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“Quantitative Methods for Integrated Food and Nutrition Security Measurements – Lessons to be learned!”
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Outline

1. Introduction
2. Why proposing this “Multidimensional Food and Nutrition Security Measurement”
3. Methodology
4. Results
5. Conclusion
Introduction

• The first attempt to measure food consumption and assess nutrition problem date back to the First World War with the development of "food balance sheet" (FAO, 2001).
  
  "food balance sheet" has been criticized to be weak to integrate socio-economic factors and exogenous shocks, like climate variability, affecting food availability and access.

• Early 1974—the redefinition of food security brought food security analysis at micro-level.
  
  However, micro-level analyses were constrained by the lack of well disaggregated data.

• The adoption of new food security definition (1996) resulted in attempting measuring food and nutrition security at household and even individual level (FAO, 1996).

• The well know methods emanating from this definition include: Food Consumption Score (FCS); Integrated Food Security Phase Classification (IPC) and Consolidated Approach for Reporting Food Security Indicators among others (WFP, 2008; FAO, 2008a; WFP, 2015).
  
  However, these estimations have shown some weaknesses in determining how changes in factors of food and nutrition security dimensions may lead to food and security variations at household level.
Why proposing this “Multidimensional Food and Nutrition Security Measurement”

• In the recent years their terminologies have known rigorous evolutions;
  ➢ and highly disaggregated data on factors affecting food and nutrition security are available than at any time in the past.

• Apace with this;
  ➢ There has been considerable advancements in methodologies to construct food and nutrition security indicators.

• Nonetheless;
  ➢ Gaps to combine food and nutrition security dimensions and develop a multidimensional food and nutrition security indicator still exist.

• This is a motivator for the development of this paper,
  ➢ Which sheds light on the usefulness of household food and nutrition security survey to construct a multidimensional food and nutrition security indicator,
    ❖ To complement information provided by other indicators existing in the area.
<table>
<thead>
<tr>
<th>Dimension</th>
<th>Factor</th>
<th>Description of factors (follow a binomial distribution)</th>
<th>Expected effect</th>
<th># Factors</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demography</td>
<td>Household size</td>
<td>Household size is below or equal to the national estimated average household size.</td>
<td>+</td>
<td>2</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Monogamous</td>
<td>Male household head has one wife</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>Education Level</td>
<td>One of the household members has completed at least secondary, vocational, university</td>
<td>+</td>
<td>2</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Attendance rate</td>
<td>HH overall primary school attendance rate</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WASH</td>
<td>Cleaned water</td>
<td>improved water (public/home tap and borehole with pump vs others)</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improved toilet</td>
<td>If there is an improved toilet in household</td>
<td>+</td>
<td>3</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>Drinking water</td>
<td>If water prepared prior drinking (boil)</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>Livestock</td>
<td>Household own at least one livestock</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Land</td>
<td>Household own farming land including pasture for livestock</td>
<td>+</td>
<td>3</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>Climate</td>
<td>Household did not experienced drought</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Livelihood</td>
<td>Activities</td>
<td>Household has at least two livelihood activities</td>
<td>+</td>
<td>3</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>Market Participation</td>
<td>HH has at least sold something at market</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food consumption</td>
<td>Meal adult</td>
<td>If adult persons in household take at least two meals per day</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Meal children</td>
<td>If children under 15 in household take at least three meals per day</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Food Diversity</td>
<td>If the diversity of household’s diet is medium or good</td>
<td>+</td>
<td>6</td>
<td>24%</td>
</tr>
<tr>
<td></td>
<td>Vitamin</td>
<td>If food with Vitamin A is daily consumed in a household</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Protein</td>
<td>If food with Protein is daily consumed in a household</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Iron</td>
<td>If Hem iron rich food is daily consumed in a household</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutrition</td>
<td>Waste</td>
<td>If there is no wasted children in a household</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stunted</td>
<td>If there is no stunted children in a household</td>
<td>+</td>
<td>3</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>Underweight</td>
<td>If there is no underweighted children in a household</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td>Road</td>
<td>If the road to the market is accessible all-round the year</td>
<td>+</td>
<td>3</td>
<td>12%</td>
</tr>
<tr>
<td>infrastructures</td>
<td>Market</td>
<td>If there is a functioning market in the village</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Health facility</td>
<td>If there is a functioning health facility in the village</td>
<td>+</td>
<td>25</td>
<td>100%</td>
</tr>
</tbody>
</table>
Methodology

• 5 steps:

➢ 1\textsuperscript{st}: Assigning food and nutrition security identification characteristic for each factor in each dimension and for each household;

➢ 2\textsuperscript{nd} Sum all identification characteristics of all factors included in each dimension;

➢ 3\textsuperscript{rd} Apply weighting factors to the average of the generated sum of food and nutrition identifiable characteristics in each dimension;

➢ 4\textsuperscript{th} Sum all weighted average sum of food and nutrition security characteristics cross all dimensions.

➢ 5\textsuperscript{th} Apply cutoff vector to categorize households: 1. Highly food and nutrition secure, 2. food and nutrition secure, 3. marginally food and nutrition secure, 4. moderately food and nutrition insecure and 5. severely food and nutrition insecure.

• Thereafter, this paper ranks provinces and districts in Rwanda by each multidimensional food and nutrition security category.
Methodology (cont’d)

• For each vector for food and nutrition characteristic factor, \(v\), in each dimension;

\[
(h_{iv}, f_{iv}) = \begin{cases} 
1, & \text{if } v \text{ is identifiable for household } i \\ 
0, & \text{Otherwise} 
\end{cases} 
\]  

(1)

• So that the sum of all food and nutrition security characteristic vectors for dimension, \(j\), is expressed as:

\[
\sum_{v=1}^{n_j}(h_{iv}, f_{iv}) = \begin{cases} 
\sum_{v=1}^{n_j} h_{iv}, & \text{If } j \text{ is fully identifiable for household } i \\
0 \leq \cdot < n_j, & \text{Otherwise} 
\end{cases} 
\]  

(2)

“where \(n_j\) is the number of all factors included in \(j\) dimension”

• An arithmetic mean of all food and nutrition security identifiable for dimension \(j\), \(\mu_d_j\), is computed as;

\[
\mu_d_j = \frac{\sum_{v=1}^{n_d}(H_{iv}, f_{iv})}{n_j}; 
\]  

(3)

• So that the resulting average fall in a closed set of rational numbers \([0, 1]\); and for household, \(i\):

\[
\mu_{dij} = \begin{cases} 
1; & \text{if for that household } i \text{ all food and nutrition security characteristics factors are identifiable in dimension } j \\
0 \leq \cdot < 1; & \text{Otherwise "depending of the number of identifiable factors in dimension } j \text{ for household } i\} 
\end{cases} 
\]  

(4)
This paper defines a weighting vector \( w \) whose \( j \)th element \( w_j \) represents the weight that is applied to dimension \( j \), as

\[
w_j = \frac{\sum_{j=1}^{n_j} f_j}{\sum_{i=1}^{N_D} f_i}
\]

(5)

Where \( \sum_{j=1}^{n_j} f_j \): total number of factors included in dimension \( j \); \( \sum_{i=1}^{N_D} f_i \): total number of all factors included in all dimensions

Then the multidimensional food and nutrition security identification characteristic for \( j \) dimension is computed as the weighted average of the total number of identifiable food and nutrition security characteristics in dimension \( j \), that is;

\[
h_{ij} = w_j \mu_{d,j}
\]

(6)

Applying the weighting factor on the computed \( \mu_{d,j} \) for household \( i \), gives that for dimension \( j \),

\[
\left( \mu_{d,j}, w_j \right) = \begin{cases} 
  w_j & \text{if all food and nutrition security characteristic factors included in dimension } j \text{ are fully identifiable for household } i \\
  < w_j & \text{Otherwise}
\end{cases}
\]

(7)

so that,

\[
\sum_{j=1}^{d} \left( \mu_{d,j}, w_j \right) \in \{0,100\}; \quad \text{as} \quad \sum_{j=1}^{d} w_j = 100
\]

(8)

The sum of weighted averages cross all dimensions is then used to give information on a household \( i \)'s multidimensional food and nutrition security, that is;

\[
h_i = \sum_{j=1}^{d} \left( \mu_{d,j}, w_j \right)
\]
The estimated values of $h_i$ approach normal distribution pattern (see figures in results),

- where $h_i$ is the vector of household $i$'s multidimensional food and nutrition security identification characteristic across all dimensions;

- so that the set $H \subseteq \{1, \ldots, n\}$ of all households has subset $H_C \subset H$ of households which may have the same or similar food and nutrition identification characteristics within each dimension and across all dimensions.

To create subset $H_C$,

- The $w$ is taken as a given and apply cutoff vector $C$ to categorize set $H$ into five subset $H_C$;

- This is done by using the cutoff vector $C$ in $R^d_+$ to created indicator variable, $h_i$, so that;

$$H_C = \begin{cases} 
\geq 80\% & \text{if household } i \text{ is highly food and nutrition secure} \\
60\% \leq < 80\% & \text{if household } i \text{ is food and nutrition secure} \\
50\% \leq < 60\% & \text{if household } i \text{ is marginally food and nutrition secure} \\
30\% \leq < 50\% & \text{if household } i \text{ is moderately food and nutrition insecure} \\
0\% \leq < 30\% & \text{if household } i \text{ is severely food and nutrition insecure}
\end{cases}$$
• In this study, we use datasets of two surveys conducted in 2012 and 2015 in Rwanda for the study of,

  • ‘Comprehensive Food Security and Vulnerability Analysis and Nutrition Survey [CFSVA&NS]’ (MINAGRI).

• These surveys follow a panel sample of 7500 households across all districts in the country.

• For the purpose of analysis, we decided to use only variables reported in Table, in the previous slide, on which these surveys have collected information.

• In our approach we follow descriptions in Table reported in the previous slide to derive a multidimensional food and nutrition security measurement.
Results

Identification of food and nutrition security factor characteristics in each dimension

- The following Figure shows that, overtime, from 2012 to 2015;
  - full identification of food and nutrition security characteristic factors was improved in WASH, demography, nutrition, livelihoods, access to physical infrastructures, food consumption and education dimensions, respectively;
  - Whereas it was deteriorated only in agricultural dimensions.
Results
Multidimensional food and nutrition security measurement

• For comparison purpose, estimated values of MFNS measurement and FCS are plotted against the normal distribution.
  • Figure 1 and Figure 3 show the density distribution of the MFNS measurement estimated using the approach developed in this paper;
  • whereas Figure 2 and Figure 4 show the density distribution of FCS as they were reported in 2012 and 2015.

• The observation demonstrates that;
  • the density of values of FCS highly deviate from the normal distribution
  • whereas the density of estimated values of MFNS approach normal distribution pattern.

• More importantly, the distribution of the estimated $h_i$ offers many advantages when modeling food and nutrition security.
  • First, the normal distribution work quite well when compared to other distributions;
  • Second, the probability distribution function (PDF) show that many phenomena are normally distributed or so very closer to normal distribution;
  • Third, with statistical and mathematical models, the normal distribution is easy to work with and in general forecasting techniques developed using normal distribution theory work quite well.
Results
Identification of food and nutrition security factor characteristics in each dimension

Fig. 1: Density distribution of MFNS (2015)
Kernel density estimate
Normal density

Fig. 3: Density distribution of MFNS (2012)
Kernel density estimate
Normal density

Fig. 2: Density distribution of MFNS (2015)
Kernel density estimate
Normal density

Fig. 4: Density distribution of MFNS (2012)
Kernel density estimate
Normal density
Results
Estimated MFNS measurement diversity cross provinces and districts

- From the categories used in this paper, the figures in the following slide shows that from 2012 to 2015:
  - The % of households which are highly food and nutrition secure increase by 0.92%;
  - The % of households which are food and nutrition secure increased by 4.02%;
  - The % of households marginally food secure decreased by 5.33%;
  - The % of households which are moderately food and nutrition insecure reduced by 2.09%; and
  - The % of households which are severely food and nutrition insecure increased by 2.49%

- More generally, the approach used demonstrates that from 2012 to 2015 the percentage of households which are severely food and nutrition insecure was increased in all provinces.
  - With Western province recording the highest increase (3.7%) followed by Southern province (3.3%).

- Therefore, one of the key findings of this paper show that between 2012 and 2015,
  - there was significant increase of households severely food and nutrition insecure which other existing techniques failed to identify.
Shift in % of households cross food and nutrition categories (National Level)

<table>
<thead>
<tr>
<th>Category</th>
<th>2015</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly Food and Nutrition Secure</td>
<td>1.15</td>
<td>0.23</td>
</tr>
<tr>
<td>Food and Nutrition Secure</td>
<td>30.80</td>
<td>26.78</td>
</tr>
<tr>
<td>Marginally Food and Nutrition Secure</td>
<td>34.48</td>
<td>39.81</td>
</tr>
<tr>
<td>Moderately Food and Nutrition Insecure</td>
<td>29.81</td>
<td>31.89</td>
</tr>
<tr>
<td>Severely Food and Nutrition Insecure</td>
<td>3.77</td>
<td>1.28</td>
</tr>
</tbody>
</table>
• Among households which are highly food and nutrition secure, at national level;
  • The percentage of households headed by females increased by 0.23% (2012 - 2015)
  • while the percentage of those headed by males increased by 1.21% from 2.12 to 2.15.
    • Cross provinces, the percentage of households headed by males is greater than that of households headed
      by females, among households highly food and nutrition secure and households which are food and
      nutrition secure.

• Among households severely food and nutrition insecure, a high increase was experienced among households
  headed by females compared to those headed by males.
  • The province which experienced the highest increase of percentage of households severely food and nutrition
    insecurity;
    • was the Southern province and Western province for households headed by males
    • while it was Northern Province for households headed by females.
Severely food and nutrition insecure, 2012 vs 2015
Conclusion

• One of the key findings of this paper show that between 2012 and 2015,
  • there was significant increase of households severely food and nutrition insecure which other existing techniques failed to identify.

• The key value added of the constructed indicator with rigorous consideration of socio-economic and physical infrastructure factors is that;
  • it bears additional information not captured in food security or nutrition security indicator when each stand alone.

• However, calling attention to the added value of the developed multidimensional food and nutrition indicator does not suggest that single-dimensional indicators of food and nutrition security be renounced but rather complemented (another picture of F&NS).
The European Commission’s science and knowledge service

Joint Research Centre

Thanks for your attention

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