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Research

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Dynamics of Multidimensional Food Security Measurement in Rural Ethiopia

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Abstract

Most studies measuring food security have used one or two of the dimensions of food security, with snapshot data at a particular point in time. Policies derived from such measurement might be misleading because of the dynamic nature of food security or insecurity in vulnerable populations. This paper presents a composite food security measure that captures the four dimensions of food security i.e., availability, accessibility, utilization, and stability over time. Principal Component Analysis (PCA) is used to reduce the four dimensions into a single index. Data from three rounds of household-level panel data, collected by the Central Statistical Agency (CSA) of Ethiopia in collaboration with the World Bank are used to demonstrate this measurement. The aggregate food security indices result revealed that 44, 57, and 45 percent of households were food secured in 2011, 2013, and 2015 respectively. On the other hand, only 20 percent of households were food secured all the time while 67 percent of households termed as transitory food insecure since they remained food insecure at least in one of the survey periods. The rest 13 percent of households were also termed chronically food insecure since they fall short of food all the time of the study. The finding confirmed a high prevalence of multidimensionally food-insecure households in rural Ethiopia. Therefore, various food security intervention programs that enhance the four dimensions should be introduced.

Key Words: Food Security, Availability, Accessibility, Utilization, Stability, and PCA

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1. Introduction

Food insecurity is at the top of the agenda of politics around the globe, as about 825 million people most of who live in Africa and Asia are threatened by hunger (Diouf & Sheeran, 2010; FAO, 2017). Food insecurity is a difficult problem both in the urban and rural parts of Ethiopia although the extent and severity of the problem vary from the moisture scarce northeast highland plateaus to some pastoral areas of the country. CSA and WFP (2014) report that 29 percent of the rural and 21 percent of urban populations were food insecure. FAO and IFAD (2016) have also reported that the percentage of undernourished people in the country declined from 74 percent in 1990 to 32 percent in 2015. To address this situation in chronically food-insecure areas, the government has designed comprehensive interventions including, soil and water management, plant nutrient generation and recycling, drought and pest-resistant crop varieties, improved post-harvest management, and diversification of livelihood in farming areas located in the moisture deficit parts of the country (FAO, 2012).

Food security is a complex concept that is influenced by multiple economic, social, political, and environmental factors. This vast-complexity makes food security an extensive and flexible concept with numerous intimately linked definitions as reflected in many research and policy papers. S. Maxwell and Smith (1992) identified about 200 definitions and 450 indicators of food security in various published writings from 1943-1992. The literature on food security measurements is heterogeneous, in terms of the unit of analysis, methodology, and dimensions involved. These make capturing all the dimensions of food security using one indicator very challenging; therefore, combining more than one indicator has been strongly recommended by several scholars (Headey & Ecker, 2012; D. Maxwell & Coates, 2012; Nathalie, 2012).
Consistent with this suggestion, composite indicators (the use of two or more indicators) have been developed to improve the measurement of food security.

Composite measures enable a group of indicators that capture various dimensions of food security to be combined into a solo measure or index. Hitherto, some researchers developed composite food security measurements: Napoli, De Muro, and Mazziotta (2011), introduced the composite food insecurity multidimensional index; Rose and Charlton (2002), developed a composite measure of food security for South Africa; others are the IFPRI Global Hunger Index (von Grebmer et al., 2013) and the nutrition index (Wiesmann, Von Braun, & Feldbrügge, 2000). These measurements emphasize national-level indicators such as income, poverty, undernourishment, food production, and macro-level data.

However, to date, most food security measurement studies use partial measures (i.e., take into account one or two dimensions). So, this paper aims to fill the gaps unexplored by previous research works (Abafita & Kim, 2013; Demeke, Keil, & Zeller, 2011) by developing a multidimensional measure of food (in)security in Ethiopia.

2. Methods

2.1 Principal Component Analysis

Principal Component Analysis (PCA) is used to generate a composite index using selected indicator variables under each dimension of food security. PCA can transform selected multiple indicators into fewer components that capture most of the information in the original indicators. Vyas and Kumananayake (2006) have outlined steps to construct composite socioeconomic indices using PCA; Qureshi (2007) and Demeke et al. (2011) have also applied it to generate a composite food security index.
Index construction can be highly subjective, particularly in the determination of weights assigned to each element of the index. PCA can extract a linear combination of indicator variables that gives maximum variance and converts them into fewer or a single index (Zeller, Sharma, Henry, & Lapenu, 2006). The derived index denotes a summary of the best linear relationship among the original variables (Conte, 2005). Suppose that there is a set of n correlated indicator variables for each food security dimension \((x_1, x_2, x_3, \ldots, x_n)\); PCA allows for the generation of different uncorrelated components whereby each component is a linear weighted sum of the original variables. Mathematically, PCA is specified as follows:

\[
PC_{11} = \rho_{11}X_1 + \rho_{12}X_2 + \ldots + \rho_{1m}X_m
\]

\[
PC_{nm} = \rho_{n1}X_1 + \rho_{n2}X_2 + \ldots + \rho_{nm}X_m
\]

Where \(\rho_{ij}\) represents the weight for variable \(X_j\) in the \(i^{th}\) (\(i = 1, 2, \ldots, n\) and \(j = 1, 2, \ldots, m\)) principal component. Estimated principal components are sorted in descending order thus the first principal component explains the largest amount of variance in a data set conditional on the constraint that the sum of the squared weights is equal to one \((\rho_{i1}^2 + \rho_{i2}^2 + \rho_{i3}^2 + \ldots + \rho_{ij}^2 = 1)\). Each subsequent component explains an extra but less proportion of the variation of indicator variables. Fewer components are required to capture the common information if a higher degree of correlation exists between the original variables (Vyas & Kumaranayake, 2006).

After identifying the components, the households’ food security score/index can be derived as follows:

\[
FSI_i = \sum F_j \left( \frac{X_j - \mu_j}{\sigma_j} \right)
\]

Where \(FSI_i\) represents household \(i\)’s food security index that is assumed to follow a normal distribution with a mean of 0 and a standard deviation of 1; \(F_j\) is the weight of variable \(j\) in the
PCA model, $X_{ij}$ is a value of the $j^{th}$ variable for the $i^{th}$ household, $\mu_j$ and $\sigma_j$ are mean and standard deviation respectively of the $j^{th}$ variable for all farm households. Since the analysis uses panel data, it is important to derive an index that can be used to make comparisons over time. Following Cavatassi, Davis, and Lipper (2004), the study pooled the three waves of survey data and conducted PCA over the combined three-period data set. Then, the derived weights were applied to the value of indicator variables for each survey round using equation (2) that computes an index that is comparable over time. Thus, the food security index of farm households in each period is the sum of the weighted z-scores of each period multiplied by the actual value of variables.

Two main aggregation methods exist in the literature for generating a combined index and each method has its advantages and disadvantages. Additive aggregation is the simplest method; it entails the calculation of the ranking of households by each indicator and summation of the resulting ranking (Fagerberg, 2001). However, this method is undesirable due to the full compensable nature of aggregation such that the low performance of some indicators can be compensated for by the high performance of other indicators. On the other hand, geometric aggregation addresses the problem of full compensable even though the computation is a little harder than the simple aggregation. For this paper, the score of each dimension was aggregated using the geometric mean to create overall food security indices. Anand and Sen (1997) have stated that power means of order greater than one are very useful in building composite indices of food security measures that place equal weight on the four dimensions. The method has been used to measure Human Development Index (HDI) and Human poverty index (HPI) by the United Nation Development Program (UNDP) and other scholars (Antony & Rao, 2007; Napoli et al., 2011). Hence, this study aggregates the four dimensions of food security using
Sen’s suggestion (Anand & Sen, 1997) of power three, which is the aggregate food security index specified as follows:

\[ Food\ Security_{index} = \frac{1}{4} \left[ (Ava_i^3 + Acc_i^3 + Uti_i^3 + Sta_i^3)^{\frac{1}{3}} \right] \tag{3} \]

\(Ava_i =\) Availability; \(Acc_i =\) Associability; \(Uti_i =\) Utilization; and \(Sta_i =\) Stability

The necessary indicator variables intimately related to each food security dimension have been selected through exploring a rich set of food security literature (Abafita & Kim, 2013; Bashir, Schilizzi, & Pandit, 2012; Demeke et al., 2011; Magrini & Vigani, 2016; Napoli et al., 2011). The number of indicator variables that are included in PCA analysis should be greater than two and sometimes only two variables can be used to do PCA analysis if a correlation greater than 0.70 exists between variables (Tabachnik & Fidell, 2007; Yong & Pearce, 2013). In general, the minimum requirements of indicator variables depend on the study design and the data sets. Based on the previous empirical works, economic theories, and dataset in hand, the study chose four indicators for each of the four dimensions of food security i.e availability, access, stability, and utilization. A total of sixteen variables were used to generate the overall food security indices of farm households (see Table 1).
Table 1: Description and Measurements Units of Selected Food Security Indicators Under Each Dimension

| Dimensions | Variables | Definition of Variables | Units |
|------------|-----------|-------------------------|-------|
| Availability | land_size | Size of cultivated land in the agricultural season | Ha |
| | production<sup>1</sup> | The total amount of cereal production in the agricultural season | Kg<sup>2</sup> |
| | crop_stored | Amount of crop stored for future consumption | Kg |
| | Food_gift | Amount of crop obtained as a gift from others | Kg |
| Accessibility | income | Households yearly real income<sup>3</sup> (sum of farm and non-farm income) | Birr |
| | FPI | The regional food price index | % |
| | market_dist | Households distance from the nearest market | Km |
| | food_exp | Amount of money spent to buy miscellaneous food items | Birr |
| Utilization | num_crops_ | Number of crops produced in the agricultural Season | Number |
| | diet_diversity<sup>4</sup> | Number of food groups consumed in 7 days | Number |
| | livestock | Number of edible livestock | TLU |
| | water_hygiene | If a household has a clean water access | 1=Yes 0=No |
| Stability | shock_freq | Number of health shocks occurred to the household heads per year | Number |
| | income_sources | Main sources of income for HHs | Number |
| | num_months | Number of months in which the Households do not have enough foods | Number |
| | asset_value | Value of physical farm and household assets | Birr |

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<sup>1</sup> Quantity of cereal production in teff equivalent of wheat, barley, sorghum, maize and millet
<sup>2</sup> Name of Ethiopian Currency (Currently 1USD=27.6 Eth Birr)
<sup>3</sup> CPI-deflated real prices are used in computing the value of crop output
<sup>4</sup> DDS: Dietary Diversity Score is often used as a proxy measure of the nutritional quality of household’s diet. An adult household member can have a food group of 0-12 while a child may have 0-8 food group. Each food group contains more than one food items. Hence when a household lays on more food groups that implies a household consumes more variety of foods.
2.2 Data Source

The measurement is based on household-plot level agricultural production panel data collected in 2010/2011, 2012/2013, and 2014/2015. The data was collected by the Central Statistics Agency of Ethiopia in collaboration with the World Bank Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA). The Survey covers all nine regions of the country but, this research included only four regions (Amhara, Oromia, SNNP, and Tigray) because the other regions were not included in the first survey period, and are also not engaged in cereal production because the agroecology in the regions is not conducive for cereal production. The number of households interviewed were 3,969 (2011), 5,262 (2013), and 4594 (2015). In this study, a total of 1,412 farm households were selected in each wave which forms a panel data of 4,236 observations. Specifically, the sample encompasses farming households who cultivated five major food crops (teff, wheat, barley, maize, and sorghum) that account for about three-fourths of total cultivated land. Table 2 shows the sample size used in the study by region and year.

| Regions/Years | 2011 | 2013 | 2015 | Total |
|---------------|------|------|------|-------|
| Tigray        | 252  | 252  | 252  | 756   |
| Amhara        | 448  | 448  | 448  | 1344  |
| Oromia        | 318  | 318  | 318  | 954   |
| SNNP          | 394  | 394  | 394  | 1182  |
| Total         | 1412 | 1412 | 1412 | 4236  |

Source: From ESS5 2011-2015

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5 Ethiopian Socioeconomic Survey
2.3 Method of Analysis

2.3.1 Descriptive Statistics

Descriptive statistics including measures of central tendencies, dispersions, and tables are used to summarize variables under each food security dimension and a mean difference test is performed to analyze yearly changes over the study period.

2.3.2 Steps of Multidimensional Food Security Index Estimation

To compute farm households’ food security index, the study follows several steps of PCA. One percent of the total observations had missing values in at least one covariate. In literature, there are various possible options to manage the problem of missing values. For example, Cortinovis, Vella, and Ndiku (1993) have suggested dropping observations with at least one missing value; however, this way of elimination might lower the sample size and reduce the validity of the results particularly if the original sample size is small (Nakagawa & Freckleton, 2008). Gwatkin et al. (2007) have recommended substituting missing values with the mean value of a variable itself. This may also reduce variations among observations which is very essential in the application of PCA. Imputing is also an alternative way of replacing missing values by estimating (imputing) missing values and then apply PCA estimation on the completed data set. Missing values were imputed in this study.

Secondly, some degree of correlations is expected to exist between some of the food security indicators to allow the use of PCA. A correlation test between variables was executed on each dimension of food security (see Appendix A). Higher correlations among food security indicators could result in a better variance to be captured by each principal component. The correlation coefficients of each food security dimension were large enough to allow the use of PCA. Also, the raw data set can be used for PCA estimation if indicator variables have the same measurement units. However, this tends to give more weight to variables with higher
variance than variables with lower variance. Since indicator variables used to generate the food security index have different units of measurement, the original indicator variables (raw data) were standardized to a zero mean and standard deviation of one before the PCA estimation was carried out.

The results of the PCA estimation were examined with an intermediate step that checked the component matrix and the weight of the coefficients of the variables. The number of extracted components from the PCA equals the number of variables included in the analysis. This notwithstanding, the number of components to be retained was determined using either the screen plot line or Kaiser's rule. Based on the estimation results the first component of each food security dimension had an eigenvalue greater than one and confirmed the retention of components. Houweling, Kunst, and Mackenbach (2003) used the first principal component as an index of households’ economic status since it explained the largest proportion of variation and had an eigenvalue greater than one. The same approach is followed here so that the first principal component of each food security dimension is used as the farm household’s food security index.

3. Result and Discussion

3.1 Descriptive Statistics Food Security Indicator Variables

The descriptive statistics of food security indicators used to derive each dimension of the food security index presented in Table 3. The means of the indicator variables do not show a consistent direction of change between 2011 and 2015 although some indicator variables show a steady upsurge. For example, income, food expenditure, and diet diversity variables, which are crucial components of food security, increased steadily. The average real income of farm households increased from 7158 Birr in 2011 to 8824 Birr in 2015. The mean food expenditure
of farm households also increased from 1726 Birr to 2353 Birr over the same period. Likewise, the average food price index (FPI) increased from 107 percent in 2011 to 134 percent in 2015\(^6\).

The average diet diversity of farm households in the seven days before the interview also increased from about 8 in 2011 to 9 in 2015, suggesting that households consumed more diverse foods in 2015 than the earlier survey periods. Similarly, the proportion of farm households who had access to safe drinking water increased from 73 percent in 2011 to 86 percent in 2015.

On the other hand, the average farm size of households declined from 1.25 ha in 2011 to 1.21 ha in 2015. While the average cereal production initially increased from 628 kg in 2011 to 716 kg in 2013 then declined to 695 kg in 2015. Similarly, the mean value of the rest of the food security indicators (crops stored, food gifts, the number of harvested crops, livestock, income sources, the number of months without enough food and asset value) increased between the year 2011 and 2013 but declined in 2015. On average, household heads faced health shock about once in 2011 and this figure declined to 0.62 in 2013. However, the shock frequency rose again to 1.10 in 2015. Alternatively, 50, 36 and 58 percent of household heads experienced health shocks in 2011, 2013, and 2015 respectively. The average distance of farm households to the nearest marketplace was 47.8 km over the study period, suggesting that households had sold and bought products in the same physical market locations.

The t-test result revealed that except for land size, market distance, number of cultivated crops, number of months without enough food, and asset values variables, there were significant differences between the values of the variables between 2011 and 2015.

\(^6\) 2010=100 (2010 was taken as a base year)
Table 3: Descriptive Statistics of Food Security Indicators

| Variables       | 2011 Mean | 2011 Std.Dev. | 2013 Mean | 2013 Std.Dev. | 2015 Mean | 2015 Std.Dev. | Full Sample Mean | Full Sample Std.Dev. | t-test |
|-----------------|-----------|---------------|-----------|---------------|-----------|---------------|-------------------|---------------------|--------|
| Availability    |           |               |           |               |           |               |                   |                     |        |
| Land size       | 1.25      | 0.88          | 1.22      | 0.95          | 1.21      | 1.01          | 1.23              | 0.95                | 0.31   |
| Production      | 627.6     | 379.4         | 715.6     | 404.1         | 694.6     | 383.5         | 679.3             | 390.8               | 0.00***|
| Crop stored     | 312.3     | 353.8         | 385.9     | 359.5         | 228.6     | 229.8         | 308.9             | 326.3               | 0.00***|
| Food gift       | 23.8      | 79.9          | 146.7     | 128.4         | 141.0     | 123.4         | 103.9             | 126.1               | 0.00***|
| Accessibility   |           |               |           |               |           |               |                   |                     |        |
| Income          | 7158.4    | 4186.7        | 8589.8    | 4680.2        | 8823.9    | 3863.5        | 8190.7            | 4319.0              | 0.00***|
| Food expenditure| 1726.1    | 404.4         | 2173.5    | 547.1         | 2352.7    | 532.6         | 2084.1            | 564.0               | 0.00***|
| Food Price Index| 1.08      | 0.074         | 1.21      | 0.027         | 1.35      | 0.052         | 1.21              | 0.12                | 0.00***|
| Market distance | 47.8      | 20.3          | 47.8      | 20.3          | 47.8      | 20.3          | 47.8              | 20.3                | 1.00   |
| Utilization     |           |               |           |               |           |               |                   |                     |        |
| Diet diversity  | 7.85      | 2.24          | 7.99      | 2.25          | 8.63      | 2.21          | 8.16              | 2.26                | 0.00***|
| Number of crops | 3.57      | 1.67          | 3.69      | 1.59          | 3.55      | 1.59          | 3.60              | 1.62                | 0.70   |
| Water hygiene   | 0.73      | 0.44          | 0.78      | 0.41          | 0.86      | 0.35          | 0.79              | 0.41                | 0.00***|
| livestock       | 4.57      | 3.31          | 4.59      | 3.52          | 2.39      | 2.45          | 3.85              | 3.29                | 0.00***|
| Stability       |           |               |           |               |           |               |                   |                     |        |
| Shock frequency | 1.05<sup>7</sup> | 1.23<sup>(50%)<sup>8</sup> | 0.62      | 0.96          | 1.03      | 1.10          | 0.90              | 1.12                | 0.68   |
| Income sources  | 1.85      | 0.76          | 2.01      | 0.78          | 1.74      | 0.72          | 1.87              | 0.76                | 0.00***|
| Number of months| 0.89      | 1.65          | 1.13      | 1.80          | 0.86      | 1.80          | 0.96              | 1.75                | 0.63   |
| Asset value     | 4755.5    | 3046.4        | 5418.2    | 3680.8        | 4803.0    | 3435.1        | 4992.2            | 3410.1              | 0.69   |

*** indicates 1 percent level of significance

Source: own computation from ESS survey (2011, 2013 & 2015)

<sup>7</sup> On average, how many times the sample household heads faced health shock in each year

<sup>8</sup> The proportion of household heads who faced health problem

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3.2 Result of Principal Component Analysis of Each Food Security Dimension

The Kaiser-Meyer-Olkin (KMO) test of sample adequacy is used to assess the suitability of the data for PCA. The values in Table 4 for each food security dimension shows the data set of the study is suitable for principal component analysis. KMO takes a value between 0 and 1. A smaller value indicates that variables have little in common to do PCA estimation while values greater than 0.5 are considered satisfactory to apply PCA (Kaiser, 1974). In other words, a high KMO value indicates that a relatively larger proportion of the variance can be explained by the principal components. All four food security dimensions have KMO values greater than 0.5 hence attesting to the existence of a medium pattern of correlation among selected indicators in each dimension. Therefore, applying PCA estimation to derive farm households’ food security index is appropriate.

Table 4 shows the first principal component of each food availability, accessibility, utilization, and stability. The first principal components explain 48, 53, 51, and 55 percent of the total variations of the indicators of the dimensions respectively.

The magnitude of the component’s loading coefficients indicates the shares of each indicator variable in the index derived. Land size, crop stored, production and food gift variables in the availability dimension have positive component loading coefficients greater than 0.4 which indicates that these variables are strongly correlated with the indices generated. Theoretically, they displayed the expected sign of the effects of the variables on households’ food security levels. Variables with positive component loading coefficients are associated with higher food security indices; conversely, variables with negative coefficients are associated with lower food security scores (Vyas & Kumaranayake, 2006). For example, land size, which is the main asset of farm households in Ethiopia, is guaranteed to increase agricultural production thereby increasing food availability. The land size variable is therefore expected to have a positive correlation with the
food security index obtained from the results. Similarly, utilization dimension indicators had positive component loading coefficients of greater than 0.38. Market distance has a negative coefficient that indicates that the farther a household is from a market center the lower their food security while the other accessibility indicators had positive component loadings that contribute positively to the food security index. However, the positive sign of the loading of the food price index variable is unexpected. This could be because most of the smallholder farmers were food crop producers so they depended on production rather than buying food crops for consumption. Sometimes smallholder farmers take food crops to the market for sale. In such a context, when there are many net food crop sellers or producers, the effect of increasing food prices on food security tends to be positive (Dimova, 2015) through the income. Finally, the stability dimension indicators such as shock frequency and the number of months households are without enough food has negative component loadings while the number of income sources and real asset value variables has positive component loadings.
Table 4: PCA Estimation Result of Food Security Dimensions

| Variables | Component Loadings |
|-----------|--------------------|
| Availability |                     |
| Land size   | 0.50               |
| Production  | 0.55               |
| Crop stored | 0.44               |
| Food gift   | 0.51               |
| The proportion of Variation Explained | 0.53 |
| The eigenvalue of the first component | 2.14 |
| Kaiser-Meyer-Olkin measure of sampling adequacy (KMO): | 0.73 |
| Accessibility |                   |
| Income      | 0.54               |
| Food expenditure | 0.63 |
| Food Price Index | 0.40 |
| Market distance | -0.38 |
| The proportion of Variation Explained | 0.53 |
| The eigenvalue of the first component | 2.12 |
| Kaiser-Meyer-Olkin measure of sampling adequacy (KMO): | 0.56 |
| Utilization |                   |
| Diet diversity | 0.60 |
| Number of crops | 0.53 |
| Livestock   | 0.38               |
| Water hygiene | 0.46              |
| The proportion of Variation Explained | 0.51 |
| The eigenvalue of the first component | 2.03 |
| Kaiser-Meyer-Olkin measure of sampling adequacy (KMO): | 0.64 |
| Stability   |                   |
| Shock frequency | -0.51 |
| Income sources | 0.55 |
| Number of months | -0.38 |
| Asset value  | 0.53               |
| The proportion of Variation Explained | 0.55 |
| The eigenvalue of the first component | 2.19 |
| Kaiser-Meyer-Olkin measure of sampling adequacy (KMO): | 0.62 |

Source: own computation from ESS survey (2011, 2013 & 2015)

Finally, the household food security index is computed using the component loading coefficients of each indicator variable as a weight. The computed household food security index ranges from negative to positive value. The indices have a mean value of zero and standard deviation of one and higher index values denote a higher level of food security (McKenzie, 2005). The
normalization\(^9\) was necessary to limit the index values between 0 and 1. Table 5 presents households’ average food security indices of each dimension and the average indices of farm households for availability, accessibility, utilization, and stability dimension were 0.57, 0.48, 0.70, and 0.54 respectively. The minimum and maximum index values of each food security dimension are also presented below.

| Variable | Mean | Minimum | Maximum |
|----------|------|---------|---------|
| Availability | 0.57 | 0.11 | 0.97 |
| Accessibility | 0.48 | 0.02 | 0.98 |
| Utilization | 0.70 | 0.03 | 0.99 |
| Stability | 0.54 | 0.02 | 0.97 |

Source: Computed from ESS survey (2011, 2013 & 2015)

### 3.3 Classification of Households’ Food Security Status

The main challenge of examining households’ food security status overtime is the arbitrariness of selecting a threshold point. Defining a cut-off point implies dividing the sample into two distinct groups, namely “food secure” and “food insecure”. This can be excessively restrictive because of the multidimensional nature of food security. The literature on PCA indicates both data-driven and arbitrary (based on the assumption that indices are uniformly distributed) segregation mechanisms, that break indices into different groups. Commonly used arbitrary cut-off points have the lowest 40 percent of households being treated as ‘food insecure’, the highest 20 percent as ‘food secure’, and the remaining 40 percent as of the households being treated as ‘vulnerable to food insecurity' (Filmer & Pritchett, 2001; Vyas & Kumaranyake, 2006). On the other hand, Abafita and Kim

\(^9\) Normalization is a ratio of the actual value of a variable minus the minimum value a viable to the maximum value of a variable minus the minimum value of a variable.
(2013); Demeke et al. (2011) applied the data-driven segregation mechanism to classify households into relative food secure and food insecure groups using the mean values of the index as a cut-off point. The research for this paper follows the latter approach to group the samples into relative food secure and food insecure classes. Hence, households with an index below the mean were grouped as relatively food insecure whereas households with an index above the mean were grouped into relative food secure. This relative classification enables analysis of the changes in households' food security status over time.

As figure 1 indicates, in terms of the food availability dimension 52, 56 and 53 percent of households were food secure while 48, 44 and 47 percent of households were food insecure in 2011, 2013, and 2015 respectively. On the other hand, in terms of accessibility 51, 54 and 53 percent of households were food secure while 58, 46 and 47 percent of households were food insecure in 2011, 2013, and 2015 respectively. The stability dimension also indicated that 54, 64 and 55 percent of households were food secure whereas 46, 36 and 50 percent of households were food insecure in 2011, 2013, and 2015 respectively. In terms of availability, accessibility, and stability, the percentages of food secure households increased between 2011 and 2013. However, between 2013 and 2015, the proportion of food secure households declined in terms of the availability, accessibility, and stability dimensions. This could be due to the drought caused by El Niño, a climatic problem that occurred during the 2014/15 agricultural season that directly affected crop production. About the utilization dimension, 55, 57 and 59 percent of households were food secure in 2011, 2013, and 2015 respectively. These show that the proportion of food-insecure households declined in the consecutive survey period.

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10 an irregularly occurring and complex series of climatic changes affecting the equatorial Pacific region. The effects of El Niño include reversal of wind patterns across the Pacific, drought, and unseasonal heavy rain
Figure 1 Food Security Status by Dimension and Year
Source: Computed from ESS survey (2011, 2013 & 2015)

Figure 1 portrays households’ food security status according to each dimension. It is also essential to know the dimension(s) in which households were food secure or insecure as it contributes to designing good policies. Households can be completely food secure in all dimensions (availability, accessibility, utilization, and stability), and food insecure in at least one dimension; or completely food insecure in all four dimensions. Table 6 shows that the percentage of food-insecure households in the four-dimensions significantly declined from 12 percent in 2011 to 3 percent in 2015. On the contrary, the percentage of food secure households in all dimensions significantly increased from 4 percent in 2011 to 16 percent in 2015. Besides, 84, 75 and 81 percent of farm households were food insecure in at least one dimension in 2011, 2013, and 2015 respectively.
### Table 6: Households Food Security Status in Terms of Dimensions

| Food security status by dimension | 2011 | 2013 | 2015 | T-test (Diff between 2015 and 2011) |
|-----------------------------------|------|------|------|----------------------------------|
| Food insecure in all dimensions   | 12   | 7    | 3    | 0.00***                          |
| Food insecure in at least one dimension | 84   | 75   | 81   | 0.08**                           |
| Food secure in all dimensions     | 4    | 18   | 16   | 0.00***                          |

*, ** and *** indicate statistically significant at 10, 5, and 1 percent level respectively

Source: own computation from ESS survey (2011, 2013 and 2015)

Finally, the indices of each food security dimension are aggregated using the power mean of equation 3 that allows the construction of overall food security indices of each farm household.

Table 7 shows that 56, 43 and 54 percent of households were food insecure in 2011, 2012, and 2015 respectively, on the other hand, the remaining 44, 57, and 46 percent of households were food secure in respectively in 2011, 2013 and 2015 using the aggregate food security indices. Thus, the subsequent dynamic analysis was done using the combination of the four dimensions.

### Table 7: Households’ food security status using the aggregate indices

| Overall food security status | 2011 | 2013 | 2015 |
|------------------------------|------|------|------|
| Food secure                  | 44   | 57   | 45   |
| Food insecure                | 56   | 43   | 55   |

*, ** and *** indicate statistically significant at 10, 5, and 1 percent level respectively

Source: own computation from ESS survey (2011, 2013 and 2015)

### 3.4 Dynamics of Households’ Food Security Status

To look at the percentage of households that move from one cluster into another cluster within the survey periods the study built an economic transition matrix. The transition matrix, which is constructed based on quantiles of the overall food security indices, shows the movement of households in and out of a given group between 2011 and 2015. The $i^{th}$ element of the transition matrix represents the percentage of households that moved from group $i$ to group $j$. Figures on the
main diagonal indicate the share of households that stayed in the same food security indices quintile. The last row of Table 8 indicates the cumulative percentage of all quantiles in the year 2015 while the last column shows the cumulative percentage of all quantiles in the year 2011.

Table 8: Transition matrix for quantiles of food security scores between 2011 and 2015

| 2015 Food Security Quantiles | 1 | 2 | 3 | 4 | 5 | Total (2011) |
|------------------------------|---|---|---|---|---|-------------|
| Quantiles                    |   |   |   |   |   |             |
| 1                            | 22| 20| 20| 20| 18| 100         |
| 2                            | 23| 21| 21| 19| 16| 100         |
| 3                            | 22| 20| 19| 18| 21| 100         |
| 4                            | 18| 19| 20| 21| 22| 100         |
| 5                            | 15| 19| 20| 22| 23| 100         |
| Total (2015)                 | 100|100|100|100|100|100          |

Source: Own Computation from ESS 2011-2015

The earlier transition matrix depicts only the movement of households between the first and the last panel year that explains an overall movement among the five groups. So, it has not given attention to the movements of households in-between and it didn’t explicate the transition between food secure and food insecure category. The subsequent tables summarize the movement of households between food secure and food insecure category in each of the panel years:

Table 9: Economic transition matrix 2011-2013

| 2013 | Food insecure (%) | Food secure (%) | Total |
|------|-------------------|----------------|-------|
| 2011 |                   |                |       |
| Food insecure | 17               | 20             | 37    |
| Food secure    | 25               | 38             | 63    |
| Total          | 42               | 58             | 100   |

Source: Own Computation from ESS 2011-2015

As table 9 revealed, 63 and 58 percent of households were food insecure in 2011 and 2013 respectively while the remaining 37 percent in 2011 and 42 percent in 2013 were food insecure.
The result indicates that the percentage of food secure households declined from the year 2011 to 2013. The most important point to note here is not all food secure households in 2011 remained food secure in 2013. There was entry into and exit out of food security status. For example, 17 percent of food-insecure households in 2011 remained food insecure in 2013 (immobile) while 20 percent of households moved from food-insecure status into food-secure status in 2013 (mobile). Conversely, 25 percent of households situated in the food-secure group in 2011 moved to food-insecure category in 2013 while 30 percent of food secure households in 2011 stayed food secure in 2013 too. Generally, a movement into food insecure status greater than an exit out of food insecure status indicates additional households fell into food insecure class between 2011 and 2013.

| 2013          | 2015       |        |        |
|---------------|------------|--------|--------|
|               | Food insecure (%) | Food secure (%) | Total  |
| Food insecure | 29         | 13     | 42     |
| Food secure   | 28         | 30     | 58     |
| Total         | 57         | 43     | 100    |

Source: Own Computation from ESS 2011-2015

Similarly, table 10 shows the change of households’ food security status between the second and last survey period. The percentage of food secure households dropped from 58 percent in 2013 to 43 percent in 2015. On the other hand, the percentage of food-insecure households increased from 42 percent in 2013 to 57 percent in 2015. This massive escalation of food insecurity in 2015 was triggered by a combination of failed rains and droughts due to El Niño effect\(^\text{11}\) (OXFAM, 2016). Besides, the table shows the mobility of households between the years 2013 and 2015. Twenty-

\(^{11}\) an irregularly occurring and complex series of climatic changes affecting the equatorial Pacific region, characterized by the appearance of unusually warm. The effects of El Niño include reversal of wind patterns across the Pacific, drought, and unseasonal heavy rain.
nine percent of households remained food insecure (immobile) between 2013 and 2015 while 13 percent of households moved to the food secure category. On the contrary, out of the total food secure households in 2013, 28 percent of them moved to the food-insecure category while 31 percent stayed in the same group. In general, the percentage of households moved into the food insecurity category exceeds households enter into the food secure group.

Table 11: Households Food Security Status Change Throughout 2011, 2013 and 2015

| Movement (2011→2013→2015) | Food secure | Food Insecure | Freq. | Percent (%) | Cum. percent |
|-----------------------------|-------------|---------------|-------|-------------|--------------|
| Food secure                 | FS\(^{12}\) → FS → FS | 3 spells       | 0 spells | 284         | 20           | 20           |
| Chronically food insecure   | FI → FI → FI | 0 spell        | 3 spells | 179         | 13           | 33           |
| Transitory food insecure    | FS → FS → FI\(^{13}\) | 2 spells       | 1 spell  | 252         | 19           | 67           |
|                             | FS → FI → FI | 1 spell        | 2 spells | 235         | 17           |
|                             | FS → FI → FS | 2 spells       | 1 spell  | 120         | 8            |
|                             | FI → FS → FI | 1 spell        | 2 spells | 134         | 9            |
|                             | FI → FS → FS | 2 spells       | 1 spell  | 142         | 10           |
|                             | FI → FI → FS | 1 spell        | 2 spells | 66          | 4            |
|                             |              |               |        | 1412        | 100          | 100          |

Source: Own Computation from ESS 2011-2015

Using the ‘spells’ approach (the time in which households remained either food insecure or food secure), food-insecure households were classified as ‘chronically’ food insecure and ‘transitory’ food insecure. Hence, households who remained persistently food insecure in three spells were considered as chronically food insecure, and households who had at least one spell of food secure state considered as transitory food insecure. Accordingly, table 11 presents household food security status change in the three survey periods. Out of the total sample, 20 percent of households were food secure throughout the three survey periods and 13 percent of the households were

\(^{12}\) Food secure

\(^{13}\) Food insecure
persistently food insecure in the entire survey period (chronically food insecure). The rest 67 percent of households were transitory food insecure that indicates households became food insecure at least in one period out of the three survey years.

4. Conclusion

A composite multidimensional food security measurement index was estimated in the study. The advantage of a composite multi-dimensional food security measurement is to captures more than one food security indicator in the food security measurement. Principal Component Analysis (PCA) was employed to derive the food security index of farm households. For each dimension of food security, four indicator variables were used to derive the household food security index. More than half of the households were food secured in each dimension and the percentage of food secure households increased in terms of availability, accessibility, and utilization over the study period. In terms of the stability dimension, the proportion of food secure households declined between 2013 and 2015. Besides, most farm households (greater than 75 percent) were food insecure in at least one dimension. However, the proportion of food-insecure households in at least one-dimension declined from 85 percent in 2011 to 81 percent in 2015. On the other hand, the proportion of farm households who were food secure in four dimensions increased from 4 percent in 2011 to 16 percent in 2015. The proportion of food secure households in all dimensions increased from 12 percent in 2011 to 16 percent in 2015. On the contrary, the proportion of food-insecure households in the four-dimension declined from 12 percent in 2011 to 3 percent in 2015. On the other hand, most farm households were transitory food insecure implying that farm households fell into the state of food insecurity at least in one period and a few proportions of households were chronically food insecure.
Abbreviation

CSA           Central Statistics Agency
ERSS          Ethiopian Rural Socio-Economic Survey
ESS           Ethiopian Socioeconomic Survey
FAO           Food and Agricultural Organization
GDP           Gross Domestic Product
HDI           Human Development Index
HPI           Human Poverty Index
IFAD          International Fund for Agriculture Development
IFPRI         International Food Policy Research Institute
LSMS-ISA      Living Standard Measurement Survey- Integrated Surveys on Agriculture
PCA           Principal Component Analysis
SNNP          Southern Nation, Nationality and People
UNDP          United Nation Development Program
WFP           World Food Program

Declarations

Competing interests

The author declares that no competing financial interests. There were no funders that had a role in this study, analysis, decision to publish, or preparation of the manuscript.

Author’s contributions

Mohammed Adem designed the study and conducted the analysis of the data. He also wrote the manuscript.
Availiability of Data and Materials

The datasets and analysed during the current study are not publically available due to confidentiality of personal data but are available in a restricted from the corresponding authors on reasonable request.

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6. Appendices

Appendix A: Principal Component Estimation of Each Food Security Dimension

. *Availability*

. corr land_size production crop_stored food_gift
(obs=4,236)

| land_s -e produc-n crop_s-d food_g-t |
|--------------------------------------|
| -------------------------------------|
| land_size | 1.0000 |
| production | 0.4418 1.0000 |
| crop_stored | 0.3297 0.3397 1.0000 |
| food_gift | 0.3503 0.4991 0.2992 1.0000 |
. pca land_size production crop_stored food_gift

Principal components/correlation
Number of obs = 4,236
Number of comp. = 4
Trace = 4
Rotation: (unrotated = principal)
Rho = 1.0000

---------------------------------------------------------------------
Component |   Eigenvalue   Difference      Proportion   Cumulative
-------------+------------------------------------------------------------
Comp1      |      2.13838      1.40217             0.5346       0.5346
Comp2      |      0.736213     .0917968             0.1841       0.7186
Comp3      |      0.644416     .163426              0.1611       0.8798
Comp4      |       0.48099     .            0.1202       1.0000
---------------------------------------------------------------------
Principal components (eigenvectors)

--------------------------------------------------------------------
Variable |    Comp1     Comp2     Comp3     Comp4 | Unexplained
-------------+----------------------------------------+-------------
land_size |   0.4968    0.0380   -0.8189    0.2849 |           0
production |   0.5475   -0.2924    0.0463   -0.7827 |           0
crop_stored |   0.4410    0.8419    0.3109    0.0124 |           0
food_gift |   0.5089   -0.4520    0.4802    0.5533 |           0
--------------------------------------------------------------------
Principal component loadings (unrotated)
component normalization: sum of squares(column) = 1

---------------------------------------------------------------------
|    Comp1     Comp2     Comp3     Comp4
-------------+----------------------------------------
land_size |    .4968    .03797    -.8189     .2849
production |    .5475    -.2924    .04631    -.7827
crop_stored |     .441     .8419     .3109    .01235
food_gift |    .5089     -.452     .4802     .5533
---------------------------------------------------------------------
. predict pcAva,score
Scoring coefficients
sum of squares(column-loading) = 1

---------------------------------------------------------------------
|    Comp1     Comp2     Comp3     Comp4
-------------+----------------------------------------
land_size |   0.4968    0.0380   -0.8189    0.2849
production |   0.5475   -0.2924    0.0463   -0.7827
crop_stored |   0.4410    0.8419    0.3109    0.0124
food_gift |   0.5089   -0.4520    0.4802    0.5533
---------------------------------------------------------------------
. estat kmo
Kaiser-Meyer-Olkin measure of sampling adequacy

---------------------------------------------------------------------
|     kmo
-------------+---------
land_size |  0.7550
production |  0.6883
crop_stored |  0.7986
food_gift |  0.7191
-------------+---------
Overall |  0.7300
---------------------------------------------------------------------
. sum pcAva
Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
pcAva |      4,236    5.56e-10     1.46232  -5.887403   4.478063

. tab FSAva

 FSAva |     Freq.     Percent        Cum.
------------+-----------------------------------
          0 |     1,999     47.19     47.19
          1 |     2,237     52.81    100.00
------------+-----------------------------------
       Total |      4,236      100.00

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. sum pcAva, meanonly
. gen npcAva = (pcAva - r(min))/(r(max) - r(min))

. *Acessablity*
. corr income food_exp FPI market_dis
(obs=4,236)

|       | income | food_exp | FPI | market_dis |
|-------|--------|----------|-----|------------|
| income |  1.0000 |          |     |            |
| food_exp |  0.6357 |  1.0000  |     |            |
| FPI    |  0.2338 |  0.5002  | 1.0000 |            |
| market_dis | -0.3004 | -0.4065  | -0.0374 | 1.0000 |

. pca income food_exp FPI market_dis
Principal components/correlation
Number of obs = 4,236
Number of comp. = 4
Trace = 4
Rotation: (unrotated = principal)
Rho = 1.0000

| Component | Eigenvalue   | Difference | Proportion   | Cumulative |
|-----------|--------------|------------|--------------|------------|
| Comp1     | 2.12303      | 1.15001    | 0.5308       | 0.5308     |
| Comp2     | .973016      | .334953    | 0.2433       | 0.7740     |
| Comp3     | .638063      | .372169    | 0.1595       | 0.9335     |
| Comp4     | .265894      |            | 0.0665       | 1.0000     |

Principal components (eigenvectors)

| Variable | Comp1 | Comp2 | Comp3 | Comp4 | Unexplained |
|----------|-------|-------|-------|-------|-------------|
| income   | .5424 | -.121 | .6905 | -.463 |             |
| food_exp | .6270 | .0698 | .0393 | .7749 |             |
| FPI      | .4050 | .7105 | -.4413| -.3693|             |
| market_dist | -.3856 | .6897 | .5717 | .2208 |             |

Principal component loadings (unrotated)
component normalization: sum of squares(column) = 1

|       | Comp1 | Comp2 | Comp3 | Comp4 |
|-------|-------|-------|-------|-------|
| income | .5424 | -.121 | .6905 | -.463 |
| food_exp | .6270 | .0698 | .0393 | .7749 |
| FPI    | .4050 | .7105 | -.4413| -.3693|
| market_dist | -.3856 | .6897 | .5717 | .2208 |

. predict pcAcc, score
Scoring coefficients
sum of squares(column-loading) = 1

| Variable | Comp1 | Comp2 | Comp3 | Comp4 |
|----------|-------|-------|-------|-------|
| income   | .5424 | -.121 | .6905 | -.463 |
| food_exp | .6270 | .0698 | .0393 | .7749 |
| FPI      | .4050 | .7105 | -.4413| -.3693|
| market_dist | -.3856 | .6897 | .5717 | .2208 |

. estat kmo
Kaiser-Meyer-Olkin measure of sampling adequacy

| Variable | kmo   |
|----------|-------|
| income   | 0.6220|
| food_exp | 0.5419|
| FPI      | 0.5000|
| market_dist | 0.6080|

| Overall | 0.5632 |

. tab FSAcc
|          | Freq. | Percent | Cum.  |
|----------|-------|---------|-------|
| 0        | 1,986 | 46.88   | 46.88 |
| 1        | 2,250 | 53.12   | 100.00|

Total | 4,236 | 100.00|

```
sum pcAcc, meanonly
.gen npcAcc = (pcAcc - r(min)) / (r(max) - r(min))
```

**Utilization**

```
corr diet_div num_crops livestock water_hygiene
(obs=4,236)
```

|          | diet_div | num_crops | livestock | water_hygiene |
|----------|----------|-----------|-----------|---------------|
| diet_div | 1.0000   | 0.5264    | 0.2578    | 0.4890        |
| num_crops|          | 1.0000    | 0.2910    | 0.2641        |
| livestock|          |           | 1.0000    | 0.0858        |
| water_hygiene| | | | 1.0000 |

```
pca diet_div num_crops livestock water_hygiene
```

Principal components/correlation

| Component | Eigenvalue | Difference | Proportion | Cumulative |
|-----------|------------|------------|------------|------------|
| Comp1     | 2.0025     | 1.05723    | 0.5006     | 0.5006     |
| Comp2     | 0.945267   | 0.29301    | 0.2363     | 0.7369     |
| Comp3     | 0.652257   | 0.252277   | 0.1631     | 0.9000     |
| Comp4     | 0.399979   |            | 0.1000     | 1.0000     |

```
predict pcUti, score
```

```
Scoring coefficients
```

```
.sum of squares(column-loading) = 1
```

```
Variable | Comp1     | Comp2     | Comp3     | Comp4     |
|----------|------------|------------|------------|------------|
| diet_div | .6031     | -.1631    | -.1017    | -.7742    |
| num_crops| .5421     | .1661     | -.6726    | .4756     |
| livestock| .3524     | .7849     | .5079     | .0425     |
| water_hygiene| | .4672 | -.5742 | .5286 | .4155 |

```
estat kmo
```
Kaiser-Meyer-Olkin measure of sampling adequacy

```
-----------------------
```

31
### Variable kmo

| Variable     | kmo       |
|--------------|-----------|
| diet_div     | 0.5987    |
| num_crops    | 0.6584    |
| livestock    | 0.7339    |
| water_hygiene| 0.6284    |
| Overall      | 0.6341    |

### Tabulation

| FSUti | Freq. | Percent | Cum.  |
|-------|-------|---------|-------|
| 0     | 1,820 | 42.97   | 42.97 |
| 1     | 2,416 | 57.03   | 100.00|
| Total | 4,236 | 100.00  |       |

### Summation

```
. gen npcUti = (pcUti - r(min)) / (r(max) - r(min))
```

### Stability

```
. corr shock_freq income_sources num_months asset_value
(36=4,236)

shock_freq  income_sources  num_months  asset_value
shock_freq  1.0000
income_sources  -0.4978   1.0000
num_months    0.3890  -0.1910   1.0000
asset_value   -0.3580   0.6167  -0.2705   1.0000
```

### Principal Component Analysis

```
. pca shock_freq income_sources num_months asset_value
Principal components/correlation Number of obs = 4,236
Number of comp. = 4
Trace = 4
Rotation: (unrotated = principal)
Rho = 1.0000

Component |   Eigenvalue | Difference | Proportion | Cumulative
-----------|-------------|------------|------------|-------------
Comp1      | 2.18633     | 1.29643    | 0.5466     | 0.5466      
Comp2      | 0.889895    | 0.29401    | 0.2225     | 0.7691      
Comp3      | 0.595886    | 0.267994   | 0.1490     | 0.9180      
Comp4      | 0.327891    |            | 0.0820     | 1.0000      

Principal components (eigenvectors)

| Variable     | Comp1     | Comp2     | Comp3     | Comp4   | Unexplained |
|--------------|-----------|-----------|-----------|---------|-------------|
| shock_freq   | -0.5171   | 0.2278    | 0.7381    | 0.3687  | 0           |
| income_sources| 0.5539   | 0.4204   | -0.0974  | 0.7120  | 0           |
| num_months   | -0.3798   | 0.8023   | -0.3975  | -0.2326 | 0           |
| asset_value  | 0.5306    | 0.3574    | 0.5364   | -0.5504| 0           |

Principal component loadings (unrotated)
component normalization: sum of squares(column) = 1

|         | Comp1     | Comp2     | Comp3     | Comp4     |
|---------|-----------|-----------|-----------|-----------|
| shock_freq | -0.5171  | 0.2278   | 0.7381    | 0.3687   |
| income_sources | 0.5539 | 0.4204  | -0.0974  | 0.7120   |
| num_months  | -0.3798  | 0.8023  | -0.3975  | -0.2326 |
| asset_value | 0.5306  | 0.3574  | 0.5364   | -0.5504 |
```

### Predict

```
. predict pcSta , score
Scoring coefficients
sum of squares(column-loading) = 1
```
### Table 1: Correlation Matrix

| Variable          | Comp1     | Comp2     | Comp3     | Comp4     |
|-------------------|-----------|-----------|-----------|-----------|
| shock_freq        | -0.5171   | 0.2278    | 0.7381    | 0.3687    |
| income_sources    | 0.5539    | 0.4204    | -0.0974   | 0.7120    |
| num_months        | -0.3798   | 0.8023    | -0.3975   | -0.2326   |
| asset_value       | 0.5306    | 0.3574    | 0.5364    | -0.5504   |

### Kaiser-Meyer-Olkin Measure of Sampling Adequacy

| Variable          | kmo       |
|-------------------|-----------|
| shock_freq        | 0.6658    |
| income_sources    | 0.5901    |
| num_months        | 0.6219    |
| asset_value       | 0.6350    |
| Overall           | 0.6253    |

### Food Security Status

| FSSta | Freq. | Percent | Cum. |
|-------|-------|---------|------|
| 0     | 1,870 | 44.15   | 44.15|
| 1     | 2,366 | 55.85   | 100.00|
| Total | 4,236 | 100.00  |      |

### Overall Food Security Indexes

- \( \text{FSI} = (0.25 \times (\text{npcAva}^3 + \text{npcAcc}^3 + \text{npcUti}^3 + \text{npcSta}^3))^{0.333} \)

| Variable | Obs   | Mean    | Std. Dev. | Min   | Max   |
|----------|-------|---------|-----------|-------|-------|
| pcAva    | 4,236 | 5.56e-10| 1.46232   | -5.887403| 4.478063|
| pcAcc    | 4,236 | 9.17e-10| 1.457061  | -4.332113| 4.617533|
| pcUti    | 4,236 | 1.29e-10| 1.415096  | -6.037987| 2.447181|
| pcSta    | 4,236 | 1.46e-09| 1.478624  | -4.925025| 4.19441|
| npcAva   | 4,236 | .5679825| .1410762  | 0     | 1     |
| npcAcc   | 4,236 | .4840541| .1628066  | 0     | 1     |
| npcUti   | 4,236 | .7115931| .1667729  | 0     | 1     |
| npcSta   | 4,236 | .5400581| .1621398  | 0     | 1     |