Building a Resilience Index in Northern Ghana Context

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1. Background

Over the last 20 years, Ghana has experienced a sustainable economic growth, becoming a country full of promise and potential to eradicate extreme hunger and poverty. Its stable political system, moderate levels of security and international assistance could be the engines of this success story. Ghana has reduced poverty by almost half, substantially reduced the prevalence of underweight children, and experienced robust growth in its Gross Domestic Product (GDP). These indicators possibly indicate a bright future for this West African country; however, these improvements are not equally distributed across all regions of Ghana, particularly not in northern Ghana.

Northern Ghana represents a challenging area in terms of economic development. Its lack of economic growth stems from poor infrastructure and roads, poor soil conditions, and an unpredictable and short rainy season, which increases risk of poverty and food insecurity (Dickson, 1968; Zereyesus, et al., 2014). In northern Ghana, hunger and poverty are more prevalent than the rest of country. In 2012, about 22 percent of population in northern Ghana experienced poverty and 3 percent experienced extreme poverty (Zereyesus, et al., 2014). While the prevalence rate of underweight children has decreased at the national level, the prevalence rate remains high in northern Ghana. Approximately, 18 percent of children under 5 years residing in northern Ghana are underweight and about 36 percent of the children are stunted (Zereyesus, et al., 2014).

Agriculture represents the main source of income in northern Ghana. Typically, in this part of the country, farmers are self-subsistence farmers with less than 2 hectares to grow staple crops such as maize, rice, sorghum, soybeans and other crops (Chamberlin, 2007). Despite climatic conditions such as poor soils and unpredictable rain, northern Ghana is still the major producing area for main cereals. The main cereals produced in northern Ghana supply the entire country.

Given the aforementioned facts, measuring the resiliency of vulnerable households and communities in northern Ghana to face shocks represents a crucial element in the understanding and ability to better address major economic and nutritional problems such as poverty and food insecurity experienced in this part of the country.

The present study seeks to measure the Resilience Level of northern Ghana and determine the main factors contributing to that level. The specific objectives for answering the research questions are:

- Describe the variables used to measure Resilience and its role in determining the level of Resilience in northern Ghana
- Asses and determine the Resilience Index Measurement and Analysis (RIMA) using the Structural Equation Model (SEM)

This study uses household level data from the Population Based Line Survey (PBS) 2015 funded by USAID and conducted in the Feed the Future Zone of Influence (ZOI) in northern Ghana, which includes districts in Upper East, Upper West, Northern and Brong-Ahafo Regions located above the 8th Parallel. The PBS-2015 is comprised of 11 modules; however, for the purpose of this study, only information from six modules were used. These six modules are Household Consumption Expenditure, Dwelling Characteristics, Access to Productive Capital, Access to Credit and Group Membership, Household Hunger Scale, and Role in Household Decision-Making around Production and Income Generation.

Results from this study will help to fill the knowledge gap associated with resilience studies in Sub-Saharan Africa and will provide additional information for effective policy intervention and program development in northern Ghana. This study will also provide a baseline from which to measure the impact of policy and program interventions aimed at improving the Resilience Level in northern Ghana over years; and will provide with having a measure for the ability to overcome shocks efficiently and in a sustainable way by protecting, restoring, and improving vulnerable food and agricultural systems could provide key insights into capacity building in northern Ghana (FAO, 2013).

The remainder of this study is organized in seven sections. The following section provides a brief explanation of the FAO Resilience Index Measurement and Analysis (RIMA) model applied to assess resilience in northern Ghana. Section 3 reports the variables used to measure Resilience and the RIMA model specification. Data used in this study is described in Section 4. Section 5 explains step-by-step the methods used to measure Resilience whose results are shown in Section 6. Finally, conclusions are set in section 7.

2. FAO's RIMA Model

The changing environment that people are exposed to is more dynamic than ever. Natural disasters, economic crisis, human-induced disasters and scarcity of resources are realities that people face on a daily basis. It is under these circumstances that the term resilience becomes important. Resilience as defined by the Resilience Measurement Technical Working Group (RM TWG) (2017) is "the capacity that ensures adverse stressors and shocks do not have long-lasting adverse development consequences" and represents key information in the implementation of effective policies and projects. Building and strengthening resilience in places with higher risk of shocks could mean a humanitarian intervention reduction for future hazards and create a sustainable progress in those places.

The Resilience Index Measurement and Analysis (RIMA) model uses resilience as a latent variable and nine dimensions as determinants. Seven out of the nine dimensions fall under the *physical category* which include: Income and Food Access (IFA); Access to Basic Services (ABS); Assets including Agricultural/Non Agricultural Assets (A); Enabling Institutional Environment (EIE); Climate Change (CC); Agricultural Practices and Technology (APT); and Social Safety Nets (SSN). The remaining two dimensions represent the *capacity category* and include Sensitivity (S) and Adaptive Capacity (AC).

3. Model Specification

The dimensions used to measure Resilience could differ according to the environment and the background of the studied place. To measure Resilience in northern Ghana, this study will only use five categories from the eight suggested by FAO's RIMA model. The primary objective of the PBS-2015, the dataset used in this study, was not to measure resilience, and as a result, proxy variables to measure *Climactic Change*, *Enable Institutional Environment,* and *Sensitivity* three pillars of the resilience's dimensions, were not included in the data collection. Following d'Errico et al. (2016) the conceptual model to measure resilience is based on the following equation:

$$R_{i,t} = f(IFA, ABS, A, SSN, AC) \tag{1}$$

where R represents the Resilience Level for household i at time t. Equation 1 explains that resilience is a function of five dimensions or pillars. These dimensions include Income and Food

Access (IFA), Access to Basic Services (ABS), Assets (A), Social Safety Nets (SSN), and Adaptive Capacity (AC), which are not directly measured from the dataset. Thus, to determine each one of the pillars with more than one proxy variable, factor analysis are developed to estimate few interpretable factors. A brief description of the pillars and the variables used to estimate them is presented below.

Income and Food Access represents the ability of the household to supply basic needs such as food. This dimension is relevant because the percentage of northern Ghanaians experiencing food insecurity which is about seven times higher than the national average of 5 percent (USAID, 2012). IFA is measured by *food expenditure* represented by per capita expenditure in food in US dollars.

Access to Basic Services denotes the capacity of the household to access primary infrastructure needs. For purposes of this study, binary variables are used to measure the household's access to services including:

Water is a binary variable where 1 indicates if there is a water source inside of the dwelling, and 0 if otherwise.

Phone is a binary variable, 1 determines the household has at least one phone and 0 if otherwise.

Electricity, another binary variable is used to measure if the household has electricity denoted by 1 and 0 if otherwise.

Toilet is a binary variable where 1 denotes access to this service and 0 otherwise.

Assets includes both Agricultural Assets and Non Agricultural Assets given the rural context in northern Ghana. This pillar represents the household's ownership of goods designed for agricultural activities and ownership of other tradable assets. The variables used in this study to build Assets include:

Land represents the farm size of the household measure in hectares.

Small Livestock is a binary variable determining 1 if the household own small livestock and 0 otherwise.

Large Livestock is a binary variables where 1 indicates the household own large livestock and 0 if the household do not own large livestock.

Dwelling status is a binary variable where 1 designate for households that own the dwelling and 0 otherwise.

Mechanized Farm Equipment is a binary variable where 1 indicates the ownership of vehicles or devices used in agriculture and 0 otherwise.

Non mechanical Farm Equipment denotes household's ownership or other good for other than agricultural purposes.

Social Safety Nets measures the access to international or national assistance in times of risk. Variables used to calculate SSN include the following:

Non-Governmental Organization (NGO) Loan is a binary variable that determines if the household received any loan or borrowed cash/in-kind from a NGO. This variable has a value of 1 if the decision to receive a loan or borrow money was made, and 0 if otherwise.

Friends or relatives is a binary variable that determines if the household received any loan or borrowed cash/in-kind from a friend or relative. It will have the value of 1 if the decision of receive a loan or borrow money was made, and 0 if otherwise.

Adaptive Capacity measures the ability of the household to diversify or change their main income generation source in the short term. The variables used to measure this dimension include:

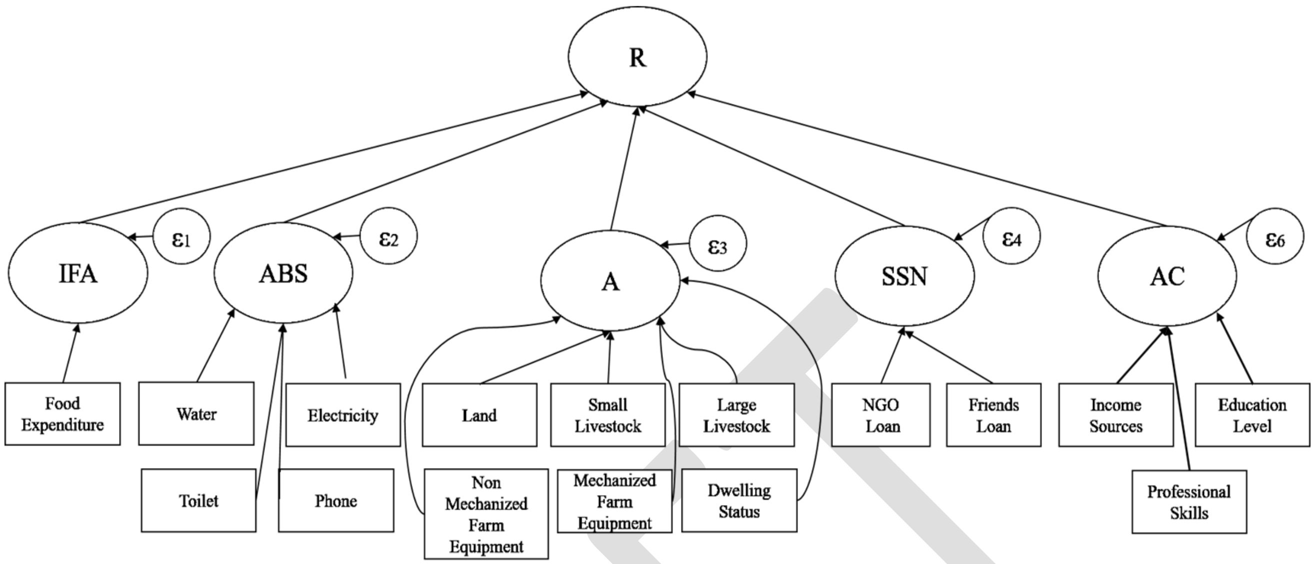
Educational Level represents the average number of the household members' years of education.

Professional Skills designates the number of household members who got an education diploma.

Income Sources is developed by counting the number of income generating activities related to agriculture, off- farm, or other business activities.

Figure 1 is a path diagram that summarizes the resilience model in northern Ghana. The boxes contain variables that will be used to measure the dimensions (gray ovals), and these dimensions are latent variables that will be used to measure resilience (white oval).

Figure 1. Path Diagram Northern Ghana Resilience Model



4. Data Source

The present study uses data from the Population Based Line Survey (PBS) 2015 funded by USAID|Ghana. The PBS is population-representative at Zone of Influence (ZOI) level that includes the three northern regions: Upper East, Upper West, and Northern; and districts from Brong Ahafo that are located above the 8th Parallel. The PBS claims to fill the knowledge gap on data required to build wellbeing indicators in the USAID|Ghana ZOI. The survey sample was designed using a two-stage probability sampling approach. First, Enumeration Areas (EA) from the Ghana Census 2010 were selected using the Probability Proportional to Size (PPS) method. Second, a systematic approach was used to determine which households would be included in the sample.

The PBS is comprised of data collected from 4,600 households. Household members in these households were asked information from 11 modules that focused on household demographics, household food security and expenditures, women and children health and nutrition, and the women empowerment in agriculture index, and these data were used in the estimation of baseline indicators for northern Ghana. For the purpose of this study, only data from the following modules were used: Demographics, Household Expenditure, Productive Assets, Access to credit, Dwelling Characteristics, Durable Goods Expenditures, Housing Expenditures, Hunger Scale, Cultivation of Key Crops, Women's Dietary Diversity, and Children's Minimum Acceptable Diet.

5. Method

The present study uses the FAO'S Resilience Index Measurement and Analysis (RIMA) model to estimate the Resilience Level of northern Ghana. FAO's RIMA sets a framework with two categories from the dimensions or pillars. Given the data constraints and the Ghanaian context, these categories are:

1. Physical dimension that includes Income and Food Access, Access to Basic Services, Assets, and Social Safety Nets.
2. Capacity dimension which includes only Adaptive Capacity

In Section 3, the variables under each one of the dimensions were discussed. Since there is no direct measurement of the pillars by itself, factor analysis was used to estimate the five pillars. Factor analysis allows for the application of data reduction mechanisms to find cross-correlations between variables, identifies the variables that can be grouped together into factors, and predicts the latent result as a linear combination of underlying factors (Bollen, 2002)

Factor Analysis method is subject to assumptions such as continuity and multivariate normal distribution (IDRE, 2017). Because many of the variables used in this model are binary variables, an additional mechanism was used to estimate the factor analysis. First, a polychoric correlation matrix was developed. This technique assumes the binary variables were built by categorizing a normally distributed variable, and the unobserved variables follow a bivariate normal distribution (Stanislav & Angeles, 2004). Thus, the polychoric correlation is the maximum likelihood of the variables used to develop the pillars.

The polychoric correlations were estimated and used to compute factor analysis for all the pillars except Income and Food Access due to this pillar has only one variable as a proxy. Once each dimension was estimated separately, a Structural Equation Model (SEM) was developed to measure Resilience. SEM is a combination of a factor analysis and a regression. The latent variable that is measured by the pillars through factor analysis and a regression is computed at the same time to establish relationship across the variables representing the pillars (Bollen, Structural Equations with Latent Variables, 1989)

6. Results

6.1 Descriptive results

Table 1 presents summary statistics of the variables used for the five resilience's pillars of northern Ghana. This study uses only 2,375 households from the PBS original data. At a glance, one can determine the main characteristics of the households in northern Ghana. On average, northern Ghanaians expend around GHS 92 in food. In regards to the four variables used to evaluate basic services, access to phone had the highest prevalence rate (70 percent) followed by electricity (52 percent). In general, a small proportion of households have a water source within their dwelling and access to toilets. Typically, households have at least two sources of income. Households in northern Ghana, have, on average, a household member who has 5 years of formal education, which is very low compared to the rest of the countries. With regards to assets, more than three-quarters of the households are owned, and 70 percent of them have mechanized farm equipment. Finally, household access to credit from a formal organization or informally is low; however, accessing credit from a relative is more prevalent than from an NGO.

Table 1. Summary Statistics of the variables used to build the pillars (N=2,375)

Variable	Mean	S.D	Min	Max
Food Expenditure	91.85	98.71	0	1691.00
Water	0.11		0	1.00
Phone	0.70		0	1.00
Electricity	0.52		0	1.00
Toilet	0.30		0	1.00
Professional Skills	0.05	0.29	0	4.00
Education Level	5.34	3.35	0	32.40
Income Sources	2.31	0.81	1	3.00
Small Livestock	0.53		0	1.00
Large Livestock	0.19		0	1.00
Land	1.39	1.94	0	28.73
Dwelling Status	0.84		0	1.00
Mechanized Farm Equipment	0.70		0	1.00
Non-Mechanized Farm Equipment	0.04		0	1.00
NGO Credit	0.03		0	1.00
Friends Credit	0.28		0	1.00

After conducting the factor analysis, mentioned in the method part, estimates from the resilience's pillars are shown in Table 2. Overall, the estimates indicate that the five pillars of resilience in northern Ghana are low. The variable Income and Food Access remains the same because food expenditure was the only variable used as a proxy of this pillar.

Table 2. Resilience Pillars Descriptive Statistics (N=2,375)

Variable	**Mean**	**S.D**	**Min**	**Max**
Income and Food Access	91.85	98.71	0.00	1691.00
Basic Services	0.36	0.29	0.00	1.08
Assets	0.64	0.40	0.00	3.50
Social Safety Nets	0.11	0.17	0.00	0.69
Adaptive Capacity	2.45	1.39	0.13	13.68

6.2 Model Diagnostic Test Results

Goodness-of-fit tests are done to confirm the robustness of the results and the stability of the models. These tests include the model chi-squared test indicated by the likelihood ratio (LR) value, root mean squared error of approximation (RMSEA) of the population error, and the Comparative Fit Index (CFI) with the baseline model. A value of RMSEA close zero indicates the best fit. The CFI value closer to 1 indicates a better fit as it measures the relative improvement of the model over that of a baseline model (Kline, 2011).

Table 3. Values of Fit Statistics for the Two Models

Fit Statistic	**Description**	**Model**
Likelihood ratio		
$X^2_{(25)}$	Model vs. Saturated	23.079
p > X^2		0.000
Population error		
RMSEA	Root mean squared error of approximation	0.039
90% CI, lower bound		0.024
90% CI, upper bound		0.056
P close-fit H_0	Probability RMSEA <= 0.05	0.850
Baseline comparison		
CFI	Comparative fit index	0.970
TLI	Tucker-Lewis index	0.939
Size of residuals		
SRMR	Standardized root mean squared residual	0.020
CD**	Coefficient of determination	0.629

**CD is like an R^2 for the whole model, and a perfect fit corresponds to a CD of 1.

Results of the above model diagnostic tests are presented in Table 3. The LR test of the model vs. the saturated model resulted with $X^2_{(25)}$ value of 23.08 ($p = 0.000$) . The saturated model is the model that fits the covariances perfectly. At the 5% or less level of significance, the null hypothesis that the model fits as well as the saturated model is rejected in the results. It is reported in the literature that such chi-squared goodness-of-fit test can be influenced by sample size, correlations, variance unrelated to the model, and multivariate nonnormality (Kline, 2011). Besides, under the population error, results of the RMSEA and its 90% confidence interval, and p close-fit (the p-value for a test of close fit, i.e., RMSEA < 0.05) are provided. Based on these estimated results (i.e. a RMSEA of 0.039 and 90% confidence interval of lower bound and upper bound values of 0.024 and 0.056, respectively), the fit is close because the lower bound of the 90% CI is below 0.05. Likewise, we fail to accept the null hypothesis that the fit is poor because the upper bound is less than 0.10. The p close-fit also provides the probability that the RMSEA value is less than 0.05, which is interpreted as the probability that the predicted moments are close to the moments in the population. Because the pclose is high (0.850), it can be concluded that the model fit is close. Furthermore, the CFI value for the model is 0.970 and the closer this value to 1, the better the fit it is.

6.3 Model Estimation Results

Estimated results of the measurement equation relating the latent resilience with its indicators in northern Ghana are presented in Table 4. The estimated coefficients on all of the resilience indicators are statistically significant at the 1 percent level confirming that the constructed underlying single common latent variable is representative of these indicators. A household will have lower resilience score if it has higher average score of all of the indicators or for the individual indicators. The three indicators positively associated with the latent resilience score are *Basic Services*, *Adaptive Capacity*, and *Income and Food Access*. For example, the positive sign on the *basic services* indicator implies that households with higher value in this indicator are associated with higher resilience scores. The results in Table 4 also provide the marginal effect of each of indicators on the latent household resiliency. This is due to the standardization of the coefficients during the estimation approach. The *Basic Services* indicator has the highest marginal effect (0.77) on the underlying resilience score followed by the *Adaptive Capacity (0.48).* Then, the coefficients show that a one standard deviation shift of the latent variable is associated with a change of 0.77 standard deviation of the *Basic Services* indicator in the household, higher than the association with any of the other indicators. Both *Assets* and *Social Safety Nets* indicators are negatively associated with the latent resilience score. The asset structure and the type of social safety nets available to the households may not be positively affecting the resilience of the households.

Table 4. Standardized Estimation Results of Resilience Model Based on the Measurement Equation for northern Ghana

Variable	**Coefficient**	**OIM Std. Err.**	**Z value**	**Sig.**
Food Expenditure	0.25	0.02	10.43	***
Basic Services	0.77	0.04	17.52	***
Assets	-0.29	0.03	-11.17	***
Social Safety Nets	-0.10	0.03	-3.71	***
Adaptive Capacity	0.48	0.03	14.43	***

7. Conclusions

Measuring the resiliency of vulnerable households and communities to shocks is important to better address major economic and nutritional problems such as poverty and food insecurity in low-income households. This research modeled the Resilience Level in northern Ghana using data from the Population Based Survey conducted in 2015 funded by USAID|Ghana. The main objective of this study is to estimate the Resilience Level of vulnerable households in northern Ghana and identify the factors associated with the levels of resilience. The FAO's The Resilience Index Measurement and Analysis (RIMA) model is used to describe the relationship between the latent resilience level and underlying indicators (i.e. five pillars) of it.

Results show that the latent variable, Resilience, is representative of the five pillars used to represent resilience. From the five pillars used, it appears that three of them show a positive association with the latent resilience. These are the *Basic Services*, *Adaptive Capacity*, and *Income and Food Access* indicators, which are associated with improved resilience in northern Ghana. While *Assets*, and *Social Safety Nets* are negatively associated with the latent resilience level. The results of this study could be used to design and develop effective policies that improve the resilience level of households in northern Ghana.

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