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Agricultural Biodiversity and Sustainable Child Nutrition in Dormaa West District of the Brong Ahafo Region

By

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AGRICULTURAL BIODIVERSITY AND SUSTAINABLE CHILD NUTRITION

IN DORMAA WEST DISTRICT OF THE BRONG AHAFO REGION

A Thesis Submitted to the School of Graduate Studies, Kwame Nkrumah University of Science and Technology in Partial Fulfilment of the Requirements for the

MASTER OF PHILOSOPHY DEGREE

IN

SUSTAINABLE AND INTEGRATED RURAL DEVELOPMENT

By

Alex Otabil

OCTOBER, 2016

DECLARATION

I do declare that except references to other people's work, which have been duly cited, the work presented as a thesis to the Department of Agricultural Economics, Agribusiness, and Extension, Faculty of Agriculture for the degree in Master of Philosophy in Sustainable and Integrated Rural Development, is the result of my own research.

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ABSTRACT

The study assessed diversities of crops and animals, and the relationship between agricultural biodiversity, dietary diversity, and malnutrition prevalence of children between 24-60 months using a cross-sectional survey in the Dormaa West District between April-May 2015.

A sample size of 217 households was targeted with 10 communities conveniently selected. Thereafter systematic sampling was used until the required sample was reached. Agricultural biodiversity was measured by counting plants and animals kept, grown and obtained from the wild. Dietary diversity was also measured using data from 24 hour recalls and their food groups calculated using dietary diversity score. Weight and height measurement of children were taken and their Z scores calculated for stunting, wasting and underweight. Pearson correlation was used to test the relationships between variables. The study revealed agricultural biodiversity to be high in the District but low among households. The household's dietary diversity level was medium with 24.5% of the households consuming from ten different food groups. Underweight (WAZ) prevalence was the highest rate (20.3%) and was (2.3%) and (7.9%) more than stunting (HAZ) and wasting (WHZ) rates respectively. There was a positive correlation between agricultural biodiversity (AB) and dietary diversity (DD) ($p<0.01$). However, agricultural biodiversity did not correlate with HAZ, WHZ, and WAZ ($p> 0.05$). With the exception of HAZ and WHZ, higher dietary diversity explained 21% of severe WAZ.

Regardless of sex and age, agricultural biodiversity and high dietary diversity have a relationship with severe underweight among children in the Dormaa West District. Underweight should be given attention for children between the ages of 24-48 months through highly diversified diets.

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DDS	Dietary Diversity Score
DD	Dietary Diversity
FAO	Food and Agricultural Organization
GSS	Ghana Statistical Service
HAZ	Height for Age
MDGs	Millennium Development Goals
SDGs	Sustainable Development Goals
UNICEF	United Nations Children's Fund
UN	United Nations
WAZ	Weight for Age
WHO	World Health Organization
WHZ	Weight for Height

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

The study assesses the diversities of cropping and animal systems in the Dormaa West District. It also examines the relationship between this agricultural biodiversity, and dietary diversity and how it lessens child malnutrition incidence and prevalence in the district.

Sustainable nutrition is one target of the Sustainable Development Goals, which envisage that, by the end of 2030, 169 targets, including malnutrition incidence and prevalence rates would have reduced. Meanwhile, reports show that one-third and one-fourth of under-five children in developing countries appear stunted and malnourished respectively (United Nations, 2004; UNICEF, 2009). Child malnutrition is the result of not being able to meet the needed nutrients at the perfect amount or meeting the nutrient above the needed amount, which results in stunting, wasting, underweight and overweight among children under-five years. Wasting records low among children under six months age and high for ages 25 months and more in Sub-Saharan Africa, but remains high through the second year life (UNICEF, 2009).

Cases of malnutrition increase the cost of health care, lower national income percentage, forgo labour market production and increases mortality as well as mobility costs. A total sum of US$ 177 million is spent yearly in Ghana on mineral and vitamin deficiencies (UNICEF, 2009). According to Hoddlinot *et al*. (2013) and Bhuttal *et al*. (2013), every GHC1 invested in malnutrition intervention brings back GHC17 in return. If these causes of malnutrition remain, then Ghana will not achieve the Sustainable Development Goal 2 (improved nutrition).

Child malnutrition effects have called for many interventions such as vitamin supplementation, food fortification among others, to reduce it. However, these interventions are not sustainable because they are expensive for the rural communities and run short before reaching the rural areas. It is expensive because of few food industries in developing countries such as Ghana (United Nation, 2004).

Currently, there is a collaboration between developed and developing world in search of sustainable ways for reducing malnutrition. Sustainability is meeting present and future children's needs with the same resources without harm.

Many studies (Arimond & Ruel, 2004; Mouri *et al*., 2008; Thorne-Lyman *et al*., 2009 ; Ekesa & Garming (2011) have shown malnutrition incidences and prevalence are results of poor diet. However, sustainable diet is the way to good nutrition. Sustainable diets are diets with low ecological effects, which add to nourishment, security and to a solid life for present and future generations. Sustainable diets are environmentally defensive, socially satisfactory, open, monetarily moderate, healthfully enough, protected, and solid while streamlining common human resource (FAO & Biodiversity International, 2012).

Agricultural biodiversity is noted by Bioversity International (2011) and Frison, Chervas & Hodgkin (2011) to offer this sustainable diet. Agricultural biodiversity is differences in species and varieties of plants and animals in the same environment. Agricultural biodiversity has proven positive in reducing malnutrition in many countries. For instance, in Kenya different traditional leafy vegetable species conserved, reduced anaemia (Gotor & Irunga, 2010).

The study is necessary because agricultural biodiversity has the potential of providing quality and diverse diets. This quality and diverse diets will meet children nutritional needs and control other diet and severe diseases (Sun *et al*., 2014). Again, when the study show a positive relationship between agricultural biodiversity, dietary diversity and nutritional status, the demand for local, nutritious fruits and vegetable will increase, motivating more farmers to cultivate local vegetables . In doing so, it conserves local fruits and vegetables.

Finally, in preserving, growing and keeping species diversities, the natural ecosystem will regenerate.

1.2 Problem Statement

Every human being, young and old eats diverse, balanced and preferred diet to live. The human diet is supposed to meet not less than 51 nutrients in sufficient sums reliably (Graham *et al*., 2007), most especially for children under five in their growth. Even though nutrient supplementation and food fortification strategies have solved minor deficiencies, they cannot ensure improved sustainable diets (Burchi *et al*., 2011), because they are expensive (Underwood, 2000). For example, Ghana is spending US$177 million on mineral and vitamin deficiencies every year (UNICEF, 2009).

In the past years, most nutritious diets obtained were local and wild foods. Nature's ecosystem provides thousands of plant species and animals with each species having different nutrient content needed by human beings. Andre *et al*. (2007) confirmed there is not less than 23-fold distinct iron substances between sweet potato varieties. However, different species containing different nutrient contents and quantities are no longer available. Crop species, vegetables, wild fruits and wild animals like taro (*Colocasia esculentus*), mushroom, snails, and grass cutters have reduced in their quantities in the ecosystem (FAO, 1999). FAO (1999) also noted that 90% of crop varieties have vanished from farmers' fields. This fall has affected the number of plants consumed by humans and so affecting human health.

Currently, out of 100,000 pregnant women in Ghana who attend to labour, 451 of them lose their lives or give birth to stillborn babies (GSS, 2009; Der *et al*., 2013). Those who safely deliver nurse 28% stunted children, 9% wasted children, 5% overweight children, and 14% underweight children (ICF Macro, 2010).

The annual average rate of stunting and anaemia reduction is 2.8 and 1.3 against the needed rate of 4.4 and 5.2. Underweight and wasting have also increased and decrease under a baseline of -0.7 and 9.5 (Stevens *et al*., 2013, UNICEF, WHO and World Bank, 2014). A sustainable diet is a way forward, and agricultural biodiversity is noted to offer this sustainable diet. Many authors associated agricultural diversity with dietary diversity and adversely identified with lack of healthy nourishment (Thrupp, 2000; Frison *et al*., 2011). However, the link between agricultural biodiversity and the anthropometric status of children are scarce in Ghana. Therefore, the study explores agricultural diversity, diet diversity and 24-60 months children malnutrition status in the Dormaa West District.

1.3 Research Questions

1. What is the agricultural biodiversity level in the study area?
2. What is the dietary intake and dietary diversity of children 2-5 years in the study area?
3. What is the proportion of malnourished children in the study area?
4. What is the relationship existing between agriculture biodiversity, dietary diversity and malnutrition status?

1.4 Objectives of the Study

1.4.1 General Objective

The study aimed to explore agricultural biodiversity in the Dormaa West District and examine the association between agricultural biodiversity, dietary diversity and the prevalence of stunting, wasting and underweight among children aged 2-5 years.

1.4.2 Specific Objectives

1. To study the extent of agricultural biodiversity and dietary diversity in the study area;

2. To measure the nutritional status for children aged 2-5 years, using anthropometric methodology; and
3. To assess the relationships between agricultural, dietary diversity and nutritional status for children aged 2-5 years.

1.5 Research Hypotheses

The study sought to test the following hypotheses:

1. H_o: There is a positive relationship between agricultural biodiversity and dietary diversity.

   H_A: There is no positive relationship between agricultural biodiversity and dietary diversity.

2. H_o: There is a negative relationship between dietary diversity and anthropometric status of children aged 2-5 years.

   H_A: There is no negative relationship between dietary diversity and anthropometric status of children aged 2-5 years.
3. H_o: Agricultural biodiversity and dietary diversity explain malnutrition rates sustainably.

   H_A: Agricultural biodiversity and dietary diversity do not explain malnutrition rates sustainably.

1.6 Justification of the Study

Children's dietary status warrants study for many reasons: first, the highest morbidity rates in Africa are the result of inadequate food intake and a poor diet (Lartey, 2004; Ajani, 2010). Even though the World Health Organization (WHO), Food and Agricultural Organization (FAO) and Sustainable Development Goals (SDGs) are all undertaking interventions to improve malnutrition, less attention is placed on the potentials of agricultural biodiversity. Politicians of African countries have low interest supporting financially huge interventions.

In addition, interventions like food fortification and nutrient supplement are expensive. In addition, food fortification affects food sensory properties, limiting micronutrients added to food products (Allen, 2008), while nutrient supplement carries risks of micronutrient interactions in malaria outbreak areas (De Benoist *et al*., 2006). Therefore, researching into food fortification and nutrient supplement is not necessary. What is needed is food-based approach research to improve malnutrition status.

Finally, the study will add to the little information on agricultural biodiversity and nutrition in Africa, and give reasons to why agricultural diversity needs promotion in the Dormaa West District.

1.7 Limitation of the Study

The dietary recall depended on the respondent's memory. This limited the extent of synthesizing dietary data reasonably. Financial and time constraints allowed selecting only communities closer to the district capital.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

The study sought to assess agricultural biodiversity in the Dormaa West District and examine the association between agricultural biodiversity, dietary diversity and the prevalence of stunting, wasting and underweight among children aged 2-5 years.

The literature reviewed information on agricultural biodiversity, dietary diversity, and underweight, stunting and wasting between the periods 2000-2015. Only children aged 2-5 years were the focus.

The review started with the meaning of sustainable development, followed by the global malnutrition, malnutrition outcome, agricultural biodiversity and its measurement and dietary diversity and its measurement. Association between agricultural biodiversity, dietary diversity, and nutritional status discussed also. Finally, a framework of the main variables was explained.

2.2 Sustainable Development: Meaning and Concept

The issue of sustainability has been the key present developmental agenda. Hopwood *et al*. (2005) and Kate *et al*. (2005) defined sustainability as meeting present people' needs without doing harm to the available environmental resource to enable future people also meet their needs within the same environment. Robinson (2004) also defined sustainable development as the goals achieved within a specific time and horizon. For instance, in

September 2015, 186 countries, including Ghana, and 147 Heads of States signed a declaration to meet 17 goals and 169 targets called the Sustainable Development Goals. These goals are:

1. End poverty in all its forms everywhere.
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
3. Ensure healthy lives and promote well-being for all at all ages.
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
5. Achieve gender equality and empower all women and girls.
6. Ensure availability and sustainable management of water and sanitation for all.
7. Ensure access to affordable, reliable, sustainable and modern energy for all.
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
10. Reduce inequality within and among countries.
11. Make cities and human settlements inclusive, safe, resilient and sustainable.
12. Ensure sustainable consumption and production patterns.
13. Take urgent action to combat climate change and its impacts.
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss.

16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development, all to be accomplished in 2030 (United Nations, 2015).

Hopwood *et al*. (2005) explained that sustainable development has two concepts. One centred on environmental issues such as biodiversity, ecosystem services, and community. And the other on socio- economic issues like child survival, life expectancy, education, economy, wealth, and society (Hopwood *et al*., 2005). The reason had been that humans depend on the environment for survival. Therefore, when the environment is sustained, it would solve socioeconomic development issues (Kate *et al*., 2005).

2.3 Malnutrition: Global and Ghana

Limited progress has been achieved despite much effort and resources employed in combating malnutrition. De Onis, Blossner and Borghi (2000) reported that even though malnutrition declined by 13% to 40 % globally (especially stunting, between 1990 and 2010), Africa and Asia countries remain at 40%.

Maternal and child malnutrition is a threatening condition in the poor and averageincome countries (Bhu-Black *et al*., 2008). Malnutrition is a state an individual physical function is impaired to the point he or she can no longer keep adequate bodily performance (World Food Programme, 2000). Maternal malnutrition is the women's nutritional deficiencies during antenatal, postnatal and conception whiles child nutrition deals with inadequate nutrients for growth and maintenance among one-month children to five years (UNICEF, 2009). On child under-nutrition indicators, Pelletier *et al*. (1993) outlined stunting (height for age), wasting (weight for height) and underweight (weight for age).

Victoria *et al*. (2008) added overweight, low birth weight and micronutrient deficiencies as maternal indicators. Stunting refers to low height for age, manifesting long period of poor nutrition and infections (Grantham-McGregor *et al*., 2007). Wasting refers to low weight for height, and unlike stunting it manifests itself within a brief period exposing severe and acute malnutrition caused by disease and inadequate nutrition (UNICEF, 2009). Underweight, that is a low weight for age, also manifested when food runs short (Reinhard & Wijayaratn, 2000). The study considered stunting, wasting and underweight as common use and recommended by World Health Organization (WHO).

Globally, maternal undernutrition contributes to 800 000 neonatal deaths annually (Bhutta *et al*., 2013). Bhu-Black *et al*. (2008) argued that body mass index is a contributing factor because in most countries, maternal body-mass index fall between 10% and 19%, which is less than the recommended 18.5 kg/ m^2. This is particularly so with Sub-Sahara Africa, where more than 20% of women have a body-mass index not exactly the standard 18.5 kg/m2. Worldwide, 150 million under-five children experience malnutrition (UN, 2004) with malnutrition responsible for half child mortality (Rice *et al*., 2000). WHO (2010) reported that, in 2009, three million children died of malnutrition out of 8.1 million children who died under five years. India's malnutrition contributes to 72 % under-five deaths (Mukuria *et al*., 2005). Worldwide, stunting, wasting, and underweight is lower among children under six months age and higher among children over one year age. In terms of ratio, United Nations (2004) and UNICEF (2009) revealed one-third and onefourth of under-five children in developing nations stunted and undernourished respectively. In sub-Saharan Africa, wasting is lower among children under six months age; and increases from age six months through the second year life. Teshome *et al*. (2009) findings also showed that wasting increases through the second year life children.

Lesiapeto *et al*. (2010) reported older children in South Africa at risk to stunting or wasting. In Ethiopia and Zambia, older children are stunted and underweight (Nzala *et al*., 2011). In Ghana, stunting has ranged from 20 % to 40% (Mukuria *et al*., 2005; UNICEF, 2009).

Currently, an annual average of stunting and anaemia rate is 2.8 and 1.3 against the required rate of 4.4 and 5.2. Underweight and wasting have also increased and decreased under a baseline of -0.7 and 9.5 (Stevens *et al*., 2013; UNICEF, WHO and World Bank, 2014).

2.4 Effect of Malnutrition

Maternal malnutrition carries many consequences for women and their children. In pregnancy, UNICEF (2009) mentioned that iodine insufficiency issues alone result in irreversible mental health. Victoria *et al*. (2008) also added its association with mental illness and chronic diseases among children and low offspring birth weight among women. For instance, diseases such as blindness are due to vitamin A deficiency and neural tube defects due to folic acid deficiency (UNICEF, 2013).

On the other hand, the development of the brain and nervous system for good performance in school is affected for not being able to meet specific micronutrients such as iron, folic acid and iodine (UNICEF, 2014). Dewey, Kathryn and Begum (2011) associated stunting with poor school performance, reducing the chances of children to continue their education and work for income. An income of 22% is lost annually in adulthood due to early child malnutrition (Grantham-McGregor *et al*., 2007). A study among South African children also revealed stunting as a predictor of school dropout

(Martorell *et al*., 2010).

Another worst consequence of malnutrition, especially stunting is child mortality. According to Black *et al*. (2008), any child severely stunted has four times the chances of dying. Other deficiencies such as vitamin A, iron or zinc deficiency also contribute to death (UNICEF, 2013).

A new developing consequence of malnutrition is the foetal programming concept, meaning poor foetal growth and small size at birth. This increases the risk of coronary heart disease, stroke, hypertension and type II diabetes (Uauy, Kain & Corvalan, 2011) Other consequence is that under nutrition increases severe and chronic bouts of illness in children by weakening the immune system. This further worsens the child's nutritional status at a period of greater nutritional needs when infections reoccurred (UNICEF, 2013).

2.5 Agricultural Biodiversity and Human Diet

The protection against hunger and rich nutrient attainment rely on agricultural biodiversity. A universal guideline set for agricultural biodiversity takes three stages: genetic, species and ecosystem variability. Genetic variability are qualities inside species, subspecies, and population, while species variability is variations between living species and their unit population at different locations. Ecosystem variability means variation within species and difference in ecological kinds.

Agricultural biodiversity includes plants, animals and microorganisms in different species, genes and ecosystems, needful in continuing key function, structure and agroecosystem processes (Rao *et al*., 2001).

A few years ago, numerous foods were growing from forest and bushes (FAO, 2004). Currently, these foods obtained from the forest and bushes are elusive because agricultural diversity loss is increasing (Jamalludin, 2004). This loss has led to a reduction in the variety of animals kept and food plants cultivated by various family units (Pillay, 2003).

Local varieties adding to biodiversity richness, adapting to different conditions and possessing micronutrient are no more (Ekesa, 2009). This had led to a reduction in dietary diversity consumed (John, 2001).

Meanwhile, agricultural diversity offer improved human diet because micronutrients for proper health come from different foods (Thrupp, 2000). Andre *et al*. (2007), examining the iron content of sweet potato varieties uncovered 23-fold distinction in iron among the varieties. A similar work in Vietnam (Ogle *et al*., 2001) on 16 vegetables showed 50-100 ug folate content in four species and 10-49 ug in remaining species. Roche *et al*. (2008) further studying local foods in six Cenepa River communities in the Amazonas District of Peru, ended finding a unique source of iron, vitamin A and C in the Awajun local foods. This traditional food diversity highly associated with human quality diet in terms of protein, fibre, vitamins, and minerals. Wild vegetables also contributed to micronutrient intake in the East Usambara Mountains (Powell *et al*., 2012).

Agricultural diversity consisting of forest and trees also improves diet quality through wild fruits, vegetables, bush meat, fish and insects (Powell *et al*., 2012). Golden *et al*. (2011) revealed 29% of anaemia reduced by bushmeat in Madagascar. Nasi *et al*. (2011) also reported that 80% fat and protein intake by local Congo communities come from bush meat.

2.6 Measuring Agricultural Biodiversity

In measuring agricultural biodiversity, Musinguzi *et al*. (2007) used the variety level biodiversity tool as a case study in Kitui District of Kenya. A list of community food with variety names and photos developed using key informant interviews, focus group discussions and market visits. The market visit could not tell the exact biodiversity of a community because on market days different food varieties come from district to district.

The study used semi-structured interviews in listing community food with varieties.

2.7 Agricultural Biodiversity and Nutritional Status

Notably, agricultural biodiversity improves human nutrition through dietary diversity (Powell, 2012). In Nambale Busia of Western Kenya, a study conducted by Nungo *et al*. (2012) on the nutritional status of under-five children in cassava consuming communities showed 26.6% stunted, 13.9% underweight and 10.1 % wasted (<−2 SD). The reason was the cropping system practised. Again, in Kenya, De Clerck *et al*. (2011) study showed that agricultural biodiversity alleviated weakness. In the same country Ekesa *et al*. (2008) found pre-school children in Western Matunga not meeting energy, fat, zinc, vitamin A, and calcium because agricultural biodiversity was severely low affecting diet diversity. The highest dietary diversity was then 3%. Hasan *et al*. (2013) added that inaccessibility to food varieties resulted in 1.62% stunting, 1.80% underweight, and 1.28% wasting. Fa *et al*. (2015) also studied deep rainforest diversity, where there was low hunting; and marginal rainforest diversity, where there was high hunting. Deep rainforest with low hunting communities experienced lower stunting compared to the marginal rainforest with high hunting in Central Africa. For instance, numerous studies show that in the United States and Europe as the number of species in a grassland area increase so does the net primary productivity (Rees *et al*., 2001). Several studies have connected meals containing a prominent number of distinctive nutrition classes with vitality, nutrient intake and birth weight (Kant, 2004; Rao *et al*., 2001). Whiles Kac *et al*. (2012) argued that unavailability and inaccessibility to agricultural biodiversity do not affect weight for height (wasting). This showed up among Brazilian children aged 0-60 months after a demographic and health survey in finding the relationship between food insecurity and prevailing weight for height. Bambona and Kikafunda (2005) also revealed that, even though Bushenyi, western

Uganda is a "food basket" district, half the population appears stunted. This was because of large households, unstable income flow, the age of introducing supplementary foods, lack of information on childcare and poor sanitation, and not the work of agricultural biodiversity alone.

2.8 Dietary Diversity

Dietary diversity counts foods or number of food groups consumed over a given period of one day to two weeks (Arimond & Ruel, 2004). It displays household's accessibility to food varieties and acts as a nutritional adequacy indicator. However, it cannot identify food quantity consumed. Moursi *et al*. (2008) determining dietary diversity efficacy scores (DDS) pointed out all scores positively correlated with mean micronutrient density adequacy.

2.9 Measuring Dietary Diversity

Food diversity is by counting Food Variety Score (Single Food Counts) or Dietary Diversity Score (Food Group Count) (FAO, 2011). Roche *et al*. (2008) used the food variety score to obtain a dietary pattern of both mothers and children in the Peruvian Amazon. However, Ogle *et al*. (2001) studying dietary diversity against nutrient intake and adult women density in Vietnam used both Food Variety Score and Dietary Diversity Score. Dietary Diversity Score is used either for Individual Dietary Diversity Score (IDDS) or for Household Dietary Score (HDDS). IDDS examines individual dietary quality in women of childbearing age or individuals in other age/sex groups' while HDDS examine household food security. In the measurement, IDDS measures consumption inside and outside the home. Whereas HDDS measures foods cooked in the home but eaten inside or outside the home or foods got outside the home but brought home and eaten

(FAO, 2011). Kennedy *et al*. (2007) argued that then HDDS would not work in urban areas because more food is consumed outside the home. Again, with HDDS, the target group are individuals living under the same roof and sharing the same meals while IDDS target only the respondent (FAO, 2011). For instance, Arimond and Ruel (2004) used IDDS to measure the association between dietary diversity and child nutritional status. Whiles Thorne - Lynam *et al*. (2010) used HDDS to measure the association between dietary diversity and monthly total household expenditure as well as monthly per capita food expenditure in Bangladesh.

Kennedy *et al*. (2007) stressed that even though Dietary Diversity Score is widely used, it has no cut-off point for when diversity is high or low. Most researchers, according to Ruel (2002), use diversity distributions, terciles or counties to explain low and high diversity. Concerning the period for recall, Ruel (2002) argued that both long and brief periods give the same result. However, Savy *et al*. (2005) claimed longer period captures proper consumption patterns.

Another measurement considered is the Food Consumption Score (FCS). Where dietary diversity, food frequency consumed and nutritional importance of various food groups consumed combine are measured (Ruel, 2003). For example, evaluating family food insecurity and its results for children 6–36 months health status in the Tamale Metropolis in Northern Ghana, Saaka, and Osman (2013) utilized the Food Consumption Score (FCS). This study used IDDS because it studied young children's nutrient adequacy among the 2-5 year age group.

2.10 Associations between Agricultural Biodiversity and Dietary Diversity

Agricultural biodiversity influence dietary diversity (Remans *et al*., 2011) and contributes to child nutrition through dietary diversity (Powell, 2012). A cross-sectional survey conducted in Kenya to assess preschool children using 24-hour recall showed a positive relationship between agricultural biodiversity and dietary diversity (Walingo & Ekesa, 2013). Again Ekesa *et al*. (2008) found 48.5% change in preschool dietary intake in Matunga Division, Western Kenya credited to changes in agricultural biodiversity.

2.11 Associations between Dietary Diversity and Nutritional Status

Suggestions from many findings have confirmed that an increase in the dietary diversity score (DDDS) increases diet nutrient adequacy. On whether dietary diversity influence stunting, Walingo and Ekesa (2013) used a cross-sectional survey in Kenya to assess preschool children, with the help of 24-hour recall and anthropometric measurement, revealed a strong influence on underweight and stunting through dietary diversity. A similar survey studying dietary scores and urban Iranian and Indian schoolchildren nutritional status proved severe and moderate stunting. Wasting and the high body mass index was the result of low, low and high diversity scores respectively (Hooshmand & Udipi, 2013). Another study in Ghana also found the effect of dietary diversity on height for age (stunting), weight for height (wasting) and weight for age (underweight) (Nti, 2011). Chua *et al*. (2012) hypothesised that dietary diversity reduces stunting and wasting of Orang Asli children in Krau Wildlife Reserve, Pahang Ali, accepted the hypothesis after the study. Ekesa (2008) also reported underweight, stunting and wasting changes of 7, 3.6 and 8.1% respectively as the outcome of changes in dietary intake in Western Kenya pre-school children.

The study of Arimond and Ruel (2004) indicated both rural and urban children dietary diversity positively associated with height for age (stunting) in Ethiopia. This was shown when a Demographic and Health Survey (EDHS), 24-hour diversity score and 7-day quasifood frequency studied 60 months children and below in Ethiopia. When all possible causes were controlled, the relationship remained significant for both 24-hour and 7- day diversity. A similar survey examining nutritional status among children 0-23 months, showed an increase dietary diversity score correlating increase stunting and wasting in countries of Ethiopia and Zambia (Disha *et al*., 2012). In Bangladesh, family units with children, less than five in both cities and villages concluded that decreased dietary diversity is a solid predictor of stunting (Rah *et al*., 2010).

This study also used a cross-sectional survey to find out how agricultural diversity could lead to dietary diversity in the Dormaa West and how it could influence children nutritional status.

2.12 Conceptual Framework

The framework shows agricultural biodiversity influence of climate, cropping system, taste and extinction, while culture, cost, nutritional knowledge and food insecurity are affecting dietary diversity. Agricultural biodiversity constituting produced anima ls and crops, wild plants and animals as well as market food product influence household dietary diversity and child nutritional status. Therefore, improved or poor dietary diversity leads to proper or poor child nutrition.

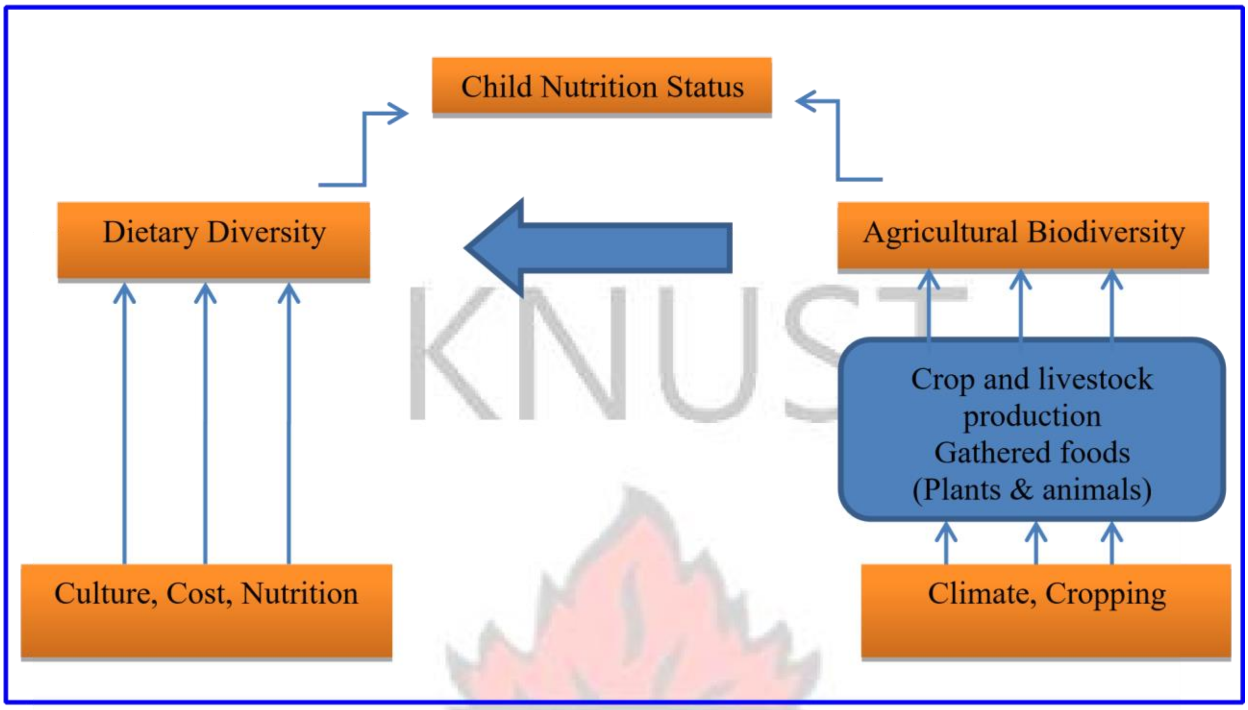

Figure 2.1: Conceptual Framework of the Relationship between Agricultural Biodiversity, Dietary Diversity, and Nutritional Status

Source: Author

2.13 Conclusion

The chapter reviewed the literature on agricultural biodiversity, dietary diversity, and child anthropometric status. It started with a discussion on global malnutrition and its outcomes, followed by literature on agricultural biodiversity, its measurement and its association with children nutritional status. Some of the literature proved a significant association between agricultural biodiversity and child's anthropometric status, but few studies disagreed. The final discussion was about dietary diversity, its measurement, and relationship with children anthropometric status.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Area

The study was carried out in the Dormaa West District of the Brong Ahafo Region, Ghana. Dormaa West is in the western part of the Brong Ahafo Region, surrounded by Dormaa Central Municipality, Asunafo North Municipality, La Cote D'Ivoire and Bia East District. It has 96 settlements with 3810003.60 square kilometres total area (Ghana Statistical Service, 2014).

Dormaa West District is within the wet, semi-equatorial climate region with two rainfall season. The first rainy season starts from May and ends in June with the heaviest rainfall occurring in June. The second rainy season starts from September to October. The mean annual rainfall range between 125cm and 175cm; and the relative humidity fall within 75 – 80 % during the two rainy seasons and 70 – 72 % from November to March. District's highest mean temperature is 30ºC and occurs between March and April and the lowest is 26.1ºC in August (Ghana Statistical Service, 2014).

The land is undulating between 180 and 375 meters above sea level. The district is a welldrained area with Bia, Nkasapim, and Pam Rivers spreading out within the district. These rivers provide water for vegetable cultivation, such as tomatoes, pepper, and okra during the dry season (Ghana Statistical Service, 2014).

Soils in the district resemble the Bekwai-Nzema soil series. The Nzema soil arrangement composes of quartz rock and ironstone. These soil types support cocoa cultivation, coffee, oil palm, citrus, kola nuts, plantain, cassava, and maize.

The population's employment is agriculture. Most household farm or do agricultural related activities such as food crop, cash crops and poultry farming. Small-scale crop production cultivated while cash crops and poultry farming on medium and large scales.

The primary food crops produced include maize, plantain, cassava, yam, cocoyam, tomatoes, and pepper; whiles the cash products are cocoa, oil palm, and coffee. Domesticated animals raised on small and medium scale are cattle, sheep, goats and grass cutters (Ghana Statistical Service, 2014).

The Ghana Demographic and Health Survey (GDHS) undertaken in 2008 showed that the national level of stunting, wasting and underweight were 28%, 9% and 14% respectively. Another survey targeting Brong Ahafo region recorded 25% stunting (ICF Macro, 2010); however, there was no available data for Dormaa West.

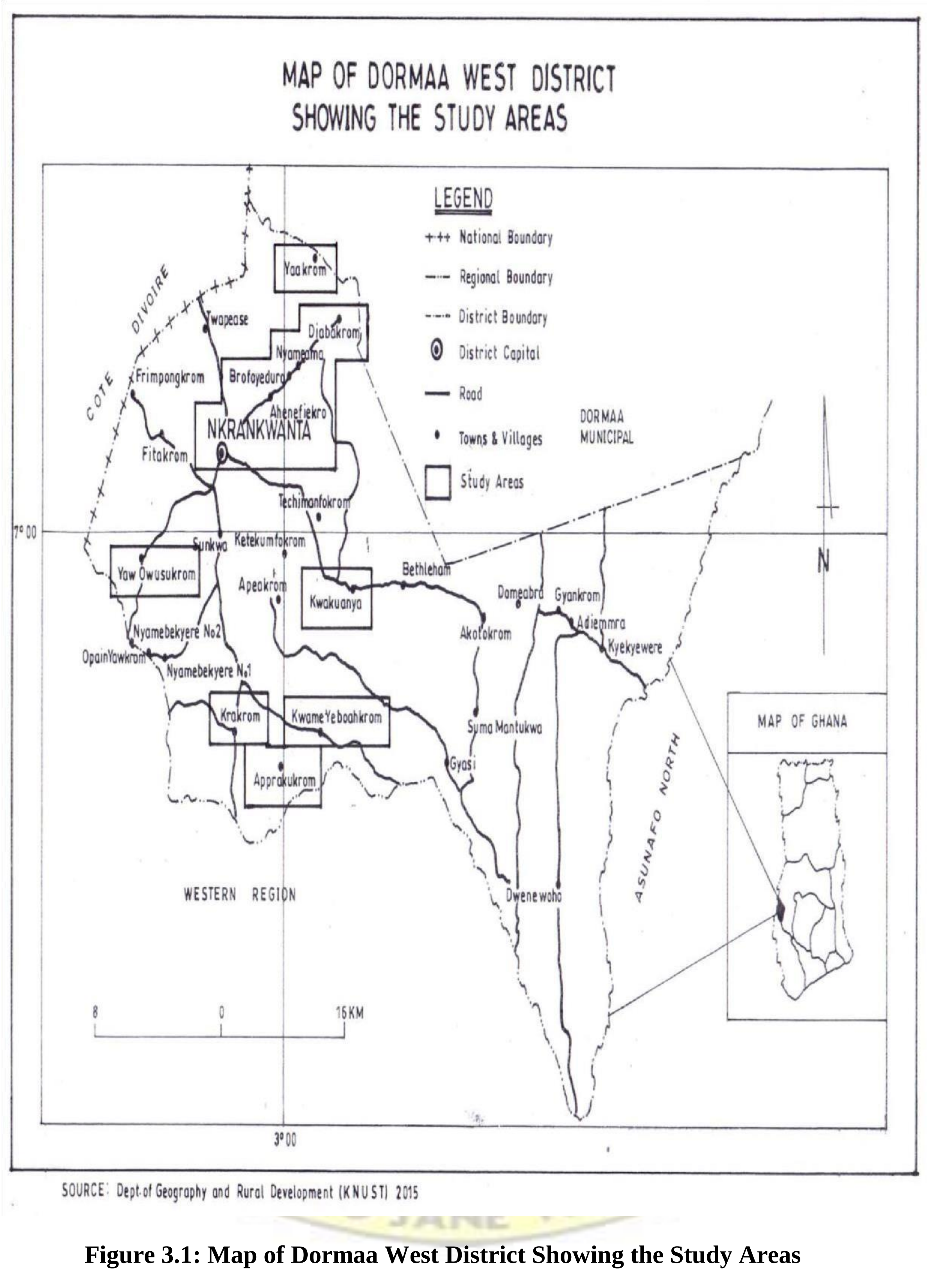

Figure 3.1: Map of Dormaa West District Showing the Study Areas

3.2 Study Population

Dormaa West has a total population of 47,678 made up of 51.8 percent males (24,681) and 48.2 percent females (22,997). The district has a rural population of 36,854 representing 77.3 percent, while the urban population is 10,824, representing 22.7 %. According to the 2010 census, 7359 children (15.4%) were five years and below. Ten thousand three hundred and twenty-seven households existed in the district, 2425 in the urban and 7902 in the rural (Ghana Statistical Service, 2014). The target population for the study was 2865 children between the ages of 2 - 5 years.

3.3 Research Methods

The study used both qualitative and quantitative methods. The qualitative method was used to collect information from key informants (Denzin & Yvonna, 2000) on agricultural biodiversity to triangulate the information obtained from the quantitative method, which was calculated by counting the number of different crops and animals eaten either from domestic sources or from the wild. The anthropometric measurement and 24-hour recall questionnaires involved quantitative method (Babbie, 2010). The 24hour recall structured interview questionnaire obtained data on dietary diversity from mothers or caregivers. Anthropometric measure (height, weight, and age of children) were obtained using a tape and a weighing scale following the procedures recommended by the World Health Organization (WHO, 2006). The data gathered were analysed using species richness and diversity, content analysis, dietary diversity score, Z scores for stunting, wasting and underweight and pearson correlation.

3.4 Research Design

A cross-sectional design was used to find out the association between agricultural biodiversity, dietary diversity and child's nutritional status between 24-60 months. This design identified and measured the association and the difference between a variety of crops, animals, and children (John, 2008). The design also estimated the malnutrition prevalence from the whole population (Bourque, 2004). The study covered two months April to May 2015.

3.5 Sample Size

Based on WHO Child Growth Standard rate of stunting 28%, wasting 9% and underweight 14% prevailing in 2008, average of 17% malnutrition rate (28+9+14 /3) was obtained. With a desired 95% confidence interva l and 5% standard error margin, the sample size was calculated as:

n= [t^2 x p (1-p)] /m^2 (Bioversity International, 2011) where, n = required sample size t = confidence level of 95% (standard value of 1.96) p = estimated prevalence of malnutrition in the project area (17%) m = margin of error of 5% (standard value of 0.05)

t^2 x p (1- p)

2

^{2} x 0.17 (1- 0.17) 1.96

2

0.05

x 0.17 (0.83)

3.8416 0.0025

m

3.8416 x 0.1411

0.0025

0.5421

0.0025
217

3.6 Sample Selection

Table 3.1: Children Sample Distribution

Community	Population of Children	Sample Size
Nkrankwanta	1230	93
Diabaa	308	23
Krakrom	263	20
Yaakrom	255	19
Kwameyaboahkrom	101	8
Apprakukrom	93	7
Yawowusukrom	100	8
Nyameiama/Brofoyadu	290	22
Ahenfiakrom	65	5
Kwakuanya	160	12
Total	**2865**	**217**

Source: Ghana Statistical Service, 2014

Depending on children availability and community size, different sample sizes from each community, made up the total sample of 217. It was calculated as:

$$n = \frac{\text{Population of children in a community}}{\text{Target Population}} \times \text{Required sample size}$$

Dormaa West District was chosen for its high farming population (81.2%) and as a newly created district (Ghana Statistical Service, 2010). Conveniently, Nkrankwanta, Diabaa, Yaakrom, Yawowusukrom, Krakrom, Kwakuanya, Kwameyaboahkrom, Ahenfiekrom, Aprakukrom and Borofoyedu communities were selected. Apart from the high population, easy access to the ten communities led to the use of convenienc e sampling. From each community, households were systematically interviewed and measurement taken for children aged 24 - 60 months. To find the sampling interval, the number of households in a community was divided by the required sample size as shown below:

$$\text{Kth (Nkrankwanta)} = \frac{\text{Number of households}}{\text{Required sample size}}$$

$$\frac{266}{84}$$

Therefore, Kth = 3

Table 3.2: Systematic Sampling Distribution

Community	No. of Household	Kth
Nkrankwanta	266	3
Diabaa	67	3
Krakrom	57	3
Yaakrom	55	3
Kwameyaboahkrom	22	3
Apprakukrom	20	3
Yawowusukrom	22	3
Nyameiama/Brofoyadu	63	3
Ahenfiakrom	14	3
Kwakuanya	34	3

Source: Ghana Statistical Service, 2014

Based on the above, every 3rd household to arrive was interviewed and measurement taken for children aged 24 - 60 months until the sample size was achieved. Households were people living and eating together and sharing the same housekeeping arrangement.

3.6.1 Inclusion and Exclusion Criteria

Inclusion criteria:

- Households with children aged 24-60 months were selected.
- Only children residing in the district for at least three years selected.
- When more than one child aged 24-60 months was available in a given household, the youngest child was selected.

Exclusion criteria:
- Children sick for 31 days or more were excluded because stunting also causes chronic diseases.

Households with children age 24-60 months were the target. Because at this age, the children's nutritional status (stunting, wasting and underweight levels) is the outcome of diet eaten (Arimond & Ruel, 2004; Mukuria *et al*., 2005; UNICEF, 2009).

3.7 Data Collection

The data were collected from April to May 2015, and the interviews conducted in the Twi language in the respondents' homes. The researcher and two community members explained the reason for the interview. To encourage participants to answer the questions freely, they were assured of treating the information as confidential.

Socio-demographic parameters were taken on marital status, mother's age, family size, formal education and occupation.

In the anthropometric measurement, children's ages were recorded as confirm from birth certificates and hospital cards. Where mothers or caregivers could not remember the age, special events and people born on the same day estimated the age with the help of close relatives. Heights were measured in a standing position, using a length board. Children had bare feet and the heels, buttocks, shoulders and the back of the head touched the length board before height was measured to the nearest 0.1cm. Measurements were taken twice and an average taken to guarantee precision. Finally, children were weighed on an electronic scale (Camry-model EB9318) to the closest kilogram (kg) with minimum clothing and without shoes and slippers. Scales were calibrated by measuring a known weight to ensure the correct measurement was achieved. Measurements were taken twice and an average taken to guarantee exactness.

At the same time, 24-hour dietary recall and an agricultural biodiversity questionnaire were administered.

In the 24-hours recall, the respondents were asked all foods eaten in the home during the previous day and night. The day excluded weekends and special event days. Dietary diversity scores were estimated using information collected (FAO, 2011). The respondents were the persons accountable for meal preparation for the family unit the earlier days. A single point awarded each food group consumed over the period, giving a total dietary diversity score of 16 points for each household when all food groups' response positive. Another structured questionnaire documented consumable crops, vegetables, fruits and animals with the species and varieties kept and grown on farms. Foods received from natural habitats were also assessed. Besides that, key informant interviews held with community extension officers and leaders of the farmers' group triangulated the information from the questionnaire. The key informant interview questions depended on the questionnaire administered to the respondents. The interview with the extension officers took place in their offices with the researcher alone while interviews with farmers' leaders were conducted at farmers' houses.

3.8 Data Collection Instrument

The survey instruments included 24-hour recall and agricultural biodiversity questionnaires. Key informant interviews and anthropometric measurements were also used.

3.8.1 Anthropometric Measurement

Child malnutrition can be assessed using anthropometry, biochemical and clinical indicators. Examples of clinical indicators are oedema, hair and skin changes, and that of the biochemical indicator is a drop in serum albumin level. However, the study decided to use anthropometric body estimations because they are delicate over full malnutrition range. Despite anthropometry estimations being sensitive to altitude, stress, and hereditary, children under five years old are not influenced, because impacts of these elements would not have come to their maximum development and their effects are irrelevant (WHO, 2005). The measurements took height and weight of children.

Children‘s anthropometric status was determined using the latest World Health Organization growth standards Z scores. Children with a Z-score less than -3 standard deviations (SD) height-for-age were classified severely stunted. Those with a Z-score of 3 to -2 SD were classified stunted; while those between -2 to -1 SD were classified mildly stunted or at risk of stunting. Those ranged within -1 to +1 SD were classified normal height. Children with Z- score less than the - 3 SD weight-for-height were classified severely wasted. Those with Z- score of - 3 to - 2 SD were classified wasted. While those between - 2 to - 1 SD classified mildly wasted or at risk of wasting. Weightfor-height of children -1 to +1 SD were classified normal. Those less than the -3 SD weight-for-age were classified severely underweight. Those with Z-score of -3 to -2 SD were classified underweight, while -2 to -1 SD classified mildly underweight or at risk of underweight. Those with a Z-score between -1 to +1 SD were categorized as having normal weight. Likewise, those with Z-score above +2 were classified overweight (WHO, 2006; Bioversity International, 2011).

Stunting, wasting, and underweight were chosen, because stunting (low height for age) reflects chronic under-nutrition whereas wasting (low weight for height) describes acute under-nutrition, usually because of famine or severe disease, and underweight (low weight for age) reflects both wasting and stunting (Bioversity International, 2011).

Again, these variables chosen were used in almost all the studies consulted (Arimond & Ruel, 2004; Rahman & Chowdhury, 2007; Rajaram *et al*., 2007; Walingo & Ekesa, 2013).

3.8.2 Consumption and Dietary Diversity

With the FAO dietary diversity questionnaire and 24 -hours recalls, food consumed were collected. Seven - day recall was not used because, according to Arimond and Ruel (2004), the 7-day recall does not provide much information beyond the 24 -hour recall. Dietary categories, low (0 to 5), medium (6 to 10) and high (11 to 16) were from 16 food groups. The dietary diversity score depended on the following food groups as recommended by FAO: ○ Cereals and grains ○ Roots and tubers ○ Vitamin A rich vegetables ○ Vitamin A rich fruits ○ Other vegetables ○ Other fruits ○ Dark green leafy vegetables

○ Legumes, seeds, and nuts ○ Meat ○ Fats and oils ○ Mushroom/snail ○ Eggs ○ Fish

○ Milk and milk products ○ Sweets ○ Spices, condiment, beverages

3.8.3 Production and Agricultural Biodiversity

Agricultural biodiversity was measured by counting food plants species grown, animals reared and food items obtained from natural habitats. Species richness and species diversity measured and documented crops, fruits, vegetables, and animals with species and varieties. These were reclassified in Low AB (≤ 30), Medium Low AB (31-50), Medium High AB (51-70) and High AB (≥71). A number of food categories in a community defined species richness. Species diversity (biodiversity) is defined as the richness and relative abundance in a community (Magarran, 2004). Themes transcribed and coded from the key informant interview on agricultural biodiversity.

3.9 Pre-testing

The structured questionnaire and anthropometric instruments were pre-tested in six households from Ademmria. Ademmria was not a selected area but in the district. Before going to the selected areas the tools were fine-tuned.

3.10 Data Analysis

A descriptive analysis was presented in tables and bar charts. It provided information on the population's characteristic, agricultural biodiversity and malnutrition status. Content analysis also provided additional information on agricultural biodiversity. Mean dietary diversity scores were calculated and Z-scores for stunting (height for age), wasting (weight for age) and underweight (weight for height) calculated using a WHO Anthro software version 3.2.2. They were followed by results of Chi-square and T-Test analyses on malnutrition and gender, dietary diversity levels, and age of children. A bivariate analysis showed the relationship between agricultural diversity and children's dietary diversity, children's dietary diversity terciles and mean stunting (HAZ), mean wasting (WHZ), and mean underweight (WAZ). The significant differences between means tested the hypothesis. All the analysis were done using the Statistical Package for Social Science (SPSS) version 16.

3.11 Ethical Consideration

Permission was sought from the District Chief Executive (DCE). The consent of mothers with children falling within the sample size was also sought and assured of confidentiality. The results reflected the communities without reference to participating individuals.

CHAPTER FOUR

4.0 RESULTS

4.1 Introduction

The chapter presents results of data collected and analysed. The first presentation covers descriptive statistics on household demographic characteristics, followed by agricultural biodiversity, dietary diversity, child anthropometric characteristic, and nutritional status. Finally, the chapter presents bivariate correlation analysis.

4.2 Demographic Characteristics of the Study Population

The majority of the mothers or caregivers (84.2%) were married, few (9.6% and 3.8%) were single and separated whi le some (1.4%) were divorced and others (1.0%) widowed (Table 4.1). More mothers or caregivers (38.4%) were illiterate. However, those who attended or completed Junior High School were more (30.8%) than those who attended or completed Primary School (17.3 %) and Senior High (8.7%), with few (4.8%) being Middle School Form Four graduates (Table 4.1a).

Even though few of the mothers or caregivers were handcrafters, housewives, businesswomen, livestock farmers and farm labourers, the greater portion of them (70.6%) were crop farmers (Table 4.1a).

Averagely, mothers or caregivers were 35 years three months; and mean children age was 41 months 9 days with more girls than boys. A minimum of six people lived in a household (Table 4.1 b).

Table 4.1a: Households Demographic Characteristic

Characteristic	Respondents (n=217)	Percentage (%)
Marital status of mothers/caregivers		
Married	183	84.2
Single	21	9.6
Separated	8	3.8
Divorced	3	1.4
Widowed	2	1.0
	217	**100**
Educational status of mothers/caregivers		
Illiterate	83	38.4
Junior High School	67	30.8
Primary School	38	17.3
Senior High School	19	8.7
Middle School Form Four	10	4.8
	217	**100**

Occupation of mothers/caregivers		
		70.6
		11.1
		6.3
		4.8
Others		4.8
Livestock farmer	3	1.4
Farm labourer	2	1.0
	217	**100**
Sex of children		
Boys	96	44
Girls	121	56
	217	**100**

Source: Field Survey, 2015

Table 4.1b: Households Demographic Characteristic

Characteristic	N	Mean	Std. Deviation	95% Confidence interval for mean Lower bound -Upper bound
Age of mother/caregiver	217	35.3	10.2	33.8 - 36.6
Household size	217	6.8	2.6	6.30 - 7.0
Age of child (months)	217	41.9	6.2	40.5 _ 43.4

Source: Field Survey 2015

4.3 Agricultural Biodiversity

The eighty-six agricultural biodiversity counted were in the categories of animals, cereals, starchy fruits, roots and tubers, fruits, vegetables, tree and arable crops, nontraditional, spice crops and legumes (Table 4.2). Non -traditional were mushrooms, snails, grass -

Crop farmer	154
Handcrafter	24
Housewife	14
Business women	10

cutters, and honey. Of the 86 consumable species identified, more (53) were from the wild. Vegetables counted were also more (32) than animals (26) among the eight food groups with the least being legumes (2). Comparing naturally obtained and domesticated food groups, vegetables, animals and fruits from the wild were 14, 10 and 3 more than the cultivated vegetables, animals and fruits respectively. Mainly, starchy fruits, roots and tubers, cereals and grains, spices, and legumes were cultivated whereas non-traditional were naturally obtained (Table 4.2).

Other Animals

Participants of the key informant interviews indicated keeping fish in ponds and monkeys captured from the natural habitat.

‘They have fish kept in ponds; normally they are mud fish and tilapia. The national best fish farmer 2011 owns the biggest fishpond' (Nkrankwata Extension Officer, 2015).

‘The people are also getting monkeys from the wild' (2013 District Best Farmer Nkranwanta, 2015).

Other Crops

‘People have been getting wild yam, we call it ‘hapaere', it has a season, and it starts from let say September to say January ‘(Yaakrom Extension Officer, 2015).

Table 4.2: Agricultural Biodiversity in the Dormaa West District

Categories	Domesticated/Cultivated	Natural Habitat	Total Number
Animals	Goat, chicken, sheep, duck, rabbit, guinea fowl, cattle, pigs (8)	Squirrels, deer, birds, crab, rat, tortoise, antelope, bat, porcupine, hyena, wolf, hedgehog, bushbuck, hare, badger, maxwell's duikers, cricket, monkey(18)	26
Vegetables	Garden egg, okra, pepper, tomatoes, onion, beans leaves, sweet pepper, cabbage, carrot (9)	Ceylon spinach, milkwort, khaki weed, bitter gourd, African nightshade, bitter leaf, sodom apple, black nightshade, purple amaranth, wild pepper, moringa, jute marrow, wawa leaves, African eggplant , pawpaw leaves, dandelion, ceiba leaves, vine spinach, pumpkin leaves, red amaranth, ridge gourd, slen der amaranth, cocoyam leaves (23)	32
Fruits	Pineapple, watermelon (2)	Pawpaw, mango, African apple, avocado pear, orange (5)	7
Cereals and Grains	Maize, rice, sorghum (3)		3
Starchy fruits, Roots & Tubers	Cassava, cocoyam, yam, sweet potato, plantain (5)		5
Tree and arable crops	cocoa (1)	Oil palm, coconut, 'dawadawa'(3)	4
Non-traditional		Snail, grass-cutter, mushroom, honey (4)	4
Species	Ginger, garlic, andan tree (3)		3
Legumes	Groundnut, cowpea (2)		2

Total biodiversity	**33**	**53**	**86**

Source: Field Survey, 2015

Every household had an average of 17 agricultural biodiversities for consumption. More of this were vegetables (6) with spices and legumes not consumed (Table 4.3).

Table 4.3: Mean Households Agricultural Biodiversity

Categories	Mean	Std. Deviation	95% Confidence Interval
			Lower - Upper
Animal	3	2.92	2.86 – 3.66
Cereals and grains	1	0.57	0.62 – 0.78
Roots and tubers	2	1.08	1.55 – 1.84
Legumes and nuts	0	0.52	0.15 – 0.29
Tree and arable crops	2	1.16	1.80 – 2.12
Spices	0	0.18	0.01 – 0.06
Vegetables	6	3.24	1.58 – 6.47
Fruits	2	1.83	1.55 – 2.05
Non-traditional	1	0.96	1.05 – 1.32
Mean total biodiversity	**17**		

Source: Field Survey, 2015

4.3.1 Common Plants and Animals Grown and Kept by Households

Using 50% as a measure for the most common plant grown and animals kept, households commonly kept goats (51%) and chicken (66%). The uncommon ones were sheep (13%), rabbit (1.9%), duck (4%), Guinea fowl (2%), pig (1%) and cattle (1%) (Figure 4.1).

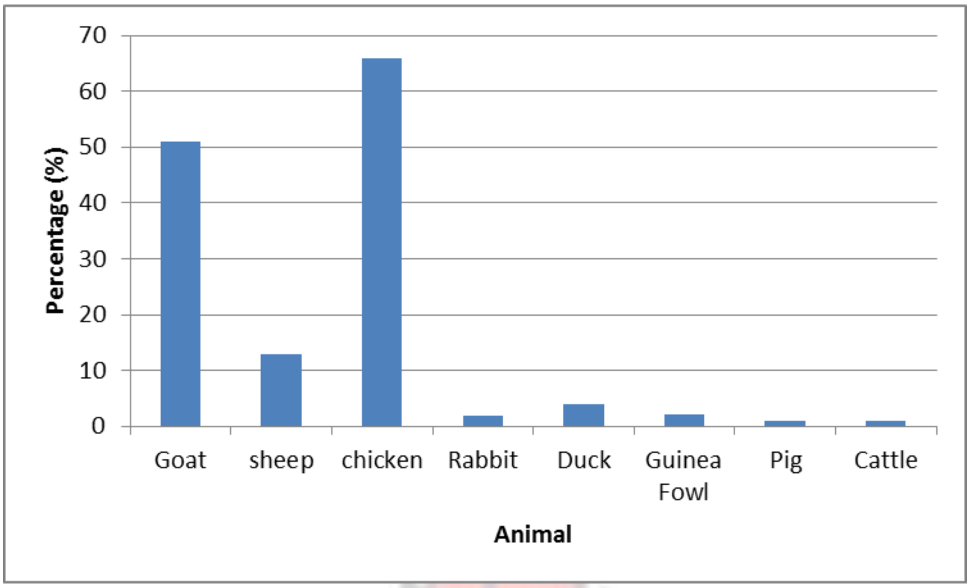

Figure 4.1: Animals Kept by Households

Source: Field Survey, 2015

Common vegetables grown by households were garden eggs (73%), pepper (71%), and tomatoes (71%). The uncommon ones were okra (39%), carrot (4%), onion (17%), beans leaves (5%), cabbage (4%) and sweet pepper (3%) (Figure 4.2).

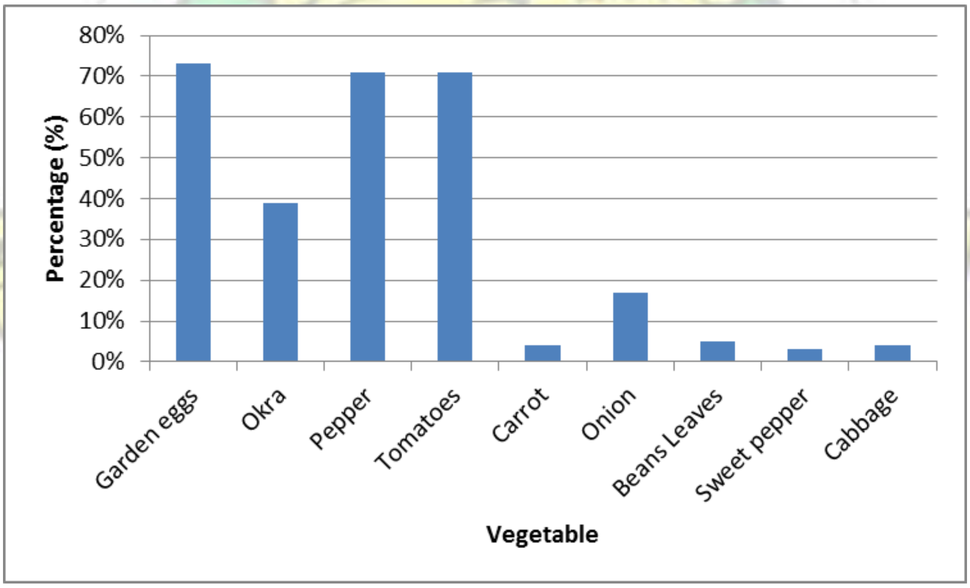

Figure 4:1: Vegetables Grown by Household

Source: Field Survey, 2015

There were no common fruits grown by the households, however, few households had an interest in growing pineapples (32.2%), watermelon (2.4%), and sugar cane (1.4%) (Figure 4.3). Maize (60.6% households) was the most common cereals and grains cultivated by households in Dormaa District compared to rice (10%) and sorghum (1%) (Figure 4.3).

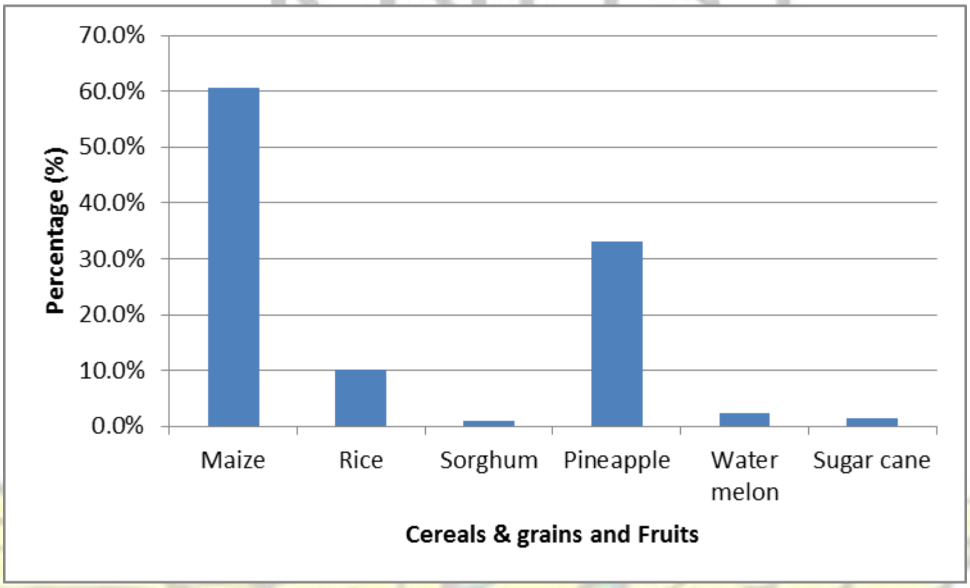

Figure 4.3: Cereals and Grains and Fruits Grown by Households

Source: Field Survey, 2015

In terms of starchy fruits, roots, and tubers category, more households commonly preferred growing plantain (70.2%) cassava (67.3%), and cocoyam (55.3%) to yam (41.3%) and sweet potato (1%) (Figure 4.4).

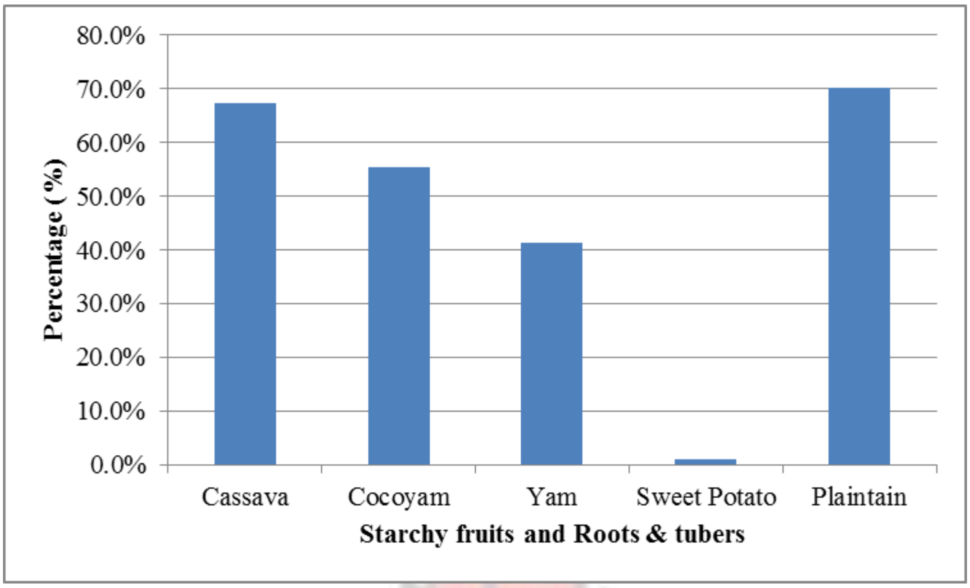

Figure 4.4: Starchy Fruits, Roots and Tubers Grown

Source: Field Survey, 2015

One tree crop, cocoa (60.1% households) and two spices, garlic (99% households) and andan tree (59.6% households) were commonly grown. However, households did not like growing ground nut (12%), ginger (10%) and cowpea (5%)) (Figure 4.5).

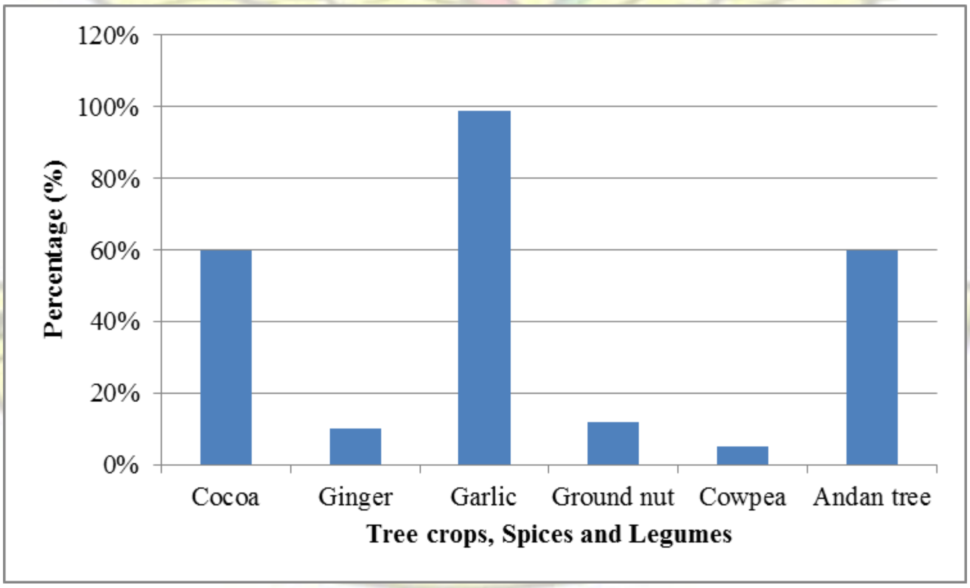

Figure 4.5: Tree Crops, Spices, and Legumes

Source: Field Survey, 2015

Table 4.4: Vegetables Obtained from Natural Habitat

	Households Responses n (217)	
Vegetable	Obtained n(%)	Total n(%)
Black nightshade	146 (67.3)	217 (100)
Purple amaranth	130 (60.1)	217 (100)
Slender amaranth	128 (59.1)	217 (100)
Khaki weed	110 (50.5)	217 (100)
Jute marrow	67 (30.8)	217 (100)
Kortomire	61 (27.9)	217 (100)
Wild pepper	26 (12)	217 (100)
Moringa	15 (6.7)	217 (100)
Ridge gourd	14 (6.2)	217 (100)
Red amaranth	13 (5.8)	217 (100)
Ceiba leaves	9 (4.3)	217 (100)
Bitter gourd	8 (3.8)	217 (100)
Milkwort	7 (3.4)	217 (100)
Sodom apple	7 (3.4)	217 (100)
Ceylon spinach	6 (2.9)	217 (100)
Bitter leaves	5 (2.4)	217 (100)
Wawa leaves	5(2.4)	217 (100)
Pawpaw leaves	5 (2.4)	217 (100)
African nightshade	5 (2.4)	217 (100)
African eggplant	4 (1.9)	217 (100)
Vine spinach	4 (1.9)	217 (100)
Pumpkin leaves	4 (1.9)	217 (100)
Dandelion	4 (1.9)	217 (100)

Source: Field Survey, 2015

Black nightshade (67.3% respondents), purple amaranth (60.1% respondents), slender amaranth (59.1% respondents) and khaki weed (50.5% respondents) were the common vegetables got from the natural habitat by households (Table 4.4).

Even though there were considerable number of animals from the natural habitat, Rat (56.7% households) and crab (56.2% households) were the most common animals obtained from natural habitat (Table 4.5).

Table 4.5: Animals Obtained from Natural Habitat

	Households Responses n (217)	
Animal	Obtained n (%)	Total n(%)
Rat	123 (56.7)	217 (100)
Crab	122 (56.2)	217 (100)
Tortoise	41 (18.8)	217 (100)
Squirrels	30 (13.9)	217 (100)
Deer	21 (9.6)	217 (100)
Antelope	19 (8.7)	217 (100)
Porcupine	11 (5.3)	217 (100)
Birds	10 (4.8)	217 (100)
Hyena	7 (3.4)	217 (100)
Wolf	7 (3.4)	217 (100)
Bat	6 (2.9)	217 (100)
Bush buck	5 (2.5)	217 (100)
Monkey	3 (1.4)	217 (100)
Hedgehog	3 (1.4)	217 (100)
Hare	3(1.4)	217 (100)
Badger	3 (1.4)	217 (100)
Maxwell's duikers	3 (1.4)	217 (100)
Cricket	3 (1.4)	217 (100)

Source: Field Survey, 2015

Of the six fruits from the natural habitat, 68.3% households commonly obtained avocado pear. The remaining uncommon five were orange (26.9%), mango (24.5%), pawpaw (22.1%) and banana (15.4%) (Figure 4.6).

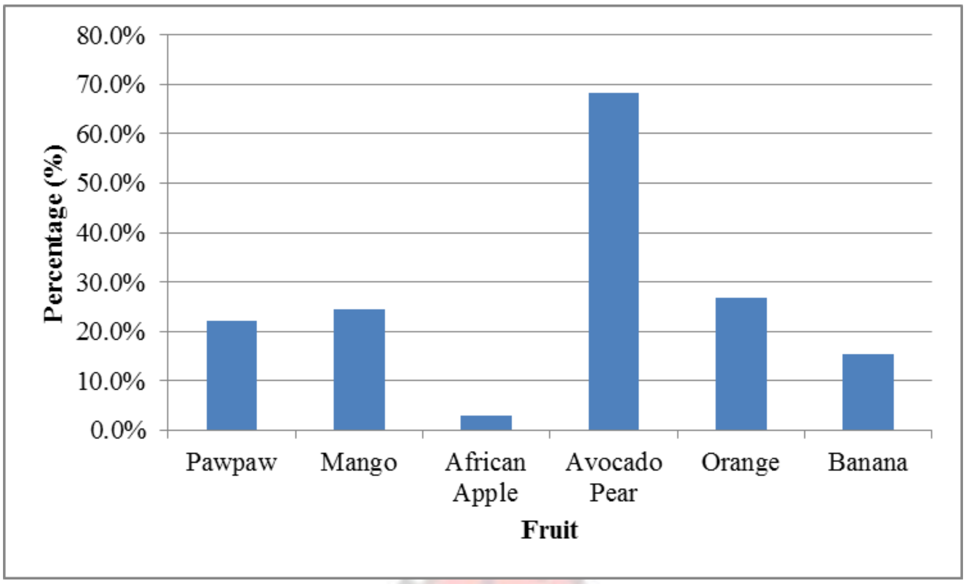

Figure 4.6: Fruits Obtained from Natural Habitat

Source: Field Survey, 2015

No household commonly obtained any tree crop from the natural habitat. However, 11.1%, 11.1% and 8.7% households got oil palm, coconut, and dawadawa respectively.

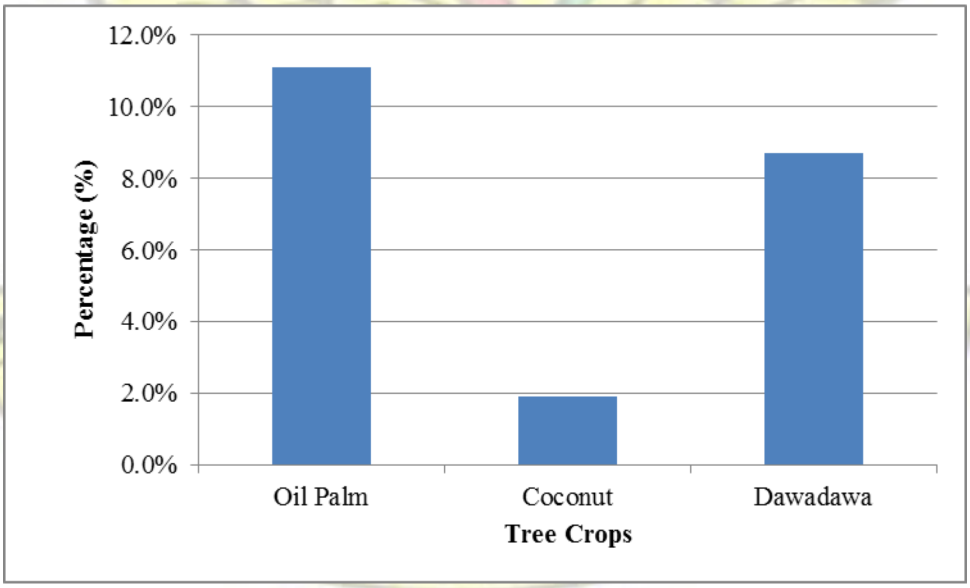

Figure 4.7: Tree Crops Obtained from Natural Habitat

Source: Field Survey, 2015

In terms of non-traditional, more households (66.8%) had mushroom from the natural habitat compared to snail (38.9%), grasscutter (28.4%) and honey (1%).

Figure 4:2 Non-traditional Obtained from Natural Habitat

Source: Field Survey, 2015

Most households (55.2%) preferred growing one variety of cereal and grains. Meanwhile a greater portion of the households (94.7% and 89.4%) disliked growing spices and legumes and nuts respectively (Table: 4.6a and b).

Table 4.6a: Agricultural Biodiversity Score

No/Variety	Cereals	Roots	Legumes	Spices	Tree and Fruits	Non-

	& Grains (%)	and Tubers (%)	(%)	& Nuts (%)	Crops	Arable (%)	(%)	Traditional (%)
6			46.5			-		
5			10.6			0.5		

4		1	14			5.8	1
3		17.3	8.7			23.1	17.3
	5.3	38.9					29.3
	55.2	13.5		10.6	5.3		13.5
	39.5	29.3		89.4	94.7		36.9

Table 4.6b: Agricultural Biodiversity Score

No/Variety	Animal (%)	Vegetable (%)
0	28.8	19.7
1-2	29.8	4.3
3-5	25	25
6-8	10.6	40
9-11	5.3	4.8
12-13	0.5	3.8
14-17	0	2.4

Source: Field Survey, 2015

4.4 Consumption and Dietary Diversity

4.4.1 Food and Food Groups Commonly Consumed by the Children

The most consumed foods were boiled rice with tomato stew (57.2% children) and fufu and light soup (53.9% children) (Table 4.7).

Table 4.7: Foods Commonly Consumed by Children

	Households Responses n (217)	
2	9.1	29.3
1	8.2	14
0	2.9	27.3

Food Type	Consumed n (%)	Total n (%)
Boiled rice and tomato stew	124 (57)	217 (100)
Fufu and light soup		217 (100)
Porridge and kosee		217 (100)
Yam and kortomire stew	56 (25)	217 (100)
Plantain and kortomire stew	46 (21)	217 (100)
Porridge and bread	33 (15)	217 (100)
Fufu and ground nut soup	32 (14.7)	217 (100)
Apele and groundnut soup	18 (8.3)	217 (100)
Cocoyam and stew	18 (8.3)	217 (100)
Jollof rice	17 (7.8)	217 (100)
Banku and okra stew	17 (7.8)	217 (100)
Boiled rice and kortomire stew	16 (7.4)	217 (100)
Mashed kenkey	15 (6.9)	217 (100)
Too	12 (5.5)	217 (100)
Kenkey and okra soup	12 (5.5)	217 (100)
Tea and bread	11 (5.1)	217 (100)
Konkotey	10 (4.8)	217 (100)
Akeyeke	9 (4.1)	217 (100)
Boiled rice and beans	7 (3.4)	217 (100)
Kenkey and pepper	7 (3.4)	217 (100)
Rice and cabbage stew	7 (3.4)	217 (100)
TZ	7 (3.4)	217 (100)
Banku and palm nut soup	7 (3.4)	217 (100)
Inpese	6 (2.9)	217 (100)
Gari and sugar	4 (2)	217 (100)

Source: Field Survey, 2015

117 (54)

58 (26)

On food groups consumed, more children consumed from other vegetables, vitamin A vegetables, cereals and grains, spices and condiments, roots and tubers and fish compared to fresh meat, other fruits, eggs, mushroom/snail, vitamin A fruits and milk (Table 4.8).

Table 4.8: Percentage Children Consuming from Different Food Groups

	Households Responses	n

(217)

Food group	Consumed n (%)	Total n (%)
Other vegetables	217(100)	217 (100)
Fat and oil	217 (100)	217 (100)
Vitamin A vegetables	216 (99.5)	217 (100)
Cereals and grains	214 (98.6)	217 (100)
Spices, condiment and beverage	211 (97.6)	217 (100)
Roots and tubers	203 (93.8)	217 (100)
Fish and seafood	199 (91.8)	217 (100)
Dark green vegetables	121 (55.8)	217 (100)
Legumes and nuts	118 (54.3)	217 (100)
Sweets	113 (51.9)	217 (100)
Fresh meat	55 (25.5)	217 (100)
Milk and milk products	8 (3.8)	217 (100)
Eggs	41 (18.8)	217 (100)
Mushroom/snails	22 (10.1)	217 (100)
Vitamin A fruits	18 (8.2)	217 (100)

Source: Field Survey, 2015

4.4.2 Household Dietary Diversity Score

Household Dietary Diversity Score (HDDS) is a summation score of the 16 possible food groups that a household consume. Food groups consumed by households scored one to calculate DDS by adding all the food groups with the scores of one. Fewer children (11.5%) consumed from seven food groups while 24.5% consumed from 10 different groups. Only a few of the children (0.5%) were consuming from 14 food groups (Figure 4.9).

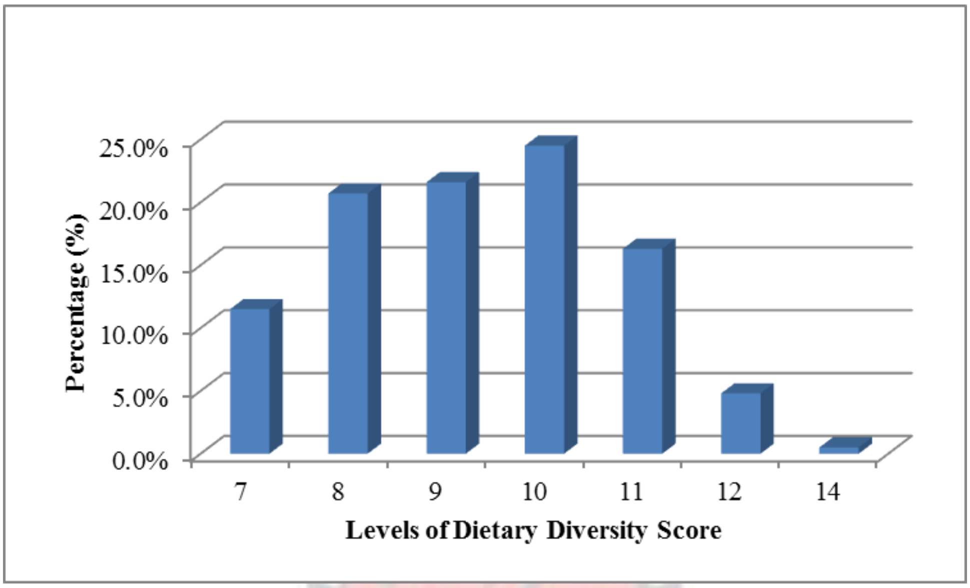

Figure 4.9: Household Dietary Diversity Score Distribution

Source: Field Survey, 2015

Grouping dietary diversity scores into three, the majority (78%) of the children consumed a diet that is medium dietary diversity (Figure 4.10).

More girls (43%) consumed medium dietary diversity than boys (35%). High dietary diversity children were few (22%). Again, more girls (13%) consumed a high dietary diversity than boys (9%).

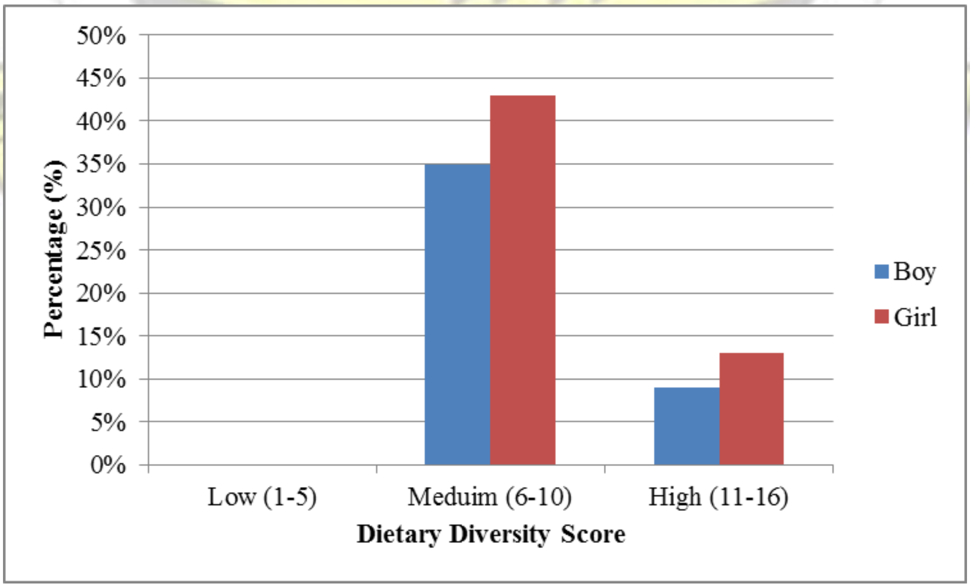

Figure 4.10: Dietary Diversity Score by Gender

Source: Field Survey, 2015

Ages of 24-36 months and 37-48 months had a higher medium level diet (28% respectively) than age 49 -60 months (20.2%) (Figure 4.11). Meaning mothers of 49-60 months children did not give much attention to their feeding, properly because mothers thought children passed the risk of malnutrition. Age of 37 - 48 months was sli ght with high-level diet (7.7%) compared to 24-36 months and 49-60 months (7.2% respectively) (Figure 4.11).

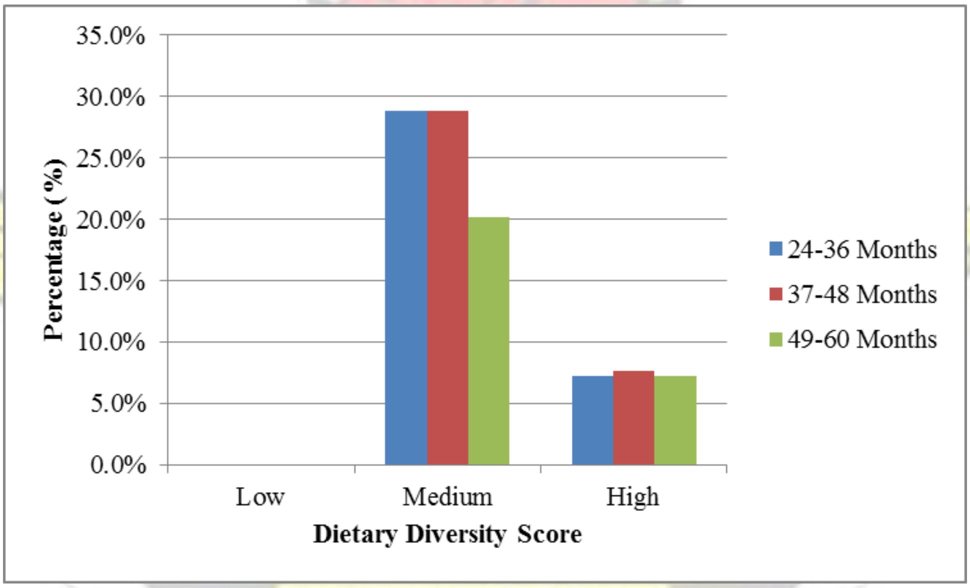

Figure 4.11: Dietary Diversity Score by Age

Source: Field Survey, 2015

Higher percentage of households (43%) ate one variety of cereals an d grains, two roots and tubers varieties (44.2%) and two varieties of vegetables constantly (25.75%). Meanwhile, more households did not eat spices (91.4%), legumes (47.7), fruits (88.9%), non-traditional (92.8%) and animals (51.65%) frequently (Table 4.9).

Table 4.9: 24-hours Food Variety Consumption among 24-60 Months Children

Food Variety	Cereals & Grains (%)	Spices (%)	Legumes & Nuts (%)	Roots & Tubers (%)	Fruits (%)	Non-traditional (%)	Animals (%)	Vegetables (%)
6								4.1
5								12.75
4				1.0				20.95
3	1			16.3				14.65
2	36.5	1.4	7.7	44.2	0.5		1.7	25.75
1	43.3	7.2	40	11.1	10.6	7.2	46.56	21.8
0	19.2	91.4	47.7	27.4	88.9	92.8	51.65	0

Source: Field Survey, 2015

Between diets consumption of 1- 4, more children consumed three different kinds of diet. Even though a smaller percentage (4.5%) ate one diet throughout the 24- hours recall, children eating 2 diets (26%) and 4 diets (25%) were slightly different (Figure 4.12).

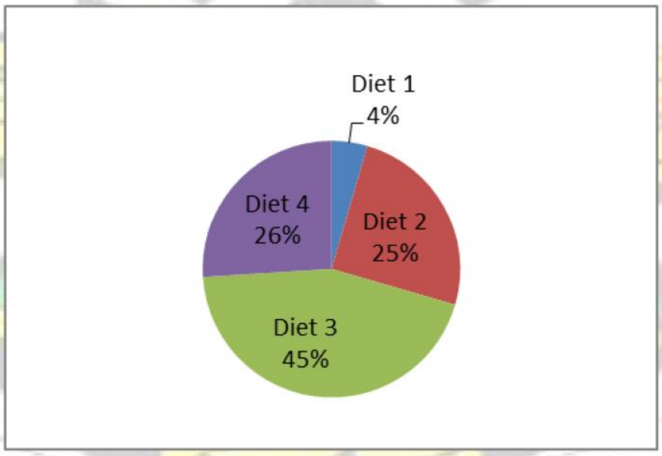

Figure 4.12: 24-Hours Recall Diet Variety Consumption among Children

Source: Field Survey, 2015

4.5 Nutritional Status

4.5.1 Anthropometric Characteristics

The mean children age was 41 months 9 days. On the average, children height and weight were 97.7cm and 12.8 kg respectively. The majority (36.5%) of these children were within 37- 48 months. The youngest children (24 - 36 months) were more than the older children (47-60 months) (Table 4.10).

Table 4.10: Children Anthropometric Characteristic

Characteristics	Mean	Std. Deviation	Confidence Interval for Mean Lower bound – Upper bound
Height of child	97.7	63.7	88.98 – 106.28
Weight of child	12.8	10.1	12.00 – 13.64
Age of child (Months)	No. of children	%	
24 - 36	78	36.1	
37 - 48	79	36.5	
49 – 60	60	27.4	
Total	**217**	**100**	

Source: Field Survey, 2015

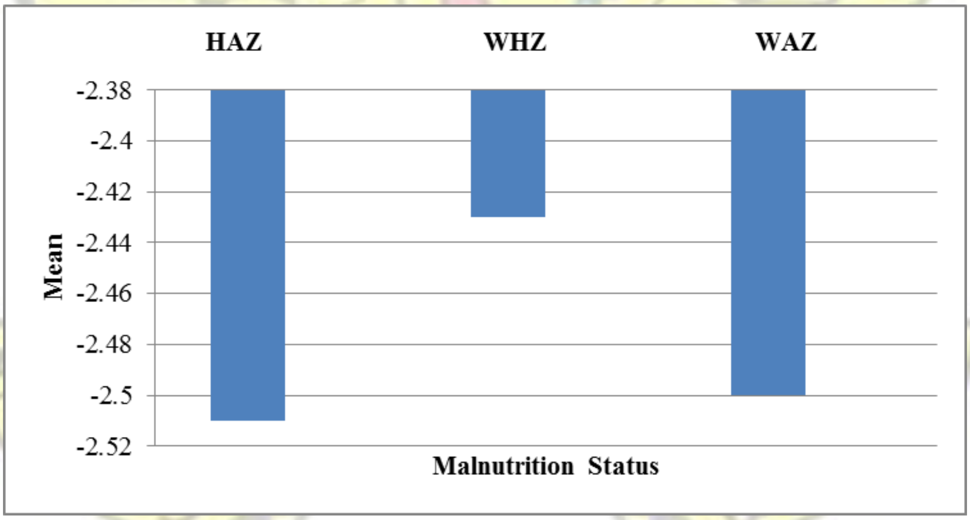

Figure 4.13: Mean Malnutrition Prevalence among 24-60 Months Children

Source: Field Survey, 2015

Below minus two standard deviations (-2SD) a child record stunted, wasted or underweight. WHZ mean was the lowest, a sign that fewer children were wasted, than stunted and underweight, and more children were stunted than there were underweight (Figure 4.13).

The mean HAZ and WHZ show boys taller but wasted for their age compared to their girl counterparts. Boys were also less underweight than girls were; suggesting that boys recorded better anthropometric measurements than girls did. T-test carried out show no significant difference between the means of boys and girls for HAZ, WAZ, and WHZ (Table 4.11).

Table 4.11 displays medium dietary scorers to be taller and less wasted for their age against their high dietary score children. A t-test shows no significant differences in the means of the medium dietary score and higher dietary score for the categories. The mean HAZ shows that 24-36 months children are tall, followed by 49-60 months children compared to their 37-48 months children score.

Mean WHZ for 49-60 months children were less wasted than 32-48 and 24-36 months children (Table 4.11).

Table 4.11: Mean Households Malnutrition by Gender, Dietary Diversity, and Age

	Boys Mean (95 CI)	Girls Mean (95CI)	*P* value (T-Test)	
Stunted (HAZ)	-2.50	-2.51	0.043	
Wasted (WHZ)	-2.50	-2.39	0.799	
Underweight (WAZ)	-2.43	-2.55	1.44	
Prevalence of malnutrition by dietary diversity				
	High DD	Medium DD		
HAZ	-2.58	-2.48	0.889	
WHZ	-2.64	-2.39	1.67	
WAZ	-2.43	-2.55	1.44	
Prevalence of malnutrition by age in months (<-3,-2-1 combined)				
	24-36 (Months)	37-48 (Months)	49-60 (Months)	*P* value (ANOVA)

HAZ	-2.401	-2.570	-2.457	0.918
WHZ	-2.780	-2.501	-2.490	0.516
WAZ	-2.202	-2.202	-2.319	0.847

Source: Field Survey, 2015

The mean WAZ for 24-36 months (-2.202) and 32-48 (-2.202) months children were less underweight compared to 49-60 (-2.319) months children.

An ANOVA-test shows no significant differences in the means of 24-36, 37-48 and 4960 months children in the three categories (Table 4.11).

Table 4.12: Malnutrition Prevalence Forms among 24-60 Months Children

	Boys (96) Prevalence N (% children)	Girls (121) Prevalence N (% children)	All (217) Prevalence N (% children)	Chi-square Test *P*/value
		Stunting (HAZ)		
Severely <-3	9(9.4)	9(7.8)	18(8.3)	
Stunted <-2	16(16.7)	24(19.8)	40(18)	
Mild<-1	32(33.3)	28(23.2)	60(28)	3.61
Total HAZ	57(59.4)	61(50.4)	118(54)	
Normal	39(40.6)	60 (49.6)	99(46)	
Sum total	**96(100)**	**121(100)**	**217(100)**	
		Wasting (WHZ)		
<-3	17(18)	24(20)	41(19)	
<-2	10(10)	17(14)	27(12.4)	
<-1	27(28)	23(19)	50 (23)	2.72
	54(56)	64(53)	118 (54.4)	
	42(44)	57(47)	99 (45.6)	
Sum total	**96(100)**	**121(100)**	**217 (100)**	
		Underweight (WAZ)		
Total (WHZ)				
Normal				
<-3	12 (13)	18(14.8)	30(13.8)	

<-2	19(20)	25(20.6)	44(20.3)	
<-1	30(31)	37(30.5)	67(30.9)	0.50
Total (WAZ)	61(64)	80 (66)	141(65)	
Normal	35(36)	41(34)	76(35)	
Sum total	**96(100)**	**121(100)**	**217(100)**	

Field Survey, 2015

In all, underweight prevalence rate (<-3, <-2, -<1 combined) among the children was higher (65% households) followed by 54% stunted and 54.4% wasted. Children severely wasted (<-3 SD) proved higher (19%) compared to 13.8% severely underweight (<-3SD) and 8.3% severely stunted (<-3SD) among the households. While children underweight (<-2) recorded higher (20.3%) among children stunted and wasted (<-2) 18% and 12.4% respectively. Children with underweight risks were higher (30.9%) against children with risks of stunting (28%) and wasting (23%). Considering <-2SD, underweight prevalence was the highest form of malnutrition followed by stunting and wasting (Table 4 12). A Pearson chi-square test showed no significant association between stunting levels with gender. The X^2 value was 3.61, degree of freedom 3, and was insignificant at $p > 0.05$. The X^2 value, wasting levels, was 2.72, the degree of freedom on which this was based were 3, and not significant at $p > 0.05$. That X^2 value for underweight was 0.50, degree of freedom 3, and not significant at $p > 0.05$ (Table 4.12).

4.6 Associations between Agricultural Biodiversity, Dietary Diversity, and Nutritional Status

Table 4.13: Relationship between Agricultural Biodiversity, Dietary Diversity, and Nutritional Status

Variable	N	Correlation (R)	R^2
Agricultural biodiversity & dietary diversity	217	0.76**	0.549
Agricultural biodiversity & stunting (HAZ)	40	-0.25	
Agricultural biodiversity & wasting (WHZ)	27	0.02	
Agricultural biodiversity & underweight (WAZ)	44	-0.18	

Dietary diversity & HAZ	39	-0.29	
Dietary diversity & WHZ	27	-0.31	
Dietary diversity & WAZ	44	-0.09	
High dietary diversity & severe underweight	30	-0.47*	0.212
Medium dietary diversity & severe underweight	30	0.42*	0.175

Source: Field Survey, 2015, Ns= not significant (p> .05), ** p < 0.01, * p< 0.05

*Correlation coefficients are not partial

A significant relationship existed between agricultural biodiversity and dietary diversity score, r = 0.76, p (two-tailed) < 0.01. This positive relationship means as agricultural biodiversity increases dietary diversity increases. However, no relationship existed between agricultural biodiversity and nutrition statuses (Table 4.13).

No significant association existed between the dietary diversity score with stunting score and wasting score (<-2SD). However, the study revealed a negative relationship for high dietary diversity with severe underweight (<-3SD) meaning high dietary diversity reduces severe underweight. However, the positive relationship between medium diversity and severe underweight reported in Table 4.13 means medium diversity does not reduces severe underweight.

Agricultural biodiversity explained 54% of the household diets eaten, while severe underweight declined as a result of 21% high-level diets eaten by households (Table 4.13).

4.7 Conclusions from Results

Agricultural biodiversity was high in the district but low among the households. Household dietary diversity was medium, only a small percentage consuming from 14 different food groups. The most prevalent malnutrition form was underweight (<-3SD) and <-3, 2, 1 combined. The results also showed agricultural biodiversity score to be a predictor of dietary diversity scores whereas high dietary diversity reduced severe underweight.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Demographic Characteristics

Most uneducated women have low knowledge on sanitation and hygiene, child healthcare and nutritional demand. Pinstrup-Andersen (2013) stressed that these nonfactors are the largest obstacles to proper nutrition. A study among Nigerian women identified educated women to be more knowledgeable in child health and nutrition than uneducated women do (Ajao *et al*., 2010). From the study, the majority of the mothers and caregivers were not educated, suggesting the reason for poor nutrition in the study area.

A high percentage of respondents being farmers confirm the District Statistical Report of 81.4% farmers in the Dormaa West (Ghana Statistical Service, 2014). However, IITA (2002) reported cocoa farming communities in Cameroon, Cote d'Ivoire, Ghana and Nigeria using their children on the farms instead of sending them to school. A similar study in Cote d' Ivoire showed a significant relationship between child labour in cocoa farms and schooling of children (Nkamleu and Kielland, 2006). This possibly could be the reason most mothers or caregivers in the study are illiterate because their parent on the farms used them.

The majority of children under five in the study being girls contradict the District 2010census report of more boys than girls do (GSS, 2010). It is not surprising because under five children in the study ranges from 2 – 5 while that of the census report ranges from
0–4.

5.2 Agricultural Biodiversity and Dietary Diversity

The study proved a considerable agricultural biodiversity level (= 86). Disagreeing with Cromwell *et al*. (2001) assertion that world food consumption is dependent on 12 crops and 5 animal species. The findings proved an increase in biodiversity at the natural habitat. Suggesting that biological diversity of the wild and agricultural ecosystems are not declining much, against other countries and districts with domesticated species taking over the natural habitat (Frison *et al*., 2006). It is also in consonance with FAO's (2004) report that many foods grow in natural habitat for household nutritional needs.

Despite the high level of biodiversity in the district, the majority of the households are with low agricultural biodiversity. The possible reasons are cropping systems used, households taste, households' culture, and market globalization (Scaffrin *et al*., 2006). The framework designed by the author for the study support this. ACF (2012) stressed there might be access to food, but the lack of health and nutrition knowledge on food could also reduce consumption. On the issue of wild food products, Termote *et al*. (2012) confirmed the distance travelled to collect wild food and the cumbersome process involved in preparing some wild foods as another factor.

More households kept goats and chicken because apart from it being less risky investment, it is free from cultural norms (Dossa *et al*., 2008). Households keep goats for money; but only sold when the households face monetary problems (Ashley & Nanyeenya, 2005). Households are rearing chicken to serve on special occasions and to serve special guests (Ampaire & Rothschild, 2010).

Maize, being the most common cereal and grain cultivated confirms the result of FAO (2000) that maize, wheat, and rice are the dependent cereals. Black nightshade, purple amaranths, slender amaranths and khaki weed were common vegetables obtained from natural habitat by households (Table 4.4). Purple amaranths and slender amaranths are leafy vegetables. According to households, these vegetables available in the wild have increased their use and are grown at the backyards.

Rat and crab were the most common animals obtained from the natural habitat. These bush animals come from forests and trees in the district as confirmed by Powell *et al*., (2012). Only two wild animals obtained from the several wild animals available. This agrees with Jamalludin (2004) that biodiversity loss worldwide is increasing. According to the households, although fewer animals are extinct because of bushfire and deforestation, many of them are difficult hunting.

Avocado pear was the only fruit obtained from the wild. Avocado pear contains 2.1% protein, 1.32% minerals and 24-26% fat (Chaddha, 2007); high availability of the fruit complements the protein and mineral needs of the children. While essential nutrients like vitamin A, B, C, calcium, magnesium, potassium and iron found in pineapple, pawpaw, and banana are less available, meaning that children needs of these nutrients are not met. The medium dietary diversity recorded resulted from the low agricultural biodiversity within households. This outcome supports Walingo and Ekese (2013) attributing changes in diet quality to agricultural diversity. Proper attention is needed because this could result in stunted children (Arimond & Ruel, 2004). Results (Table 4.1) showed mother or caregiver to be less educated. Moreover, several studies have attributed low dietary diversity to low education. This suggests that medium dietary diversity in Dormaa District is because of low education of mothers or caregivers.

One cereal and grains variety and two roots and tubers were foods commonly consumed, because only one cereals and grains type and two roots and tubers type were grown and obtained from natural habitat (Table 4.6 and 4.9). Most children had no spices, legumes and non-traditional in their foods because they were commonly not grown, kept or obtained from natural habitat (Table 4.6 and 4.9). It suggests if more cereals and grains, spices, legumes, non-traditional and roots and tubers are grown and obtained, more foods will be consumed. This also indicates that children of the study constantly depend on few and the same nutrients for daily growth. The situation, according to Arimond and Ruel (2004), Nti (2011), is poor because less diversified food could lead to malnutrition. A significant number of fruits and vegetable types grown and obtained from natural habitat, however, were consumed less probably because of the households taste and the cost of various fruit varieties (Scaffrin, 2008).

5.3 Anthropometric Status

The mean HAZ and WHZ show boys taller but wasted for their age compared to their girl counterparts. Boys were also less underweight than girls, an indication that boys recorded better anthropometric measurements than girls did. The reason is boys follow their fathers and often access balance diet of their fathers, which probably is helping them grow well. Locally, fathers eat the most quality diet out of the day's meal believing that it is a reward for their diligent work. The result concurred with Nungo *et al*. (2012) which found that boys had a higher percentage wasting than girls did. However, underweight as Lesiapeto *et al*. (2010) found South Africans was different; boys were more underweight than girls were.

Medium dietary scorers were taller and less wasted for their age against their high dietary score children (Table 4.11). The result agreed with Disha's *et al*. (2012) studies in Ethiopia and Zambia where higher dietary diversity scores also resulted in higher HAZ and WAZ. This suggests that high dietary diversity diet has traits that are more nutritious. While the medium diversity diet had less benefit of nutrient traits for child development.

The mean HAZ shows that 24-36 months children are tall, followed by 49-60 months children compared to their 37-48 months children score. The fluctuation in stunting score among age groups shows inconsistent feeding on a quality diet or possibly micronutrient are loss during food preparation and some cooking practices (Fassil *et al*., 2000). Chronic undernutrition is best reduced immediately after 2 years (Sun, 2010). Since the lowest stunting fall between 24-36 month children, it, therefore, means chronic undernutrition is eliminated. Another possible reason is 24-36 months are starting ages for development; therefore, any quality diet helps the child to build their physical features. Lesiapeto *et al*. (2010) and Nzala *et al*. (2011) reported older children in South Africa risk of stunting.

Mean WHZ for 49-60 months children recorded less wasting than 32-48 and 24-36 months children. This decreasing wasting with increasing age means as children grow food quality eaten increases. Probably mothers or caregivers give no restriction to children, to the kinds of food they must eat and not eat. Therefore, children access food diversities, which have resulted in this. The transition from exclusive to complementary feeding could account for the high wasting between 24-36 months children. The result differs from the study of Mukuria *et al*. (2005) and Teshome *et al*. (2009) in that, wasting increases through the second year life.

The mean WAZ for 24-36 months (-2.202) and 32-48 (-2.202) months children were less underweight compared to 49-60 (-2.319) months' children. The result supports Nzala *et al*. (2011) who found that older children are underweight in Ethiopia and Zambia, possibly because of inadequate diets due to socioeconomic hardships faced by the households. Most often rural children from 49-60 months take care of their bathing, brushing teeth and other personal and sanitation hygiene, having no benefit knowledge and therefore do not adhere to personal hygiene practices. Because personal hygiene and sanitation contribute to undernutrition, it suggests the cause of the underweight.

In all underweight prevalence (<-3 (13.8%), <-2 (20.3%), -<1 (30.9%) combined) among the children were higher (65% households) followed by 54% stunted and 54.4% wasted. A suggestion that malnutrition in the district is devastating compared to 28% stunting (moderate and severe combined), 9% wasting and 14% underweight from 2006 WHO Child Growth Standard in Ghana.

Children severely wasted (<-3 SD) proved higher (19%) compared to 13.8% severely underweight (<-3SD) and 8.3% severely stunted (<-3SD) among the households. While children underweight (<-2) recorded higher (20.3%) among children stunted and wasted (<-2) 18% and 12.4% respectively. Bases on WHO Child Growth Standard (2006) where stunting for under-five children was 25% in Brong Ahafo, stunting in the Dormaa District is reduced.

Considering <-2SD, underweight prevalence is the top malnutrition level, followed by stunting and wasting the lowest level in the district. UNICEF, WHO and World Bank (2014) also found wasting to be the lowest form of malnutrition in Africa, while UNICEF (2009) found stunting to be the highest malnutrition level in Ghana instead of underweight.

5.4 Relationship between Agricultural Biodiversity and Dietary Diversity

A positive relationship between agricultural biodiversity and dietary diversity is expected. Because rural farmers eat, what is grown and what grows around them. In the various households, it is evident food items commonly grown and obtained from the natural habitat found also in their common food and food groups eaten. Ekesa *et al*. (2008) and Walingo and Ekesa (2013)also showed a positive correlation between agricultural biodiversity and dietary diversity.

5.5 Relationship between Dietary Diversity and Anthropometric Status

Many studies have shown an association between WAZ and WHZ with DDS (Chua *et al*., 2012; Hooshmand & Udipi, 2013). The study showed no significant relationship between HAZ and WHZ (<-2SD) with DDS. A similar study in Kenya found no relationship between wasting and DDS. Nevertheless, the study revealed a negative relationship between high dietary diversity and severe underweight (<-3SD); and a positive relationship between medium dietary diversity with severe underweight, meaning that medium dietary diversity does not contribute to reducing severe underweight. In addition, a negative relationship between high dietary diversity and severe underweight means high dietary diversity influence severe underweight reduction. Twenty-one percent severe underweight reduction by high dietary diversity in the study is higher than 7% reduction in the study of Walingo and Ekesa (2013) because the 7% reduction covers severe underweight, underweight, and mildly underweight.

5.6 Relationship between Agricultural Biodiversity and Anthropometric Status

The study found no relationship between agricultural biodiversity and nutritional status. Indicating that agricultural biodiversity is not a precursor of malnutrition. Rather large households, unstable income, the age of introducing supplementary foods, poor childcare and poor sanitation play a major role (Nungo *et al*., 2012). A similar low agricultural biodiversity in Brazilian children aged 0 - 60 months did not affect nutritional status, especially stunting (Kac *et al*., 2012). Even though Bushenyi, western Uganda, is a high agricultural biodiversity district, half the population are stunted (Bambona & Kikafunda, 2005); whereas cassava-growing communities having low biodiversity are recording large stunting, wasting and underweight rates (Nungo *et al*., 2012).

5.7 Accepting and Rejecting Hypotheses

The correlation analysis showed a positive significant difference between agricultural biodiversity and dietary diversity accepting the null hypothesis that a positive relationship exists between agricultural biodiversity and dietary diversity. This agrees with Remans *et al*. (2011) that agricultural biodiversity affects dietary diversity.

A positive and negative relationship showed between medium and high dietary diversity and severe WAZ scores in children. The null hypothesis that a negative relationship existed between dietary diversity, HAZ, WAZ and WHZ rejected for HAZ and WHZ and accepted for WAZ (<-3SD). Frison *et al*. (2011) also proved that agricultural diversity directly relates dietary diversity and inversely relate to malnutrition.

Based on MDG 2 of reducing half prevalence of malnutrition and 50% as a sustainability ratio, agricultural biodiversity sustained dietary diversity at 54%, and inversely through 21% dietary diversity influenced severe underweight. The null hypothesis that agricultural biodiversity is sustainably reducing malnutrition rates is rejected because agricultural biodiversity could not sustainably explain severe underweight reduction through its dietary diversity.

CHAPTER SIX

6.0 CONCLUSIONS, RECOMMENDATIONS AND FUTURE RESEARCH

6.1 Conclusions

Child malnutrition if not eradicated will promote irreversible mental sickness and chronic diseases among children. However, education on nutritious foods and making it available and accessible to mothers or caregivers can prevent this problem. Because agricultural biodiversity relates diet diversification and inversely relate malnutrition.

Of the 86 agricultural biodiversities discovered in the district, only chicken, goat, garden eggs, pepper, tomatoes, maize, cassava, cocoyam and plantains are accessible and usable by the households. The others are black nightshade, purple amaranths, slender amaranths, khaki weed, rat, crab, andan tree, and mushroom.

Household diets are of medium diversity, mainly boiled rice and tomatoes stew and fufu and light soup. Only a few are consuming from 14 food groups and more consuming from 10 different food groups out of the recommended 16 food groups.

Underweight prevalence is the highest malnutrition rate in the district. It occurs within 3738 and 49-60 months children and dominates among girls.

However, agricultural biodiversity is explaining 54% to the difference of household diet, while 21% of the high dietary diversity eaten reduced households severe underweight.

Meanwhile, medium dietary diversity could not reduce any of the underweight forms. Meaning growing and conserving agricultural biodiversity at the highest level will eradicate underweight in the study area.

The study is important because it confirms other studies on agricultural biodiversity potentials to malnutrition and contributes to biodiversity loss discussions.

Concluding that, achieving sustainable nutrition starts with high agricultural biodiversity conservation. Because, regardless of age and sex, agricultural biodiversity and high dietary diversity could help mothers and caregivers in the Dormaa West District reduce severe underweight.

6.2 Recommendations

It is needful finding ways to conserve the high agricultural biodiversity in the district. Oneway is to encourage farmers to practice mixed cropping, mixed farming and agroforestry systems. However, agricultural biodiversity must be diversifying in various households. This can be awareness in the community among reproductive women on the importance of fruits, vegetables, crops and animals explored in the district.

By feeding on highly diversified diet underweight rate will reduce. Much quality diet must go to the girl child. Stunting should be given attention for children between the ages of 24-36 months; wasting, ages of 49-60 months; and underweight, ages of 24-48 months.

6.3 Future Research

1. Repeating similar study is necessary for personal health and sanitation areas because agricultural biodiversity did not appear to affect stunting and wasting significantly.
2. Though agricultural biodiversity was high in the district, it was lower in households. It is necessary discovering the cause in similar studies in the district.

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APPENDICES

DEPARTMENT OF AGRICULTURAL ECONOMICS, AGRIBUSINESS AND EXTENSION, KNUST

Agricultural Biodiversity and Sustainable Child Nutrition Development

Household Survey Questionnaire for Dormaa West District

BASIC DATA

Date of Survey (dd /mm/ yyyy) Name of Enumerator

____

Community: Household No.: Questionnaire No. :

RESPONDENTS PERSONAL INFORMATION

Age of Mother/Caregiver: Age of Child: Sex of Child:

APPENDICE A: Socio-demographic characteristics 1.
What is your marital status? (Circle one number only)

1	2	3	4	5	6
Single	Married	Divorced	Separated	Widowed	Other Specify…

5) Please describe the foods (meals and snacks) that you ate or drank yesterday during the day and night, whether at home or outside the home. Start with the first food or drink of the morning.

Circle one number only for every question:

2. What is your highest formal education level?

1. No Education

2. Few years Primary School

3. Completed Primary School

4. Few years Junior Secondary School
5. Completed Junior Secondary School

6. Few years Senior Secondary School

7. Completed Senior Secondary School

8. Tertiary

3. What is your main occupation?

1. Crop farmer 2. Artisan 3. Livestock farmer

1. Handcrafts 5. Crop and livestock farmer 6. Student

9. Farm labour service 8. Housewife 9. Non -farm casual service

10. None 11. Business/Private service 12. Others

13. Formal employment

4. What is your family size?

APPENDICE B: 24-Hour Recall Dietary Diversity Questionnaire

Time	Name of Food	Ingredients			

Question Number	Food groups, items, and varieties consumed	Examples	YES=1 NO =0
1	CEREALS,GRAINS, AND BY-PRODUCTS	Corn/maize, rice, wheat, sorghum, millet or bread, porridge or other grain products	
2	WHITE ROOTS AND TUBERS	White potatoes, white yam, white cassava, or other foods made from roots	
3	VITAMIN A RICH VEGETABLES AND TUBERS	Pumpkin, carrot, or sweet potato that are orange inside, red sweet pepper	
4	DARK GREEN LEAFY VEGETABLES	Dark green leafy vegetables, including wild leaves such as amaranth, cassava leaves, spinach	
5	OTHER VEGETABLES	Tomato, onion, eggplant and other locally available vegetables	

6	VITAMIN A RICH FRUITS	Ripe mango, ripe papaya, and 100% fruit juice made from these and other locally available vitamin A rich fruits	
7	OTHER FRUITS	Other fruits, including wild fruits and 100% fruit juice made from these	
8	NON-TRADITIONAL	Mushroom, snails	
9	FRESH MEAT AND ORGAN MEAT	Beef, pork, lamb, goat, rabbit, game, chicken, duck, other birds, insects liver, kidney, heart or other organ	

		meats or blood-based foods ,	
10	EGGS	Eggs from chickens, ducks, guinea fowls or any other egg	
11	FISH AND SEAFOOD	Fresh or dried fish or shellfish	

12	LEGUMES, NUTS AND SEEDS	Dried beans, dried peas, lentils, nuts, seeds or foods made from these (e.g., peanut butter)	
13	MILK AND MILK PRODUCTS	Milk, cheese, yogurt or other milk Products	
14	OILS AND FATS	Oil, fats or butter added to food or used for cooking	

15	SWEETS	Sugar, honey, sweetened soda or sweetened juice drinks, sugary foods such as chocolates and cakes	
16	SPICES, CONDIMENTS, BEVERAGES	Spices (black pepper, salt), condiments (soy sauce, hot sauce), coffee, tea, alcoholic Beverages	
Individual level	Did you eat anything (meal or snack) OUTSIDE the home yesterday?		

APPENDICE C: Agricultural Biodiversity

6. Tell me all the animals reared, hunted and food and food items obtained from natural habitats.

Domestic Animals	Domestic cereals, roots and tubers and arable crops	Domestic vegetables & fruits	Wild animals hunted for food	Wild vegetables, fruits, roots, crops collected for food

APPENDICE D: **Nutritional FD Outputs**

Name of food items category	Name of each food items in the category	Total number of food item in category	Number of food items naturally obtained per household	Number of foo d items cultivated per household	Richness between categories (How many categories are there?)	Evenness within category (How many food items in this category or total biodiversity?)

APPENDICE E: Nutritional Assessment

10. Child anthropometric measurement

Weight 1	Weight 2	Average Weight	Height 1	Height 2	Average Height	Wasting Wgt/Hgt	Stunting Hgt/Age	Underweight Wgt/Age

APPENDICE F: Key Informant Conversation Guide for Community Leaders

Name of Community: …………………………………Date……………………

1. Introduction

I. Introduce yourself

II. Summarize the purpose of the visit

III. Turn on recorder

Questions

11.

a. What food crops have been grown in your community in the past years?
b. What cereals are grown?
c. What vegetables are grown?
d. What roots and tubers are grown?
e. What fruits are grown?

12.

a. What animals have been reared in your community in the past years?
b. What animals do the community hunt for food?
c. What foods are collected from the natural habitat?