional counting framework. It adds to the downside of the mean semi-difference measurement of vulnerability to poverty in a single dimension. This vulnerability index includes individuals who are already poor but are still at risk of remaining poor and those who are not yet poor but are at risk of becoming so (Gallardo, 2013). The estimate used mean semi-deviation, which could be affected by outliers and the Bayesian network is too subjective as there is no universally acknowledged method for constructing networks from data. The design of Bayesian networks is also complicated compared to other networks.

The sixth multidimensional vulnerability index was contributed by UNDP in 2021. The index was developed to estimate vulnerability using macroeconomic variables (Assa and Meddeb, 2021). The estimate is highly exposed to outliers due to the use of the max-min approach and is also not applicable to household data.

Christopher Connor (2022) proposed the seventh piece of work to calculate vulnerability to poverty. The author used the estimated medians with quantile regression to standardize strategies that identify individuals or households vulnerable to future episodes of poverty. Given that the method used is median, it is only sensitive to skewness problems and can tackle the problem of outliers. However, the suggested method applies only to continuous data. Besides that, the quantile regression parameters are harder to estimate and are usually used for global effects, so the estimate is insensitive to transfers at an individual level.

In its Economic Report for Africa (2021), the Economic Commission for Africa made the most recent attempt to estimate poverty. The method uses the World Bank poverty threshold of $1.90 as a benchmark, and it calculates the number of people who are vulnerable to falling into poverty due to COVID-19 by recalculating poverty at different poverty thresholds. This method uses the FGT measure of income poverty and does not apply to multidimensional poverty.

3. Proposed estimation method

This section presents the estimation procedures of VIMPI. The proposed approach accommodates the dynamic nature of poverty by estimating the risk of falling into and staying in poverty. Before discussing the details of the estimation method, let us first illustrate the notations and definitions of the variables used in the paper.

Let n represent the number of households, and $y \geq 1$ be the dimensions. Each dimension is represented by the well-being indicator *j,* where *j* is between 1 and *d.* Throughout this paper, I use only indicators to define well-being and compute VMPI. The role of dimensions is only to decompose the vulnerability estimate across dimensions. Let $Y = Y_{ij}$ denote the $n \times d$ matrix of endowments, where the typical entry $0 < Y_{ij} \leq Y_j^{max}$ is the endowment of a household. $i = 1,2, \ldots, n$ in the well-being indicator $j = 1,2, \ldots, d$. Y_j^{max} is the maximum achievable endowment i*n the j categorical indicator* and it is always greater than or equal to Y_{ij}. Similarly, Y_j^{min} is the minimum achievable endowment i*n the j categorical* indicator, and it is always less than or equal to Y_{ij}. In indicator *j,* $|Z_j| > 0$ is the indicator cutoff below which a person is deprived.

The well-being gap equation is a powerful tool used to estimate the VIMPI. It was first introduced by Andualem (2024) to estimate welfare-based income poverty index (WIPI) and welfare-based multidimensional poverty index (WMPI) [1]. The concept of well-being is a measure of how well an individual or community is doing in terms of their overall quality of life. It is defined as having a specific level of endowment, which refers to the amount of resources or capabilities that an individual or community has at their disposal. For indicators with continuous data, the well-being gap can be calculated using the following equation:

$$WG_{ij} = \frac{Z_j - Y_{ij}}{Z_j + Y_{ij}}$$

The well-being gap measures the distance between an individual's endowment (Y_{ij}) and the minimum expected threshold (Z_j). WG_{ij} is a matrix whose j^{th} entry is greater than zero when household i is deprived in the j^{th} indicator and negative when a person is not. The well-being gap estimate can have a value ranging from a negative one to a positive one. The estimate has two major components:

First, the numerator indicates the individual's location in the complete set of endowment information. A positive well-being gap indicates deprivation in the j indicator, and the negative indicator shows an entitlement above the expected minimum threshold.

Second, the denominator $Z_j + Y_{ij}$ is used to normalize the estimates so that the overall well-being gap falls between negative one and positive one. Furthermore, the inclusion of Y_{ij} gives weight to the well-being estimate. For the positive well-being gap, it gives more weight to an indicator that is far from the indicator's threshold (Z_j), than an indicator closest to Z_j. The attached weights are both individual and indicator specific.

The concept of the well-being gap provides two significant benefits over the standard poverty gap. First, it normalizes the distribution of endowments above and below the poverty line, while the standard poverty gap only normalizes endowments below the poverty line. Normalizing endowments above the poverty line is not necessary for poverty estimation. However, for vulnerability study, all values below and above the poverty line are required (Gallardo, 2013). Vulnerability analysis requires a comprehensive understanding of the entire endowment information, which can only be achieved through the well-being gap. Positive values indicate the probability of remaining in poverty, while negative values indicate the likelihood of falling into poverty. Second, the minimum and maximum values always range between negative one and positive one. As a result, outliers will not affect the estimation result when we reach the aggregation stage. Third, the well-being gap assigns greater weight to individuals further from the poverty threshold than the standard severity of poverty estimates.

3.1 Properties of the well-being gap and income and multidimensional poverty estimation

3.1.1 Property 1: when $Y_1 = Z$, $WG_1 = 0$. When the endowment for Y_1 is the same as the poverty threshold, the individual or household has just enough resources to meet the basic needs required for survival. In such a case, both the standard poverty and well-being gaps would equal zero. Therefore, if the endowment for Y_1 is at the poverty threshold, it implies that the individual or household is neither experiencing poverty nor enjoying a higher level of well-being, and this condition is referred to as a zero-well-being gap.

3.1.2 Property 2: when $Y_1 < Z$, $WG_1 > 0$ and if $Y_1 > Z$, $WG_1 < 0$. When an individual's endowment falls below the poverty threshold, they experience a positive well-being gap. This gap is the difference between their current level of well-being and the minimum level required for a decent standard of living. The positive well-being gap is measured on a scale of 0 to 1, where 0 means the individual's well-being matches the minimum threshold and one means they have no endowment. A positive well-being gap indicates that the person's welfare falls short of the necessities for a decent standard of living. On the contrary, when an individual's endowment, which refers to their available resources, is higher than the poverty threshold, the resulting well-being gap is called a negative well-being gap. This implies that the individual has access to more resources than the minimum level required for a decent standard of living. In other words, they possess enough resources to meet their basic needs for food, clothing, shelter, and other essential goods and services and participate fully in their community and society.

3.1.3 Property 3. When the endowment Y is lower (higher) than the poverty threshold Z, the well-being gap approaches zero when Y is significantly closer to the poverty threshold in both directions. In other words, the closer the endowment is to the poverty threshold, the closer the well-being gap approaches zero:

$$\lim_{Y \to Z} WG_Y = 0$$

3.1.4 Property 4. When the endowment Y is lower than the poverty threshold Z, the well-being gap approaches one when an individual has no substantive endowment. In other words, the closer the endowment is to zero, the closer the well-being gap approaches one:

$$\lim_{Y \to 0} WG_Y = 1$$

On the contrary, when the endowment Y is higher than the poverty threshold Z, the well-being gap approaches a negative one when an individual has a higher endowment. In other words, the closer the endowment is to the maximum value, the closer the well-being gap approaches negative one:

$$\lim_{Y \to Y^{\max}} WG_Y = -1$$

3.1.5 Property 5. If the endowment for person 2 is higher than for person 1 (Y2 > Y1), the well-being gap for Y1 will be higher than for Y2. In other words, Y1 is farther away from the optimal level of well-being (the poverty threshold) than Y2. Therefore, we can conclude that Y1 has a lower welfare level than Y2.

3.1.6 Property 6. If the endowment for person 2 is higher than for person 1 (Y2 > Y1), then the rate of change (second-order difference) in the well-being gap of person 1 is higher than the rate of change (second-order difference) in the well-being gap of person 2. This indicates that more weight is given to Y1 than Y2 to demonstrate the severity of poverty.

3.1.7 Property 7. The standard squared poverty gap (severity of poverty) for a given endowment, Y1, is always lower than the well-being gap for the same endowment. This implies that the well-being gap gives more weight to the poor people than the standard FGT-squared poverty gap.

3.2 Well-being gap for categorical variables

In exceptional cases where the variable is measured with categorical (binary or ordinal) and ratio variables, the well-being gap is measured using the following equation:

$$WG_{ij} = \frac{Y_j^{max} - Y_{ij}}{Y_j^{max} - Y_j^{min}}$$

where Y_j^{min} is the minimum attainable value and Y_j^{max} is the maximum attainable value. For instance, if a health indicator has four categories (one to four). The maximum attainable value for this indicator is four, and the minimum attainable value is one. The concept of the well-being gap differs from the min-max approach. The min-max approach focuses on actual data to determine attained scores, while the well-being gap only considers the minimum and maximum attainable scores based on indicator labels. Moreover, the min-max approach is less applicable for measuring the well-being gap, as the numerator calculates the difference between the actual value and the minimum achieved score (Y − Ymin). To identify the threshold for the the estimation of deprivation score, the researcher sets a threshold based on the country's strategic priorities. However, if there is no clear criterion, the deprivation threshold can be determined by taking the maximum achievable value of an inidcator or the average of the minimum and the maximum values of an indicator by assuming that at least 50% of the indicator entitlement should be achieved. Some research studies have used the 50% threshold as a standardized approach (López-Calva and Ortiz-Juarez, 2014). The deprivation threshold can be demonstrated as follows:

$$Z_j = \frac{(Y_{max} + Y_{min})}{2}$$

3.3 Estimation of vulnerability to income and multidimensional poverty

The estimation of vulnerability to poverty is based on the well-being index. The vulnerability index is estimated using the following equation for indicators with continuous data:

$$V_{ij} = \frac{(1 + WG_{ij})}{2}$$

$$\text{Where } 0 < V_{ij} \leq 1.$$

For indicators with binary, ordinal and ratio data, the vulnerability index is estimated using the following equation:

$$V_{ij} = WG_{ij}$$

$$\text{Where } 0 \leq V_{ij} \leq 1.$$

Taking 50% is the most common approach regarding the vulnerability threshold since it is the level at which an individual's well-being is equal to or less than the poverty threshold z. This threshold level is a natural choice because an individual who is identified as vulnerable according to this threshold is more likely than not to be poor if faced with a random downside shock to their current level of consumption (López-Calva and Ortiz-Juarez, 2014). There are other approaches to choosing vulnerability thresholds. For example, ECA-ERA (2022) used a probability of poverty cutoff of 10% as a dividing line between economic security and vulnerability; Chaudhuri *et al.* (2002) defined an individual as vulnerable to poverty if his or her level of vulnerability is greater than or equal to the current poverty rate.

In this paper, vulnerability is defined and calculated along with the complete information set of an indicator. A value that approaches 1 shows high vulnerability to poverty; on the contrary, a value that approaches 0 shows a low level of vulnerability. Besides, a value greater than 0.5 is defined as the probability of staying in poverty, whereas a value less than 0.5 is defined as the probability of falling into poverty.

3.4 Properties of the vulnerability to income and multidimensional poverty estimation

3.4.1 Property 8. For any amount of an endowment Y_1, the vulnerability index goes between zero and one.

The vulnerability index for an endowment Y_1 is categorized into three parts. If the endowment for Y_1 is equal to the poverty threshold, the vulnerability index stands at 0.50. If Y_1 is above the poverty threshold, the vulnerability index ranges from 0 to 0.5, and it measures the probability of individuals falling into poverty or remaining nonpoor. If Y_1 is below the poverty threshold, the vulnerability index ranges from 0.5 to 1, and it measures the probability of individuals staying in poverty or escaping it.

3.4.2 Property 9. Vulnerability to poverty is calculated by adding the likelihood of remaining in poverty to the probability of falling into poverty. Therefore, vulnerability is assessed using the entire endowment information.

3.4.3 Property 10. When the endowment Y is higher than the poverty threshold Z, the vulnerability score approaches 0.5 when Y is significantly closer to the poverty threshold. In other words, the closer the endowment is to the poverty threshold, the more likely the person is to fall into poverty:

$$\lim_{Y \to Z} WG_Y = 0.5$$

On the contrary, when the endowment Y is lower than the poverty threshold Z, the vulnerability score approaches 0.5 when Y is significantly closer to the poverty threshold. In other words, the closer the endowment is to the poverty threshold, the more likely the person is to exit from poverty:

$$\lim_{Y \to Z} WG_Y = 0.5$$

3.4.4 Property 11. When the endowment Y is higher than the poverty threshold Z, the vulnerability score approaches 0 when Y is significantly closer to the maximum endowment. In other words, the closer the endowment to the maximum achievable value, the person is not vulnerable and stays nonpoor:

$$\lim_{Y \to \max} WG_Y = 0$$

On the contrary, when the endowment Y is lower than the poverty threshold Z, the vulnerability score approaches 1 when Y is significantly closer to zero endowment. In other words, the closer the endowment to zero endowment value, the more vulnerable the person is to stay as poor:

$$\lim_{Y \to 0} WG_Y = 1$$

3.4.5 Property 12. If the endowment for person 2 is higher than for person 1 ($Y_2 > Y_1$), the vulnerability score of Y_1 is higher than the vulnerability score of Y_2. In other words, Y_1 is farther away from the optimal level of well-being (the poverty threshold) than Y_2. Therefore, we can conclude that Y_1 is more vulnerable than Y_2.

3.4.6 Property 13. If the endowment for person 2 is higher than for person 1 ($Y_2 > Y_1$), then the rate of change (second-order difference) in the vulnerability score of person 1 is higher than the rate of change (second-order difference) in the vulnerability score of person 2. This indicates that more weight is given to Y_1 than Y_2 to demonstrate the exposure of vulnerability to the individual with a lower endowment.

3.5 Aggregation and decomposition of vulnerability score

If the dimension is only income, the estimate will give us vulnerability to income poverty (VIP). However, if there is more than one dimension, the estimate gives us VMP. Hence, the aggregated vulnerability can be estimated using the following equation:

$$VIMPI = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{\sum_{j=1}^{d} V_{ij}}{d}\right)$$

Finally, the aggregate VIMPI can be decomposed by dimensions, indicators and by different groups to better inform policymakers. The decomposition methodology is based on Shorrock's decomposition (Shorrocks, 1999) with slight modifications. Vulnerability can be decomposed across different population subgroups and created into maps for visual policy analysis. Suppose the population size of the achievement matrix Y is denoted by n. Y is divided into two population subgroups: $Y\ 'with\ a$ population size of n_1 and $Y\ 'with\ a$ population size of $n_{2,}$ such that $n = n_1 + n_2$.

Population subgroup decomposability: a vulnerability measure is additive population subgroup decomposability if:

$$VIMPI(Y) = \frac{n_1\ \ VIMPI(Y')}{n} + \frac{n_2 VIMPI(Y\ \prime')}{n}$$

The contribution S(Y′) of each group to overall vulnerability can then be calculated as follows:

$$S(x') = \frac{n_1 VIMPI(Y')}{n VIMPI(Y)}$$

The decomposition by dimensions or indicators for the vulnerability can be calculated by aggregating the vulnerability index of each indicator j:

$$d_j^v = \frac{1}{n}\sum_{i=1}^{n} V_{ij}$$

This can again be illustrated with the following illustration: Let's assume that there are two indicators, 1 and 2. The VMPI can be easily decomposed as follows:

$$VMPI(Y) = \frac{\sum_{i=1}^{n} V_{i1}}{n} + \frac{\sum_{i=1}^{n} V_{i2}}{n}$$

3.6 Selection of dimensions and indicators

The VIMPI provides a new estimation procedure to estimate the number of people vulnerable to income and multidimensional poverty. There is no limit to the number and type of dimensions and indicators used to estimate VIMPI. The selection of dimensions and indicators and the associated cutoffs usually depend on the ultimate use of the result-global comparison or policy intervention. For instance, the global MPI uses three dimensions and ten indicators to estimate all countries' poverty and rank countries globally (Alkire and Foster, 2011). However, if the estimation is for policy purposes, the dimensions and indicators could vary from country to country. The same estimation procedure, AF methodology, is used to produce national and regional MPI in Africa. For instance, United Nations. Economic Commission for Africa (2022) used the Alkire Foster methodology with four dimensions and 12 indicators to estimate poverty in African countries. Therefore, policymakers should select the dimensions and indicators relevant to a country's strategic priority. It is important to note that selecting dimensions and indicators is not a methodological contribution but rather an empirical exercise that should consider the country's needs and priorities.

3.7 Determination of indicators cutoff

The Alkire Foster methodology and the welfare-based multidimensional poverty (WMP) estimation use two cutoffs to determine the level of multidimensional poverty. The first cutoff helps identify if a person is deprived of a specific indicator, while the second determines whether a person is poor. There are three approaches to determining poverty at the aggregate stage: intersection, union, and intermediate. Unlike the AF methodology, which assumes censoring at the indicator and aggregate stages, the WMPI uses censoring at the last stage to determine poverty. Therefore, WMP uses two cutoffs but one censoring at the aggregate stage to determine multidimensional poverty (Andualem, 2024). However, for the VIMP, only one cutoff at the indicator level is used, and it uses no censoring. The researcher usually determines the cutoff for indicators by considering the country's strategic policy and priorities.

4. Illustration of vulnerability to income and multidimensional poverty index

In this section, the paper applies the VIMPI estimation method to a practical case using the 2016 household survey for Ghana (14,009 households) and Namibia (1,090 households). These two countries are selected only to demonstrate the methodology. To measure vulnerability to income poverty, the paper uses household expenditures. Moreover, to measure VMP, the paper used three dimensions to measure multidimensional poverty and vulnerability: health, unemployment and education. These dimensions are selected based on their relevance to the country's strategic plan. Moreover, experience and data availability guided the selection of indicators for each dimension [2]. Table 1 shows the indicators and associated cutoffs for identifying deprived households. The study estimated using three dimensions and five indicators.

Dimensions of MPI	Indicator	Data type	Description of the indicator	Poverty cutoff (z) [4] [5]	Achievable scores	
					Max	Min
Education	Years of education	Categorical ordinal	4 = Degree and above 3 = Secondary education 2 = Primary education 1 = No formal education	>2.5	4	1
	Ability to read and write of the head of the household	Binary	1 = Yes 0 = No	>0.5	1	0
Health	Infant mortality	Continuous	Number of infants died	0	–	–
	Food security score	Ratio	0 < FSS < 1	>0.5	1	0
Unemployment and security	Dependency ratio	Ratio	0 < DR < 1	>0.5	1	0

Source: Own construction

Table 1. A summary report of well-being indicators and the associated cutoffs for the VMP

As indicated in Table 1, indicators such as years of education and food security score are individual-level information. On the other hand, household head's ability to read and write, dependency ratio and infant mortality are household level information. Like the AF methodology, the household information will be shared by all individuals within the household. For example, if there is one infant mortality in a household, all household members will have this value. Hence, the unit of analysis used for the estimation of VIMP is the individuals [6].

5. Result and discussion

This section presents income and multidimensional vulnerability estimates using data from Ghana and Namibia. For ease of understanding, the paper presents first income and multidimensional poverty estimates, followed by the vulnerability estimate.

5.1 Income poverty and vulnerability to income poverty

The welfare-based income poverty estimate proposed by Andualem (2024) and the standard FGT income poverty measures are presented in Table 2. The headcount poverty estimate by the WIP gives a similar result as the standard FGT measure. The only slight difference is when we estimate the severity of poverty. As indicated in Table 2, the headcount poverty for Ghana with the WIP and FGT methodology is 23.4%. Similarly, Namibia's headcount of poverty in both approaches is 17.4. However, for the severity of poverty, the WIP measure gives more weight to people far from the poverty line. For Ghana, 5.7% of the population is severely poor, while with FGT, 4.2% is severely poor.

Vulnerability to income poverty is measured based on the welfare-based income poverty measure. Table 3 shows the vulnerability to income poverty. According to the estimates, 37.9% of the population in Ghana is vulnerable to income poverty. This value is decomposed into two parts: vulnerability to staying poor (14.57%) and vulnerability to falling into poverty (23.4%). Of the 23.4% of the poor population (Table 2), 14.57% is vulnerable to staying poor, indicating the extent of poverty is very high.

On the other hand, out of the 23.4% of the poor population, 8.83% could escape poverty. Moreover, of the nonpoor population, 23.4% are vulnerable to falling into poverty, while 53.05% will stay nonpoor. For Namibia, 31.63% of the population is vulnerable to income

Table 2. Income poverty with different approaches

	WIP		FGT	
Country	Headcount poverty	Weighted poverty estimate: severity of poverty	Headcount poverty	Weighted poverty estimate: severity of poverty
Ghana	23.4	5.7	23.4	4.2
Namibia	17.4	4.04	17.4	2.9

Source: Own computation the survey data, 2024

Table 3. Vulnerability to income poverty

Countries	Vulnerability to stay poor	Vulnerability to fall into poverty	Stay nonpoor	Slipped out of poverty	Vulnerable headcount
Ghana	14.57	23.4	53.05	8.83	37.9
Namibia	10.71	20.91	61.69	6.66	31.63

Source: Own computation the survey data, 2024 poverty, out of which 10.71% will remain poor, and 20.91% will fall into poverty. Of the 17.4% of the poor population (Table 2), 10.71% will remain poor, while 6.66% will exit from poverty. On the other hand, of the nonpoor population, 20.91% of the population will fall into poverty, and the rest, 61.69% of the population, will remain nonpoor.

5.2 Multidimensional poverty and vulnerability to multidimensional poverty

The multidimensional poverty estimate proposed by Andualem (2024) based on welfare and the standard AF methodology are presented in Table 4. The WMP estimates using two poverty cutoffs: union and intersection approaches. In the case of the tight poverty policy (deprivation of at least one indicator), Ghana's multidimensional poverty level is 38.5%. In the case of the loose poverty policy (on average deprivation of three or more indicators), it is 33.3%. The AF methodology's estimation result (43.7) is higher than the WMP estimation. This happened because the AF methodology gives an equal weight of 16% to all individuals deprived of an indicator, even though the actual deprivation is less than 16%. This is due to the censoring that occurred in the first stage of the estimation (see Andualem, 2024 for detailed comparison).

WMP is extended to consider the VMP. To estimate VMP, a vulnerability index should be calculated for each indicator, and that score should be normalized by the number of indicators and the population size to obtain the actual vulnerability score. This estimation process is similar to the vulnerability to income poverty method, with the only difference being the inclusion of multiple indicators. According to the estimation presented in Table 5, Ghana has 56%, and Namibia has 48% of the population vulnerable to multidimensional poverty.

6. Conclusion and policy implication

This study has introduced a new methodology to estimate vulnerability to income and multidimensional poverty using a well-being-based estimation method. The proposed methodology introduced the concept of well-being gap, individual-specific weighting and vulnerability into the estimation. The empirical results using the Ghana and Namibia data also showed that the proposed method could accurately estimate the number of people at risk of falling into poverty and the number of poor people staying in poverty.

Country	WMP MPI (intermediate approach)	WMP MPI (union approach)	AF methodology MPI
Ghana	33.32	38.53	43.75
Namibia	23.34	27.45	31.62

Source: Own computation of the survey data, 2024

Table 4. Multidimensional poverty: WMP and AF methodology

Countries	Vulnerability to stay poor	Vulnerability to fall into poverty	Stay nonpoor	Slipped out of poverty	Vulnerable headcount
Ghana	21	35	49	7	56
Namibia	16	32	41	7	48

Source: Own computation of the survey data, 2024

Table 5. Vulnerability to multidimensional poverty

Notes

1. Please refer to the study by Andualem (2024) for the rationale behind using the well-being gap to estimate multidimensional poverty.
2. Note that only three dimensions are selected for demonstration purpose. The use of many dimensions and indicator could change the result.
3. The unit of analysis, households or individuals is basically determined by the indicators used in the estimation. In both cases, however, the estimation result is the same.
4. The poverty cutoff as indicated by Andualem (2024) for categorical variables.
5. The poverty cutoff for the WMP used only to find the well-being gap. There is no censoring, unlike the AF methodology.

References

Abraham, R. (2008), "Multidimensional poverty and vulnerability", *Economic and Political Weekly*, Vol. 43 No. 20, pp. 79-87.

Alkire, S. and Foster, J. (2011), "Counting and multidimensional poverty measurement", *Journal of Public Economics*, Vol. 95 Nos 7/8, pp. 476-487.

Alkire, S. and Foster, J. (2016), "Dimensional and distributional contributions to multidimensional poverty".

Alkire, S. and Foster, J. (2019), "The role of inequality in poverty measurement".

Andualem, G.M. (2024), "Estimating multidimensional poverty: a new methodological approach", *Journal of Poverty*, pp. 1-19, doi: 10.1080/10875549.2023.2301620.

Assa, J. and Meddeb, R. (2021), "Towards a multidimensional vulnerability index", *UNDP Discussion Paper*, available at: www.undp.org/publications/towardsmultidimensional-vulnerability-index

Bourguignon, L. and Chakravarty, K. (2003), "The measurement of multidimensional poverty", *Journal of Economic Inequality*, pp. 25-49.

Calvo, C. (2013), "Vulnerability to individual and aggregate poverty", *Social Choice and Welfare*, Vol. 41 No. 4, pp. 721-740.

Calvo, C. (2008), "Vulnerability to multidimensional poverty: Peru, 1998-2002", *World Development*, Vol. 36 No. 6, pp. 1011-1020.

Celidoni, L. (2013), "Vulnerability to poverty: an empirical comparison of alternative measures", *Applied Economics*, Vol. 45 No. 12, pp. 1493-1506.

Celidoni, L. (2015), "Decomposing vulnerability to poverty", *Review of Income and Wealth*, Vol. 61 No. 1, pp. 59-74.

Cerioli, A. (1990), "A fuzzy approach to the measurement of poverty", in Dagum, C. and Zenga, M. (Eds), *Income and Wealth Distribution, Inequality and Poverty*, Springer: Studies in contemporary economics, Berlin.

Chaudhuri, S., Jalan, J. and Suryahadi, A. (2002), "Assessing household vulnerability to poverty from cross-sectional data: a methodology and estimates from Indonesia", *Department of Economics Discussion Papers*, Columbia University, pp. 0102-52, doi: 10.7916/D85149GF.

Chiwaula, L.W. (2011), "An asset-based approach to vulnerability: the case of small scale fishing areas in Cameroon and Nigeria", *Journal of Development Studies*, Vol. 47 No. 2, pp. 338-353.

Christopher Connor (2022), "Robust estimates of vulnerability to poverty using quantile estimators".

Dutta, I.F. (2011), "On measuring vulnerability to poverty", *Social Choice and Welfare*, Vol. 37 No. 4, pp. 743-761.

ECA-ERA (2022), Economic Report on Africa United Nations Economic Commission for Africa, Addis Ababa, Ethiopia.

Feeny, K., McDonald, O. and, (2016), "Vulnerability to multidimensional poverty: findings from households in melanesia", *The Journal of Development Studies*, Vol. 52 No. 3, pp. 447-464.

Gallardo, K. (2013), "Using the downside mean-semi deviation for measuring vulnerability to poverty", *Economics Letters*, Vol. 120 No. 3, pp. 416-418.

Gallardo, K. (2018), "Identifying vulnerability to poverty: a critical survey", *Journal of Economic Surveys*, Vol. 32 No. 4.

Günther, I. (2014), "Poverty, vulnerability, and reference-dependent utility", *Review of Income and Wealth*, Vol. 60 No. 1, pp. 155-181.

Hohberg, M.L. (2018), "Vulnerability to poverty revisited: flexible modeling and better predictive performance", *Journal of Economic Inequality*.

Klasen, S. (2013), *Vulnerability to Poverty: Theory, Measurement, and Determinants, with Case Studies from Thailand and Vietnam*, Palgrave Macmillan, New York.

López-Calva, L.F. and Ortiz-Juarez, E. (2014), "A vulnerability approach to the definition of the Middle class", *The Journal of Economic Inequality*, Vol. 12 No. 1, pp. 23-47.

Ophi, O. (2018), *Global Multidimensional Poverty Index 2018: The Most Detailed Picture to Date of the World's Poorest People*, University of Oxford, Oxford.

Povel, F. (2015), "Measuring exposure to downside risk with an application to Thailand and vietnam", *World Development*, Vol. 71, pp. 4-24.

Shorrocks, A.F. (1999), *Decomposition Procedures for Distributional Analysis: A Unified Framework Based on the Shapley Value*, University of Essex, Essex.

The World Bank (2000), "Quantifying vulnerability to poverty: a proposed measure, applied to Indonesia".

United Nations Economic Commission for Africa (2022), Measuring the multiple dimensions of poverty in Africa A case study of Côte d'Ivoire, Uganda, the United Republic of Tanzania, Zambia and Zimbabwe: final report. Addis Ababa:. © UN. ECA, available at: https://hdl.handle.net/10855/49377

Further reading

Bigsten, A., Mengistae, T. and Shimeles, A. (2007), *Mobility and Earnings in Ethiopia's Urban Labor Markets*, Vol. 4168, World Bank Publications, pp. 1994-2004.

Dercon, S.D., Gilligan, J., Hoddinott, T. and Woldehanna, M. (2009), "The impact of roads and agricultural extension on consumption growth and poverty in fifteen Ethiopian villages", *American Journal of Agricultural Economics*, Vol. 91 No. 4, pp. 1007-1021.

Maasoumi, K. (1986), "The measurement and decomposition of multidimensional inequality", *Econometrica*, Vol. 54 No. 4, pp. 771-779.

Subramanian, S. (2009), "Poverty measurement in the presence of a 'group-affiliation'externality", *Journal of Human Development and Capabilities*, Vol. 10 No. 1, pp. 63-76.

Corresponding author
Andualem Goshu Mekonnen can be contacted at: andulaser@gmail.com