UNIVERSITY OF CAPE COAST

RELATIONSHIP BETWEEN REGIONAL CHILD MALNUTRITION DIFFERENTIALS AND FOOD AND NUTRITION SECURITY IN NORTHERN GHANA

ERIC KOJO WU AIKINS

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BY

ERIC KOJO WU AIKINS

Thesis submitted to the Department of Geography and Regional Planning, Faculty of Social Sciences of the College of Humanities and Legal Studies, University of Cape Coast, in partial fulfilment of the requirements for the award of Doctor of Philosophy degree in Geography and Regional Planning.

SEPTEMBER, 2016

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature…………………….. Date…………………………

Name: Eric Kojo Wu Aikins

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature:………………… Date…………………………

Name: Prof. Stephen Owusu Kwankye

Co-Supervisor's Signature:……………………..

Name: Prof. Kwabena Barima Antwi Date…………………………

ABSTRACT

Traditionally, northern Ghana (defined in this study as: Northern, Upper East and Upper West Regions) is noted for the production of nutritious foodstuffs such as groundnuts, beans, guinea and corn/millet that are commonly used in the preparation of healthy children food. Nevertheless, child malnutrition has been relatively high in northern Ghana with some regional variations, particularly between the periods 1993 and 2014. This thesis analyzed the regional differentials in child malnutrition and food and nutrition security in northern Ghana. Methodologically, the survey questionnaires and interview schedules approach formed the main primary data collection sources and instruments. Geographic data and information from the Ghana Demographic and Health Survey (1993-2008) were the secondary data employed. Additionally, based on cross tabulation, discriminant, factor, linear regression and multiple linear regression analyses the study data were analyzed. The findings of the study revealed that significant regional differences in child malnutrition and food and nutrition security exist between the Northern, Upper East and Upper West regions. Lack of income and limited access to good food were found to be the main factors that account for child malnutrition in northern Ghana. It is recommended that the activities of the Northern Ghana Food Security Resilience Project (NGFSRP) that promotes effective and intensive agricultural production including dry season gardening and the preparation and sale of nutritious infant and child food in the Upper West and Northern regions should be extended to cover the Upper East Region.

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DEDICATION

To my children; Erica Precious Aba Essandoa Aikins, Eric Kwesi Wu Aikins and Erica Araba Sompa Aikins.

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LIST OF ACRONYMS

Acronym	Meaning
BMI	Body Mass Index
CPA	Center for Policy Analysis
DD	Diarrhoea
DHS	Demographic and Health Survey
DHSCLUST	Demographic and Health Survey Cluster
EA	Enumeration Area
FAO	Food and Agriculture Organization
GDHS	Ghana Demographic and Health Survey
GHS	Ghana Health Service
GIS	Geographic Information System
GSS	Ghana Statistical Service
HTF	Hunger Task Force
IDD	Iodine Deficiency Disorder
IFPRI	International Food Policy Research Institute
IUGR	Intrauterine Growth Retardation
MDG	Millennium Development Goals
MOFA	Ministry of Food and Agriculture
MOH	Ministry of Health
NGFRSP	Northern Ghana Food Security Resilience Project
ODI	Overseas Development Institute
PAHO	Pan American Health Organization

RMSE	Root Mean Square Error
SCN	Standing Committee on Nutrition
SD	Standard Deviation
SPSS	Statistical Package for Social Sciences
SSA	sub-Saharan African
UN	United Nations
UNACC	United Nations Administrative Committee on Coordinating
UNDP	United Nations Development Programme
UNFPA	United Nations Fund for Population Activities
UNICEF	United Nations Children’s Fund
URI	Upper Respiratory Infections
USGS	United States Geological Survey
WFP	World Food Programme
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

Background to the Study

Malnutrition is a silent and invisible emergency and the world leading cause of disease burden that accounts for about 50 percent deaths in children under five (Tonukari & Omotor, 2010; Black, Morris, & Bryce, 2003; Ezzati, Lopez, Rodgers, Vander Hoorn, Murray & the Comparative Risk Assessment Collaborating Group, 2003; World Health Organization [WHO], 2002; United Nations Children's Fund [UNICEF], 2001; de Onis, Blossner & Villar, 1998; UNICEF, 1998). The proportion of deaths in children under five attributed to malnutrition increased to 54 percent in 2004 (Blossner & de Onis, 2005). Similarly, the proportion of children that are malnourished (stunted and underweight) are expected to increase among sub-Saharan African (SSA) countries and in other developing countries (de Onis, Blossner, Borghi, Morris & Frongillo, 2004; de Onis, Frongillo, & Blossner, 2000; Frongillo, de Onis & Hanson, 1997).

Generally, malnutrition refers to the deficiency in nutrition (Blossner & de Onis, 2005). The nature and impact of malnutrition, especially child malnutrition pose serious public health threat to affected countries because malnutrition is largely associated with the health of a given population, capital (wealth) accumulation and sustainable development (Food and Agriculture Organization [FAO], 2012; Ghana Health Service [GHS], 2010; Quaye, 2008; Van de Poel, Hosseinpoor, Speybroeck, Van Ourti & Vega, 2008). In recognition of the impact of malnutrition on socio-economic wellbeing and development, the governments of various countries in the world through the Millennium Development Goals (MDGs: 1, 2, 5 and 6 as indicated in Appendix D) have outlined achievable goals and steps to controlling and curbing the present and future trends of child mortality and malnutrition as a measure to help improve the health of children and that of the world's population in general (FAO, 2012; GHS, 2010; Van de Poel et al., 2008).

About 20 million children world-wide suffer from perennial malnutrition, which demands careful attention and treatment in order to help affected countries, particularly SSA countries to achieve the MDGs that they have worked hard to implement (WHO, Republic of Angola & United Nations Environment Programme [UNEP], 2010; Victora, de Onis, Hallal, Blossner & Shrimpton, 2010; UNICEF, 2005). Failure to sustain and improve the current efforts to achieving the MDGs through the intensification of programmes consistent with MDGs 1, 2, 4, 5 and 6 would largely confirm the fears of the WHO and other beneficiary countries. According to a report by the WHO et al. (2010) and a study by Victora et al., (2010), relatively large proportions of African countries are not likely to achieve the MDGs if current trends of child malnutrition (stunting/underweight) and increasing population growth persist (Gross, Schoeneberger, Pfeifer & Preuss, 2000).

Due to Africa's high population growth, the absolute numbers of stunted children have increased irrespective of the relative decreases in the rate of stunting that this region has experienced over the years (Gross, Schoeneberger, Pfeifer & Preuss, 2000). For instance, the 1990-2000 saw a decline in malnutrition in developing countries from 32 percent to 28 percent (UNICEF, 2001). This decline is however, low in SSA (4%) than in South Asia (23.0%) (Smith & Haddad, 2000). The resultant impact of this relative decline implies that about 200 million SSAs are undernourished and are largely unable to meet their energy intake requirements (Benson, 2004).

Also, undernutrition is found to account for about 5.6 million deaths world-wide, which represents about 53 percent of deaths in children under age five (Blossner & de Onis, 2005; de Onis, Blossner & Villar, 1998). Similarly, underweight that results from the long term effects of malnourishment explains about 140 million (25%) deaths in children in developing countries. In terms of the rate of malnutrition attributed to underweight, Smith and Haddad (2000) and WHO (1997) indicated that the proportion of underweight children increased from 28.8 percent to 31.1 percent between 1990 and 1995. The observed increase in the proportion of underweight children in developing countries may be attributed to low birthweight or poor nutrition.

According to the literature some causes of malnutrition include poor or inadequate diet, severe and repeated infections (diseases), poor environmental conditions (destruction of ecosystems, loss of biodiversity, climate change and the environmental effects of globalization), low general standard of living, poor housing and health care, intrauterine growth retardation (IUGR), political instability, illiteracy and slow economic growth (Aikins, 2012a; Aikins, 2012b; Blossner, & de Onis, 2005; Johns & Eyzaguirre, 2000; de Onis, Blossner & Villar, 1998; UNICEF, 1998; Frongillo et al., 1997). Generally, births attributed to young mothers are associated with low birthweight (Blossner, & de Onis, 2005; Kramer, 1987). Usually, births that result from preterm births mainly due to maternal under-nutrition is common to developing countries (Blossner, & de Onis, 2005; Bakketeig, Butte, de Onis, Kramer, O'Donnell, Prada & Hoffman, 1998; WHO, 1995; King & Weininger, 1989; Kramer,1987).

In respect of the specific cause of malnutrition, hunger due to limited availability and accessibility to food as well as inadequate food intake largely account for the staggering and pervasive malnutrition trends in SSA. Regardless of the various efforts made by SSA countries in respect of achieving the MDGs that aim at reducing hunger by 50 percent by the year 2015, hunger is relatively high in SSA (Thomas & Zuberi, 2012; Clemens, Kenny & Moss, 2007; UNICEF, 1998). For instance, relative increases in hunger has been observed over the past decades with about a third of the population of Africa living in chronic hunger situation (Thomas & Zuberi, 2012; Lobell, Burke, Tebaldi, Mastrandrea, Falcon, & Taylor, 2008; Sanchez, Swaminathan, & Yuksel, 2005).

Hunger is indicative of a population's limited physical access to food, which is mainly associated with inadequate dietary intake that usually predispose children to a higher risk of disease infection through poor nutrition (Smith &

Haddad, 2000). This rather high prevalence of hunger mainly due to limited access to the required quantity and quality of food may be attributed to the relatively small share of government expenditure on agriculture (food production) in SSA (Benson, 2004). For instance, the periods 1992 to 1998 saw a decline in government expenditure on agriculture in most SSA countries from 6.5 to 4.2 percent (Tonukari & Omotor, 2010; Benson, 2004; FAO, 2001).

In relation to the rather small expenditure on agriculture (food production), are the observable changes in climate world-wide due to the general observed increases in temperature that manifest as floods or droughts in various affected countries globally (Aikins, 2012b; World Food Program [WFP], 2003). A WFP (2003) estimate indicates that about 40 million Africans face acute or serious food shortages (on the brink of disaster) that are mainly attributed to drought or flood situations, civil strife and their associated refugee situations and internally displaced persons or land disputes (Benson, 2004; Clover 2003; WFP, 2003). Specifically, the current and anticipated future changes in climate is expected to lead to general increases in temperature and mixed precipitation changes in SSA, which have some implications for food and nutrition security in this region. It is estimated that by 2050 food production, affordability and calorie availability may decline considerably with a consequent increase in food prices and childhood malnutrition (Thomas & Zuberi, 2012; Ringler, Zhu, Cai, Koo, & Wang, 2010).

About 15 percent of babies (all births) in developing countries are born with low birthweight as compared with seven percent low birthweight in babies born in industrialized countries (Blossner, & de Onis, 2005; de Onis, Blossner & Villar, 1998). Similarly, about 30 million children born with low birthweight suffer severe health consequences while 161 million children in pre-school suffer from chronic malnutrition that result in about six million deaths in children per annum (Blossner, & de Onis, 2005; de Onis, Blossner & Villar, 1998).

Child malnutrition is considered to be one of the key human development indicators (Gabriele & Schettino, 2007; Pelletier & Frongillo, 2003). Smith and Haddad (2000) estimate that child malnutrition prevalence would remain high by the year 2020 with about 20 percent (140 million) malnourished children under age five in developing countries. Child malnutrition in SSA was expected to increase from 19 percent (1995) to more than 35 percent in 2020 (Smith & Haddad, 2000). Gross et al. (2000) referring to an United Nations Administrative Committee on Coordinating (UNACC)/Standing Committee on Nutrition (SCN) /International Food Policy Research Institute (IFPRI) (1999) study intimated that about 50 percent of diseases world-wide are associated with malnutrition, which accounts for more than one percent reduction in global economic growth (UNICEF, 1998). They intimated that malnutrition forms one of the key human development indicators that largely determines the survival and development of children in SSA (UNICEF, 2001 and 1998).

In examining the relationship between malnutrition and micronutrient deficiency, some studies indicate that about 80 percent (5 billion) of the world's population suffer from iron deficiency (Van de Poel, Hosseinpoor, Speybroeck, Van Ourti and Vega, 2008; Gross, et al., 2000). Additionally, about a third of the world's population suffers from iodine deficiency disorder (IDD). These deficiencies are considered to have public health implications on national development (Van de Poel et al., 2008; Gross et al., 2000). Health and nutrition-wise, malnutrition is related to child death or mortality through the lowering of a child's resistance to infections and illness such as diarrhoea (DD) and upper respiratory infections (URIs) (UNICEF, 2001). Developmental-wise, improved nutrition for children and women is found to be associated with improvements in the intellectual and technical capacity of a given population as well as the production of quality and healthy human resource base that is needed for an accelerated socio-economic and developmental growth (Benson, 2004; Pan American Health Organization [PAHO], 1998; Martorell, Rivera, Kaplowitz, & Pollitt, 1992).

Statement of the Problem

The trend in child malnutrition in Ghana between 1988 and 2008 could be described as staggering and largely increasing (GSS, 1989; GSS, 1994, GSS, 1999; GSS, 2004; GSS, 2009). Generally, the national prevalence of child malnutrition increased between 1988 and 2003 (GSS, 1989; GSS, 1994, GSS, 1999; GSS, 2004). However, between 2003 and 2008 child malnutrition prevalence declined marginally from 32.6 percent to 28.0 percent. Additionally, some regional and local variations in child malnutrition nationwide were experienced, especially among the rural areas of the three regions of northern Ghana where poverty is widespread (FAO, 2012; GHS, 2010). For example, the

1988-2008 GDHS reports largely indicate that the trend in child malnutrition in the Upper West and the Northern regions decreased while the observed trend in the Upper East Region increased (GSS, 1989; GSS, 1994; GSS, 1999; GSS, 2004; GSS, 2009).

The overall national decrease in child malnutrition between 2003 and 2008, notwithstanding, some relative increases in child malnutrition were observed in five regions of Ghana, namely the Greater Accra, Central, Eastern, Volta and the Upper East Regions (GSS, 1989; GSS, 1994; GSS, 1999; GSS, 2004; GSS, 2009). This rather continuing increasing trend in child malnutrition in the affected five regions, especially in the Central, Eastern, Volta and the Upper East regions that are largely rural and contribute substantially to Ghana's local food production have implications on Ghana's efforts at sustaining and improving its current economic growth and development as means of consolidating its current lower middle income development status as well as keeping its promise to achieving the MDGs 1,2,4,5 and 6, which is largely dependent on food and nutrition security (Benson 2004; Gross et al., 2000, UNICEF 2001). For instance, the Upper East, Upper West and Northern regions are noted for the production of groundnuts, guinea corn/millet, and beans that are commonly used in the preparation of nutritious infant weaning food and children food.

However, food and nutrition security is relatively low in the three northern regions of Ghana (Northern, Upper East and Upper West), particularly in the Upper East Region. This implies that food and nutrition insecurity is relatively high in northern Ghana. The level and extent of food insecurity in northern Ghana may be attributed to decreasing food stock and increasing cost of foodstuff, particularly grains. For instance, in 2011 high prices of grains were observed in the major food stuff markets in the three northern regions of Ghana. The observed high prices of grains in northern Ghana was attributed to a general low production of grains in southern Ghana due to lack of/limited rainfall and poor harvest (Ministry of Food and Agriculture [MOFA], Ministry of Health [MOH]/GHS & WFP, 2012), which compelled some southern Ghana grain buyers to purchase grains from northern Ghana. The increased demand for northern Ghana grains led to increases in grain prices in northern Ghana (MOFA, MOH/GHS & WFP, 2012). Traditionally, situations of high food prices affect the food security needs of food-poor households (FAO, 2012; MOFA, MOH/GHS & WFP, 2012). Also, differences in regional and local food prices affect the level of child malnutrition and food and nutrition security responses of affected areas. For instance, the similar socio-economic, cultural, and spatial attributes of the Upper East, Upper West and Northern regions, notwithstanding, different food prices were observed in 2012 (FAO, 2012; MOFA, MOH/GHS & WFP, 2012) with comparable differences in regional responses to child malnutrition and food and nutrition security needs of affected regions. Specifically, in the Northern Region between March and April, 2012 the price for a 100kg of maize increased from GH¢61.00 to GH¢67.00 representing about nine percent increase in the price of maize within the same year (FAO, 2012; MOFA, MOH/GHS & WFP, 2012).

Additionally, increases in maize price were observed in certain parts of the Northern Region, including Bimbila (14%), Walewale (3%), Nalerigu (19%), Kumbungu (8%), Zabzugu (22%) and Saboba (7%) (FAO, 2012; MOFA, MOH/GHS & WFP, 2012). However, the national wholesale price of maize within the same period (March and April, 2012) did not change in Salaga, Damongo, Bole and Sawla. In the Upper East and Upper West regions, the national wholesale price for a 100kg of maize increased by four percent (4%) in Bolgatanga and 12 percent in Wa respectively (FAO, 2012; MOFA, MOH/GHS & WFP, 2012). Generally, the number of meals eaten per day decreased in northern Ghana than in southern Ghana, especially in the rural and farming communities. This signifies the worsening state of food availability and nutrition security among the rural farming communities of northern Ghana (FAO, 2012; MOFA et al., 2012). The observed food insecurity situation in Ghana and in particular northern Ghana may be explained by the persistent level of poverty and the lowering of the purchasing power of the people (especially rural farmers), unstable food production partly due to the global and local changes in weather and climate, as well as the limited physical access to food and markets as a result of the poor state of available road networks and vehicles (FAO, 2012).

The situation of food insecurity in northern Ghana and in other regions of the country is found to affect negatively the level of malnutrition and health statuses of both children and adults, particularly children (FAO, 2012; GSS, 2012; WFP, 2009). In 2009, about five percent of the population of Ghana (1.2 million) in both rural and urban areas was considered to be food insecure (WFP, 2009). The spatial distribution of this food insecure population that is expected to be poor was found to be skewed towards rural Ghana, particularly in the rural areas of the three northern regions of Ghana that represented nearly 60 percent (59%) (Upper West, 34%; Upper East, 15%; and Northern, 10%) of the total rural population that were food insecure in Ghana in 2009 (WFP, 2009).

In Ghana food insecurity is associated with poverty. Nation-wide, about 30 percent of Ghana's population is poor and lives below the poverty line with per capita income of about US$ 600.00 (Quaye, 2008; United Nations Development Programme [UNDP], 2005). The northern Ghana with disproportionately large farming and rural communities is considered to be one of the worse poverty stricken and hunger spots in Ghana (Quaye, 2008; GSS, 2000). About 60 percent of Ghana's population, especially those in northern Ghana depend on and obtain their daily life sustenance from agriculture (Quaye, 2008; Al-Hassan & Diao, 2007). Some studies mainly attribute the relatively high incidence of poverty in northern Ghana to decline in staple crop production (Quaye, 2008; Overseas Development Institute [ODI] & Center for Policy Analysis [CPA], 2005; Aryeetey & McKay, 2004). High rural poverty and low agricultural production largely affect access to the required quantity and quality of food that largely results in low intake of food, which in turn affects child malnutrition levels (Quaye, 2008; GSS, 2004). For instance, in 2002 about 13 percent of Ghanaians had dietary composition levels below minimum (Quaye, 2008; GSS, 2004).

In respect of the overall increasing trend in child malnutrition (1988-2008), coupled with limited food and nutrition security, widespread rural poverty, and the changing global climatic conditions, limited health infrastructure and care in northern Ghana, this study posed the following research questions that helped the study analyze the observed regional differences in child malnutrition and food and nutrition security in northern Ghana.

Research Questions

(i) Why did the Upper East Region that has socio-economic, cultural, and spatial attributes similar to that of the Upper West and the Northern regions experience persistent and increasing child malnutrition between 1993 and 2008?

(ii) Why is the Upper East Region, noted for the production of some of the most nutritious staple foods such as groundnuts, guinea corn/millet, and beans commonly used in the preparation of nutritious infant weaning food and children food confronted with the problem of increasing child malnutrition among the three northern regions of Ghana?

(iii) Are there significant differences in ethnicity, traditional practices, cultural acceptability of food and food taboos practised among the people of the three northern regions of Ghana that affect child malnutrition and food and nutrition security in the three regions?

(iv) Are there significant differences in the determinants of child malnutrition and food and nutrition security among the three northern regions of Ghana?

Study Objectives

The main objective of this study was to analyze the regional differentials in child malnutrition and food and nutrition security in northern Ghana as a means of contributing to the quest for plausible solutions to the current state of relatively low food and nutrition security and high child malnutrition in northern Ghana.

The specific objectives of the study were to:

(i) Analyze the observed differences in child malnutrition between the three regions of northern Ghana (Upper East, Northern and Upper West) between 1993 and 2008 (GDHS periods);

(ii) Examine the impact of food and nutrition security on child malnutrition in northern Ghana;

(iii) Analyze the spatial and statistical relationships that exist between selected child malnutrition factors and food and nutrition security in northern Ghana;

(iv) Assess the role of agriculture (food production) in the attainment of food and nutrition security in northern Ghana; and

(v) Propose strategies for managing child malnutrition and improving food and nutrition security in northern Ghana.

Study Hypotheses

The study tested the following null hypotheses:

(i) A statistically significant negative relationship exists between food and nutrition security and child malnutrition.

(ii) A statistically significant positive relationship exists between spatial attribute of northern Ghana communities and food and nutrition security.

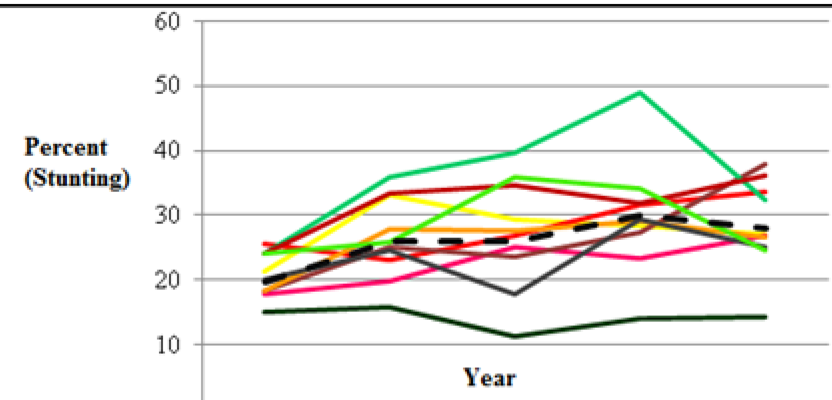
(iii) Food and nutrition security exerts a stronger statistical significant impact on child malnutrition than the health status of children under age five.

(iv) A statistically significant regional variation in child malnutrition exists between the Upper West, Upper East and Northern regions of Ghana.

Justification of the Study

The study was driven by the recognition that child malnutrition plays a key role in determining the health status, the general wellbeing of a people in a given country as well as the health of the country's workforce. Generally, high levels of child malnutrition are found to have negative impact on food and nutrition security as well as the attainment of national economic development goals and spatial infrastructural development aspirations (FAO, 2012; GHS, 2010; Tonukari & Omotor, 2010; Gabriele & Schettino, 2007; Van de Poel et al., 2008; Benson, 2004; Pelletier & Frongillo, 2003; Gillespie, 2001; Ruel, Garrett, Morris, Maxwell, Oshaug, Engle, Menon, Slack, & Haddad, 1998).

Child malnutrition as a health and nutrition phenomenon largely determines the occurrence, the state and the distribution of socio-economic development and wellbeing, which represents the structures or the product variables associated with child malnutrition. The observed structures of limited spatial infrastructural development and poor wellbeing (poverty) largely influence the prevalence of child malnutrition through limited availability and access to the required food and nutrients needed for the growth, physical development and intellectual development of children. For instance, poor mental and cognitive development of children is found to limit the learning abilities and intellectual development of affected children (Benson, 2004; PAHO, 1998; Martorell, Rivera, Kaplowitz, & Pollitt, 1992). Also, in the long term, malnutrition limits the ability of affected children to contributing meaningfully to nation building due to its debilitating effects and other negative health related consequences including slow mental and physical developments (Benson, 2004; ORC Macro, 2005). The 1988 and 2003 GDHS reports indicate a general increase in child malnutrition in Ghana, especially in the three northern regions of Ghana (Figure 1).



Regions/Ghana	1988	1993	1998	2003	2008
Western	21.3	33.1	29.4	28.4	27.0
Central	25.5	23.0	26.8	31.6	33.7
Greater Accra	14.9	15.7	11.3	13.9	14.2
Volta	17.7	19.8	25.1	23.3	26.8
Eastern	18.2	25.0	23.6	27.4	37.9
Ashanti	18.4	27.9	27.6	29.1	26.5
Brong Ahafo	20.1	24.5	17.8	29.4	25.2
Northern	24.2 *	35.9	39.6	48.8	32.4
Upper East	24.2 *	33.3	34.6	31.7	36.0
Upper West	24.2 *	26.0	35.9	34.1	24.6
Ghana (Total)	19.8	26.0	25.9	29.9	28.0

Source: Aikins (2012) * This percentage represents the three northern regions combined.
Data Source: GDHS/Ghana Statistical Service (1988-2008)

Figure 1. Regional child malnutrition trends in Ghana (1988-2008)

Source: Author's compilation based on the 1988-2008 GDHS reports (GSS, 1989-2009).

The current levels of child malnutrition in Ghana, particularly in northern Ghana poses a considerable challenge to the attainment of the MDGs 1, 2, 4, 5 and 6 as well as the provision of quality health care services and improved wellbeing for the people of Ghana (DiMario, 2008; Van de Poel et al., 2008). In addition to the general poor level of food security in Ghana (DiMario, 2008; Van de Poel et al., 2008) and in northern Ghana in particular, the three northern regions of Ghana largely present the worst case scenario of poor child health and quality of life, which requires careful investigation to isolate the main factors that account for the current regional disparities in child malnutrition in northern Ghana.

It is against this background that this study investigated and analyzed the regional differences in child malnutrition and food and nutrition security in northern Ghana as a contribution to providing plausible solutions to the relatively persistent high child malnutrition and low food and nutrition security in northern Ghana. The findings, conclusions and recommendations of the study would add to and further strengthen the current discourse on the spatial variations and effects of child malnutrition and food and nutrition security in northern Ghana in particular and in Ghana in general.

Organization of the Study

This study is organized in seven chapters. Chapter one constitutes the introductory chapter of the study. Chapter two covers the literature review and the conceptual framework that informed the present study. It mainly discusses the spatial, social and economic interrelationships between and among factors that largely affect food and nutrition security and child malnutrition levels in Ghana and in northern Ghana in particular.

Chapter three constitutes the study methodology while chapters four, five and six focus on the spatial and statistical analyses aspects of the study. Chapter seven, the concluding chapter covers the summary of research, key findings, conclusions, recommendations, contribution to knowledge, limitations of the study results and suggested areas for future research.

CHAPTER TWO

CONCEPTUALIZING CHILD MALNUTRITION AND FOOD AND NUTRITION SECURITY

Introduction

This chapter discusses the theoretical and conceptual underpinnings of the study. Specifically, it discusses the conceptualization of child malnutrition and food and nutrition security, the causes and solutions to food insecurity and the impact of agriculture on sustainable food and nutrition security. Additionally, it discusses the relevance of other theoretical and conceptual frameworks and the adapted conceptual framework to the study.

Child Malnutrition and Nutritional Status of Children

Nutritional status of children affects negatively child malnutrition world-wide. According to Benson (2004), at the individual level nutritional status refers to the 'physiological condition of an individual that results from the balance between nutrient requirements and intake and the ability of the body to use these nutrients'. These observations connote that the poorer the nutritional statuses of children are the higher the risk of them being malnourished. Although, malnutrition has declined significantly world-wide and in some developing countries over the past 25 years, the rate of stunting in all developing countries moderately declined to about 19 percent, that is, from 49 percent to 30 percent between 1980 and 2000 (Benson, 2004; de Onis et al., 2004).

In general, the trend in malnutrition and child malnutrition in SSA in particular did not decrease significantly over the same period (Van de Poel et al., 2008; de Onis et al., 2004). For example, between 1980 and 2000, child malnutrition rates measured in terms of ‘stunting’ decreased marginally from 39.0 percent to 34.5 percent, which represents a drop of only 4.5 percent within this period (Benson, 2004; de Onis et al., 2004).

Malnutrition together with hunger typifies the consequences of food insecurity with poverty as one of the main causes of food insecurity in Africa (Thomas & Zuberi, 2012). Various efforts made by African countries towards achieving the Millennium Development Goal (MDG) of reducing hunger by 50 percent by the year 2015 have yielded relatively very little results (Thomas & Zuberi, 2012; Clemens, Kenny & Moss, 2007; UNICEF, 1998). Rather, relative increases in hunger have occurred over the past decades with about a third of the world’s population living in chronic hunger (Thomas & Zuberi, 2012; Lobell et al., 2008; Sanchez, Swaminathan, Dobie & Yuksel, 2005).

Inadequate dietary intake predisposes children to a higher risk of disease infection (Smith & Haddad, 2000). Micronutrient deficiency in Vitamin A and iron contribute substantially to public health problems and the loss of human capital in developing countries. For instance, vitamin A deficiency contributes to more than 500,000 deaths in children in Africa annually (Benson, 2004; UNICEF & the Micronutrient Initiative, 2004). Vitamin A deficiency largely reduces children's ability to fight against diseases thereby predisposing most African children that have limited access to vitamin A supplements, drugs and quality food resources to a greater risk of ill-health and to a greater extent death (Benson, 2004; UNICEF & Micronutrient Initiative, 2004). Usually, children that are affected by micronutrient deficiency are undernourished.

Generally, undernourished rates are high in Africa compared to the rest of the world. For example, the periods 1990-1992 (29%) to 1999-2001 (27.5%) saw a decrease of only 1.5 percent in undernourishment in Africa (Benson, 2004). Benson (2004) estimated that about 30 to 40 million Africans annually face acute or serious food shortages that could be attributed mainly to drought/flood and civil strife and their associated refugees and internally displaced persons or land disputes (Clover, 2003; WFP, 2003). This implies that relatively large proportions of Africans have limited access to food per annum.

Increased availability and access to food is one of the key mechanisms for reducing malnutrition in Africa. This could largely be achieved through increased agricultural production that mainly results from an efficient and reliable trade and marketing mechanisms (Tonukari & Omotor, 2010; Smith & Haddad, 2000; Smith & Haddad, 2000). Comparing the use of fertilizer by farmers world-wide in 2000, which is estimated as 111.5 kilogram per hectare to that used by farmers in SSA (100 kilogram per hectare) indicates that the general use of fertilizer in farming is low among farmers in SSA (Benson, 2004; World Bank, 2003). Also, the share of government expenditure on agriculture is generally low in SSA. For instance, the periods 1992 to 1998 saw a decline in government expenditure in agriculture in most SSA countries from 6.5 percent to 4.2 percent (Tonukari & Omotor, 2010; FAO, 2001).

Generally, the rate of stunting in Africa decreased from 39.0 percent in 1980 to 34.5 percent in 2005. However, in absolute terms the proportion of children that were stunted between 1980 and 2005 represents an increase from 32.8 million to 48.5 million. Similarly, the share of the West Africa sub-region that Ghana is a member decreased marginally from 36.5 percent to 32.0 percent within the same period with an overall increase in the absolute numbers of stunted children from 8.8 million to 13.9 million (de Onis et al., 2004; WHO, 2003).

In the case of underweight, a similar pattern was observed. Underweight children rate increased one percent between 1980 and 2005 from 23.5 percent to 24.5 percent. However, in absolute terms, the number of underweight children almost doubled from 19.8 million to 34.5 million within the same period. A similar pattern of underweight was observed in West Africa where the underweight rate decreased by 1.6 percent from 28.4 percent to 26.8 percent, which translated into a relative increase in the number of underweight persons from 6.9 million to 11.7 million (Benson, 2004; de Onis et al., 2004; WHO, 2003). Related to the problem of increasing child malnutrition and its associated poor nutritional status of children in SSA is the important role that food and nutrition security plays in determining the occurrence and distribution of child malnutrition.

Conceptualizing Food and Nutrition Security

The concept of food and nutrition security is over 50 years old (Benson 2004). The basic tenets and the principles underlying this concept were accepted by the advanced countries as well as their bilateral agencies in the Hot Spring Conference on Food and Agriculture in 1943. In this conference, the concepts 'secure, adequate and suitable supply of food for all' were accepted and adopted. Based on these concepts the USA and Canada were encouraged to send some reasonable proportions of their agricultural produce (mainly food) surplus overseas to support food and nutrition insecure countries (Gross et al., 2000).

General efforts at controlling and curbing food and nutrition needs of most African countries are on the increase. However, most North African countries are more secure nutrition-wise than most countries in SSA. Differences in climate, drainage, income and socio-economic wellbeing account for the differences in nutrition security among African countries. Food insecurity and lack of or limited health care provision, availability and accessibility to food compound nutritional insecurity situation. Food and nutrition insecurity largely limits human welfare, socio-economic and developmental efforts of most African countries (Jenkins & Scanlan, 2001; Conway, 1999). Relatively large proportions of Africans have limited access to and are largely unable to obtain and effectively use the needed quality and quantity of food that they need for their daily healthy living (Tonukari & Omotor, 2010).

This observation may be attributed to lack of or limited access to arable land that largely manifests as fragmented small farm sizes, pest infestation and post-harvest loses, poor soil quality, drought and limited availability of irrigation and modern facilities for farming that contributes to a relatively low food production at the subsistence level (Tonukari & Omotor, 2010; Conway & Toenniessen, 2003; Vasil, 1998). Consequently, about 200 million Africans are estimated to be malnourished. The cost of food and nutrition insecurity contribute to a slower national economic growth, development and limited improvement in the general welfare of people in affected African countries (Benson, 2004).

Traditionally, good nutrition security is achieved through an improved access to the needed quality and quantity of food coupled with the achievement of good environmental quality, good sanitation and quality health care services. The availability and accessibility of nutrition security in most African countries is limited by the prevailing socio-economic structures, political structures, and cultural/traditional institutions. Benson (2004) examined the multiple facets of food and nutrition security in Africa and noted that as a means to solving Africa's food and nutrition problems, policy makers need to understand the broad and multi-sectoral nature of the problem as discussed above (Van de Poel et al., 2008).

Biotechnology, through the production of pest and disease resistant food products, higher yielding crops, poor soil and adverse weather tolerant crops with refined textures and flavours hold promise for the reduction, control and the elimination of hunger, malnutrition and nutrition insecurity in developing countries (Tonukari & Omotor, 2010). Biotechnology (green revolution) can be used for a sustainable agricultural production of food products in order to ensure the availability of food as well as to help provide food crops for developing countries with limited ecological and environmental consequences (Tonukari & Omotor, 2010; Swaminathan, 2000; UNICEF, 1998).

The application of biotechnology to small scale farming in Africa for the production of food and the maintenance of food security requires a greater collaboration with countries where biotechnology is far advanced and accepted (Conway & Toenniessen, 2003). This technology could be employed effectively to produce micronutrient enhanced crops (crops rich in vitamin A and iron) and to increase the overall production of food as well as to cut down the time and labour needed for farming per unit plot of farm land through agricultural mechanization.

The use of weedicides, pesticides, fertilizers and good storage facilities positively affects the food and nutrition security situation of affected countries (Tonukari & Omotor, 2010; Benson, 2004). Even where agricultural technology has been improved, limited access to income (low disposable income), generally low standard of living and poverty among SSA countries limit the ability of affected countries to achieve and maintain food and nutrition security (Thomas & Zuberi, 2012; IFPRI, 2010; Wodon & Zaman, 2009).

As a separate notion nutrition security largely refers to the degree to which individual household members gain access to food coupled with good sanitary environment, adequate health care services and knowledge based care for the healthy life and wellbeing of individual household members. In broad terms, nutrition security is food security in addition to all aspects of life that improves and sustains the wellbeing and healthy life of all household members. Nutrition security forms one of the main requirements of socio-economic and sustainable developments in the long run (Quaye, 2008; Benson, 2004).

Though nutrition security covers in broad spectrum all aspects of an individual's life that produce healthy life and better welfare, it has attracted less attention in the literature than food security that primarily covers the availability and accessibility to food at the household and community levels (Quaye, 2008; Van de Poel et al., 2008; Benson, 2004). Although both food security and nutrition security are measured at the individual, household or community levels the attainment of nutrition security largely goes beyond the individual or the household to include all sectors and institutions that ensure the provision and attainment of healthy and active life such as health care service, agriculture, political commitment or governmental aspirations and decisions, economic development policies, and cultural norms and available traditional institutions (Quaye, 2008; Van de Poel et al., 2008; Benson, 2004).

The attainment of nutrition security therefore calls for a multisectoral approach (Quaye, 2008; Van de Poel et al., 2008; Benson, 2004). To a larger extent, nutrition security determines individual contribution to the development of their communities since it focuses on the provision of healthy lives that contribute positively to the production of healthy workforce needed for the production of food produce, goods and services for an improved local and national economic growth and development. Also, nutrition security plays a key role in poverty reduction efforts and initiatives as well as help maintain both community level and national level economic growth in most African countries (Quaye, 2008; Van de Poel et al., 2008; Benson, 2004).

In respect of the role of nutrition security to national development, this study examined the extent of nutrition security in Ghana and the extent to which it affects the past, current and future child malnutrition trends. Similarly, this study observes that, nutrition insecurity is largely multidimensional in nature, which requires secure physical, economic, social and physiological access to adequate food, sanitary environment, adequate health services, and knowledge-based care as well as the full participation of all sectors and institution in a given country to help solve this problem (Benson, 2004).

The multidimensional nature of nutrition security makes it difficult for it to be measured comprehensively. Traditionally, individual factors that present a one dimensional aspect of food and nutrition security are used to measure it. The factors that measure food and nutrition security include:

i. Access: This factor refers to basic income, assets, wage rates and poverty related information (poverty and welfare inequity measures, indicators of various aspects of human capital);

ii. Health and nutritional care practices: This covers breastfeeding practices, feeding patterns of children, and the number of children (dependants) to a mother (woman). A direct relationship exists between mother's care and a child's care. Generally, when a mother's care suffers the child's care suffers accordingly (Smith & Haddad, 2000; Engle, Menon, & Haddad, 1999; Ramalingaswami, Johnson & Rohde, 1996). Also, the health of a mother affects the quality of breastfeeding, which invariably affects the health (physical growth and mental development) of affected infants and children (Smith & Haddad, 2000; Engle et al., 1999; Mendez & Adair, 1999; Ramalingaswami et al., 1996; Pollitt et al., 1993).

iii. Basic health and sanitation information: It measures disease incidence, source of water, waste disposal practices, availability and quality of health care services and health care services;

iv. Nutritional status: It refers to the contributions of political, economic and institutional structures to solving food and nutrition security problems;

v. Market: It assesses market prices and commodity price ratios and prevalence of consumption of nontraditional staple food crops; and

vi. Coping strategies: It refers to productive assets sale and migration.

The attainment of food and nutrition security is of prime concern to most governments in developing countries, including Ghana. This is largely due to the observation that, food and nutrition security ensures a better quality of life for both children and adults. Thus, the attainment of food and nutrition security could help developing countries achieve the MDGs. Measures for the attainment of food and nutrition security includes:

i. The provision of sufficient food resources for a balanced diet;

ii. The use of clean water and maintenance of sanitary/hygienic environment;

iii. Increase access to quality and affordable health care; and

iv. The means to acquire sufficient food through improvements in income and educational levels of parents, specifically improvements in income and socio-economic status of fathers as well as improvements in mothers' level of education (Van de Poel et al., 2008).

Causes and Solutions to Food Insecurity

Generally, food insecurity refers to limited physical and economic access to food. From the literature the major causes of food insecurity include: (i) population growth, (ii) urbanization, (iii) outdated agricultural practices and farming systems, (iv) poverty, (v) health and (vi) politics (Thomas & Zuberi, 2012; O'brien, 2012; Jarosz, 2011; United Nations [UN], 2011; Godfray, Beddington, Crute, Haddad, Lawrences, Muir, Pinstrup-Andersen, Robinson, Thomas & Toulmin, 2010; Tonukari & Omotor, 2010; Alexandratos, 2005; Conway & Toenniessen, 2003; Ruel et al., 1998).

Firstly, population growth (age composition, density and dependency ratios) affects food security. In some studies food insecurity is associated with population growth. For instance, observed increases in fertility trends and decreases in mortality are expected to keep the momentum of SSA's population growth (Thomas & Zuberi, 2012; United Nations [UN], 2009). On the other hand, food production is expected to decrease in most developing countries including SSA where fertility and poverty levels are relatively higher than in other developing countries (Thomas & Zuberi, 2012; Mueller et al., 2011; Long et al. 2006; Schoumaker, 2004; Moser & Ichida, 2001; Kirk & Pillet, 1998; dos Santos & Beral, 1997; Caldwell & Caldwell, 1990). The expected increase in Africa's population from 1.01billion (2009) to 2.0 billion (2050) largely implies the need for more food to feed Africa's growing population. The observed and expected growth in Africa's population is envisaged to affect negatively the level of food security among Africa's population (Thomas & Zuberi, 2012; UN, 2011; Godfray et al. 2010; Alexandratos, 2005). For example, the population growth rate of SSA is expected to increase from 1.6 percent in 2010 to about 2.4 percent by the year 2050. Owing to the current declining global economic growth and food production levels, more efforts and initiatives are required to provide the needed food and nutrients that are essential to help keep up with the health and nutrient security levels of most developing countries.

Traditionally, as more mouths are produced by births in the midst of scarce and limited food resources malnutrition and undernutrition rates are bound to increase to compound the already existing poor health statuses of affected developing countries. Thus, high population growth is largely identified to have both direct and indirect impacts on the recent increases in malnutrition in developing countries where food and nutrition insecurity persists (Tonukari & Omotor, 2010; Conway & Toenniessen, 2003; Ruel et al., 1998). Specifically, increases in population and population growth are found to have negative impacts on malnutrition, particularly child malnutrition, food and nutrition security, poverty, hunger, increased demand for food, constraints that limit the availability and use of natural resources and negative effect of lack of caloric availability in the short and long terms (Thomas & Zuberi, 2012).

Secondly, African countries are becoming more urbanized. On the one hand, the UN (1998) estimated an increase in Africa's urban population from 251 million to 864 million by the year 2030 (Tonukari & Omotor, 2010; Ruel et al., 1998; UN, 1998). On the other hand, food availability and accessibility are limited in urban areas and cities of the developing world. This inverse relationship between the rate of growth of the urban population in developing countries and urban food security mainly accounts for the levels of malnutrition and undernutrition observed in most cities in developing countries. For instance, the Greater Accra Region where the capital town of Ghana, Accra is located has experienced an increasing trend in child malnutrition for the past two decades (Tonukari & Omotor, 2010; GSS, 1989-2009).

Thirdly, outdated agricultural practices and farming systems affects food security. Farmers in Africa, particularly, subsistence and small scale farm holders produce at a relatively small scale level that is barely enough to cater for their local (household) and national food requirements. The relatively small level of food production by African farmers is compounded by problems such as pest and disease infestations, pre-and post harvest losses, poor soil quality, drought, limited income, transportation and market infrastructure as well as limited availability of storage facilities that these farmers face. This adversely affects the quantity, quality, availability and accessibility to food for the attainment of food and nutrition security that ensures the proper growth and development of the people, especially children (Tonukari & Omotor, 2010; Benson, 2004; Ruel et al., 1998).

Fourthly, poverty is associated with food insecurity. Traditionally, most developing countries are considered poor. Hunger and poverty are closely related

(O'brien, 2012). About 800 million in the world that are found malnourished are also considered to be poor and live on less than one US dollar a day (Tonukari & Omotor, 2010; Van de Poel et al., 2008). The proportion of the world's poor population is estimated to increase to about 600 million out of the total population of 8 billion by the year 2025 (Tonukari & Omotor, 2010). Though rural-urban poverty dichotomy exists, the recent trend of urbanization in developing countries largely highlights the effects of urban poverty.

Ruel et al. (1998) argued that the real force that explains urban poverty is not only lack or limited income but rather the lack of or limited availability of well paying and regular jobs for most urban dwellers. For instance, urban jobs such as industries that pay regular wages account for 10 percent of the total employment by all sectors in most African countries (Tonukari & Omotor, 2010; Ruel at al., 1998). Limited access to income and low disposable income tends to limit the accessibility and the ability of people in developing countries and Africa in particular to obtain the needed food resources in their right proportions, quantity and quality.

This observation largely coincides with the findings of some studies that indicate that a positive association exists between wage (income) and nutritional status of people (Strauss & Thomas, 1991; Haddad & Bouis, 1991; Pryer & Crook, 1988; Satyanarayana, Nadamuni & Narasinga, 1980). Relatedly, O'brien (2012) noted that hunger and poverty are closely related, especially rural poverty. He observed that rural poverty may persist if efforts are not made to transform, increase and intensify small scale farm holding (smallholder agriculture) production through increased fertilizer use, irrigation and the cultivation of improved nutrient enriched crop varieties that are drought and pest tolerant. To achieve this, O'brien (2012) noted that both political and private initiatives are needed to create the needed platform for the expansion of smallholder agriculture to increase the production and availability of food and other agriculture produce. The author suggested that this effort should mainly focus on the implementation of good land tenure policies, the provision of agricultural subsidies, and the implementation and pursuance of good trade and investment policies that could help transform smallholder farms into relatively large scale agribusiness farms (O'brien, 2012).

Fifthly, the overall health condition of an individual indicates the health status and the general wellbeing of that individual. Poor health and other related factors such as poor sanitation, poor water quality, poor housing and congestion and disease prone environment limit both mental and physical ability of individuals to contribute meaningfully to the developmental and socio-economic productive efforts of their communities and countries (Tonukari & Omotor, 2010; Benson, 2004; Ruel et al. 1998). Malnutrition is one of the ill-health conditions that negatively affect the ability of individuals to have the needed strength, energy and the psychological boost to help turn the wheels of the national economy for a productive development and the improvement of national income (Tonukari & Omotor, 2010; Pryer & Crook, 1988).

Lastly, government policies, initiatives, and programmes that focus on curbing food and nutrition insecurity are limited in most African countries. Where they exist without the financial and technical support from international institutions and bi-lateral governments (donor support), little or non-sustainable financial support is offered by most governments of developing countries to assist the poor and the needy to access the required food resources to better their lives nutritional and health-wise. In situations where some affected countries in Africa and other developing world have the capacity to produce enough food resources to safe guard their food and nutrition security needs, the prevailing unfavorable and unstable micro-economic environment compels them to export most of their food resources and primary products in order to help them obtain the required income to service their foreign and local debts and to lower or contain their balance of payment deficit (Tonukari & Omotor, 2010, Clover, 2003).

According to Tonukari and Omotor (2010) and Gross et al. (2000) the causes of food insecurity discussed thus far can be controlled and limited through the implementation of plausible strategies and solutions that aim at improving both physical and economic access to food. These strategies include: (i) the encouragement of farmers to intensify their use of agriculture biotechnology, (ii) doubling of efforts in food production, (iii) improvement in farmers' access to modern farm tools and equipment, (iv) the delivery of timely and reliable extension and (v) technical support to farmers and the implementation of initiatives and programmes to reduce poverty and fertility levels.

First, farmers could be encouraged to intensify their use of agriculture biotechnology and improved farming technologies to increase food production where necessary (Thomas & Zuberi, 2012; Tonukari & Omotor, 2010; Soetan, 2008). The review of the literature indicates that there is the need for more regenerative agricultural practices that focus on high yield adverse weather condition tolerant food crop production in addition to food crops produced through subsistence traditional farming that are organic in nature, which help to preserve the cultural taste of some food products such as maize, rice and cassava (Tonukari & Omotor, 2010; Dyson, 1999; Pinstrup-Andersen, Pandya-Lorch & Rosegrant, 1999). In relation to this observation Dyson (1999) noted that not much gains in agricultural production would be realized in the near future in SSA where farming is subsistence and organic in nature. This is because high turnover and increase in production by organic farming require good quality soil and large farm holdings that are lacking under the subsistence farming system practised widely in SSA (Dyson, 1999).

Second, farmers in Ghana and other developing countries could be encouraged to double their efforts in food production. It is estimated that, developing countries would need to produce about 500 million extra tones of grains by the year 2020 to cater for the food needs of the developing world's growing population (Tonukari & Omotor, 2010). Based on the current capacity in grain production of developing countries, the IFPRI of the UN predicts that less developed countries are likely to double their grain imports of maize and wheat (Tonukari & Omotor, 2010; Pinstrup-Andersen et al., 1999; UNACC/SCN/IFPRI, 1999).

Third, farmers' access to modern farm tools and equipment including fertilizer use, irrigation, storage transportation infrastructure and market facilities could be improved in Ghana and SSA as a means of helping them produce the required and the needed quantity and quality of food products that could make their communities and countries food secure (Tonukari & Omotor, 2010).

Fourth, timely and reliable extension and technical support could be provided to farmers including the education of farmers on recent improvements in agriculture and food production techniques that could help farmers to modernize and improve their methods of farming in order to improve on both the quality and quantity of food produced per available land for farming (Tonukari & Omotor, 2010).

Finally, programmes that aim at poverty and fertility reduction, especially in rural areas of SSA countries and Ghana could be initiated and implemented to control both local and national population growth and poverty (Thomas & Zuberi, 2012).

Impact of Agriculture on Sustainable Food and Nutrition Security

Food and nutrition security in SSA is largely tied to agricultural production. Usually, where vehicles and motorable roads are available higher productivity results in cheaper food prices and increased access to food. Hunger is quite widespread in some areas in Ghana and in SSA. For instance, Benson (2004) estimates that about 30-40 million Africans annually do not have secure access to food and could be described as the population that faces acute hunger in SSA (Tonukari & Omotor, 2010; Clover, 2003). This requires that most SSAs countries practise sustainable production of food in order to help them meet and maintain their food requirements both in the short and long terms.

In this study, sustainable food and nutrition security refers to the provision of secure and accessible quality and quantity of food and nutrition to the present and future generations that relies on the use of affordable, reliable and environmentally friendly technologies (traditional and industrial). Sustainable food production in Ghana, SSA and other parts of the world is not limited only by the changing global climate and inefficient agriculture production techniques that limit food production. Also, it is affected by other spatial and environmental factors that largely hamper the production and availability of food needed to feed the increasing poor and malnourished growing population in developing countries, particularly in SSA (O'brien, 2012; Van de Poel et al., 2008). These other factors include deforestation, fresh water scarcity and pollution, land degradation, desertification, ecosystem and biodiversity loss, demand for fuel-wood energy, low world food prices and improved prices for local food producers, and improved economic opportunities for smallholder farmers. Related to these factors is the availability of food supply and marketing systems that largely ensure food is provided and available on a sustainable basis. Usually, effective food market systems provide the avenue for food to be supplied and purchased at reasonable prices to satisfy the nutrition needs of countries.

In Africa, the food market is not effective enough. This is because most African countries have comparatively low disposable incomes and relatively large proportion of moribund food production sectors that largely rely on subsistence method of farming. Nevertheless, these markets facilitate the effective supply and demand (purchasing) of food that enhances the production of food by farmers and the utilization of food produced by consumers, which eventually contributes positively to the achievement of food security in Africa (Tonukari & Omotor, 2010; Benson, 2004).

Theoretical and Conceptual Framework

Based on the review of the available literature the following conceptual frameworks were examined to guide the thesis: (i) causes of child malnutrition; (ii) cycle of child malnutrition; (iii) burden of child malnutrition; (iv) spatial dimension of food and nutrition security (food and nutrition security and spatial and socio-organizational dimension of food and nutrition); (v) determinants of nutritional status; (vi) impact of good nutrition on national productivity; and (vii) the framework of spatial determinants of food and nutrition security and child malnutrition in Ghana.

Causes of child malnutrition framework

In the causal framework of child malnutrition (Figure 2), child malnutrition is mainly the result of the interplay of four main causal factors, namely, basic causes, underlying causes, intermediate causes and exposure (outcome) variables. These determinants (variables or factors) work together to produce an outcome variable (pre-mature death). The interaction between the determining factors and the outcome variable occurs in five main stages (Figure 2).

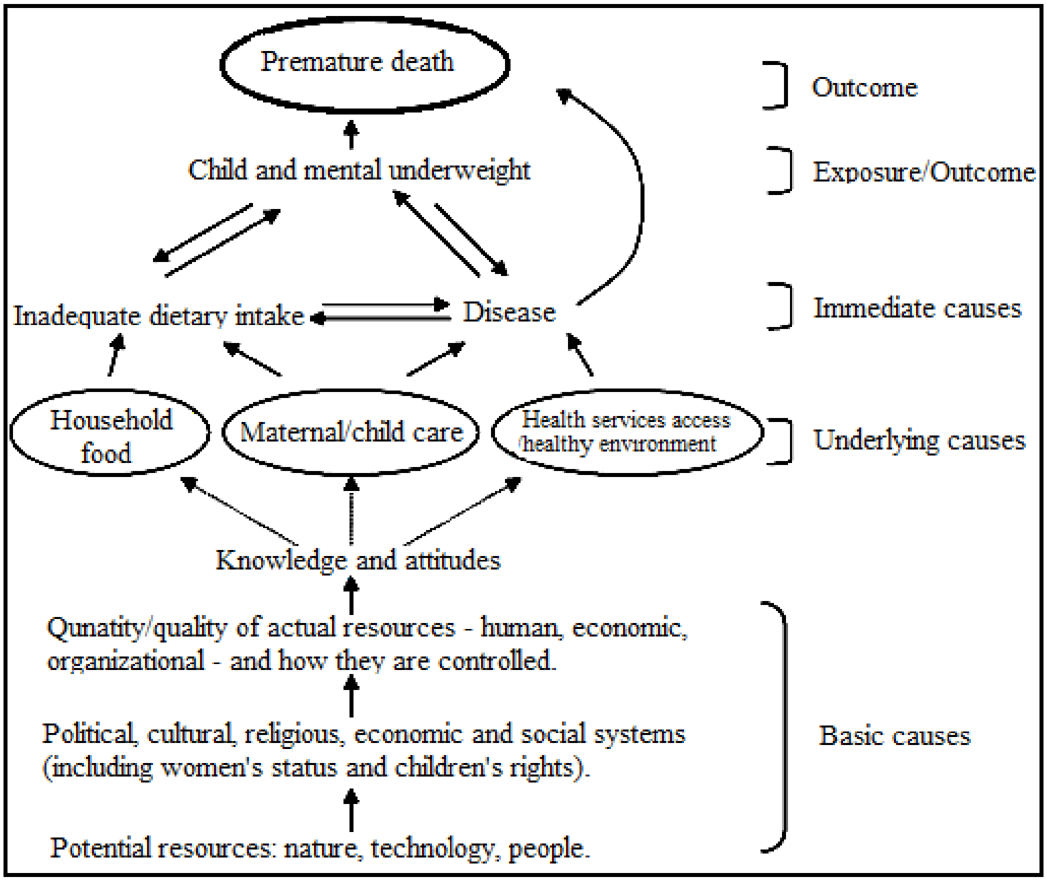


Figure 2. Causal framework for child malnutrition

Source: Blossner and de Onis (2005) and UNACC/SCN (2000).

First, this framework indicates that the basic causes of child malnutrition cover the potential resources (nature, technology and people) availability to a given community. These potential resources influence and determine the products of the political, cultural, social, economic and religious systems including women's status and the rights of children that exist in a given community. Additionally, these potential resources in turn affect the quantity and quality of resources (human, economic, organizational and how they are controlled) that may be made available in the community to help provide for the needs of the community including the provision of good health and wellbeing of children.

The interaction between the potential resources and the actual resources that are made available in the community as well as the socio-cultural, economic, political and religious systems here in referred to as community systems help to provide knowledge and the required information about the needs of the community through which new attitudes may be formed about the needs of the community as well as old attitude changed in favour of new, appropriate and productive attitudes (Blossner & de Onis, 2005; UNACC/SCN, 2000).

. Second, the basic causes largely influence the underlying causes to help identify and deal with specific problems and specific needs of the community. The underlying causes of child malnutrition are identified to include household food security, maternal and child care, and access to health services and healthy environment. Although this framework does not examine the possible forward and backward linkages between and among the three identified underlying causal factors, this study assumes that at the household level, food security affects both maternal health and child cares. In this instance, access to the required food and the intake of the needed food nutrients affect the health and nutritional statuses of both children and their mothers, which have some implications for the occurrence and the extent of malnutrition that a given community experiences. This relationship typifies the cycle of mother-child malnutrition, which explains that a malnourished mother is likely to give birth to a malnourished child who is likely to give birth to a child with low birthweight that may be at risk of malnutrition.

The reverse relationship indicates that maternal care and child care, particularly in the provision of the required food for physical growth and mental development of children have implications for food production, which mainly ensure food security at the household level. In farming communities, especially in rural communities where food production is largely manual in nature, healthy and energetic workforce is often needed to help produce the needed quality and quantity of food for the survival of respective households and the community as a whole.

Where both children and mothers who provide major labour support base for rural farming activities are unhealthy and weak, food production may be limited. This may ultimately result in a food insecure situation if the weak and ill-health conditions of mothers and children are not addressed. The forward and backward relationship between maternal care and child care and access to health services and healthy environment are largely the same and similar. Women and children's access to good health care services and healthy environment with respect to good hygienic and sanitary practices in their place of residence help to improve their health, which eventually enhances their ability to contribute meaningfully to the developmental and farming efforts of their households and communities.

Third, at the intermediate causal level the factor inadequate dietary intake interact with the disease factor to determine the extent of child and maternal underweight. The factors inadequate dietary intake and disease are the products of the underlying causal level that could be referred to as adverse effect factors. For instance, the framework (Figure 2, page 38) reveals that the factor inadequate dietary intake is a product of the household food security that signifies that food security is limited at the household level. Similarly, the disease factor is a product of access to health services and healthy environment factors that suggest that if the health and sanitation needs of a household are not met the affected household could be predisposed to a relatively higher risk of disease. This study observes that the relationships between the inadequate dietary intake and disease infection are complementary and circularly causative in nature.

Generally, people that experience inadequate dietary intake tend to be weaker, develop slowly physically and mentally. As a result, they tend to have lower resistance to diseases and may fall sick often in less healthy and poor sanitary environments. Similarly, sick people tend to have poor appetite and may not be able to eat well and absorb all the required nutrients they need from their diet for their healthy growth and development even when the household has access to food and the best meal (balanced diet) is provided. The disease condition of people affects their level of physical performance, which usually limits their contribution to the production of food and other resources that ensure household and community food security (Blossner & de Onis, 2005; Benson, 2004; UNACC/SCN, 2000; PAHO, 1998; Martorell et al., 1992). Furthermore, excessive exposure to disease and disease infection without or with limited treatment and health care may result in premature deaths in children in particular. In this study, the disease factor is found to have a direct bearing on the outcome variable (premature death).

Fourth, the factor child and maternal underweight that determine the level of child malnutrition represent the exposure variable. At this level, relationship between child and maternal underweight and inadequate dietary intake on one hand and disease on the other could be identified to be circularly causative. On one hand, inadequate dietary intake results in child and maternal underweight that largely determines the effective productive base of households and communities may have limited access to the required food they need for their effective contribution to the socio-economic development of their households and communities. Likewise, child and maternal underweight sometimes creates health situations for affected persons that limit their ability to eat well and absorb the necessary nutrients they need for their healthy growth and development. Also, some disease situations usually result in child and maternal underweight that may develop from the debilitating effects of disease that mainly cause children and mothers not to eat well or cause them to lose weight by the direct effect of the disease.

Finally, the outcome variable (premature death) is considered to be a direct consequence of the exposure variable (child and maternal underweight) and the disease factor (intermediate cause). This relationship is unidirectional in nature. The framework indicates that child and maternal underweight (malnutrition) and disease (poor health status) result in premature death, particularly in children that leads to the loss of both human and social capital, which impose a relatively higher disease burden on affected communities and countries.

The cycle of child malnutrition framework

According to UNICEF (1998) and UNACC/SCN, (1992), malnutrition could be perpetuated from generation to generation if the causal factors and their related links are not carefully isolated and delinked. This notion is commonly referred to as the cycle of malnutrition. This concept states that all things being equal, a mother that is malnourished is likely to give birth to a child with low birthweight who eventually becomes malnourished and continues the cycle of malnutrition if steps are not taken to prevent further malnutrition in affected children.

The UNACC/SCN (1992) framework (Figure 3) identifies five main stages that influence the level of child malnutrition and perpetuate it from generation to generation. It is worth noting that in this framework, child growth failure instead of child malnutrition was preferred. This is because unlike child malnutrition that examines the cumulative effect of poor health and nutritional statuses of children at the end of a given study period, usually below five years, growth failure (faltering) factors that affect the growth of children are considered and monitored continuously during the growth process of a child and not necessary at the end of a selected study period. Normally, the process of growth and factors that result in growth faltering are examined by the third month of a child's delivery (Shrimpton, Cesar, de Onis, Lima, Blossner, & Clugston, 2001; Victora et al., 2010).

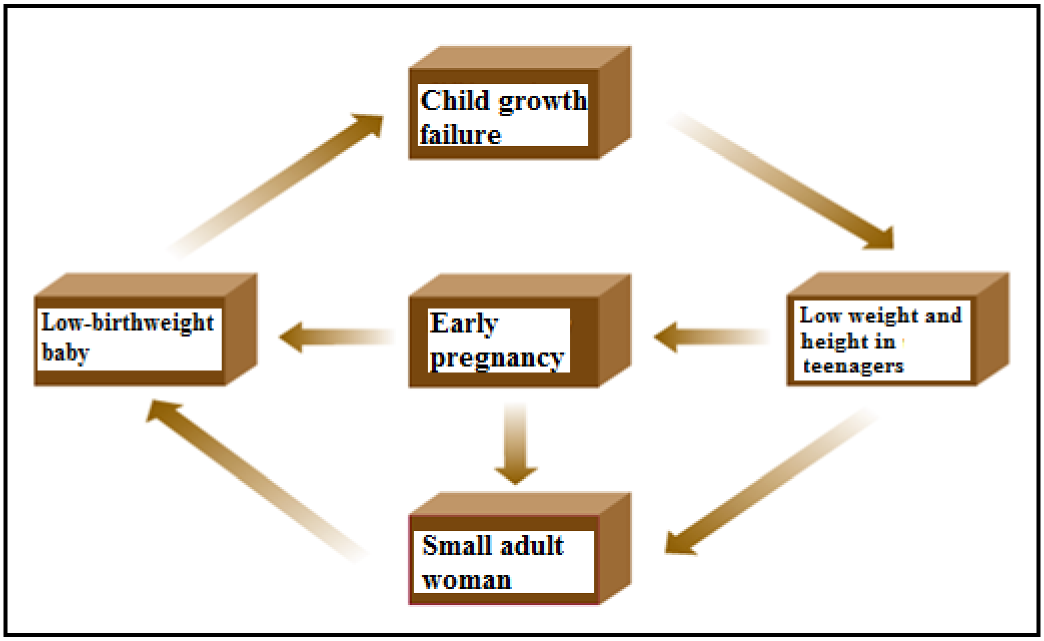


Figure 3. Intergenerational cycle of growth failure and malnutrition

Source: UNACC/SCN (1992); Second Report on the World Nutrition Situation: Vol. 1: Global and Regional Results (1992).

With reference to the intergenerational cycle of growth failure and malnutrition framework, child growth failure largely results in low birthweight and height in teenagers that is indicative of their malnutrition status. It is worthy to note that other intervening variables could exist between these two factors. For instance, it is possible for a child to fail in growth and still develop into a healthy teenager, which portrays both the expected height and weight qualities if proper nutrition and health interventions as well as food supplements and micronutrients are given to correct the growth faltering causing factors that are usually identified after birth. In the absence of such interventions, child growth failure may have relatively high propensity to cause low weight and height in affected teenagers (malnutrition). The degree of malnutrition in teenagers is identified to cause early pregnancy and depreciation in the body size of the female young adults in particular (Benson, 2004; UNACC/SCN, 2000).

The predisposing of malnourished teenagers to the risk of early pregnancy may be explained by the inability of malnourished teenagers to pursue higher education, which delays the onset of early child birth and marriage in order to improve their socio-economic statuses that could help them access high paid jobs. Also, poor intellectual and mental development associated with malnutrition may limit their access to full and effective education as well as some job opportunities, which predispose them to poorer socio-economic statuses (Almond et al., 2007; Alderman & Berhman, 2006; Godfrey & Barker, 2000).

In their effort to survive economically, some malnourished teenage girls usually get lured and forced into early sex by some relatively rich men who are considered as having better economic prospects that are capable of helping them meet their varying socio-economic needs. This situation often results in early and unwanted pregnancies, which invariably worsen their already existing poor socio-economic and malnutrition statuses. Consequent on their poverty and malnourishment, the pregnant malnourished young female adult further depreciates in physical body size partly due to lack of income for the provision of both medical and nutritional needs necessary for their healthy development as pregnant women and that of the unborn fetuses. A direct relationship is found to exist between mothers care and a child’s care.

Generally, when a mother's care suffers the child's care suffers accordingly (Smith & Haddad, 2000; Engle, Menon, & Haddad, 1999; Ramalingaswami, Johnson & Rohde, 1996). Similarly, the health of a mother largely affects the quality of breastfeeding of infants, which invariably affects the physical growth, mental development and the general health conditions of children (Benson, 2004; Smith & Haddad, 2000; Engle et al., 1999; Mendez & Adair, 1999; Ramalingaswami, Johnson & Rohde, 1996; Pollitt et al., 1993). As indicated in the intergenerational cycle of growth failure and malnutrition framework, low birthweight is the resultant effect of early pregnancy and the malnourished state of young mothers (small adult women). Low birthweight tends to create situations of growth failure, which when not controlled could start another cycle of mother-child malnutrition.

Burden of child malnutrition framework

Usually, child malnutrition imposes socio-economic and health burden on affected communities and countries (Tonukari & Omotor, 2010; Black et al 2003; Ezzati et al., 2003; WHO, 2002; UNICEF, 2001; de Onis, Blossner & Villar, 1998; UNICEF, 1998). For instance, about 349.5 million deaths per annum are attributed to malnutrition (Benson, 2004; Ezzati at al., 2003; WHO, 2002; de Onis, Blossner & Villar, 1998). The burden imposed on national development by malnutrition and its attendant consequences through life and across generations is shown by the burden of malnutrition through the life cycle and across generations framework (Figure 4).

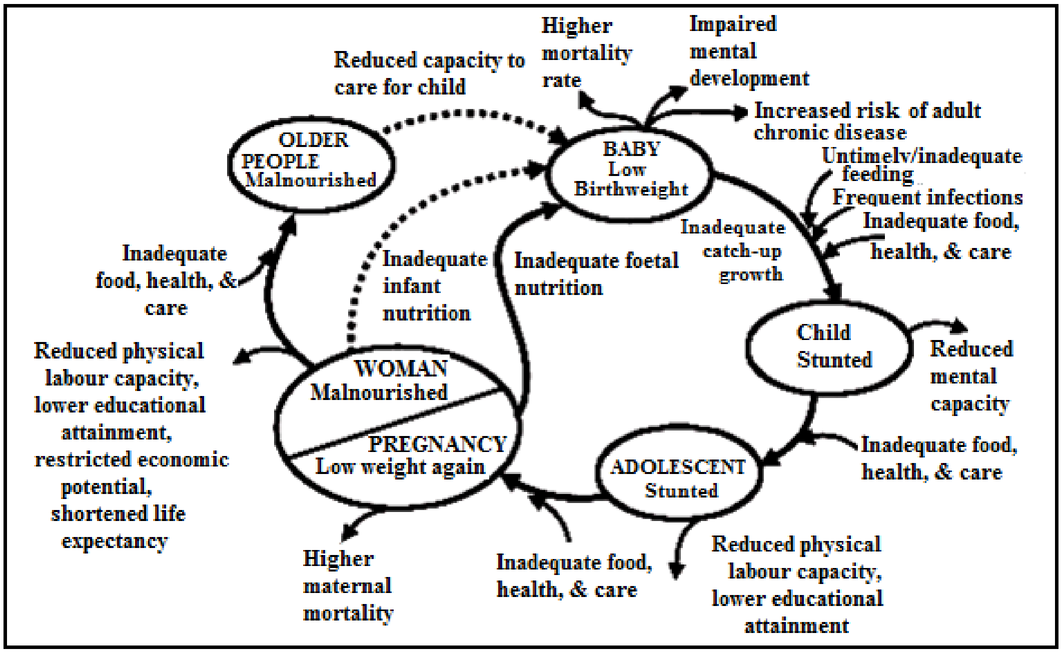


Figure 4. Burden of malnutrition through the life cycle and across generations framework

Source: Benson (2004) and UNACC/SCN (2000).

This framework and the intergenerational cycle of growth failure and malnutrition framework is similar and related. However, the burden of malnutrition through the life cycle and across generations framework (Figure 4) is more detailed and portrays more intervening factors than the intergenerational cycle of growth failure and malnutrition framework (Figure 3, page 44). The burden of malnutrition through the life cycle and across generations framework indicates that low birthweight in babies results in stunting in children. The framework indicates that stunting in children could result from a set of intervening variables such as untimely or inadequate feeding, inadequate food, limited health and child care and frequent infection. These intervening factors largely limit the ability of affected children to grow to their expected heights by their ages commonly referred to as the inadequate catch-up in growth (stunting in children).

Reduced mental capacity is found to be associated with stunting in children, which measures child malnutrition in the present study (Benson, 2004; Smith & Haddad, 2000; UNACC/SCN, 2000; Engle, Menon, Haddad, 1999; Mendez & Adair, 1999; Ramalingaswami, Johnson & Rohde, 1996; Pollitt, Gorman, Engle, Martorell, & Rivera, 1993). In situations of inadequate food, health and child care, children stunted normally grow up to become stunted adolescents that have limited or reduced physical labour capacity and lower educational attainment (low socio-economic status). Stunted adolescents often grow to become stunted adults (malnourished women), especially where inadequate food, health, and child care persist. The relatively low socio-economic status of stunted women largely predisposes them to early pregnancy that often results in low birthweight due mainly to inadequate fetal nutrition. In some situations, early pregnancy in stunted women may lead to the death of affected young mothers thereby worsening the already existing increasing maternal mortality rates.

Alternatively, malnutrition in women has the ability to create a situation where mothers may not be in the best position to provide their infants with required quality and quantity of breast milk (inadequate infant nutrition), particularly during the pre-weaning stage of infants, which could lead to low weight (malnutrition) in infants and children alike. Usually, as these young women progress in life without significant changes in their socio-economic, education, and employment wellbeing, their malnourished state could be worsened as they become older (older people malnourished). Births attributed to these older malnourished women tend to result in low birthweight in babies, especially if the poor socio-economic state of their mothers persists (Benson, 2004; UNACC/SCN, 2000). Also, this framework recognizes that older women by nature have reduced capacity to take care of children. As a result, child bearing at this stage is considered unsafe and unhealthier. Finally, low birthweight is mainly associated with higher mortality rates, impaired mental development in children and increased risk of adult chronic disease.

Spatial dimensions of food and nutrition security

The spatial dimensions of food and nutrition security model is considered under two situations: food and nutrition security framework and spatial or socio-economic dimensions of food and nutrition security framework.

First, the food and nutrition security framework examines the degree to which individual household members gain access to food (food security) coupled with sanitary environment, adequate health care services and knowledge based care for the healthy life and wellbeing of individual household members (Benson, 2004; UNACC/SCN, 2000).

The achievement and the attainment of nutritional security, that represents the goal element in the access-based conceptual framework of nutrition security (Figure 5) is largely dependent on three other elements; context, activities, and the dimension of access to secure food, sanitary environment, adequate health services, and knowledge based care. According to this framework, the context within which nutrition security occurs forms the basic tenet for the attainment and maintenance of food and nutrition security.

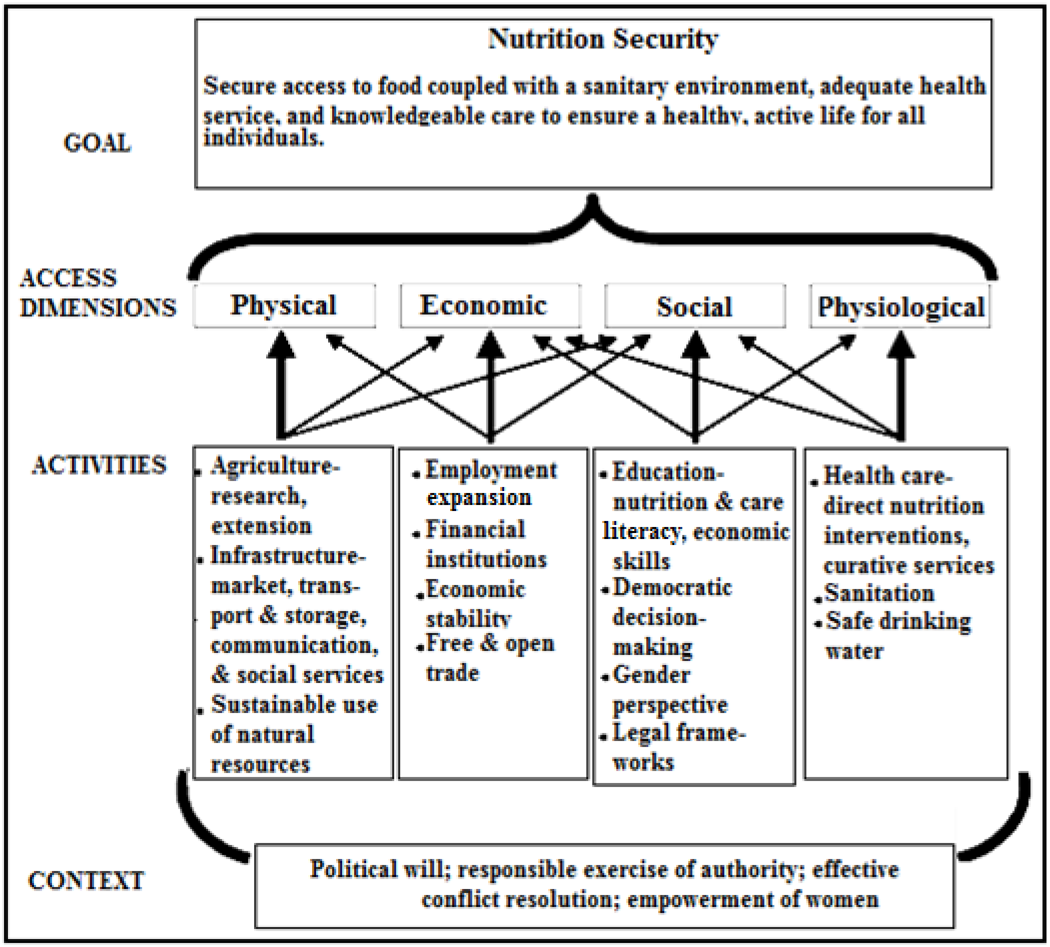


Figure 5. Access-based conceptual framework of nutrition security

Source: Benson (2004) and HTF (2003).

The factors political will, responsible exercise of authority, effective conflict resolution, and empowerment of women represent the context element. It is found that, the attainment of food and nutrition security requires a concerted effort of all sectors that cater for a better welfare and wellbeing of the people of a given country (Benson, 2004; UNACC/SCN, 2000). This view largely coincides with the context elements that the access-based conceptual framework outlines. For instance, the achievement and the maintenance of food and nutrition security in Ghana largely require strong political will and commitment of the ruling government.

Traditionally, a strong political commitment ensures that government policies are implemented and the right proportions of resources are made available for the successful completion of projects and programmes that the government considers important. This largely depicts the responsible exercise of authority since projects and programmes implemented and completed in a given community mainly show the commitment of the government in respect of the mandate given it by the people.

Furthermore, a strong political commitment is required in the empowering of women and other vulnerable groups in the community that form part of the effective workforce needed for the production of goods and services, especially in the production of agricultural produce for the sustenance and wellbeing of the people. Mainly, the interrelationships between and among the factors that constitute the context element in the framework and their associated operational efficiency influence the occurrence and operational efficiency of the activities element and its proximate factors.

The activity element is composed of specific areas that need to be considered by a given community. These activities are grouped under physical, economic, social, and physiological factors that represent the access dimension element of nutrition security. First, the physical factor of nutrition security covers specific activities such as agriculture including agriculture extension and research, infrastructural development such as markets, transportation facilities (roads and vehicles), storage, communication and social services, and sustainable use of natural resources. These specific activities mainly represent spatial development infrastructure that are required to provide physical achievement and maintenance of food and nutrition security. Principally, they ensure physical access to food and nutrition security as well as easy accessibility to the available resources in a community. Second, employment expansion, availability of financial institutions, economic stability and free and open trade constitute the economic factor.

The access-based framework indicates that a direct relationship exists between the physical factor and the economic factor. This relationship could be explained based on the importance of income that forms the main economic resource that is used to purchase materials for the development of basic physical infrastructure such as agricultural implements and tools, roads, markets, storage facilities and vehicles. Usually, these facilities are needed to provide physical access to food and health care services that mainly ensure food and nutrition security for a community.

At the individual or activity level, the economic factor also provides financial and economic access to nutrition security through the provision of the needed income (purchasing power) for the purchase of the required food and for the payment of good health care services. Third, education (knowledge about nutrition and care), democratic decision making, gender perspective, legal frameworks that pertain to a given community form the social factor as indicated in the framework. Education about the importance of available care for children and mothers together with knowledge based nutritional care provides the basis for better accessibility and attainment of food and nutrition security. Generally, the social factor represents the socio-economic status of people in a given community, which principally determines their physical and economic access to food and nutrition security. In this wise, these three factors (physical, economic, and social) are found to be related.

Similarly, health care activities including direct nutrition interventions and curative services, sanitation and availability of safe drinking water constitute the physiological factor. This factor covers the health aspects of individuals in a community as well as the provision of sanitary environment that is needed for a healthy and active life and for the attainment of food and nutrition security. Health-wise, the physiological condition of an individual largely influences the individual's ability to attain some level of education that is associated with type of occupation, which mainly determines their economic and social (socio-economic status) statuses that usually guarantee their physical access to food and nutrition security (Benson, 2004; HTF, 2003; Smith & Haddad, 2000; UNACC/SCN, 2000; Engle, Menon, Haddad, 1999; Mendez & Adair, 1999; Ramalingaswami, Johnson & Rohde, 1996; Pollitt, Gorman, Engle, Martorell, & Rivera, 1993). At the goal element and final stage, the physical, economic, social, and physiographic factors interact to determine the food and nutrition security of a given community, which largely measures the degree of secure access to food coupled with the provision of sanitary environment, provision of adequate health services and knowledge based care that normally ensures healthy and active life for all members of the community.

Second, the ensuing section discusses the spatial or socio-organizational dimension of food and nutrition security framework (Table 1), which examines food and nutrition security indicators at different spatial scales.

Table 1. Spatial and socio-organizational dimension of food and nutrition security framework

Social Level	Spatial Level	Availability	Accessibility	Utilization	Stability
Macro	World Region Nation	Fertility rate Food production Population Flows	Food price Wages per capita food consumption	Stunting rate Wasting rate Low Birthweight rate	Food price fluctuations Regional gaps
Meso	Community: Province/City District/Town Village	Harvesting time Staple food production	Market and retail food prices	Laterine coverage Diarrhea rate	Pre-/post harvest food Women's Body Mass Index
Micro	Household/Family Individual	Food storage Consumption of wild foods	Meal frequency Food frequency Employment	Weight-for-age Goiter Anemia	Pre-harvest food practices Migration

Source: Author's Compilation based on Gross et al. (2000).

This framework provides the basis for explaining the relationship between the determinants of food and nutrition security and child malnutrition in the context of space. It forms one of the four dimensions of food and nutrition security indicated by Gross et al. (2000).

The second scale refers to analysis at the meso-level that covers food and nutrition analysis in a local area or a community such as a village, town, city, or a district. In respect of the spatial dimension of analysis, this scale depicts a second scale of spatial analysis that is bigger than a household and a housing unit. Usually, at this level of analysis the spatial extent of food and nutrition security represents both rural and urban spatial units that largely signify the differences in the analysis of food and nutrition security at different spatial units or social levels of society.

The third and final scale refers to the analysis at the micro-level that primarily focuses on an individual or a household. In respect of space, this analysis mainly covers housing unit analysis, which forms one of the basic spatial units of analysis. In this respect, the spatial extent within which food and nutrition security is measured is limited to individuals or households in a given housing unit. These three dimensions largely represent the spatial dimension of geographical analysis, which Gross et al. (2000) denote as socio-organizational dimension.

In their framework, Gross et al. (2000) identified malnutrition to occur and change or be affected by the socio-organizational level within which malnutrition occurs, which in spatial terms represents the spatial unit within which malnutrition occurs. Basing their observation on the nature of food and nutrition security at various levels of social-organization (spatial units) in which malnutrition occurs, they suggested an interdisciplinary approach that employs techniques from both the natural and social sciences disciplines to analyzing the dimensions of food and nutrition security, which largely coincides with the focus of this study. With reference to this framework, food and nutrition security at the macro (regional, national, international), meso (village, town, city) and micro (household/individual) levels is mainly determined by the availability, accessibility, utilization and stability factors.

Similarly, at the national or macro level, food and nutrition security is largely influenced by fertility rate and its associated population flows as well as the extent of food production in a country. Although high fertility rates and large family sizes set limit for resource use and impose both environmental and economic hardships on a given country, high fertility rates and large family sizes are preferred in 'agrarian' societies such as Ghana where farming is mainly subsistence in nature and less mechanized (Tonukari & Omotor, 2010; Benson, 2004; Conway & Toenniessen, 2003; World Bank, 2003; Vasil, 1998; Aikins, 1999). As a result, large family sizes that provide relatively more farm hands are usually preferred in rural farming communities regardless of the negative consequences of increasing population growth.

In respect of a nation-wide accessibility to food and nutrition security, national and international food prices, wages (disposable incomes of the people) and per capita food consumption are identified as key determinants of national food and nutrition security (Gross et al., 2000; HTF, 2003; UNACC/SCN, 2000; UNACC/SCN, 1992; UNICEF, 1990). Related to the accessibility to the required national food and nutrition security is the stability in prices of food and health care services. Principally, price stability affects the degree of access to food and nutrition in a country. Price instability and increases in food prices, health and nutrition related services usually limit the accessibility to and utilization of precious nutrition and health resources (life resources) by the people of a given country for their normal activities daily.

The level and the rate of effective utilization of food and nutrition largely determine both nutritional and health statuses of a given population, which eventually influences the level of child malnutrition (the level of stunting, wasting, and low birthweight) that a given country experiences (Gross et al., 2000; HTF, 2003; UNACC/SCN, 2000; UNACC/SCN, 1992; UNICEF, 1990) . In this wise, child malnutrition could be found to occur in a given country not only when affected children have lack of or limited availability and accessibility to good food and the required nutrients for healthy growth and development only. Also, child malnutrition may occur when affected children are not able to utilize effectively the nutrients they obtained from food and nutrient supplements for their effective physical growth, mental and intellectual development. Usually, the ineffective absorption and utilization of food and nutrient occur when the general health condition of a given population is poor and have limited access to proper health and nutrition care.

At the village, town or city level (meso level) harvesting time for staple food production mainly determines the availability of food while local market prices and retail food prices, diarrhea (DD) rate and the distribution of public places of convenience (latrines/toilet facilities) principally determine the level of accessibility and utilization of food and nutrition security resources.

In terms of utilization of food and nutrition resources, the distribution of toilet facilities and the prevalence of diarrhea are used as two key indicators of ill-health situations in most local and rural communities, which predispose affected communities to greater risk of diseases such as diarrhea (Gross et al., 2000). Since sicknesses and disease infections are commonly associated with debilitating effects and loss of appetite, these adverse health conditions largely limit the ability of affected sick people, particularly children to consume and absorb (utilize) the required essential food nutrients needed for their healthy growth and development.

Relatedly, stability in food production and women's body mass index (BMI) that are associated with food availability and consumption need to be considered by affected communities in their effort to achieving food and nutrition security (Gross et al., 2000).. In this regard, affected communities would need to limit or prevent pre and post harvest losses in order to increase food production and the overall increase in food availability in such communities. Also, due consideration could be given to measures that aim at improving the general health status of women, specifically the improvement in the body mass index (BMI) of women in rural areas in particular mainly because most rural women serve as farming and development partners whose efforts provide the needed impetus for food production in most rural areas of Ghana.

Finally, at the micro or household level, accessibility to food and nutrition security is largely achieved through proper food storage and the consumption of surplus food. Pre-harvest practices and migration, particularly rural to urban migration affects the level of food and nutrition security stability that largely determines the level of food production and food availability at the household level. Usually, good pre-harvest practices that control the wanton destruction of crops by pests and diseases limit both harvest and post harvest losses and contribute substantially to a general increase in rural food production of respective rural households (Tonukari & Omotor, 2010; Benson, 2004; Ruel et al., 1998).

Traditionally, migration is selective, especially, in the case of rural to urban migration. Usually, a larger proportion of rural-urban migrants are young and energetic. The old and the weak do not migrate but stay behind to farm to produce food to meet the needs of their households. In terms of household accessibility to food and nutrition security, meal and food frequency and employment form the main explanatory factors. The number of times that members of a household, particularly children eat balanced meal per day largely determines the accessibility of that given household to food.

Poverty that is related to unemployment also sets limits for the degree of access of a household to food and nutrition security. In some instances, food may not be available to a given household because that household may have limited financial resources to purchase the required food to meet their household food needs. Normally, this situation occurs if affected households are unable to produce the required food resources to cater for their nutrition needs.

Related to household accessibility to food and nutrition security is the utilization of food and nutrition resources for the proper function of the body, physical growth and mental development, which offers individual family members the opportunity to stay healthy and contribute to the achievement of their households and national developmental aspirations. This helps them meet their food and nutrition security requirements at both household and national levels. Lack of or limited utilization and absorption of micronutrient often results in increases in malnutrition, particularly child malnutrition (stunting: height-for-age), anemia and goiter (Smith & Haddad, 2000; Engle et al., 1999; Mendez & Adair, 1999; Ramalingaswami et al., 1996; Pollitt et al., 1993).

Based on the tenets of the spatial or socio-organizational dimension of food and nutrition security frameworks, this study examined the regional (spatial) variability in child malnutrition and food and nutrition security in northern Ghana at both the micro (individual) and meso (rural and urban) levels taking due cognizance of the fact that most of the communities in northern Ghana are rural in nature.

Determinants of nutritional status framework

Nutritional status refers to the 'physiological condition of an individual that results from the balance between nutrient requirements and intake and the ability of the body to use these nutrients' (Benson, 2004; Smith & Haddad, 2000; UNACC/SCN, 2000; UNICEF, 1990). The UNICEF framework for the determinants of nutritional status of individuals in a given community (Figure 6) mainly focuses on the interrelationships between the basic, underlying and immediate determinants (factors) and their resultant impact on the outcome factor that determines the nutritional status of individuals.

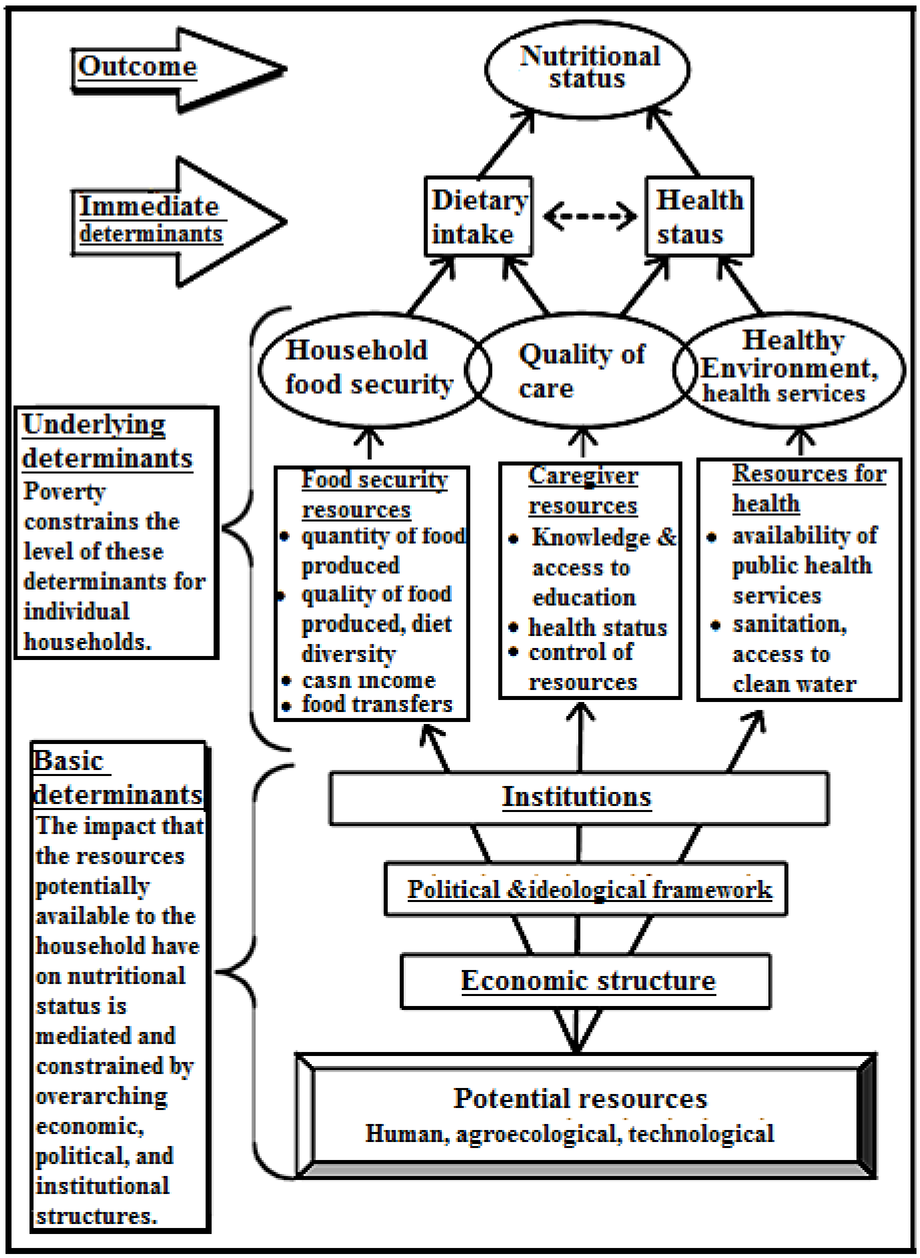


Figure 6. UNICEF conceptual framework of the determinants of nutritional status

Source: Benson (2004); Smith and Haddad (2000); UNICEF (1990).

In this framework, the basic determinants of nutritional status of individuals are primarily dependent on the availability of potential resources (human, agroecological, technical) that are mediated and constrained by the prevailing economic, political and institutional factors. At the national level, the achievement of good nutritional status requires strong political commitment, which ensures the provision of the required income needed to provide good nutrition, health and improved standard of living for the people at the individual and household levels so as to help foster greater spatial and economic development.

The occurrence and the interaction between the basic determinants of nutritional status is largely constrained by poverty and lack of income that form the underlying determining factor at the household level, which largely limit the use of potential resources (basic determinants) to achieve better nutritional status and a better general wellbeing for individual members of a household. Similarly, poverty at the household level serves as a constraint that limits household food security, quality of care, and the provision of healthy environment and quality health care services. The impact of poverty on household food security is made evident through limited availability of income to help the household access and utilize the required quantity and quality of food, diet diversity and the transfer of food where necessary (Benson, 2004; Smith & Haddad, 2000; UNICEF, 1990). Like-wise, resources available to caregivers including the level of control that caregivers have over resources, the educational level and knowledge of caregivers as well as their health statuses usually limit the quality of care they provide at the household level. Relatedly, resources for health, mainly the availability of public health services, sanitation and access to clean water set limits for the availability of healthy environment and the provision of health care services.

The three underlying nutritional status determining factors (household food security, quality of care, and healthy environment and health care services) interact to produce two key factors; dietary intake and health status factors that constitute the immediate determinants of nutritional status of individuals (Benson, 2004; Smith & Haddad, 2000; UNICEF, 1990). As indicated in the framework, a forward and backward relationship exists between dietary intake and health status of individuals. Generally, limited intake of nutritious diet predisposes individuals to a higher risk of illness, particularly children. This occurs where the required balanced diets are not given in their required proportions and frequency, which limit the ability of affected children to obtain the necessary nutrients required for healthy growth and development, which mainly help the body fight against diseases (Benson, 2004; Smith & Haddad, 2000; UNICEF, 1990). In the absence of and as a result of limited dietary intake, the health of individuals largely suffers as these affected individuals tend to achieve relatively low health statuses. The outcome of the interaction between the basic, underlying, and immediate determinants is the achievement of nutritional status that reflects the attributes of these three determinants. Generally, positive and better attributes of the basic, underlying, and immediate determinants of nutritional status results in a better nutritional status and vice versa.

Impact of good nutrition on national productivity

Government policies and strategies that aim at providing good nutrition and quality health care largely help to provide the necessary healthy workforce, which is needed for national economic growth, improved spatial infrastructure development, and increased national productivity (Kurpad, Muthayya & Vaz, 2005; Benson, 2004; UNICEF, 1998). In the context of space, the observed relationship between good nutrition and national productivity is largely circularly causative in nature (Kurpad et al., 2005; Abler, Adams, & Gould, 1971). This means that the structures of good nutrition provide the basis for an increased national productivity while the processes that lead to the achievement of increased national productivity in turn provide the needed spatio-economic structures and impetuses (resources) that are required for a better and improved nutrition. Invariably, this initiative helps countries that aspire to achieve better nutritional status obtain better health status and the provision of healthy workforce necessary for an accelerated economic growth.

According to the 'from good nutrition to greater productivity and beyond framework' (UNICEF, 1998; Gillespie et al., 1996; Figure 7), improved child nutrition provides enhanced human capital whose expertise and skills help increase the production of goods and services in a given country. Traditionally, increased productivity provides the required income and financial resources needed for an accelerated economic growth.

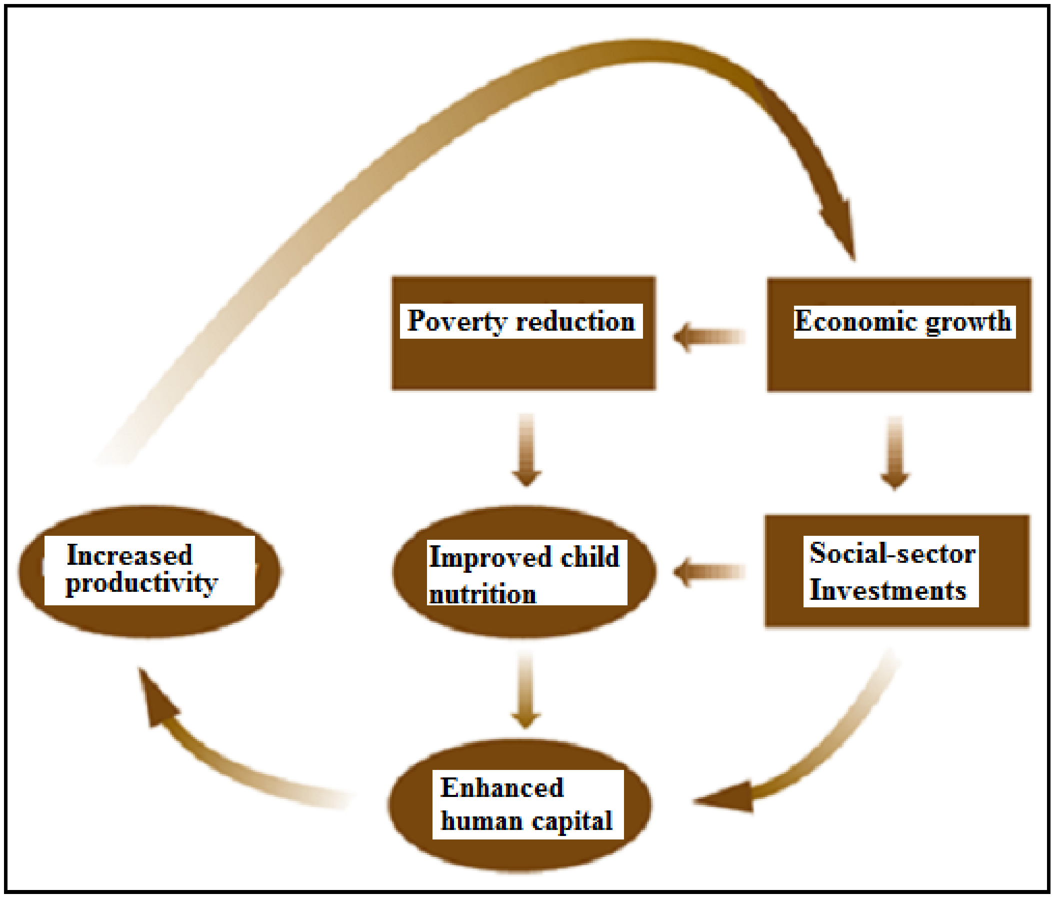


Figure 7. From good nutrition to greater productivity and beyond

Source: UNICEF (1998); Gillespie, Mason and Martorell (1996).

Relatedly, the observed growth in the national economy often provides the required economic resources for social-sector investment mainly in the area of education and the provision of affordable quality health care services and food and nutrition security (Quaye, 2008; Van de Poel et al., 2008; Benson, 2004; UNACC/SCN, 2000).

Additionally, the economic growth associated with the attainment of a better nutritional status usually creates relatively better economic environment where poverty tends to be low and children have access to improved nutrition.

This, therefore, helps countries that aspire to achieve better nutritional status to produce enhanced human capital and healthy workforce that are needed for increased national productivity.

Spatial determinants of food and nutrition security and child malnutrition in Ghana

The conceptual framework informing this study; spatio-economic determinants of food and nutrition security and child malnutrition framework (Figure 8) is adapted from the frameworks of Gross et al. (2000) (Table 1, page 54), HTF (2003) (Figure 5. page 50), UNACC/SCN (2000 and 1992) (Figures 2 [page 38] and 4 [page 47]), UNICEF (1998 and 1990) (Figures 6 [page 61] and 7 [page 65]) and the "spatial process and spatial structure" theoretical construct propounded by Abler, Adams and Gould (1971). The above stated theoretical frameworks and construct were adapted because they provided the needed theoretical building blocks and explanations that guided the construction of the study conceptual framework (Figure 8).

In respect of the spatial process and structure concept, the spatio-economic determinants of food and nutrition security and child malnutrition framework mainly focuses on the spatial variability in food and nutrition security and its associated consequences on child malnutrition in Ghana. It recognizes that though the determinants and the relationships between food and nutrition security and child malnutrition have been studied broadly at both local and global levels (FAO, 2012; GHS, 2010; Tonukari & Omotor, 2010; Quaye, 2008; Van de Poel et al., 2008; Black et al 2003; Ezzati et al., 2003; WHO, 2002; UNICEF, 2001; de Onis, Blossner & Villar, 1998; UNICEF, 1998), few studies have, however, focused on the differences in the spatial attributes of their study areas (unit of analysis) at the individual or community level (GSS, 1989-2009; ORC Macro, 2005; Gross et al., 2000; UNICEF, 1998 and 1997).

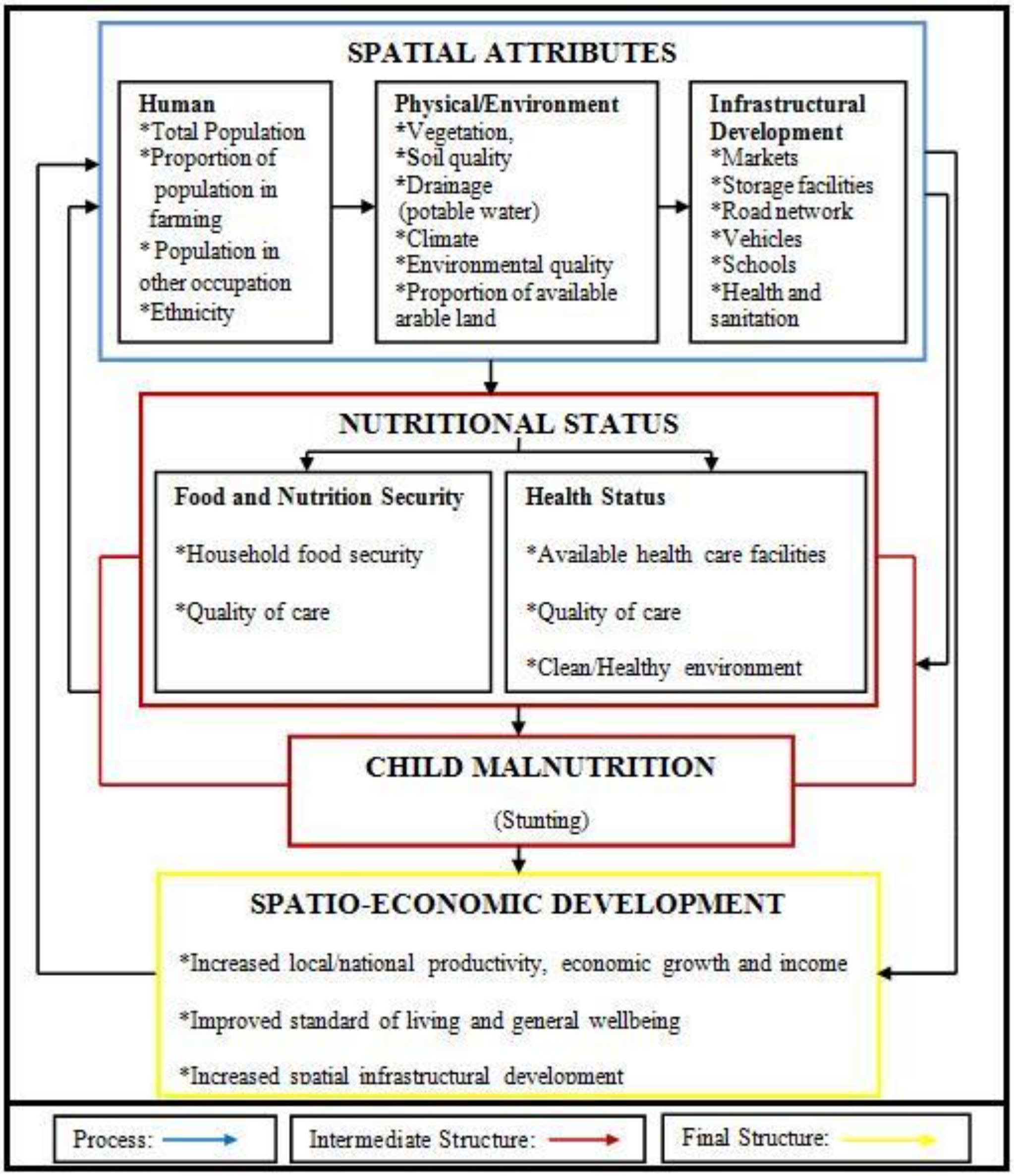


Figure 8. Framework of the spatio-economic determinants of food and nutrition security and child malnutrition

Source: Adapted from Gross et al. (2000), HTF (2003), UNACC/SCN (2000 and 1992), UNICEF (1998 and 1990) and Abler, Adams and Gould (1971).

In these studies, the effect of the variability in the spatial attributes of communities or countries are grossly generalized. Also, these effects are mainly held constant without controlling for the varying attributes and the corresponding effects that each of the spatial units that they studied has on the analysis of the nature and the extent of food and nutrition security and child malnutrition problems that exist at different spatial scales or units that form a particular study area.

However, the present study recognizes that though the communities in the study area (northern Ghana) are rural in nature and have similar cultures, some pertinent spatial differences exist in respect of ethnicity, population size, proportion of the population that is engaged in farming activities, the proportion of the population in other occupations, proportion of arable land available, drainage systems (rivers, lakes, ponds, and wells) available, local variability in weather and climate, social infrastructural development such as schools, hospitals, markets and road network, and the sizes of the communities that form northern Ghana. The spatial attributes of these communities present spatial differences that largely account for the observable differences in the levels of food and nutrition security and child malnutrition prevalent in the Northern, Upper East and Upper West regions of Ghana. In respect of this observation, this study analyzed the problem of food and nutrition security and child malnutrition at the community level and aggregated the local effects of food and nutrition security and child malnutrition prevalence to form the basis of a regional level analysis upon which answers were provided and recommendations made for policy implementation to help address the problem of food and nutrition security and child malnutrition in northern Ghana in particular.

Primarily, the framework of the spatio-economic determinants of food and nutrition security and child malnutrition (Figure 8, page 67) is underpinned by the spatial process and structure concept, which explain that the spatial attributes of a given community largely influence the nutritional status (food and nutrition security and health status of children) attained by that community. Similarly, the level of nutritional status attained is found to determine the level of child malnutrition that a given community (study area) experiences over a given period of time, which have both spatial and economic (spatio-economic) developmental consequences. An observed spatial attribute of a community form the processes that create the structures of food and nutrition security and the level of child malnutrition in that community, which in turn creates structures of spatio-economic development that sets in motion further spatial attribute processes in line with the observed spatial process-structure relationships espoused by Abler, Adams, and Gould (1971). According to Abler et al. (1971), spatial processes create spatial structure. Similarly, spatial structure set in motion spatial process. Based on the cyclical nature of the observed relationship between spatial process and structure, Abler, Adams, and Gould (1971) explain that spatial process and structure are circularly causative. For instance, the process of food shortage usually creates the structure of hunger in affected communities that largely results in child malnutrition. Also, the prevailing structure of child malnutrition in affected communities usually leads to the production of weak and unhealthy workforces. The weak and ill-health status of the workforce largely limits the ability of the affected population to contribute meaningfully to the food production needs of their communities. This, therefore, helps intensify the already existing process of food shortage.

In this study, selected spatial attributes (spatial process) of the study area are identified to have effects on the level of food and nutrition security, child malnutrition, and spatio-economic development (spatial structure) prevalent in the study area. Like-wise, nutrition security, child malnutrition, and spatio-economic development (spatial structure) are identified to have effect on the selected spatial attributes (spatial process) of the study area. Nor does this study's framework examine the general and overall relationships in the spatial process-structure construct but also it examines the internal linkages that are mainly responsible for the operational efficiency of this framework.

First, the study framework indicates that spatial attributes of a given community can be grouped into three, namely, physical and environmental, human, and spatial infrastructural development factors. The physical and environmental factor is composed of processes that are commonly found in nature that form the physical aspect of the earth, specifically vegetation, soil quality, drainage (potable water), climate, environmental quality and proportion of arable land. The human factor represents the social, economic and cultural attributes (total population, proportion of population that are engaged in farming activities, proportion of population in other occupation and ethnicity) of the population that make demands on the available resources provided by nature (physical and environmental factor) in the study communities to produce goods and services to meet the needs and wants of the study communities.

Usually, the consequences of the activities of humans as agents of change in space largely result in observable structures and changes on the earth surface (Aikins, 2014). The spatial infrastructural development factor comprises of all physical infrastructure such as markets, road network, vehicles, schools, health care and sanitation facilities that are used by humans (population) to achieve a better nutritional status and wellbeing in life. These factors together form the spatial process that creates intermediary spatial structures comprising of the nutritional status and child malnutrition structures and a final spatial structure factor denoted as the spatio-economic development structure.

Second, the nutritional status of individuals in the study area is noted to be affected by two main factors. These factors are food and nutrition security and health status. Food and nutrition security at the individual and household level comprises of two main sub-factors: household food security and quality of care that individual household members receive, especially children. Usually, the availability, accessibility, and the utilization of the required quantity and quality of food provide individual households in the study area with a better food and nutrition security.

Better food and nutrition security coupled with quality of care (knowledge based care) strengthens food and nutrition security levels prevalent in the study communities. Health status forms the second sub-factor that represents the nutritional status of individuals. Principally, the quality of health care services and general care available and accessible to individuals in the study area coupled with clean and healthy environmental conditions provide affected individuals with better health statuses.

Although better food and nutrition security can be used as a proxy for the measurement of nutritional status, it is mainly found to be weak in itself without health status because the nutritional status of an individual covers both food and nutrition security and health status of the individual. Similarly, health status alone does not provide a comprehensive measure of nutritional status although the health of individuals largely affects their dietary and nutrient intake requirements through loss of appetite and general weakness associated with illness (debilitating effect) that predisposes sick people to lesser food consumption and nutrient intake. The combined effects of both food and nutrition security and health status, therefore, are found to offer a better explanatory power for the determination of nutritional statuses of individuals and communities. On the other hand, poor nutritional status consequent on food and nutrition insecurity (household food insecurity and poor care) and poor health status (poor health services, poor care and poor sanitation and unhealthy environment) usually result in malnutrition, especially child malnutrition and a general low standard of living (Blossner & de Onis, 2005; Johns & Eyzaguirre, 2000; de Onis, Blossner & Villar, 1998; UNICEF, 1998; Frongillo et al., 1997).

Third, child malnutrition (stunting) limits the provision of healthy population that forms the human resource or human capital base of communities and countries. This is largely because stunted children are comparatively weaker and shorter in height for their ages. They tend to develop rather slowly physically, intellectually and mentally (Smith & Haddad, 2000; Engle, Menon, Haddad, 1999; Mendez & Adair, 1999; Ramalingaswami, Johnson & Rohde, 1996; Pollitt, Gorman, Engle, Martorell, & Rivera, 1993).

These physical and health characteristics mainly limit stunted and malnourished children from accessing higher levels of educational qualifications and their corresponding job opportunities. Likewise, the physical and health characteristics of stunted children limit their efforts at participating fully in the spatio-economic development of their communities and countries (Aikins, 2011; Tonukari & Omotor, 2010; Benson, 2004; Ruel et al. 1998; PAHO, 1998; Pryer & Crook, 1988; Martorell et al., 1992). At this stage in the framework, it is recognizable that spatial attributes of the selected study communities directly affect both the nutritional status of mothers and children as well as the level of child malnutrition that the study communities experience (intermediate structures). Likewise, the two intermediary structures (nutritional status and child malnutrition) directly impact the nature and distribution of spatial attributes (spatial process) that characterize the study area.

Fourth, the resultant spatio-economic development refers to all forms of development that occur in a given spatial unit (place or community or country) and their interrelatedness that brings about economic and social benefits that provide the needed impetus for further development (Aikins, 2014; Aikins, 2011). According to Aikins (2011), it is not only the economic gains of an area that primarily bring about further economic gains and development but rather it is the spatial dimensions of economic growth that bring about visible physical spatial infrastructure development such as industrial development, expansion in trade relations and institutions as well as increase in commercial firms that mainly create further increases in economic gains. These gains often provide the needed economic impetus for further physical spatial infrastructure development that leads to further economic gains and improvement in social wellbeing.

In this regard, available physical spatial infrastructure development in an area is identified to serve as agents for further physical spatial infrastructural development and economic gains that provide relatively better socio-economic wellbeing for the people in the study area. In this sense, physical spatial infrastructural development is noted to bring about relatively more physical spatial infrastructure development and an improved general wellbeing. The reverse holds true. In the study framework, increasing child malnutrition level largely limits the production of the necessary workforce that is capable of using the available resources that the study area provides to produce goods and services for sale to generate the necessary and needed economic gain (income). The resultant economic gain obtained from the positive interaction between the local workforce and available community resources could serve as the basis for an improvement in physical infrastructure already existing in affected communities for additional economic gains. The effective and efficient use of the additional economic gain could help provide new and additional physical infrastructure for further spatial and economic (spatio-economic) development in the study area (Aikins, 2014; Aikins, 2011).

On the other hand, limited spatio-economic development (final spatial structure) in the study area set limits for the effective operation and use of available resources (spatial attributes) to provide the needed economic impetus for the provision of good health, nutrition, and socio-economic wellbeing of the people in the study area. Consequently, child malnutrition that largely determines the health and nutritional status of the study area remains relatively high while spatio-economic development of the study area remains relatively low. This, therefore, presents an inverse relationship between spatio-economic development and child malnutrition prevalent in the study area. The spatio-economic determinants of child malnutrition and food and nutrition security framework based on the spatial process and structure relationship and other theoretical frameworks guided the present study to examine the statistical significant relationship between child malnutrition and food and nutrition security in northern Ghana.

CHAPTER THREE

METHODOLOGY

Introduction

Broadly, chapter three of the study discusses the procedures for the conduct of the present study. Specifically, it discusses the geographical profile of the study, research design, study population and unit of enquiry, sources of data, sampling procedures, research instruments and data collection techniques, ethical consideration, data processing and analysis, and data evaluation and limitations of the research.

Profile of the Study Area

The three regions of northern Ghana with a total land area of 97,702 Sq. Km (Northern = 70,384; Upper East = 8,842; Upper West = 18,476) form the study area. Geographic-wise, this area is located to the north of Kintampo, the geographical center of Ghana. It covers about 50.0 percent of the total land area of Ghana. The study area, northern Ghana is made up of three regions: Upper East, Upper West and Northern (Figure 9). Figure 9 shows the map of the study area (northern Ghana) and the locations of Northern, Upper East, and Upper West Regions that form the study area.

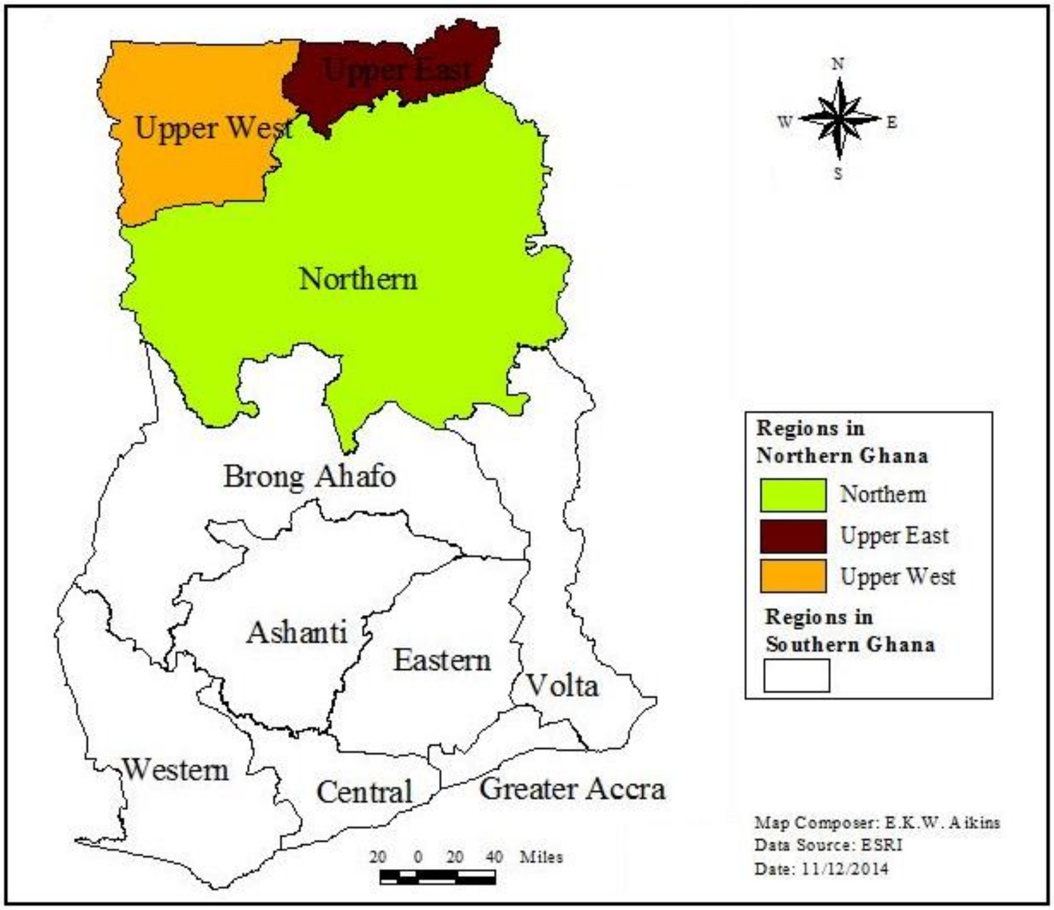


Figure 9. Map of Ghana showing the study area (northern Ghana)

Source: Author (2014).

The physical geography of the three northern regions of Ghana (Upper East, Upper West and Northern) that form the study area is similar. Generally, temperatures are higher in the study area coupled with a uni-modal rainfall pattern (one major raining season), which normally occurs between April and October (Appendix H). The vegetation of northern Ghana is mainly of the Guinea Savanna type. The soils of the study area fall under two main Great Soil Groups of Ghana: Savanna Ochrosol and Savanna Ochrosol with groundwater laterite. At the regional level, a larger proportion of the soils in the Upper East Region are of the

Savanna Ochrosol Great Soil Group (Appendix H). On the other hand, soils in the Upper West and Northern Regions are mainly made up of the Savanna Ochrosol with groundwater laterite, which allows for the cultivation of some tree crops such as cashew nuts and mangoes (Appendix H). In terms of food production, the study area is noted for the production of savanna food and cash crops such as groundnut, beans, guinea corn, yam, cotton and cashew nut.

Socio-demographic wise, the study area forms a cluster of one of the low population density regions with relatively large rural population, low income, low educational attainment levels and limited physical infrastructure development areas in Ghana (See Appendix H).

Research Design

The philosophical thrust of this study is the Applied Geography (Radical Geography) perspective of research in Geography. This is mainly because, the present study seeks to address community problems through empirical data collection and analyses and makes plausible recommendations that aim at addressing the problems of child malnutrition and food and nutrition security in the study area (Johnston, 1991).

In respect of the tenets of Applied Geography research, both quantitative and qualitative research techniques were used in the data collection, analyses and interpretation aspects of this study. The main quantitative data set for this study were obtained through the administration of survey questionnaires. On the other hand, information obtained from structured interviews and the review of available literature formed the main qualitative data source for this study.

With regard to the nature and scope of analyses, this study used the cross-sectional study technique. The main objective of this study that sought to provide an explanation for the differences in the levels of child malnutrition and food and nutrition security experienced in the three northern regions of Ghana (Northern, Upper East, and Upper West) influenced the selection of the cross-sectional study technique over the cohort study technique. The cross-sectional study technique provides a snapshot (one time) of events and phenomena that the primary data collection aspect of this study refers. Also, information provided with the aid of this technique contributes substantially to the provision of plausible explanations for the distribution of spatial phenomena at a given point in time.

Statistical and spatial-wise, this study characterizes a comparative study that focuses on examining the spatial and statistical differences in child malnutrition and food and nutrition security at the individual level among and between selected communities in the Northern, Upper East, and Upper West regions of Ghana.

In order to obtain regional level information on the differences in child malnutrition and food and nutrition security in the study area two levels of data aggregations were done. First, the views of respondents in the selected study communities in northern Ghana were aggregated to obtain Districts, Municipality, and Metropolitan level information. Second, the Districts, Municipality, and Metropolitan level information were aggregated to generate the needed regional data and information, which provided the basis for the measured comparison of the regional differentials in the child malnutrition and food and nutrition security in northern Ghana.

Study Population and Units of Inquiry

Notwithstanding the large spatial extent that the three regions in northern Ghana cover (97,702 Sq. Km), the total population of northern Ghana according to the 2010 population and housing census was 4,228,116, which forms about a fifth (20.0 percent) of the national population (Table 2).

Table 2. Geo-demographic characteristics of northern Ghana (2010)

Geo-demographic characteristics	Northern Ghana Regions		
	Northern	Upper East	Upper West
Total Population	2,479,461	1,046,545	702,110
Total Male Population	1,229,887	506,405	341,182
Total Female Population	1,249,574	540,140	360,928
Sex Ratio	98.4	93.8	94.5
Total Female Population (15-49)	582,897	243,377	166,230
Proportion (%) of Females (15-49)	(46.6)	(45.1)	(46.1)
Mean Age	22	25	24
Average Household Size	7.7	5.8	6.2
% Rural	69.7	79.0	83.7
% Urban	30.3	21.0	16.3
Land Area (Sq Km)	70,384	8,842	18,476

Source: Author's compilation (2014) based on the 2010 Population and Housing Census (GSS. 2012).

Additionally, the regions (Northern, Upper East and Upper West) of northern Ghana are characterized by rural farming communities with low populations (Table 2, page 80). The average household size of northern Ghana is relatively large (Northern = 7.7; Upper East = 5.8; Upper West = 6.2) (Table 2, page 80). Comparatively, there are more females than males in the study area with a sex ratio of about 96 males to 100 females (Northern = 98.4; Upper East = 93.8; Upper West = 94.5) (Table 2, page 80).

Sources of Data

Data for this study were gathered from both primary and secondary sources. Data obtained from these two main data sources were analyzed to provide spatial (GIS) and statistical information about the causes and consequences of the measured differences in food and nutrition security and child malnutrition in northern Ghana.

Field survey data formed the primary data while the GDHS data reported in the 1994 to 2009 survey reports formed the secondary data. Additionally, GDHS digital geographic data sets were obtained (downloaded with permission) from the MEASURE DHS website (Appendix B) that provided information about the location of selected communities in northern Ghana that the GDHS covered for the past fifteen years (1993-2008).

Formal permission regarding the use of the online GDHS geographic data set was sought. Also, the ethical consideration regarding the use of GDHS geographic dataset was adhered to accordingly (Appendix B). The geographic data were used to compose base maps that guided the selection of study communities in the Northern, Upper East and Upper West regions.

Selected variables (Appendix I) that mainly cover the research questions posed, objectives, and hypotheses of the study were garnered from the 1994-2009 GDHS reports and the field survey data to form the main data source for the spatial and statistical analyses aspect of the present study.

Secondary information was utilized to augment the information derived from both primary and secondary data sources. Also, other relevant information from journals and publications on child malnutrition and food and nutrition security was used to help explain the measured patterns and distributions of child malnutrition and food and nutrition security in the study area.

Measurement of variables (Child Malnutrition)

In this study, child malnutrition is measured in terms of the level of stunting (height for age) among children less than five years. This measure is preferred because stunting measures the linear growth in children and largely account for recurrent/chronic illness and lack of or limited good nutrition (inadequate nutrition) in children over a long period of time (GSS, 1989; GSS, 1994; GSS, 1999; GSS, 2004; GSS, 2009; Blossner & de Onis, 2005; ORC Macro, 2005). Additionally, stunting as a measure of malnutrition largely controls for some major short term factors such as seasonal effects of data collection, epidemic illnesses, acute food shortages and changes in socioeconomic policies that are likely to affect the measurements and analyses of malnutrition in the short while (GSS, 1989; GSS, 1994; GSS, 1999; GSS, 2004; GSS, 2009; ORC Macro, 2005). Also, it measures the linear growth in children that is considered to be compatible with the least square regression statistical analysis (Kachigan, 1991) that the study used in analyzing the statistical relationships between child malnutrition and food and nutrition security in the study area.

Measurement of variables (Food and Nutrition Security)

In this study, food and nutrition security covers food security in addition to all aspects of life that improves and sustains the wellbeing and healthy life of all household members. Due to the multiple and varying nature of the variables that measure food and nutrition security, an index of food and nutrition security based on the factor analysis statistical technique was composed to measure it.

In all, twenty (20) variables that best measure food and nutrition security were selected to form part of the composition of the index of food and nutrition security (See Appendix A). The index of food and nutrition security formed the main independent variable of the regression analysis on the impact of food and nutrition security on child malnutrition in the study area.

Sampling Procedures

Sample size determination

Child malnutrition is wide spread in the study area. This makes it almost impossible to interview all mothers in the study area about child malnutrition situation in their respective communities. Based on the population of mothers in the study area and the main objective of the study a sample size of 300 mothers was selected to present the total sample size of respondents (mothers) in the study area who have malnourished children.

For the purposes of regional comparison of the difference in child malnutrition and food and nutrition security among the three northern regions of Ghana, which form the study area equal proportions of 100 mothers were selected to present the sample size of each of the three northern Ghana regions (Northern Region; 100 mothers; Upper East: 100 mothers; Upper West: 100 mothers). The ensuing section discusses the procedures for the section of the study sample size.

Sampling methods

The selection of appropriate sample size is important to this study because of the nature of the spatial phenomena investigated, time available for the study and the cost of the study data collection exercise.

Based on the preceding reasons, sampling in research in geography, therefore, becomes imperative and necessary, especially at this level of academic pursuit. As a result, this study employed a multi-stage (two stage) cluster sampling technique (spatial and statistical cluster sampling techniques) to obtain a representative sample of respondents (mothers) that were interviewed to provide relevant information on child malnutrition and food and nutrition security that pertains to the study area.

First, in an effort to obtain a representative study sample size, a spatial cluster analysis was performed using the 1993-2008 GDHS geographic data sets (vector files) that contain some spatial information about the enumeration areas (EAs) that the 1993-2008 GDHS covered. The spatial cluster analysis did not include the geographic attributes of the 1988 GDHS period because this data set is not available. Using the ArcMap version 10.0 and the Arcview version 3.3 geographic information systems (GIS) softwares, maps that show the spatial distribution of significant clusters of EAs were made to cover the 1993 and 2008 GDHS periods (Appendix B).

With the help of the Cluster and Outlier function of the Spatial Statistics tools in the Arc Toolbox of the ArcMap version 10.0 software, areas of significant clusters of EAs based on the DHSCLUST data attribute column was calculated and mapped at the 95 percent significant level. The EA cluster maps revealed more distribution of significant cluster of EAs in the three northern regions of Ghana (Northern, Upper West and Upper East) that form the study area than in the other remaining regions between the 1993-2008 GDHS study periods (Appendix B). Figure 10 shows the distribution of significant cluster of EAs in the three northern regions of Ghana (Northern, Upper West and Upper East).

In order to obtain EAs that largely remained unchanged between the 1993-2008 GDHS periods for a comparable spatial analysis, Theme on Theme selection in Arcview version 3.3 was performed. This procedure allowed the selection of all significant clusters of EAs within five miles of each survey point that formed part of the 1993-2008 GDHS. In all, 28 significant clusters of EAs were obtained that cover the study area (Figure 10). The 28 significant clusters of EAs in the study area form about seven percent (6.8 %) of the 412 EAs that were surveyed nation-wide during the 2008 GDHS.

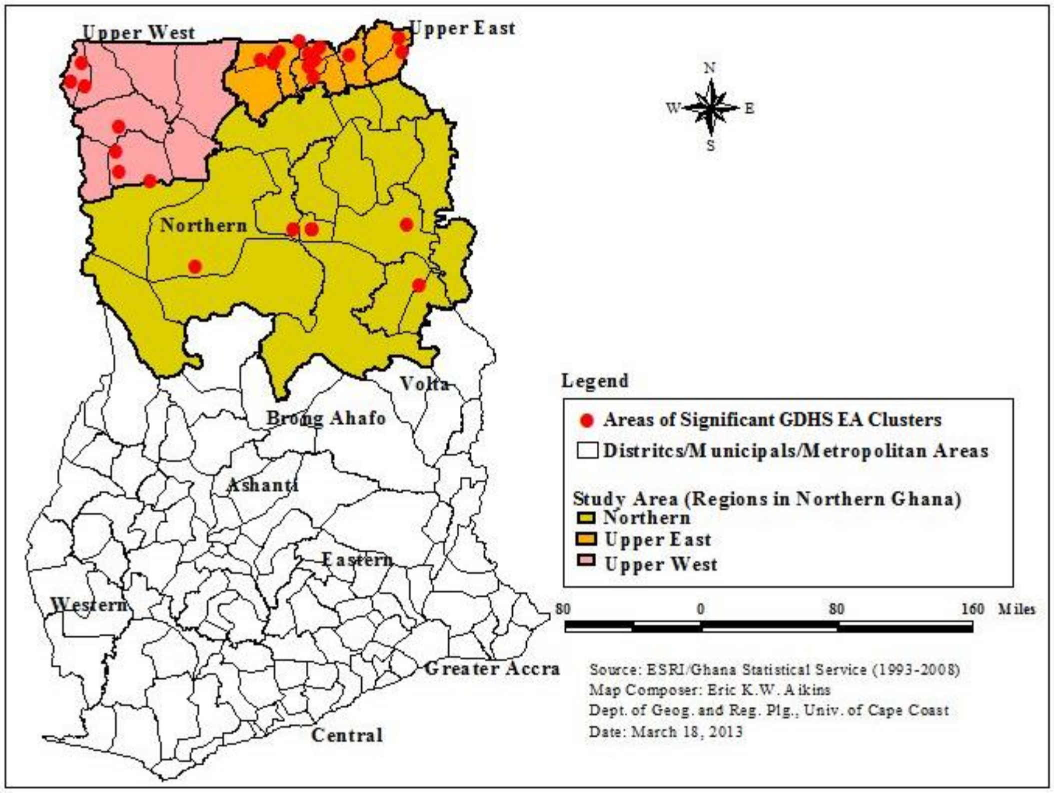


Figure 10. A map of Ghana showing the spatial distribution of significant cluster of EAs in the Northern, Upper West and Upper East Regions

Source: Author's data analysis (2014).

The selection of the EAs guided the selection of survey communities that are largely represented by the EAs. Since the 1993-2008 GDHS geographic data do not contain community level information, the identification and labeling of the survey communities was done with the help of a base map that has both latitude and longitude information (geo-referenced), which portrays the geo-locational position of communities in the study area by dots. Using the geo-referencing tool in ArcMap version 10.0 the base map that shows the locations of communities was co-registered to the cluster map that portrays the geo-locational position of selected EAs (Appendix B), which represent cluster of houses in the selected communities from which the 1993-2008 GDHS survey sample points (individuals or household per housing unit) were sampled.

The co-registration exercise yielded a root mean square error (RMSE) of 0.15693. With reference to the guidelines of the national map accuracy assessment of the United States of America Geological Survey (USGS), an RMSE of less than 0.5 or 50 percent is acceptable and preferred (Aikins, 2003; Eastman, 1999). Generally, an RMSE of 0.15693 signifies that the two co-registered maps largely have the same ground reference unit and that a dot on the cluster map largely coincides with a dot on the base map that shows the location of communities. With reference to place names on the base map, the cluster sample points (EAs) were identified and labeled to produce a survey community/locality map (Figure 11). This map shows the distribution of EAs by the names of the communities in each EA.

Secondly, a statistical cluster sampling was done based on the result of the cluster mapping. This procedure facilitated the unbiased sampling of respondents in the selected EAs to form part of the study sample. Spatial-wise, 14, 7, and 7 EAs were identified in the Upper East, Upper West, and Northern Regions respectively (Figure 11, page 88). According to the 2010 population and housing census report, a total of 992, 504 females (15-49 years) were counted in the three northern regions of Ghana (Northern = 582,897; Upper East = 243,377; and Upper West = 166,230).

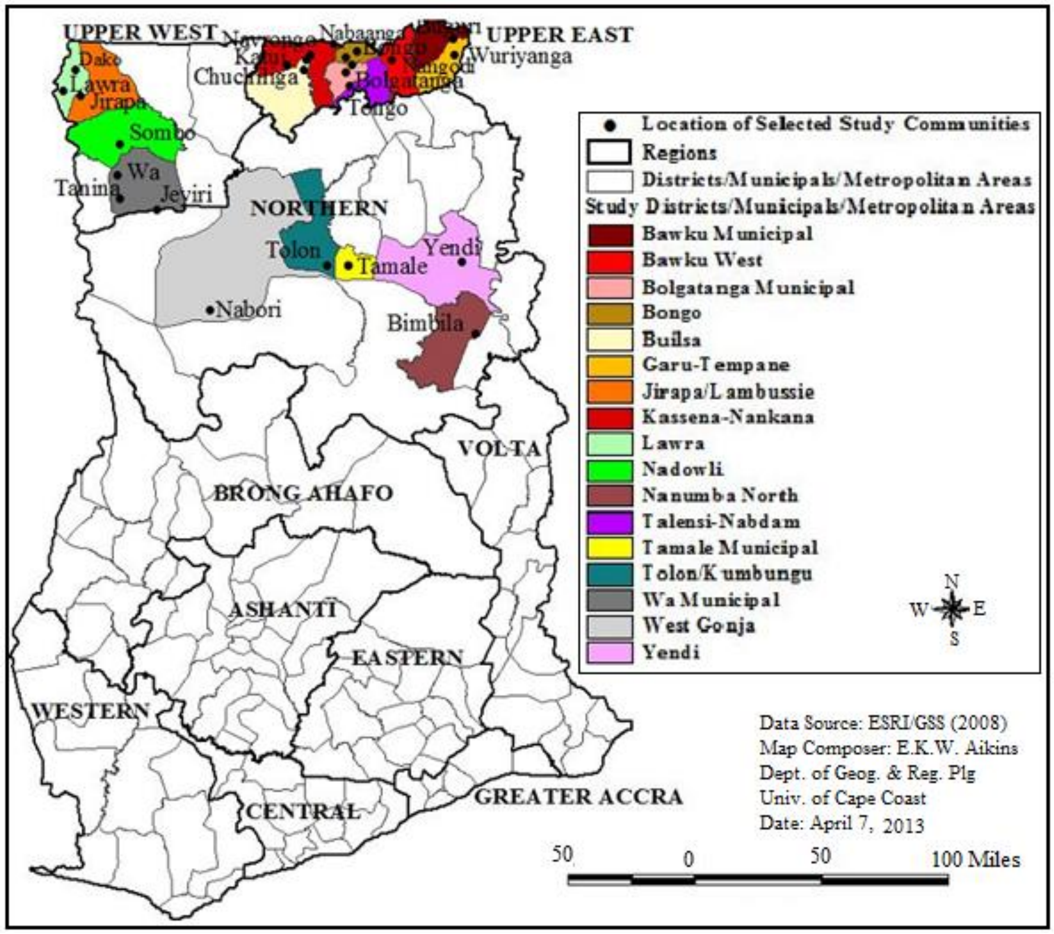


Figure 11. A map of Ghana showing the location of selected study communities in the Northern, Upper West and Upper East Regions

Source: Author (2014).

The population of females in 2010 aged 15-49 years in northern Ghana represents about 18 percent (17.6 %) of the total number of females in Ghana in 2010 within the 15-49 year age group. Due to financial and time constraints and for the purposes of comparative analysis in spatial differential analysis, a total number of 300 females (mothers) in northern Ghana between the ages of 15-49 years were selected to represent the sample size for the study instead of the calculated sample size of 384 females (Table 3).

Table 3. Regional sample size selection: EAs and study respondents

Age Group	Population of females (15-49)			
	Northern	Upper East	Upper West	Total
15-19	123,016	55,642	37,301	215,959
20-24	112,364	42,298	29,934	184,596
25-29	105,915	37,173	25,872	168,960
30-34	87,399	32,369	23,328	143,096
35-39	64,434	28,630	19,209	112,273
40-44	54,198	26,112	17,400	97,710
45-49	35,571	21,153	13,186	69,910
Total	582,897	243,377	166,230	992,504
Number of EAs	8	14	6	28
Calculated sample size (female 15-49)	225	94	65	384
*Equal proportion sample size	100	100	100	300

* Preferred sample size

Source: Author's compilation (2014).

The calculated sample size was derived with the help of a sample size calculator (Appendix B) with the following parameters:

Total Population of females (15-49 years) = 992,504

Confidence Level = 95.0%

Confidence Interval (margin of error) = 5.0%

Additionally, the selection of the study sample size was done to reflect the number of EAs per region in northern Ghana. In order for the study to obtain a comparable regional sample size the total northern Ghana sample size of 300 mothers was divided equally among the three northern regions of Ghana (Upper East,100; Upper West, 100; and Northern, 100) to obtain an equal proportion sample size of 100 mothers per region necessary for the regional differential analysis. Also, the 100 mothers per region sample size was preferred because it provides the basis for comparing the views of equal numbers of mothers in all the three regions of northern Ghana on the causes and consequences of the regional differences in child malnutrition and food nutrition security in the study area.

In respect of sample size selection at the community level the number of EAs per region were used to guide the selection of 100 mothers per region to form part of the study respondents. With the exception of Bolgatanga (Upper East Regional capital) and Tamale (Northern Regional capital) that were found to have two and three EAs respectively between 1993 and 2008 GDHS, the remaining survey communities were represented by one EA. This implies that spatially, each EA represents one community. Given that what pertains to a given EA largely represents what occurs in a corresponding survey community, a purposive sample technique was used to select a total regional sample of 100 female respondents (mothers), which have at least one malnourished child under age five from the total number of EAs in each of the three northern regions of Ghana (Table 3, page 89) to form part of the survey respondents. Appendix H portrays information on the communities that formed part of the study.

Research Instruments and Data Collection Techniques

Survey questionnaires and structured interview guide formed the main research instruments that were used to obtain primary data on the relationship between child malnutrition and food and nutrition security in the study area. Questions in the study survey instrument mainly focused on the collection of quantitative data that allowed the testing of the study hypotheses and the achievement of the study objectives. On the other hand, the structured interview schedule helped in the collection of qualitative data (information) that were used to answer the research questions that this study posed (See Appendix A).

In respect of both the quantitative (survey questionnaires) and qualitative (structured interview) data collection exercises, the researcher employed the data collection recording method where a researcher or a research assistant interviews or poses questions to respondents and records back their responses. This method was preferred because, a larger proportion of the population of the study area is illiterate who have limited reading and writing skills, which could allow them to self-respond to the questions contained in both research instruments. Since the researcher (author) has no working knowledge of the languages and dialects spoken in the study area, research assistants that are proficient in both the local languages and dialects of the selected study communities and the English language were employed to administer the study questionnaires as well as to conduct the structured interview. In all, sixteen (16) research assistants (Northern Region: 5; Upper East: 6; and Upper West Region: 5) were employed and trained for the data collection exercise. During the training exercise emphasis was placed on the best equivalent translation of the study questions in the local languages and dialects. Also, due to limited funds and differences in local dialects among the three northern regions of Ghana, research assistants were selected and trained in the same form and manner on regional basis. However, the study acknowledges the likelihood that not all study questions were posed the same way in all the three northern regions of Ghana. This limitation is common to all studies that rely on translators.

In all, 300 questionnaires and structured interviews were completed to solicit the views of mothers in the study area who had stunted children at the time of the data collection exercise in 2013. For the purposes of comparative analysis the same respondents (mothers) responded to both survey questionnaires and structured interviews that covered four main questions. Finally, the study acknowledge that the selected sample size for the study is less than the calculated sample size due to limited time and funds that usually characterize student thesis. Additionally, in the statistical analysis section of the study the total number of respondents (n) in some instances are less than 300 due to the number of Not Stated, Not Applicable and Missing responses.

Ethical Consideration

This study followed the guidelines for the use of GDHS geographic datasets (Appendix B). No attempts were made to contact individuals that have participated in a previous GDHS. Also, the survey questionnaires advised the study research assistants not to inform mothers of the malnutrition status of their children. In all communities and where necessary permission for the conduct of the study data collection exercise (administration of survey questionnaires and structured interview) was sought from community leaders and the individual respondents of the selected study communities. Also, respondents were informed of their rights in the data collection exercise through an informed consent that formed the preamble of the survey questionnaire and the interview guide (Appendix A).

Data Processing and Analysis

A cluster analysis using the ArcMap version 10.0 software was performed to identify areas (spatial-wise) of significant cluster of malnutrition cases between 1993 and 2008. Additionally, map overlays were created to help analyze the spatial relationships between child malnutrition and food and nutrition security in northern Ghana. Traditionally, maps portray the distribution of spatial phenomena. In instances where two or more map layers are overlaid, the resultant map (map overlay) offers map readers and users the opportunity to examine the observable spatial interrelationships among the features that the composite map output portrays. Additionally, map overlays help to provide the means for answering some spatial questions such as 'the reason why some spatial features co-occur' (Chang, 2008; Lo & Yeung, 2007).

In relation to the above stated observations, the present study used thematic maps and map overlays in GIS to portray the observed spatial relationships between child malnutrition and food and nutrition security in northern Ghana.

As a preamble to the statistical analysis of selected study variables that reflect the objectives and hypotheses of the study, a test of normality of the selected study variables was done. This is because the normality of variables forms one of the cardinal assumptions underlying most multivariate analyses such as the regression and discriminant analyses (Kachigan, 1991; Kachigan, 1986). The test of normality of the study variables revealed that all the selected variables that formed part of the multivariate analyses are normality distributed (Appendix F).

Specifically, a discriminant analysis in Statistical Package for Social Sciences (SPSS version 16.0) was performed to establish the presence of significant regional differentials in child malnutrition in the study area. Finally, factor and regression analyses were carried out to ascertain whether a statistically significant relationship exists between child malnutrition and food and nutrition security in northern Ghana (Appendix I).

Additionally, information obtained from the review of the available literature form the basis of the linear regression analysis aspect of this study. For instance, the review of the available literature revealed that food and nutrition security largely impacts the occurrence and distribution of child malnutrition in affected communities over a considerable long period of time (FAO, 2012; GHS, 2010; Tonukari & Omotor, 2010; Quaye, 2008; Van de Poel et al., 2008; Black et al 2003; Ezzati et al., 2002; WHO, 2002; UNICEF, 2001; de Onis, Blossner &

Villar, 1998; UNICEF, 1998). Finally, relevant information based on the responses obtained from the study structured interview was garnered to provide additional information that helped the study answer the study research questions.

Evaluation of Secondary Data and Limitation of the Study

The GDHS is a national survey that is largely based on a representative sample of women aged 15-49 years. Additionally, the GDHS covers all the ten regions of Ghana. Spatial-wise, it takes cognizance of differences in population and makes allocation and selection of EAs proportional to the population of females at the household level in each selected community. Information garnered from the selected communities provides information that are aggregated to form the regional level information on the demographic and health characteristics of selected mothers and their children in Ghana.

The main research instrument of GDHS (survey questionnaires) is broad based and covers most demographic and health attributes of selected respondents. Nonetheless, some of the questions contained in the 1988-2008 GDHS questionnaires lack consistency and have not been repeated in their same form in some of the GDHS. For instance, the question on mothers' income (in a typical day, week, or month, how much do you earn for this work?) was posed in the 1993 GDHS and never got repeated the same way in the subsequent GDHSs (GSS, 1989). Nonetheless, the secondary data obtained from the 1993-2008 GDHS reports provided a credible secondary data source that formed part of the data analysis of the present study.

With respect to the measurement of child malnutrition, the study did not consider all the three main measures of malnutrition (anthropogenic, biochemical and clinical) (Setboonsarng, 2005). The present study considered only the anthropogenic measure of child malnutrition because the tenets of the anthropogenic measure coincide with that of the present study and social science research where primary data are obtained mainly through field surveys and interviews. The requirements of the biochemical and clinical measures are beyond the scope of this study because they require specialized professional skills and training in the health and medical sciences. Also, they are expensive and time consuming (Setboonsarng, 2005).

Also, the study employed the cross-sectional study design that is limited by the time of occurrence of spatial events and phenomena. For instance, the nature of child malnutrition in the study area that the study measured in 2003 could be different from what existed a day or a year before and after the survey. However, the anthropogenic measure (stunting) that was used in measuring child malnutrition controlled for the long term time effects of child malnutrition.

CHAPTER FOUR

SPATIAL ANALYSIS OF THE RELATIONSHIP BETWEEN CHILD MALNUTRITION AND FOOD AND NUTRITION SECURITY

Introduction

This chapter presents the Geographic Information Systems (spatial) analysis aspect of this study. Sections covered include the regional distribution of child malnutrition, cluster analysis of child malnutrition, percent change in child malnutrition and spatial and statistical relationship between child malnutrition factors and food and nutrition security in northern Ghana.

Regional Distribution of Child Malnutrition (1993-2008 GDHS)

Child malnutrition is widespread in Ghana, particularly in the three regions of northern Ghana. However, the level of increase in child malnutrition between 1993 and 2008 (1994-2009 GDHS reports) do not show a uniform increasing trend among the three northern regions of Ghana (Table 4).

Table 4. Regional distribution of percent child malnutrition (1993-2008)

Region		Year		
	1993 (%)	1998 (%)	2003 (%)	2008 (%)
Northern	35.9	39.6	48.8	32.4
Upper East	33.3	34.6	31.7	36.0
Upper West	26.0	35.9	34.1	24.6

Source: Author's data analysis (2014) based on 1993-2008 GDHS reports.

For instance, in 1993 the Northern followed by the Upper East regions recorded the highest levels of child malnutrition of 35.9 percent and 33.3 percent respectively. On the other hand, the Upper West Region recorded the lowest level of child malnutrition of 26.0 percent. Further to these observations, the 1998 GHDS saw a second wave of increases in child malnutrition in all the three regions of northern Ghana (Northern: 39.6%, Upper East: 34.6% and Upper West: 35.9%). Also, the 1998 GHDS saw an appreciable increase in the level of child malnutrition in the Upper West Region (i.e. from 26.0% in 1993 to 35.9% in 1998) (Figure 1, page 15).

The results of the 2003 GDHS revealed further increases in child malnutrition. Additionally, an increasing child malnutrition trend in northern Ghana was recognized with a momentum of growth that called for an immediate health, nutrition, agricultural, and socio-economic intervention and remedial actions (UNICEF, 2005; Kunfaa, 1996). For instance, the Northern Region recorded about 10 percent increase (39.6% in 1998 to 48.8% in 2003) in child malnutrition (Table 4, page 97). The observed general increasing trend in child malnutrition in northern Ghana between the 1993-2003 GDHS could be attributed to the general poor economic conditions of the 1990s and the global climatic changes that affected food production worldwide (FAO, 2012; MOFA, MOH/GHS & WFP, 2012).

In respect of Ghana achieving the Millennium Development Goal and improvement in the standard of living, health and welfare of its people, the Government of Ghana and other international and multi-lateral organizations in the year 2000 instituted remedial measures to help control the observed increases in child malnutrition (WHO, Republic of Angola, & UNEP, 2010; Victora et al., 2010; UNFPA, 2009; UNICEF, 2005).

This initiative (both Governmental and Non-governmental) was expected to have yielded a uniform decreasing child malnutrition trend in Ghana, particularly in northern Ghana. However, a two way dichotomous trend was observed in northern Ghana (Figure 1, page 15 and Table 4, page 97). First, a general decrease in child malnutrition was observed between 2003 and 2008 in the Upper West (from 34.1% to 24.6%) and Northern (from 48.8% to 32.4%) regions. Second, within the same period a general increase in child malnutrition was observed in the Upper East Region (from 31.7% to 36.0%).

Based on the observed trend in child malnutrition (Figure 1, page 15 and Table 4, page 97) in the study area, it can be explained that if all initiatives and remedial measures including regular intake of micronutrients such as iodine, improvement in maternal malnutrition and education, reduction in poverty, improved access to basic healthcare and sanitation that were instituted and implemented in the late 1990s were sustained and intensified, Ghana could have experienced an overall decrease in child malnutrition within the 2003-2008 GDHS (UNICEF, 2013; ORC Macro, 2005; FAO and International Life Sciences Institute, 1997). It is worthy to note that the activities of the Northern Ghana Food Security Resilience Project [NGFSRP] (NGFSRP, 2014) that promotes effective and intensive agricultural production, including dry season gardening and the preparation of nutritious infant and child foods in the Upper West and Northern regions could have been extended to cover the Upper East Region. The extension of this project to cover the Upper East Region could have helped to control the prvalence of increasing child malnutrition in this region (Author's structured interview (2013); NGFSRP, 2014).

Cluster Analysis of Child Malnutrition in Northern Ghana

Figure 12 shows that in 2008 a relatively larger proportion of child malnutrition in northern Ghana was recorded in the Upper East and Northern regions than in the Upper West Region.

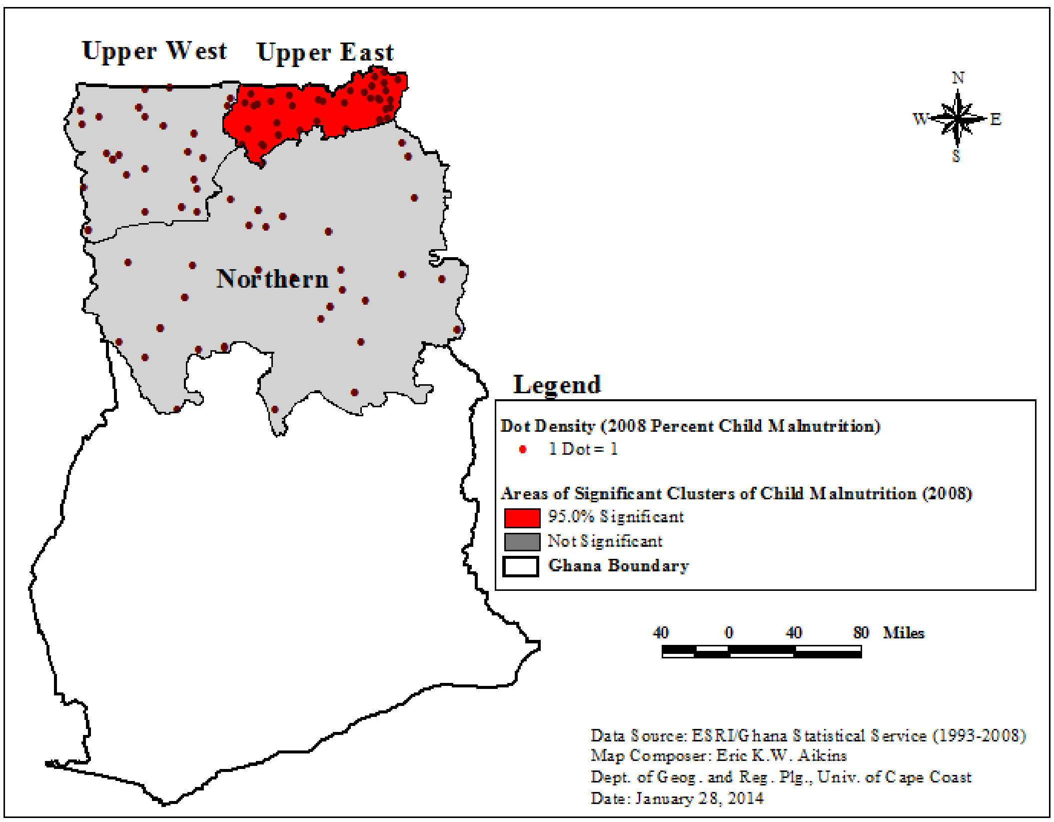


Figure 12. A child malnutrition cluster and dot density map of Northern Ghana

Source: Author's data analysis (2014).

This observation is made in recognition that Figure 12 (page 100) shows a relatively higher concentration of dots, which signifies a relatively higher density of child malnutrition in the Upper East Region.

Similarly, the result of the cluster analysis (Figure 12, page 100) portrays a significant cluster of child malnutrition in the Upper East Region. The test of significance associated with the cluster map analysis indicates that the cluster of child malnutrition in the Upper East Region is 95.0 percent significant (Appendix E). As a result, the occurrence of cluster of child malnutrition in this region is not due to chance. This implies that any remedial measure or intervention taken to address the problem of child malnutrition in northern Ghana needs to focus particularly on the Upper East Region where significant clusters of child malnutrition exist. On the other hand, no significant clusters of child malnutrition were observed in the Upper West and Northern regions within the same study period.

Percent Change in Child Malnutrition in Northern Ghana

In the study percent change in child malnutrition was calculated as: percent child malnutrition in 1993 – percent child malnutrition in 2008. In all, two forms of changes in child malnutrition were observed in northern Ghana between 1993 and 2008. First, a general positive change was observed in the Upper West (1.4%) and Northern (3.5%) regions (Figure 13). This change indicates a relative decrease in percent child malnutrition from 1993 to 2008 with the Northern Region portraying the largest decrease of 3.5 percent over the same study period

(Figure 13). Additionally, Figure 1 (page 15) shows that in 1993 a larger proportion of the children in the Upper West (26.0%) and Northern (33.3%) regions were malnourished than in 2008 (Upper West: 24.6% and Northern: 32.4%). This positive trend in percentage change in child malnutrition (Figures 1 [page 15] and 13) signifies an overall improvement in child nutrition and health in the Upper West and Northern regions of Ghana between 1993 and 2008.

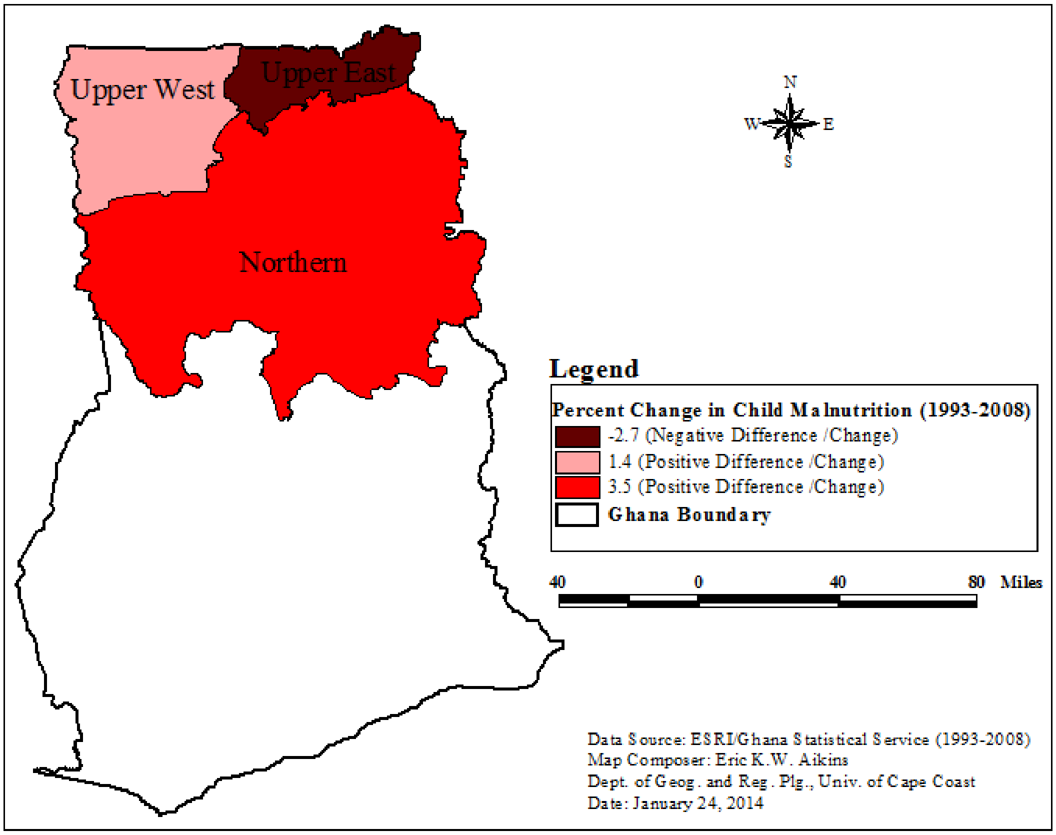


Figure 13. A map of the study area showing percent change in child malnutrition (1993-2008)

Source: Author's data analysis (2014).

Second, a negative percent change in child malnutrition (-2.7%) was observed in the Upper East Region within the same survey period (Figure 13). On the other hand, the negative percent change in child malnutrition signifies a rather worsening of health and nutrition status of children in the Upper East Region. This is because a significant cluster of child malnutrition was found in this region (Figure 12, page 100). This pattern of change in percent child malnutrition tends to portray the Upper East Region as the 'Hot Spot' of child malnutrition in northern Ghana, which requires attention. This observation coincides with the result of the cluster analysis (Figure 13, page 102) that shows that significant cluster of child malnutrition exists in the Upper East Region only.

Spatial and Statistical Relationships of Factors Influencing Child Malnutrition in Northern Ghana

Figure 14 portrays the spatial and statistical relationships between child malnutrition and the selected factors that were identified by the analysis of the study data which could have contributed to the observed changes in child malnutrition in the three northern regions of Ghana. Overall, five factors: (i) limited access to good food; (ii) lack of/limited income; (iii) limited knowledge based care; (iv) poor child care; and (v) limited access to good drinking water were identified to be the main factors responsible for the prevalence and changes in child malnutrition (Figure 14). Among these five factors, two major factors, namely, limited access to good food and lack of/limited income were identified to have contributed substantially to the observed levels of child malnutrition in the three northern regions of Ghana. For instance, with the exception of the Northern Region (23.2%) about 50 percent of respondents in the Upper West Region

(50.5%) and Upper East Region (44.2%) indicated that lack of/limited income is one of the major causes of child malnutrition.

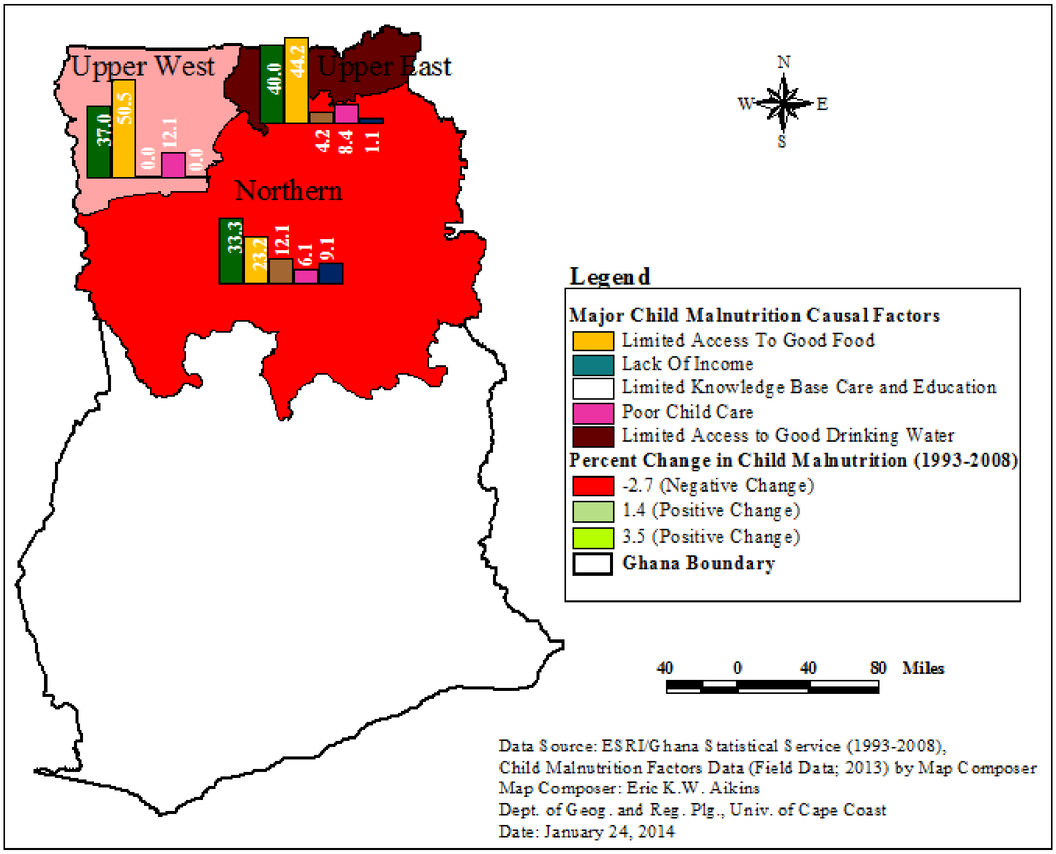


Figure 14. A map of the study area showing the spatial and statistical relationships between selected child malnutrition factors and percent change in child malnutrition

Source: Author's data analysis (2014).

On the other hand, similar proportions of respondents (Northern Region, 33.3%; Upper West Region, 37.0%; Upper East Region, 40.0%) indicated that limited access to good food forms one of the two main forces that account for child malnutrition in northern Ghana.

Additionally, Figure 15 indicates that in the Upper East Region the distribution of the factors “limited access to good food and lack of/limited income” coincides with the percent negative change in child malnutrition that this region observed between 1993 and 2008.

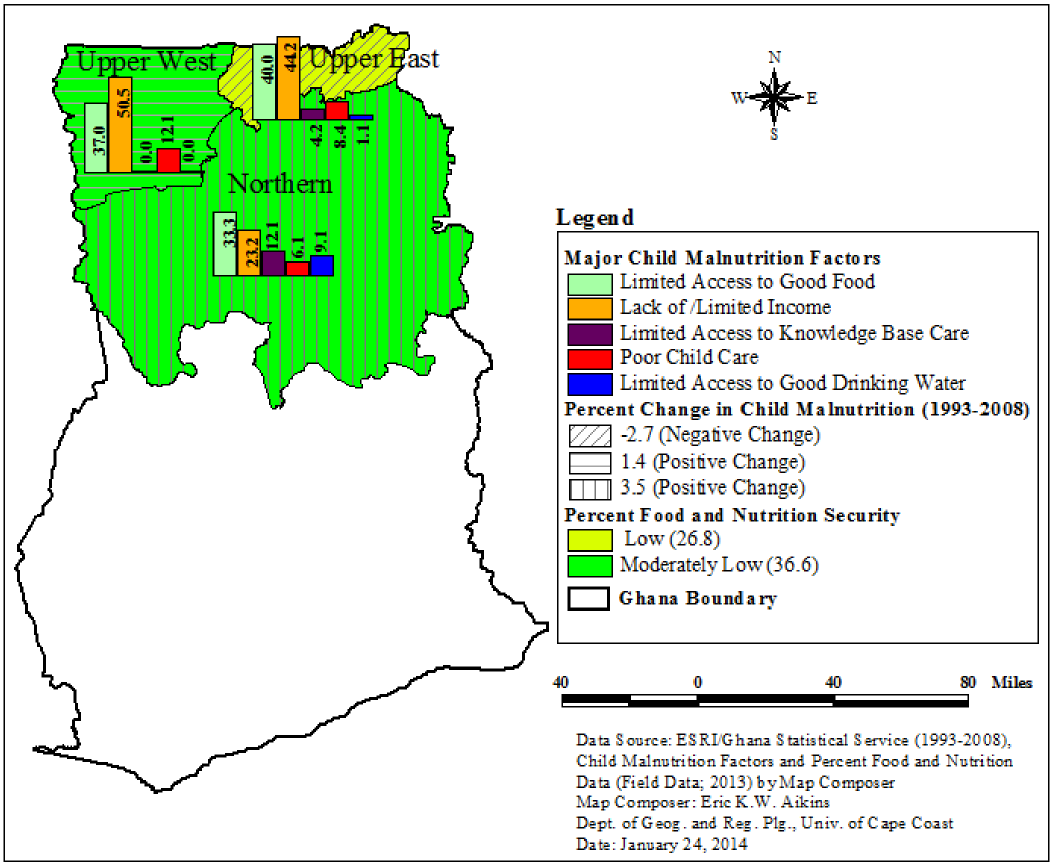


Figure 15. A map of the study area showing the spatial and statistical relationships between major child malnutrition factors, change in child malnutrition and food and nutrition security

Source: Author’s data analysis (2014).

Based on the preceding discussions the present study explain that if child malnutrition interventions and remedial measures in the study area were focused on rural capacity building, farmers in the study area, particularly in the Upper

East Region could improve their access to income and good food during both the lean and bumper harvest seasons. For instance, eleven respondents in the Upper West Region during the structured interview indicated that the intervention of the NGFSRP has equipped them with the skills of preparing supplementary foods for sale. One of them intimated that beneficiaries of NGFSRP are able to prepare enough supplementary food for their children and have enough left to sell to other nursing mothers and students (Field data, 2013). This observation largely implies that the activities of some non-governmental organizations, particularly the NGFSRP have become beneficial to farmers in the Upper West and Northern Regions where they operate.

Spatial and Statistical Relationships between Major Child Malnutrition Factors and Food and Nutrition Security in Northern Ghana

Figure 15 (page 105) shows an overlay of three map layers. These are percent change in child malnutrition, major child malnutrition factors, and percent food and nutrition security. In respect of food and nutrition security, Figure 15 (page 105) indicates that both the Upper West and Northern regions fared better (moderately low). In order words, about 37.0 percent (36.6%) of the respondents supported the view that food and nutrition security is moderately low in the Upper West and Northern regions (Figure 15, page 105).

On the other hand, the Upper East Region was singled out as the region of relatively low food and nutrition security (26.8%) (relatively high food and nutrition insecure area). Within the same region a negative percent change in child malnutrition was observed between the 1993 and 2008 GDHS (Figure 15, page 105). These observations may be explained in terms of the length of time required for the full benefits of nutrition, health, and population-related educational sensitization and outreach programmes to be realized by beneficiary communities. For instance, the evaluation and findings of some child malnutrition and food and nutrition security projects in northern Ghana found that improvements in the health and nutritional status of children and mothers in northern Ghana are in their incipient stages with relatively few of them that have reached their full term impact success stages (NGFSRP, 2014; WFP, 2009).

Additionally, the map overlay (Figure 15, page 105) shows that in the Upper East Region negative percent change in child malnutrition corresponds to the distribution of low food and nutrition security that this map portrays. The overlap of these two map layers helped in isolating the Upper East Region as a critical region that requires care and attention if the overall trend in child malnutrition in northern Ghana could be controlled and brought to the barest minimum. The overlay of the major child malnutrition causal factors layer with the percent change in child malnutrition and percent food and nutrition security layers (Figure 15, page 105) shows that the factors; limited access to good food and lack of/limited income constitute the two main factors that account for the regional differences in food and nutrition security and child malnutrition among the three northern Ghana regions.

CHAPTER FIVE

EMPIRICAL EVIDENCE OF REGIONAL VARIATION IN CHILD MALNUTRITION

Introduction

Traditionally, spatial analysis in GIS involves the use of maps to portray the distribution of phenomena and the relationships between and among them. Also, it provides the means for making critical decisions on the observed patterns of spatial distribution as well as the possible future scenarios of the observed distribution (Aikins, 2003; Chang, 2008). However, most GIS and mapping analyses such as thematic mapping and map overlays mainly lack the ability to provide data on the statistical significance of observed spatial relationships (Aikins, 2003; Kachigan, 1991). According to Aikins (2003), it is not always the case that observed spatial relationships on maps produce statistical significant relationships. Although this study recognizes that spatial (regional) differences exist in child malnutrition and food and nutrition security in northern Ghana (Figures 12 [page 100], 13 [page 102], 14 [page 104] and 15 [page 105]) the statistical significance of these relationships are not provided by the GIS (spatial) analyses in the previous chapter (chapter four) of the study.

In respect of the inability of most GIS analysis and their associated maps to establish statistical significant relationships between mapped spatial phenomena, this study employed the discriminant analysis statistical technique that allowed for the test of statistical significance of the mapped spatial relationships. The ensuing sections discuss the results and findings of the discriminant analysis including the background characteristics of respondents.

Background Characteristics of Respondents

The statistical analysis of the background characteristics of study respondents (mothers in northern Ghana) shows a mean age of 32.1 years and a median age of 31 years. This result signifies that the study population characterizes a mature population that may be described as independent and self sustaining (Table 5).

Table 5. Age of respondents

Mothers' Age	Region			Northern Ghana
	Northern	Upper East	Upper West	
Mean	33.92	30.0	31.98	32.1
Median	33.0	30.0	32.0	31.0
Minimum	18.0	14.0	19.0	14.0
Maximum	60.0	50.0	49.0	60.0
n = 273				

Source: Author's data analysis (2014).

In northern Ghana the minimum age that represents the youngest mother or mothers that were interviewed is 14 years (Table 5). This age coincides with the minimum age of mothers (14 years) in the Upper East Region. On the other hand, the minimum ages of mother in the Upper West and Northern Regions (18 and 19 years respectively) are higher than that of the Upper East Region (Table 5, page 109). In general, the relatively low minimum age of 14 years for the whole of northern Ghana signifies that early child birth largely persists in the study area. The maximum age of respondents (mothers) in northern Ghana is 60 years. This age coincides with the maximum age of the Northern Region (60 years). The maximum ages in the Upper East and Upper West Regions (50 and 49 respectively) are relatively lower than that of the Northern Region and fall within the expected reproductive age of 49 years when most women are expected to limit considerably the number of children they give birth to. The maximum age of 60 years for northern Ghana implies that the affected mothers in the study area do not know their real age or are still giving birth at relatively older stages of their lives. This is because the study interview only mothers with children less than five years. This implies that mothers with children less than 5 years at the time of the interview might have given birth to their children by the age of 55 years, which is above the expected female reproductive age limit of 49 years. Although child birth by this age is expected mainly in rural areas that the study area covers, late child birth is also associated with some negative socio-economic and infant/child health problems such as growth failure (faltering) and stunting that need to be avoided (Victora, 2010; Shrimpton, Cesar, de Onis, Lima, Blossner, & Clugston, 2001).

Table 6 portrays information on the highest level of education attained by the study respondents. In general, there are no striking regional differences in the level of educational attainment of mothers among the three northern regions of Ghana (Table 6). However, the least proportion of mothers with primary education and above (Northern: 11.7%.; Upper East: 10.6%; Upper West: 11.8%) is found in the Upper East Region (10.6%).

Table 6. Highest educational level attained by respondents

Mothers' Highest Educational Level	Region							
	Northern		Upper East		Upper West		Northern Ghana	
	No.	%	No.	%	No.	%	No.	%
No education	56	18.7	53	1 7.7	49	16.4	158	52.8
Some/Uncompleted primary School	9	3.0	14	4.7	16	5.3	39	13.0
Primary	18	6.0	23	7.6	12	4.0	53	17.7
Junior High School/ Middle School	5	1.7	5	1.7	12	4.0	22	7.4
Senior High School and above	12	4.0	4	1.3	11	3.8	27	9.1
Total	100	33.5	99	33.0	100	33.5	299	100

Source: Author's data analysis (2014).

Additionally, the distribution of mothers with respect to their level of educational attainment indicates that 18.7 percent, 17.7 percent, 16.4 percent and 52.7 percent of the mothers in Northern, Upper East, and Upper West Regions and northern Ghana respectively have no formal education (Table 6). These figures may be an indication of the general high level of illiteracy and limited formal knowledge on basic nutrition, health and child care in the study communities.

Second to the relatively high proportion of mothers with no education in northern Ghana is the proportion of mothers with some or uncompleted primary school education (Northern: 3.0%; Upper East: 4.7%; Upper West: 5.3; Northern Ghana: 13.0%). Although a sizable proportion (34.2%) of the mothers in northern Ghana are found to have completed various levels of education (primary school: 17.7%; Junior Secondary School or Middle School: 7.4%; Senior High School and above 9.1%) the full impact of these various levels of education on transforming the health, nutrition and socio-economic situations of mothers in the communities that form the study area may be limited.

By adding the proportion of mothers with no education (52.8%) to the proportion of mothers with some or uncompleted primary school education (13.0%) yields a total of 65.8 percent of mothers with no or little education. This figure (65.8%) represents the proportion of mothers in the study area (northern Ghana) with limited education, which have relatively little formal knowledge on proper nutrition and child care.

With respect to ethnicity, Table 7 indicates that the Mole-Dagbani ethnic group forms the major (67.64%) ethnic group in northern Ghana with the Grussi ethnic group as the second major ethnic group (27.64%). At the regional level, 34.5 percent of the respondents in the Upper West Region indicated that they belong to the Mole-Dagbani ethnic group.

Table 7. Ethnicity of respondents by region of residence

Mothers' Ethnicity	Region (%) Northern		Upper East		Upper West		Northern Ghana	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Mole-Dagbani	90	33.7	1	0.4	95	34.5	186	67.64
Grussi	3	1.1	73	26.5	0	0.0	76	27.64
+Others	6	2.2	3	1.1	4	1.5	13	4.72
Total	99	36.0	77	28.0	99	36.0	275	100

+Others refer to Akan, Ga/Adangbe, Ewe, Gruma, Hausa and Fulani.

Source: Author's data analysis (2014).

Similarly, 33.7 percent of respondents in the Northern Region indicated the same. On the other hand, 26.5 percent of the mothers in the Upper East Region indicated that they belong to the Grussi ethnic group. The above stated distributions are expected because the Mole-Dagbani and Grussi ethnic groups form the major ethnic groups in northern Ghana (GSS 1994; GSS 1999; GSS 2004; GSS, 2009).

In respect of occupation, 50.7 percent of the mothers in northern Ghana indicated that farming is their major occupation (Table 8). Additionally, 27.3 percent of them indicated that they do private work while 5.3 percent specified that they do government work. Nonetheless, 16.0 percent confirmed that they do other works other than farming, government work, and private work (Table 8).

In all, 48.6 percent of the mothers indicated that they work in other occupations other than farming (Government work, 5.3%; Private work, 27.3%, and None of the above, 16.0%). This proportion signifies the diversification of spatio-economic sustenance of mothers in the study area.

Table 8. Occupation of respondents

Mothers' Occupation	Region						Northern Ghana	
	Northern		Upper East		Upper West			
	No.	%	No.	%	No.	%	No.	%
Farming	45	15.0	51	17.0	56	18.0	152	50.7
Government Work	8	2.7	4	1.3	4	1.3	16	5.3
Private Work	39	13.0	13	4.3	30	10.0	82	27.3
None of the above	7	2.3	31	10.3	10	3.3	48	16.0
Not stated	1	0.3	1	0.3	0	0.0	2	0.7
Total							300	100

Source: Author's data analysis (2014).

Therefore, mothers in the study area may be considered not to be dependant solely on farming for income to cater for their socio-economic needs and that of their children. In terms of regional distribution of mothers' occupation Table 8 indicates that relatively little variations in mothers' occupation types exist among the three northern regions of Ghana. Nonetheless, with respect to the Private Work occupation type Table 8 indicates that the Upper East Region have the least proportion of mothers (4.3%) that do private work (Northern: 13.0%; Upper West: 10.0%).

Tables 9 and 10 provide information on the income and income status of mothers that were selected to form part of the study. The income status variable present information on whether mothers receive remuneration by the end of the month from their major occupations (Table 9).

Table 9. Remuneration status of respondents

Mothers' Remuneration Status	Region							
	Northern		Upper East		Upper West		Northern Ghana	
	No.	%	No.	%	No.	%	No.	%
Yes	41	14.6	11	3.9	40	14.2	92	32.7
No	52	18.5	79	28.1	58	20.6	189	67.3
Total							281	100

Source: Author's data analysis (2014).

In respect of the regional distribution of mothers that indicated that they earn income from their major occupation Table 9 shows that differences in income status of mothers exist between the Upper East Region (3.9%) on one hand and the Northern (14.6%) and the Upper West (14.2%) regions on the other.

Additionally, a larger proportion of mothers in northern Ghana (67.3%) indicated that typically, they do not receive remuneration at the end of the month from their major occupation while 32.7 percent of them indicated otherwise. The relatively large proportion of mothers that indicated that they received no end of month income from the work they do may be explained by the relatively large proportion (50.7%) of them who stated that they do farming for a living (Table 8, page 114). Traditionally, farming in Ghana is a family undertaken (GSS, 2015; GSS, 2009). Normally, proceeds from farming activities are controlled and disbursed by the heads of households. It is, therefore, not uncommon for mothers in the study area with disproportionally large male household heads to indicate that they are not remunerated for the farming work they do (GSS, 2015; GSS, 2009). Table 10 shows the income of mothers based on the amount of monies paid to mothers by the end of the month.

Table 10. Income of respondents

Mothers' Income (GH¢)	Region			
	Northern	Upper East	Upper West	Northern Ghana
Mean	785.27	926.53	627.18	778.56
Median	999.00	999.00	999.00	999.00
Minimum	40.00	0.00	5.00	0.00
Maximum	1000.00	999.00	999.00	*1000.00

* Further analysis of the study data revealed that the maximum income (GH¢ 1,000.00) refers to the income of a mother who is a private worker in the Northern Region.

Source: Author's data analysis (2014).

With respect to the amount of money (income) that mothers in the study area earn, Table 10 indicates that most mothers in Northern Region, Upper East Region, Upper West Region and northern Ghana earn on the average GH¢ 785.27, GH¢ 926.53, GH¢ 627.18 and GH¢778.56 per month respectively.

Generally, Table 10 indicates that both mean and median incomes of mothers in the study area are relatively high (Northern Ghana: Mean Income =

GH¢778.56; Median Income = GH¢999.00). The high mean and median incomes of mothers in the study area may be explained by the relatively large proportion of mothers (48.6%), which indicated that they work in non-farming occupations (Table 8, page 114). These mothers are mainly employed by the government and private institutions that are likely to be paid or earn better stable monthly remuneration. For instance, Table 10 (page 116) shows that a mother who is a private worker in the Northern Region earn a monthly income of GH¢ 1,000.00 (the highest monthly income for the study area).

At the time of the survey, respondents were asked of the number of children they have had who were alive. The responses to this question are presented in Table 11.

Table 11. Number of children living per woman at the time of the survey

No. of Children	Region: Northern		Upper East		Upper West		Northern Ghana	
	No.	%	No.	%	No.	%	No.	%
1	20	7.3	11	4.0	10	3.6	41	14.9
2	22	8.0	16	5.8	23	8.4	61	22.2
3	14	5.1	14	5.1	18	6.5	46	16.7
4	16	5.8	12	4.4	22	8.0	50	18.2
5	10	3.6	12	4.4	14	5.1	36	13.1
6	7	2.5	10	3.6	5	1.8	22	8.0
7 and above	4	1.5	10	3.6	5	1.8	19	6.9
Total							275	100

Source: Author’s data analysis (2014).

Generally, 85.1 percent of the mothers in northern Ghana were found to have 1 to 5 children alive. On the other hand, 14.9 percent, 22.2 percent, 16.7 percent, and 18.2 percent of the mothers stated that they have 1, 2, 3 and 4 children alive respectively (Table 11, page 117). Although these proportions of mothers with relatively fewer number of children ever born that are alive are not relatively large by themselves at the regional level, the sum of their distribution (57.1%) represents more than half of the population of mothers that were interviewed in the three northern regions of Ghana that form the study area (northern Ghana).

Additionally, some proportions of the mothers (8.0%, 4.0%, 1.8% and 1.1%) had large numbers of children (6, 8, 7 and12) per woman. These figures indicate the general preference for large family sizes in rural farming communities that characterize the study area.

On the other hand, 83.4 percent of them noted that they were not pregnant. Of all the mothers that were interviewed, 16.6 percent of them indicated that they were pregnant at the time of the survey (Table 12).

Table 12. Regional distribution of mothers by pregnancy status at the time of the survey

	Region							
Pregnancy Status	Northern		Upper East		Upper West		Northern Ghana	
	No.	%	No.	%	No.	%	No.	%
Yes	21	7.4	9	3.2	17	6.0	47	16.6
No	75	26.5	78	27.6	83	29.3	236	83.4
Total							283	100

Source: Author’s data analysis (2014).

Demographically, the proportion of mothers pregnant (16.6%) at the time of the survey may be considered high. Similarly, the 2015 GDHS report indicates that total fertility rate (based on the number of mothers currently pregnant) is relatively high in northern Ghana, particularly in the Northern Region (8.9) (GSS, 2015).

Discriminant Analysis of the Regional Differentials in Child Malnutrition in Northern Ghana

Based on the main objective, specific objective one (1) and the fourth (4) hypothesis of the study a discrinimant analysis was performed. Usually, discriminant analysis is performed to test the statistical significance of the degree of differences (variability) among and between a set of categorical variables. Also, it is used to classify variables into fewer defined groups (Kachigan, 1991; Stevens, 1992). In this section two (2) categorical variables; 'Region' (Northern, Upper East, and Upper West) and 'Child Malnutrition' (stunted and severely stunted) were analyzed using discriminant analysis to ascertain and validate the existence and significance of regional differentials in child malnutrition in northern Ghana. This analysis generated the statistical result that provided the answer to the question as to whether the spatio-economic, nutrition, demographic and health characteristics of a given region in northern Ghana is associated with the differences in the level, distribution and trend in child malnutrition. The ensuing section discusses the result of the discriminant analysis.

According to Table 13, the means and the standard deviations (SDs) of the two main categories that measure the dependent variable (child malnutrition) are different.

Table 13. Group statistics

Malnutrition Status	Mean	Std. Deviation	Valid N (listwise) Unweighted	Weighted
Stunted	1.49	0.774	99	99.000
Severely Stunted	2.25	0.721	200	200.001
Total	2.00	0.819	*299	*299.000

Source: Author's data analysis (2014).

The SD of the category 'stunted' is 0.774 with a mean of 1.49. On the other hand, the SD of the category severely stunted is 0.721 with a mean of 2.25. These distributions present a difference in SD of 0.053 and a mean difference of 0.76. Statistically, the measured differences in the means and the SD indicate that group differences exist in the various categories that measure the dependent variable child malnutrition.

Additionally, the analysis of the independent variable (Region) produced a significant test result. The statistical significance of the measured group differences in the independent variable (Region) is provided in Table 14 (test of equality of group means). The F statistic of 69.11 with two Degrees of Freedom (df 2 = 297) and a corresponding significant value of 0.001 indicates that a 99.0

percent significant group differences exist in child malnutrition between the three northern regions of Ghana (Northern, Upper East and Upper West) that measure the independent variable region.

Table 14. Discriminant analysis

Tests of equality of group means

	Wilks' Lambda	F	df1	df2	Sig.
Region	0.811	69.11	1	297	0.001

Wilks' Lambda statistics

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1	0.811	62.026	1	0.001

Canonical discriminant function coefficients

	Function (1)
Region	1.353
(Constant)	-2.706

Eigenvalues of the canonical discriminant functions

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation	R^2
1	0.233*	100.0	100.0	0.434	0.188

*First 1 canonical discriminant functions were used in the analysis.

Source: Author's data analysis (2014).

Relatedly, the Chi-Square statistic and its associated significant value in Table 14 show that significant group differences (significance level of 0.001 [99.0% significance]) exist between the categories that measure both the dependent (child malnutrition) and the independent (region) variables that were analyzed. Also, the discriminant analysis generated only one function though two categories (stunted and severely stunted) measure the dependent variable child malnutrition. This is because, typically in discriminant analysis of this kind, only one function is interpreted (Table 14, page 121). Additionally, the Wilks' Lambda statistics indicates that discriminant Function 1 that measures the statistical significant relationship between the dependent (child malnutrition) and the independent (region) is statistically significant at the significance level of 0.001 (99.0%). To measure the combined effect or contribution of all the variables to the occurrence of function (1), canonical discriminant function coefficients (Table 14, page 121) were generated and used to compute Eigenvalues statistics that Table 14 portrays.

Table 14 (page 121) indicates that the canonical correlation between the dependent variable (child malnutrition) and the independent variable (region) is 0.434. This signifies that there is 43.4 percent association or relationship between the dependent variable child malnutrition and the independent variable region. This implies that an increase in a unit difference in the socio-spatial, economic, environmental and other important characteristics of the three regions in northern Ghana largely results in a corresponding increase in a unit difference in child malnutrition in the study area. By squaring the canonical correlation value of 0.434 an R^2 statistic (coefficient of variability) value of 0.188 was derived. The R^2 of 0.188 signifies that the discriminant analysis model (function 1) explains about 19 percent variability in child malnutrition at the regional level in the study area. Thus, with respect to the main objective and specific objective one of the study, it can be concluded that significant (99.0%) regional differentials in child malnutrition exist in the study area. Accordingly, the study retains the fourth null hypothesis that a statistical significant (99.0%) spatial variation (differences) in child malnutrition exists between the Upper West, Upper East, and Northern regions of Ghana.

CHAPTER SIX

STATISTICAL ANALYSIS OF THE RELATIONSHIP BETWEEN CHILD MALNUTRITION AND FOOD AND NUTRITION SECURITY

Introduction

In respect of specific objective two and null hypothesis one of the study a regression analysis was performed to assess the impact of food and nutrition security on child malnutrition. Food and nutrition security is multifaceted (Van de Poel et al., 2008; Benson, 2004). Unlike food security that measures mainly the availability and the level of access to required quality and quantity of food by a given population, food and nutrition security covers food security in addition to nutritional and dietary practices that affect the health and nutritional status of a given population (Quaye, 2008; Van de Poel et al., 2008; Benson, 2004).

The measurement of food and nutrition security, therefore, requires the composition of an index that adequately represents it. In this study, twenty variables that best measure or represent food and nutrition security were selected to form part of the composition of a single index of food and nutrition security. These variables are: mothers' educational level, mothers' ethnicity, mothers' age, mothers' occupation, mothers' earn income, number of children per mother, communities spatial attributes (market; communal food storage facility; motorable roads; vehicles; primary school; quality of soil for farming; communal availability of arable land; major occupation of members of the community; availability of food stock all year round), community facilities (primary health care), community members practise good sanitation, community access to good/potable drinking water and availability of community garbage disposal site. The ensuing section discusses the composition of the index of food and nutrition security based on the factor analysis technique.

Factor Analysis and the Composition of Index of Food and Nutrition Security

Primarily, factor analysis is a data reduction technique that seeks to group many variables into fewer sets of similar variables called factors (Kachigan, 1991). Usually, each factor is loaded up with scores of variables (factor loading) that represent the number of variables that form or define a particular factor. Although factor analysis generates scores of tables and figures that are sometime regarded as complicated in their interpretation (Kachigan, 1991), this study used four main parameters that are key in the composition of a single index (factor). The remaining factor analysis statistics and parameters (descriptive statistics, correlation matrix and communalities) form part of Appendix G.

First, Table 15 shows the number of factors (components) extracted with their corresponding Eigenvalues and associated total variances explained by each factor. In Table 15 and under initial Eigenvalues, two main factors namely, components (1) and (2) with a corresponding total Eigenvalues of 3.234 and 2.320

respectively are found to be the main factors that best measure food and nutrition security.

Table 15. Total variance explained by factors (components)

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Com-ponent	Total	% of Variance	Cumul-ative %	Total	% of Variance	Cumul-ative %	Total	% of Variance	Cumul-ative %
1	3.234	16.172	16.172	3.234	16.172	16.172	2.359	11.796	11.796
2	2.320	11.601	27.773	2.320	11.601	27.773	2.040	10.200	21.996
3	1.961	9.805	37.579	1.961	9.805	37.579	1.942	9.709	31.704
4	1.665	8.325	45.903	1.665	8.325	45.903	1.704	8.519	40.223
5	1.518	7.588	53.492	1.518	7.588	53.492	1.677	8.386	48.610
6	1.325	6.624	60.116	1.325	6.624	60.116	1.591	7.954	56.563
7	1.214	6.069	66.184	1.214	6.069	66.184	1.289	6.445	63.009
8	1.067	5.337	71.522	1.067	5.337	71.522	1.287	6.437	69.446
9	0.961	4.806	76.328	0.961	4.806	76.328	1.186	5.932	75.378
10	0.913	4.567	80.895	0.913	4.567	80.895	1.103	5.517	80.895

Extraction Method: Principal Component Analysis.

Source: Author’s data analysis (2014).

Each of the two components is composed of variables that best measure it (Table 16). The selection of the variables listed below is based on the component scores of the variables as shown in Table 16:

Component 1 - Communal Food Storage Facility, Motorable Roads, Vehicles;

Component 2 - Major Occupation of Members of Community, Community Access to Good Drinking Water

Table 16. Component score coefficient matrix

Variables	Component		
	1	2	3
Mother's educational level	-.130	.051	-.067
Mother's ethnicity	.055	.064	-.128
Number of children per mother	.079	-.011	.061
Mother's earned Income	.084	-.020	-.131
Market	-.039	-.023	.419
Communal food storage facility	.359	.000	-.127
Motorable roads	.388	-.016	-.101
Vehicles	.358	-.024	.040
Primary school	-.024	-.049	-.044
Regular wet and dry seasons	-.019	.033	.180
Quality of soil for farming	.149	.049	-.274
Communal availability of arable land	.019	.005	-.087
Major occupation of members of the community	-.023	.498	-.027
Availability of food stock all year round	.002	.005	.040
Primary health care	-.052	-.015	.437
Community members practice good sanitation	.161	-.018	-.061
Community access to good drinking water	-.024	.498	-.028
Community garbage disposal site	-.073	.006	.246
Mother's age	-.021	.011	-.046
Mother's occupation	.044	-.006	.003

Extraction Method: Principal Component Analysis.

Source: Author's data analysis (2014).

The corresponding percent of variance values of factors (components) 1 and 2 are 16.2 and 11.6 percent respectively. In all, factors 1 and 2 explain 27.8 percent of the total variability in the measurement of the index of food and nutrition security. Notably, factor 1 (component 1) explains 16.2 percent of the total variability in the measurement of the index of food and nutrition security (Table 15, page 126).

Also, Table 16 (page 127) shows the component score coefficient matrix of the two selected components. Based on the main objective of this study, factor one, which best measures the index of food and nutrition security is selected to represent the food and nutrition security index. This is because component 1 accounts for by far the largest proportion (16.2 %) of the variability in food and nutrition security among the two main components identified (Table 15, page 126). This observation coincides with the distribution of Eigenvalues by factors (component number) as shown by the scree plot (Figure 16).

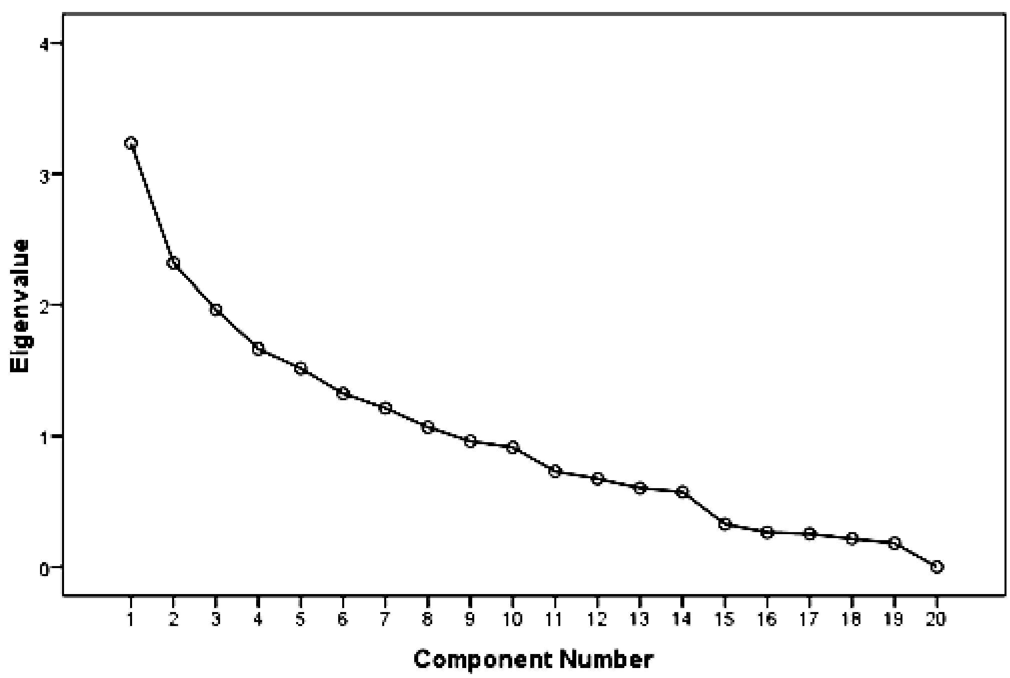


Figure 16. Graphical representation of index of food and nutrition security eigenvalues by component number (Scree Plot)

Source: Author's data analysis (2014).

Figure 16 (page 128) shows that components 1 and 2 are the key factors that measure food and nutrition security adequately. Traditionally, in factor analysis and in scree plot analysis in particular, prime factors are identified by the number of factors that occur before the first bend of the scree plot/line graph (Kachigan, 1991).

Table 17 (component score matrix) shows the number of variables that measure factor 1 and their corresponding factor loadings (component scores coefficients).

Table 17. Component score coefficient matrix (selected variables)

Variables	Component
	1
Mother's educational level	-0.130
Number of children living per mother	0.079
Mother's earned income	0.084
Communal food storage facility	0.359
Motorable roads	0.388
Vehicles	0.358
Quality of soil for farming	0.149
Community members practice good sanitation	0.161
Availability of community garbage disposal site	-0.073

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Component Scores.

Source: Author's data analysis (2014).

In all, six variables; communities spatial attributes (motorable roads; communal food storage facility; vehicles), community members practice good sanitation, communities spatial attributes (quality of soil for farming) and mothers' educational level with the highest factor loadings (component scores/correlation coefficients) of 0.388, 0.359, 0.358, 0.161, 0.149 and -0.130 respectively best measure the index of food and nutrition security. Similarly, these variables represent the most important variables that are closely associated with the index of food and nutrition security (Table 17, page 129).

Linear Regression Analysis of the Impact of Food and Nutrition Security on Child Malnutrition

Generally, linear regression analysis tests the statistical relationship between a dependent variable and an independent variable or a given set of independent variables (Kachigan, 1986 as cited in Aikins, 2003; Kachigan, 1991). In this study, the linear regression analysis was preferred due to the nature of the variables that formed part of the linear regression analysis aspect of this study and the main assumption underlying the regression analysis. First, the selected variables that formed part of the regression analysis are continuous and non-categorical in nature with data cases that are normally distributed (Appendix F.). Second, this study assumes that, the rate of growth or change in the factors that contribute to the occurrence and distribution of both the dependent and independent variables are largely constant or remain relatively the same over a given period of time and space.

Statistically, the relationship between the dependent and independent variable is represented by the linear regression model:

$$y = a + b_{1}(x_{1}) + b_{2}(x_{2}) \ldots\ldots\ldots\ldots\ldots\ldots b_{n}(x_{n}) + e$$

Where;

y = the dependent variable

a = Constant of the regression model (slope of the regression equation)

b = Regression coefficient of the independent variable

x = Independent variable

e = Margin of error

The subscript 1, 2, and n = Identification numbers of independent variables

Similarly, in this study a linear regression model that examines the relationship between child malnutrition (dependent variable) and food and nutrition security (independent variable) is established as:

$$y = a + b(x)$$

Where the e (margin of error) is considered insignificant.

That is:

Child malnutrition = a +b (food and nutrition security)

Where:

Child malnutrition = Dependent variable (y)

Food and nutrition security = Independent variable (x)

The linear regression model indicated above examines the statistical relationship between only two variables (child malnutrition and food and nutrition security). Consequently, the enter regression option that provides the best linear regression result with fewer variables (Kachigan, 1991) was used to analyze the statistical relationship between child malnutrition and food and nutrition security in northern Ghana.

Table 18 presents a summary information on the correlation (R) between the dependent variable (child malnutrition) and the independent variable (food and nutrition security) as well as the proportion of variability (R^2) in child malnutrition explained by food and nutrition security in the study area.

Table 18. Model summary of the statistical relationship between child malnutrition and food and nutrition security

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	0.198	0.039	0.031	0.494	0.039	4.895	1	120	0.029

Source: Author's data analysis (2014).

Specifically, the R value of 0.198 signifies that a 19.8 percent direct (positive) relationship exists between child malnutrition and food and nutrition security. This implies that, all things being equal an improvement in the level of food and nutrition security is associated with a corresponding improvement in child malnutrition in the study area. The reverse holds true. Relatedly, the R^2 of 0.039 suggests that the linear regression model:

Child malnutrition = a +b (food and nutrition security) accounts for 3.9 percent variability in the dependent variable. The relatively small proportion of variability explained by the resultant regression model is expected because the independent variable (food and nutrition security) that largely accounts for the occurrence and the distribution of the dependent variable consist of other health parameters (clinical and non-clinical) that this study did not cover due to limited time, financial constraints and the main objective of this study.

Additionally, Table 19 shows the coefficients of the regression model that represents the relationship between child malnutrition and food and nutrition security in northern Ghana.

Table 19. Regression coefficients of the statistical relationship between child malnutrition and food and nutrition security

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	1.516	0.045		33.912	0.001
	Food and nutrition security	0.099	0.045	0.198	2.212	0.029

Source: Author's data analysis (2014).

First, the coefficient of the constant of the resultant linear regression model (1.516) is 99.0 percent significant (significance level = 0.001). This implies that the resultant linear regression model that represents the significant statistical relationship between child malnutrition and food and nutrition security is stable. Also, it implies that the resultant linear regression model could be used to predict other future scenarios of the measured relationship between child malnutrition and food and nutrition security with a relatively higher degree of certainty.

Second, this study interpreted the coefficient of the B statistic that represents the coefficients of the independent variable(s) of a given sample data other than the Beta statistic that represents the coefficient of independent variable(s) for a given population or census data (Kachigan, 1991).

Table 19 (page 133) indicates that the regression model coefficient (B) for the independent variable food and nutrition security is 0.099. This demonstrates that food and nutrition security (independent variable) have a positive impact on the occurrences and distribution of child malnutrition (dependent variable) in the study area. This relationship signifies that a 0.099 unit increase in food and nutrition security is likely to result in a corresponding one unit improvement in child malnutrition and vice versa. Percentage-wise, this study found that a 0.9 percent improvement in food and nutrition security is likely to result in a 10.0 percent improvement in child malnutrition. The reverse holds true. This relationship is 99.0 percent significant (significance level = 0.029), which implies that the measured positive relationship (positive impact) between child malnutrition and the food and nutrition security is 95.0 percent significant and not due to chance. As a result, this study concludes with a relatively higher degree of certainty that the statistical relationship that exist between child malnutrition and food and nutrition security in northern Ghana is positive and that an improvement in food and nutrition security or otherwise largely determines the extent of child malnutrition that could be observed in the study area.

Finally, the resultant linear regression model that represents the statistical relationship between child malnutrition and food and nutrition security is established as:

Child malnutrition = 1.516 + 0.099 (food and nutrition security)

Where the error term (e) is insignificant.

In respect of the goodness of fit of the resultant linear regression model this study asserts that the preceding linear regression model is good and stable. The significance of the regression coefficients of the model and the normality plot of the residuals of the regression model demonstrate this. This observation is confirmed by the distribution of the residuals of the resultant linear regression model close to the normal line of the P-P plot as shown in Figure 17.

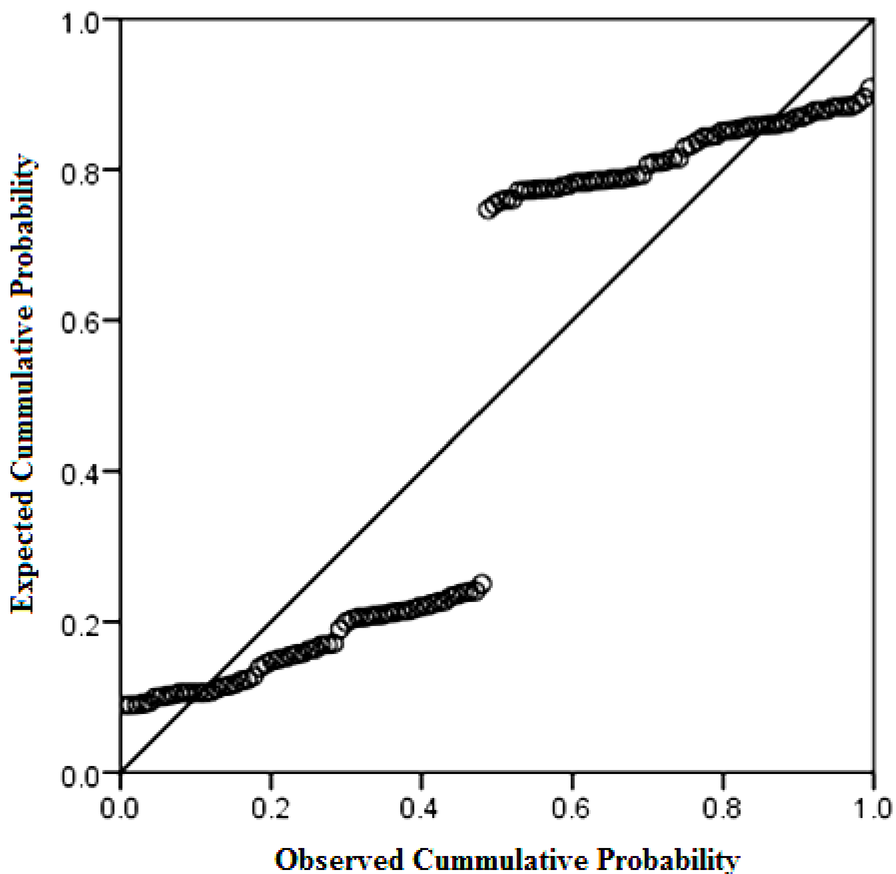


Figure 17. Normal P-P plot of regression standardized residual of the relationship between major child malnutrition factors and food and nutrition security

Source: Author's data analysis (2014).

Additionally, the coefficients of the resultant linear regression model are 99.0 and 95.0 percent significant, both the constant (significance level = 0.001) and the B coefficient (significance level = 0.029) respectively.

With regard to specific objective two of the study, the present study concludes that the factor Food and Nutrition Security exerts a positive statistical significant (95%) impact on child malnutrition in the study area. Additionally, the present study does not retain the first null hypothesis of the study, which states that a statistical significant negative relationship exists between child malnutrition and food and nutrition security. Rather, it accepts the alternative hypothesis that a statistical significant positive relationship exists between child malnutrition and food and nutrition security in northern Ghana

Crosstabulation analysis of the relationship between major child malnutrition factors and food and nutrition security

Based on specific objective three of the study a regression analysis was performed to evaluate the statistical relationship between the selected major child malnutrition factors and food and nutrition security discussed in chapter four of this study. In chapter four the spatial relationship between the major factors identified to contribute to the distribution of child malnutrition and food and nutrition security in northern Ghana were discussed. However, the significance of the distribution of child malnutrition factors and food and nutrition security by region and their associated spatial statistical relationships could not be ascertained by the spatial analysis in GIS (Figures 14 [page 104] and 15 [page 105]).

Consequently, a crosstabulation analysis with its associated chi-square statistics (Tables 20 and 21) that is common to the test of significance of categorical data was performed.

Table 20 indicates that in all the three northern regions of Ghana the factors limited access to good food (Northern: 33.3%, Upper East: 40.0%, and Upper West: 37.4%) and lack of income (Northern: 23.2%, Upper East: 44.2%, and Upper West: 50.5%) are the two main factors that affect the level of child malnutrition in the study area.

Table 20. Major child malnutrition factors by region

Major Child Malnutrition Factor	Region							
	Northern		Upper East		Upper West		Northern Ghana	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Poor child care	6	6.1	8	8.4	12	12.1	26	8.9
Limited access to good food	33	33.3	38	40.0	37	37.4	108	36.9
Lack of income	23	23.2	42	44.2	50	50.5	115	39.2
+Spatio-economic, child nutrition and health	37	37.4	7	7.4	0	0.0	44	15.0
Total	99	100	95	100	99	100	293	100

+ Refers to spatio-economic, child nutrition and health factor including lack of health facility, limited access to good drinking water, poor sanitary environment, mother's limited access to knowledge based care and education, high cultural acceptability of non-nutritious foods, poor breastfeeding practices and poor weaning practices.

Source: Author's data analysis (2014).

The results of both the spatial and statistical analysis of the regional distribution of the major explanatory factors of child malnutrition, particularly in the Upper East Region are expected. This is because, the study area is generally rural in nature with farming as the major occupation characterized by irregular food production mainly due to the recent global changes in climate, which usually affect regional and to some extent local variability in rainfall. In a situation where food production is mainly rain fed and largely subsistence in nature, limited food production mainly due to limited rainfall could result in the lowering of mothers' income and access to good food. Additionally, lack of income limits the ability of mothers that are predominantly farmers to procure farm inputs and implements to sustain and increase food production in order to help them gain better access to good food at all times (FAO, 2012; MOFA et al., 2012).

The result of the Chi-Square analysis presented in Table 21 tested the statistical significance of the tabular relationship between the major child malnutrition factors by the region of residents of the study respondents.

Table 21. Chi-square analysis of the significant statistical relationship between major child malnutrition factors and the region of residence of respondents

Statistic	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	64.457	6	0.001
Likelihood Ratio	71.266	6	0.001
N of Valid Cases	293		

Source: Author's data analysis (2014).

In all, the crosstabulation analysis yielded a Pearson Chi-Square value of 64.457 with a significant value of 0.001, which signifies that the relationship between child malnutrition factors and the region of the study respondents is 99.0 percent significant.

Correlation analysis of the relationship between major child malnutrition factors and food and nutrition security

The result of the correlation analysis in Table 22 tested the significance of the measured statistical relationship (association) between child malnutrition factors and food and nutrition security.

Table 22. Correlations analysis of the statistical relationship between major child malnutrition factors and food and nutrition security

Variables	Pearson Correlation Coefficient	Significance (2-tailed)
Food security factor and Major child malnutrition factor	0.120	*0.065

*Pearson correlation is not significant at p-value less than 0.05.

Source: Author's data analysis (2014).

First, the statistical association between child malnutrition factors and food and nutrition security is represented by the Pearson correlation coefficient of 0.120. Percentage-wise, the Pearson correlation coefficient of 0.120 implies that a 12.0 percent positive association exists between child malnutrition factors and food and nutrition security in northern Ghana.

Second, the positive Pearson correlation coefficient of 0.120 indicates that a positive (direct) relationship exists between child malnutrition factors and food and nutrition security. The measured positive (direct) relationship signifies that the distribution of child malnutrition in the study area occurs hand in hand. This implies that all things being equal the better the level of food and nutrition security in the study area the better the level of child malnutrition. Third, the significance value of 0.065 for a two tailed distribution indicates that the measured association between child malnutrition and food and nutrition security is not significant at p-value less than 0.05 (Table 22, page 139).

In conclusion this study found that the selected child malnutrition factors; Lack of/limited Income and Access to Good Food are positively associated with food and nutrition security in northern Ghana.

Relationship between Agricultural Production (food production) and Food and Nutrition Security

This section focuses on the analysis of the statistical relationship between food and nutrition security (dependent variable) and agricultural production (independent variable) in respect of achieving specific objective four. In order to obtain a single measure of agricultural production, a factor analysis was performed based on nine (9) key variables that characterize agricultural production in Ghana and in the study area in particular. These variables, namely the availability of community attributes such as: (i) market, (ii) communal food storage facility, (iii) motorable roads, (iv) vehicles, (v) regular wet and dry seasons, (vi) quality of soil for farming, (vii) availability of arable land, (viii) availability of food stock all year round and (ix) the availability of primary health care measure the quantitative and spatial attributes of agricultural production in the study area. The application of the factor analysis technique helped in the computation of an index of agricultural production, which represents the independent variable. Second, a linear regression analysis was performed to examine the impact of agricultural production (independent variable) on food and nutrition security (dependent variable).

Composition of index of agricultural production

Table 23 provides information on the total variance explained by nine factors (component) that measure agricultural production in northern Ghana. Out of these nine factors, four factors (components) are identified to be the factors that best measure agricultural production in the study area.

Table 23. Total variance explained by the composition of the index of agricultural production

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Vari-ance	Cumul-ative %	Total	% of Vari-ance	Cumu-lative %	Total	% of Vari-ance	Cumu-lative %
1	2.232	24.796	24.796	2.232	24.796	24.796	1.889	20.989	20.989
2	1.468	16.315	41.111	1.468	16.315	41.111	1.450	16.109	37.097
3	1.255	13.941	55.052	1.255	13.941	55.052	1.367	15.184	52.281
4	0.949	10.549	65.600	0.949	10.549	65.600	1.041	11.568	63.849
5	0.851	9.453	75.053	0.851	9.453	75.053	1.008	11.204	75.053
6	0.733	8.145	83.198						
7	0.623	6.918	90.116						
8	0.522	5.805	95.921						
9	0.367	4.079	100.001						

Extraction Method: Principal Component Analysis.

Source: Author's data analysis (2014).

Each of the four factors (components) is composed of variables that best measure it (Table 24). The selection of the variables listed below is based on the component scores of the variables as shown in Table 24:

Component 1 - Markets, Regular Wet and Dry Season; Primary Health Care;

Component 2 - Community Food Storage Facility, Vehicles;

Component 3 - Communal Arable Land, Availability of Food Stock All Year Round.

Component 4 - Regular Wet and Dry Season, Quality Soil for Farming, Primary Health Care.

The selected components 1, 2, 3, and 4 have total eigenvalues of 2.232, 1.468, 1.255, and 0.949 respectively. Also, they have a corresponding percent of variance values of 24.796, 16.31, 13.941 and 10.549 percent respectively.

Table 24. Component score coefficient matrix of nine agricultural production variables

Variables	Component			
	1	2	3	4
Market	0.434	-0.060	-0.015	0.011
Communal food storage facility	-0.199	0.704	0.014	-0.058
Motorable roads	0.014	-0.041	0.018	0.001
Vehicles	0.144	0.448	-0.056	-0.018
Regular wet and dry seasons	0.266	-0.045	0.260	-0.483
Quality of soil for farming	0.086	-0.048	0.027	0.825
Communal availability of arable land	-0.054	0.138	0.470	0.123
Availability of food stock all year round	-0.045	-0.123	0.679	-0.159
Primary health care	0.507	-0.118	-0.180	0.249

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization Component Scores.

Source: Author's data analysis (2014).

Generally, the four main components account for over 65.6 percent variability in the independent variable (agricultural production). Although, traditionally an eigenvalue equal to or greater than one is preferred, in this study factor 4 with an eigenvalue of 0.949 was included in the possible factors that measure adequately the index of agricultural production since the eigenvalue of this factor is close to one. On the other hand, the graphical representation of eigenvalues by the number of components (factors) shows that two factors (factors one and two) characterize the portion of the scree plot where the scree plot graph line takes its first bend and declines to the end of the graph line (Figure 18). Relatedly, Table 23 (page 141) indicates that factors one (24.796%) and two (16.315%) account for a total of 41.11 percent variability in the factors that measure agricultural production in the study area.

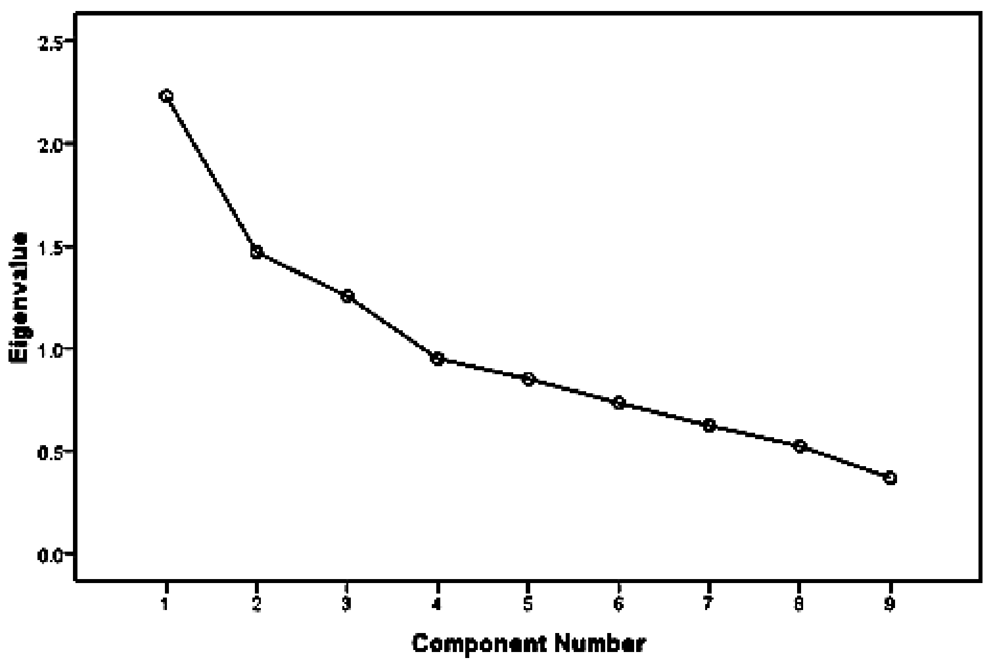


Figure 18. Graphical representation of index of agricultural production eigenvalues by component number (Scree Plot)

Source: Author's data analysis (2014).

Since this study aimed at composing one major index that adequately measure agricultural production in the study area, factor one (component one) that explains a relatively larger percent variability (24.796%) in agricultural production is chosen. Additionally, this factor is composed of variables that measure six main community attributes related to agricultural production. These variables are: (i) the Availability of Market, (ii) Community Food Storage Facilities, (iii) Availability of Vehicles, (iv) the Present of Regular Wet and Dry Season, (v) Quality Soil for Farming and (vi) Availability of Primary Health Care.

The selection of the variables that measure factor one is based on the component scores of the selected variables. Traditionally, variables with the highest component scores (factor loadings/correlation coefficients) are selected to measure a given factor. Table 25 shows that six variables with the highest component scores (factor loadings) form the variables that are closely associated with and adequately measure the index of agricultural production (food production).

Table 25. Component score coefficient matrix of variables that measure the index of agricultural production

Variables	Component 1
Market	0.434
Communal food storage facility	-0.199
Vehicles	0.144
Regular wet and dry seasons	0.266
Quality of soil for farming	0.086
Primary health care	0.507

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Component Scores.

Source: Author's data analysis (2014).

Linear regression analysis of the relationship between food and nutrition security and agricultural production

This section presents the results of the linear regression analysis that modeled the impact of agricultural production on food and nutrition security in the study area (northern Ghana). The enter regression method was used. Model statistics provided in Table 26 indicates that agricultural production is 17.8 percent (R= 0.178) associated with food and nutrition security. The corresponding coefficient of variability (R^2) of the model is 0.032.

Table 26. Model summary of the statistical relationship between food and nutrition security and agricultural production (food production)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.178	0.032	0.024	0.98812	0.032	3.926	1	120	0.050

Source: Author's data analysis (2014).

This implies that the derived linear regression model accounts for 3.2 percent variability in the statistical relationship between food and nutrition security and agricultural production in the study area. The small proportion of variability in food and nutrition security explained by the model may be explained by the limited inclusion of health and nutrition related variables that did not form part of the analysis of the study. The result indicated above coincide with the observation that food and nutrition security goes beyond food security that is mainly driven by agricultural (food) production to include all factors that positively affect the health and socio-economic wellbeing of people.

The resultant regression model that demonstrates the impact of agricultural production (independent variable) on food and nutrition security (dependent variable) may be established as:

$y = a + b_{(x)} + e$

That is;

Food and nutrition security = a + b (agriculture production)

Where;

y = Food and nutrition security (dependent variable)

a = Constant

b = Agricultural production (independent variable)

e = The error term of the regression model is insignificant

Table 27 shows the coefficients (B) and the corresponding significant values of the regression model constant and that of the independent variable (agricultural production).

Table 27. Coefficients of the statistical relationship between food and nutrition security and agricultural production

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-0.014	0.090		-0.151	0.880
	Agric production factor	0.180	0.091	0.178	1.982	0.050

Source: Author's data analysis (2014).

The coefficient of the constant is – 0.014 with a corresponding significant value of 0.880. The significant value of the model constant of 0.880 signifies that the coefficient of the constant of the derived regression model is not significant. Consequently, the resultant linear regression model may be classified as unstable and limited in predicting future occurrences of the measured relationship between food and nutrition security (dependent variable) and agricultural production (independent variable) in the study area. As a result, this study cautions that care has to be taken in the general applicability of this model. This is because, the replication of this measured relationship under a similar condition, time and place may differ.

Nonetheless, the coefficient of the independent variable; agricultural production (B = 0.180) is 95.0 percent significant (i.e p-value = 0.05). This portrays a stable positive relationship between food and nutrition security and agricultural production in the study area. That is, agricultural production in the study area has positive impact on the level and extent of food security in the study area. Thus, a unit increase in agricultural production is expected to result in a corresponding increase in food and nutrition security. The reverse holds true.

Based on the results of the modeled relationship between agricultural production (food production) and food and nutrition security a resultant linear regression model is established as:

$y = a + b_{(x)}$

That is:

Food and nutrition security = -0.014 + 0.180 (agricultural production) Where the error term (e) is considered to be insignificant.

Statistically, this preceding resultant linear regression model demonstrates that agricultural production has a positive impact on food and nutrition security and that a 0.180 increase in agricultural production is likely to result in corresponding one unit increase in food and nutrition security in the study area. Alternatively, an 18.0 percent increase in agricultural production is likely to generate 10.0 percent increase in food and nutrition security. This signifies that, agricultural production (food production) is one of the key components of food and nutrition security in the study area.

In terms of the goodness of fit of the resultant model, the study found that the resultant regression model is relatively good (Figure 19). The close distribution of the residuals of the resultant modeled relationship between agricultural production (food production) and food and nutrition security along the normal line of the PP-plot demonstrates this (Figure 19). In all, this study concludes that the factor agricultural production (food production) exerts a weak (R = 0.178 or 17.8%) but significant positive (95.0%) impact on food and nutrition security in the study area.

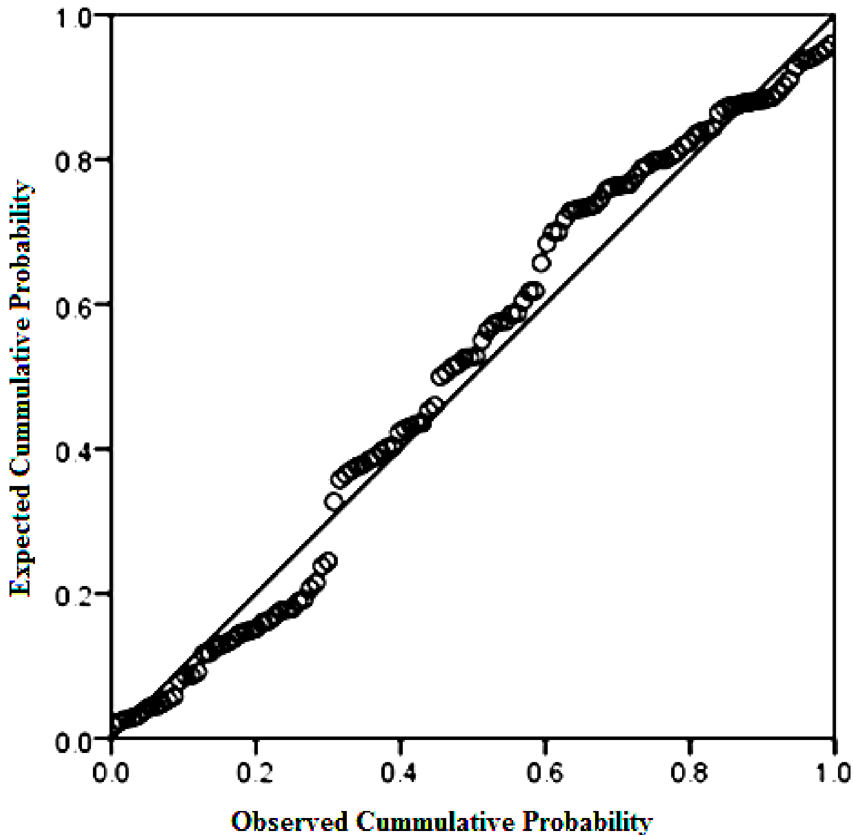


Figure 19. Normal P-P plot of regression standardized residual of the relationship between community attributes and food and nutrition security

Source: Author's data analysis (2014).

Relationship between the Spatial Attributes of Study Communities and Food and Nutrition Security

The statistical analysis of the relationship between spatial attributes of the study communities and food and nutrition security tested the second null hypothesis of the study. According to Figure 8 (page 67), a direct link exists between spatial attributes of study communities and the nutritional status of children (food and nutrition security and health status of children). In this study, two main variables (indices); Food and Nutrition Security; and Health Status of Children measure the Nutritional Status of Children in the study area (Figure 8, page 67).

In order to access the full impact of the spatial attributes of the study communities on the nutritional status of child, two indices representing the measured relationship between the spatial attributes of the study communities and health status of children in the study area are composed. The ensuing sub-section discusses the composition of the index of spatial attributes of the study communities and the linear regression analyses of the relationship between food and nutrition security and spatial attribute of study communities. Additionally, it discusses the measured statistical relationship between health status of malnourished children and spatial attributes of the study communities.

Composition of index of spatial attributes of study communities

With regard to the composition of the index of spatial attributes of the study area, this study selected fourteen variables that characterize the spatial attributes of the study area. These variables represent community facilities and developments such as markets, communal food storage facilities, motorable roads, vehicles, availability of schools (at least primary school), regular wet and dry seasons, quality of soil for farming, communal availability of arable land, major occupation of members of the community, availability of food stock all year round, availability of primary health care, access to potable drinking water, availability of community garbage disposal site and good sanitation practices.

Tables 28, 29 and 30 as well as Figures 20 and 21 provide information on the measured coefficients and parameters that were used to compose the index of spatial attribute of the study area. By employing the factor analysis technique an index of spatial attributes of the study area was composed based on the attributes of the selected variables that characterize the spatial attributes of the individual communities that form the study area.

Table 28. Total variance explained by the factors that measure the index of spatial attributes of study communities

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Comp-onent	Total	% of Variance	Cumul-ative %	Total	% of Variance	Cumul-ative %	Total	% of Variance	Cumul-ative %
1	2.563	18.307	18.307	2.563	18.307	18.307	1.961	14.008	14.008
2	1.702	12.160	30.468	1.702	12.160	30.468	1.946	13.899	27.907
3	1.471	10.506	40.974	1.471	10.506	40.974	1.717	12.265	40.172
4	1.235	8.822	49.795	1.235	8.822	49.795	1.335	9.538	49.710
5	1.091	7.791	57.587	1.091	7.791	57.587	1.103	7.877	57.587
6	1.022	7.300	64.886						
7	1.002	7.160	72.046						
8	0.955	6.821	78.868						
9	0.828	5.911	84.778						
10	0.639	4.564	89.343						
11	0.514	3.674	93.017						
12	0.414	2.960	95.978						
13	0.296	2.116	98.094						
14	0.267	1.906	100.00						

Extraction Method: Principal Component Analysis.

Source: Author’s data analysis (2014).

Table 29 indicates that out of a total of fourteen components that were

Table 29. Component score coefficient matrix of the factors that measure the spatial attributes of study communities

Variables	Component 1	2	3	4	5
Market	-0.066	0.404	-0.014	-0.104	-0.073
Communal food storage facility	0.418	-0.203	-0.004	-0.040	0.008
Motorable Roads	0.410	0.003	-0.017	0.101	-0.037
Vehicles	0.376	0.084	-0.021	-0.024	0.015
At least primary school	-0.166	0.102	0.017	0.078	0.564
Regular wet and dry seasons	0.073	0.276	-0.014	0.348	0.302
Quality of soil for farming	-0.040	.134	0.038	0.509	-0.371
Communal availability of arable land	-0.011	-0.086	0.034	-0.112	0.425
Major occupation of members of the community	-.037	0.002	0.540	-0.039	0.033
Availability of food stock all year round	0.063	-0.015	-0.050	0.391	0.139
At least primary health care	-0.100	0.467	-.011	-0.012	-0.076
Community access to good/potable Drinking water	0.001	-0.052	.541	-0.018	0.010
Community garbage disposal site	0.015	0.119	-0.007	-0.426	-0.021
Community members practice good Sanitation	-0.106	0.023	0.012	-0.116	-0.388

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

generated five main factors (components) were selected.

Source: Author’s data analysis (2014).

Each of the five components is composed of variables that best measure it (Table 29, page 152):

Component 1: Communal Food Storage Facility, Motorable Roads, Vehicles, Primary School, Primary Health Care, Good Sanitation Practises;

Component 2: Markets, Primary Health Care, Quality of Soil for Framing, Regular Wet and Dry Season, Community Food Storage Facility;

Component 3: Major Occupation of Members of Community, Community Access to Good Drinking Water;

Component 4: Regular Wet and Dry Season, Quality of Soil for Framing, Arable Land, Food Stock all Year Round, Garbage Disposal Site; and

Component 5: Primary School, Regular Wet and Dry Season, Quality of Soil for Framing, Arable Land, Food Stock all Year, Good Sanitation Practises.

The selected five components represent the key components that explain the largest proportion of variance in the composition of the index of spatial attributes of the study communities. In all, the five factors (components) explain 57.59 percent of the total variance accounted for by the factor analysis. However, factor 1 (component 1) explains 18.31 percent variability in the factor analysis (Table 28, page 151), which by far constitutes the largest proportion of variance explained among the five selected factors (component 2 = 12.160%, component 3 = 10.506%, component 4 = 8.822% and component 5 = 7.791%).

Additionally, the scree plot graphical representation of the eigenvalues by their respective components (Figure 20) largely indicates that components one and two (factors 1 and 2) better measure and represent the index of spatial attribute of study communities. This is because they form the two main factors on the scree plot graph line that define where the scree plot graph line bends and decreases gradually in eigenvalues (Kachigan, 1991).

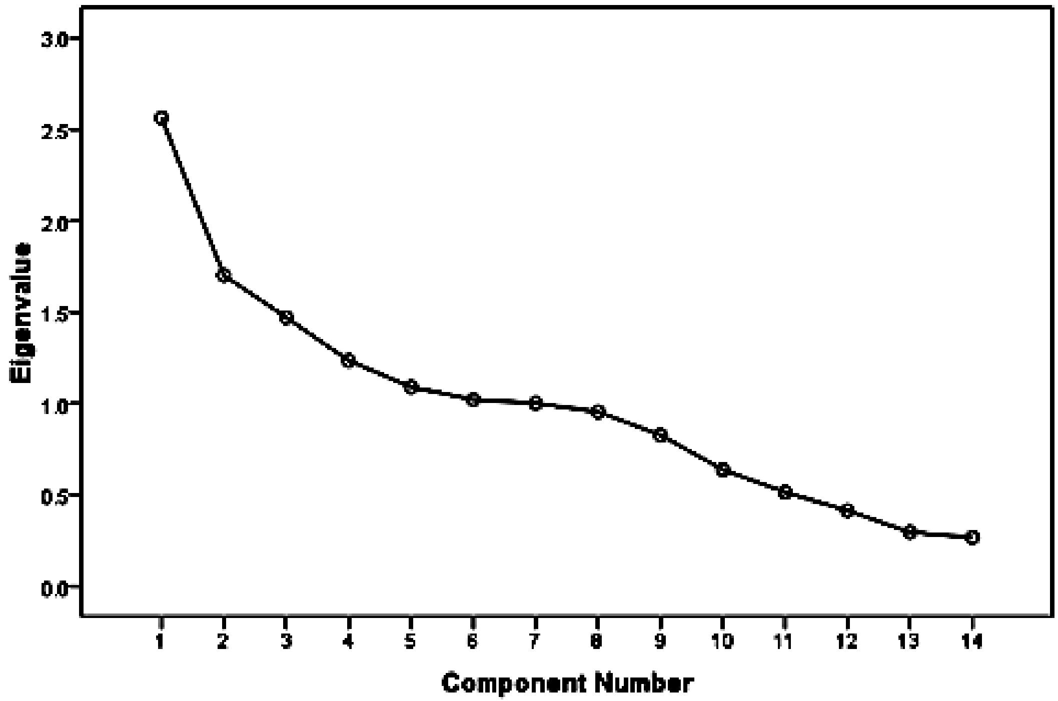


Figure 20. Graphical representation of index of spatial attributes eigenvalues by component number (Scree Plot)

Source: Author's data analysis (2014).

Since this study is interested in generating a single index that adequately measures and represents the index of spatial attribute of the study area, factor one (component 1) with the highest percent variance explained (Table 28, page 151) was selected. Table 29 (page 152) shows the component scores of all the fourteen variables and the five main factors (components) that were found to better represent the index of spatial attributes of the study area.

Traditionally, variables with the highest component or factor scores are considered to be more representative and characteristic of the factors or components they measure. In all, six variables that scored the highest on factor one (component one) were selected as the key variables that best measure and represent the index of spatial attribute of the study area. Table 30 shows the selected variables that measure the index of spatial attribute and their corresponding component scores (correlation coefficient).

Table 30. Component score coefficient matrix of six variables that best measure the index of spatial attributes of study communities

Variables	Component 1
Communal food storage facility	0.418
Motorable roads	0.410
Vehicles	0.376
At least primary school	-0.166
Primary health care	-0.100
Community members practice good sanitation	-0.106

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

Source: Author’s data analysis (2014).

Composition of index of health status of children under five

Table 31 indicates that factors one to five explain 62.28 percent (Cumulative % of Variance) of the variance in the composition of the index of health status of children under five in the study area. Similarly, factors one, two and three account for 45.4 percent of the total variance explained (% of Variance: factor 1 = 19.89%, factor 2 = 15.29%, and factor 3 = 10.25%).

Table 31. Total variance explained by the composition of the index of health status of children under five

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Comp -onent	Total	% of Vari- ance	Cumul- ative %	Total	% of Vari- ance	Cumul- ative %	Total	% of Vari -ance	Cumul- ative %
1	2.785	19.895	19.895	2.785	19.895	19.895	2.681	19.151	19.151
2	2.140	15.288	35.183	2.140	15.288	35.183	2.090	14.926	34.078
3	1.435	10.250	45.433	1.435	10.250	45.433	1.519	10.848	44.926
4	1.281	9.147	54.580	1.281	9.147	54.580	1.316	9.402	54.327
5	1.078	7.702	62.282	1.078	7.702	62.282	1.114	7.954	62.282
6	1.027	7.332	69.614						
7	0.908	6.485	76.099						
8	0.887	6.333	82.432						
9	0.631	4.506	86.937						
10	0.581	4.149	91.087						
11	0.480	3.428	94.514						
12	0.403	2.880	97.394						
13	0.338	2.413	99.807						
14	0.027	0.193	100.00						

Extraction Method: Principal Component Analysis.

Source: Author's data analysis (2014).

In respect of the composition of the index of health status of children under five in the study area, the first three factors are preferred because each of the factors contributes more than 10.0% of the total percent variance explained by the factor analysis. Cumulatively, factors 1, 2 and 3 account for the largest proportion of variance (45.433%) explained by the factor analysis. Similarly, Figure 21 indicates that factors one, two and three are the most important factors of all the fourteen factors (components) generated by the factor analysis. The distribution of the three factors on the scree plot graph line explains this. As portrayed by the scree plot factors one, two and three occur at the first upper arm of the scree plot graph line just before the graph line makes its first major bend and extends downward.

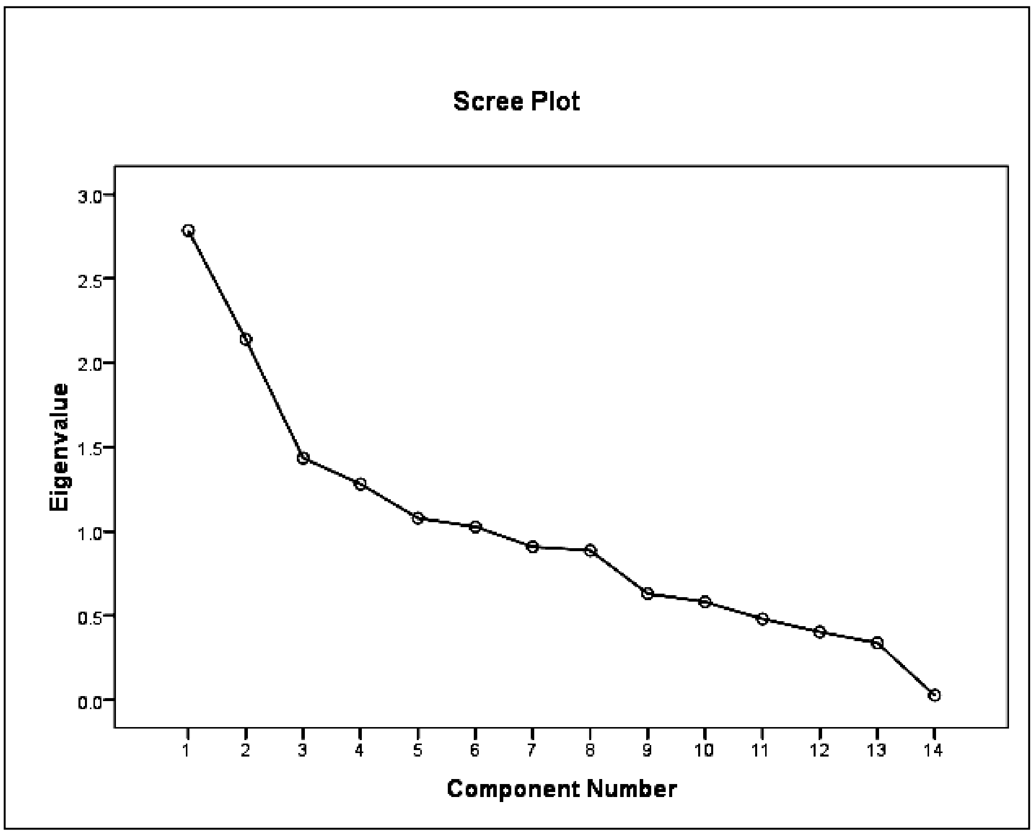


Figure 21. Graphical representation of index of health status eigenvalues by component number (Scree Plot)

Source: Author's data analysis (2014).

Among the three factors identified, factor one was selected as the factor that best measures the index of health status of children under five in the study area. This is because factor one accounts for the largest percent of the variance explained (19.89%) by the factor analysis. The factor (component) scores that measure the degree of importance (correlation) of variables that measure factors one, two and three are shown in Table 32.

Table 32. Index of health status components score coefficient matrix

Variables	Component		
	1	2	3
Mother's educational level	0.066	-0.316	-0.057
Mother's occupation	0.047	-0.261	-0.048
Mother's income	0.051	-0.025	-0.032
Mother's age	0.094	0.374	-0.145
Number of children per mother	0.001	0.407	-0.010
Number of times of breastfeeding	0.321	-0.010	-0.157
Age at weaning	-0.351	0.001	-0.017
Type of weaning food	-0.347	-0.006	-0.015
Mother ever attended post-natal clinic	0.039	-0.072	0.241
Community facilities (at least primary health care)	-.018	-0.044	0.522
Community access to good/potable drinking water	-0.009	-0.011	-0.093
Community members practice good sanitation	0.022	0.040	0.045
Community garbage disposal site	-0.111	0.007	0.470
Improvement in standard of living/social wellbeing (Past 10 years)	0.076	0.052	0.271

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

Source: Author's data analysis (2014).

Table 33 indicates that eight variables have the highest factor scores and are loaded the highest on factor one that represents the index of health status of children under five in the study area. Out of the eight variables indicated in Table 33, four variables with relatively high component scores (Number of times of breast feeding = 0.32, Age of children at weaning = -0.35, Type of weaning food = -0.35 and the Availability of community garbage disposal site = -0.11) and are better associated with factor 1 (Component 1) are considered to be the key variables that best measure the index of health status of children under five in the study area.

Table 33. Variables that measure the index of health status by their component score coefficients

Variables	Component 1
Mother's educational level	0.066
Mother's income	0.051
Mother's age	0.094
Number of times of breastfeeding	0.321
Age at weaning	-0.351
Type of weaning food	-0.347
Community garbage disposal site	-0.111
Improvement in standard of living/social wellbeing (Past 10 years)	0.076

Extraction Method: PC. Rotation Method: Varimax with Kaiser Normalization.

Source: Author's data analysis (2014).

Relationship between Nutritional Status of Children and Spatial Attributes of Study Communities

In this section, two sub-concepts; food and nutrition security and health status of children measure the concept nutritional status of children under five in the study area. In theory, an index of nutritional status of children could have been composed based on the combined effects of the sub-concepts of food and nutrition security and health status of children data. In practice, the composition of an index based on two or more sub-concepts tends to over generalize the effectiveness of the resultant index that measure the major concepts (Kachigan, 1991).

Consequently, this study composed two main indices; index of food and nutrition security and index of health status of children under five to measure the nutritional status of children under five in the study area. Similarly, two linear regression analyses that examined the statistical significant relationships between the spatial attribute of the study community and food and nutrition security on one hand and the health status of children under five on the other were performed. These analyses helped better measure the statistical significant relationship between spatial attributes of study community and nutritional status of children (food and nutrition security and health status of children under five) in the study area.

Based on the review of the available literature and the results of the statistical analysis of the study, the study discusses the relationship between food and nutrition security and spatial attribute of the study area on one hand and the relationship between the health status of children under five and spatial attributes of study communities on the other.

. First, a general linear regression model that examines the relationship between food and nutrition security and spatial attribute of community is sated as:

$$y = a + b (x) + e$$

Where:

y = Dependent variable (food and nutrition security)

a = Constant of the linear regression model

b = Coefficient of the independent variable (spatial attribute of community)

x = Independent variable (spatial attribute of community)

e = Error margin of the linear regression model

Table 34 provides summary statistics of the linear regression model that shows the statistical significant relationship between spatial attributes of the study area communities and food and nutrition security based on the R, R^2 and Significant F Change statistics. The R statistic, which measures the strength of the association between food and nutrition security and the spatial attributes of the study communities, is 0.938. This indicates that the variables food and nutrition security and spatial attribute of study communities are strongly and positively related. Percentage-wise, the dependent variable food and nutrition security is 93.8 percent associated with the independent variable spatial attributes of study communities.

Table 34. Model summary of the statistical relationship between food and nutrition security and spatial attribute of the study area

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.938	0.881	0.880	0.34787533	0.881	862.416	1	117	0.001

Source: Author's data analysis (2014).

This level of association signifies that all things being equal the better the spatial attributes of the study communities the better the food and nutrition security situation in the study communities. The reverse holds true. Similarly, the coefficient of variability ($R^2 = 0.880$) indicates that the derived linear regression model accounts for 88.0 percent variability in the relationship between the dependent variable food and nutrition security and the independent variable spatial attributes of community. Overall, the model fit of the derived linear regression model is good since the R^2 and F change statistics are 99.0 percent significant (significant level 0.001). Additionally, the normal P-P plot of the regression standardized residual (Figure 22a) shows that the residuals of the resultant linear regression model are normally distributed along the normal line of the P-P plot.

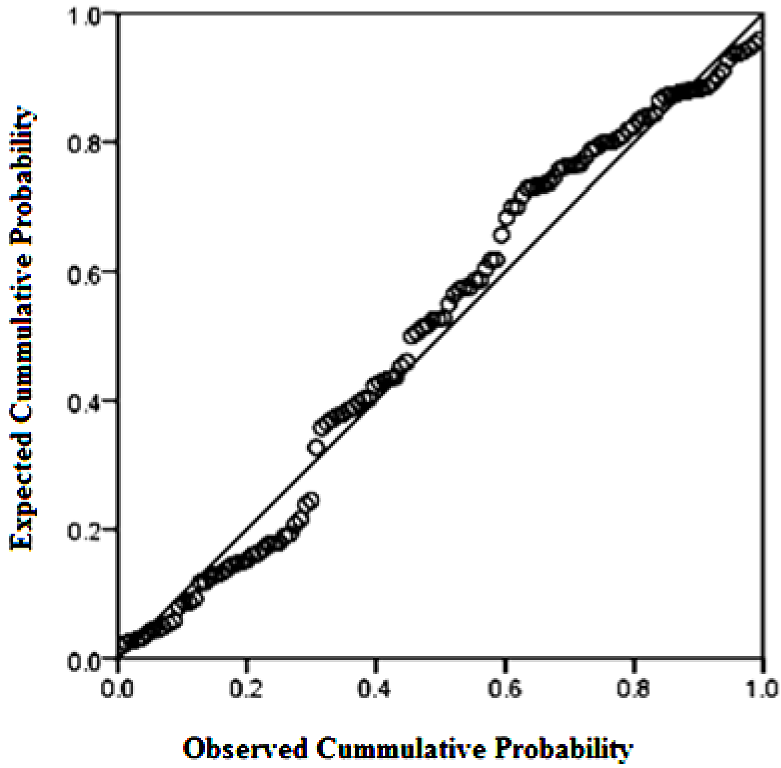


Figure 22a. Normal P-P plot of regression standardized residual of the relationship between the spatial attributes of study communities and food and nutrition security

Source: Author's data analysis (2014).

Table 35 provides information on the coefficients of the linear regression model. First, the coefficient of the B statistic that represents the constant of the resultant lineal regression model is 0.124 with a significant level of 0.001 (99.0% significant). This implies that the resultant linear regression model is stable and can be used to predict future measured relationship between the dependent and independent variables under similar conditions. Second, the coefficient of the B statistic of the independent variable spatial attributes of study communities is 0.944 with a significant value of 0.001. This means that the coefficient of the independent variable spatial attribute of community is 99.0 percent significant.

Table 35. Coefficients of the statistical relationship between food and nutrition security and spatial attributes of the study area

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	0.124	0.032		3.857	0.001
	Spatial attribute of community	0.944	0.032	0.938	29.367	0.001

Source: Author's data analysis (2014).

Based on the coefficients of the linear regression model stated in Table 35, a resultant linear regression model that depicts the statistical significant relationship between food and nutrition security (dependent variable) and spatial attribute of community (independent variable) is established as:

Food and nutrition security = 0.124 + 0.944 (spatial attribute of community) where the error term is insignificant

In respect of the coefficient of the independent variable (spatial attribute of community) the resultant linear regression model portrays that a 99.0 percent significant (significant value = 0.001) positive statistical relationship exists between food and nutrition security (dependent variable) and spatial attribute of study communities (independent variable). Also, it signifies that the nature, types, and quantity of spatial attribute of the study communities that form the study area have a positive impact on the level of food and nutrition security in the study area. For instance, the resultant regression model indicates that a 0.944 improvement in community spatial attributes is associated with a corresponding one unit increase in food and nutrition security in the study area. In percentage terms, a 94.4 percent increase or improvement in the spatial attributes of study communities is associated with a corresponding 10.0 percent increase in food and nutrition security of the study area. Consequently, the study accepts and affirms the second null hypothesis that a positive statistical significant (99.0% significance) relationship exists between spatial attributes of selected northern Ghana communities and food and nutrition security.

Second, a general linear regression model that represents the significant statistical relationship between the dependent variable health status of child under five and spatial attribute of selected communities that form the study area is represented as:

$$y = a + b\,(x) + e$$

Where:

y = Dependent variable (health status of children under five)

a = Constant of the linear regression model

b = Coefficient of the independent variable (spatial attribute of community)

x = Independent variable (spatial attribute of community)

e = Error margin of the linear regression model

Table 36 shows that the R statistic of the observed statistical relationship between health status of children under five (dependent variable) and spatial attribute of community (independent variable) is 0.219. This figure represents 21.9 percent positive association between the dependent variable health status of children under five and the independent variable spatial attribute of community.

Table 36. Model summary of the statistical relationship between the health status of children and spatial attributes of study communities

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	0.219	0.048	0.043	0.97915	0.048	9.162	1	182	0.003

Source: Author's data analysis (2014).

The positive coefficient signifies that a unit increase or improvement in the spatial attributes of the selected study communities is associated with a corresponding one unit increase or improvement in the health status of children under five in the study area and vice versa. Additionally, Table 36 indicates that the coefficient of variability (R^2) of the modeled statistical relationship between the health status of children under five and the spatial attributes of study communities is 0.043 with a significant F change value of 0.003 (99.0 % significant).

Although the resultant model explains only 4.3 percent of the variability in the dependent variable ($R^2 = 0.043$), the overall model fit is good in that the F change statistic 99.0 percent significant. Also, the distribution of the residual of the linear regression model shows most of the modeled residuals are normally distributed along the normal line of the P-P plot (Figure 22b).

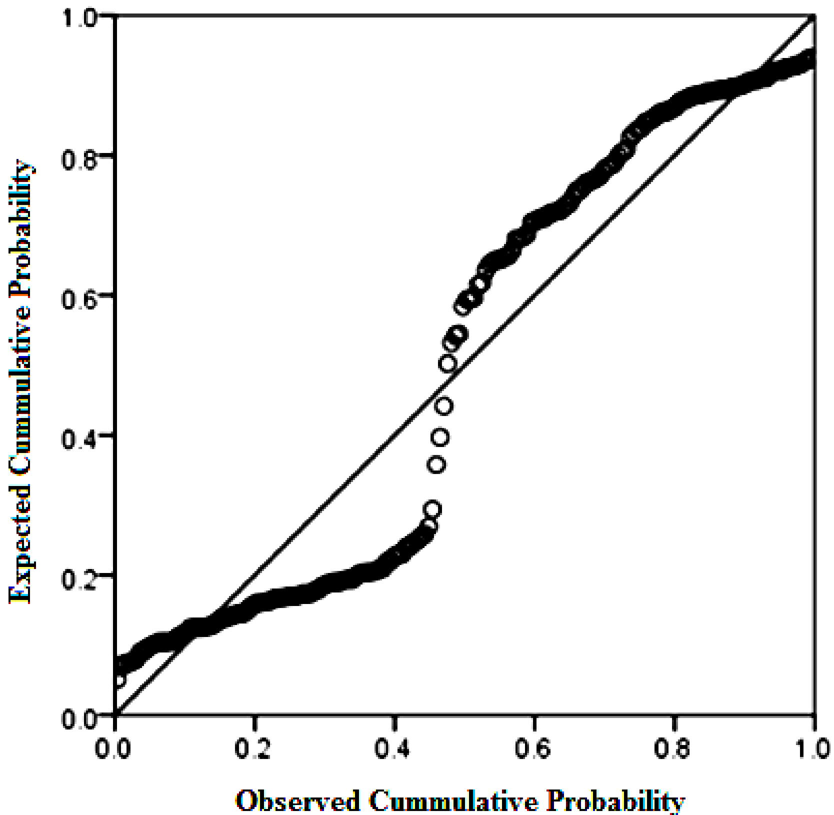


Figure 22b. Normal P-P plot of the regression standardized residual of the relationship between spatial attribute of the study area and health status of children under five

Source: Author’s data analysis (2014).

Table 37 provides information on the linear regression coefficients of the measured statistical relationship between the health status of children under five (dependent variable) and the spatial attribute of community (independent variable).

Table 37. Linear regression coefficient of the statistical relationship between the health status of children and spatial attributes of study communities

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	T	Sig.
1	(Constant)	-0.001	0.072		-0.018	0.986
	Spatial attribute of community factor	-0.216	0.071	-0.219	-3.027	0.003

Source: Author's data analysis (2014).

The B coefficient of the constant is – 0.001 with a corresponding significant value of 0.986. This implies that the constant of the resultant regression model is not significant at p-value ≤ 0.5 (i.e the constant is not significant at the 95.0 and 99.0 percent significant levels). Since the constant of the regression model is not significant, this study suggests that the application and interpretation of the resultant linear regression model be limited to the selected study communities and other communities with similar spatio-economic, agricultural, demographic and health characteristics.

On the other hand, the B coefficient of the independent variable spatial attribute of community (-0.216) represents a negative impact or an indirect relationship. This statistical relationship is 99.0 percent significant (significance level = 0.003). This demonstrates that the independent variable spatial attribute of community exerts a negative impact on the dependent variable health status of children under five in the study area. The negative relationship between the dependent variable health status of children under five and the independent variable spatial attribute of community means that an inverse or indirect statistical relationship exists between the two variables. Thus, a 0.216 unit decrease in the quality of spatial attribute of the selected study communities is associated with a corresponding one unit increase in the worsening conditions of the health status of children under five in the study area. That is, the better the spatial attribute of the study community the better the health status of children under five in the study area. The reverse holds true. The resultant linear regression model that represent the relationship between the health status of children under five and spatial attribute of study communities is represented by the linear regression model:

Health status of children under five = -0.001 + -0.216 (spatial attributes of communities)

Where the error term (e) is insignificant.

Linear Regression Analysis of the Relationship between Child Malnutrition and Health Status of Children Under Five

The statistical relationship between the dependent variable (child malnutrition) and the independent variable (health status of children under five) is established by the linear regression model:

$y = a + b(x) + e$

Where:

y = Dependent variable (health status of children under five)

a = Constant of the linear regression model

b = Coefficient of the independent variable (spatial attribute of community)

x = Independent variable (spatial attribute of community)

e = Error margin of the linear regression model

Table 38 presents information on the model fit of the linear regression model that demonstrates the statistical significance of the relationship between the dependent variable child malnutrition and the independent variable health status of children under five. First, the R value of 0.153 indicates that 15.3 percent positive association exists between child malnutrition and health status of children under five. Second, the R^2 value of 0.023 signifies that the resultant linear regression model explains 2.3 percent variability in the dependent variable.

Table 38. Model summary of the statistical relationship between child malnutrition and health status of children under five

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.153	0.023	0.019	0.469	0.023	4.932	1	206	0.027

Source: Author’s data analysis (2014).

Notwithstanding the small proportion of variability (2.3%) in the dependent variable explained by the resultant linear regression model, the overall goodness of fit of the resultant model is good. This is because, the F change of the resultant linear regression model is 99.0 percent significant (significance value = 0.027). Additionally, the P-P plot of the regression standardized residual shows that the residuals of the derived linear regression model are normally distributed close to the normal line of their distribution. The use of an index relative to the individual variables that measure the independent variable may account for the break in the distribution of the regression residual as shown by Figure 23.

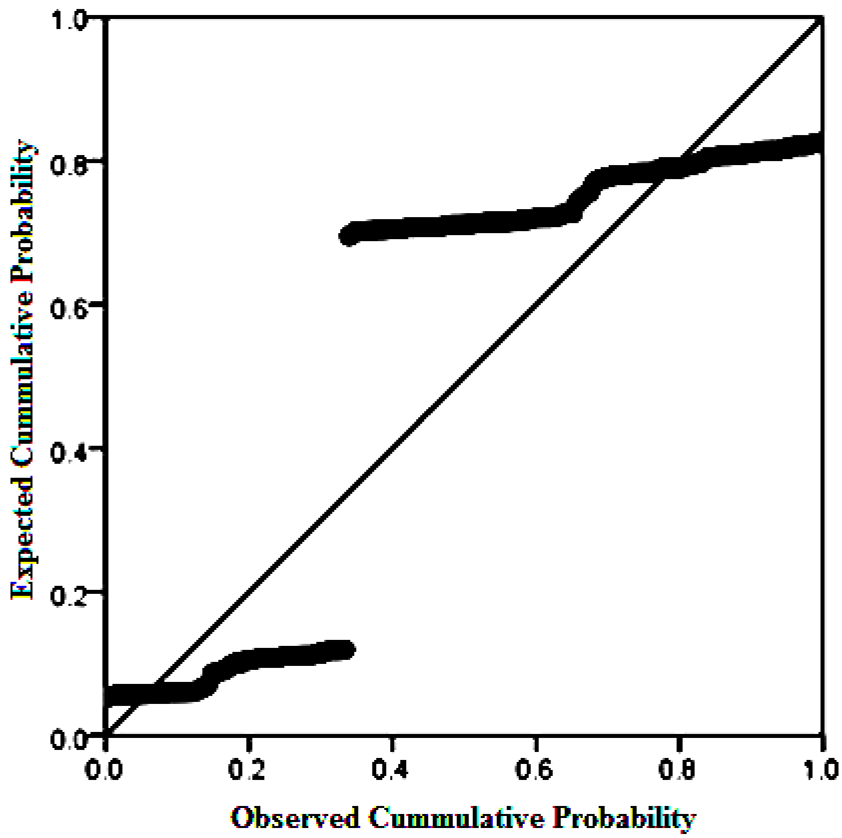


Figure 23. Normal P-P plot of the regression standardized residual of the relationship between child malnutrition and health status of children under five

Source: Author's data analysis (2014).

Table 39 presents statistical information on the coefficients of the resultant linear regression model. The coefficient of the constant (B = 1.663) is 99.0 percent significant (significance value = 0.001). Similarly, the coefficient of the independent variable health status of children under five (-0.072) is 95.0 percent significant (significance value = 0.027).

Table 39. Linear regression coefficients of the relationship between child malnutrition and health status of children under five

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	T	Sig.
1	(Constant)	1.663	.033		51.128	0.001
	Health status of children	-0.072	.033	-.153	-2.221	0.027

Source: Author's data analysis (2014).

Specifically, the resultant linear regression model that demonstrates the statistical significant relationship between child malnutrition (dependent variable) and health status of children under five (independent variable) is represented as:

$y = a + b (x)$

That is,

Child malnutrition = 1.663 – 0.072 (health status of children under five) Where the error term (e) is insignificant.

The regression coefficient (– 0.072) of the independent variable (health status of children under five) indicates that an inverse (negative impact) relationship exists between child malnutrition and health status of the children under five in the study area. That is, a 0.072 unit decrease in the health status of children under five in the study area is likely to result in a corresponding one unit increase in child malnutrition of children under five in the study area and vice versa. Stated differently, a 7.2 percent increase in the health status of children under five is likely to result in a corresponding 10.0 percent decrease in child malnutrition in the study area and vice versa.

The observed inverse relationship signifies that the independent variable health status of children under five exerts a negative impact on the dependent variable child malnutrition. Based on this finding, the present study suggests that measures and projects that aim at improving the health status of children in the study community be intensified and expanded to cover all communities in the study area so as to help further reduce the current levels of child malnutrition experienced in the three northern regions of Ghana, particularly in the Upper East Region.

Relationship between Child Malnutrition and Spatio-economic Development

This section discuses the statistical relationship between child malnutrition and spatio-economic development of the study area. Based on the factor analysis statistical technique, an index of spatio-economic development was composed. The resultant index of spatio-economic development formed the independent variable of the linear regression analysis that this study discusses.

Composition of index of spatio-economic development

Table 40 shows ten main factors that measure adequately the index of spatio-economic development. Three main factors out of the ten factors are indentified to best measure the index of spatio-economic development of the study area. In all, factors one, two and three explain 34.44 percent of the total variance in the composition of the index of spatio-economic development (factor one = 15.15%, factor two = 9.84% and factor three = 9.45%).

Table 40. Total variance explained

Comp-onent	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Vari-ance	Cumu-lative %	Total	% of Vari-ance	Cumu-lative %	Total	% of Vari-ance	Cumu-lative %
1	3.031	15.155	15.155	3.031	15.155	15.155	2.036	10.179	10.179
2	1.967	9.837	24.992	1.967	9.837	24.992	2.018	10.091	20.270
3	1.890	9.448	34.440	1.890	9.448	34.440	1.942	9.712	29.983
4	1.707	8.534	42.973	1.707	8.534	42.973	1.749	8.745	38.728
5	1.340	6.700	49.673	1.340	6.700	49.673	1.635	8.174	46.902
6	1.204	6.022	55.695	1.204	6.022	55.695	1.445	7.223	54.125
7	1.161	5.803	61.498	1.161	5.803	61.498	1.177	5.883	60.008
8	1.018	5.092	66.590	1.018	5.092	66.590	1.158	5.789	65.797
9	0.980	4.902	71.493	0.980	4.902	71.493	1.077	5.386	71.184
10	0.970	4.850	76.343	0.970	4.850	76.343	1.032	5.159	76.343
11	0.865	4.327	80.669						
12	0.738	3.689	84.358						
13	0.649	3.244	87.602						
14	0.572	2.859	90.461						
15	0.564	2.821	93.282						
16	0.410	2.048	95.330						
17	0.375	1.875	97.205						
18	0.301	1.504	98.709						
19	0.258	1.291	100.00						
20	5.078E-5	0.001	100.00						

Extraction Method: Principal Component Analysis.

Source: Author's data analysis (2014).

This observation, notwithstanding, the scree plot analysis (Figure 24) shows that two main factors largely account for the composition of the index of spatio-economic development. These factors are factors one and two. The scree plot portrays that factors one and two distinctly show a sudden break in the distribution of their eigenvalues by their components generated. Also, the graph line takes a sharp bend from the second factor and declines gradual to the last component.

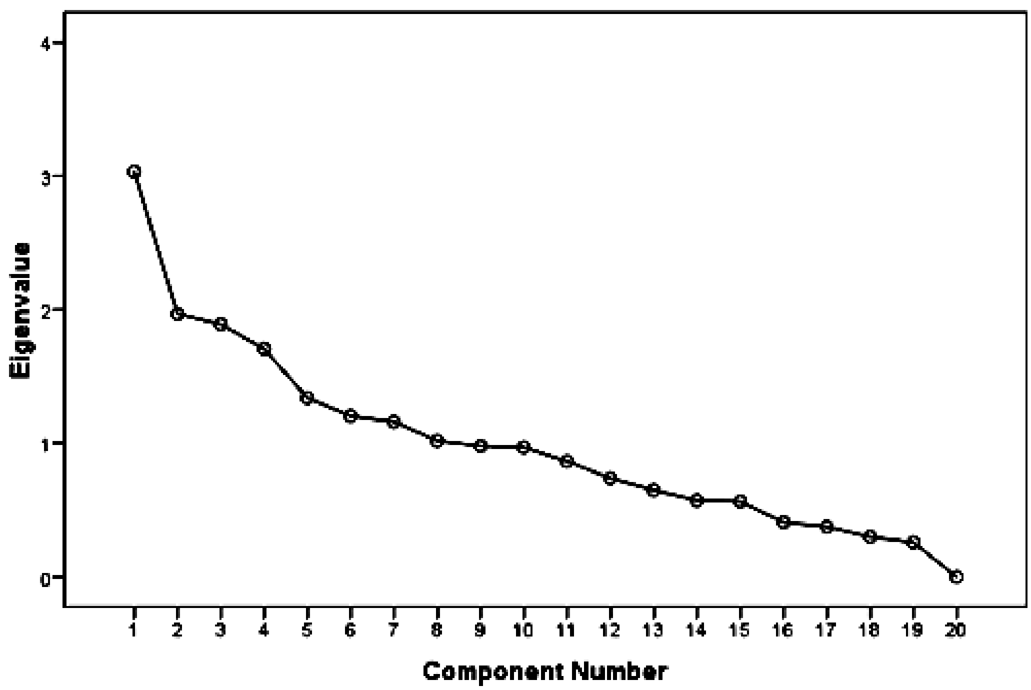


Figure 24. Graphical representation of Spatio-Economic Development factor eigenvalues by component number (Scree Plot)

Source: Author's data analysis (2014).

Table 41 reveals that five main factors (factors one to five) best measure and represent the index of spatio-economic development. Overall, factors one to five explain 49.67 percent variability in the composition of the index of spatio-economic development. However, factor one that explains the largest proportion of variance (15.15%) in the composition of the index of spatio-economic development is preferred over factors two (9.84%) (Table 40).

Table 41. Index of spatio-economic development component score coefficient matrix

	Component				
Variables	1	2	3	4	5
Mother’s educational level	0.028	0.017	-0.108	0.141	0.327
Mother’s occupation	-0.026	-0.020	0.173	-0.147	-0.165
Mother’s earn income	-0.091	0.046	-0.061	0.016	0.279
Number of children per mother	0.017	-0.007	-0.015	-0.042	0.047
Market	-0.074	-0.011	0.442	-0.001	0.047
Communal food storage facility	0.399	0.013	-0.192	-0.015	0.048
Motorable roads	0.443	-0.019	-0.077	0.012	-0.088
Vehicles	0.379	-0.030	0.067	-0.025	0.002
Regular wet and dry seasons	0.118	0.002	0.059	0.114	-0.087
Primary school	-0.059	-0.008	-0.064	-0.085	0.076
Quality of soil for farming	0.043	0.033	-0.046	0.152	-0.504
Communal availability of arable land	-0.042	0.004	-0.007	-0.028	0.022
Major occu. of members of the community	-0.019	0.499	-0.010	-0.027	-0.004
Availability of food stock all year round	-0.043	0.021	-0.003	0.001	0.126
Primary health care	-0.082	-0.006	0.508	-0.125	0.004
Access to good/potable drinking water	-0.020	0.499	-0.011	-0.026	-0.002
Good sanitation	0.026	0.015	-0.044	-0.016	0.012
Garbage disposal site	0.034	0.008	0.149	0.014	0.394
Increase in local economic productivity	0.032	-0.016	-0.148	0.558	-0.016
Improvement in standard of living	-0.050	-0.030	0.052	0.482	-0.140

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Component Scores.

Source: Author’s data analysis (2014).

Similarly, Table 42 shows the variables that measure factor one and their respective component or factor scores.

Table 42. Variables that measure the index of spatio-economic development by their component score coefficient

Variables	Component 1
Communal food storage facility	0.399
Motorable roads	0.443
Vehicles	0.379
Regular wet and dry seasons	0.118

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization. Component Scores.

Source: Author's data analysis (2014).

In all, eight main variables (Mothers Earn Income , Market, Communal Food Storage Facility, Motorable Roads, Vehicles, Regular Wet and Dry Seasons, Primary School and Primary Health Care) contribute substantially to the composition of factor one, which represent the index of spatio-economic development. Four out of the eight variables identified demonstrate the strongest association with the index of spatio-economic development. Table 42 portrays the four selected variables; Communal Food Storage Facility, Motorable Roads, Vehicles and Regular Wet and Dry Seasons and their corresponding component scores. In percentage terms, the variables Communal Food Storage Facility, Motorable Roads, Vehicles and Regular Wet and Dry Seasons present the strongest degree of association of 39.9 percent, 44.3 percent, 37.9 percent, and 11.80 percent respectively with factor one that adequately measure the index of spatio-economic development.

Linear regression analysis of the relationship between child malnutrition and spatio-economic development

Statistically, the relationship between child malnutrition (dependent variable) and spatio-economic development of the study area is represented by the linear regression model:

$y = a + b\,(x) + e$

Where:

y = Dependent variable (child malnutrition)

a = Constant of the linear regression model

b = Coefficient of the independent variable (spatial attribute of community)

x = Independent variable (spatio-economic development)

e = Error margin of the linear regression model

The model summary of the linear regression analysis indicates that the R (0.155), R^2 (0.024) and the F change (5.024) statistics that mainly measure the model fit of the linear regression model are 99.0 percent significant (Table 43).

Table 43. Model summary of the statistical relationship between child malnutrition and spatio-economic development

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.155	0.024	0.019	0.470	0.024	5.023	1	204	0.026

Source: Author's data analysis (2014).

This implies that the model fit of the resultant linear regression model that shows the statistical relationship between child malnutrition (dependent variable) and spatio-economic development of the study area is good. Also, the stanadardized residual of the resultant linear regression model is fairly distributed along the normal P-P plot normal line (Figure 25). The use of an index relative to the individual variables that measure the independent variable may explain the break in the distribution of the regression residual as shown by Figure 25.

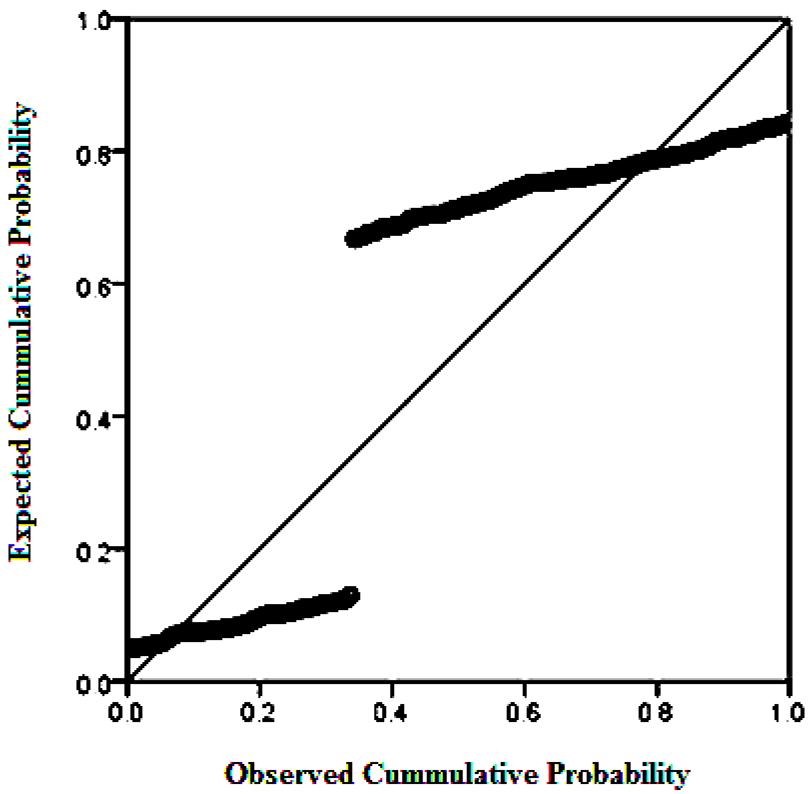


Figure 25. Normal P-P plot of the regression standardized residual of the relationship between child malnutrition and spatio-economic development

Source: Author's data analysis (2014).

The good fit of the resultant regression model, notwithstanding, this study suggests that the result of the resultant regression model be interpreted with care. This is because; the R coefficient of 15.5 percent demonstrates a relatively weak but significant association between the dependent variable child malnutrition and the independent variable spatio-economic development. Also, the coefficient of variability (R^2 = 0.024 or 2.4%) is small. The coefficient of variability of 0.024 means that the resultant regression model explains only 2.4 percent variability in the dependent variable. Table 44 shows the coefficients of the linear regression model.

Table 44. Linear regression coefficients of the statistical relationship between child malnutrition and spatio-economic development

		Unstandardized Coefficients		Standardized Coefficients		
	Model	B	Std. Error	Beta	t	Sig.
1	(Constant)	1.660	0.033		50.676	0.001
	Spatio-economic development	-0.074	0.033	-.155	-2.241	0.026

Source: Author's data analysis (2014).

Based on the coefficient of the linear regression model a resultant linear regression model is established as:

Child malnutrition = 1.660 – 0.074 (spatio-economic development)

Where the error term (e) is insignificant.

The coefficient of the B statistic (1.660) is 99.0 percent significant (significance value = 0.001). This signifies that the resultant linear regression model is stable and could be used to explain the statistical relationship between the dependent variable child malnutrition and the independent variable spatio-economic development under similar measured conditions in the study area. Additionally, the coefficient of the independent variable spatio-economic development (B) is -0.074. This implies that a negative statistical relationship exists between child malnutrition (dependent variable) and spatio-economic development (independent variable). That is, child malnutrition is inversely associated with spatio-economic development in the study area. As a result, a 0.074 increase in spatio-economic development of the study area is expected to contribute to a unit decrease in child malnutrition in the study area. The reverse holds true. Alternatively, a 7.4 percent increase in spatio-economic development is expected to lead to a corresponding 100.0 decrease in child malnutrition in the study area and vice versa.

The above result suggests that an improvement in the spatial and economic development of communities that form the study area is likely to generate a better standard of living with a corresponding reduction in child malnutrition levels experienced in the three northern regions of Ghana (Northern, Upper West and Upper East) that form the study area. Consequently, this study suggests the improvement in the spatial infrastructure and development facilities (spatio-economic development) in the study area such as markets, communal food storage facilities, motorable roads particularly during the raining season, vehicles, schools, and primary health care facilities as a means of improving the standard of living of the people. This could help reduce the relatively high child malnutrition levels in the affected communities of northern Ghana, particularly in the Upper East Region to a reasonable and manageable level.

Relationship between Spatio-Economic Development and the Spatial Attributes of the Study Area

The under stated linear regression model represent the statistical relationship between spatio-economic development (dependent variable) and spatial attributes of study communities (independent variable):

y = a + b (x) +e

Where:

y = Dependent variable (child malnutrition)

a = Constant of the linear regression model

b = Coefficient of the independent variable (spatial attribute of community)

x = Independent variable (spatio-economic development)

e = Error margin of the linear regression model

Table 45 provides information on the model summary of the linear regression model that examined the statistical relationship between spatio-economic development and spatial attribute of community.

Table 45. Model summary of the statistical relationship between spatio-economic development and spatial attribute of community

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	0.187	0.035	0.030	0.984715	0.035	7.413	1	204	0.007

Source: Author’s data analysis (2014).

The model summary information in Table 45 indicates that the R, R^2 and the F change are 99.0 percent significant (significance level = 0.007). The coefficient of the R statistic of 0.187 signifies a positive but weak (18.7%) correlation between the dependent variable spatio-economic development and the independent variable spatial attribute of communities that form the study area.

Relatedly, the coefficient of variability (R^2) of 0.035 indicates that the resultant linear regression model explains 3.5 percent variability in the independent variable (spatial attribute of community).

Additionally, the distribution of the standardized residual of the resultant linear regression model as portrayed by the Normal P-P plot shows that the residuals of the resultant linear regression model are distributed close to the P-P plot normal line (Figure 26). This signifies that the model fit of the resultant linear regression model is good but weak.

In respect of the coefficients of the resultant linear regression model the coefficient of the constant (B = 0.002) is not significant at the 90.0, 95.0 and 99.0 percent significant levels (significance value = 0.977) (Table 46). This largely indicates that the constant of the resultant linear regression model is not stable. As result, the resultant linear regression model may not yield good estimates when it is used to predict further and future relationships between spatio-economic development and spatial attribute of study communities.

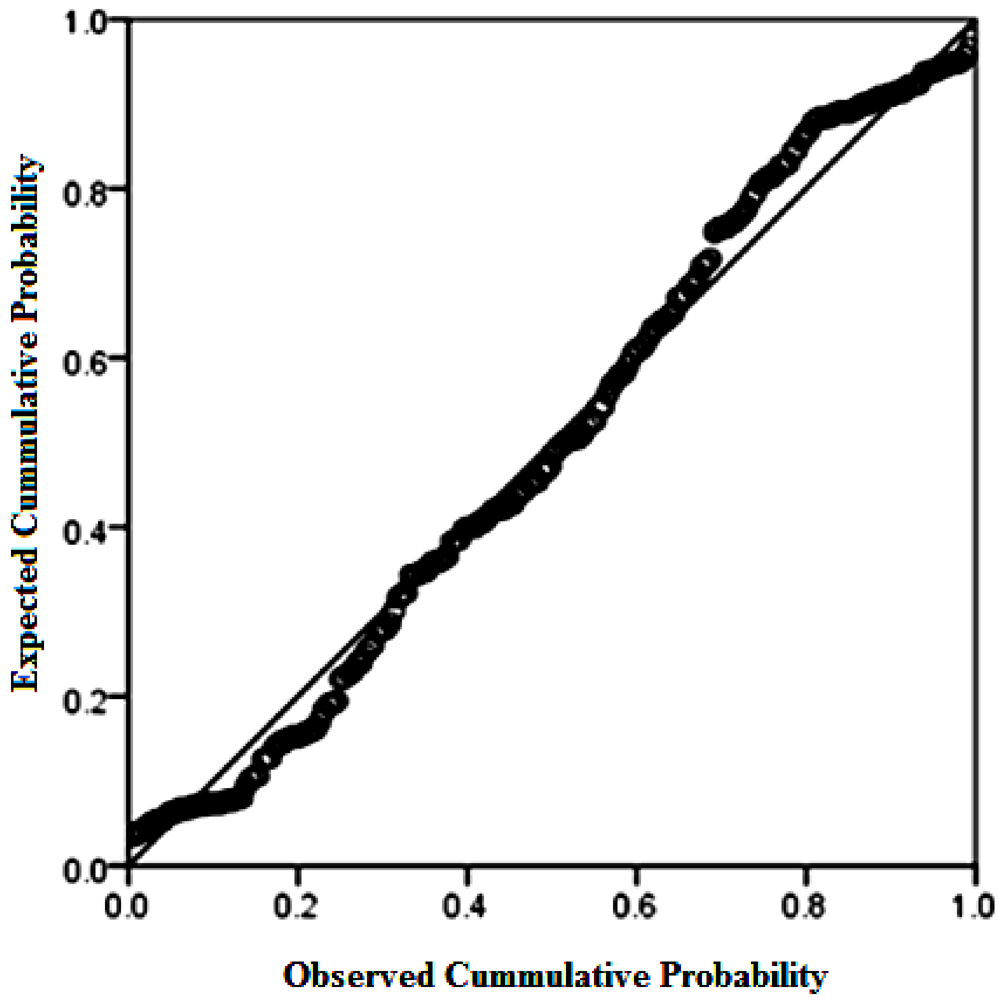


Figure 26. Normal P-P plot of the regression standardized residual of the relationship between spatio-economic development and spatial attribute of community

Source: Author's data analysis (2014).

Table 46. Linear regression coefficients of the statistical relationship between spatio-economic development and spatial attribute of community

	Model	Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	0.002	0.069		0.028	0.977
	Spatial attribute of community	0.186	0.068	0.187	2.723	0.007

Source: Author's data analysis (2014).

However, the coefficient of the independent variable spatial attribute of community (B = 0.186) portrays that a 99.0 percent significant (significant value = 0.007) positive relationship exists between the dependent and the independent variable.

The measured linear regression coefficient of 0.186 largely indicates that 1.86 percent increase or improvement in the spatial attributes of the study communities results in a corresponding 10.0 percent increase in spatio-economic development of the study area. The reserve hold true. Thus, spatial attribute of study communities (independent variable) is found to have a positive significant impact on the extent of spatio-economic development experienced by the study communities in northern Ghana.

Multiple Regression Analysis of the Impact of Spatial Attributes of Study Communities, Food and Nutrition Security and Health Status of Children Under Five on Child Malnutrition

This aspect of the statistical analysis of the study data tested the third null hypothesis of the study. A multiple linear regression that examines the significant statistical relationship between child malnutrition (dependent variable) and spatial attributes of study communities, food and nutrition security and health status of children under five (independent variables) is established as:

$$y = a + b_1 (x_1) + b_2(x_2) + b_3(x_3) + e$$

Where:

y = Dependent variable (child malnutrition)

a = Constant of the linear regression model

b_1 = Coefficient of the independent variable (spatial attribute of community)

x_1 = Independent variable (spatial attribute of community)

b_2 = Coefficient of the independent variable (food and nutrition security)

x_2 = Independent variable (food and nutrition security)

b_3 = Coefficient of the independent variable (health status of children under five)

x_3 = Independent variable (health status of children under five)

e = Error margin of the linear regression model

Table 47 indicates that the R (0.278), R^2 (0.077) and the F change (2.898) statistics are 99.0 percent significant (significance value = 0.039). The R value of 0.278 implies that 28.7 percent positive association exists between the dependent variable child malnutrition and the three independent variables; spatial attribute of community, food and nutrition security and the health status of children under five in the study area. As a result, a unit increase in the independent variables is expected to result in a corresponding one unit increase in the dependent variable although the strength of the measured associations are weak but 99.0 percent significant.

Table 47. Model summary of the statistical relationship between child malnutrition, spatial attribute of community, food and nutrition security, and health status of children under five

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.278	0.077	0.051	0.489	0.077	2.898	3	104	0.039

Source: Author's data analysis (2014).

Additionally, the coefficient of variability (R^2) of 0.077 signifies that the resultant linear multiple regression model explains 7.7 percent variability in the dependent variable. Thus, the proportion of the variability in the dependent variable by the independent variables is fairly small. This is because the present study did not cover all variables that help in the determination of health status and nutrition status of children from the clinical stand point due to limited finances and time constraints that characterize student thesis. Consequently, this study asserts that the inclusion of other important variables that measure the clinical aspect of child health and nutrition could have improved the proportion of the variability in the dependent variable (child malnutrition) explained by the independent variables (spatial attribute of community, food and nutrition security, and health status of children under five).

Nevertheless, the model fit of the measure statistical significant relation between the dependent variable child malnutrition and the three independent variables (spatial attribute of community, food and nutrition security, and health status of children under five) is fairly good and 99.0 significant. This observation coincides with the graphical distribution of the standardized residuals of the resultant linear multiple regression (Figure 27). On this graph, a large proportion of the regression residuals are distributed long the normal line.

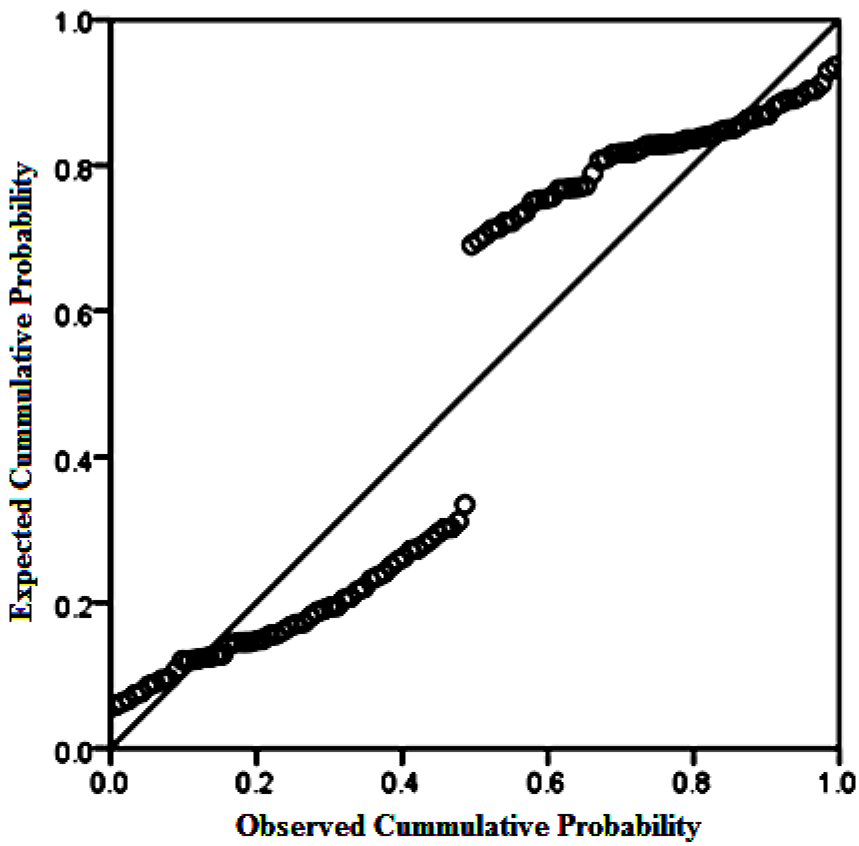


Figure 27. Normal P-P plot of the statistical relationship between child malnutrition, spatial attribute of community, food and nutrition security, and health status of children under five

Source: Author's data analysis (2014).

Based on the information provided in Table 47 (page 187), a linear multiple regression model that portrays the statistical significant relationship between the dependent variable child malnutrition and the three independent variables spatial attribute of community, food and nutrition security and health status of children under five is established as:

Child malnutrition = 1.496 -0.135 (spatial attribute of community) + 0.271 (food and nutrition security) – 0.080 (health status of children under five)

Where the error term (e) is considered insignificant.

The coefficient of the B statistics is 1.496. This demonstrates that the resultant linear multiple regression model has a positive slope and is 99.0 percent significant (significance value = 0.001). Thus, the resultant linear multiple regression model stated above could be considered to be stable and could be used to predict future scenarios of possible statistical relationships between child malnutrition (dependent variable) and spatial attribute of community, food and nutrition security and health status of children under five (independent variables) in Ghana and in northern Ghana in particular.

In respect of the statistical relationship between the dependent variable and the three independent variables, the resultant linear multiple regression coefficients represented in Table 48 indicates that the independent variable spatial attribute of community (B = -0.135) exerts negative impact on child malnutrition. This implies that a 0.135 decrease (lack of or limited development) in spatial attribute of the selected study communities is associated with a corresponding one unit increase in child malnutrition and vice versa. Percentage-wise, a 1.35 percent decrease (lack of or limited development) in spatial attribute of community is likely to result in a corresponding 10.0 percent increase in child malnutrition. The reverse holds true. However, this measured statistical relationship is not significant (significance value = 0.34). As a result, the observed measured statistical relationship between child malnutrition and spatial attribute of community may not hold at all times and under similar conditions.

Table 48. Multiple regression coefficients of the statistical relationship between child malnutrition, spatial attribute of community, food and nutrition security and health status of children

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.496	0.052		28.543	0.001
	Spatial attribute of community	-0.135	0.144	-0.271	-0.940	0.349
	Food and nutrition security	0.217	0.144	0.434	1.512	0.134
	Health status of children	-0.080	0.047	-0.164	-1.698	0.093

Source: Author's data analysis (2014).

Therefore, this result suggests that the interpretation of the measured statistical relationship between the dependent variable child malnutrition and the independent variable spatial attributes of study communities be done with reference to the objectives of the present study and the objectives of other similar studies.

On the other hand, the coefficients of the resultant multiple linear regression (B = 0.217) portrays a positive statistical relationship between the dependent variable child malnutrition and the independent variable food and nutrition security. This relationship demonstrates that the independent variable food and nutrition security exerts a positive impact on the dependent variable child malnutrition. Thus, a 0.217 increase in food and nutrition security in the study area is expected to lead to a corresponding one unit improvement in the level of child malnutrition experienced in the study area. Alternatively, a 2.17 percent increase in food and nutrition security is likely to result in a corresponding 10.0 percent improvement in the level of child malnutrition experienced in the affected communities of the three northern regions of Ghana that form the study area. Also, this measured statistical relationship is 90.0 percent significant (significant value 0.134) and that this measured relationship signifies a stable statistical significant relationship between child malnutrition and food and nutrition security. As a result, this study is 90.0 percent confident that an appreciable improvement in food and nutrition security of affected communities in northern Ghana holds promise for a reduction in the current levels of child malnutrition experienced in the study area.

Additionally, the measured statistical relationship between the dependent variable child malnutrition and health status of the children under five is 90.0 percent significant (significance value = 0.093) with a multiple linear regression coefficient of B = -0.080. The negative multiple linear regression coefficient demonstrates that health status of children under five exerts a negative impact on child malnutrition (inverse relationship). Relatedly, a 0.080. decrease in the health status of children under five is expected to produce a corresponding one unit increase in the level of child malnutrition experienced in the study area. Stated differently, as little as 8.0 percent improvement in the health status of children under five could lead to a substantial 100.0 percent decline in child malnutrition status of children in the study area. The significance value of 0.093 largely represents a 90.0 percent statistical significant relationship between child malnutrition and health status of children under five in the study communities. As a result, this study can conclude with 90.0 percent confidence that improvements in programmes and projects that aim at improving the health status of children under five in the selected study communities is key to any effort at improving the child malnutrition levels of affected communities in Ghana and in the study area (northern Ghana) in particular.

In respect of the individual contribution of the independent variables to the occurrence and distribution of the dependent variable the respective coefficients of the resultant multiple linear regression model indicates that the independent variable food and nutrition security (B = 0.217 or 21.7 percent) holds the greatest explanatory power for the occurrence and distribution of the dependent variable child malnutrition than the independent variables spatial attribute of community (B = -0.135 or -13.5 percent) and health status of child under five (B = -0.080 or -0.80 percent).

Based on the results stated above the present study retains the null hypothesis that the factor food and nutrition security exerts a stronger statistical significant impact on child malnutrition than the factor health status of children under five in the study area. As a result, this study suggests that in situations where resources are limited project that mainly seek to address and improve the food and nutrition security needs of affected communities could be implemented first followed by projects that seek to improve and enhance the spatial attribute of affected communities and the health status of children under five.

Assessment of the Study Conceptual Framework

Finally, this aspect of the spatial and statistical analyses of the study data assesses the statistical significance of the relationships and linkages between the major child malnutrition and food and nutrition security factors that are represented in the conceptual framework (Figure 8, page 67) that guided this study. The results of the statistical analyses indicate that the relationships between the factor spatial attribute of the community, nutritional status of children under five (food and nutrition security), and child malnutrition are significant. For instance, the linear regression analysis that examined the statistical relationship between the factors spatial attribute of community and food and nutrition security (Table 34) revealed a strong positive correlation (R = 93.8 %) and coefficient of variability (R^2 = 88.0 %) between the two variables with a corresponding significant F Change value of 0.001 (99.0 % significant). On the other hand, the remaining statistical relationships between the variables spatial attribute of community and health status of children (R = 21.9 %, R^2 = 4.8 %, Significant F Change = 99.0 %), child malnutrition and food and nutrition security (R = 19.8 %,

R^2 = 3.9 %, Significant F Change = 99.0 %), child malnutrition and health status of children under five (R = 15.3 %, R^2 = 2.3 %, Significant F Change = 99.0 %), spatio-economic development and child malnutrition (R = 15.5 %, R^2 = 2.4 %, Significant F Change = 99.0 %) and spatio-economic development and spatial attribute of community (R = 18.7 %, R^2 = 3.5 %, Significant F Change = 99.0 %) are weak but significant (Tables 18, 35, 38, 43 and 45).

In respect of the above stated findings of the linear regression analyses, this study concludes that the statistical relationships between the selected drivers of child malnutrition and their related factors as shown in Figure 8 (page 67) are significant and that these factors could be used to derive plausible explanations for the nature and distribution of child malnutrition in Ghana. However, where weak associations, impacts, coefficient of variability were realized other relevant variables could be added on to the selected variables in Figure 8 (page 67) in order to help enhance the explanatory power of future regression models. Consequently, this study do not suggest a major modification or revision of the study conceptual framework (Figure 8, page 67), except where other relevant variables are required to help future studies examine the full impact of food and nutrition security on child malnutrition in Ghana and in the study area in particular.

Qualitative Analysis of the Study Research Questions

This section presents the main views of respondents and findings of the structured interview of the present study, which sought to answer the study research questions. With respect to research question one (Why is the Upper East Region that has socio-economic, cultural, and spatial attributes similar to that of the Upper West and the Northern regions experienced persistent and increasing trend in child malnutrition between 1993 and 2008?), this study found that the general lack of or limited education, poverty (lack of/ or limited income), limited practice of exclusive breast feeding and poor child care account for the observed increases in child malnutrition in the Upper East Region over the past two decades. For instance, some of the respondents noted that *"mothers in the Upper East Region do not breastfeed their children often. That is why their children are malnourished"*. Similarly, a respondent intimated that *"the main problem is poverty. Most parents are not able to provide sufficiently for the nutritional needs of their children. As a result, they are not able to provide their children with three square healthy meals daily"*.

In response to research question two (Why is the Upper East Region, noted for the production of some of the most nutritious staple foods such as groundnuts, guinea corn/millet, and beans commonly used in the preparation of nutritious infants weaning food and children food is confronted with the problem of increasing child malnutrition among the three Northern regions of Ghana?), a respondent in the Upper East Region explained that *"the Upper West and Northern regions can produce additional nutritious crops (staple food, vegetables and fruits) such as yam, cassava, banana and mangoes that our land cannot support well. Therefore, when it comes to food security they are better than us"*. Also, the problem of limited knowledge of the importance of balanced diet was cited as one of the factors that largely contribute positively to the observed increases in child malnutrition in the Upper East Region. For instance, a respondent in the Upper East Region indicated that *"even though groundnuts and beans are produced in the Upper East Region, small quantity is consumed among households and a chunk of it is sold for money. Unfortunately, Tou Zafi (one of the staple foods in northern Ghana) which is consumed by most families is prepared from millet and the soup also is prepared from the same millet".* This largely demonstrates the lack of knowledge on balance diet preparation even where other sources of protein such as groundnut are available for the preparation of nutritious soup that contains the needed ingredient for proper child growth and healthy development. With regards to research question three (Are there significant differences in ethnicity, traditional practices, cultural acceptability of food and food taboos practised among the people of the three northern regions of Ghana?), this study found that there are no major differences in ethnicity, traditional practices and food taboos practiced among the three northern regions of Ghana. For instance, a respondent indicated that *"not much difference exists between the three northern regions of Ghana. Even our language is similar. We eat similar food stuffs and have similar taboos. For example, children seven years and below are not expected to eat eggs else they will grow up to be thieves. This could affect their growth and healthy development".*

Finally, the responses to research question four (Are there significant differences in the determinants of child malnutrition and food and nutrition security among the three northern regions of Ghana?) indicate that some degree of difference in nutritional needs and child malnutrition exist between the Upper West, Upper East, and Northern regions of Ghana that form the study area. In response to research question four, a respondent in the Upper West Region explained that *"the vegetation of northern Ghana may be the same but differences in climatic factors (seasonal weather variability) and soil quality play a major role. Because there are certain things that we can grow in Wa but not in Bolga and that of Tamale. Because of the high cost of standard of living some individuals cannot afforded certain food stuffs for children in Wa that we cannot grow. Hence, you may have a single meal repeated to provide three square meals a day".*

Similarly, a respondent in the Upper East Region was of the view that *"food and nutrition security and child malnourishment are quite different in the three northern regions of Ghana. The ability and availability of a particular food type to produce sufficient nutrient are not the same in all the three regions of northern Ghana. Soil types in these regions are dissimilar, especially in the Upper East Region. Most stem crops such as yams do well in the Northern Region than in the Upper East Region".* Also, a respondent in the Upper East Region stated that *"to a large extent the other two Regions (Upper West and Northern) have bushes (vegetation) and game that we do not have. Also, they grow crops that our soil does not support such as yam and cassava. So, they are able to sell these crops to purchase other nutritious ingredient that they do not produce to prepare nutritious meal for their children"* (See the soil map of Ghana: Appendix H).

CHAPTER SEVEN

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter discusses the key findings of the study with reference to the study objectives, research questions and hypotheses. Specifically, it presents the summary of research, key findings, conclusions, recommendations, contribution to knowledge, limitations of the study results and suggested areas for future research.

Summary of Research

Mainly, the thesis examined the causes and consequences of the regional differentials in child malnutrition and food and nutrition security in northern Ghana. Based on cross tabulation, discriminant, factor and linear regression analyses the study data were analyzed. The findings of the data analyses revealed that significant regional differences in child malnutrition and food and nutrition security exist between the Northern, Upper East and Upper West regions. Lack of/limited income and limited access to good food were found to be the main factors that account for child malnutrition in northern Ghana. Generally, the thesis recommended the improvement in both direct and indirect investment in community level education and infrastructural development, which is capable of improving the food and nutrition security and health status of affected children in the study area (northern Ghana) and in Ghana as whole.

Key Findings of the Study

Findings based on the research objectives

This section presents the findings of the study based on the research objectives as follows:

i. In respect of specific objective one (To analyze the observed differences in child malnutrition between the Upper East Region on one hand and the Northern and Upper West regions on the other between 1993 and 2008 GDHS periods), the study found that a 99.0 percent significant regional differentials in child malnutrition exists between the three regions of northern Ghana that form the study area. The canonical correlation coefficient of the regional differentials in child malnutrition is 0.434, which signifies that a 43.4 percent association exists between the discriminant variables child malnutrition and region. Relatedly, the coefficient of variability (R^2) of the discriminant model is 0.188, which implies that the independent variable (region) explains 18.8 percent variability in the dependent variable child malnutrition. The chi-square significance of this relationship is 0.001, which indicates that the observed differences in child malnutrition among the three northern regions of Ghana (Upper East, Upper West, and Northern) are not due to chance.

ii. With reference to specific objective two (To examine the impact of food and nutrition security on child malnutrition), the study found that the factor food and nutrition security exerts a positive statistical significant impact on child malnutrition in the study area. The statistical relationship between child malnutrition and food and nutrition security is established by the linear regression model: Child malnutrition = 1.516 + 0.099 (food and nutrition security).

iii. With regard to specific objective three (To analyze the spatial and statistical relationships that exist between selected child malnutrition factors and food and nutrition security), it came out that in all three northern Ghana regions the factors; limited access to good food (Northern: 33.3%, Upper East: 40.0%, and Upper West: 37.4%) and lack of/limited income (Northern: 23.2%, Upper East: 44.2%, and Upper West: 50.5%) form the two main factors that account for child malnutrition.

iv. In line with objective four (To assess the role of agriculture (food production in the attainment of food and nutrition security in northern Ghana), this study found that a 95.0 percent significant (significant value = 0.05) positive relationship exists between agricultural production (food production) and food and nutrition security. However, the strength of this statistical association (correlation coefficient = 0.178) is relatively weak.

This implies that agricultural production (food production) plays a moderate key role in the attainment and maintenance of food and nutrition security in the study area (northern Ghana). This is because food and nutrition security does not cover only food security, which agricultural production mainly measures but also the health and socio-economic wellbeing aspects of the affected population.

Findings based on the research questions

Table 49 summarizes the main responses and answers that were garnered from the structured interview of the study that covered mainly the research questions of the study.

Table 49. Research questions and answers

Research Questions	Answers
1. Why is the Upper East Region that has socio-economic, cultural, and spatial attributes similar to that of the Upper West and the Northern regions experienced persistent and increasing trend of child malnutrition between 1993 and 2008?	The general lack of or limited education, poverty (lack of/ or limited income), limited practice of exclusive breast feeding and poor child care account for the observed increases in child malnutrition in the Upper East Region over the past two decades. For instance, some of the respondents noted that "mothers in the Upper East Region do not breastfeed their children often. That is why their children are malnourished".

Source: Compiled from field data (Structured interview) (2014).

Table 49. Continued

Research Questions	Answers
2. Why is the Upper East Region, noted for the production of some of the most nutritious staple foods such as groundnuts, guinea corn/millet, and beans commonly used in the preparation of nutritious infants weaning food and children food is confronted with the problem of increasing child malnutrition among the three northern Ghana regions?	Limited knowledge of the importance of balanced diet was cited as one of the factors that largely contribute positively to the observed increases in child malnutrition in the Upper East Region. For instance, a respondent in the Upper East Region indicated that "even though groundnuts and beans are produced in the Upper East Region, small quantity is consumed among households and a chunk of it is sold for money. Unfortunately, Tou Zafi (one of the staple foods in northern Ghana) which is consumed by most families is prepared from millet and the soup also is prepared from the same millet".
3. Are there significant differences in ethnicity, traditional practices, cultural acceptability of food and food taboos practised among the people of the three northern Ghana regions?	There are no major differences in ethnicity, traditional practices and food taboos practiced among the three northern regions of Ghana. For instance, a respondent indicated that "not much difference exists between the three northern regions. Even our language is similar. We eat similar food stuffs and have similar taboos".

Source: Compiled from field data (Structured interview) (2014).

Table 49. Continued

Research Questions	Answers
4. Are there significant differences in the determinants of child malnutrition and food and nutrition security among the three northern regions of Ghana?	Difference in nutritional needs and child malnutrition exist between the Upper West, Upper East, and Northern regions of Ghana. For instance, a respondent in the Upper East Region was of the view that "nutrition security and child malnourishment are quite different in the three northern regions of Ghana. The ability and availability of a particular food type to produce sufficient nutrient are not the same in all the three regions of northern Ghana. Soil types in these regions are dissimilar, especially in the Upper East Region. Most stem crops such as yams do well in the Northern Region than in the Upper East Region".

Source: Compiled from field data (Structured interview) (2014).

Findings based on the research hypotheses

Findings of the research hypotheses is presented as follows:

i. Based on the review of the available literature this study tested the null hypothesis that a statistical significant negative relationship exists between food and nutrition security and child malnutrition. The result of the statistical analysis revealed that a 99.0 percent positive significant statistical relationship (significance value = 0.029) exists between child malnutrition (dependent variable) and food and nutrition security (independent variable). The coefficients (B statistics) of the resultant linear regression model demonstrate this relationship:

Child malnutrition = 1.516 + 0.099 (food and nutrition security) where the error term (e) is insignificant.

In respect of the resultant linear regression coefficients (B statistics), which indicate that a positive significant statistical relationship exists between the dependent variable child malnutrition and the independent variable food and nutrition security, this study does not retain the null hypothesis that a negative significant statistical relationship exists between child malnutrition and food and nutrition security. Rather, it retains the alternative hypothesis that a statistical significant negative relationship does not exist between food and nutrition security and child malnutrition in the study area.

ii. Secondly, the results of the linear regression analysis (Table 35, page 164) affirms the second null hypothesis that a statistical significant positive relationship exists between spatial attributes of selected northern Ghana communities and food and nutrition security. The coefficients of the resultant linear regression model (B statistics) and their respective significant values presented in Table 35 (page 164**)** confirm this observation. Statistically, the resultant linear regression model demonstrates that a 99.0 percent positive statistical significant relationship exists between the dependent variable food and nutrition security and the independent variable spatial attributes of community is presented as:

Food and nutrition security = 0.124 + 0.944 (spatial attribute of community) where the error term (e) is insignificant.

iii. In respect of the impact of the factors that account for child malnutrition in northern Ghana, this study tested the third null hypothesis that nutrition security exerts stronger statistical significant impact on child malnutrition than the health status of children under five. Based on the result of the multiple linear regression analysis [Child malnutrition = 1.496 -0.135 (spatial attribute of community) + 0.271 (food and nutrition security) – 0.080 (health status of children under five) where the error term (e) is considered insignificant], this study affirms the null hypothesis that the independent variable food and nutrition security exerts stronger statistical significant impact on child malnutrition (27.1%) than the health status of children under age five (8.0%).

iv. Finally, based on the significance level (99.0%) of the chi-square statistic (Under Wilks' Lambda statistics in Table 14, page 121) this study retains the fourth null hypothesis that a statistical significant spatial variability in child malnutrition exists between the Upper West, Upper East, and Northern regions of Ghana. This assertion is supported by the results of the canonical discriminant functions, which indicates that the overall discriminant analysis accounts for 18.8 percent variability in child malnutrition among the three northern regions of Ghana (Under Eigenvalues of the canonical discriminant functions in Table 14, page 121).

Conclusions

Based on the findings of the spatial and statistical analysis of the study and the review of the available literature the present study concludes that:

i. Significant regional differentials in child malnutrition exists among the three northern regions of Ghana (Upper West, Upper East, and Northern). Specifically, two main factors; limited access to good food and lack of/ limited availability of income account for the observed differentials in child malnutrition among the three northern regions of Ghana.

ii. Additionally, significant positive statistical relationship was observed between child malnutrition and food and nutrition security in the study area. Also, food and nutrition security is found to have a relatively higher impact on child malnutrition than the factors spatial attribute of community and health status of children under five in the study area.

Recommendations

Based on the study key findings and conclusions the following recommendations are made to the government of Ghana and all stakeholders (community leaders, local/district/municipal/metropolitan authorizes, and non-governmental organizations) in the quest for a plausible solution to the problems associated with child malnutrition and low food and nutrition security in northern Ghana for consideration and further action:

i. With regard to regional differences in child malnutrition and food and nutrition security, the study recommends that governmental and non-governmental projects and programmes that focus on improving the spatial attributes as well as the general well-being of communities in the study could be extended to cover all rural communities in northern Ghana, especially rural communities in the Upper East Region. This may be achieved through both direct and indirect investment in community level education, health, agricultural development as well as improvement in spatio-economic development infrastructure that largely characterize spatial attributes of communities.

ii. In respect of the findings on the analysis of the factor that most impacts child malnutrition in the study area, the study suggests that where limited resources are available to cater for the nutrition and health needs of affected communities in the study area, agencies (both governmental and non-governmental) responsible for the nutrition and health needs of the population could prioritize their programmes and projects. First, they could implement projects that cater for the food and nutrition security needs of the affected communities. This could be followed by projects that seek to improve and enhance the spatial attribute (development) and health status of children under five.

iii. Based on the observation that spatial variability in child malnutrition exists among the three northern regions of Ghana, the present study suggests that as part of the measures to achieving the Millennium Development Goals 1, 2, 4, 5 and 6 and the general aspiration of improving the standard of living, health and welfare of the people Ghana, particularly children the Government of Ghana (through the local/district/municipal/metropolitan assemblies) and her development partners could institute remedial measures including an inter-regional collaboration on food, nutrition and health security to help control the observed increases in child malnutrition in the study area, particularly in the Upper East Region. For instance, the World Food Programme, Ministry of Food and Agriculture, Ministry of Health and the NGFSRP in the three northern regions could work together to provide a collaborative lasting solution to the prevailing child malnutrition and food and nutrition insecurity in northern Ghana.

iv. With reference to the finding on the regional distribution of percent food and nutrition security and the role of agricultural production (food production) on the attainment and maintenance of food and nutrition security, the study recommends that the activities of the NGFSRP that promotes effective and intensive agricultural production including dry season gardening and the preparation and sale of nutritious infant and child food in the Upper West and Northern regions could be extended to cover the Upper East Region.

v. Based on the finding that a larger proportion of mothers interviewed in the study area have no education, the study suggests that current initiative by the governmental and non-governmental organizations that aim at improving school enrolment, increase school attendance rate and school completion rate such as the Free Compulsory Basic Education and the

School Feeding Programme could be intensified, particularly in the rural farming communities of northern Ghana. This could help school pupils and students attend and complete their various levels of education on schedule as well as help them contribute meaningfully to the developmental efforts of their local communities in particular and Ghana in general.

vi. With regard to the finding on the impact of food and nutrition security on child malnutrition and the health status of children in northern Ghana, the study advocates for the intensification and broadening of governmental and non-governmental nutrition and health projects and programmes, particularly child health and nutrition programmes to cover all rural communities of northern Ghana. For instance, the successes of the NGFSRP can be extended to cover rural communities in the Upper East Region that presents the worst case scenario of child malnutrition among the three northern regions of Ghana. With the involvement of the affected communities (community-based partner projects) the work of NGFSRP and other related organizations could cover basic training of mothers on child nutrition care and the preparation of nutritious infants and children food that is capable of helping children in the affected rural farming communities of northern Ghana to grow better and healthier. As a supplement to post-natal care, high nutritious food rations can be distributed by concerned child health and nutrition non-governmental projects to affected communities for a given period to help correct child malnutrition and other child growth related health disease that are common to children whose mothers do not attend post-natal clinic.

vii. With reference to the finding on the analysis of the major causes of child malnutrition in the three northern regions of Ghana this study recommends that government organizations (community health department of the GHS and district/municipal/metropolitan assemblies) responsible for child health and nutrition could implement child malnutrition intervention and remedial measures, which focus on the establishment and expansion of rural capacity building projects that aim at improving the incomes of mothers of affected communities, particularly farmers in the Upper East Region so as to help them have an improved access to income and good food, especially during the lean farming season. Additionally, the responsible government organizations could implement new projects or intensify already existing programmes and projects including the Ghana National Family Planning programme and Adolescent Reproductive Health projects that aim at discouraging teenage pregnancy, early marriage and early child birth. This is because, usually early child birth is associated with growth failure (faltering) and stunting in children with young mothers (Victora et al., 2010; Shrimpton, Cesar, de Onis, Lima, Blossner, & Clugston, 2001).

viii. As a means to forestall the limited accessibility to food that most developing countries face, the present study suggests that public work programmes could be initiated by affected district/municipal/metropolitan assemblies as part of the measures to improve food accessibility in the study area. Similarly, affected district/municipal/metropolitan assemblies could focus on the provision of social, transport and market infrastructure as well as access to improved wages that has the overall ability to provide the affected communities with efficient, reliable and affordable access to food. Finally, affected district/municipal/metropolitan assemblies could be focused on increasing the availability of irrigation facilities that relies relatively little on rainfall for the production of the needed food crops to forestall hunger, undernourishment and malnutrition.

Contribution to Knowledge

First, based on the results, findings and review of the available literature the study has contributed to the debate on the regional differential in child malnutrition and food and nutrition security in Ghana. Specifically, the study has isolated the main factors that account for child malnutrition in northern Ghana and has made recommendations to help address the observed regional differences in child malnutrition and food and nutrition security among the Upper East, Upper West and Northern regions that form the study area.

Second, the conceptual framework that guided the study could serve a guide for future and further studies where applicable. Also, the application of the co-registration technique in GIS allowed for the identification of study communities. The resultant maps that show the location of selected study communities could serve as base maps for future studies in the study area.

Third, the study does not suggest a major modification or revision of the study conceptual framework (Figure 8, page 67), except where other relevant variables are required to help future studies examine the full impact of food and nutrition security on child malnutrition in Ghana and in the study area in particular.

Areas for Future Research

Based on the findings of the study and the review of available literature on child malnutrition and food and nutrition security the present study suggests that for further and future research on child malnutrition and food and nutrition security other relevant variables that measure the clinical aspect of child health and nutrition (assessment of the thyroid, blindness and hemoglobin levels) be considered. The inclusion of these variables in future studies could improve the proportion of variability in child malnutrition explained by linear regression models of similar studies.

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Appendix A

Data Collection Instruments

UNIVERSITY OF CAPE COAST
School of Graduate Studies and Research

Questionnaire No.…Reg./Mt./Mn./Dist…………Locality………….House #.........

Informed Consent:

This questionnaire is administered to solicit information about the characteristics of mothers and the health and nutritional characteristics of their children under age five. Any information provided shall be treated confidential and would be used solely for the writing of student dissertation in the Department of Geography and Regional Planning, University of Cape Coast. Thank you.

SECTION A: Identification of respondents that have malnourished children.

INSTRUCTION (**Research Caveat):** In order to identify mothers whose children are malnourished the interviewer is supposed to first indicate if the prospective respondent have a child under age five. Second, note the age (months) and height (cm) of the child on a separate piece of paper. Calculate the height for age ratio of the child concerned to find out if the child is malnourished. If the child is found to be malnourished record the Height (cm)………………… and Age (months)………………of the child and proceed to complete question 1.

DO NOT inform the respondent that her child is malnourished. If the child is found **NOT** to be malnourished thank the respondent and move on to another respondent.

1. Based on the NCHS/CDC/WHO reference population guide for the determination of child malnutrition is the child of the respondent: a. Stunted b. Severely stunted

SECTION B: Socio-demographic characteristics of mothers and children.

MOTHERS

2. Indicate the highest level of education you have attained:
   a. No education
   b. Some/Uncompleted primary education
   c. Completed primary education
   d. Some/Uncompleted junior secondary/middle school education
   e. Completed junior secondary/middle school education
   f. Some/Uncompleted senior secondary/secondary school/Technical/ Vocational education

g. Completed senior secondary/secondary school/Technical/Vocational education
h. Some/Uncompleted Teacher/Nursing training and other related fields education
i. Completed Teacher/Nursing training and other related fields education
j. Some/Uncompleted Tertiary education (Universities and Polytechnics and their equivalents)
k. Completed Tertiary education (Universities and Polytechnics and their equivalents)

3. Indicate the type of occupation that your are engaged in:
a. Farming
b. Government work
c. Private work (remuneration for any work done other than government work and farming)
d. None above

4. Do you earn regular income by the type of occupation you indicated in question 3? a. Yes b. No

5. If Yes to question 4 in a typical month, how much do you earn for this work? GH¢ ....

6. Indicate the major ethnic group that you belong to:
a. Akan
b. Ga/Adangbe
c. Ewe
d. Guan
e. Mole-Dagbani
f. Grussi
g. Gruma
h. Hausa

7. How old are you (in completed years)? ………………………………

8. Indicate the sex of your child:
a. Male b. Female

9. Currently, how many children do you have?...

10. Currently, are you pregnant?
a. Yes b. No

SECTION C: Spatial attributes of the study community.

Questions 11-21: Does the community in which you reside have the following facilities and attributes?

11. Markets
 a. Yes b. No
12. Community level food storage facilities for farmers
 a. Yes b. No
13. Roads that are motorable during the raining season
 a. Yes b. No
14. Vehicles to transport food produce and humans
 a. Yes b. No
15. Schools: at least a primary school
 a. Yes b. No
16. Regular wet and dry seasons
 a. Yes b. No
17. Experience longer periods of severe drought situation
 a. Yes b. No
18. Experience longer periods of flood situation
 a. Yes b. No
19. Indicate the general quality of the soil available for farming
 a. Poor b. Good c. Best
20. Indicate the proportion of arable land available
 a. Large b. Medium c. Small
21. Is a larger proportion of the population:
 a. Farmers b. Govt. workers c. Private workers
22. Generally, do food stocks available to your household run out before the next harvesting period?
 a. Yes b. No

SECTION D: Nutrition security, health status, and spatio-economic development characteristics.

FEMALE FARMERS (MOTHERS)

Questions 23-31: Pose these questions to respondents that indicated that farming (Q3) is their main occupation.

23. Indicate the major crop that you produce:
 a. Grain (corn, rice, millet/sorghum)
 b. Beans
 c. Groundnut
 d. Yam
 e. Vegetables
 f. Mixed produce

24. If you are a grain farmer in a typical good farming season how many bags of grains do you produce ?……………………………………………………

25. Judging your current grain output with that of the past 5 years indicate whether your total grain production has been:
a. Increasing b. decreasing c. staggering

26. If you are a beans farmer in a typical good farming season how many bags of beans do you produce? …………………………………………………

27. Judging your current beans output with that of the past 5 years indicate whether your total beans production has been:
a. Increasing b. decreasing c. staggering

28. If you are a groundnut farmer in a typical good farming season how many bags of groundnuts do you produce?..…………………………

29. Judging your current groundnut output with that of the past 5 years indicate whether your total groundnut production has been:
a. Increasing b. decreasing c. staggering

30. If you are a yam farmer in a typical good farming season how many tubers of yam do you produce?. ……………………………………………

31. Judging your current yam output with that of the past 5 years indicate whether your total yam production has been:
a. Increasing b. decreasing c. staggering

BREASTFEEDING AND CHILD NUTRITION

32. Currently, are you breastfeeding your child? a. Yes b. No

33. If Yes (to question 32), how many months have you breastfed your child?.

34. Generally, how many times do you breastfeed your child daily?................

35. Have you weaned your child? a. Yes b. No

36. If Yes at what age did you wean your child……………………………….

37. If Yes (to question 35) state the most common type of weaning food you give to your child:………………………………………………………..

38. If No (to question 35) have you started given your child supplementary food such as baby instant milk formula in addition to breast feeding?
a. Yes b. No

39. If Yes (to question 37) at what age (child) did you introduced supplementary feeding:…………………...

40. Have you attended post-natal clinic with your child for your child to be immunized? a. Yes b. No

41. During the post-natal clinic visit was your child given micro-nutrient supplements (vitamins/minerals)? a. Yes b. No

42. Indicate the most important factor that contributes to child malnutrition in your locality: a. Poor child care b. Limited access to good food (quantity and quality) c. Lack of income d. Lack of health care facility e. Limited access to good drinking water f. Poor sanitary environment g. Mothers' limited access to child knowledge based care and education h. High cultural acceptability of non-nutritious foods i. Poor breastfeeding practices j. Poor weaning practices k. Some negative religious practices l. Some negative cultural/traditional practices

HEALTH, SANITATION, AND DEVELOPMENT

43. Does your community have any health care facility available (at least a primary health care facility)? a. Yes b. No

44. Do you have regular access to potable water? a. Yes b. No

45. Do residents of your community practice good sanitation practices (at least periodic communal labour)?
a. Yes b. No

46. Does your community have a designated garbage disposal sites (good sanitation)? a. Yes b. No

47. In your opinion, for the past 10 years, has the provision of spatial infrastructure development such as schools, manufacturing firms and markets increased? a. Yes b. No

48. In your opinion, for the past 10 years, have spatial infrastructure developments such as schools, manufacturing firms and markets been rehabilitated or expanded? a. Yes b. No

49. In your opinion, for the past 10 years, has there been an increase in local productivity, economic growth and income? a. Yes b. No

50. In your opinion, for the past 10 years, has there been an improvement in the standard of living (social wellbeing) of the residents of this community? a. Yes b. No

Thank you for your cooperation.

UNIVERSITY OF CAPE COAST

School of Graduate Studies and Research

STRUCTURED INTERVIEW GUIDE

Int.Gd. No…….Reg./Mt./Mn./Dist…..……….Locality…………House #…...

Informed Consent:

This interview is being organized to solicit information about the characteristics of mothers and the health and nutritional characteristics of their children under age five. Any information provided shall be treated confidential and would be used solely for the writing of student dissertation in the Department of Geography and Regional Planning, University of Cape Coast. Thank you.

Question 1:

In your opinion why is the Upper East region that has socio-economic, cultural, and spatial attributes similar to that of the Upper West and Northern regions for the past 15 years (1993-2008) have experienced an increasing trend in child malnutrition while the observed trend have changed in the past five years (2003-2008) in favour of decreasing child malnutrition trend in the Upper West and Northern regions?

Question 2:

Kindly explain why the Upper East region, noted for the production of some of the most nutritious staple foods such as groundnuts, guinea corn/millet, and beans commonly used in the preparation of nutritious infants weaning food and children food is confronted with the problem of increasing child malnutrition among the three regions of northern Ghana?

Question 3:

Are there major differences in ethnicity, traditional practices, cultural acceptability of food and food taboos practiced among the people of the three northern regions? Kindly explain these major differences and their possible effect on the nutrition and health statuses of the people in these three regions of northern Ghana.

Question 4:

To what extent are nutrition security needs and the problem of child malnutrition different among the three regions of northern Ghana?

Nutritional Status of Children by NCHS/CDC/WHO International Reference Population

Age group (months)	Height (cm) for Age (months)		
	-3 SD (Severely Stunted)	-2 SD (Stunted)	Mean Z Score of Reference Population (Normal or No Stunting)
Less than 6	0.0	0.8	0.5
6-8	1.7	5.7	0.0
9-11	4.2	11.9	-0.03
12-17	5.9	21.2	-0.08
18-23	10.3	38.3	-1.4
24-35	8.6	22.4	-1.1
36-47	11.8	29.5	-1.2
48-59	8.5	28.7	-1.2

Source: Ghana Statistical Service (2009): 2008 GDHS Report, Accra

Selected variables that measure food and nutrition security

No.	**Variables**
1	Mother's educational level
2	Mother's ethnicity
3	Mother's age
4	Mothers' occupation
5	Mother's earned income
6	Number of children per mother
7	Communities spatial attributes (market)
8	Communities spatial attributes (communal food storage facility)
9	Communities spatial attributes (motorable roads)
10	Communities spatial attributes (vehicles)
11	Communities spatial attributes (primary school)
12	Communities spatial attributes (regular wet and dry season)
13	Communities spatial attributes (quality of soil for farming)
14	Communities spatial attributes (availability of arable land)
15	Communities spatial attributes (major occupation of members of the community)
16	Communities spatial attributes (availability of food stock all year round)
17	Community facilities (primary health care)
18	Community members practise good sanitation
19	Community access to good/potable drinking water
20	Availability of community garbage disposal site.

Source: Compiled by the author (2015).

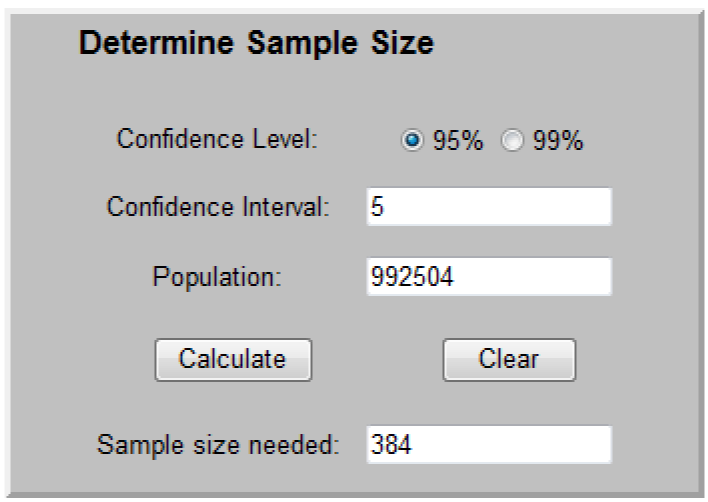
Appendix B

Geo-statistical Measuring Instruments

Sample size calculator

[http://www.surveysystem.com/sample-size-formula.htm 22/03/2013](http://www.surveysystem.com/sample-size-formula.htm)

Creative Research Systems
15 Lone Oak, Suite 2
Petaluma CA 94952
Tel: (707) 765-1001



Sample Size Formulas for our Sample Size Calculator

Here are the formulas used in our Sample Size Calculator:

Sample Size

$$ss = \frac{Z^2 * (p) * (1-p)}{c^2}$$

Where:

Z = Z value (e.g. 1.96 for 95% confidence level)
p = percentage picking a choice, expressed as decimal
(.5 used for sample size needed)
c = confidence interval, expressed as decimal
(e.g., .04 = ±4)

Correction for Finite Population

$$\text{new ss} = \frac{\text{ss}}{1 + \dfrac{\text{ss-1}}{\text{pop}}}$$

Where: pop = population

CONDITIONS OF USE FOR MEASURE DHS GEOGRAPHIC DATASETS

http://www.measuredhs.com/data/dataset_admin/create-new-project.cfmA 9/11/2012

Conditions of Use for MEASURE DHS Geographic datasets:

Please read and accept the Conditions of Use for MEASURE DHS Geographic datasets:

Conditions of Use:

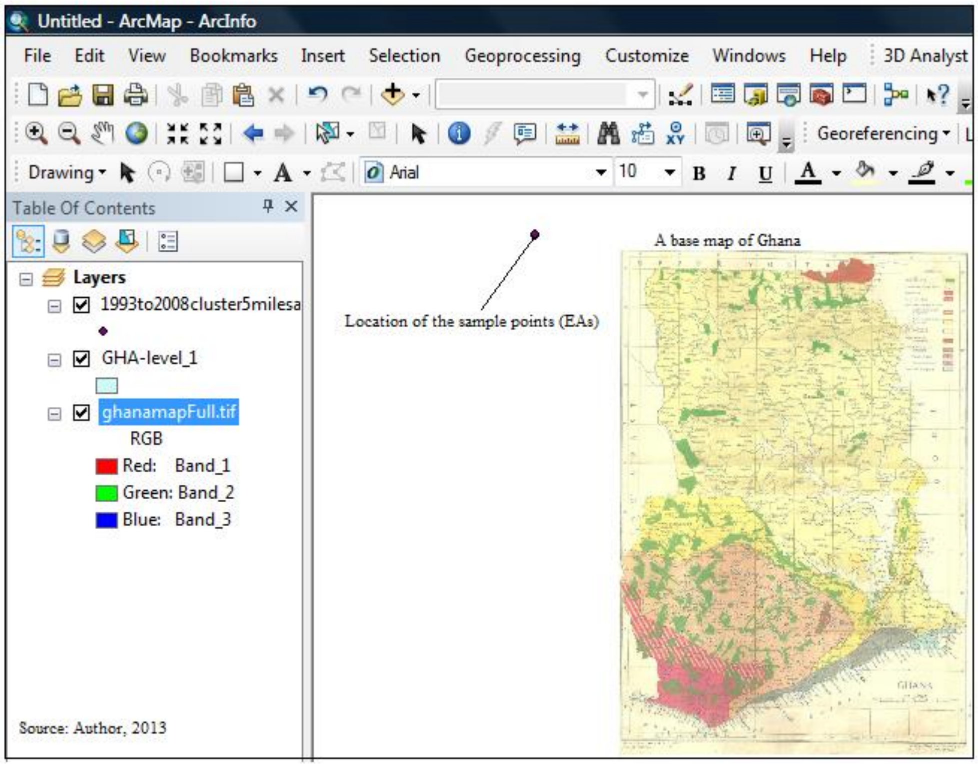
1. **No attempt will be made to identify or contact survey respondents.**
2. **No results will be published where communities or individuals can be identified.**
3. **The data will be kept on a secure computer where they cannot be accessed by unauthorized users.**
4. **The data will not be used for any purpose other than the above study.**
5. **The data will not be released to anyone other than the above listed researchers without the prior approval of ICF Macro.**
6. **The data will not be used for any marketing activity.**
7. **The use of the data by researchers in the United States will comply with the USAID Regulations for Protection of Human Research Subjects (22 CFR 225); and use of the data by researchers outside of the United States will comply with the Declaration of Helsinki and/or the International Ethical Guidelines of the Council of International Organizations of Medical Sciences for Biomedical Research Involving Human Subjects.**
8. **Users are requested to submit an electronic or hard copy of any reports/publications resulting from using the DHS data files.**

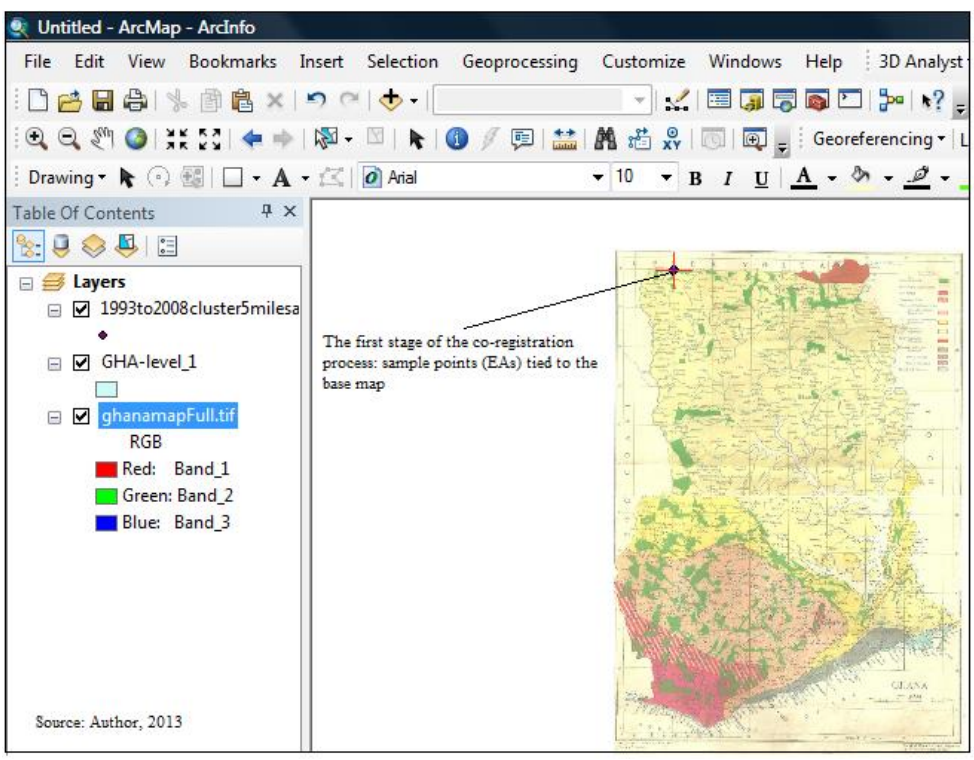
Please enter your password(case sensitive):

I Accept the Conditions of Use

Geo-Registration

Co-registration**:** An overlapping boundary between the base map and a map of Ghana showing the distribution of EAs clusters





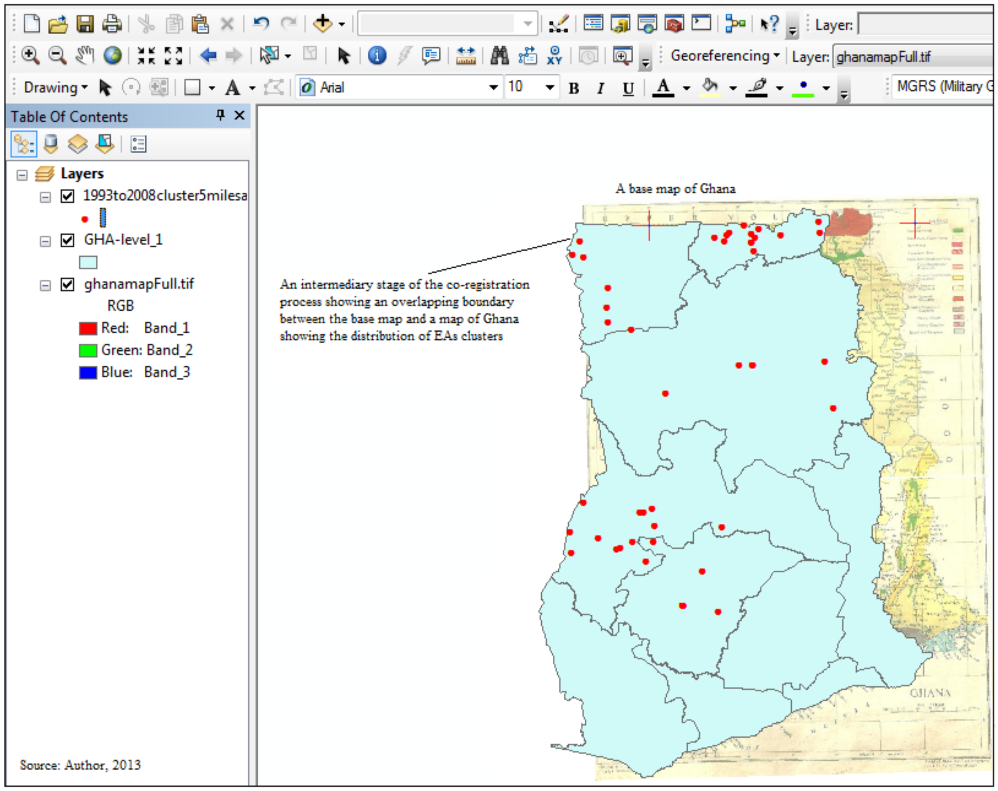
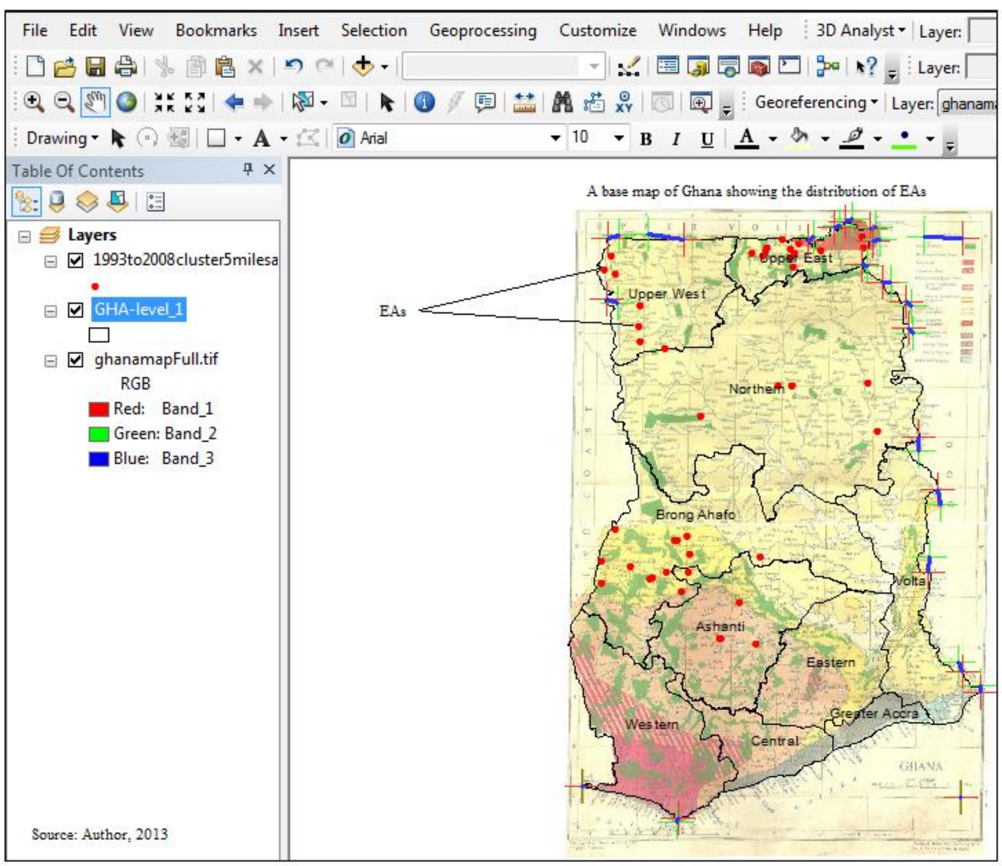
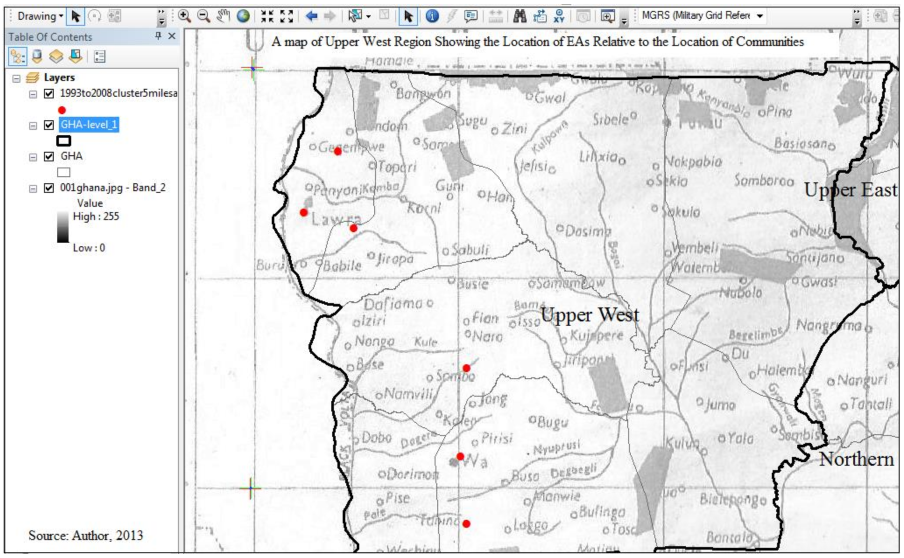
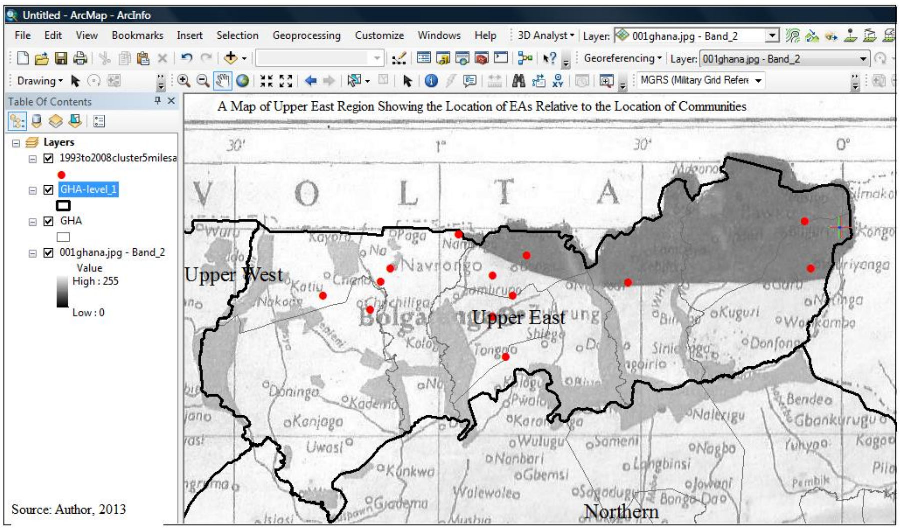
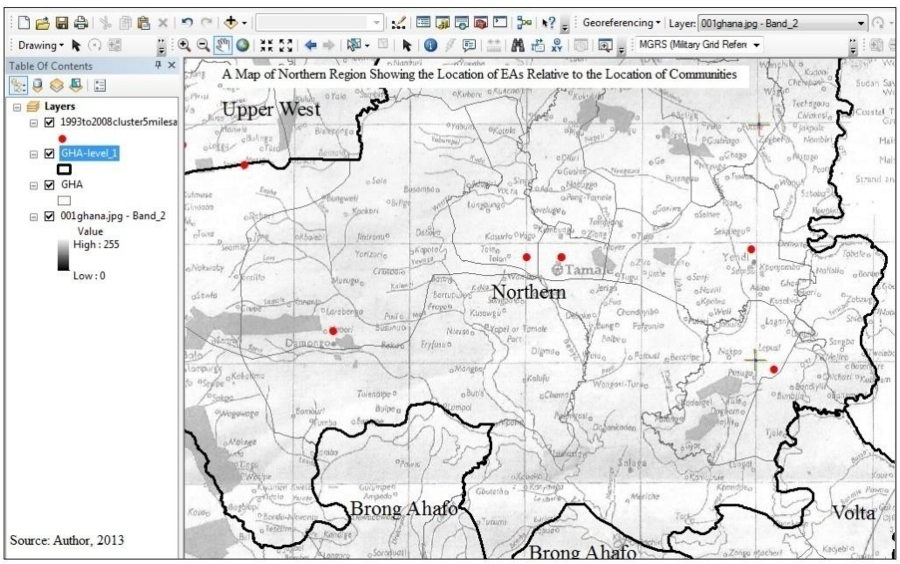


Table Of Contents
Layers
1993to2008cluster5milesa
GHA-level_1
ghanamapFull.tif
RGB
Red: Band_1
Green: Band_2
Blue: Band_3
A base map of Ghana
An intermediary stage of the co-registration process showing an overlapping boundary between the base map and a map of Ghana showing the distribution of EAs clusters
Source: Author, 2013

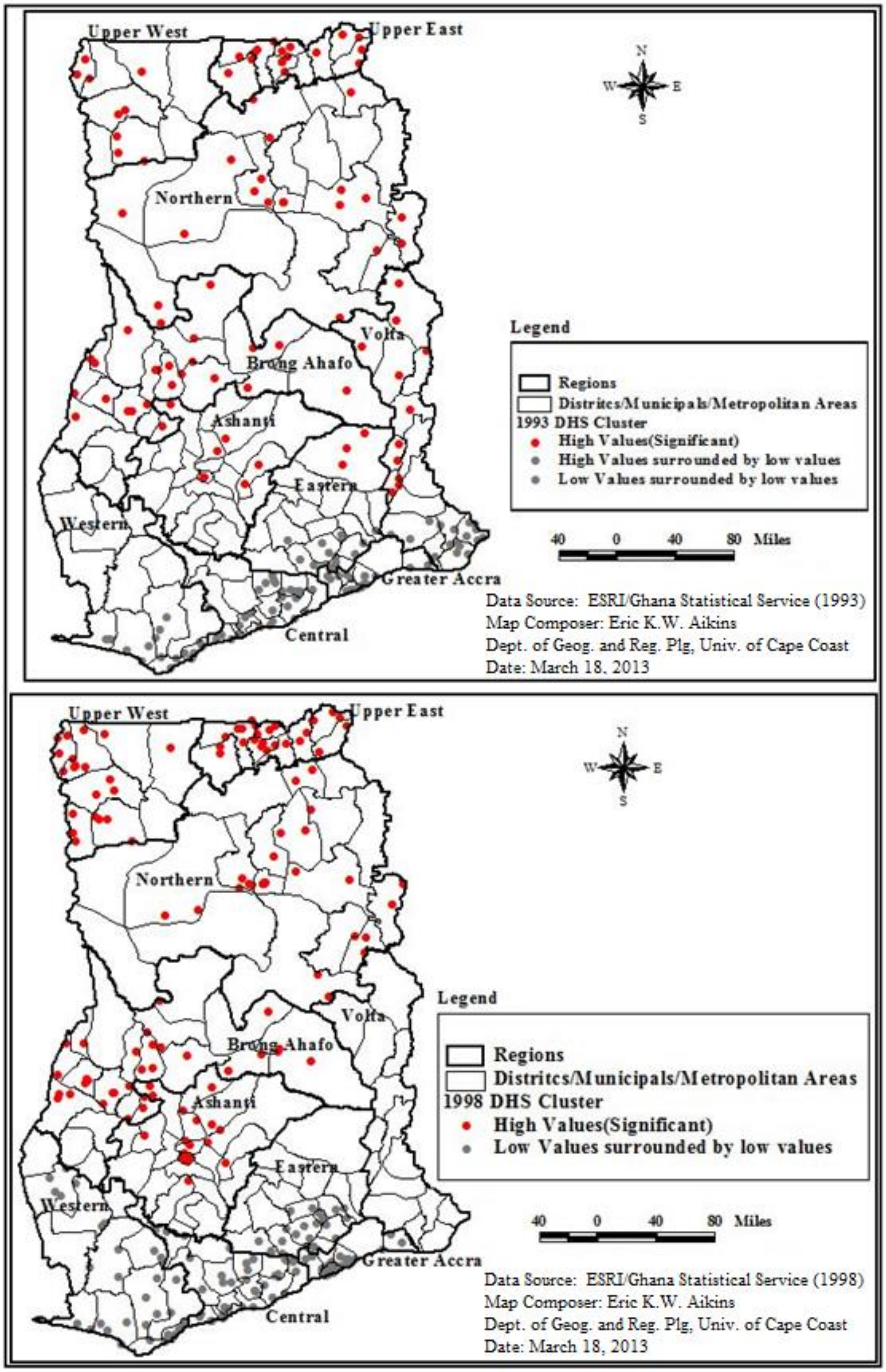

File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Table Of Contents
Layers
1993to2008cluster5milesa
GHA-level_1
ghanamapFull.tif
RGB
Red: Band_1
Green: Band_2
Blue: Band_3
A base map of Ghana showing the distribution of EAs
EAs
Upper East
Upper West
Northern
Brong Ahafo
Volta
Ashanti
Eastern
Greater Accra
Western
Central
Source: Author, 2013


A map of Upper West Region Showing the Location of EAs Relative to the Location of Communities
Upper West
Upper East
Northern
Source: Author, 2013


A Map of Upper East Region Showing the Location of EAs Relative to the Location of Communities
Upper West
Upper East
Northern
Source: Author, 2013

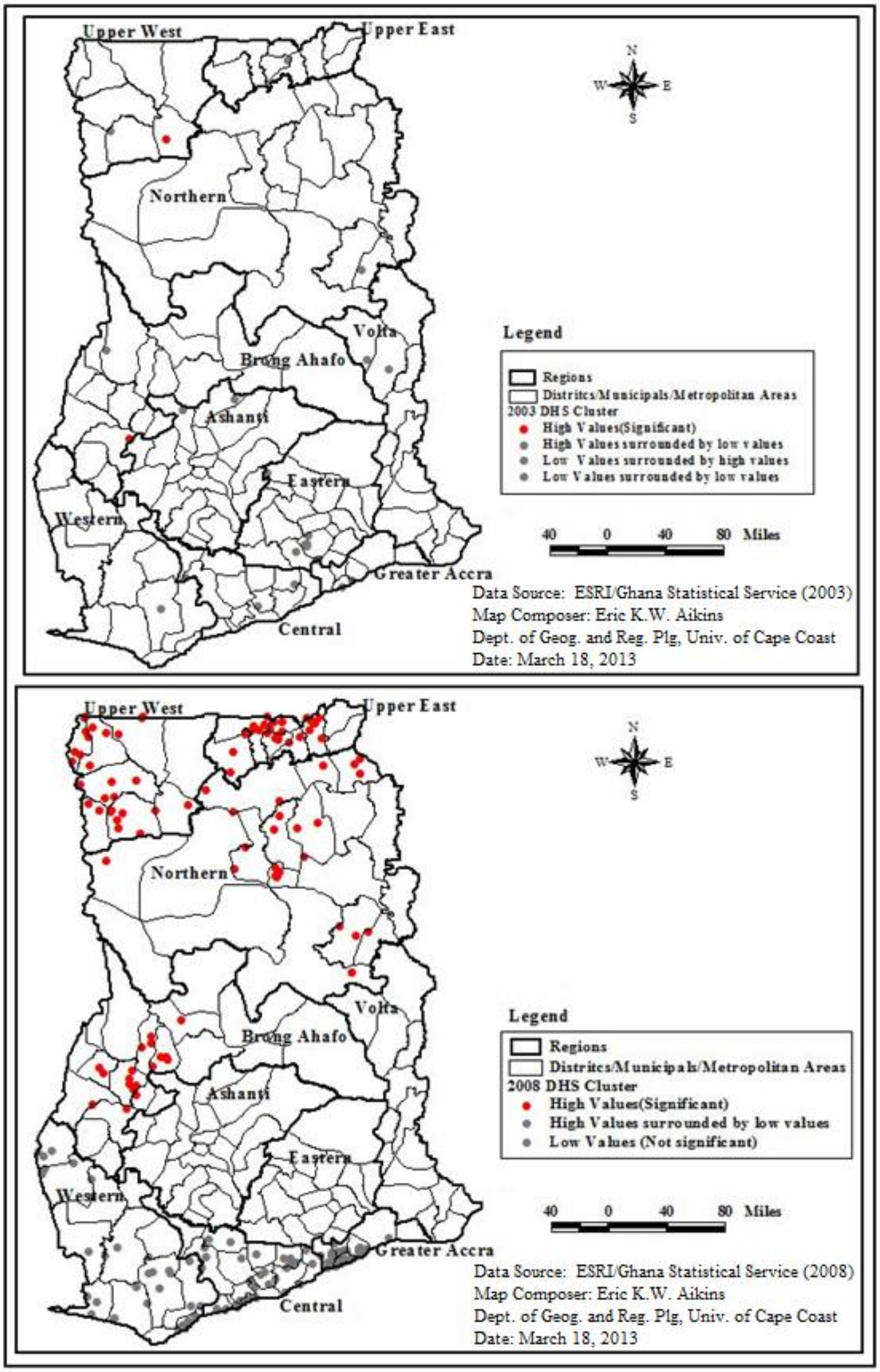

A Map of Northern Region Showing the Location of EAs Relative to the Location of Communities
Upper West
Northern
Brong Ahafo
Volta
Source: Author, 2013

A map of Ghana showing the spatial distribution of EAs clusters



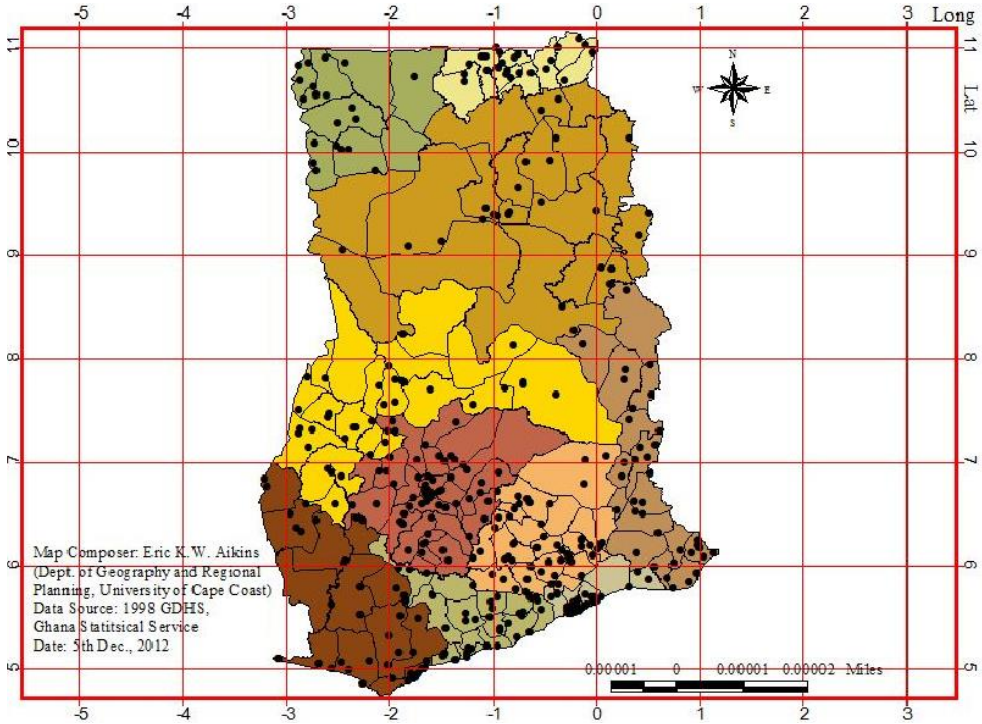
Source: Author (2013).

A map of Ghana showing the spatial distribution of EAs clusters



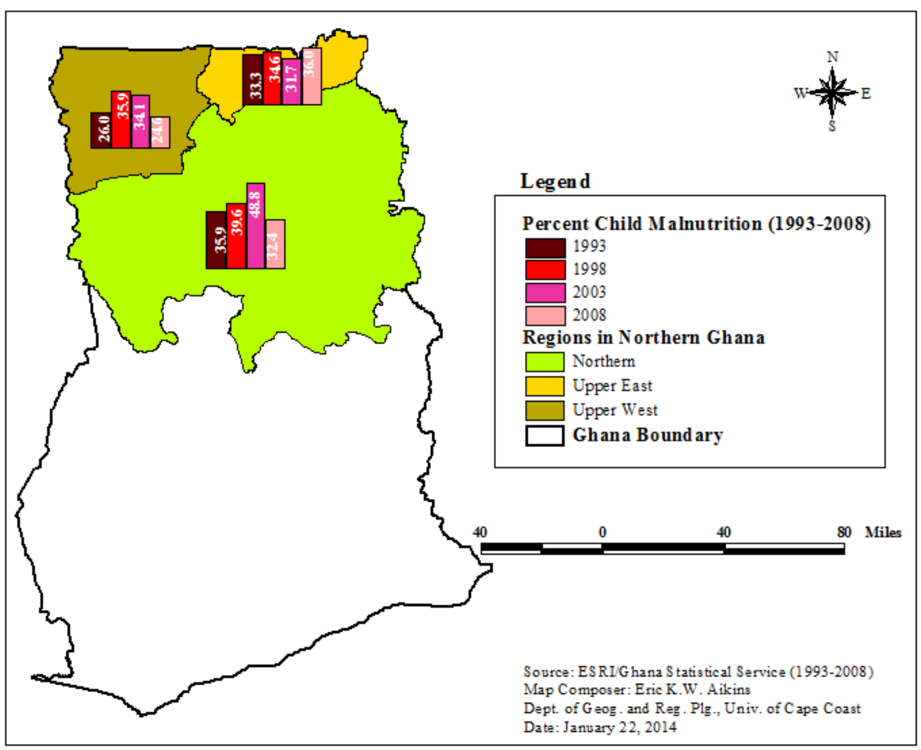
Source: Author (2013).

Geo-locations of selected EAa in northern Ghana



Source: Author (2014).

A map of Ghana showing the percent distribution of child malnutrition by Northern Ghana Regions

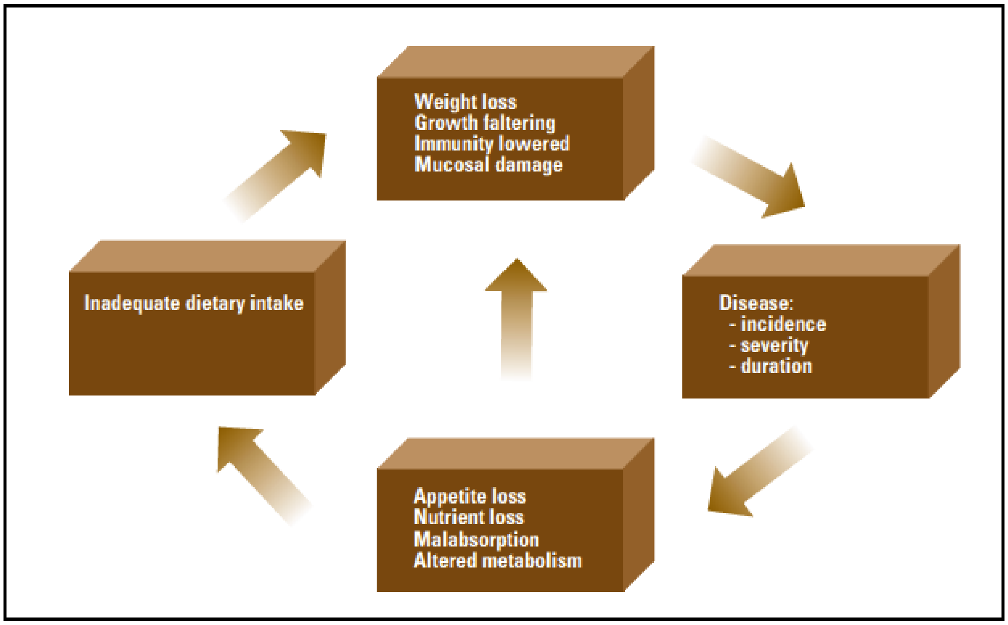


Source: Author (2014).

Appendix C

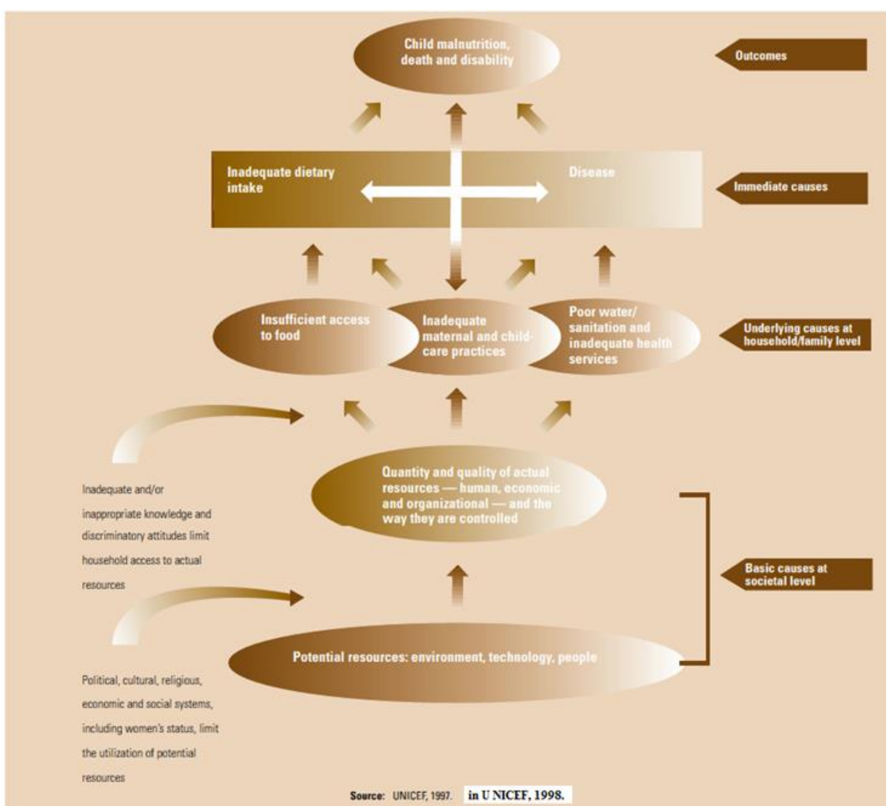
Other Frameworks of Food and Nutrition Security and Child Malnutrition

Inadequate dietary intake/disease cycle



Source: Andrew Tomkins and Fiona Watson, Malnutrition and Infection, ACC/SCN, Geneva, 1989. **in UNICEF, 1998.**

The causes of Child Malnutrition



Panel 4

Recognizing the right to nutrition

Nutrition has been expressed as a right in international human rights instruments since 1924. Among these are *declarations*, which are non-binding, and *conventions* and *covenants*, which are treaties carrying the force of law.

Some of these human rights milestones are noted below.

1924: Declaration of the Rights of the Child (also known as the Declaration of Geneva). Adopted after World War I by the League of Nations through the efforts of British child rights pioneer Eglantyne Jebb, the Declaration marks the beginning of the international child rights movement and is also the first international affirmation of the right to nutrition. The Declaration affirms that "the child must be given the means needed for its normal development, both materially and spiritually" and states that "the hungry child should be fed."

1948: Universal Declaration of Human Rights. This human rights landmark, adopted by the United Nations General Assembly, proclaims in article 25 that "everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services . . . ." This article also affirms that "motherhood and childhood are entitled to special care and assistance."

1959: Declaration of the Rights of the Child. Adopted unanimously by the United Nations General Assembly, the Declaration states in principle 4 that children "shall be entitled to grow and develop in health" and that children "shall have the right to adequate nutrition, housing, recreation and medical services."

1966: International Covenant on Economic, Social and Cultural Rights. Adopted by the United Nations and ratified by 137 States as of mid-September 1997, this Covenant was the first to spell out States' obligations to respect people's economic, social and cultural rights. Article 11 affirms the right of everyone to an adequate standard of living, including adequate food, and the "fundamental right of everyone to be free from hunger." The Covenant also mandates States parties to take steps to realize this right, including measures "to improve methods of production, conservation and distribution of food."

1986: Declaration on the Right to Development. Article 1 of the Declaration, which was adopted by the United Nations General Assembly, proclaims that the right to development "is an inalienable human right," with all people entitled to participate in and enjoy economic, social, cultural and political development "in which all human rights and fundamental freedoms can be fully realized." Article 8 calls for all States to ensure equal opportunity for all in access to health services and food.

1989: Convention on the Rights of the Child. The most widely ratified human rights treaty, the Convention establishes as international law all rights to ensure children's survival, development and protection. Article 24 mandates States parties to recognize children's right to the "highest attainable standard of health" and to take measures to implement this right. Among key steps, States are mandated to provide medical assistance and health care to all children, with an emphasis on primary health care; combat disease and malnutrition, within the framework of primary health care, through the provision of adequate nutritious foods, and safe drinking water and adequate sanitation; and provide families with information about the advantages of breastfeeding.

Ratifications: 191 States as of mid-September 1997, with only two countries — Somalia and the United States — yet to ratify.

1990: World Declaration and Plan of Action on the Survival, Protection and Development of Children. The unprecedented numbers of world leaders attending the World Summit for Children committed themselves to "give high priority to the rights of children" in the Summit's World Declaration. The Summit's Plan of Action set out the steps in 7 major and 20 supporting goals for implementing the Declaration. Reducing severe and moderate malnutrition by half of 1990 levels among under-five children by the end of the century is the main nutrition goal.

The 7 supporting nutrition goals are: reduction of low-weight births to less than 10 per cent of all births; reduction of iron deficiency anaemia in women by one third of 1990 levels; virtual elimination of iodine deficiency disorders; virtual elimination of vitamin A deficiency; empowerment of all women to exclusively breastfeed their children for about the first six months; institutionalization of growth monitoring and promotion; and dissemination of knowledge and supporting services to increase food production to ensure household food security.

Source: UNUCEF, 1998

Appendix D

The Millennium Development Goals (MDGs)

Table 1. How investing in nutrition is critical to achieving the Millennium Development Goals (MDGs)

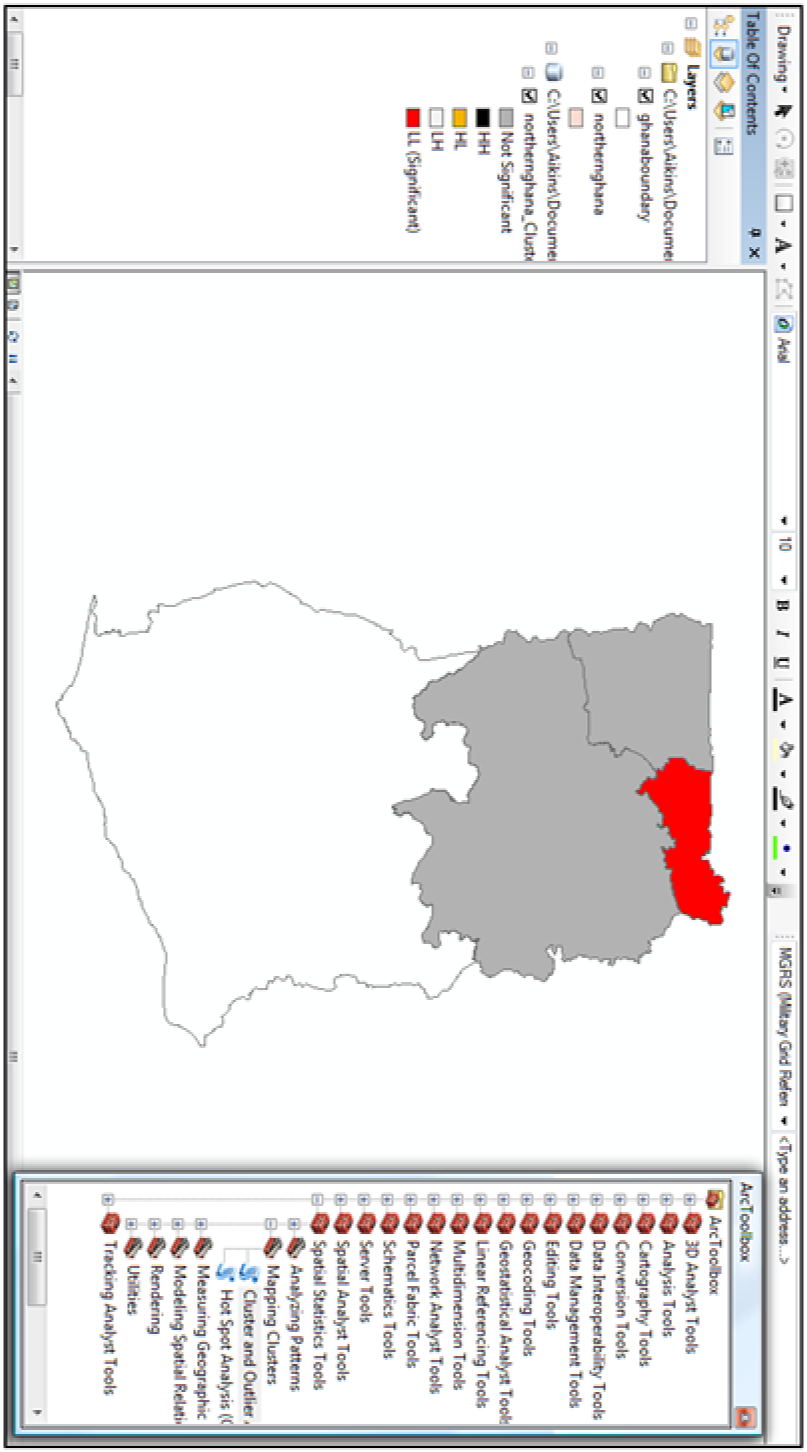
Goal	**Nutrition effect**
Goal 1: Eradicate extreme poverty and hunger.	Malnutrition erodes human capital through irreversible and intergenerational effects on cognitive and physical development.
Goal 2: Achieve universal primary education.	Malnutrition affects the chances that a child will go to school, stay in school, and perform well.
Goal 3: Promote gender equality and empower women.	Anti-female biases in access to food, health, and care resources may result in malnutrition, possibly reducing women's access to assets. Addressing malnutrition empowers women more than men.
Goal 4: Reduce child mortality.	Malnutrition is directly or indirectly associated with most child deaths, and it is the main contributor to the burden of disease in the developing world.
Goal 5: Improve maternal health.	Maternal health is compromised by malnutrition which is associated with most major risk factors for maternal mortality. Maternal stunting and iron and iodine deficiencies particularly pose serious problems for mothers and children.
Goal 6: Combat HIV/AIDS, malaria, and other diseases.	Malnutrition may increase risk of HIV transmission, compromise antiretroviral therapy, and hasten the onset of full-blown AIDS and premature death. It increases the chances of tuberculosis infection resulting in disease, and it also reduces malarial survival rates.

Source: Gillespie and Haddad (2003) and Ghana Health Service (2012).

Appendix E

Cluster Sampling

Spatial Cluster



Source: Author (2014).

How Cluster and Outlier Analysis (Anselin Local Moran's I) works
ArcGIS 10 (Help Tool)

Given a set of weighted features, the Cluster and Outlier Analysis tool identifies spatial clusters of features with attribute values similar in magnitude. The tool also identifies spatial outliers. To do this, the tool calculates a local Moran's I value, a z-score, a p-value, and a code representing the cluster type for each feature. The z-scores and p-values represent the statistical significance of the computed index values.

Calculations

statistical significance of the computed index values.

Calculations

The Local Moran's I statistic of spatial association is given as:

$$I_i = \frac{x_i - \bar{X}}{S_i^2} \sum_{j=1, j \neq i}^{n} w_{i,j}(x_i - \bar{X}) \qquad (1)$$

where x_i is an attribute for feature i, $\bar{X}$ is the mean of the corresponding attribute, $w_{i,j}$ is the spatial weight between feature i and j, and:

$$S_i^2 = \frac{\sum_{j=1, j \neq i}^{n} w_{ij}}{n-1} - \bar{X}^2 \qquad (2)$$

with n equating to the total number of features.

The z_{I_i}-score for the statistics are computed as:

$$z_{I_i} = \frac{I_i - \mathrm{E}[I_i]}{\sqrt{\mathrm{V}[I_i]}} \qquad (3)$$

where:

$$\mathrm{E}[I_i] = -\frac{\sum_{j=1, j \neq i}^{n}}{n-1} \qquad (4)$$

$$\mathrm{V}[I_i] = \mathrm{E}[I_i^2] - \mathrm{E}[I_i]^2 \qquad (5)$$

Source: ESRI, ArcMap (version 10.0) help tool. Accessed (2014).

Interpretation

A positive value for I indicates that a feature has neighboring features with similarly high or low attribute values; this feature is part of a cluster. A negative value for I indicates that a feature has neighboring features with dissimilar values; this feature is an outlier. In either instance, the p-value for the feature must be small enough for the cluster or outlier to be considered statistically significant. For more information on determining statistical significance, see What is a z-score? What is a p-value? Note that the local Moran's I index (I) is a relative measure and can only be interpreted within the context of its computed z-score or p-value.

The output field, cluster/outlier type (COType), distinguishes between a statistically significant (0.05 level) cluster of high values (HH), cluster of low values (LL), outlier in which a high value is surrounded primarily by low values (HL), and outlier in which a low value is surrounded primarily by high values (LH).

Appendix F

Descriptives Statistics

Table 1. **Descriptives Statistics: Description of variables**

Variables	Mean	Median	Std. Deviation	Skewness	Kurtosis
Malnutrition Status	1.54	2.00	0.50	-0.15	-2.03
Communities Spatial Attributes (Market)	1.39	1.00	0.49	0.45	-1.84
Communities Spatial Attributes (Communal food storage facility)	1.70	2.00	0.46	-0.90	-1.22
Communities Spatial Attributes (Motorable Roads)	1.49	1.00	0.50	0.05	-2.05
Communities Spatial Attributes (Vehicles)	1.45	1.00	0.50	0.19	-2.01
Communities Spatial Attributes (Atleast Primary School)	1.01	1.00	0.11	9.17	84.00
Communities Spatial Attributes (Quality of soil for farming)	1.64	2.00	0.48	-0.61	-1.67
Communities Spatial Attributes (Communal Availability of Arable land)	13.8	2.00	108.79	9.16	83.99
Communities Spatial Attributes (Major Occupation of members of the community)	13.3	1.00	108.84	9.16	83.99
Communities Spatial Attributes (Availability of food stock all year round)	25.1	1.00	153.00	6.36	39.40
Major Crops that Farmers Grow	418.5	6.00	493.53	0.34	-1.93
Major Child Malnutrition Factor	3.44	3.00	2.05	2.01	3.69
Community Facilities (at least Primary Health Care)	1.37	1.00	0.49	0.55	-1.74

Source: Author (2014).

Table 1: Cont'd

Variable	Mean	Median	Std. Deviation	Skewness	Kurtosis
		Descriptives Statistics			
Community Access to Good/Potable Drinking Water	13.07	1.00	108.87	9.16	84.00
Community Members Practice Good Sanitation	1.25	1.00	0.44	1.18	-0.63
Community Garbage Disposal Site	1.56	2.00	0.50	-0.24	-1.99
Provision of Spatial Infrastructure/Development (Past 10 years)	13.31	1.00	108.84	9.16	84.00
Rehabilitation of Spatial Infrastructure (Past 10 years)	13.40	2.00	108.83	9.16	84.00
Increase in Local Productivity, Econ. Growth and Income (Past 10 years)	1.51	2.00	0.50	-0.05	-2.05
Improvement in Standard of Living/Social Wellbeing (Past 10 years)	1.55	2.00	0.50	-0.19	-2.01

Source: Author (2014).

Variables	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Malnutrition Status	0.358	84	0.000	0.635	84	0.000
Communities Spatial Attributes (Market)	0.395	84	0.000	0.620	84	0.000
Communities Spatial Attributes (Market)	0.395	84	0.000	0.620	84	0.000
Communities Spatial Attributes (Communal food storage facility)	0.444	84	0.000	0.574	84	0.000
Communities Spatial Attributes (Vehicles)	0.364	84	0.000	0.633	84	0.000
Communities Spatial Attributes (Vehicles)	0.364	84	0.000	0.633	84	0.000
Communities Spatial Attributes (At least Primary School)	0.532	84	0.000	0.086	84	0.000
Communities Spatial Attributes (Quality of soil for farming)	0.413	84	0.000	0.606	84	0.000
Communities Spatial Attributes (Communal Availability of Arable land)	0.528	84	0.000	0.089	84	0.000
Communities Spatial Attributes (Major Occupation of members of the community)	0.526	84	0.000	0.089	84	0.000
Communities Spatial Attributes (Availability of food stock all year round)	0.536	84	0.000	0.141	84	0.000
Major Crops that Farmers Grow	0.382	84	0.000	0.629	84	0.000

Source: Author (2014).

Table 2. Continued

Variables	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Major Child Malnutrtion Factor	0.347	84	0.000	0.710	84	0.000
Community Facilities (at least Primary Health Care)	0.407	84	0.000	0.611	84	0.000
Commuity Accsess to Good/Potable Drinking Water	0.529	84	0.000	0.087	84	0.000
Community Members Practice Good Santation	0.467	84	0.000	0.538	84	0.000
Community Grabage Disposal Site	0.371	84	0.000	0.631	84	0.000
Provision of Spatial Infrastructure/Devel opment (Past 10 years)	0.529	84	0.000	0.088	84	0.000
Rehabilitation of Spatial Infrastructure (Past 10 years)	0.530	84	0.000	0.088	84	0.000
Increase in Local Productivity, Econ. Growth and Income (Past 10 years)	0.346	84	0.000	0.636	84	0.000
Improvement in Standard of Living/Social Wellbeing (Past 10 years)	0.364	84	0.000	0.633	84	0.000

a. Lilliefors Significance Correction
Source: Author (2014).

Appendix G

Other Tables on Factor Analysis

Food and nutrition security factor

Descriptive Statistics

Variable	Mean	Std. Deviation	Analysis N
Mothers Educational Level	2.57	2.300	122
Mothers Ethnicity	5.25	.836	122
Number of children per mother	3.39	2.023	122
Mothers Earn Income	1.61	.489	122
Communities Spatial Attributes (Market)	1.42	.495	122
Communities Spatial Attributes (Communal food storage facility)	1.67	.471	122
Communities Spatial Attributes (Motorable Roads)	1.48	.502	122
Communities Spatial Attributes (Vehicles)	1.43	.497	122
Communities Spatial Attributes (At least Primary School)	1.02	.156	122
Communities Spatial Attributes (Regular Wet and Dry Seasons)	1.25	.437	122
Communities Spatial Attributes (Quality of soil for farming)	1.62	.487	122
Communities Spatial Attributes (Communal Availability of Arable Land)	10.19	90.266	122
Communities Spatial Attributes (Major Occupation of members of the community)	9.63	90.317	122
Communities Spatial Attributes (Availability of food stock all year round)	279.94	1559.750	122
Community Facilities (at least Primary Health Care)	1.38	.487	122
Community Members Practice Good Sanitation	1.25	.437	122
Community Access to Good/Potable Drinking Water	9.41	90.335	122
Community Garbage Disposal Site	1.53	.501	122
Mother's Age	32.70	8.559	122
Mother's Occupation	2.01	1.087	122

Source: Author (2014).

Communalities

Variable	Initial	Extraction
Mother's Educational Level	1.000	.820
Mother's Ethnicity	1.000	.766
Number of children per mother	1.000	.843
Mother's Earned Income	1.000	.837
Communities Spatial Attributes (Market)	1.000	.762
Communities Spatial Attributes (Communal food storage facility)	1.000	.762
Communities Spatial Attributes (Motorable Roads)	1.000	.799
Communities Spatial Attributes (Vehicles)	1.000	.856
Communities Spatial Attributes (At least Primary School)	1.000	.794
Communities Spatial Attributes (Regular Wet and Dry Seasons)	1.000	.738
Communities Spatial Attributes (Quality of soil for farming)	1.000	.678
Communities Spatial Attributes (Communal Availability of Arable Land)	1.000	.903
Communities Spatial Attributes (Major Occupation of members of the community)	1.000	.994
Communities Spatial Attributes (Availability of food stock all year round)	1.000	.880
Community Facilities (at least Primary Health Care)	1.000	.726
Community Members Practice Good Sanitation	1.000	.792
Community Access to Good/Potable Drinking Water	1.000	.994
Community Garbage Disposal Site	1.000	.724
Mother's Age	1.000	.849
Mother's Occupation	1.000	.663

Extraction Method: Principal Component Analysis.
Source: Author (2014).

Correlation Matrix

		Mothers Educational Level	Mothers Ethnicity	Number of children per mother	Mothers Earn Income	Communities Spatial Attributes (Market)	Communities Spatial Attributes (Communal food storage facility)	Communities Spatial Attributes (Motorable Roads)	Communities Spatial Attributes (Vehicles)	Communities Spatial Attributes (Atleast Primary School)	Communities Spatial Attributes (Regular Wet and Dry Seasons)	Communities Spatial Attributes (Quality of soil for farming)	Communities Spatial Attributes (Communal Availablity of ArableLand)	Communities Spatial Attributes (Major Occupation of members of the community)	Communities Spatial Attributes (Availability of food stock all year round)	Community Facilities (at least Primary Health Care)	Community Members Practice Good Santation	Commuity Accsess to Good/Potable Drinking Water	Community Grabage Disposal Site	Mothers Age
Correlation	Mothers Ed	1	-0.086867	-0.3758437	-0.2797204	-0.125265	0.0072495	-0.0634035	-0.0856648	0.0064407	-0.1051257	0.0693721	-0.0627169	-0.0606908	-0.0771926	-0.0546017	0.3552709	-0.0623703	0.134186	-0.1571945
	Mothers Et	-0.086867	1	0.1035551	0.0719426	-0.2302843	0.0804239	-0.1872568	-0.095266	0.0802163	-0.0366893	-0.1358252	-0.025581	-0.0285511	-0.0529889	-0.18909	0.1215565	-0.0266159	-0.0391289	0.002139
	Number of	-0.3758437	0.1035551	1	0.1044414	-0.0252886	-0.0456105	0.0226908	-0.0366873	-0.0047376	-0.0111845	-0.2006638	0.0281053	0.0255902	-0.0166521	-0.1183613	-0.1326825	0.0280557	0.0279415	0.5457025
	Mothers Ea	-0.2797204	0.0719426	0.1044414	1	-0.0803319	0.2005709	-0.1439335	-0.0329421	0.0169371	-0.040908	-0.1988338	0.0715467	0.0712817	-0.2265086	-0.148698	0.0364684	0.0725034	0.3052122	0.0101395
	Communitie	-0.125265	-0.2302843	-0.0252886	-0.0803319	1	0.2379374	0.2439566	0.4120659	-0.1345684	0.3832836	-0.0607091	0.1074766	0.108233	-0.034364	0.4378925	-0.1511233	0.1067874	0.2940406	-0.2611629
	Communitie	0.0072495	0.0804239	-0.0456105	0.2005709	0.2379374	1	0.3963719	0.6019712	-0.114591	0.1670034	-0.1110364	0.065368	0.066244	-0.1331612	0.1110364	0.3675389	0.0645131	0.1858848	-0.294586
	Communitie	-0.0634035	-0.1872568	0.0226908	-0.1439335	0.2439566	0.3963719	1	0.6916241	-0.0477455	0.0379846	0.1775407	0.0943094	0.0951464	0.1537055	0.19474	0.1886876	0.0940447	0.0514687	-0.0915801
	Communitie	-0.0856648	-0.095266	-0.0366873	-0.0329421	0.4120659	0.6019712	0.6916241	1	-0.0298259	0.2203193	0.0207441	0.107161	0.1074653	-0.0478783	0.4238531	0.3345358	0.1056959	0.20913	-0.2501836
	Communitie	0.0064407	0.0802163	-0.0047376	0.0169371	-0.1345684	-0.114591	-0.0477455	-0.0298259	1	0.2720364	0.0143219	-0.0162292	-0.015236	-0.0285124	-0.0143219	0.0288976	-0.0142542	-0.0634738	0.1483119
	Communitie	-0.1051257	-0.0366893	-0.0111845	-0.040908	0.3832836	0.1670034	0.0379846	0.2203193	0.2720364	1	0.0655964	0.1564854	0.1583382	-0.0926297	0.3228871	-0.0379298	0.1553487	-0.0572237	-0.1189554
	Communitie	0.0693721	-0.1358252	-0.2006638	-0.1988338	-0.0607091	-0.1110364	0.1775407	0.0207441	0.0143219	0.0655964	1	-0.1202824	0.0720222	0.1286016	-0.0577803	-0.0509487	0.0704705	-0.2200622	0.0643415
	Communitie	-0.0627169	-0.025581	0.0281053	0.0715467	0.1074766	0.065368	0.0943094	0.107161	-0.0162292	0.1564854	-0.1202824	1	-0.0077261	-0.0163573	-0.0691734	-0.0510711	-0.0064962	0.0853003	0.0450986
	Communitie	-0.0606908	-0.0285511	0.0255902	0.0712817	0.108233	0.066244	0.0951464	0.1074653	-0.015236	0.1583382	0.0720222	-0.0077261	1	-0.0171723	0.1193937	-0.0520302	0.9999448	0.0840149	0.0227484
	Communitie	-0.0771926	-0.0529889	-0.0166521	-0.2265086	-0.034364	-0.1331612	0.1537055	-0.0478783	-0.0285124	-0.0926297	0.1286016	-0.0163573	-0.0171723	1	-0.1394895	0.0165543	-0.0167274	-0.0751376	0.0903862
	Community	-0.0546017	-0.18909	-0.1183613	-0.148698	0.4378925	0.1110364	0.19474	0.4238531	-0.0143219	0.3228871	-0.0577803	-0.0691734	0.1193937	-0.1394895	1	0.2063421	0.1162088	0.1861637	-0.1734748
	Community	0.3552709	0.1215565	-0.1326825	0.0364684	-0.1511233	0.3675389	0.1886876	0.3345358	0.0288976	-0.0379298	-0.0509487	-0.0510711	-0.0520302	0.0165543	0.2063421	1	-0.0530958	0.2824068	-0.0593148
	Commuity A	-0.0623703	-0.0266159	0.0280557	0.0725034	0.1067874	0.0645131	0.0940447	0.1056959	-0.0142542	0.1553487	0.0704705	-0.0064962	0.9999448	-0.0167274	0.1162088	-0.0530958	1	0.0858953	0.0251388
	Community	0.134186	-0.0391289	0.0279415	0.3052122	0.2940406	0.1858848	0.0514687	0.20913	-0.0634738	-0.0572237	-0.2200622	0.0853003	0.0840149	-0.0751376	0.1861637	0.2824068	0.0858953	1	0.0176947
	Mothers A	-0.1571945	0.002139	0.5457025	0.0101395	-0.2611629	-0.294586	-0.0915801	-0.2501836	0.1483119	-0.1189554	0.0643415	0.0450986	0.0227484	0.0903862	-0.1734748	-0.0593148	0.0251388	0.0176947	1
	Mothers Oc	0.2625875	-0.0295077	-0.193152	-0.3518331	0.1010336	0.1504423	0.0381247	0.1925037	-0.0012021	0.0999266	0.2089772	-0.0849965	-0.081534	-0.0501155	0.1815746	0.0825356	-0.0849502	-0.1294855	-0.3124088
Sig. (1-taile	Mothers Educational L		0.1707007	9.947E-06	0.0009032	0.0846005	0.468417	0.2439027	0.174075	0.4719345	0.1245796	0.2238465	0.2462696	0.2533249	0.1990263	0.2751424	2.966E-05	0.2474691	0.0703017	0.04189
	Mothers Et	0.1707007		0.1281701	0.2155026	0.0053587	0.189269	0.0194457	0.1482909	0.1898869	0.3441327	0.0678867	0.3898585	0.3774539	0.2810708	0.0184928	0.0911403	0.3855226	0.3343594	0.4906726
	Number of	9.947E-06	0.1281701		0.1261354	0.3910858	0.3089396	0.4020363	0.344141	0.4793481	0.4513428	0.0133396	0.3793081	0.3898198	0.4277728	0.0970656	0.0725736	0.3795147	0.3799903	4.012E-11
	Mothers Ea	0.0009032	0.2155026	0.1261354		0.1895426	0.0133755	0.0568615	0.3593451	0.4265501	0.3273004	0.014062	0.216776	0.2176306	0.0060569	0.0510647	0.345023	0.2137063	0.0003149	0.45587
	Communitie	0.0846005	0.0053587	0.3910858	0.1895426		0.0041568	0.0033856	1.204E-06	0.0697326	6.577E-06	0.2532607	0.1193358	0.1176819	0.3535454	2.28E-07	0.048298	0.1208569	0.0005057	0.0018331
	Communitie	0.468417	0.189269	0.3089396	0.0133755	0.0041568		3.099E-06	1.119E-13	0.1044105	0.0329902	0.1116918	0.2371976	0.2342404	0.0718442	0.1116918	1.56E-05	0.240103	0.0201856	0.0004944
	Communitie	0.2439027	0.0194457	0.4020363	0.0568615	0.0033856	3.099E-06		5.752E-19	0.3007533	0.3389303	0.0252099	0.1507404	0.1485958	0.0454838	0.0157992	0.0186985	0.151423	0.2867137	0.1578744
	Communitie	0.174075	0.1482909	0.344141	0.3593451	1.204E-06	1.119E-13	5.752E-19		0.372167	0.0073743	0.4102927	0.1200307	0.1193607	0.3002471	5.73E-07	8.29E-05	0.1232934	0.0103954	0.0027241
	Communitie	0.4719345	0.1898869	0.4793481	0.4265501	0.0697326	0.1044105	0.3007533	0.372167		0.001218	0.4377919	0.4295878	0.4338563	0.3776147	0.4377919	0.3760145	0.4380835	0.2436609	0.0515165
	Communitie	0.1245796	0.3441327	0.4513428	0.3273004	6.577E-06	0.0329902	0.3389303	0.0073743	0.001218		0.2364247	0.0426014	0.0407626	0.1551055	0.0001432	0.3391497	0.0437618	0.2656367	0.0959432
	Communitie	0.2238465	0.0678867	0.0133396	0.014062	0.2532607	0.1116918	0.0252099	0.4102927	0.4377919	0.2364247		0.0934705	0.2152472	0.0790196	0.2636402	0.288656	0.2202591	0.007434	0.2406887
	Communitie	0.2462696	0.3898585	0.3793081	0.216776	0.1193358	0.2371976	0.1507404	0.1200307	0.4295878	0.0426014	0.0934705		0.4663451	0.429038	0.2244988	0.2881981	0.4716931	0.1751062	0.3109167
	Communitie	0.2533249	0.3774539	0.3898198	0.2176306	0.1176819	0.2342404	0.1485958	0.1193607	0.4338563	0.0407626	0.2152472	0.4663451		0.4255421	0.0951213	0.2846232	1.37E-239	0.1787733	0.4017925
	Communitie	0.1990263	0.2810708	0.4277728	0.0060569	0.3535454	0.0718442	0.0454838	0.3002471	0.3776147	0.1551055	0.0790196	0.429038	0.4255421		0.0627176	0.4281923	0.4274496	0.2053842	0.1610628
	Community	0.2751424	0.0184928	0.0970656	0.0510647	2.28E-07	0.1116918	0.0157992	5.73E-07	0.4377919	0.0001432	0.2636402	0.2244988	0.0951213	0.0627176		0.0112962	0.1012116	0.0200333	0.02801
	Community	2.966E-05	0.0911403	0.0725736	0.345023	0.048298	1.56E-05	0.0186985	8.29E-05	0.3760145	0.3391497	0.288656	0.2881981	0.2846232	0.4281923	0.0112962		0.280676	0.0008119	0.2581756
	Commuity A	0.2474691	0.3855226	0.3795147	0.2137063	0.1208569	0.240103	0.151423	0.1232934	0.4380835	0.0437618	0.2202591	0.4716931	1.37E-239	0.4274496	0.1012116	0.280676		0.1734247	0.3917148
	Community	0.0703017	0.3343594	0.3799903	0.0003149	0.0005057	0.0201856	0.2867137	0.0103954	0.2436609	0.2656367	0.007434	0.1751062	0.1787733	0.2053842	0.0200333	0.0008119	0.1734247		0.4233041
	Mothers A	0.04189	0.4906726	4.012E-11	0.45587	0.0018331	0.0004944	0.1578744	0.0027241	0.0515165	0.0959432	0.2406887	0.3109167	0.4017925	0.1610628	0.02801	0.2581756	0.3917148	0.4233041	
	Mothers Oc	0.0017391	0.3734845	0.0165204	3.535E-05	0.134082	0.0490627	0.3383693	0.0168227	0.4947575	0.136735	0.0104431	0.1759686	0.185985	0.2917808	0.0226649	0.1830522	0.1761002	0.0775883	0.0002298

Source: Author (2014).

Agricultural production factor

Descriptive Statistics

Variable	Mean	Std. Deviation	Analysis N
Communities Spatial Attributes (Market)	1.37	.484	173
Communities Spatial Attributes (Communal food storage facility)	1.72	.449	173
Communities Spatial Attributes (Motorable Roads)	65.02	763.434	173
Communities Spatial Attributes (Vehicles)	1.44	.498	173
Communities Spatial Attributes (Regular Wet and Dry Seasons)	1.27	.443	173
Communities Spatial Attributes (Quality of soil for farming)	117.16	1071.800	173
Communities Spatial Attributes (Communal Availability of Arable Land)	475.94	2105.708	173
Communities Spatial Attributes (Availability of food stock all year round)	556.08	2226.053	173
Community Facilities (at least Primary Health Care)	1.36	.483	173

Source: Author (2014).

Communalities

Variable	Initial	Extra-ction
Communities Spatial Attributes (Market)	1.000	.639
Communities Spatial Attributes (Communal food storage facility)	1.000	.852
Communities Spatial Attributes (Motorable Roads)	1.000	.990
Communities Spatial Attributes (Vehicles)	1.000	.736
Communities Spatial Attributes (Regular Wet and Dry Seasons)	1.000	.649
Communities Spatial Attributes (Quality of soil for farming)	1.000	.803
Communities Spatial Attributes (Communal Availability of Arable Land)	1.000	.584
Communities Spatial Attributes (Availability of food stock all year round)	1.000	.760
Community Facilities (at least Primary Health Care)	1.000	.741

Extraction Method: Principal Component Analysis. Source: Author (2014).

Correlation Matrix										
		Communities Spatial Attributes (Market)	Communities Spatial Attributes (Communal food storage facility)	Communities Spatial Attributes (Motorable Roads)	Communities Spatial Attributes (Vehicles)	Communities Spatial Attributes (Regular Wet and Dry Seasons)	Communities Spatial Attributes (Quality of soil for farming)	Communities Spatial Attributes (Communal Availablility of ArableLand)	Communities Spatial Attributes (Availability of food stock all year round)	Community Facilities (at least Primary Health Care)
Correlation	Communiti	1	0.12721	-0.04811	0.334948	0.378924	0.029102	0.060763	0.083518	0.465126
	Communiti	0.12721	1	0.051944	0.470476	0.080737	0.066993	0.133785	-0.04279	0.012872
	Communiti	-0.04811	0.051944	1	0.094795	-0.05018	-0.00907	-0.01873	-0.02082	-0.06301
	Communiti	0.334948	0.470476	0.094795	1	0.231769	0.013173	0.144067	-0.00088	0.395099
	Communiti	0.378924	0.080737	-0.05018	0.231769	1	-0.06512	0.06352	0.102944	0.305841
	Communiti	0.029102	0.066993	-0.00907	0.013173	-0.06512	1	0.232996	0.216531	0.030504
	Communiti	0.060763	0.133785	-0.01873	0.144067	0.06352	0.232996	1	0.316749	0.120923
	Communiti	0.083518	-0.04279	-0.02082	-0.00088	0.102944	0.216531	0.316749	1	-0.02139
	Community	0.465126	0.012872	-0.06301	0.395099	0.305841	0.030504	0.120923	-0.02139	1
Sig. (1-tail	Communities Spatial .		0.047674	0.264796	3.33E-06	1.37E-07	0.351943	0.213553	0.137317	5.69E-11
	Communiti	0.047674		0.248657	3.26E-11	0.145495	0.190581	0.039646	0.288071	0.43326
	Communiti	0.264796	0.248657		0.10738	0.256013	0.452864	0.403386	0.39286	0.205079
	Communiti	3.33E-06	3.26E-11	0.10738		0.001077	0.431715	0.029309	0.495416	3.73E-08
	Communiti	1.37E-07	0.145495	0.256013	0.001077		0.197316	0.203197	0.088864	2.14E-05
	Communiti	0.351943	0.190581	0.452864	0.431715	0.197316		0.001018	0.002109	0.345167
	Communiti	0.213553	0.039646	0.403386	0.029309	0.203197	0.001018		1.09E-05	0.056507
	Communiti	0.137317	0.288071	0.39286	0.495416	0.088864	0.002109	1.09E-05		0.390011
	Community	5.69E-11	0.43326	0.205079	3.73E-08	2.14E-05	0.345167	0.056507	0.390011	

Source: Author (2014).

Spatial Attribute of Community factor

Descriptive Statistics

Variable	Mean	Std. Deviation	Analysis N
Communities Spatial Attributes (Market)	1.40	.492	233
Communities Spatial Attributes (Communal food storage facility)	1.72	.452	233
Communities Spatial Attributes (Motorable Roads)	1.49	.501	233
Communities Spatial Attributes (Vehicles)	1.51	.501	233
Communities Spatial Attributes (At least Primary School)	1.03	.159	233
Communities Spatial Attributes (Regular Wet and Dry Seasons)	1.34	.476	233
Communities Spatial Attributes (Quality of soil for farming)	1.52	.509	233

Source: Author (2014).

Cont'd.

Communities Spatial Attributes (Communal Availability of Arable Land)	10.76	92.156	233
Communities Spatial Attributes (Major Occupation of members of the community)	5.61	65.364	233
Communities Spatial Attributes (Availability of food stock all year round)	31.38	170.662	233
Community Facilities (at least Primary Health Care)	1.36	.481	233
Community Access to Good/Potable Drinking Water	9.82	92.241	233
Community Garbage Disposal Site	1.63	.484	233
Community Members Practice Good Sanitation	5.62	65.361	233

Source: Author (2014).

Communalities

Variable	Initial	Extraction
Communities Spatial Attributes (Market)	1.000	.653
Communities Spatial Attributes (Communal food storage facility)	1.000	.570
Communities Spatial Attributes (Motorable Roads)	1.000	.653
Communities Spatial Attributes (Vehicles)	1.000	.742
Communities Spatial Attributes (At least Primary School)	1.000	.471
Communities Spatial Attributes (Regular Wet and Dry Seasons)	1.000	.572
Communities Spatial Attributes (Quality of soil for farming)	1.000	.675
Communities Spatial Attributes (Communal Availability of Arable Land)	1.000	.252
Communities Spatial Attributes (Major Occupation of members of the community)	1.000	.850
Communities Spatial Attributes (Availability of food stock all year round)	1.000	.288
Community Facilities (at least Primary Health Care)	1.000	.749
Community Access to Good/Potable Drinking Water	1.000	.854
Community Garbage Disposal Site	1.000	.496
Community Members Practice Good Sanitation	1.000	.236

Extraction Method: Principal Component Analysis. Source: Author (2014).

Correlation Matrix

		Communities Spatial Attributes (Market)	Communities Spatial Attributes (Communal food storage facility)	Communities Spatial Attributes (Motorable Roads)	Communities Spatial Attributes (Vehicles)	Communities Spatial Attributes (Atleast Primary School)	Communities Spatial Attributes (Regular Wet and Dry Seasons)	Communities Spatial Attributes (Quality of soil for farming)	Communities Spatial Attributes (Communal Availablility of ArableLand)	Communities Spatial Attributes (Major Occupation of members of the community)	Communities Spatial Attributes (Availability of food stock all year round)	Community Facilities (at least Primary Health Care)	Commuity Accsess to Good/Potable Drinking Water	Community Grabage Disposal Site
Correlation	Communiti	1	0.012166	0.150575	0.262362	-0.07846	0.252881	-0.0829	0.01817	0.081056	-0.09357	0.566858	0.018377	0.284542
	Communiti	0.012166	1	0.296734	0.356476	-0.13834	0.15368	-0.10732	-0.04373	0.043447	-0.05722	-0.08344	0.058244	0.091577
	Communiti	0.150575	0.296734	1	0.657134	-0.0521	0.153943	0.004713	0.000666	0.066521	0.02735	0.152697	0.094685	0.132465
	Communiti	0.262362	0.356476	0.657134	1	-0.05769	0.237623	-0.11486	-0.00158	0.064628	-0.079	0.341508	0.091876	0.247712
	Communiti	-0.07846	-0.13834	-0.0521	-0.05769	1	0.110703	-0.0595	-0.01548	-0.0115	-0.02884	0.047229	-0.01439	0.01205
	Communiti	0.252881	0.15368	0.153943	0.237623	0.110703	1	0.061456	0.030429	0.092144	0.083903	0.266538	0.030125	0.04735
	Communiti	-0.0829	-0.10732	0.004713	-0.11486	-0.0595	0.061456	1	-0.09758	0.063548	0.06707	0.006644	0.087755	-0.25097
	Communiti	0.01817	-0.04373	0.000666	-0.00158	-0.01548	0.030429	-0.09758	1	-0.00458	-0.01615	-0.06993	-0.0081	-0.02476
	Communiti	0.081056	0.043447	0.066521	0.064628	-0.0115	0.092144	0.063548	-0.00458	1	-0.01222	0.089141	0.705288	0.048515
	Communiti	-0.09357	-0.05722	0.02735	-0.079	-0.02884	0.083903	0.06707	-0.01615	-0.01222	1	-0.13199	-0.01625	-0.0733
	Communit	0.566858	-0.08344	0.152697	0.341508	0.047229	0.266538	0.006644	-0.06993	0.089141	-0.13199	1	0.027337	0.240881
	Commuity	0.018377	0.058244	0.094685	0.091876	-0.01439	0.030125	0.087755	-0.0081	0.705288	-0.01625	0.027337	1	-0.02414
	Communit	0.284542	0.091577	0.132465	0.247712	0.01205	0.04735	-0.25097	-0.02476	0.048515	-0.0733	0.240881	-0.02414	1
	Communit	-0.05474	-0.10358	-0.0645	-0.06497	-0.01027	-0.04857	0.060635	-0.00742	-0.00498	-0.01223	-0.04823	-0.00676	0.052658
Sig. (1-tail	Communities Spatial .		0.426726	0.010747	2.51E-05	0.116416	4.75E-05	0.103682	0.391316	0.108854	0.077253	1.65E-21	0.390111	5.13E-06
	Communiti	0.426726		2.02E-06	1.09E-08	0.017409	0.009458	0.05112	0.253286	0.254646	0.192289	0.102223	0.188073	0.081768
	Communiti	0.010747	2.02E-06		1.74E-30	0.2143	0.009356	0.471479	0.495967	0.155993	0.338956	0.009851	0.074825	0.02169
	Communiti	2.51E-05	1.09E-08	1.74E-30		0.190333	0.000126	0.040085	0.490451	0.162993	0.114823	4.48E-08	0.08108	6.66E-05
	Communiti	0.116416	0.017409	0.2143	0.190333		0.045907	0.182946	0.407095	0.430694	0.330701	0.236548	0.413506	0.42742
	Communiti	4.75E-05	0.009458	0.009356	0.000126	0.045907		0.175173	0.322012	0.080468	0.100961	1.88E-05	0.323669	0.235985
	Communiti	0.103682	0.05112	0.471479	0.040085	0.182946	0.175173		0.06877	0.167076	0.154002	0.459828	0.090954	5.39E-05
	Communiti	0.391316	0.253286	0.495967	0.490451	0.407095	0.322012	0.06877		0.472258	0.403118	0.143882	0.451073	0.353451
	Communiti	0.108854	0.254646	0.155993	0.162993	0.430694	0.080468	0.167076	0.472258		0.426378	0.08754	1.14E-36	0.230562
	Communiti	0.077253	0.192289	0.338956	0.114823	0.330701	0.100961	0.154002	0.403118	0.426378		0.022069	0.402532	0.132561
	Communit	1.65E-21	0.102223	0.009851	4.48E-08	0.236548	1.88E-05	0.459828	0.143882	0.08754	0.022069		0.339027	0.000103
	Commuity	0.390111	0.188073	0.074825	0.08108	0.413506	0.323669	0.090954	0.451073	1.14E-36	0.402532	0.339027		0.356951
	Communit	5.13E-06	0.081768	0.02169	6.66E-05	0.42742	0.235985	5.39E-05	0.353451	0.230562	0.132561	0.000103	0.356951	
	Communit	0.202789	0.057425	0.16346	0.161712	0.438074	0.23032	0.178415	0.455123	0.469845	0.426367	0.231879	0.459127	0.211849

Source: Author (2014).

Health status factor

Descriptive Statistics

Variable	Mean	Std. Deviation	Analysis N
Mothers Educational Level	2.55	2.334	208
Mothers Occupation	1.91	1.109	208
Mothers Income	764.99	398.388	208
Mothers Age	32.51	7.567	208
Number of children per mother	3.43	1.845	208
Number of Times of Breastfeeding	356.77	473.431	208
Age at Weaning	494.12	491.758	208
Type of Weaning Food	481.35	499.316	208
Mother Ever Attended Post-Natal Clinic	1.06	.243	208
Community Facilities (at least Primary Health Care)	1.36	.480	208
Community Access to Good/Potable Drinking Water	10.85	97.601	208
Community Members Practice Good Sanitation	6.13	69.177	208
Community Garbage Disposal Site	1.62	.488	208
Improvement in Standard of Living/Social Wellbeing (Past 10 years)	1.56	.497	208

Source: Author, 2014

Communalities

Variable	Initial	Extra-ction
Mothers Educational Level	1.000	.508
Mothers Occupation	1.000	.607
Mothers Income	1.000	.695
Mothers Age	1.000	.681
Number of children per mother	1.000	.704
Number of Times of Breastfeeding	1.000	.667
Age at Weaning	1.000	.921
Type of Weaning Food	1.000	.897
Mother Ever Attended Post-Natal Clinic	1.000	.363
Community Facilities (at least Primary Health Care)	1.000	.672
Community Access to Good/Potable Drinking Water	1.000	.728
Community Members Practice Good Sanitation	1.000	.208
Community Garbage Disposal Site	1.000	.527
Improvement in Standard of Living/Social Wellbeing (Past 10 years)	1.000	.540

Extraction Method: Principal Component Analysis.

Source: Author, 2014

Correlation Matrix														
		Mothers Educational Level	Mothers Occupation	Mothers Income	Mothers Age	Number of children per mother	Number of Times of Breastfeeing	Age at Weaning	Type of Weaning Food	Mother Ever Attended Post-Natal Clinic	Community Facilities (at least Primary Health Care)	Commuity Accsess to Good/Potable Drinking Water	Community Members Practice Good Santation	Community Grabage Disposal Site
Correlation	Mothers E	1	0.285399	0.017295	-0.21119	-0.41589	0.168327	-0.07505	-0.04867	0.007464	-0.08004	-0.00225	-0.01515	0.05028
	Mothers O	0.285399	1	-0.251	-0.34884	-0.29586	0.101654	-0.08149	-0.07264	-0.06959	0.058145	0.051489	0.067613	-0.19588
	Mothers In	0.017295	-0.251	1	-0.00985	0.011896	0.015378	-0.0739	-0.06944	0.152033	-0.09094	0.058769	-0.11839	0.114251
	Mothers A	-0.21119	-0.34884	-0.00985	1	0.567907	0.149629	-0.14026	-0.14518	0.024665	-0.08342	-0.05172	0.004722	0.059913
	Number of	-0.41589	-0.29586	0.011896	0.567907	1	-0.02766	-0.01783	-0.02501	-0.03844	0.050931	0.004594	0.02176	0.103231
	Number of	0.168327	0.101654	0.015378	0.149629	-0.02766	1	-0.62866	-0.606	0.059461	0.040968	0.031068	0.093151	-0.06081
	Age at We	-0.07505	-0.08149	-0.0739	-0.14026	-0.01783	-0.62866	1	0.971295	-0.168	-0.24288	0.100672	-0.06805	0.035587
	Type of W	-0.04867	-0.07264	-0.06944	-0.14518	-0.02501	-0.606	0.971295	1	-0.1692	-0.23285	0.101685	-0.06658	0.028999
	Mother Ev	0.007464	-0.06959	0.152033	0.024665	-0.03844	0.059461	-0.168	-0.1692	1	0.181503	-0.02531	-0.01691	0.08165
	Communit	-0.08004	0.058145	-0.09094	-0.08342	0.050931	0.040968	-0.24288	-0.23285	0.181503	1	0.030016	-0.05049	0.257227
	Commuity	-0.00225	0.051489	0.058769	-0.05172	0.004594	0.031068	0.100672	0.101685	-0.02531	0.030016	1	-0.00751	-0.02232
	Communit	-0.01515	0.067613	-0.11839	0.004722	0.02176	0.093151	-0.06805	-0.06658	-0.01691	-0.05049	-0.00751	1	0.057246
	Communit	0.05028	-0.19588	0.114251	0.059913	0.103231	-0.06081	0.035587	0.028999	0.08165	0.257227	-0.02232	0.057246	1
	Improveme	-0.12956	-0.06024	0.047519	0.004333	0.083901	0.159449	-0.3084	-0.2764	0.027525	0.270754	0.087436	0.060702	0.139443
Sig. (1-tail	Mothers Educational l		1.47E-05	0.402089	0.001099	2.09E-10	0.007541	0.140644	0.242553	0.457393	0.125218	0.487145	0.414024	0.235382
	Mothers O	1.47E-05		0.000128	1.21E-07	7.17E-06	0.072003	0.120973	0.148551	0.15896	0.202077	0.230075	0.165933	0.002288
	Mothers In	0.402089	0.000128		0.443867	0.432296	0.412754	0.144386	0.159468	0.014183	0.09572	0.199556	0.044274	0.05017
	Mothers A	0.001099	1.21E-07	0.443867		1.85E-19	0.015498	0.021656	0.018208	0.361806	0.115466	0.229072	0.473013	0.194992
	Number of	2.09E-10	7.17E-06	0.432296	1.85E-19		0.345816	0.399112	0.359939	0.290754	0.232517	0.473748	0.377529	0.06893
	Number of	0.007541	0.072003	0.412754	0.015498	0.345816		1.4E-24	1.53E-22	0.19679	0.278424	0.32799	0.090406	0.191473
	Age at We	0.140644	0.120973	0.144386	0.021656	0.399112	1.4E-24		9.7E-131	0.007642	0.000204	0.073971	0.164376	0.304918
	Type of W	0.242553	0.148551	0.159468	0.018208	0.359939	1.53E-22	9.7E-131		0.007279	0.000356	0.071943	0.16966	0.338781
	Mother Ev	0.457393	0.15896	0.014183	0.361806	0.290754	0.19679	0.007642	0.007279		0.004349	0.358361	0.404233	0.120512
	Communit	0.125218	0.202077	0.09572	0.115466	0.232517	0.278424	0.000204	0.000356	0.004349		0.333455	0.23446	8.82E-05
	Commuity	0.487145	0.230075	0.199556	0.229072	0.473748	0.32799	0.073971	0.071943	0.358361	0.333455		0.457134	0.374478
	Communit	0.414024	0.165933	0.044274	0.473013	0.377529	0.090406	0.164376	0.16966	0.404233	0.23446	0.457134		0.205735
	Communit	0.235382	0.002288	0.05017	0.194992	0.06893	0.191473	0.304918	0.338781	0.120512	8.82E-05	0.374478	0.205735	
	Improveme	0.031082	0.193694	0.247751	0.475237	0.114126	0.01071	2.92E-06	2.66E-05	0.346547	3.82E-05	0.10459	0.19188	0.02228

Source: Author (2014).

Spatio-economic development factor

Descriptive Statistics

Variable	Mean	Std. Deviation	Analysis N
Mothers Educational Level	51.12	696.487	206
Mothers Occupation	1.86	1.078	206
Mothers Earn Income	1.66	.475	206
Number of children per mother	3.40	1.853	206
Communities Spatial Attributes (Market)	1.41	.494	206
Communities Spatial Attributes (Communal food storage facility)	1.69	.462	206
Communities Spatial Attributes (Motorable Roads)	1.50	.501	206
Communities Spatial Attributes (Vehicles)	1.51	.501	206
Communities Spatial Attributes (Regular Wet and Dry Seasons)	1.34	.476	206
Communities Spatial Attributes (At least Primary School)	1.02	.138	206
Communities Spatial Attributes (Quality of soil for farming)	1.53	.500	206
Communities Spatial Attributes (Communal Availability of Arable Land)	7.00	69.457	206
Communities Spatial Attributes (Major Occupation of members of the community)	6.15	69.517	206
Communities Spatial Attributes (Availability of food stock all year round)	30.46	168.166	206
Community Facilities (at least Primary Health Care)	1.36	.482	206
Community Access to Good/Potable Drinking Water	6.08	69.519	206
Community Members Practice Good Sanitation	6.17	69.513	206
Community Garbage Disposal Site	1.61	.489	206
Increase in Local Productivity, Econ. Growth and Income (Past 10 years)	1.58	.494	206
Improvement in Standard of Living/Social Wellbeing (Past 10 years)	1.57	.497	206

Source: Author (2014).

Communalities

Variable	Initial	Extraction
Mother's Educational Level	1.000	.623
Mother's Occupation	1.000	.707
Mother's Earn Income	1.000	.641
Number of children per mother	1.000	.535
Communities Spatial Attributes (Market)	1.000	.746
Communities Spatial Attributes (Communal food storage facility)	1.000	.738
Communities Spatial Attributes (Motorable Roads)	1.000	.751
Communities Spatial Attributes (Vehicles)	1.000	.780
Communities Spatial Attributes (Regular Wet and Dry Seasons)	1.000	.671
Communities Spatial Attributes (At least Primary School)	1.000	.839
Communities Spatial Attributes (Quality of soil for farming)	1.000	.619
Communities Spatial Attributes (Communal Availability of Arable Land)	1.000	.915
Communities Spatial Attributes (Major Occupation of members of the community)	1.000	.997
Communities Spatial Attributes (Availability of food stock all year round)	1.000	.850
Community Facilities (at least Primary Health Care)	1.000	.802
Community Access to Good/Potable Drinking Water	1.000	.997
Community Members Practice Good Sanitation	1.000	.857
Community Garbage Disposal Site	1.000	.617
Increase in Local Productivity, Econ. Growth and Income (Past 10 years)	1.000	.794
Improvement in Standard of Living/Social Wellbeing (Past 10 years)	1.000	.790

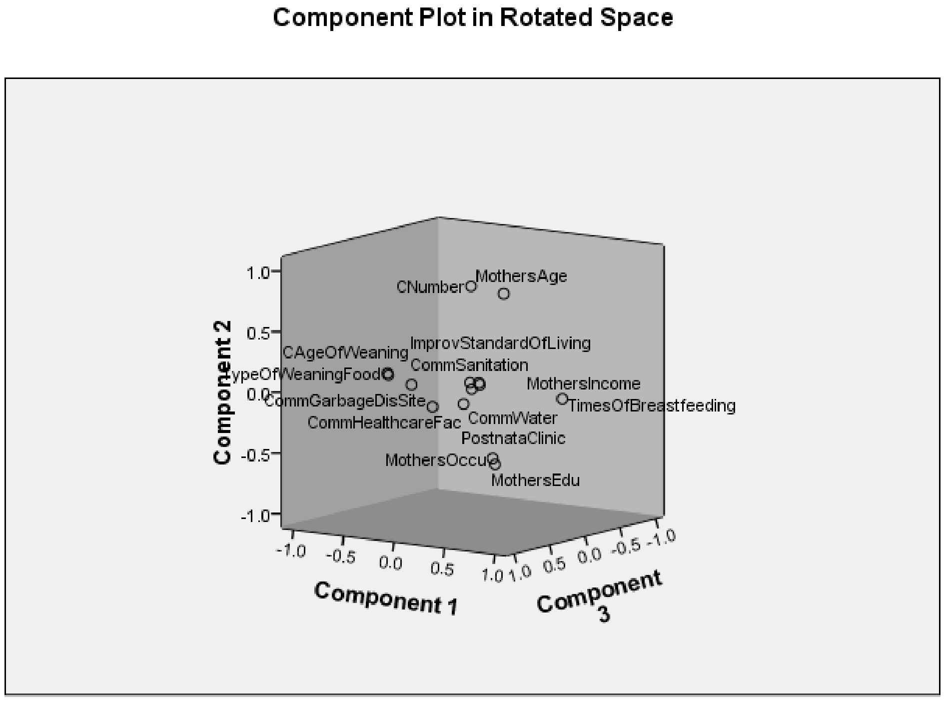
Extraction Method: Principal Component Analysis.
Source: Author (2014).

Correlation Matrix

		Mothers Educational Level	Mothers Occupation	Mothers Earn Income	Number of children per mother	Communities Spatial Attributes (Market)	Communities Spatial Attributes (Communal food storage facility)	Communities Spatial Attributes (Motorable Roads)	Communities Spatial Attributes (Vehicles)	Communities Spatial Attributes (Regular Wet and Dry Seasons)	Communities Spatial Attributes (Atleast Primary School)	Communities Spatial Attributes (Quality of soil for farming)	Communities Spatial Attributes (Communal Availablility of ArableLand)	Communities Spatial Attributes (Major Occupation of members of the community)	Communities Spatial Attributes (Availability of food stock all year round)	Community Facilities (at least Primary Health Care)	Commuity Accsess to Good/Potable Drinking Water	Community Members Practice Good Santation	Community Grabage Disposal Site	Increase in Local Productivity, Econ. Growth and Income (Past 10 years)
Correlation	Mothers E	1	0.139756	0.049374	-0.09216	-0.05897	0.046421	-0.07119	-0.07188	-0.05124	-0.00985	-0.0743	-0.00419	-0.00534	-0.01208	-0.0532	-0.00528	-0.00426	0.055712	0.058726
	Mothers O	0.139756	1	-0.25272	-0.29	0.032584	0.082663	-0.11615	-0.10591	-0.03182	-0.01493	0.234854	-0.05668	-0.05266	0.021495	0.067497	-0.05713	0.073224	-0.20261	-0.24432
	Mothers E	0.049374	-0.25272	1	0.106501	0.06003	0.102149	-0.13653	0.013933	-0.1051	0.026681	-0.27986	0.051327	0.049391	-0.24096	-0.05356	0.051101	-0.09579	0.22744	0.099274
	Number of	-0.09216	-0.29	0.106501	1	0.052035	-0.13464	0.126599	0.129755	0.035335	0.007393	-0.13859	0.023125	0.020754	-0.09982	0.020644	0.023944	0.022686	0.119826	0.05673
	Communiti	-0.05897	0.032584	0.06003	0.052035	1	0.042697	0.17922	0.328904	0.242828	-0.11794	-0.10651	0.083109	0.084549	-0.08651	0.574889	0.083745	-0.05893	0.323905	0.189663
	Communiti	0.046421	0.082663	0.102149	-0.13464	0.042697	1	0.333065	0.381708	0.170997	-0.13566	-0.13431	0.047593	0.048491	-0.0735	-0.06707	0.04591	-0.10458	0.076395	-0.04916
	Communiti	-0.07119	-0.11615	-0.13653	0.126599	0.17922	0.333065	1	0.640739	0.166608	-0.07173	0.00907	0.068802	0.069283	-0.00182	0.143991	0.06936	-0.07024	0.167108	0.008219
	Communiti	-0.07188	-0.10591	0.013933	0.129755	0.328904	0.381708	0.640739	1	0.261751	-0.07311	-0.11812	0.069513	0.068853	-0.11866	0.378837	0.069358	-0.06915	0.294414	0.075515
	Communiti	-0.05124	-0.03182	-0.1051	0.035335	0.242828	0.170997	0.166608	0.261751	1	0.19404	0.042741	0.09582	0.097603	0.05587	0.257928	0.095462	-0.05142	0.074878	0.116834
	Communiti	-0.00985	-0.01493	0.026681	0.007393	-0.11794	-0.13566	-0.07173	-0.07311	0.19404	1	-0.00959	-0.01117	-0.01044	-0.02471	-0.03336	-0.0093	-0.00948	-0.03224	-0.02355
	Communiti	-0.0743	0.234854	-0.27986	-0.13859	-0.10651	-0.13431	0.00907	-0.11812	0.042741	-0.00959	1	-0.07837	0.066652	0.103475	-0.02121	0.065098	0.063895	-0.24522	-0.041
	Communiti	-0.00419	-0.05668	0.051327	0.023125	0.083109	0.047593	0.068802	0.069513	0.09582	-0.01117	-0.07837	1	-0.00434	-0.01224	-0.05285	-0.00326	-0.00635	0.055919	0.057822
	Communiti	-0.00534	-0.05266	0.049391	0.020754	0.084549	0.048491	0.069283	0.068853	0.097603	-0.01044	0.066652	-0.00434	1	-0.01261	0.093991	0.999925	-0.00551	0.054097	0.05657
	Communiti	-0.01208	0.021495	-0.24096	-0.09982	-0.08651	-0.0735	-0.00182	-0.11866	0.05587	-0.02471	0.103475	-0.01224	-0.01261	1	-0.13093	-0.01244	-0.01266	-0.09841	-0.08759
	Community	-0.0532	0.067497	-0.05356	0.020644	0.574889	-0.06707	0.143991	0.378837	0.257928	-0.03336	-0.02121	-0.05285	0.093991	-0.13093	1	0.09264	-0.05176	0.271713	0.026814
	Commuity	-0.00528	-0.05713	0.051101	0.023944	0.083745	0.04591	0.06936	0.069358	0.095462	-0.0093	0.065098	-0.00326	0.999925	-0.01244	0.09264	1	-0.00544	0.056961	0.059772
	Community	-0.00426	0.073224	-0.09579	0.022686	-0.05893	-0.10458	-0.07024	-0.06915	-0.05142	-0.00948	0.063895	-0.00635	-0.00551	-0.01266	-0.05176	-0.00544	1	0.057827	0.058856
	Community	0.055712	-0.20261	0.22744	0.119826	0.323905	0.076395	0.167108	0.294414	0.074878	-0.03224	-0.24522	0.055919	0.054097	-0.09841	0.271713	0.056961	0.057827	1	0.274725
	Increase in	0.058726	-0.24432	0.099274	0.05673	0.189663	-0.04916	0.008219	0.075515	0.116834	-0.02355	-0.041	0.057822	0.05657	-0.08759	0.026814	0.059772	0.058856	0.274725	1
	Improveme	0.060499	-0.08291	0.098428	0.078794	0.352794	-0.15353	0.018268	0.105152	0.26135	-0.01931	0.029944	0.059685	0.060194	-0.1401	0.252602	0.061518	0.060502	0.149534	0.573198
Sig. (1-tail	Mothers Educational l		0.022561	0.240476	0.093839	0.19992	0.253802	0.154627	0.152266	0.232269	0.444145	0.144261	0.476165	0.469657	0.431599	0.223795	0.469982	0.475795	0.213197	0.200883
	Mothers O	0.022561		0.000124	1.18E-05	0.320983	0.118753	0.048197	0.06487	0.324918	0.415673	0.000339	0.209181	0.226107	0.379546	0.167532	0.207333	0.147788	0.001746	0.000201
	Mothers E	0.240476	0.000124		0.063803	0.19569	0.072005	0.025187	0.42122	0.066353	0.351718	2.31E-05	0.231874	0.240401	0.000242	0.222252	0.232861	0.085401	0.000505	0.077848
	Number of	0.093839	1.18E-05	0.063803		0.228802	0.026839	0.034894	0.031523	0.307052	0.458005	0.023478	0.370725	0.38358	0.076718	0.38418	0.36632	0.373095	0.043122	0.208991
	Communiti	0.19992	0.320983	0.19569	0.228802		0.271139	0.004975	6.93E-07	0.000218	0.045668	0.063787	0.117488	0.113469	0.108155	8.1E-20	0.115701	0.200056	1.02E-06	0.003163
	Communiti	0.253802	0.118753	0.072005	0.026839	0.271139		5E-07	7.52E-09	0.006996	0.025937	0.027135	0.248468	0.244423	0.146892	0.169069	0.256146	0.067339	0.13755	0.241436
	Communiti	0.154627	0.048197	0.025187	0.034894	0.004975	5E-07		1.67E-25	0.008345	0.152784	0.448523	0.162888	0.161199	0.48964	0.019469	0.16093	0.157868	0.008181	0.453329
	Communiti	0.152266	0.06487	0.42122	0.031523	6.93E-07	7.52E-09	1.67E-25		7.22E-05	0.148178	0.045423	0.160397	0.162711	0.044687	9.83E-09	0.160936	0.161649	8.71E-06	0.140341
	Communiti	0.232269	0.324918	0.066353	0.307052	0.000218	0.006996	0.008345	7.22E-05		0.002598	0.270935	0.085334	0.081406	0.212544	9.09E-05	0.08614	0.231488	0.142387	0.047221
	Communiti	0.444145	0.415673	0.351718	0.458005	0.045668	0.025937	0.152784	0.148178	0.002598		0.445616	0.436697	0.440794	0.362219	0.317017	0.447235	0.446231	0.322762	0.368445
	Communiti	0.144261	0.000339	2.31E-05	0.023478	0.063787	0.027135	0.448523	0.045423	0.270935	0.445616		0.131426	0.170581	0.069426	0.381119	0.17628	0.180774	0.000191	0.279237
	Communiti	0.476165	0.209181	0.231874	0.370725	0.117488	0.248468	0.162888	0.160397	0.085334	0.436697	0.131426		0.475333	0.430676	0.225271	0.481448	0.463911	0.21234	0.204531
	Communiti	0.469657	0.226107	0.240401	0.38358	0.113469	0.244423	0.161199	0.162711	0.081406	0.440794	0.170581	0.475333		0.428645	0.089507	0	0.468658	0.219973	0.209651
	Communiti	0.431599	0.379546	0.000242	0.076718	0.108155	0.146892	0.48964	0.044687	0.212544	0.362219	0.069426	0.430676	0.428645		0.030333	0.429572	0.428353	0.079673	0.105294
	Community	0.223795	0.167532	0.222252	0.38418	8.1E-20	0.169069	0.019469	9.83E-09	9.09E-05	0.317017	0.381119	0.225271	0.089507	0.030333		0.092686	0.23001	3.9E-05	0.351017
	Commuity	0.469982	0.207333	0.232861	0.36632	0.115701	0.256146	0.16093	0.160936	0.08614	0.447235	0.17628	0.481448	0	0.429572	0.092686		0.469073	0.208042	0.19671
	Community	0.475795	0.147788	0.085401	0.373095	0.200056	0.067339	0.157868	0.161649	0.231488	0.446231	0.180774	0.463911	0.468658	0.428353	0.23001	0.469073		0.204513	0.20036
	Community	0.213197	0.001746	0.000505	0.043122	1.02E-06	0.13755	0.008181	8.71E-06	0.142387	0.322762	0.000191	0.21234	0.219973	0.079673	3.9E-05	0.208042	0.204513		3.22E-05
	Increase in	0.200883	0.000201	0.077848	0.208991	0.003163	0.241436	0.453329	0.140341	0.047221	0.368445	0.279237	0.204531	0.209651	0.105294	0.351017	0.19671	0.20036	3.22E-05	
	Improveme	0.193839	0.118065	0.079634	0.130131	9.91E-08	0.01379	0.397191	0.066264	7.4E-05	0.391491	0.334596	0.197056	0.195042	0.022292	0.000125	0.189862	0.193828	0.015967	1.09E-19

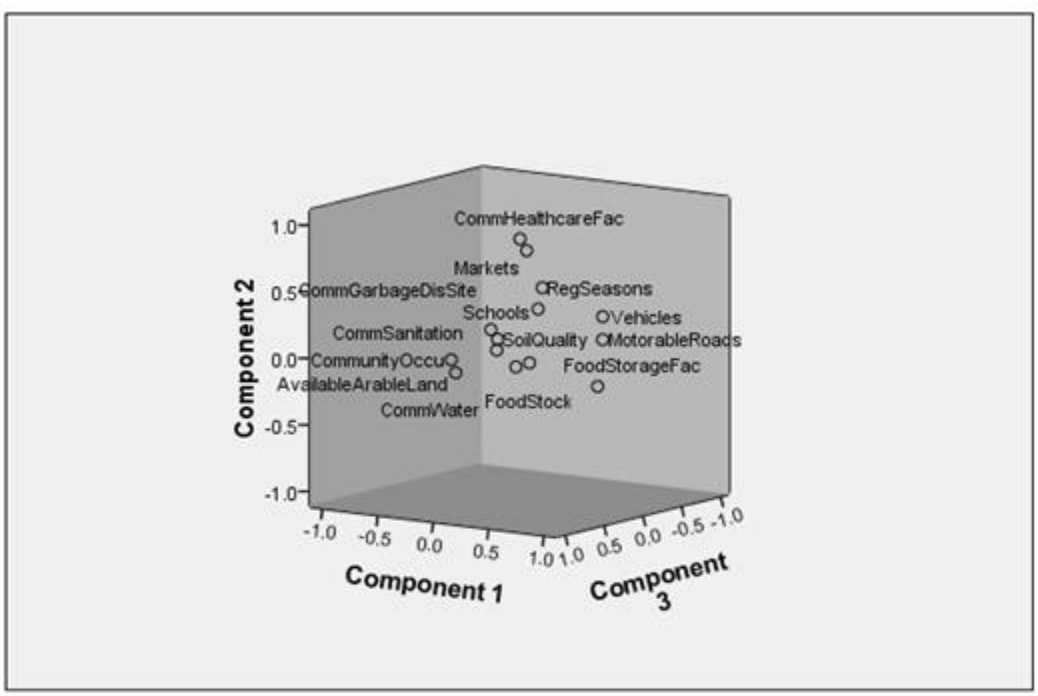
Source: Author (2014).

Index of health status component plot in rotated space



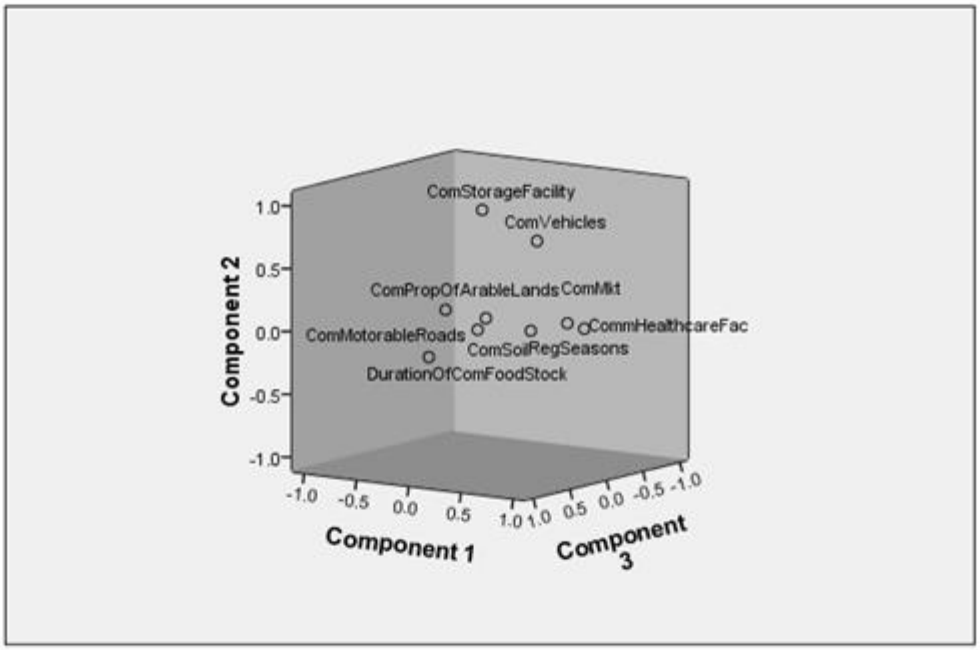
Source: Author (2014).

Component plot in rotated space of index of spatial attributes



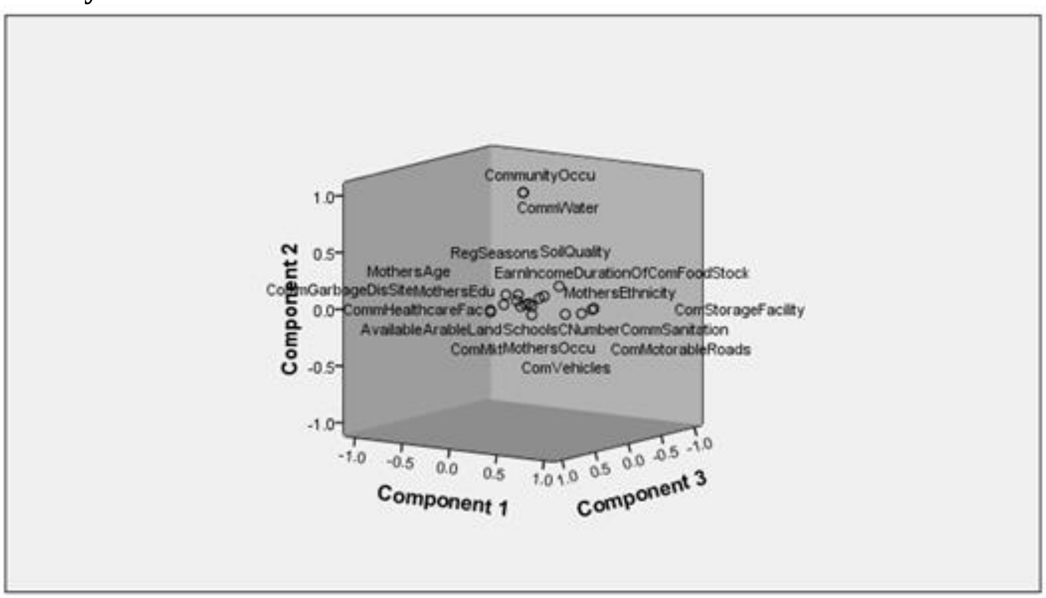
Source: Author (2014).

Figure 6.6.1 b. Component plot in rotated space of index of agricultural production



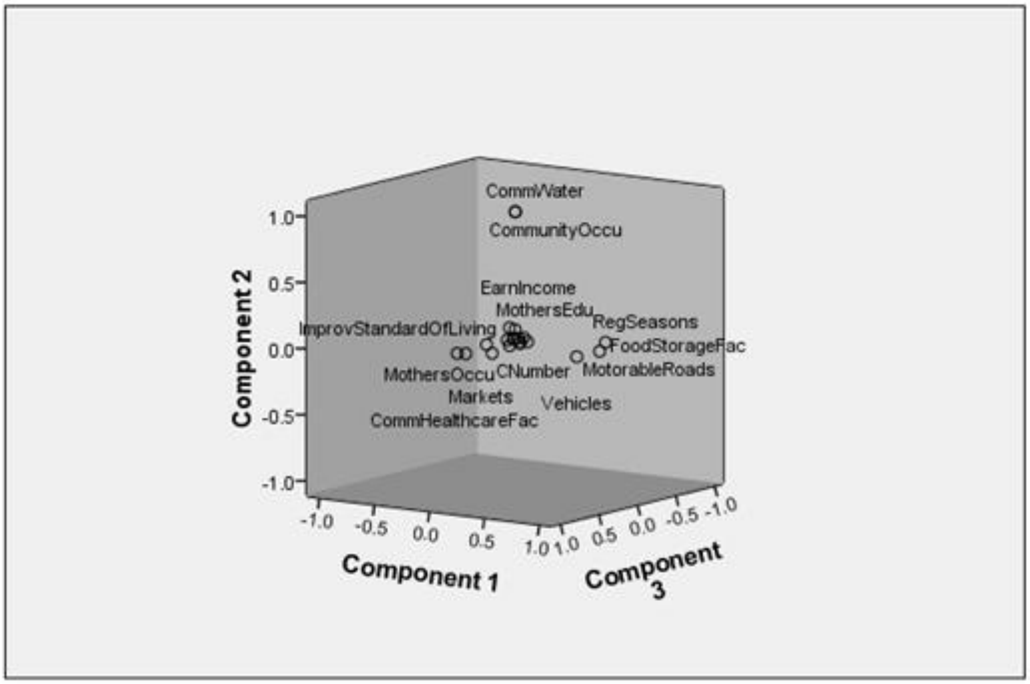
Source: Author (2014).

Figure 6.4.1b. Component plot in rotated space of index of food and nutrition security



Source: Author (2014).

Figure 6.9.1b. Index of Spatio-Economic Development component plot in rotated space



Source: Author (2014).

Appendix H

Geographic and Socio-demographic characteristics of the study area

REGION	MET./MIN./DIST	LOCALITY	SAMPLE SIZE PER LOCALITY
Upper West	Jirapa/Lambussie	Jirapa	14
Upper West	Nandom	Danko	14
Upper West	Lawra	Lawra	14
Upper West	Nadowli	Sombo	14
Upper West	Wa West	Tanina	14
Upper West	Wa Municipal	Wa	16
Upper West	Wa East	Jeyiri	14
EAs: 7			Total:100
Research Assistants			5
REGION	**MET./MIN./DIST**	**LOCALITY**	**SAMPLE SIZE PER LOCALITY**
Upper East	Garu-Tempani	Bugri	7
Upper East	Nabdam	Nangodi	7
Upper East	Bolgatanga Municipal	Bolgatanga	8
Upper East	Bolgatanga Municipal	Zuarungu	7
Upper East	Bolgatanga Municipal	Bolgatanga	8
Upper East	Bongo	Samboligo	7
Upper East	Bongo	Bongo	7
Upper East	Builsa	Chuchiliga	7
Upper East	Garu-Tempane	Wuriyanga	7
Upper East	Kassena-Nankana	Chiana	7
Upper East	Kassena-Nankana	Katui	7
Upper East	Kassena-Nankana	Navrongo	7
Upper East	Kassena-Nankana	Mirigu-Nabaanga	7
Upper East	Talensi	Tongo	7
EAs: 14			Total:100
Research Assistants			6

Source: Author (2013).

REGION	MET./MIN./DIST	LOCALITY	SAMPLE SIZE PER LOCALITY
Northern	Nanumba North	Bimbila	14
Northern	Tamale Municipal	Tamale	14
Northern	Tamale Municipal	Tamale	14
Northern	Tamale Municipal	Tamale	15
Northern	Tolon	Tolon	15
Northern	West Gonja	Nabori	14
Northern	Yendi	Yendi	14
EAs: 7			Total:100
Research Assistants			5

Source: Author (2013).

Geographic Characteristics of the Study Area

Upper West

Annual Rainfall: 115cm

Min Temperature: 20 ^{o}C

Max Temperature: 40^{o}C

Soil: Savanna Ochrosols with Groundwater Laterites

Vegetation: Guinea Savanna with trees such as Dawadawa, Boabab and Shea Acacia

http://acdep.org/wordpress/acdep-operational-regions/the-upper-west/

Upper East

Annual Rainfall: 645mm-1250mm

Min Temperature: 15 ^{o}C

Max Temperature: 45 ^{o}C

Soil: Savanna Ochrosols

Vegetation: Guinea Savanna

http://mofa.gov.gh/site/?page_id=654 27/11/2014 http://acdep.org/wordpress/acdep-operational-regions/the-upper-east/ 27/11/2014

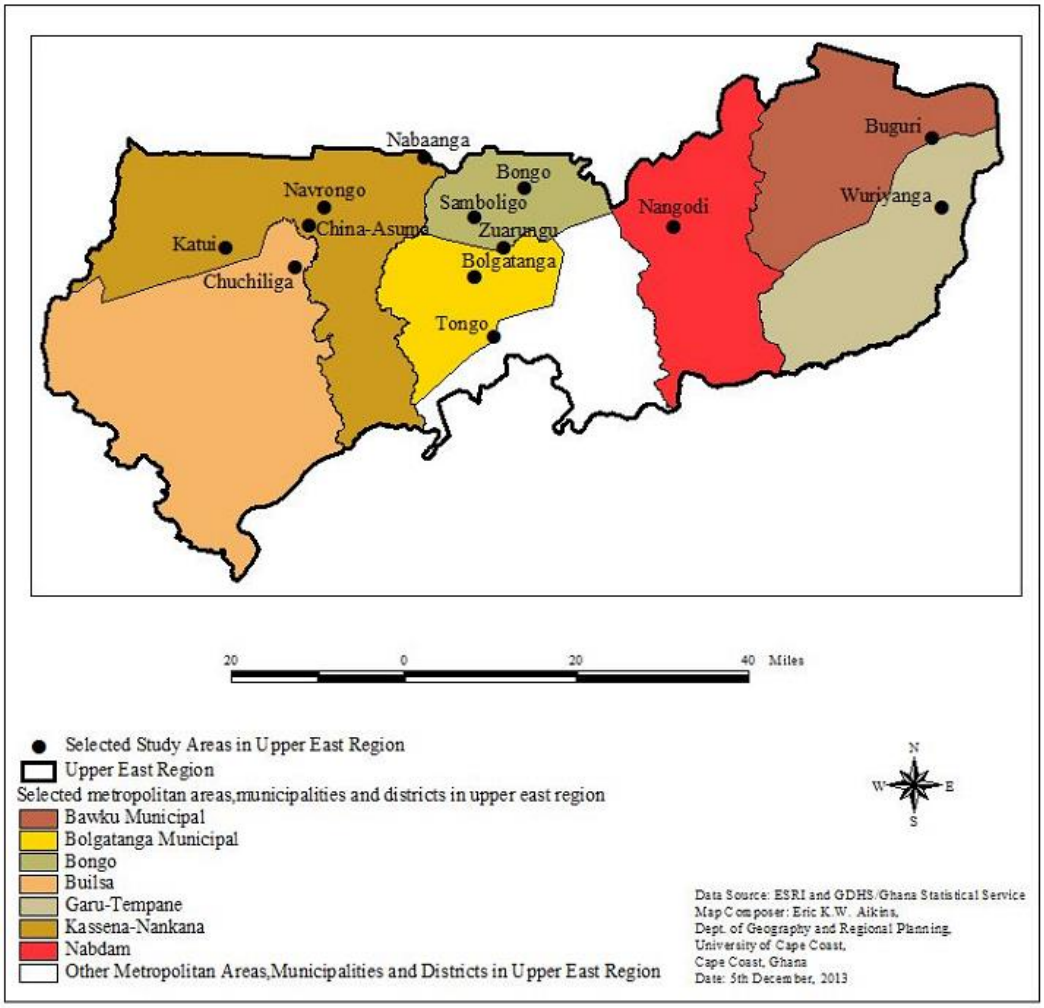
Northern

Annual Rainfall:	750-1050mm (30-40in) Starts in April and Peaks in August and September and declines in October
Day Temperature:	14^{o}C
Night Temperature:	38 ^{o}C
Soil:	Savanna Ochrosols with Groundwater Laterites
Vegetation:	Guinea Savanna interspersed with grasses and short trees

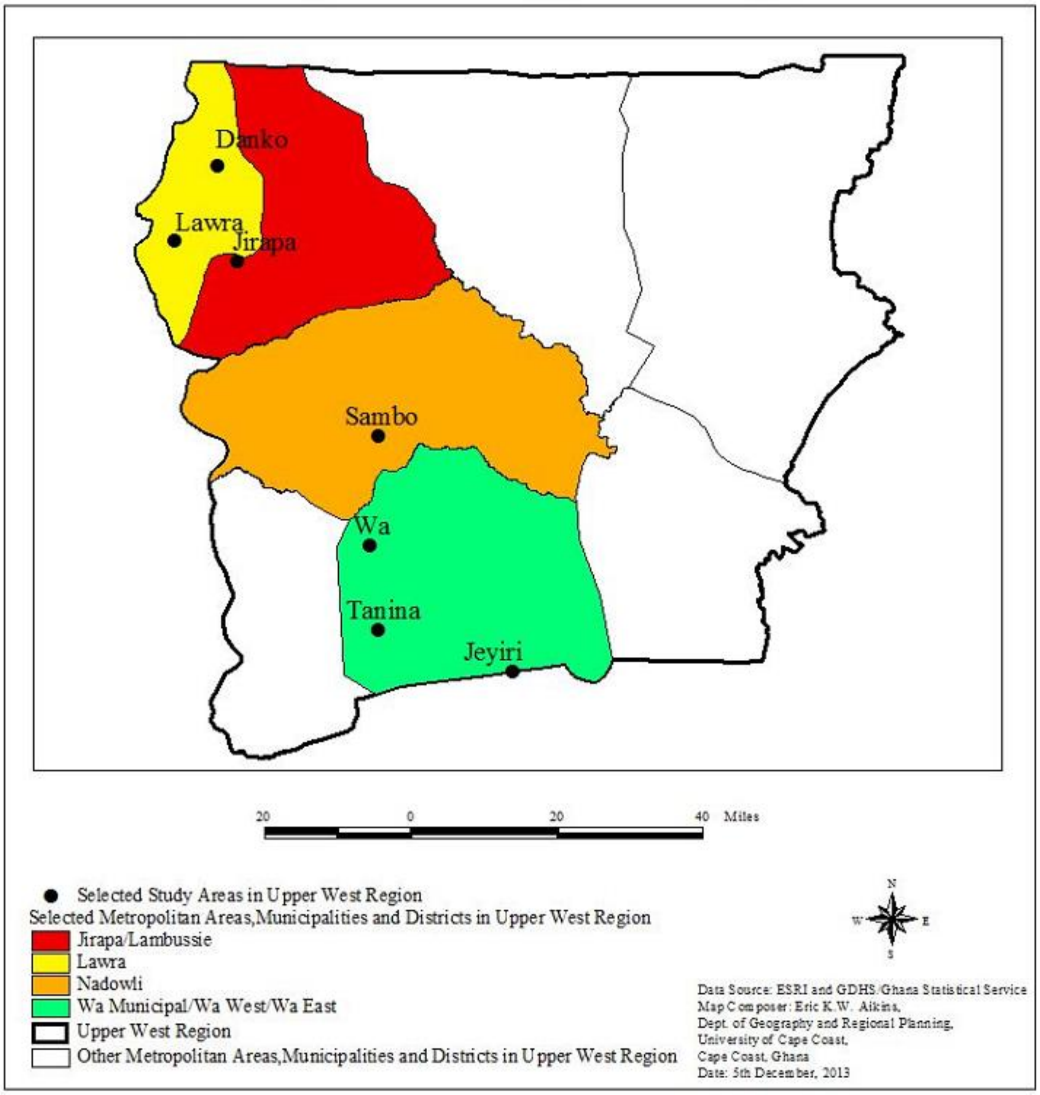
http://acdep.org/wordpress/acdep-operational-regions/the-northern/ 27/11/2014

(http://en.wikipedia.org/wiki/Northern_Region_(Ghana) 27/11/2014)

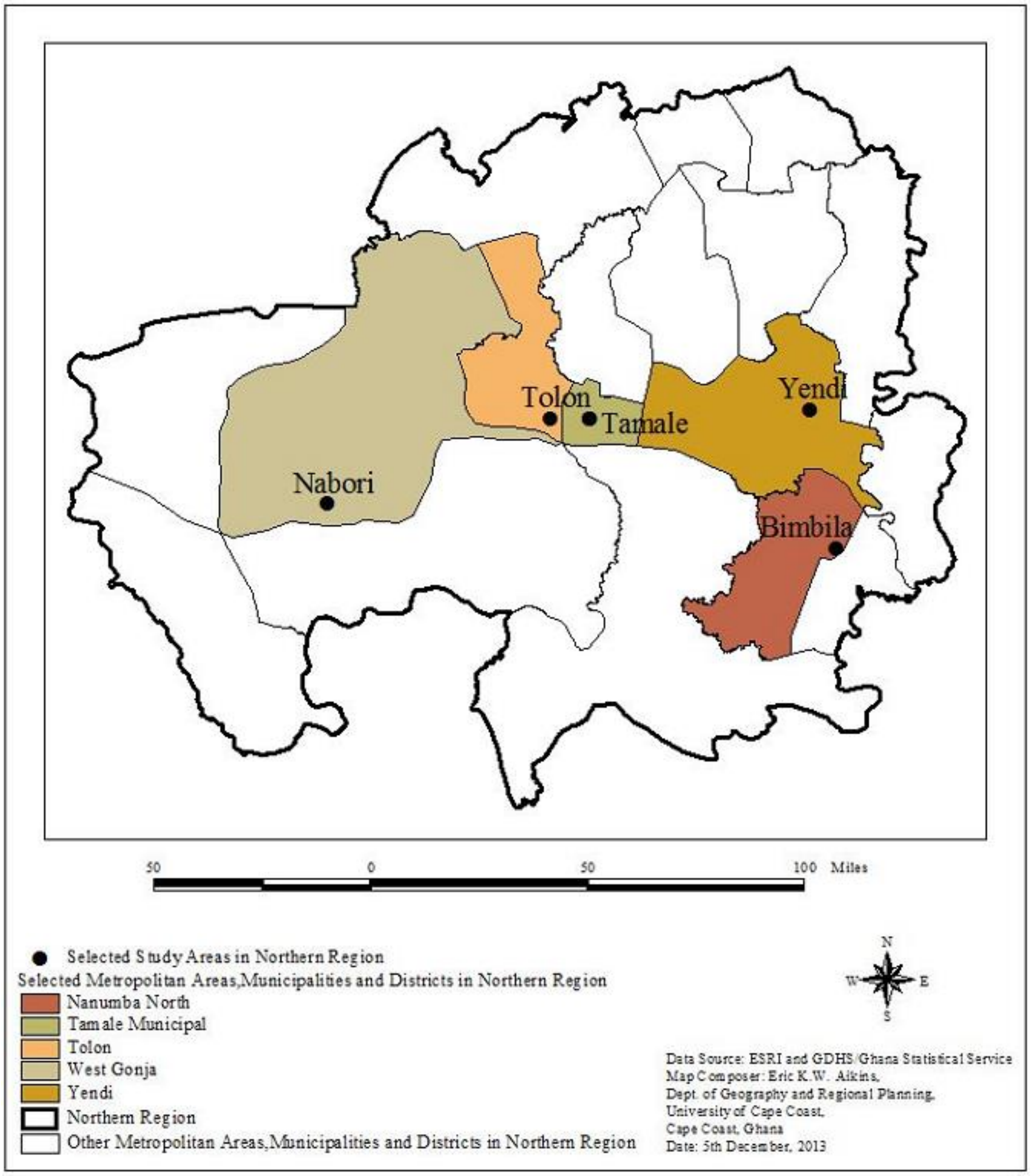
Map of Selected Study areas in Upper East region



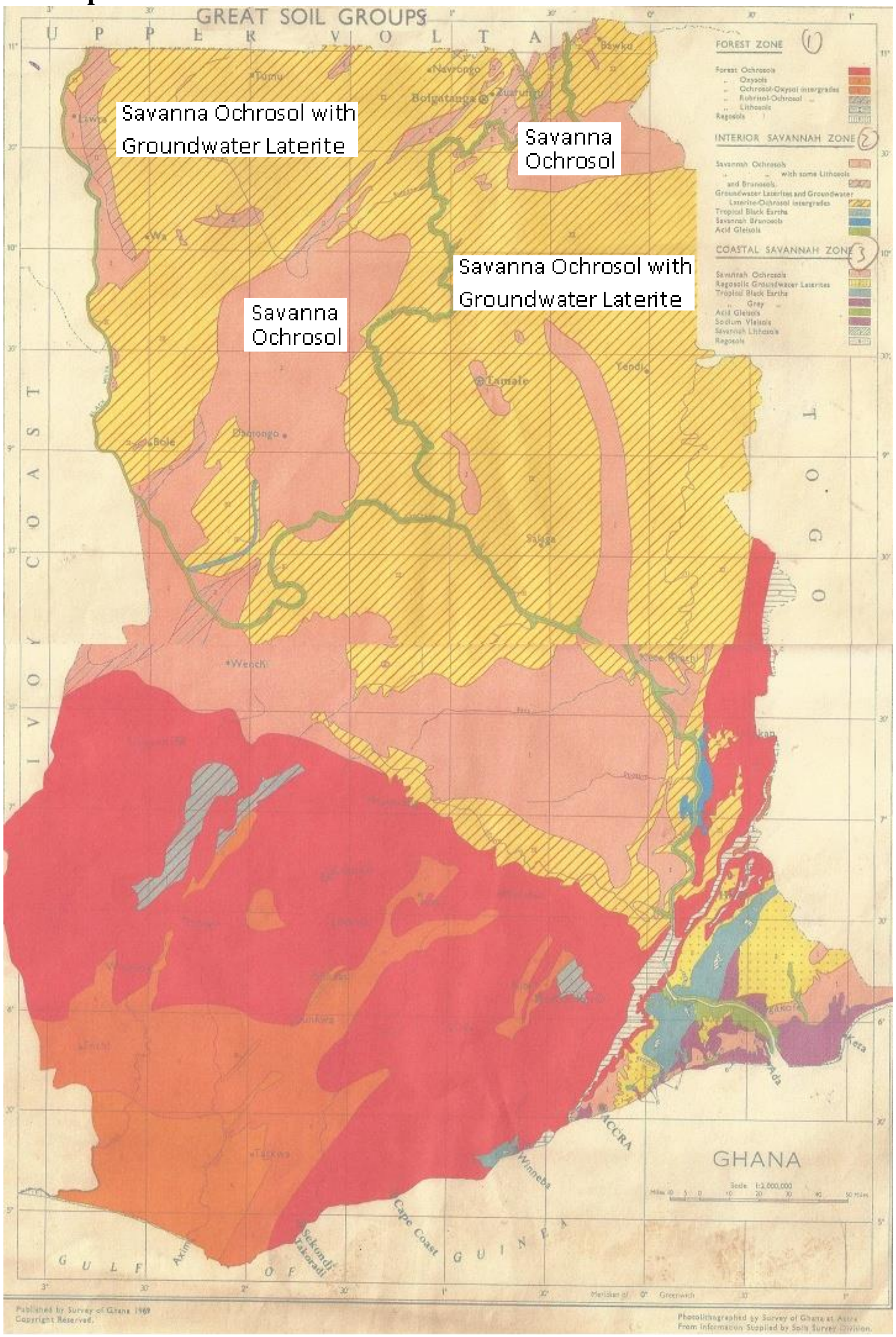
Map of Selected Study areas in Upper West region



Map of Selected Study areas in Northern region



Soil Map of Ghana



Appendix I

Selected child malnutrition and food and nutrition security variables

Major primary data variables	Some selected variables (Questions)
Spatial Attribute variables	<u>Human</u> Proportion of respondents in farming Proportion of respondent in other occupation Average monthly income <u>Physical/Environment</u> Soil quality (without fertilizer) Prevailing weather/Climatic condition (dryer or wetter) The length of dry or wet season Proportion of available arable land <u>Infrastructural Development</u> Availability of markets Availability of storage facilities Availability of road network Availability of vehicles Availability of schools Availability of health and sanitation facilities
Food and nutrition security variables	<u>Food Security</u> Availability of food stock before the next harvesting period <u>Quality of care</u> - Food type at weaning - Age at supplementary feeding
Health Status variables	<u>Health care</u> Available health care facilities <u>Clean/Healthy environment</u> - Availability garbage disposal site - Availability and type of drinking water
Spatio-Economic Development Variable	Increase in the proportion of spatial infrastructural development Increase in standard of living

Source: Author (2013).

Selected research objectives variables

Specific objectives	Some selected variables
1. Analyze the observed differences in child malnutrition between the Upper East Region on one hand and the Northern and Upper West Regions on the other between 1993 and 2008 GDHS periods.	- Height for age measure (stunting)
2. Examine the impact of food and nutrition security on child malnutrition.	- Height for age measure (stunting) - Availability of food stock before the next harvesting period - Food type at weaning - Age at supplementary feeding - Number of months of breastfeeding - Number of times of breastfeeding
3. Analyze the spatial and statistical relationships that exist between selected child malnutrition factors and food and nutrition security.	- Major child malnutrition factors - Index of food and nutrition security (Availability of food stock before the next harvesting period, food type at weaning, age at supplementary feeding, number of months of breastfeeding, number of times of breastfeeding).
4. Assess the role of agriculture (food production) in the attainment of food and nutrition security in Northern Ghana.	- Quantity of food produced per harvesting period - Availability of food stock before the next harvesting period
5. Propose strategies for managing child malnutrition and improving food and nutrition security in the Upper East Region of Ghana.	- Based on the study results and findings
6. Make recommendations for policy formulation and implementation that aim at managing child malnutrition and improving food and nutrition security in Ghana.	- Based on the study results and findings

Source: Author (2013).

Selected research question variables

Research questions	Selected variables
1. Why is the Upper East Region that has socio-economic, cultural, and spatial attributes similar to that of the Upper West and the Northern Regions experienced persistent and increasing trend in child malnutrition between 1993 and 2008?	- Responses from in-depth interview
2. Why is the Upper East Region, noted for the production of some of the most nutritious staple foods such as groundnuts, guinea corn/millet, and beans commonly used in the preparation of nutritious infants weaning food and children food is confronted with the problem of increasing child malnutrition among the three Northern Ghana Regions?	- Responses from in-depth interview
3. Are there significant differences in ethnicity, traditional practices, cultural acceptability of food and food taboos practised among the people of the three Northern Ghana Regions?	- Responses from in-depth interview
4. Are there significant differences in the determinants of child malnutrition and food and nutrition security among the three Northern Ghana Regions?	- Responses from in-depth interview

Source: Author (2013).

Selected research hypotheses variables

Research hypotheses	Some selected variables
1. Null hypothesis (N_o): There is a statistical significant negative relationship between food and nutrition security and child malnutrition.	Food and nutrition security - Index of food and nutrition security Child malnutrition - Age and height of children
2. Null hypothesis (N_o): There is a statistical significant positive relationship between spatial attribute of selected Northern Ghana communities and food and nutrition security.	Food and nutrition security - Index of food and nutrition security Spatial attributes (Index) - Proportion of respondents in farming - Average monthly income - Soil quality (without fertilizer) - Prevailing weather/Climatic condition - Proportion of available arable land - Availability of markets - Availability of storage facilities - Availability of road network - Availability of vehicles - Availability of schools - Availability of health facilities
3. Null hypothesis (N_o): Food and nutrition security exerts a stronger statistical significant impact on child malnutrition than the health status of children under age five.	Child malnutrition - Age and height of children Health Status (Index) -Available health care facilities - Availability and type of toilet facility - Availability and type of drinking water
4. Null hypothesis (N_o): A statistical significant regional variability in child malnutrition exists between the Upper West, Upper East and Northern Regions of Ghana..	Child malnutrition - Age and height of children Spatial scale - Region

Source: Author (2013).

Study objectives, research questions and hypothesis by data analyses technique

Study objectives, research questions and hypothesis	Data analysis technique
Specific Objectives 1	- Discreminant analysis.
Specific Objective 2	- Linear regression analysis.
Specific Objective 3	-GIS, Crosstabs and Chi-Square Analyses.
Specific Objectives 4	- Linear regression analysis.
Specific Objectives 5	- Qualitative analysis: Relevant information shall be obtained from the analysis of the study data and the review of the available literature to help achieve specific objectives 5.
Research question 1- 4	- Relevant information based on an in-depth interview shall be analyzed to provide additional information to help answer research questions 1- 4.
Study hypotheses 1-3	- Linear regression analysis.
Study hypotheses 4	- Discreminant analysis.

Source: Author (2013).