The association between the diversity of crop production and nutritional indicators of rural households in Northern Ghana

Final Thesis Report

Sofia Eirini Argyropoulou

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Author	Sofia Eirini Argyropoulou 840705018010
Supervisors	Dr. Ir. Inge Brouwer Wageningen University, The Netherlands Division of Human Nutrition Ilse de Jager (MSc) Wageningen University, The Netherlands Division of Human Nutrition

ABSTRACT

In this study, we address a gap in our understanding of how household production diversity affects the diets and nutrition of infants and young children living in rural farming communities in northern Ghana. In the country of Ghana, child malnutrition rates are high including the prevalence of micro-nutrient deficiencies. Agricultural programs emphasizing nutrition objectives may provide the necessary framework for sustainable, long-term efforts towards decreasing micronutrient deficiencies. One of the first steps is to identify strategies to improve the nutritional quality of the diet based on locally available foods. Few studies have researched the associations between crop diversity and child nutrition. The specific objectives of this study will (1) investigate the associations between the diversity of household production and nutrition reflected in coverage of nutrient requirements supplied through household production, the individual dietary diversity score and the nutritional status of children 6 to 23 months old in northern rural Ghana; and (2) evaluate the validity of the interview method based on self-reporting, to an observation method, to determine potential underestimations when reporting on crop diversity indicators. From the data previously collected for the *Global Alliance for Improved Nutrition* study (GAIN) in northern Ghana, 24hr recalls, crop production data and household survey data was collected from 400 households of which 329 household were included in this study. For the evaluation study, a sub-selection of 51 households was chosen from the total sample. Our findings show that increased crop diversity is associated with a higher potential of crops to meet the nutrient needs of household members. However, this study does not show associations between diversity of household production and dietary diversity of children 6 to 23 months or nutrition status of these children. Our findings also indicate underestimations of crop production data comparing the self-reported interview to the observation method. We conclude that an increase in crop diversity can improve the potential coverage of nutrient requirements supplied by household production. Food production in subsistence households plays an important role in providing a diversity of nutrient supply. Future research should explore the areas of income expenditure, intra-household distribution of food and food waste to determine the potential of household production diversity to affect the dietary quality of infants and young children 6-23 months in rural areas of sub-Saharan Africa.

Keywords: crop diversity, agro-diversity, richness, evenness, shannon-wiener Index, individual dietary diversity score, nutritional status, wasting, stunting, underweight, agriculture, nutrition.

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LIST of ABBREVIATIONS

DD	Dietary Diversity
EAR	Estimated Average Nutrient Requirements
FAO	Food and Agriculture Organization
FBDRs	Food-based dietary recommendations
FCT	Food Composition Tables
GAIN	Global Alliance for Improved Nutrition
GFCT	Ghana Food Composition Table
HAZ	Low Height for age (stunting)
HH	Hidden Hunger
IDDS	Individual Dietary Diversity Score
IVACG	International Vitamin A Consultative Group
IYCF	Infant and young child feeding
IZiNCG	International Zinc Nutrition Consultative Group
LAZ	Length for age
MFCT	Mali Food Composition Table
MOFA	Ministry of Food and Agriculture Ghana
MUAC	Mid-Upper Arm Circumference
NFD	Nutritional Functional Diversity
RAE	Retinol Activity Equivalents
RNI	Recommended Nutrient Intake
SWI	Shannon-Wiener Index
USDA	United States Department of Agriculture
VAD	Vitamin A deficiency
WAFCT	West Africa Food Composition Table
WAZ	Low Weight for age (undernutrition)
WHO	World Health Organization
WHZ	Low Height for length (wasting)
24hR	24-Hour Recall

LIST of CONCEPTS

***Agro-biodiversity*.** The variety and variability of living organisms (plants, animals, micro- organisms) that are involved in food and agriculture. It includes genetic crop varieties, animal breeds and races, pollination and pest control and microorganism strains, which are used directly or indirectly for food and agriculture [1].

***Biodiversity*.** The variability among living organisms from all sources including inter alia; terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems [2].

Crop Diversity. Also referred to as plant genetic resources for food and agriculture, embraces the diversity within and among crops, their wild relatives and wild edible plant species [3] **.**

Cropping Systems. Pattern of crops taken up for a given piece of land, or sequence in which the crops are cultivated on a piece of land over a fixed period and their interaction with farm resources and other farm enterprises [3].

Dietary Diversity (Score). A qualitative measure of food consumption that reflects household access to a variety of foods, and is also a proxy for nutrient adequacy of the diet of individuals [4], [5]. A DDS is the number of individual foods or food groups consumed over a fixed period of time and is reflective of adequate nutrient intake [4, p. 5]. A higher dietary diversity score increases the probability that an individual meets adequate intake and requirements of key nutrients from the diet. A DDS depends on whether it is measured at the individual level or the household level.

EAR. Estimated average requirement is the average daily nutrient intake level that meets the needs of 50 per cent of the “healthy” individuals in a particular age and gender group. It is based on a given criteria of adequacy which will vary depending on the specified nutrient. Therefore, estimation of requirement starts by stating the criteria that will be used to define adequacy and then establishing the necessary corrections for physiological and dietary factors. Once a mean requirement value is obtained from a group of subjects, the nutrient intake is adjusted for inter-individual variability to arrive at a recommendation [9].

Individual Dietary Diversity Score (IDDS). The ability of the diet to meet energy and micronutrient needs of the individual. A higher IDDS or higher amount of food groups consumed, is associated with an increased probability of nutrient adequacy of the diet based on the individual intake [7].

Hidden Hunger. A chronic lack of micro-nutrients - minerals and vitamins – whose effects may not be immediately apparent and whose consequences may be long-term and profound [7].

Household Dietary Diversity Score (HDDS). The household dietary diversity score (HDDS) is meant to reflect, in a snapshot form, the economic ability of a household to access a variety of foods. The greater the food groups available, the higher the HDDS. Studies have shown that an increase in dietary diversity is associated with socio-economic status and household food security (household energy availability) [7].

Dietary Quality. The probability of adequate intake of key nutrients in the human diet. Dietary quality can also comprise the microbiological quality, but we are not addressing these in our study. It also covers aspects related to over-nutrition or excessive intake of dietary characteristics such as saturated fat, cholesterol, sodium and sugar where such foods do not necessarily increase the nutrient adequacy or diversity of the diet [7].

***Eco-nutrition*.** Linking agriculture, ecology and human nutrition and health to tackle malnutrition [8].

Functional Diversity. *A* metric used in ecology that reflects the 'trait distinctiveness of species in a community and the degree of complementarity in traits of species within a community' [1], [9].

Nutrient Adequacy. How well the diet is able to meet the individual requirements for energy and essential nutrients (macronutrients and micronutrients) [7].

Nutritional Functional Diversity (NFD). A novel metric that bridges agriculture, ecology and nutrition studies. The NFD metric is based on plant species composition at the farm and the nutritional composition of these plants (17 different nutrients) that are a key in human diets [1], [9].

Nutrient Gap. Signifies a lack or insufficiency in meeting the Required Nutrient Intake (RNI) on a regular daily basis, deteriorating nutritional status [10].

Malnutrition. Imbalance of intake of food and utilization of nutrients compared to the requirements. It includes under-nutrition and over-nutrition [7].

Under-nutrition. A form of malnutrition which has two sides: hunger in reference to food insecurity causing stunting, wasting and deficiencies of essential vitamins and minerals and macronutrients. New body of evidence shows under-nutrition to also include obesity and over-consumption where a lack of specific nutrients such as key vitamins and minerals (micronutrients) in a diet may contribute to poor dietary adequacy [7].

Over-nutrition. A form of malnutrition in which the intake of nutrients is oversupplied. The amount of nutrients exceeds the amount required for normal growth, development, and metabolism. Overweight and obesity are outcomes of this form of malnutrition [7][11].

RNI. Recommended nutrient intake (RNI) is the daily intake, set at the EAR plus 2 standard deviations (SD), which meets the nutrient requirements of almost all apparently healthy individuals (97.5 per cent) in an age- and sex-specific population group. The definition of RNI used in this report is equivalent to that of the recommended dietary allowance (RDA) as used by the Food and Nutrition Board of the United States National Academy of Science [12].

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1. INTRODUCTION

Undernutrition in children is a multi-faceted problem, encompassing insufficient quantity and quality of food, lack of proper health care facilities and the inability to adopt proper childcare and feeding practices [13]. These three determinants of undernutrition, *food*, *health* and *care* have been recognized and understood to be linked to each other [14]. However, the adoption of these three determinants rarely occur in unison as much attention has primarily been focused on nutrition-specific interventions such as breastfeeding programs and aligning much of the work within the health sector [15]. Recent international strategies to tackle undernutrition work with these direct interventions in addition to nutrition-sensitive programs and policies, one of them being food-based programs [16]. Addressing the food determinant of undernutrition involves to some extent the alignment of nutrition to the agricultural sector. Over the past decades of the 20th century, there have been great strides to reduce hunger through agriculture [17]. With the use of various technologies such as pesticides, herbicides, fertilizers and new breeds of high yielding staple crops, the advent of the Green Revolution post World War II (WWII) brought with it a determination to tackle food insecurity through increased agricultural production [18], [19]. Such strides have indeed been made to address a lack of calories in the diet. However, great challenges remain in the management of agriculture and the food system to increase the potential to provide an adequate diversity of nutrients for proper human growth and development [8], [20]. Optimizing the nutritional output of farming systems has not been a primary objective in modern agriculture [1]. With the success of crop yields evaluated by economic output and cost-benefit ratios, agricultural production systems have changed from diverse towards more simple, cereal-based food systems [17]. The latter may be characterized by foods that provide calories but do not necessarily provide complementary nutrients. Ultimately, this contributes to a decrease in quality of the diet and lower nutrient adequacy further perpetuating micronutrient deficiencies and malnutrition in both developing and industrialized societies [20].

Lack of access to food and decreasing quality of the diet have become a global problem [21]. Worldwide more than 795 million people are undernourished [22], 2 billion afflicted with one or more micronutrient deficiency [11], [12], and over 1 billion adults are overweight [25]. Iron, vitamin A, zinc and iodine deficiencies have the highest global prevalence and are tied to forms of health deterioration lowering the defense mechanisms of the immune system leading to chronic bacterial infections and in some cases to (fatal) diseases [26], [27]. In numerous developing and emerging societies, such public health challenges disproportionally affect women and children, as micronutrient needs are higher for these segments of the population [28]. Such deficiencies may lead to complications for the mother during childbirth, low-birth weight and stunting and wasting among children.

Agricultural programs emphasizing nutrition objectives, may provide the necessary framework for sustainable, long-term efforts towards decreasing micronutrient deficiencies [29]–[31]. Food-based interventions to tackle under-nutrition in the past have been mostly single-nutrient oriented or have made recommendations for high-protein or high-energy diets [1], [32]. These were due to a lack of knowledge in earlier years about the interactions among nutrients in human physiology. The recognition that nutrient deficiencies rarely occur in isolation has called for dietary diversification as a strategy to increase the nutrient adequacy of the diet and ultimately, to benefit nutritional status [9], [33]–[38]. An integrative focus on agricultural food-based approaches and dietary diversification may be better suited to address multi micro-nutrient challenges. Examining these dimensions in the context of Sub-Saharan Africa is particularly important given the widespread food insecurity and malnutrition seen across the continent, the kinds of agricultural policies currently promoted in response to this poor nutrition, as well as the fact that more than two-thirds of the population depends on agriculture as a source of livelihood [39][40].

In the African continent, progress has been made to decrease hunger, yet forms of malnutrition persist to a large degree [41]. Research on integrating agriculture and public health initiatives as a potential strategy to decrease nutrient gaps has paved the road for agricultural based food-based interventions to take form [1]. In the country of Ghana, child malnutrition rates are high including micro-nutrient deficiencies with child anemia rates in excess of 70 per cent and anemia afflicting almost half of women of childbearing age [42] [43]. This has led to Ghana's inclusion in the 2008 World Health Organization's (WHO) list of 36 high-burden countries for malnutrition [44]. Although recent data on the prevalence of micro-nutrient deficiencies are not readily available, the FAO and several Ghanaian publications indicate that deficiencies exist within the population primarily among the following: energy and protein, iodine, iron and vitamin A [43], [45]. The FAO has declared that the proportion of households using adequately iodized salt remains unacceptably low requiring the national programme of salt iodization to be monitored and re-evaluated. Moreover there is a lack of recent and nationally representative surveys on vitamin A deficiency (VAD) among young children. Vitamin A supplementation programmes have been implemented throughout the country but coverage has not been thoroughly extended among children and women, and especially among women living in the Eastern and Northern regions of the country [43]. Child malnutrition is also reflected in high stunting, wasting and underweight rates. Food-based energy shortages, particularly stunting, primarily results from diets which do not meet energy and nutrient requirements to support the rapid growth of infants and young children. Over the past two decades, the prevalence of childhood stunting rates in Ghana have hovered around 28-29 per cent of children under the age of five and in rural areas, around 32.5 per cent with 9 per cent who are wasted [42], [37]. Moreover, more than one third of infants less than 6 months are not exclusively breastfed and 36 per cent of children 6-23 months are fed appropriately for their age [42]. Due to rural urban disparities, childhood malnutrition is worse in rural areas. However, there are also regional disparities. For example, prevalence of chronic and acute malnutrition (i.e. stunting and wasting, respectively) is higher in the Northern and Upper East regions of Ghana compared to the national averages [42]. Initiatives linking agriculture and nutrition potentially offer a sustainable approach to tackle under-nutrition. Additionally, it also complements the efforts to promote, protect and support optimal breastfeeding together with appropriate complementary feeding recognized as key public health strategies for child survival [42], [7].

As part of continued efforts needed to understand and develop promising and sustainable interventions to improve the feeding of infants and young children in Ghana, USAID/Ghana aims to find the linkages between agriculture and nutrition. One of the first steps is to identify strategies to improve the nutritional quality of the diet based on locally available foods. As a starting point, it is necessary to obtain an overview of the different pathways that agriculture is deemed to affect child nutrition (see figure 1 – *Pathways* below) [47]. These pathways include: (1) the production of food to be eaten by a household or sold for income and if this assists the purchase of other food and health services; (2) income, the food market and the ability to access food; and (3) gender specific pathways including women's socio-economic status [48], [49]. However, evidence on the effect of different pathways to child nutrition outcomes is few and far between. In subsistence farming, the link between agriculture and nutrition is more direct, as what is produced tends to be consumed within the home [15]. Therefore, greater production diversity can have direct impacts on the diversity of nutrients supplied, potentially improving dietary quality. Several authors argue that increased biodiversity, specifically agro-biodiversity, known as 'the variety and variability of living organisms (i.e. plants, animals, micro-organisms) that are involved in food and agriculture' [1], might lead to increase diversity of foods in the diet at a population level [17], [20], [14], [19], [20]. Additionally, a more diversified cropping system, defined as 'a pattern of crops embracing the diversity within and among crops', is further argued to have an impact on dietary quality with increasing production diversity [9]. Several studies do indicate that nutrient adequacy of the diet improves as a higher diversity of food items or groups are consumed [1], [5], [26], [52], [53]. This increasing body of evidence shows a high correlation between the dietary diversity score, (DDS: number food groups consumed by an individual) nutrient adequacy of the diet and positive health outcomes such as a decrease in stunting, mortality and incidence of cancer among women and children [20], [52].

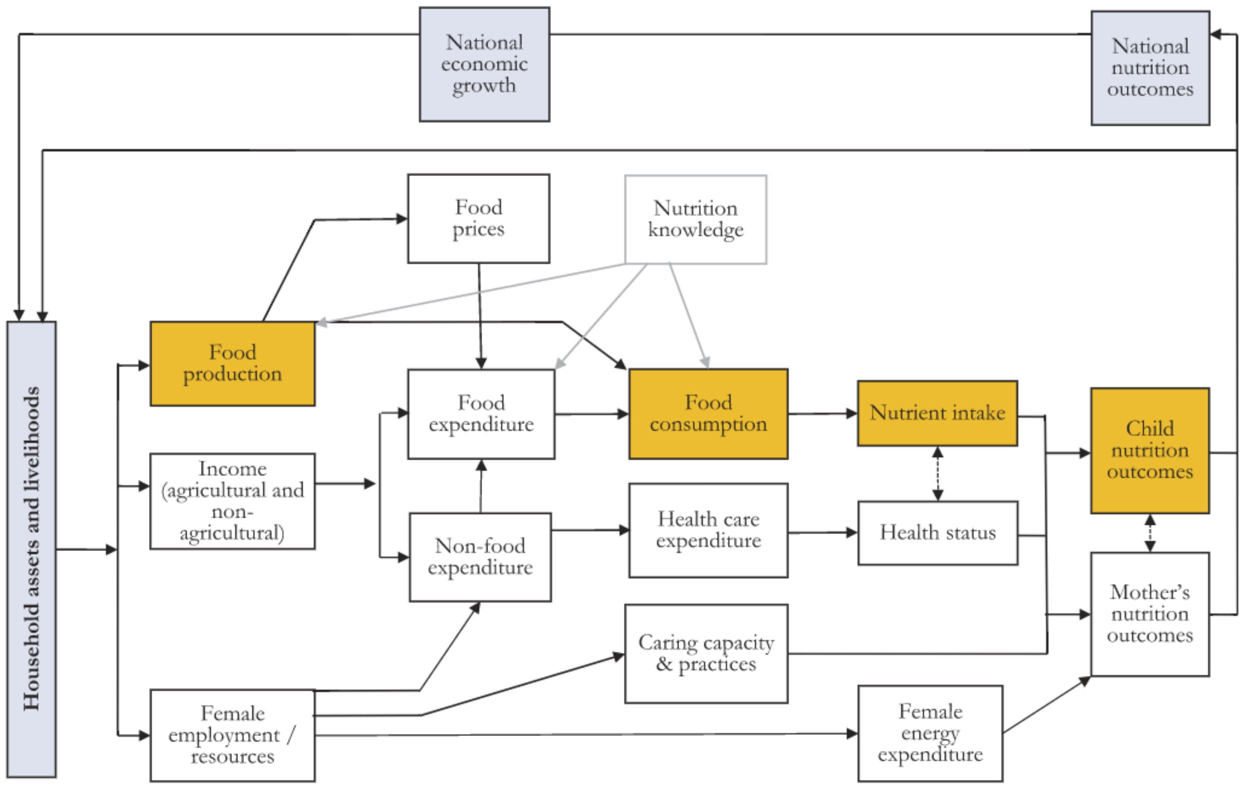


Figure 1. Pathways adapted from Gillespie, Harris and Kadiyala (2012) [48]

This study will primarily focus on the first pathway between agriculture and nutrition to determine if production diversity and specifically crop diversity, does benefit child nutrition. Different crop diversity indicators have been used in ecological research to determine the levels of diversity among species. The indicators that will be used in this study include:

1. *Specie richness (crop count)*: a crop count variable counting the total number of different crops species cultivated by a household or group [39], [54];
2. *Specie evenness*: determines the abundance levels of different crops within a cropping system [39];
3. *The Shannon-Wiener Index (SWI)*: reflects both richness and evenness but also captures the amount of yield per crop in proportion to total household production [55].

Infant and young child feeding (IYCF) is a pivotal determinant of nutritional status accompanied by indicators for complementary feeding practices [7]. Dietary diversity is a central indicator of IYCF [7]. Dietary diversity scores have been examined to assess the quality of the diet. Nutrition status indicators have been used to assess the degree of acute or chronic malnutrition within the population. The indicators that will be used in this study include:

1. *Individual Dietary Diversity Score (IDDS)*. IDDS is 'the number of individual foods or food groups consumed over a fixed period of time and is reflective of adequate nutrient intake' [4, p. 5]. Validated for infants and young children and a proxy for nutrient adequacy of the diet.
2. Validated nutrition status indicators include stunting, wasting and underweight (i.e. also overweight but this indicator is not addresses in this thesis). *Stunting* is defined as a chronic restriction of vertical growth indicated by low height for age; *Wasting* is defined as acute weight loss indicated by a low weight for height; *Underweight* is defined as a low weight for age [56].

It must be noted that few studies have researched these associations and current research methodologies have used different indicators for crop diversity and child nutrition. Moreover, with research performed in different contexts, comparison among results is challenged. Three arguments have been identified to further understand where the information gaps lay and what could be done to close them.

1. It is unclear if an increase in crop diversity does indeed benefit nutrient adequacy of the diet [1], [9], [57]. The few articles that discuss these links have associated different crop diversity indicators with a household dietary diversity score (HDDS) and have indeed found significant between them. Jones (2014) investigated farm diversity indicators (crop count and livestock count) with a HDDS in Malawi and found significant associations between the two [55]. Similar results were found from Rajendram (2014) who investigated the same indicators but in Tanzania [58]. The critical point here is that although HDDS is reflective of household food access and household energy availability, it is not reflective of dietary adequacy. As dietary adequacy is a determinant of micro-nutrient status, using HDDS might not bring enough depth in understanding the strength of production diversity to contribute to quality of the diets. Masset (2012) and Rumar (2015) on other hand, do investigate production diversity with IDDS and find significance between the two but not with nutrition status of children 6-23 months [15], [59]. Clearly identifying appropriate crop diversity indicators and aligning them with indicators that reflect dietary adequacy and nutritional status can help to better construct the evidence;
2. The difference between total production diversity and the proportion of production that is maintained in the home and used for consumption is an important characteristic to capture. Seldom, have previous studies made these distinctions. Jones (2014), Rajendram (2014), Masset (2012), have primarily focused on total production diversity and associated this with HDDS or IDDS. Including the amount of production diversity that is actually consumed, provides greater accuracy when interpreting the associations;
3. Linking ecological metrics to nutrition ones do not reflect dimensions of food consumption or food habits (i.e. ways in which foods are usually eaten) [17], [52]. The exclusion of such data from the analysis weakens possible associations between crop diversity and nutrient adequacy of the diet. Food preparation techniques such as frying, and retention factors such as retention of nutrients after boiling, all play a role in the

bioavailability of the nutrients found in plants and the inclusion of these factors might demystify the links [1], [9], [50], [52].

In particular, evidence is needed on the links between the diversity of food production within a household, how much of that food is consumed in the home and the subsequent effects on IDDS and nutrition status. With high levels of malnutrition in rural Northern Ghana and farming being the main stay of work, this study will investigate whether crop diversity indicators are associated with (1) coverage of nutrient requirements by the nutrients supplied at household level; (2) nutrient adequacy of the diet of children 6-23mo old; and (3) nutritional status of children 6-23mo old, in rural Northern Ghana. Demystifying these associations could be potentially useful for monitoring the nutrition sensitivity of agricultural interventions and potentially show if production diversification strategies increase dietary diversity.

2. RESEARCH OBJECTIVE AND HYPOTHESIS

2.1 RESEARCH OBJECTIVES

This thesis research is composed of two main research objectives. The first objective is to look at the associations between crop diversity of household production and nutrition reflected in coverage of nutrient requirements supplied through household production, the individual dietary diversity score and the nutritional status of children 6 to 23 months old in northern rural Ghana. Divisions between total household production per year and production used for home consumption per year will be distinguished to reflect food intake from own production.

In order to break down the components within the first research objective, specific objectives have been created:

1. To determine if a greater diversity of household production is associated with a greater coverage of nutrient requirements at the household level;
2. To determine if a greater diversity of household production is associated with an improvement in nutrient adequacy: are the crop diversity indicators associated with IDDS of children 6 to 23 months old and the nutrition Status of these children;
3. To determine if the coverage of nutrient requirements supplied through household production is associated with an improvement in nutrient adequacy and nutrition status indicators.

The second research objective was to evaluate the validity of the interview method based on self-reporting, to an observation method, to determine potential underestimations when collecting data and reporting on crop diversity indicators.

2.2 HYPOTHESIS

It is hypothesized that a larger diversity in household production would reflect in a higher individual diversity score and better nutritional status of infants and young children between the ages of 6-23 months in Northern rural Ghana. The associations would be stronger when taking into account the production used for home consumption.

It is hypothesized that data collected in Karaga, Ghana in 2015, will show an underestimation of the actual crop count within a family plot when comparing the self-reported interview method to the observation method.

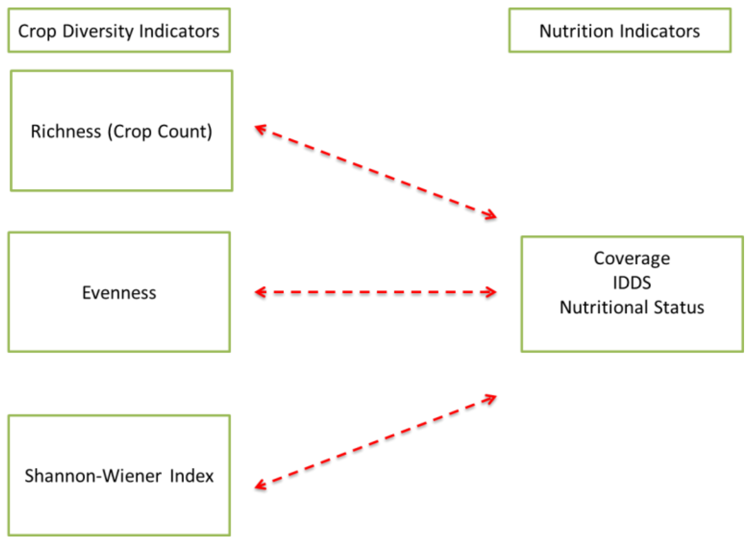


Figure 2. Hypothesis

3. METHODOLOGY

Under the request of USAID/Ghana, the Global Alliance for Improved Nutrition (GAIN) conducted a Food Consumption Survey of Infants and Young Children (6-23 months) to develop a set of evidence-based, population-specific, food-based dietary recommendations (FBDRs) which may promote and improve dietary intake and the nutritional status of young children (6-23 months) in farming communities of Northern and Southern Ghana (GAIN research protocol). Data collected from the GAIN study in Northern Ghana was used for this thesis.

This thesis research consists of two parts. Firstly, based on previously gathered data from the GAIN study, it was possible to determine the associations between crop diversity indicators and IDDS and nutrition status indicators. Secondly, fieldwork which commenced in October 2015 in Northern Ghana served to evaluate the validity of using the self-reported interview method to the observation method and determine potential underestimations when reporting data on crop diversity indicators.

3.1 STUDY DESIGN

The design of this thesis research was created to determine how the diversity of cropping systems may increase nutrients supplied subsequently increasing the coverage of nutrient requirements, benefitting IDDS and nutrition status of mothers and children in Northern rural Ghana (see figure 3 - *Study Design* below). Looking at production, consumption and nutritional status, different components within each have been identified in addition to their respective indicator. The food consumption and crop production data used for this thesis was collected in the cross-sectional study to develop FBDRs by GAIN, Wageningen University and University of Development studies in Ghana.

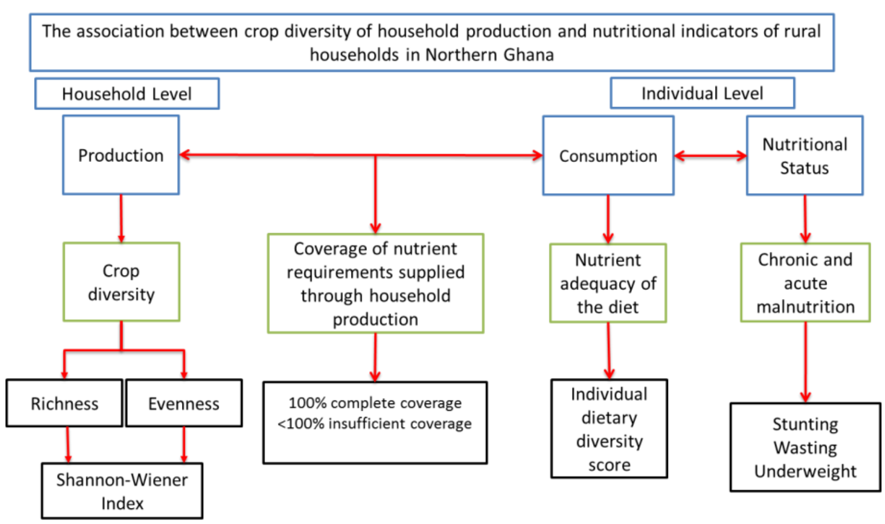


Figure 3. Study Design

3.2 STUDY AREA

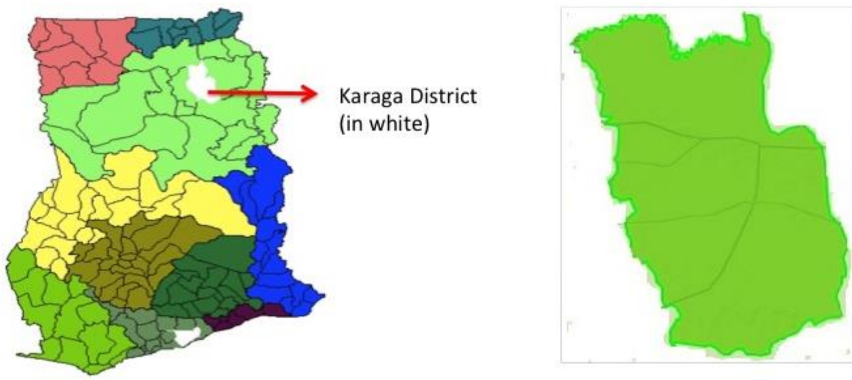
Four sub-districts as used by Ghana Health Service in Karaga district were randomly selected. However, two of these sub-districts were not included in the random selection due to the advent of the raining season and their inaccessibility caused by it. The remaining two sub-districts were selected. The data used for this study came from the remaining two sub-districts from within the Karaga district.

This study has been conducted in Karaga District in the Northern sector (see figure X below - Karaga district, Ghana). It is located in North-East of the Northern Region of Ghana, roughly between latitudes 9°30’ and 10°30’ North and longitudes 0° and 45’West. Karaga district is within the Guinea Savannah vegetation zone having a typical uni-modal rainy season (April – September). The vegetation in Guinea Savannah is characterized by tall grasses interspersed with drought resistant trees such as the shea (*Butyrospermum Parkii*) and dawadawa (*Parkia Biglobosa*) with a typical uni-modal rainy season between the months of May-October, peaking in August-September.

Karaga District consists of 205 communities. The district has a population of 77,706 (48 per cent male and 52 per cent female) and an average household size of 10 people [60]. Over 70 per cent of the communities in the district have a population of 800 people or less. The most populated communities are located on the Western border of the district along the main roads, making them the most accessible areas of the district. Karaga district is known as having the largest household sizes on average in the Northern region [61]. Karaga town is by far the largest in terms of population, about 12.800 (20 per cent of the total district population) [61]. The inhabitants of the district are predominantly subsistence rain fed farmers. Major traditional cultivated crops include: cereals (maize, sorghum, millet and rice), legumes (soya groundnuts and cowpeas) and starchy roots (cassava and yam). About 17.8 per cent of the households in the district are food insecure with 11 per cent severely or moderately food insecure [46]. According to the WFP, 34.7 per cent of households in the district live in the two poorest wealth quintiles defined by the 2006 Ghana Living Standards Survey as annual income below GH ¢370 [60].

As this district is relatively new, data on nutrition is scarce particularly regarding nutritional status of children 6 – 23 months. Nonetheless, there are indications that malnutrition rates are high and may point to suboptimal infant and young child feeding practices in rural communities in Northern Ghana [42]. Additionally, according to the Centre for Democratic Development (CDD) and UNICEF’s ranking tool, Karaga District was scored lowest on the progression towards delivering development and key basic services. Indicators of the ranking tool include the quality of education, sanitation, rural water, health, security and governance in the districts. The health status of the people of Karaga is among the worse in the region [62].

Despite these challenges, Karaga district has an enormous economic potential in terms of agriculture [63]. Major traditional crops cultivated in the district include maize, sorghum, millet, soya groundnuts, cowpeas, cassava, rice and yam.



Map of Ghana
Adapted from Gain Protocol

Karaga District

Figure 4. Karaga district, Ghana

3.3 STUDY POPULATION

The selection process for the study population was done for the purpose of the GAIN study. Infants and young children between 6 –23 months are the primary target of this study. Primary caregivers of the children 6 – 23 months, namely their mothers, have been interviewed and asked to provide 24 hour recalls (24hR) of their children's dietary data.

3.4 SAMPLE SIZE AND SAMPLING PROCEDURE

The sample size estimation for the collection of dietary data, sufficient to capture the potential variability in dietary patterns of children, is based on the requirements of the GAIN study, which have then been adapted to this research thesis. GAIN's approximation for the sample size requirement was based on what was previously discussed in literature, in-line with linear programming techniques and from recommendations of one of the researchers experienced with linear programming and the development of Optifood (Elaine Ferguson, personal communication).

The sample size (n) of ≈100 per target group is based on estimating population mean food serving sizes for commonly consumed foods in the study areas to within 10% (95% CI), assuming a SD of 50% of the mean serving sizes in this age group and allowing for a 5% rate of attrition. The total sample size among all target groups started at n=400. However, in the target group of 12-23 months old, there were not enough children which were not breastfed. Thus, only 37 cases were available for inclusion in the group of non-breastfed children 12-23 months. Thus, data of 337 children in the Karaga district were collected in May 2014. A census was conducted and included sex, date of birth and the breastfeeding status of the infants. The children included in the sample size calculation were grouped in the following way:

1. Breastfed infants between the ages of 6 – 8 months;
2. Breastfed infants between the ages of 9 – 11 months;
3. Breastfed young children between the ages of 12 – 23 months;

4. Non-breastfed young between the ages of 12 – 23 months;

Eligibility of the participants for the study was cross-checked in the field prior to the start of the 24hR and ineligible children were replaced with other eligible children in the same community. Where there was no eligible child for replacement in a community, the index child was replaced with another from a nearby community. One child per household was selected and where a mother or caregiver had two or more children who qualify, one of them was randomly chosen (age and breastfeeding status inclusion criteria). The main sampling frame was then divided into four different sampling frames according to the four groups of interest, to match the four groups of interest for the study.

When there was more than one child present who is of 6-23 months, 1 child was randomly selected by writing down their names on a paper and blindly selecting one of them. The caregiver/mother was selected for a household questionnaire (demographic and socio-economic characteristics), and an assessment of infant and young child feeding, including a 24hour recall of dietary data. Next to this, also anthropometric measures, such as height and weight were measured of both the caregiver/mother and the child. Moreover, the size of household plots, the total yield of household crop production and the yield consumed in the home were reported. Further, a market survey was done to determine the prices of locally available foods identified during the 24hour recalls.

3.4.1 SAMPLE SIZE FOR CROP DIVERSITY AND NUTRITION ANALYSIS

From a total sample of n=337 children and their households, exclusions were made based on households that did not produce yield for their crop(s) (see Figure 5 – *Sample Size Flow Chart* below). This is because the criteria for inclusion of households into this study were based on: (1) 1 or more crops in household production; (2) yield more than 0. If households did not farm, had no harvest or had missing information on household production, they were then excluded. This was done to ensure that subsequent analysis would include data on crops present in a household farm. As the analysis for this thesis was sub-divided in *total production yield per year* and *yield consumed in the household per year*, exclusions differed per category. Eight households were excluded from the total production yield analysis as five households did not farm, two households had missing crop production data and one household had no harvest for that year. Nine households were excluded from the yield consumed in the household analysis as five households did not farm, two households has missing crop production data and two households had no harvest for that year. It should be clarified that although only an additional household was excluded for yield consumed in the home (n=328), there were households that also produced less crops and obtained less yields per crop in this category. These households were not excluded from the analysis but the reduction of production diversity used in the home did have an effect on the final amount of yield available for home consumption.

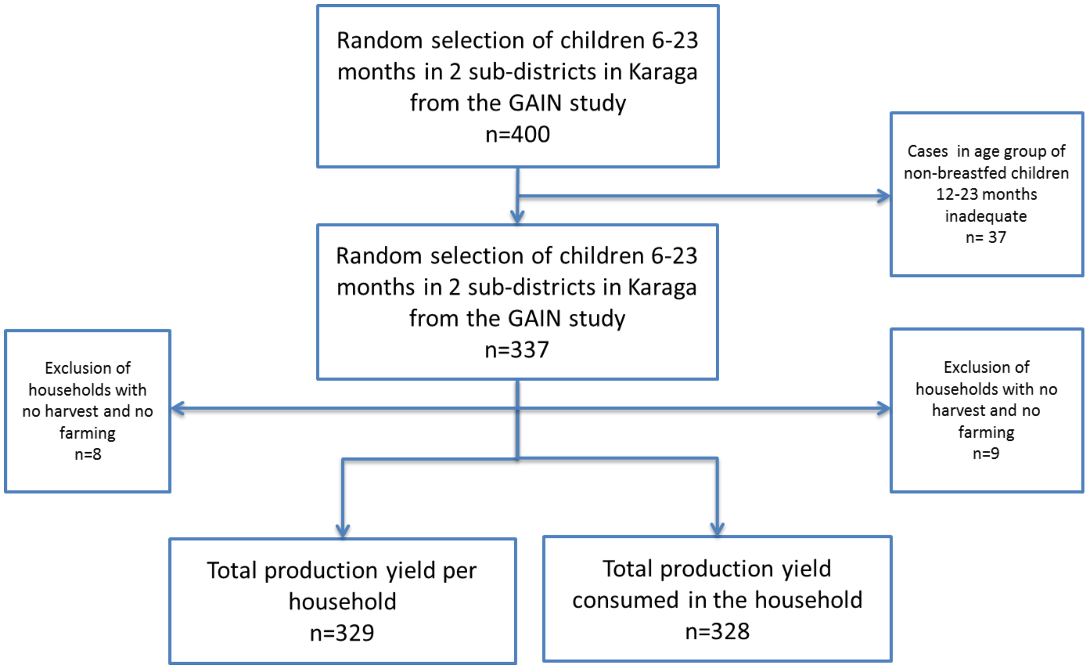


Figure 5. Sample Size Flow Chart

3.4.2 SAMPLE SIZE FOR EVALUATION STUDY OF CROP PRODUCTION, KARAGA 2015

Out of the 337 households selected for the previous survey in June 2014 a sub-selection of n=51 households was made in 2015 (see Figure 5 – *Sample Size Flow Chart Evaluation study of crop production data 2015* below). The households were primarily chosen based on: (1) IDDS; (2) total child food expenditure; (3) household total land use; and (4) hunger presence. Households were first allocated to one out of three levels (high, average or low) of the selection characteristics IDDS, total child food expenditure and total land use. Hunger presence was categorized by the presence or absence of hunger. A grid was created in which all households were allocated to low, average, or high levels of IDDS, expenditure and land use, and the absence or presence of hunger. From each group, two households were randomly selected. However, not all groups contained households satisfying the criteria (i.e. none of the households met the criteria of IDDS 0, 1 or 2 food groups, high expenditure, high land use and hunger presence) and hence it was not possible to select two household from all the categories within the grid. Therefore, the final sample included 51 households, representing different levels of IDDS, total child food expenditure, total land use and hunger presence.

The field work was carried out between the 28th of October and 14th of November 2015 within the Karaga District. The fieldwork was done together with a community health nurse/farmer whose functions included being a translator, translating from Dagbani to English, and also a guide, organizing and informing the households that we would visit. Interviews were conducted throughout Karaga District. Semi-structured interviews were conducted based on plots of land in a household and crop production *(see Appendix A– Evaluation study of crop production data,* *Karaga 2015)*. The questions were targeted at the head of the household, as they would be most knowledgeable about the crop production within their plots of land. The research began in the household using the self-reported interview method with the head of household and translator. Questions regarding crops produced for harvest period 2014 and 2015 were asked. It was only upon completion of the interview method that it was revealed that we would like to visit his various plots. Thus, this session was continued with the observation method where the head of household lead us to the various plots he and his family were responsible for. The translator then identified all the crops that were on the land. If he was unable to identify one, he would then ask the head of household for assistance. When attempting to conduct the observation, a total of three households and their plots were inaccessible due to poor roads and one household with the head being a chief of the community was not able to accompany us to the plots at that time. Upon completion of the interviews, body soap and clothes soap were given to the head of household and caregiver as appreciation for their time.

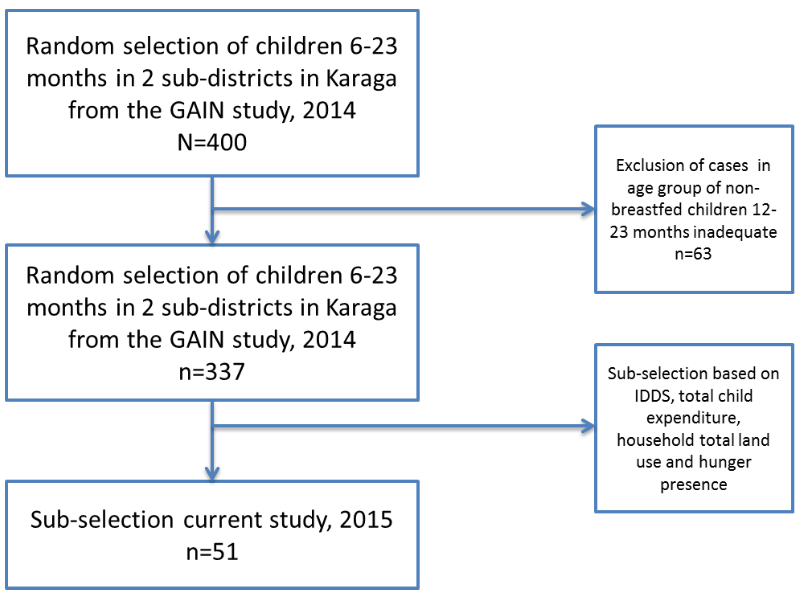


Figure 6. Sample Size Flow Chart Evaluation study of crop production data, Karaga 2015

3.5 DATA COLLECTION

Data on three main crop diversity indicators were collected for this study and they include: (1) Richness, (2) Evenness, and (3) the Shannon-Wiener Index. Data for (1) coverage of nutrient requirements by the supply of household production, (2) IDDS and (3) nutritional status indicators was also collected (see figure X - Study Design above)

3.5.1 DATA COLLECTION FOR RICHNESS, EVENNESS and SHANNON-WIENER INDEX

To obtain data for the calculations of the crop diversity indicators, the *Northern Ghana Crop Production Survey* from the GAIN study was used *(see Appendix B - Food consumption survey of infants and young children 6-23 months).* In this survey, data was collected on season harvested, crops cultivated per household per year, total yield per crop produced, yield used for home consumption, yield sold and yield used as seedlings. For richness, data was collected on the species of crops cultivated within a household. For evenness, data was collected on the species of crops cultivated within a household and the yield per crop per year. The same information was collected for the SWI. For all three crop indicators, data was collected for total yield per year and yield used for home consumption per year.

3.5.2 DATA COLLECTION FOR COVERAGE OF NUTRIENT REQUIREMENTS SUPPLIED THROUGH HOUSEHOLD PRODUCTION

To obtain data on the nutrients supplied, the count of crops produced per household along with the yield per crop was collected from the *Northern Ghana Crop Production Survey from the GAIN study (see Appendix B -Food consumption survey of infants and young children 6-23 months)*. In this survey, data was collected on season harvested, crops cultivated per household per year, total yield per crop produced, yield used for home consumption, yield sold and yield used as seedlings. Data from the *24hR* was also used to obtain information on most frequently cooked foods and methods of preparation. To collect data needed to convert yields reported in different units to kilograms, a combination of own *market study* using scales was performed in 2014 and 2015 in addition previous data collection obtained from the *Ministry of Food and Agriculture in Ghana* (MOFA). Moreover, *food composition tables* specifically created for the GAIN study were developed and used for this study. For the nutrients required, the *Household Survey* data from the GAIN study provided the identification numbers of household family members per age category *(see Appendix B -Food consumption survey of infants and young children 6-23 months).* Information on age, gender and for women menarche, lactating and pregnancy information was collected.

3.5.3 DATA COLLECTION FOR INDIVIDUAL DIETARY DIVERSITY SCORE

For IDDS, the data was found from the *24hR* conducted for the GAIN study *(see Appendix B - Food Consumption Survey of Infants and Young Children 6-23 months)*. A quantitative *24hR* using a standard multiple-pass procedure was used to assess dietary intake of infants and young children, while mothers were interviewed.

The use of the standardized multi-pass procedure helped minimize measurement errors. In the standard multiple pass procedure, a mother or caregiver was first asked to mention all foods and drinks including snacks that were consumed the previous day (from the moment the child woke up the previous day until the moment the child woke up on interview day) by the index child, this includes foods consumed outside the home. She was then probed for likely forgotten foods and then asked to give a detailed description of foods and beverages consumed, including ingredients and cooking methods for mixed dishes, place, time of consumption and condition consumed of each food item or ingredient. The *24hR* ends by probing if the mother or caregiver had forgotten any foods consumed by the child on the recall day.

3.5.4 DATA COLLECTION FOR NUTRITIONAL STATUS INDICATORS

The data for nutritional status of mothers and children is found from *Anthropometry From* collected from the GAIN study (*see Appendix B -Food consumption survey of infants and young children 6-23 months)*. Information was asked on the age of the child, the weight of the child, the mid-upper arm circumference of the child and the weight and height of the caregivers.

Weight and height measurements of children and caregivers were conducted following standard procedures. Weight of both children and their caregivers were precisely measured to 0.1 kg with an electronic scale (UNIscale; Seca GmbH, Hamburg, Germany). For children who were unable to stand on their own, the mother/child function on the scale was used to obtain the child's weight after the mother's weight was recorded. A known weight (20 kg) was used to calibrate the scale on each measurement day. An infantometre was used to measure the length of all infants and young children precise to 0.1 cm. For caregivers, stadeometre was used to precisely measure height to 0.1 cm. For all measurements (weight, height and length), two measurements were taken and an average of the two readings was transcribed. Ages of the children were determined using the date of birth (from a verifiable document such as child health record booklet, birth certificate) and the date of anthropometric measurement. In the absence of verifiable documents, parents/caregivers were asked to estimate age based on another child's records or event on the traditional calendar. Mid-upper arm circumference (MUAC) was measured in centimeters precise to the nearest 0.1 cm, using standard MUAC measuring tape. The anthropometric data collectors were trained to locate the mid-point between the shoulder and the tip of the elbow on the left arm with the arm bent at a right angle. The measurement was taken at this mid-point with the arm extended and relaxed.

3.5.5 DATA COLLECTION FOR EVALUATION STUDY OF CROP PRODUCTION DATA, KARAGA 2015

Two methods of data collection were conducted: (1) interview with the head of the household and (2) field observation with the translator and the head of the household. During the self-reported interview method, the head of the household was asked questions from the *Crop Production Survey,* adapted from the GAIN study, on the details of their harvest in 2014 and 2015 *(see Appendix A– Evaluation study of crop production data, Karaga 2015)*. The number of crops cultivated per year, total production yield, yield kept for consumption within the home and amount of food sold, was collected. However data on yields and amount of food sold was only possible for the previous harvest in November 2014. Concerning data for harvest in 2015, it was only possible to collect data on the number of crops cultivated per year as harvest season was still in progress during the time of this fieldwork. Once the data for the interview method was collected, the head of household was asked to accompany us to the location of the different plots that belonged to the household. By walking, driving or biking, it was possible to leave the home and visit the different plots in the surrounding areas.

During the observation method, which took place directly in the family plots, the same questions were asked from the *Crop Production Survey* (*see Appendix A– Evaluation study of crop production data, Karaga 2015*). Moreover, with the help of the translator, it was possible to observe autonomously all crops that were cultivated by the head of household and his family, for the harvest period of 2015. The head of household was then probed for further detail on the continuity or change of crops in the plots. As with the self-reported interview method, it was not possible to determine further production details such as yields and amount of yield kept in the household or sold, as the harvest period was still underway during the time of this fieldwork.

3.6 DEVELOPMENT OF THE INDICATORS

Throughout this analysis and during the process of developing the indicators, distinctions were made between the total yield produced on a farm and the yield used for home consumption.

3.6.1 CROP DIVERSITY INDICATORS

Approaches quantifying dietary diversity in nutrition are similar to ones whose aim is to quantify biological diversity in ecology. For example, counting the number of food groups consumed is comparable to counting the species richness in a cropping system. Brief paragraphs explaining each crop diversity indicator are presented.

RICHNESS
Richness or crop count, reflective of crop diversity, is the total number of different crops or species cultivated in a cropping system in one household farm. One household farm can consist of different plots of land. The richness count, in this study, includes crops from all plots under one household. A simple crop count variable was created that sums the total number of different crop species cultivated over the 2014 harvest season by the selected households throughout the district of Karaga [1], [39]. The count is not bound by a definitive range, thus it is a relative rather than absolute number. This indicator does not discriminate crops based on how much land they occupy, rather it considers trait differences as the most important element for diversity. Determining the percentage of households producing the following food groups: (1) grains, roots, tubers; (2) legumes, nuts; (3) dairy products; (4) flesh foods; (5) eggs; (6) vitamin A rich fruits and vegetables; (7) other fruits and vegetables, was based on the variety or count of crops in one household [64]–[66]. Richness was also calculated for the evaluation study of crop production in Karaga, 2015 to determine crop count during the self-reported interview method and during the observation method.

The Richness score was calculated by: the count of the different crops within a household.

EVENNESS

Evenness is another metric used in ecological studies to determine diversity among species by looking at the abundance levels of different crops within a cropping system [39]. Abundance can be understood as having *equal land use* by species on a farm or *equal number of yield* among the species in a farm's crop production. An evenness score is bound between 0 and 1. An evenness score of 1 implies that there is equal abundance among crops in a plot (i.e. maize = 10kg production and millet = 10 kg production) [39]. Varying degrees of abundance or different yields, where evenness would obtain a score closer to 0, implies a lower abundance (i.e. maize = 10 kg production and millet = 5 kg production) [39]. Evenness has also been understood by studying patterns or scenarios [64]–[67]. For example, if richness would increase, the land space available to obtain equality among species would decrease reducing the evenness score but having a positive association on biodiversity. If we now consider monocultures, where richness would decrease and evenness would increase with greater equality among the crop(s), this pattern would result in no relationship to biodiversity [66].

The Evenness score was calculated using the following equation [64], [66], [67]:

E= H/H max

Where:

H = Shannon-Wiener Index, explained in the coming section;

Hmax = Ln (Pι) the logarithm of the maximum diversity possible in a household (crop count)

A logarithm, in the case of assessing diversity among species, is the change in dominance proportion of species over time [67]. Mathematically, the LN of 1 is invalid. When a household scored 1 for richness/crop count, it was not possible to obtain the Ln(crop count) as this creates an invalid number. However, for households with a richness score of 1, where the plot of land would be considered as perfectly even or abundant, adjustments were made by allocating a final evenness score of 1 [65]–[67]. Moreover, as all indicator calculations were made for total yield and for yield used for home consumption, adjustments were made when households sold part of their yield, reducing the amount of kilograms of food retained in the home. For example, looking at total production yield and crop count of 4 reduced to 2 at the level of yield used in the home (i.e. the other 2 crops were sold), the crop count was then adjusted to a new crop count, in this case, 2, which would alter the Hmax.

THE SHANNON-WIENER INDEX

The Shannon-Wiener Index, a diversity index used in ecological studies reflects both richness (crop count) and evenness (abundance) and is understood as being the compromise between the two [67]. The SWI shows the pattern or probability of change in species diversity over time [64]. This index has greater impact for biodiversity, as the mathematical equation is more affected by variations in species richness [67]. The score is not bound by a definitive range thus it is a relative rather than absolute number. An increasing SWI function reflects greater diversity in a cropping system, positively associated to biodiversity.

The Shannon-Wiener Index score was calculated using the following equation [64], [66], [67]:

$$\mathbf{H} = \boldsymbol{\Sigma} - (\mathbf{P}\boldsymbol{\iota} * \boldsymbol{ln}\mathbf{P}\boldsymbol{\iota})$$

Where:

H = Shannon-Wiener Index, the sum of all products

Σ = the sum of species 1 to species S

$P\iota$ = sample value of specieι (yield per crop) / total value of the population made up of specie ι (total crop yield in one household)

Ln$P\iota$ = the logarithm for each crop produced

$P\iota$* Ln$P\iota$= for each crop produced

-(Sum of $P\iota$* Ln$P\iota$)= to obtain the positive outcome for the SWI of one household

No adjustments were made to the SWI even when yields would be zero, as the equation automatically excludes crops with zero yields. Many scenarios exist that better explain the interaction among richness, evenness and the SWI. To summarize: (1) If species are equally abundant, the evenness would be 1; (2) depending on a higher or lower crop count, the SWI would then increase or decrease; (3) If crop count is 1, SWI is 0 and evenness is adjusted to 1 (perfectly abundant).

3.6.2 COVERAGE OF NUTRIENTS REQUIREMENTS SUPPLIED THROUGH HOUSEHOLD PRODUCTION

NUTRIENTS SUPPLIED

The coverage of nutrient requirements from the nutrients supplied reflects the ability of total crop yields in a household to meet the daily nutrient requirements of all members in a household. The nutrients supplied divided by the nutrients requirements per day and multiplied by 100, results in the percentage of coverage per day. To calculate percentage coverage, the following information was required:

For nutrients supplied: (1) crop production units were converted to kilograms; (2) food codes per crop were allocated; and (3) nutrient composition per food code and crop was allocated:

1. Conversion factors from Ghanaian production units were collected to convert yields reported in different units to kilograms. Units including, cocoa bags, baskets, bowls and pieces of food were weighed into kilograms to estimate the kilograms per unit. It was then possible to calculate the amount yield in kilograms per crop and per household;
2. Data on the nutrient composition of crops cultivated by households was found from the Food Composition Table prepared for Ghanaian crops and foods. The *FCT-Ghana* file was specifically created for the *GAIN Food Consumption Survey of Infants and Young Children 6-23 months*. Firstly, energy and the nutrient content of food were derived from different FCTs and they include protein, carbohydrates, fat, water, Ca, Fe, Zn, vitamin A (RAE), folate, vitamin C, thiamine, riboflavin, niacin, vitamin B_6, and vitamin B_{12}. However, the primary source of nutrient data is from the West Africa Food Composition Table (WAFCT) [68]. Secondly, missing values or missing foods from the WAFCT was imputed with other FCTs. The order of preference for the use of the other FCTs was the Mali Food Composition Table (MFCT), United States Department of Agriculture (USDA) nutrient database for standard reference and Ghana Food

Composition Table (GFCT). This order was chosen, as the GFCT is limited in coverage of food list and nutrients values. Thirdly, computation of nutrient intake involved a FCT, coding system for matching foods listed on the recall with entries in the food composition database and software for calculating the nutrients [69]. The general Atwater factors: 17KJ/g (4kcal/g) for protein and carbohydrates and 37KJ/g (9kcal/g) for fat were considered for the calculation of energy content of foods. The metabolizable energy factor for dietary fibre of 8.0 kJ/g (2.0 kcal/g) as recommended by the FAO was also used. Total vitamin A (RAE) was calculated as the sum of retinol and 1/12 β-carotene [70].

3. Retention factors of the USDA were applied to calculate nutrient content of reported cooked food based on most frequent preparation method used for specific food.

NUTRIENTS REQUIRED

The estimated average requirements (EAR) were used to assess the probability of adequate nutrient intake [71]. The EAR approach has been recommended as an improvement over using recommended nutrient intakes (RNI) for nutrient assessment of groups or populations [72] . This is because it allows for calculation of the probability that the individual's intake is adequate given the requirement distribution. Recommended nutrient intake (RNI) is the daily intake, set at the EAR plus 2 standard deviations (SD), which meets the nutrient requirements of almost all healthy individuals in an age- and sex-specific population group (i.e. 97.5 per cent of the population). For parts of this study, both EARs and RNIs were used.

For nutrients required per household member: (1) nutrient requirements per age category; and (2) per life-cycle (pregnant, lactating) were required. These categories were then merged:

1. For the this study, micro-nutrient requirements of infants and mothers were based on *WHO/FAO 2004* apart from zinc, which was defined by the International Zinc Nutrition Consultative Group (IZiNCG) [12],[73], [74]. EARs are based on RNIS of WHO and conversion factors from IOM. For infants, EARs are not found. However, AIs were used as good estimates of EAR for this age group [12]. Thus, for infants the AIs for calcium, vitamin C, thiamine, riboflavin, niacin, vitamin B6 and iron were used. Iron bioavailability was assumed to be low at 5% for infant girls, all children, adolescent females at menarche, adult women and pregnant women as the iron needs during these phases of the life-cycle are required in greater amounts. Adolescent boys and adult males do not have the same requirement needs for iron [12];
2. Energy kcal requirements for infants and children were based on recommendations by the *FAO/WHO 2001*, per median body weight of the different age categories and a moderate physical activity level (PAL) [75]. Nutrient requirements for infants were also based on breastfed children as it was assumed that formula based feeding would not be affordable in this district. For the energy kcal requirements of adults, the elderly and pregnant/lactating women, the following was defined:
    a. For adults (i.e. 19-50 years), energy kcal requirements were based on recommendations by the *FAO/WHO 2001* [75]. However, due to a lack of clear evidence of median body weight for adult and elderly males and females in developing countries, estimated average body weights of 60kg and 70kg respectively, were based on recommendations by the *FAO/WHO 2001*. Median body weights (kg) were then used to estimate energy and protein requirements.

A moderate to high PAL of 1.90 was allocated due to the non-mechanized agricultural work and active lifestyle of the sample population [75].

   b. For the elderly (i.e. 65 years and up), energy kcal requirements were based on recommendations by the *FAO/WHO 2001* [75]. However, the median body weights were assumed to be the same as those for adults (60kg-70kg) as *the FAO/WHO, 2001* explains that this age group has high variability in weight, even more so when coming from a developing country and having varying health status. Their recommendation to reduce the PAL is the variable to consider when making adjustments for kcal requirements, considering the highly variable data on body weight for this age category. Moreover, recommendations from *FAO/WHO 2001* explain the importance of calculating energy kcal based on PAL, as using PAL brings more accuracy to the basal metabolic rate (BMR). Thus using activity levels to determine energy calculations while keeping body weight constant has been adapted to this thesis particularly for the elderly age category. What can be assumed is that the PAL will decrease and this is the basis for the kcal energy requirements. In populations such as those in the United States of America, the PAL for the elderly decreases substantially (1.7 to 1.21), but as the population of interest for this research (North Rural Ghana) continue to work and walk, well into their older age, the PAL was decreased to moderate exercise, from 1.9 to 1.60. To assume lower might underestimate the activity levels of the elderly in this population and their energy requirements per day.
   c. For pregnant women, energy kcal requirements were based on recommendations by the *FAO/WHO 2001* [75]. A kcal increase of: 85 kcal/day (2500+85) for trimester 1; 285 kcal/day (2500+285) for trimester 2; and 475kcal/day (2500+475) for trimester 3 was assigned;
   d. For lactating women, energy kcal requirements were based on recommendations by the *FAO/WHO 2001* [75]. An increase of 645 kcal/day during the first six months of lactation was assigned. This increase of 645 kcal/day assumes that the mother is undernourished with insufficient gestational weight gain;
3. Protein requirements were taken from *IOM 2005* EARs and calculated based on median body weight per age category from *FAO/WHO 2001* [76][75];
4. Carbohydrate requirements were taken from *IOM 2005* EARs and calculated based on grams per day [76];
5. Total Fat requirements were taken from *WHO 2010* and calculated based on percentage of energy per day with a final calculation to obtain gram per day [77];
6. For a section of the percentage coverage analysis, the EARs and RNIs were compared to total production yield and yield used for home consumption.
   a. For micronutrients, the RNIs were based on *FAO/WHO 2004* recommendations with iron assumed at 5 per cent bioavailability [12].
   b. For macronutrients, comparable estimates for RNIs were based on IOM 2005 RDA. For protein, the protein safe levels were used and for carbohydrate, the RDAs were taken as an estimate for RNIs' intake levels that meet the nutrient requirement of nearly all healthy individuals (97.5 per cent) [12], [76].

To determine if the nutrients supplied suffice the nutrient requirement of an entire household, two main calculations were made. Firstly, nutrients supplied per year were calculated using the food composition table to determine the nutrient composition of each crop and multiplying this by the yields obtained per crop. Per household, the total nutrients supplied per crop were added.

To obtain the nutrient supply per day, the sum of nutrients per household was divided by 365 days. Calculations were made to reflect 100grams of consumption. Secondly, the nutrients requirements per household family member were added to determine the total requirement per household and per nutrient (i.e. household 1001 = 45mg of Vitamin C). Data on nutrients supplied per crop and required per age category was determined for energy kcal, protein, carbohydrates, fat, water, calcium, iron, zinc, vitamin A, folate, thiamine, riboflavin, niacin, vitamin B_6, vitamin B_{12}, and vitamin C. Finally, the nutrients supplied formed the numerator and the nutrients required formed the denominator and subsequently multiplied by 100 to obtain a percentage. If the percentage was equal to 100, then the nutrients supplied covered the nutrient requirements per household. If the percentage was not equal to 100, the nutrients supplied were concluded to not sufficiently cover the nutrient requirements per household.

3.6.3 INDIVIDUAL DIETARY DIVERSITY SCORE INDICATORS

For children under two years of age, there is an established cut-off set by the WHO for dietary diversity of 4 out of 7, below 4 being low, and 7 being high DD [7]. Using 7 food groups is most useful for this age group as this range contains the highest density of nutrients, necessary for growing children [7][15]. The food groups include: (1) grains, roots, tubers; (2) legumes, nuts; (3) dairy products; (4) flesh foods; (5) eggs; (6) vitamin A rich fruits and vegetables; (7) other fruits and vegetables. To obtain the IDDS, the followings steps were taken: (1) every food group consumed in the previous 24hR received a score of 1, (irrespective of number of food items eaten from the food group); (2) the total scores were finally summed up to arrive at the total IDDS for each child; (3) the minimum dietary diversity score followed similar calculations but illustrated if a child consumed food items from at least 4 different food groups out of the 7 previously described [7].

3.6.4 ANTHROPOMETRIC DATA INDICATORS

Z-score calculations were used to obtain the values for the nutritional indicators. A z-score is the individual value subtracted by the median of the reference and divided by the standard deviation of the reference population [78]. It is also defined as “the number of standard deviations that an individual is above or below the median of the reference”[78].

3.7 DATA ANALYSIS

All data was analysed using IBM SPSS Statistics. Tests of normality were performed. Differences were made for total yield and yield used for home consumption for all crop diversity indicators.

3.7.1 RICHNESS, EVENNESS and SHANNON-WIENER INDEX ANALYSIS

A first analysis obtained the median and inter-quartile range for each crop diversity indicator. Aggregation was used per household to determine the percentage of households producing foods reflective of the 7 food groups proposed for the IDDS. During the analysis of the correlations, crop diversity indicators were correlated with IDDS, nutritional status indicators and the coverage of nutrient requirements by the nutrient supply. As the data was not normally distributed and present to outliers, spearman correlations were used to determine the associations.

3.7.2 COVERAGE OF NUTRIENT REQUIREMENTS SUPPLIED THROUGH HOUSEHOLD PRODUCTION

To obtain the percentage coverage for EAR and RNI, nutrients supplied were divided by the required, multiplied by 100 to obtain a percentage and subsequently truncated to adjust for percentage coverage above 100 per cent. The median coverage per nutrient was then obtained. To determine if significant differences existed between the coverage of nutrients when comparing them from total yield to yield used for home consumption, a paired sample t-test was performed. As multiple comparisons were made among the different nutrients, the chance of committing a Type I error was inflated and finding significant effects could be increased due to this chance. Thus, a Bonferroni correction was used to adjust the alpha value [78], [79]. By dividing the alpha of .05 by the 17 different nutrient values (including macro and micro nturients), the adjusted alpha value was obtained. Thus, when the paired sample t-test was performed it was possible to determine significance not only at .05 but also at the adjusted .0029 value to better determine the effect. During the analysis of the correlations, only the EAR was used. As the data was not normally distributed and present to outliers, the spearman correlations were used to determine associations between the percentage coverage, the crop diversity indicators, IDDS and the nutritional status indicators.

3.7.3 INDIVIDUAL DIETARY DIVERSITY SCORE ANALYSIS

A first analysis obtained the median and inter inter-quartile range for IDDS and minimum IDDS. Aggregation was used per household to determine the percentage of households consuming foods in line with the 7 food groups. Spearman correlations were used to assess categorical data. Thus, when determining the associations between IDDS, the crop diversity indicators or the percentage coverage, spearman correlations were used.

3.7.4 ANTHROPOMETRIC DATA ANALYSIS

Anthropometric Z-scores for weight-for-age (WAZ), length-for-age (LAZ), and weight-for-length (WLZ) of the infants were calculated with the 2006 Child Growth Standards using the IBM SPSS syntax for WHO Anthro (version 3.2.2.). Underweight, stunting, and wasting were defined as a Z-scores < -2 SD. Z-scores that may fall outside the WHO flags: WHZ –5 to +5; HAZ –6 to +6; WAZ –6 to +5 have been excluded from analysis. The MUAC of children was also used to classify their nutritional status in SPSS with the standard reference cut-off points. For MUAC, the cut-off value of 12.5 cm was used to classify the nutritional status of infants and young children. As the data was not normally distributed and present to outliers, spearman correlations were used to determine the associations.

3.7.5 EVALUATION STUDY OF CROP PRODUCTION, KARAGA 2015 ANALYSIS

The number of crops cultivated per year (i.e. richness) was compared using both the self-reported interview and observation method from the same harvest season of 2015. Using a paired sample t-test, to assess the difference in crop count within groups, it was possible to identify which method gave a more accurate recording of the number of crops within household plots. Moreover, frequencies showed the number of under-reported crops during the interview method.

4. RESULTS

4.1 HOUSEHOLD CHARACTERISTICS

Table 1 shows the different characteristics of children 6 to 23 months old and their households in Karaga district, Ghana. From the 329 households selected for this study, the median number of residents in one household was 14 ± 13 with a median of 2 ± 3 for infants within the age range of 0 to 23 months. 4.3 per cent of head of household and 2.1 per cent of mothers of selected subjects have completed the highest education level compared to 84.5 per cent and 92.7 per cent respectively who have received no education. Farming is the main stay of work for both the head of the household and the care keeper (mother of the child). Various assets are available in the households, but to different degrees. Owning a bicycle as a means of transportation is the most widely available household asset, in 90 per cent of households. The total value of household functional assets was found to be 1630 Ghanaian cedi. The distance from households to markets was a median of 8 ± 19 km and an average travelling time of 60 minutes. Finally, the median land size of households is averaged at 18 ± 21 acres with 14 ± 16 acres being cropped.

Table 1 - Characteristics of children 6 to 23 months old and their households in Karaga district, Ghana (n=329)

Characteristics	Unit	Overall
Households of subjects		
People in Household	Median (IQR)	14 (13)
Adults in Household[1]	Median (IQR)	6 (6)
Children in Household[1]	Median (IQR)	6 (5)
Infants and young children, 0 to 23 mo	Median (IQR)	2 (3)
Female headed households	%	0
Education level of head of household/mother of child		
None	%	84.5/92.7
Primary	%	2.7/2.7
Highest education (S.H.S. or higher)	%	4.3/2.1
Occupation of head of household/mother of child		
Farmer	%	80.5/63.5
Trader	%	9.4/18.2
Assets (functional) in households		
Radio	%	73.9
TV	%	33.7
Mill	%	5.5
Bicycle	%	90.9
Motorbike	%	51.4
Vehicle private	%	0.9
Vehicle common	%	8.2
Total value of household functional assets GHS[3]	Median (IQR)	1630 (1600)
Total relative value of assets in proportion to most valuable asset (vehicle)[4]	Median (IQR)	0.16 (0.16)
Markets		
Distance to markets: kilometers[5,6]	Median (IQR)	8 (19)
Reported travel time: minutes[7]	Median (IQR)	60 (95)
Crop land size		
Total Land Size (acres)	Median (IQR)	18 (21)
Cropped Land Size (acres) (n=324)[2]	Median (IQR)	14 (16)

[1]All household members ≥ 19 years old are classified as adults and 1 to 9 years, as children [75].
[2]Excluded 5 households with zero cropped land size in addition to households that do not farm or missing.
[3]Based on local market prices if available in Ghanaian cedi, otherwise on prices in nearest larger city. Prices of all assets available in a household are summed. 1 GHS = 0.234506 EUR.
[4]Conversion factors per asset: radio (.0015); television (.0106); mill (.2128); bicycle (.0128); motorbike (.1489); private vehicle (1); common vehicle (2).
[5]Estimated as straight lines from household to market by the author using GPS coordinates.
[6]Excluded 17 households with distance to market less than 0.1km.
[7]Excluded 16 households with distance to market less than 1 minute.

4.2 CROP DIVERSITY INDICATORS

Table 2 shows the different medians obtained for the crop diversity indicators differencing between total production yield and yield used for home consumption. At total production yield, the median richness per household was 4 ± 2 and at yield used for home consumption, richness decreased to an average of 3 ± 2 per household. On average, one crop was used elsewhere than in the home and the actual number of crops consumed in a household was lower than what was originally produced. Evenness scores remained to the far end of the boundary with a median for total production and a lower median for amount of yield used for home consumption, of .86 ± .21 and .81 ± .27 respectively. The SWI was also lower for yield used for home consumption .79 ± .53 compared to total yield 1.04 ± .61.

Table 2- Crop diversity indicators of total production yield and amount of yield used for home consumption by households with children 6 to 23 months old in Karaga district, Ghana

Characteristics	Unit	Total yield (n=329)	Yield used for household consumption (n=328)
Richness (crop count)[1]	Median (IQR)	4 (2)	3 (2)
Evenness[2-3]	Median (IQR)	.86 (.21)	.81 (.27)
Shannon-Wiener Index[4-5]	Median (IQR)	1.04 (.61)	.79 (.53)

[1]Richness (crop count) is the total number of different reported crops cultivated in a household.
[2]Evenness reflects the abundance levels (yields) of different crops within a cropping system. If equally abundant, the score is set at 1, if not, the score lowers towards 0.
[3]In households with a crop count of 1, the evenness is expressed as the highest value equal to 1, as the abundance is equal to itself [65]–[67] .
[4]Shannon-Wiener Index includes both richness and evenness in its calculation of diversity and captures the amount of yield per crop in proportion to the total production yield in a household, making it possible to estimate with greater accuracy the nutrients supplied through production.
[5]The Shannon-Wiener Index equation: $H = \Sigma\text{-}(P_\iota * \ln P_\iota)$ where P_ι = sample value of specie ι (yield per crop) / total value of the population made up of specie ι (total crop yield in one household) [67].

4.3 FOOD GROUPS CONSUMED AND PRODUCED

Table 3 provides an overview of the percentage of food groups consumed by children and the percentage of food groups that are reflected in household produced. 96.4 per cent of children consumed grains, roots and tubers; between 45-60 per cent of children consumed legumes and nuts, flesh foods, vitamin A rich fruits and vegetables and other fruits and vegetables; less than 15 per cent consumed dairy products; and only 1.5 per cent consumed eggs. On the production side, 97 per cent of households produced grains, roots and tubers with 91.6 per cent of them also producing legumes and nuts; and less than 15 per cent produced other fruits and vegetables. There was no production of vitamin A rich fruits and vegetables and there was no reported production of dairy foods, flesh foods or eggs.

Table 3 - Percentage of different food groups consumed by children 6 to 23 months old and percentage of food groups produced in their households in Karaga district, Ghana (n=329)

Food Groups	% of food groups consumed by children 6 to 23 mo	% of food groups produced in household
Grains, roots and tubers[1]	96.4	97.0
Legumes and nuts[2]	60.8	91.6
Dairy products	13.7	n/a[3]
Flesh foods[4]	60.8	n/a[4]
Eggs	1.5	n/a[5]
Vit. A rich fruits and vegetables[6]	49.8	0
Other fruits and vegetables[7]	49.2	14.5

[1]Food Group 1 (grains, roots and tubers): Cassava, Guinea Corn, Maize, Millet, Sorghum, Rice, Yam.
[2]Food Group 2 (legumes and nuts): Bambara Bean, Soybean, Cowpea, Pigeon Pea, Groundnut.
[3]Food Group 3 (dairy products): n/a: no data available on livestock (all farm animals) in the household.
[4]Food group 4 (flesh foods): Mainly small dried fish: n/a: no data available on livestock (all farm animals) in the household.
[5]Food group 5 (eggs): n/a: no data available on eggs provided by the farm.
[6]Food Group 6 (vitamin A rich fruits and vegetables): includes fruits and vegetables which contain 60gram RAE or more. No production of vitamin A rich fruits and vegetables in the households.
[7]Food Group 7 (other fruits and vegetables): Cucumber, Melon (yellow), Okro, Pepper (dry), Tomato, Watermelon.

4.4 IDDS AND NUTRITIONAL STATUS

Table 4 provides detail on IDDS and nutritional status of children between 6 to 23months. The median IDDS being 4 ± 4 food groups consumed per day, with 56.8 per cent of infants and children attaining the minimum dietary diversity score and 5.8 per cent of them reaching the highest IDDS (IDDS:6) in the dataset. The nutritional status indicators illustrate that 13.7 per cent of the sample children are wasted; 39.7 per cent are stunted; and 36.2 per cent are underweight.

Table 4 –Individual dietary diversity score (IDDS) and nutritional status of children 6 to 23 months old in Karaga district, Ghana (n=329)

Characteristics	Unit	Overall
Individual dietary diversity score		
IDDS (7 food groups, 0 to 7)[1]	Median (IQR)	4 (4)
Minimum dietary diversity, IDDS≥ 4[2]	%	56.8
Children with IDDS of 6[3]	%	5.8
Nutrition status[4]		
WHZ (Wasting)	Mean Z- score (SD)	-1.02 (1.02)
	% <-2SD	13.7
	% <-3SD	3.3
HAZ (Stunting)	Mean Z- score (SD)	-1.69 (1.32)
	% <-2SD	39.7
	% <-3SD	14.8
WAZ (Underweight)	Mean Z- score (SD)	-1.64 (1.14)
	% <-2SD	36.2
	% <-3SD	12.8

[1]IDDS is computed by sum of 7 food groups being consumed: 1. Grains, roots and tubers, 2. Legumes, nuts and seeds, 3. Dairy products, 4. Flesh foods, 5. Eggs, 6. Vitamin A rich fruits and vegetables and 7. Other fruits and vegetables [7].
[2]An individual dietary diversity score of 4 or higher in infants and young children reflect a nutrient adequate diet [7].
[3]No child has an IDDS higher than 6.
[4] 2 children with missing data.

4.5 COVERAGE OF NUTRIENT REQUIREMENTS SUPPLIED THROUGH HOUSEHOLD PRODUCTION

Table 5 shows the percentage coverage of nutrients requirements by the nutrients supplied, for both EAR and RNIs. Looking at total yield, the EAR was covered at 100 per cent for energy, protein, carbohydrates, iron, zinc, vitamin B1, niacin, vitamin B6, and folate; 40-70 per cent was covered for fat, vitamin B2; and less than 40 per cent for calcium and vitamin A. Overall macronutrient coverage was 88.2 per cent and micronutrient coverage was 66.1 per cent. In general, coverage by production used for household consumption is significantly lower. Looking at yield used for home consumption, the EAR was covered at 100 percent for carbohydrates, vitamin B1, and B6; 40-70 per cent was covered for iron and zinc; less than 40 percent was covered for calcium, vitamin A, vitamin B2, folate, vitamin B12 and vitamin C. Overall, macronutrient coverage decreased to 70.3 per cent and micronutrient coverage to 43.4 per cent. The values obtained for RNI followed similar patterns compared to the EAR values. Using a paired sample t-test identified significant differences for all nutrients when comparing them to total yield and yield used for home consumption.

Table 5– Percentage coverage of nutrient requirements of all household members by the nutrients supplied from total yield and yield used for home consumption in households per day, in Karaga district, Ghana[1]

Nutrient (RNI/EAR)	Unit	Total Yield (n=329)		Amount of yield used for home consumption (n=328)	
EAR and RNI[2]		*EAR*	*RNI*	*EAR*	*RNI*
Energy coverage (kcal)[3]	median (IQR)	100 (41.8)	100 (0.00)	43.5 (49.1)	43.5 (49.1)
Protein coverage (g)[4]	median (IQR)	100 (0.00)	100 (0.00)	91.1 (47.2)	75.6 (55.6)
Fat coverage (g)[5]	median (IQR)	68.6 (76)	68.6 (76)	21.9 (28.3)	21.9 (28.3)
Carbohydrate coverage (g)[6]	median (IQR)	100 (0.00)	100 (0.00)	100 (22.8)	100 (40.3)
Calcium coverage (mg)	median (IQR)	38.8 (65)	32.2 (53.3)	10.7 (14.1)	8.9 (11.7)
Iron coverage (mg)	median (IQR)	100 (43.6)	76.5 (59)	46.6 (57.1)	34.1 (41)
Zinc coverage (mg)	median (IQR)	100 (5)	100 (42.2)	67.2 (61.3)	40.4 (44.2)
Vitamin A coverage (μg)	median (IQR)	.49 (2.6)	.25 (1.4)	.14 (.68)	.07 (.36)
Vitamin B1 coverage (mg)	median (IQR)	100 (0.00)	100 (98.6)	100 (18.2)	100 (31.8)
Vitamin B2 coverage (mg)	median (IQR)	85.7 (53.6)	71.3 (61.4)	35.6 (47.6)	29.3 (39.8)
Niacin coverage (mg)	median (IQR)	100 (0.00)	100 (98)	81.6 (58.1)	62.8 (67.7)
Vitamin B6 coverage (mg)	median (IQR)	100 (0.00)	100 (0.00)	100 (38.2)	88.9 (48.3)
Folate coverage (μg)	median (IQR)	100 (52)	87 (99)	30.7 (39.2)	25.3 (32.2)
Vitamin B12 coverage (μg)[7]	median (IQR)	0.00	0.00	0.00	0.00
Vitamin C coverage (mg)	median (IQR)	0.00 (50)	0.00 (44.8)	0.00 (15.7)	0.00 (13)
Macronutrient coverage	median (IQR)	88.2 (26.2)	87.7 (266)	70.3 (29)	63.1 (36.3)
Micronutrient coverage	median (IQR)	66.1 (22)	60.3 (28.3)	43.4 (30)	35.8 (28.2)

[1]All values are percentages. Values at 100% cover the nutrient requirements per household, per day. Paired sample t-test indicated that the mean differences among nutrients between total yield and yield used in the home were statistically significant ($p < .001$) for all nutrients both at alpha .05 and adjusted alpha of .0029 .

[2] Estimated energy requirements EAR: the average daily nutrient intake level estimated to meet the requirement of half the healthy individuals in a particular life stage and gender group [12] [75].

[2]Recommended nutrient intake RNI: the average daily dietary nutrient intake level sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) healthy individuals in a particular life stage and gender group [12].

[3]Energy requirements were based on median weight for appropriate age category and based on g/day [75].

[4]Protein EARs and RNIs for infants, children and adolescents were based on the median weight for the appropriate age category (g/day) [12], [76].

[5]Fat requirements were determined from percentage of energy per age category based on g/day [76].

[6]Carbohydrate requirements were based on EARs or RDAs (replacing RNI) (g/day) per age category [76].

[7]There was no supply through crop production of B12.

4.6 CORRELATIONS

4.6.1 CROP DIVERSITY INDICATORS AND COVERAGE OF NUTRIENT REQUIREMENTS SUPPLIED THROUGH HOUSEHOLD PRODUCTION

Table 6 and 7 show the associations between crop diversity indicators and percentage coverage at total yield and yield used for home consumption. The correlations between richness, energy and single nutrients for total yield varied from ρ=.38 to ρ=.63 with an average correlation with macronutrients being ρ=.45 and micronutrients being ρ=.46. The correlations between evenness, energy and singe nutrients for total yield varied from ρ= -.11 to ρ= -.33 with an average correlation with macronutrients being ρ= -.18 and micronutrients being ρ= -.22. The correlations between SWI, energy and singe nutrients for total yield varied from ρ=.51 to ρ=.33 with an average correlation with macronutrients being ρ=.39 and micronutrients being ρ=.38. All correlations were significant.

Looking at the yield used for home consumption, the correlations between richness, energy and single nutrients varied from ρ=.39 to ρ=.59 with an average correlation with macronutrients being ρ=.43 and micronutrients being ρ=.46. The correlations between evenness, energy and singe nutrients for total yield varied from ρ= -.12 to ρ= -.36 with an average correlation with macronutrients being ρ=-.30 and micronutrients being ρ= -.26. The correlations between SWI, energy and singe nutrients for total yield varied from ρ=.51 to ρ=.24 with an average correlation with macronutrients being ρ= .33 and micronutrients being ρ= .39. All correlations were significant.

Table 6. – Crop diversity indicators for total yield and percentage coverage of nutrient requirements of all household members by nutrients supplied from total yield, in Karaga district, Ghana

n=329	Richness	Evenness	Shannon-Wiener Index
Percentage coverage kcal	.429**	-.181**	.370**
Percentage coverage protein (g)	.474**	-.138**	.461**
Percentage coverage fat (g)	.384**	-.110**	.400**
Percentage coverage carbohydrate (g)	.425**	-.203**	.342**
Percentage coverage calcium (mg)	.561**	-.218**	.507**
Percentage coverage iron (mg)	.424**	-.152**	.370**
Percentage coverage zinc (mg)	.477**	-.176**	.429**
Percentage coverage vitamin A (ug)	.634**	-.314**	.508**
Percentage coverage vitamin B1 (mg)	.419**	-.220**	.326**
Percentage coverage vitamin B2 (mg)	.480**	-.207**	.401**
Percentage coverage niacin (mg)	.390**	-.152**	.386**
Percentage coverage vitamin B6 (mg)	.462**	-.232**	.372**
Percentage coverage folate (ug)	.517**	-.209**	.470**
Percentage coverage vitamin B12 (ug)	-	-	-
Percentage coverage vitamin C (mg)	.556**	-.325**	.391**
Percentage coverage macronutrients	.449**	-.182**	.393**
Percentage coverage micronutrients	.459**	-.220**	.382**

All values are correlations
** Correlation is significant at the 0.05 level (2-tailed, Spearman correlation)

Table 7– Crop diversity indicators for yield used for home consumption and percentage coverage of nutrient requirements of all household members by the nutrients supplied from the yield used for home consumption, in Karaga district, Ghana

n=328	Richness	Evenness	Shannon-Wiener Index
Percentage coverage kcal	.416**	-.285**	.329**
Percentage coverage protein (g)	.445**	-.242**	.382**
Percentage coverage fat (g)	.424**	-.120**	.446**
Percentage coverage carbohydrate (g)	.381**	-.360**	.244**
Percentage coverage calcium (mg)	.534**	-.231**	.500**
Percentage coverage iron (mg)	.398**	-.314**	.288**
Percentage coverage zinc (mg)	.438**	-.275**	.358**
Percentage coverage vitamin A (ug)	.593**	-.334**	.509**
Percentage coverage vitamin B1 (mg)	.409**	-.292**	.324**
Percentage coverage vitamin B2 (mg)	.436**	-.305**	.338**
Percentage coverage niacin (mg)	.456**	-.126**	.480**
Percentage coverage vitamin B6 (mg)	.445**	-.289**	.368**
Percentage coverage folate (ug)	.516**	-.201**	.502**
Percentage coverage vitamin B12 (ug)	-	-	-
Percentage coverage vitamin C (mg)	.557**	-.222**	.514**
Percentage coverage macronutrients	.427**	-.304**	.332**
Percentage coverage micronutrients	.457**	-.262**	.395**

All values are correlations

** Correlation is significant at the 0.05 level (2-tailed, Spearman correlation)

4.6.2 CROP DIVERSITY INDICATORS, IDDS AND NUTRITIONAL STATUS INDICATORS

Table 8 and 9 show the associations between crop diversity indicators with IDDS and nutritional status indicators. There was one significant association ($p < .005$) between IDDS and Evenness ($\rho = -.11$). There were no other significant associations between crop diversity indicators and nutritional status indicators. When looking at the yield used for home consumption, no significant associations were identified.

Table 8– Crop diversity indicators of total yield, nutrition status and IDDS of households with children 6 to 23 months old in Karaga district, Ghana

n=329	Richness	Evenness	Shannon-Wiener Index
Wasting (WHZ)	.037	-.011	.001
Stunting (HAZ)	-.046	.061	-.023
Underweight (WAZ)	-.004	.036	-.006
IDDS	.033	-.111*	-.022

All values are correlations
** Correlation is significant at the 0.05 level (2-tailed, Spearman correlation)

Table 9– Crop diversity indicators of yield used for home consumption, nutrition status and IDDS of households with children 6 to 23 months old in Karaga district, Ghana

n=328	Richness	Evenness	Shannon-Wiener Index
Wasting (WHZ)	-.031	.016	-.070
Stunting (HAZ)	-.048	.052	-.029
Underweight (WAZ)	-.040	.047	-.050
IDDS	.041	-.017	.014

All values are correlations
** Correlation is significant at the 0.05 level (2-tailed, Spearman correlation)

4.6.3 IDDS, NUTRITIONAL STATUS AND COVERAGE OF NUTRIENT REQUIREMENTS SUPPLIED THROUGH HOUSEHOLD PRODUCTION

Table 10 and 11 show the associations between IDDS, nutritional status and percentage coverage. Looking at total yield, the correlations between wasting, energy and single nutrients varied from ρ=.10 to ρ=.17 with an average correlation for macronutrients being ρ=.15 and micronutrients being ρ=.14. The associations were significant for all nutrients except for fat, vitamin A and vitamin C. The correlations between stunting, energy and singe nutrients varied from ρ=.11 to ρ=.17 with an average correlation for macronutrients being ρ=.11 and micronutrients being ρ=.09. The associations were only significant for energy, iron, zinc, niacin and macronutrients. The correlations between underweight, energy and singe nutrients varied from ρ=.11 to ρ=.17 with an average correlation for macronutrients being ρ=.17 and micronutrients being ρ=.15. The associations were significant for all nutrients but vitamin A and vitamin C. The correlations between IDDS, energy and singe nutrients varied from ρ= -.07 to ρ= -.01 with an average correlation for macronutrients and micronutrients being ρ= -.04. However, no significant associations were found.

Looking at yield used for home consumption, the correlations between wasting, energy and single nutrients varied from ρ=.11 to ρ=.13 with an average correlation for macronutrients being ρ=.13 and micronutrients being ρ=.12. The associations were significant for energy, carbohydrates, iron, vitamin B1, B2, B6 and macro and micro-nutrients. The correlations between stunting, energy and singe nutrients varied from ρ= -.02 to ρ=.09 with an average correlation for macronutrients being ρ=.09 and micronutrients being ρ=.08. However, no significant associations were found. The correlations between underweight, energy and singe nutrients varied from ρ=.11 to ρ=.13 with an average correlation for macronutrients being ρ=.14 and micronutrients being ρ=.13. The associations were significant for all nutrients but fat, vitamin A, niacin, folate and vitamin C. The correlations between IDDS, energy and singe nutrients varied from ρ= -.06 to ρ= -.01 with an average correlation for macronutrients and micronutrients being ρ= -.05. No significant associations were found.

Table 10– IDDS, nutrition status of children 6 to 23 months and percentage coverage of nutrient requirements of all household members by the nutrients supplied from total yield, in Karaga district, Ghana

n=329	Wasting (WHZ)	Stunting (HAZ)	Underweight (WAZ)	IDDS
Percentage coverage kcal	.159**	.120**	.175**	-.024
Percentage coverage protein (g)	.142**	.107	.159**	-.019
Percentage coverage fat (g)	.094	.078	.113**	-.073
Percentage coverage carbohydrate (g)	.174**	.102	.172**	-.001
Percentage coverage calcium (mg)	.139**	.062	.131**	.007
Percentage coverage iron (mg)	.139**	.110**	.156**	-.012
Percentage coverage zinc (mg)	.143**	.111**	.161**	-.017
Percentage coverage vitamin A (ug)	.083	.015	.046	-.021
Percentage coverage vitamin B1 (mg)	.160**	.106	.162**	-.026
Percentage coverage vitamin B2 (mg)	.164**	.098	.163**	-.009
Percentage coverage niacin (mg)	.109**	.121**	.148**	-.057
Percentage coverage vitamin B6 (mg)	.156**	.091	.153**	-.011
Percentage coverage folate (ug)	.129**	.072	.129**	-.014
Percentage coverage vitamin B12 (ug)	-	-	-	-
Percentage coverage vitamin C (mg)	.065	-.027	.008	-.008
Percentage coverage macronutrients	.156**	.109**	.171**	-.037
Percentage coverage micronutrients	.143**	.099	.153**	-.039

All values are correlations
** Correlation is significant at the 0.05 level (2-tailed, Spearman correlation)

Table 11– IDDS, nutrition status of children 6 to 23 months and percentage coverage of nutrient requirements of all household members by the nutrients supplied from yield used for home consumption, in Karaga district, Ghana

n=328	Wasting (WHZ)	Stunting (HAZ)	Underweight (WAZ)	IDDS
Percentage coverage kcal	.131**	.078	.133**	-.030
Percentage coverage protein (g)	.097	.080	.115**	-.036
Percentage coverage fat (g)	.031	.043	.053	-.085
Percentage coverage carbohydrate (g)	.136**	.079	.138**	-.007
Percentage coverage calcium (mg)	.089	.075	.112**	-.019
Percentage coverage iron (mg)	.111**	.074	.118**	-.023
Percentage coverage zinc (mg)	.099	.085	.117**	-.032
Percentage coverage vitamin A (ug)	.046	.039	.045	-.032
Percentage coverage vitamin B1 (mg)	.133**	.073	.129**	-.031
Percentage coverage vitamin B2 (mg)	.126**	.078	.131**	-.013
Percentage coverage niacin (mg)	.054	.067	.081	-.057
Percentage coverage vitamin B6 (mg)	.125**	.061	.119**	-.013
Percentage coverage folate (ug)	.078	.063	.095	-.032
Percentage coverage vitamin B12 (ug)	-	-	-	-
Percentage coverage vitamin C (mg)	.061	-.024	.013	.018
Percentage coverage macronutrients	.127**	.085	.138**	-.054
Percentage coverage micronutrients	.116**	.077	.126**	-.054

All values are correlations
** Correlation is significant at the 0.05 level (2-tailed, Spearman correlation)

4.7 EVALUATION STUDY OF CROP PRODUCTION, KARAGA 2015

Table 12 shows the average crop count reported between the two research methods. There was a significant difference between the self-reported interview method and the observation method when reporting on crops cultivated per year, (i.e. harvest 2015). Conducting a paired sample t-test revealed a mean difference of +2 which was statistically significant (95% CI: 1.71;2.29). For the self-reported interview method, the mean of 4.06 ± 1.46 crops per household was reported compared to the observation method with a mean of 6.06 ± 2.15. It was calculated that an additional 9 crops were reported in total during the observation method, including: cowpea, garden egg, green leafy vegetables (ayoyo leaves), mango fruit, okro, pepper, shea nut, sugar cane and tomatoes. Moreover, some crops were also observed to be cultivated more frequently than the self-reported interview method, especially for beans. Staple crops were self-reported as frequently as observed.

Table 12– Average crop count per interview method from 51 households in Karaga district, Ghana with children 6 to 23 months old, November 2015

N= 47[1]	unit	Frequency	Richness[2-3]	Paired Sample T-Test	P-value
				2+	.001 (95% CI: 1.71; 2.29)
Interview Method	Mean (SD)		4.06 (1.46)		
Observation Method	Mean (SD)		6.06 (2.15)		
Crops reported during Interview /Observation method					
Bambera Beans	Frequency	1/6			
Beans	Frequency	8/13			
Groundnut	Frequency	19/19			
Guinea corn	Frequency	3/4			
Guinea Millet	Frequency	5/5			
Maize	Frequency	47/47			
Millet	Frequency	21/21			
Rice	Frequency	27/27			
Soyabean	Frequency	41/41			
Yam	Frequency	19/19			
Additional crops reported during Observation method					
Cowpea	Frequency	2			
Garden egg	Frequency	1			
Green leafy vegetable	Frequency	13			
Mango fruit	Frequency	2			
Okro	Frequency	41			
Pepper	Frequency	21			
Shea nut	Frequency	1			
Sugar cane	Frequency	1			
Tomatoes	Frequency	1			

[1] 4 household plots were inaccessible due to poor road conditions. When plots were inaccessible, further questions were asking during interview phase to determine additional crops in the field.

[2]Richness (crop count) is the total number of different reported crops cultivated in a household.

[3] It was not possible to determine other crop diversity indicators as the 2015 harvest period was in progress during the time of the fieldwork.

[4]Using the interview method compared to the observation indicates 9 under-reported crops including: cowpea, garden egg, green leafy vegetable, mango fruit, okro, pepper, shea nut, sugar cane and tomatoes.

[5] Total reported crops during interview method are 191 and total reported crops during observation method are 285.

5. DISCUSSION

The primary aim of this study was to investigate the associations between the diversity of household crop production and nutritional indicators of rural households in northern Ghana. Our findings show that increased crop diversity is associated with a higher potential of crops to meet the nutrient needs of household members. However, this study does not show associations between diversity of household crop production and dietary diversity of children 6 to 23 months or nutrition status of these children. Significant patterns were identified between a higher potential of crops to meet the nutrient needs of household members (specifically macro and micro-nutrients needs) and lower wasting and underweight rates among infants and children 6 to 23 months. The secondary aim of this study was to evaluate the validity of the self-reported interview method to an observation method, and determine potential underestimations when reporting on crop diversity indicators. Our findings do indicate a significant difference between both methods which reflect underestimations when collecting data on household crop production from the self-reported interview method.

There is a growing body of research on the linkages between agriculture and nutrition and specifically on diversity of crop production and nutrition. Studies used varied indicators reflective of different nutrition outcomes to measure characteristics of crop diversity and nutritional status [17], [20], [54], [55], [58], [80], [81]. This study aims to address some of these limitations in methodologies by narrowing in on the characteristic of crop diversity and nutrition that capture specific variables related to nutrient adequacy of the diet. A number of decision were made to de-mystify the relationships between crop diversity and nutrition and these included: (1) obtaining production yields (kg) to have a better representation of the nutrients supplied through household crop production; (2) including both total yield produced by a household and yield used for home consumption; (3) using nutrition indicators whose main outcome is to determine nutrient adequacy of the diet and not only access to food or food supply [55], [58]; (4) enhancing FCT by incorporating local food varieties and local food preparation techniques to adjust for retention factors; (5) comparing the nutrients supplied through subsistence home production at the household level with the nutrients required for that same household, to determine the coverage of each nutrient; (6) coverage of nutrients also accounted for differing bioavailability percentages of certain critical nutrients as well as adjusting nutrient requirements based on the life-cycle of members of the households.

5.1 DISCUSSION OF MAIN RESULTS

Crop diversity indicators and coverage of nutrient requirements supplied through household production

We observed positive associations between richness and the percentage coverage of all nutrients. Increased crop diversity is associated with a higher potential of crops to meet the nutrient needs of household members. The relevance of specie richness to nutrition is partially implied by the inherent understanding that diverse crops provide diverse foods, but also that greater specie richness increases the supply of different nutrients. However, higher crop diversity does not necessarily imply greater supply of complementary nutrients required for physical health over the life-course [17]. Increased crop diversity is also reflected in the SWI which was also associated with a higher potential of crops to meet the nutrient needs of household members. This index can relate to nutrition by the way it captures crop count and yield to obtain an indication of the nutrients supplied by production. A decreasing evenness score, on the other hand was associated with a higher potential of crops to meet the nutrient needs of household members. As crops are less equally abundant (score closer to 0), there is greater coverage of nutrient requirements by the production. The question remains how evenness is related to nutrition outcomes. Evenness scores do not reflect whether the dominant species differ in important traits or nutrients, compared to rare species. The interpretation is based on the equitability, abundance or dominance of species occupying land. Thus, an increasing evenness score does not necessarily increase the probability of consuming diverse food groups. It is possible that with a lower evenness score and decrease in equitability among species, the space for inter-species interactions is increased, increasing the diversity of crops. Another element to consider is that, as nutrient requirements are not needed in equal amounts, an equal supply of different foods does not necessarily match with nutrient requirements needs as these are varied, not equal. This understanding makes it difficult to draw concrete conclusions on the relationship between evenness and nutrition.

Crop diversity indicators, IDDS and nutritional status

In this study, no significant associations between crop diversity indicators, IDDS and nutritional status indicators, were found (only one with evenness and IDDS but the interpretation does not allow for concrete conclusions). This is not what we would expect in a context where markets do not function properly and most households have to rely on their own production to satisfy their food needs. These results are strikingly different compared to previous studies which have found direct significant association between richness and SWI and dietary diversity [52], [78]. However, it must be noted that in those studies, dietary diversity was measured using HDDS which reflects the economic aspects of food accessibility. Measurements of IDDS were not conducted. Moreover, testing for possible correlations between HDDS and IDDS were not clearly identified in past studies, thus it cannot be assumed that higher HDDS results in better IDDS. This can help explain the results of this study where no significant associations were found between greater agro-biodiversity levels and better micro-nutrient status. Kumar, Harris and Rawat (2015), on the other hand presented results on HDDS and household production diversity and then assessed if the results held true for IDDS and found significance for both dietary diversity outcomes. The household production diversity score included different elements compared to this study; agricultural income, livestock count, and agricultural activities (i.e. production of field crops, fruit crops, rearing animals and production of animal source foods). This suggests that household income and livestock production could have an effect on the strengths of the associations. When analysing the IDDS however, it should be noted that it does not indicate: (1) the quantities consumed; or (2) urban or rural differences as food markets in urban and peril-urban centres might be more adequately supplied and better accessible [6]. Another element to consider is that crop diversity indicators were measure at the household level and nutrition indicators were measured at the individual level, thus intra-household distribution of food was not reflected in household production nor crop diversity indicators. This could potentially contribute to the absence of significant associations. A final aspect that was not addressed in this study is the notion that IDDS can fluctuate with the seasons and the harvest. However, in a recent dissertation thesis evaluating dietary diversity scores to assess nutrient adequacy of the diet among rural Kenyan women, it was concluded that the IDDS used as a proxy for micronutrient adequacy can be used independent of season [82]. One explanation given for these findings was that women actually diversified their diets to non-conventional foods or reduced the amount of food consumed rather than consuming less food groups [82]. Thus, the effect of seasonality and harvest on IDDS in this study would not have necessarily weakened the associations between IDDS and crop production diversity.

In this study, associations between crop diversity indicators and nutrition indicators were found between evenness and dietary adequacy only. Greater equality among crops is associated with decreased IDDS. As nutrients are needed in different amounts, it is not necessarily expected that more equality in amounts produced from different crops result in better nutrition outcomes. Previous studies have not purposefully isolated evenness during analyses. Rajendran (2014) did not consider evenness but found associations between SWI and HDDS and explained the results in a similar way as this study; higher equality among crops' abundance levels does not necessarily benefit dietary diversity, even if more calories are indeed supplied [58].

Moreover, this study did not find associations between crop diversity indicators and nutritional status indicators. These results are in-line with previous studies. Different explanations have been given to potentially explain the lack of associations and these include: (1) younger children have smaller stomachs and rely more on breast-milk than food from diversified crop production; (2) the care-giver is not appropriately weaning the child nor using complementary foods provided by household crop production; (3) intra-household dynamics could play a role in determining how food is allocated among household members, with personal preferences determining food allocation; and (4) it is possible that accrued benefits of household production diversity are not noticeable until after the child has been fully exposed to diverse diets during the first 1000 days, up until 24 months - thus the benefits to linear growth may only be realized in later childhood [15]. As previously explained, Kumar, Harris and Rawat (2015) did find significant associations between production diversity and IDDS and explained these results to suggest that the diversity of diets consumed by infants and young children is directly related to diversity in agricultural production [15]. However significance was also not extended to nutritional status indicators for the same age group and explained these results to be because nutrient benefits accrued over an infants' life will most probably not be indicated until they reach an older age [15]. Their study then stratified for children between the ages of 24 months to 5 years and found significance with stunting [15].

IDDS, nutritional status and coverage of nutrient requirements supplied through household production

The results from these associations shed light on a very important determinant of food supply and nutrient supply. Regardless of an increase in the supply of nutrients, the market-orientation of a household can significantly diminishes the effects of household production diversity to supply the necessary nutrients [15], [40], [55]. It is established in table 5 that differences between total food production and production used for home consumption exist. These differences are also shown in the reduced number of significant associations between coverage, IDDS and nutritional status indicators when considering production used for home consumption. We can determine from these associations that a higher potential of crops meeting the nutrient needs of household members is associated with lower wasting and underweight scores, but had no effect on stunting nor on IDDS. What these results could imply is that with greater nutrient supply (i.e. yield) from home production, wasting, a form of acute malnutrition and underweight levels can be reduced. A few arguments potentially explaining the lack of associations between IDDS, stunting and coverage include: (1) stunting is reflective of chronic malnutrition and thus greater yield from home production might not provide complementary nutrients nor a quality diet; (2) nutrients are potentially 'sold' to the market or bartered and not used in the home reducing the actual nutrient supplied from production; (3) household production and coverage does not consider food purchased outside the home and consumed; (4) knowledge on how income from household production is used for the home in terms of more food or health care is unknown [15], [55]; (5) household production diversity and coverage are measured at the household level which means that individual and intra-household dynamics of food exchange, and how production trickles down to individual intake, is omitted [15], [40], [47], [59], [80].

Evaluation study of crop production, Karaga 2015
Our evaluation study shows underestimations in crop count when using the self-reported interview method compared to the observation method during the collection of data on crop diversity indicators. When collecting data on crop count, there is greater accuracy in reporting when applying the observation method as compared to the self-reported interview method. Moreover, during the field observations, there was a lot of dynamic exchange of information, especially when it came to the responsibilities of different family members to their plots and how each farmer either focussed on mono-cropping or inter-cropping cash crops. It was also possible to understand that information on vitamin-rich crops were not a topic of great interest. Some of the under-reported crops included green-leafy vegetables and mango, both rich in vitamin A. As one of the main problem nutrients identified in this study to be a lack of vitamin A food production, such underestimations incorrectly reflect the potential of crop production diversity to meet nutrient needs. This insight might explain why the percentage coverage of vitamin A (significantly below 100 per cent), was not associated with IDDS for example. Thus, the nutrients supplied from household production are potentially under-reported.

5.2 STRENGTHS OF THE STUDY

The choice of crop diversity indicators that are relevant to nutrition
This study aimed to look at associations between established indicators of biodiversity and validated indicators of young child feeding practices and nutritional status [81]. Firstly, to capture dietary diversity it was decided that the appropriate focus would be the quality of the diet rather than access to food. Secondly, all crop diversity indicators were then chosen on the basis of applying species diversity and the yields produced to their equation to properly allocate the nutrient supplied per household. With this focus, it was possible to capture what was

consumed in the home from own production, if this sufficed the nutrient requirements, and which key nutrients stood out as problem nutrients.

Household consumption of total production, a potential important characteristic to capture

Assessing the production orientation of farming households is vital for understanding the relative importance of subsistence vs. market-oriented production in influencing household diets; two of the principle pathways through which agricultural production is argued to influence nutrition outcomes [47]. Detailed information on production of yield per year was collected and captured two important characteristics lacking in current research linking crop and nutrition indicators: (1) collecting data on yields rather than on land size; and (2) crops used for home consumption. Previous research combining crop diversity and nutrition indicators by Remans (2011), Jones (2014) and Luckett (2015) did not include data on yield kept for home consumption as the focus was to estimate food quantity based on the land used for a specific crop [17], [55], [81]. In this study, using yields instead of land size, for example, gave a more accurate reflection of the supply of nutrients produced and how much of those nutrients remained in the home.

Food composition tables, incorporate elements of consumption: accounting for special species varieties, food preparation methods and retention factors

Current food composition tables and databases are not always available or reliable and fail to capture individual foods by variety, strain or breed, preferring instead to group foods generically. The absence of food composition data on underutilized, local varieties of crops limits the possibility to test these for their nutrient potential which might lead to an underestimation of the nutrient supply of a particular cropping system. Previous research has not considered elements of consumption including food preparation methods such as boiling, frying, raw and retention factors coupled with nutrition status of people suffering from micronutrient deficiencies [17], [20], [55], [81]. In this research, it was possible to combine the elements of nutrient composition to methods of food preparation and retention, obtaining greater accuracy in estimating the true nutrient supply.

IDDS versus HDDS

This study aimed to focus on the quality of the diet as it is a better indication of micronutrient adequacy of the diet. Different indicators reflecting dietary diversity are used in past studies linking crop diversity and nutrition outcomes [17], [54], [55], [58], [81]. HDDS reflects in a snapshot form, the economic ability of a household to *access* a variety of food while IDDS reflects the *consumption* of food and the micro-nutrient adequacy of the diet [7]. HDDS is indeed the most recurring indicator used in similar studies. This is mainly because access to food and income play a determining factor in a households' ability to obtain enough food/calories. However, Arimond *et al.* (2004, 2010) have explained that nutritional status of children measured by anthropometry is associated with food intake reflective of micro-nutrient density and quality of the diet [83], [53].

5.3 LIMITATIONS OF THE STUDY

Partly correlated measurement error

A correlated measurement error can inflate the found associations when data for two variables is collected and analyzed from the same survey [78]. This creates co-dependence between the data. For example, if one variable was underestimated (i.e. crop count) then this underestimation would carry over and affect the second variable of interest. This kind of measurement error can be solved spatially, by analyzing data from different areas and temporally, by analyzing data at different time points [78]. Several factors may have influenced the results of this study. Part of the correlation that we find can probably be explained because multiple analyses are conducted on the same collected data (i.e. crop diversity indicators and percentage coverage, use same data from the crop production survey).

Intra-household distribution of food

A care-giver's knowledge of appropriate feeding practices plays a significant role in the intra-household distribution of food [15] [56]. What the child actually eats will be determined by such dynamics. Even if households produce many different crops, the nutrients supplied might not reach the child if the caregiver is not aware of foods children require for optimal growth and development [15]. For this study, data on intra-household distribution of food was not collected at the household level. As previously discussed, no associations were found between IDDS and the increased potential of covering the nutrient requirements from household production. The inclusion of intra-household distribution of food might better evaluate the potential of crop production to supply the required nutrients specifically needed for infants and young children based on the allocation of produced food in the home.

Food waste, food loss and storage

This study did not obtain data on food waste. Losses of stored food are a major factor affecting the availability of food in developing countries due to high temperatures, high humidity levels and lack of clean water supply [56]. Food loss at the household level may also be caused due to improper storage facilities and subsequent deterioration of the food [56]. Drying, salting and preserving foods are methods used to maintain the integrity of the food [56]. In this study, details on food preservation in the home were not taken into account. The inclusion of food waste data per household could decrease the potential of crop production diversity to satisfy the nutrient requirements per household.

Farm diversity, under-reporting

There was no consistent recording of total farm diversity data in this study. Livestock count including the typical animals on a household farm such as chickens, goats, pigs, guinea fowl and cattle were not reported. Thus, the information that was found was centered on crops, fruit trees and vegetables. This underestimation in nutrient supply could have underestimated the potential of household production from the farm to satisfy nutrient requirements of household members. Both Kumar, Harris and Rawat (2015) and Jones (2014) did include animal diversity along with crop diversity and found statistical significance between dietary diversity scores and household production [15], [39].

Evaluation study of crop production, Karaga 2015 – underestimations and measurement bias
Although underestimations in crop count were determined, further underestimations should be considered as information was not collected on livestock or animal husbandry. This could have affected the results by way of reduced nutrient supply reported by a household. This was mainly due to the fact that in many households, it was looked down upon to count the animals as this was understood to bring a curse to the household. However, this is obviously not a data collection problem in previous research. Thus, it is suggested that the collection of livestock count should be done discretely. Moreover, as the self-reported interview and observation methods occurred on the same day, this could result in a certain degree of measurement bias. However, the head of household was aware of a potential excursion to the plots only after the interview method was fully completed.

6. CONCLUSIONS AND RECOMMENDATIONS

Food production in subsistence households plays an important role in providing a diversity of nutrient supply. This study has looked at various indicators of crop diversity, the potential coverage of nutrient requirements supplied by household production, IDDS and nutritional status in order to improve our understanding of the links between household crop production and nutrition. We have found that all three crop diversity indicators are significantly associated with an increase potential of covering the nutrient requirements of household members. Significant patterns were also identified between a higher potential of crops to meet the nutrient needs of household members (specifically macro and micro-nutrients needs) and lower wasting and underweight rates among infants and children 6 to 23 months. However, crop diversity indicators were not associated with IDDS or nutritional status indicators of children 6 to 23 months old. As reductions in undernutrition are achieved through a balancing act between food, health and care determinants, it is challenging to find the appropriate fit within the agricultural sector. Long-term nutrition-sensitive and agricultural food-based approaches and policies to combatting the complexities of malnutrition could also be assisted by behavior change communication to translate and spread the knowledge of diversity in home production to better nutrition for children.

Recommendations for future research could focus on: (1) different aspects of intra-household distribution of food to understand how household production trickles down to infants and young child food intake; (2) data on food waste to identify how much food is lost post-harvest and during food preparation and how this affects the food intake of younger members of the household; (3) income expenditure data to determine spending behavior of households on food, health care or other provisions; (4) animal and farm diversity to include a better representation of the potential of diversity to affect nutrition; and (5) to supplement data collection on self-reported harvest with observations in the field to avoid underestimations of production diversity and crop count.

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APPENDICES

APPENDIX A– EVALUATION STUDY OF CROP PRODUCTION DATA, KARAGA 2015

STUDENTS: Sofia Argyropoulou and Froukje Takens, Wageningen University

Volunteer agreement: In the first two weeks of November, two researchers from the Netherlands will be carrying out a study among households within Karaga district. The aim is to obtain insight on intra-household dynamics and information on crops that are produced per family plot. We would like to ask some questions to the mother of CHILD_INDEX_ID and to the head of household. The first researcher, Sofia, will ask some questions on crop production to the head of household and then possibly join the head of household to visit the family plot. Simultaneously, the second researcher, Froukje, would like to interview the mother of CHILD_INDEX_ID.
I have been given an opportunity to have any questions about the research answered to my satisfaction. Taking part in this research is my choice. I know that I may decide to pull out at any time. I agree to participate as a volunteer.

Date: /11/2016 ___________________________

Name of Respondent

____

Signature (or thumb print of respondent in the case that respondent cannot sign name)

____

Signature of witness (if respondent is non-literate)

I certify that the nature and purpose, the potential benefits, and possible risks associated with participating in this research have
been explained to the above individual. I have watched them indicate consent to participate in the study with a mark/signature.

Date: /11/2016

Signature of person who obtained consent:____

Printed name of person who obtained consent:____

HOUSEHOLD NAME	COMMUNITY NAME	DATE OF FIRST VISIT (dd/mm/yy): HOUSEHOLD Time Started: Time Ended:
NAME OF INDEX CHILD	INDEX CHILD ID	DATE OF SECOND VISIT (dd/mm/yy): FIELD Time Started: Time Ended:
GUIDE NAME	WUR STUDENT NAME	INTERVIEWEE NAME

PHASE 1: INTERVIEW WITH HEAD OF HOUSEHOLD (IN THE HOME): HOUSEHOLD FARM SIZE(S)

Plots/farms of the household (eg. Family plot, bush plot, women's plot)					
Shared plot? (N=no, Y=yes)					
Size of each farm (acres)					
Size of farm used currently for farming (acres)					

PHASE 1: INTERVIEW WITH HEAD OF HOUSEHOLD (IN THE HOME): CROP PRODUCTION AND USE

Crops cultivated (all crops during the previous year)	Fertilizing inputs (code 0, 1 or 2*)	Season harvested (indicate month(s))	Total production during last year (indicate units: kg, 50 kg bags)	Amount for **sale** (indicate units: kg, 50 kg bags)	Amount for **food in the household** (indicate units: kg, 50 kg bags)	Amount used as payment / food for **hired labour** (indicate units: kg, 50 kg bags)	Amount kept as **seed / planting material** (indicate units: kg, 50 kg bags)	How is specific crop mostly **prepared in household** (indicate: boiling, steamed, raw, fresh, fried)
A	B	C	D	E	F	G	H	

PHASE 2: INTERVIEW WITH HEAD OF HOUSEHOLD IN THE HOUSEHOLD PLOTS (FIELD)

CROP PRODUCTION AND USE IN THE FIELD

Crops cultivated (all crops during the previous year)	Fertilizing inputs (code 0, 1 or 2*)	Season harvested (indicate month(s))	Total production during last year (indicate units: kg, 50 kg bags)	Amount for **sale** (indicate units: kg, 50 kg bags)	Amount for **food in the household** (indicate units: kg, 50 kg bags)	Amount used as payment / food for **hired labour** (indicate units: kg, 50 kg bags)	Amount kept as **seed / planting material** (indicate units: kg, 50 kg bags)	How is specific crop mostly **prepared in household** (indicate: boiling, steamed, raw, fresh, fried)
A	B	C	D	E	F	G	H	

APPENDIX B - FOOD CONSUMPTION SURVEY OF INFANTS AND YOUNG CHILDREN 6-23 MONTHS

NOGUCHI MEMORIAL INSTITUTE FOR MEDICAL RESEARCH

VOLUNTEER AGREEMENT

The above document describing the benefits, risks and procedures for the research titled ***'A Focused ethnographic study and quantitative food consumption survey of infants and young children in rural northern and southern Ghana'*** has been read and explained to me. I have been given an opportunity to have any questions about the research answered to my satisfaction. Taking part in this research is my choice. I know that I may decide to pull out at any time. I agree to participate as a volunteer.

______________________ ______________________________

Date Name of respondent

____

Signature (or thumb print if respondent cannot sign name)

____

Signature of witness (if respondent is non-literate)

I certify that the nature and purpose, the potential benefits, and possible risks associated with participating in this research have been explained to the above individual. I have watched them indicate consent to participate in the study with a mark/signature.

__________________ ______________________________________

Date Name Signature of Person Who Obtained Consent

GAIN FES/Optifood Research, Ghana

Food Consumption Survey of Infants and Young Children 6-23 months

Karaga and Gomoa East Districts, 2014

NMIMR/UDS/WU

A. General Information

1. District Name:	2. Sub-district Name:	3. Community Name:
4. Household name:	5. Household number:	10. Date of 1st visit (dd/mm/yy): Time Started: Time Ended:
6. Name of index child:	7. Index child ID:	11. Date of 2nd visit (dd/mm/yy): Time Started: Time Ended:
8.Interviewer's name:	9. Interviewer's number:	12. Date of 3rd visit (dd/mm/yy): Time Started: Time Ended:
13. Supervisor name & No:	14. Date Supervisor check: Signature:	15. GPS coordinates household North/South: __ __ . __ __ __ __ __ East/West: __ __ __ . __ __ __ __ __ Altitude (meter): ______________
16. Supervisor2 name & No:	17. Date Supervisor2 check: Signature:	18. Data entry (dd/mm/yy): Signature:

Household Survey

Respondent: 1 <u>Head of household</u> 2 Mother of index child (circle)

1. Household Roster *(if there are remarks, these should be numbered and written at empty page)*

								IF FEMALE AND ≥ 14 YEARS								
NO.	USUAL RESIDENTS	RESIDENCE		AGE			SEX	PERIODS	PREGNANCY		LACTATING	RELIGION	EDUCATION	OCCUPATION	WEEKLY EARNINGS	
	Names of persons who eat from the same cooking pot as the index child	Does NAME usually live here?	Did NAME stay here last night?	How old is NAME? 0 – 6 mnths	6 – 11 mnths	> 12 mnths	Is NAME male or female?	Does NAME has her periods?	Is NAME pregn ant?	If yes, in which trimester?	Is (NAME) brestfeedin g?	Religion of NAME?	1=S.H.S or higher 2=J.H.S. or higher 3=primary school 4=literate (Arabic) 5=none, 6=other*	1=office work 2=trader 3=farmer 4=housewife 5=none 6=other*	Does NAME earn money?	If yes, how much per week?
		N=no Y=yes	N=no Y=yes	N=no Y=yes	N=no Y=yes	Compl eted years	M=male F=female	N=no Y=yes	N=no Y=yes	1=1-12 wks 2=13-28 wks 3=29-40 wks	N=no Y=yes	1=Christian 2=Muslim 3=Others	Code: 1 to 6 *specify	Code: 1 to 5 *specify	0=no** 1=yes, F 2=yes, OF	1=1-3 GH₵ 2=3-7 GH₵ 3=>7 GH₵
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Head of household															
2	Mother of index child															
3																
4																
5																
6																
7																
8																
9																

**[1=yes, F] = yes, mainly farm income; [2=yes, OF] = yes, mainly off-farm income (includes working on other people's farm)*

Household Roster continued

								IF FEMALE AND ≥ 14 YEARS						
NO.	USUAL RESIDENTS	RESIDENCE		AGE			SEX	PERIODS	PREGNANCY		LACTATING	RELIGION	EDUCATION	OCCUPATION
	Names of persons who eat from the same cooking pot as the index child	Does NAME usually live here?	Did NAME stay here last night?	How old is NAME? 0 – 6 mnths	6 – 11 mnths	> 12 mnths	Is NAME male or female?	Does NAME has her periods?	Is NAME pregn ant?	If yes, in which trimester?	Is (NAME) breastfeedi ng?	Religion of NAME?	1=S.H.S or higher 2=J.H.S. or higher 3=primary school 4=literate (Arabic) 5=none 6=other*	1=office work 2=trader 3=farmer 4=housewife 5=none 6=other*
		N=no Y=yes	N=no Y=yes	N=no Y=yes	N=no Y=yes	Compl eted years	M=male F=female	N=no Y=yes	N=no Y=yes	1=1-12 wks 2=13-28 wks 3=29-40 wks	N=no Y=yes	1=Christian 2=Muslim 3=Others	Code: 1 to 6 *specify	Code: 1 to 6 *specify
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
10														
11														
12														
13														
14														
15														
16														
17														
18														
19														
20														

'1=yes, F' = yes, mainly farm income; '2=yes, O F' = yes, mainly off-farm income (includes working on other people's far

2. Household Assets

	Assets	Available	Functioning
		N=no, Y=yes	N=no, Y=yes
A	Radio/sound system		
B	TV/DVD		
C	Corn mill/Rice mill		
D	Bicycle		
E	Motor bike		
F	Private vehicle		
G	Commercial vehicle		

3. Household Farm Size(s)

Plots/farms of the household (eg. Family plot, bush plot, women's plot)					
Shared plot? (N=no, Y=yes)					
Size of each farm (acres)					
Size of farm used currently for farming (acres)					

4. Crop production and use

Crops cultivated (all crops during the previous year)	Fertilizing inputs (code 0, 1 or 2*)	Season harvested (indicate month(s))	Total production during last year (indicate units: kg, 50 kg bags)	Amount for **sale**	Amount for **food in the household**	Amount used as payment / food for **hired labour**	Amount kept as **seed / planting material**
A	B	C	D	E	F	G	H

**0=no; 1=manure; 2=fertilizer*

5. Household market access

Name of market					
Number of visits per week					
Time to travel to market, the last time					
Cost of transportation to and from this market, the last time (GH₵)					

Interview Date:	**Date of assessed food intake:**	**Recall number:** 1 2 (circle)
Enumerator Name:	**Childs Name:**	**Child ID Number:**
Breastfed: Yes No (circle)	**Caregiver's Name:**	**Respondent: 1 Mother 2 Caregiver** (circle)
Scale number:	**Weight of mobile: ....**	

Yesterday: (Circle)

1. Did the child take medicine yesterday? Yes No If yes, name:
2. Was yesterday a celebration/feast day where the child ate unusual foods: Yes No
3. Did the child feel unwell yesterday: Yes No If yes, symptoms:

Quick list	**Logbook**

Meal code*	Place of preparation**	Dish name	Ingredients				Amounts per ingredient				Total volume cooked		Total volume served to the child		Left over (of food served to the child)	
			Description	Origin***	Method of preparation - *What did you do with the ingredient?* (condition consumed, eg. boiled, raw, peeled, fried etc)	No. days in last 7 days	Quantity	Unit (eg. g, kg, ml, GH₵, pieces)	Measured with	Condition measured (eg. raw, (un)cleaned, (un)peeled, **brandname** etc)	Quantity	Unit	Quantity	Unit	Quantity	Unit
A	**B**	**C**	**D**		**E**	**F**	**H**	**I**		**G**	**J**	**K**	**L**	**M**	**N**	**O**

* Meal code: 1=before breakfast, 2=breakfast, 3= mid-morning, 4= lunch, 5=afternoon, 6=dinner/supper, 7=before sleep, 8=during night
** Place: 1= inside, 2= outside
*** Origin: 1=own production, 2=purchase, 3=gift, 4=in kind, 5=from wild

Karaga district Child ID: ....

1. Are other foods consumed yesterday in the household but <u>not consumed by the child</u>?

1 Yes, fill in the table below **2 No,** go to the next page (circle)

2. Which foods are consumed yesterday in the household but were not consumed by the child?
(fill in table below)

Meal code*	Place of preparation**	**Dish name**	**Ingredients**			
			Description	Origin***	Method of preparation - *What did you do with the ingredient?* (condition consumed, eg. boiled, raw, peeled, fried etc)	No. days in last 7 days
A	**B**	**C**	**D**		**E**	**F**

* Meal code: 1=before breakfast, 2=breakfast, 3= mid-morning, 4= lunch, 5=afternoon, 6=dinner/supper, 7=before sleep, 8=during night
** Place: 1= inside, 2= outside
*** Origin: 1=own production, 2=purchase, 3=gift, 4=in kind, 5=from wild

Household Hunger Scale

Inform respondent that the questions may sound similar but they are different and stress on the difference when asking the questions.

A yi yen labsi bohisi âô, nyin lihimi a biâhigu biâê'30din gari âô puuni ka labsi

QNo.	Question	Response Option (circle response)	Code (do not fill)
1	***In the past 4 weeks/30 days***, was there ever no food at all in your household because there were not enough resources to get more? A daa bi toi nya, bee a sulinsi maa so daa bi nya bindirgu yiko kalinsi øuêu?	0 = Aayi (skip to Q2) 1 = Iii	....|___|
1a	How often did this happen ***in the past 4 weeks/30 days***? Bu la ka lala daa niâ biâê'30 din gari âô puuni?	1 = Di bi yoli (yim bee buyi biâê'30 maa puuni) 2 = Chirigili (but 3 øaâ cheni 10 biâê'30 maa puuni) 3 = Di niâda (Di gari bu 10)	....|___|
2	***In the past 4 weeks/30 days***, did you or any household member go to sleep at night hungry because there was not enough food? A daa min gbe kum, bee a sulinsi maa so daa min gbe kum bindirpooli zuêu?	0 = Aayi (skip to Q3) 1 = Iii	....|___|
2a	How often did this happen ***in the past 4 weeks/30 days***? Bu la ka lala daa niâ biâê'30 din gari âô puuni?	1 = Di bi yoli (yim bee buyi biâê'30 maa puuni) 2 = Chirigili (but 3 øaâ cheni 10 biâê'30 maa puuni) 3 = Di niâda (Di gari bu 10)	....|___|
3	***In the past 4 weeks/30 days***, did you or any member of your household go a whole day without eating anything because there was not enough food? A daa min be di dabsili pulni bee a sulinsi maa so daa min be di dabsili pulni domin bindirpooli zuêu?	0 = Aayi (end questionnaire) 1 = Iii	....|___|
3a	How often did this happen ***in the past 4 weeks/30 days***? Bu la ka lala daa niâ biâê'30 din gari âô puuni?	1 = Di bi yoli (yim bee buyi biâê'30 maa puuni) 2 = Chirigili (but 3 øaâ cheni 10 biâê'30 maa puuni) 3 = Di niâda (Di gari bu 10)	....|___|

Anthropometry Form

1. Interview date: _____/_____/2014

2. District name: ________________________ 3. District number: _______

4. Sub-district name: ________________________ 5. Sub-district number: _______

6. Community name: ________________________ 7. Community number: _______

8. Household name: ____

Index child (6 – 23 months)

9. Name of index child: ____

10. Sex of child: 1 Male 2 Female (circle)

11. Date of birth of child: _____/_____/_________ (dd/mm/yyyy)

12. Date of birth verified from:
   0 Not verified
   1 Birth certificate
   2 Health records booklet
   3 Community register
   4 Other document, specify: ________________________

13. Age of child: |_____|_____| (in completed months)

Karaga district Child ID ....

Anthropometry Form

1. Interview date: _____/_____/2014

2. District name: ________________________ 3. District number: _______

4. Sub-district name: ________________________ 5. Sub-district number: _______

6. Community name: ________________________ 7. Community number: _______

8. Household name: ____

Index child (6 – 23 months)

9. Name of index child: ____

10. Sex of child: 1 Male 2 Female (circle)

11. Date of birth of child: _____/_____/_________ (dd/mm/yyyy)

12. Date of birth verified from:
0 Not verified
1 Birth certificate
2 Health records booklet
3 Community register
4 Other document, specify: ________________________

13. Age of child: |_____|_____| (in completed months)

14. Weight child: A. __ __.__(kg) 15. Length child: A. __ __ __ .__ (cm)

B. __ __.__(kg) B. __ __ __ .__ (cm)

16. MUAC child: A. _________ (mm)

B. _________ (mm)

17. Presence of bilateral pitting edema: 0 No 1 Yes (circle)

Mother of index child

18. Weight mother: A. __ __ __.__(kg) 19. Height mother: A. __ __ __ .__ (cm)

B. __ __ __.__(kg) B. __ __ __ .__ (cm)

Number of scale used: _________