RELATIONSHIP BETWEEN FOREST COVER, DIETARY INTAKES AND ANAEMIA PREVALENCE AMONG WOMEN IN SELECTED COMMUNITIES IN SOUTHWEST CAMEROON

BY

CALEB YENGO TATA

(10509052)

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DECLARATION

I, Caleb Yengo Tata hereby declare that, this piece of work is the result of my own efforts and idea in the Department of Nutrition and Food Science, University of Ghana, under the supervision of Dr. Esi K. Colecraft and Dr. Amy Ickowitz. No previous submission for a degree has been done here or elsewhere, besides the works of others which served as source of information and have been duly acknowledge by making reference to the authors.

CALEB YENGO TATA
(STUDENT)
SIGNATURE…………………………….
DATE …………………………………

DR. ESI COLECRAFT
(PRINCIPAL SUPERVISOR)

SIGNATURE…………………………….
DATE …………………………………….

DR. AMY ICKOWITZ
(CO-SUPERVISOR)

SIGNATURE…………………………….
DATE…………………………..………..

DEDICATION

I dedicate this piece of work to my faithful heavenly father whose steadfast love and covenant of peace has never departed from me, and to my sweet mother Lydia Tata.

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ACRONYMS AND ABBREVIATIONS

ASF: Animal source food

BMI: Body Mass Index

CIFOR: Center for International Forestry Research

CDC: Centre for Disease Control

DDS: Dietary Diversity Score

DGLV: Dark green leafy vegetable

FAO: Food and Agriculture Organization

FBV: Forest Based Village

FOREP: Forests, Resources and People

Hb: Haemoglobin

HH: Household

MDD-W: Minimum Dietary Diversity-Women

NGO: Non-governmental Organization

NTFP: Non Timber Forest Product

RBCs: Red blood cells

SPSS: Statistical Package for Social Sciences

TNP: Takamanda National Park

UNICEF: United Nations Children Emergency Fund

WB: World Bank

WHO: World Health Organization

ABSTRACT

Background and objective: Forest cover has been associated with better diets and nutritional status. We investigated whether living in close proximity to forest cover was associated with better diet quality and anaemia prevalence among women of reproductive age in Southwest Cameroon.

Methodology: Comparative cross-sectional survey of 247 randomly selected women of reproductive age from four forest-based villages (n=126) and four non-forest villages (n=121). A semi-structured questionnaire was used to interview women about their socio-demographic characteristics, anaemia-related morbidity, and use of forests for food, income and medicine. Qualitative 24-hour recall method was used to assess the women's dietary intake in the past day. Additionally, the women's weight, height and Haemoglobin (Hb) were measured. Differences between groups were assessed with Pearson's chi-square and independent T-tests; logistic regressions were used to identify predictors of anaemia.

Results: Compared with women from non-forest villages significantly more women from forest-based villages consumed Vitamin A rich fruits and vegetables (98% vs. 92%; p=0.04) and animal source foods (84% vs. 68%; p=0.002). Women from forest-based villages were also significantly more likely to have obtained iron-rich foods such as dark green leafy vegetables (42% vs. 1%; p=0.001) and animal source foods (17% vs. 1%; p=0.001) from the forest, whereas these foods were more likely to be from their own farms or purchased by the non-forest women. Mean haemoglobin concentration was higher for the forest-based women (forest 11.10±1.53 g/dl vs.10.68±1.55g/dl; p=0.03) but there was no group difference in anaemia prevalence. Significant predictors of anaemia among the women were: living in a compound setting (OR=2.37; 95% CI: 1.27-4.43), not consuming pulses the previous day

(OR=2.60; 95% CI: 1.32-5.13) and not having a toilet facility at home (OR=2.24; 95% CI: 1.07-4.67).

Conclusion: Despite having a higher mean haemoglobin concentration women from forest-based communities had similar anaemia prevalence to women living farther from forest cover. However, for women living near forest cover, the forest was an important source of iron-rich foods. Efforts to prevent forest loss and maintain ecosystem services are warranted to enhance diets and nutrition of rural forest dependent communities.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Anaemia remains a major public health problem worldwide. Although global anaemia prevalence declined from 40.2 to 32.9 percent between 1990 to 2010, nearly one-quarter of the world's population, representing about 1.6 billion people are anemic with women and children being the most affected (Kassebaum *et al.*, 2014).

Countries in Africa have the highest prevalence of anaemia across all population groups (WHO, 2011; Black *et al.*, 2013). The prevalence of anaemia in 2011 for pregnant women was reported to be between 38.9 to 48.7 percent and for non-pregnant women, it was between 37.7 to 41.5 percent for women in the WHO African region (WHO, 2015). However, in Cameroon, the prevalence of anaemia among women of reproductive age still remains high. The DHS reports in 2011, revealed that 40 percent of women were anaemic. Another study in 2013, showed a prevalence of 38.8% in women of reproductive age (Engle-stone, 2013). Thus anaemia in women of reproductive age in Cameroon still remains a public health problem.

There are several consequences of anaemia. A systematic review by Rahman *et al.*, (2016) revealed that a significant number of children with low birth weight (12%), perinatal mortality (18%), and preterm births (19%), in low-and middle income countries were attributable to maternal anaemia (Rahman *et al.*, 2016). The primary cause of maternal and infant mortality in women with severe anaemia, may be as a result of the difficulty in meeting oxygen requirements near and during delivery (Black *et al.*, 2013). An estimate by WHO in 2004, showed that anaemia accounted for 22 percent of deaths in mothers and 24 percent of perinatal deaths occurring annually around the world (WHO, 2010).

In most cases, anaemia is caused by nutritional disorders and infections especially in developing countries. Anaemia usually does not occurs on its own, but will often co-exists with an underlying disease (Osungbade & Oladunjoye, 2012). Kassebaum *et al*., (2014) attributed the main causes of anaemia worldwide to three syndromes: iron deficiency (iron deficiency anaemia, hookworm and schistosomiasis), haemoglobinopathy (sickle cell disorders and thalassemia), and malaria. In Sub-Saharan Africa, iron deficiency and malaria were the top causes of anaemia (Kassebaum *et al*., 2014).

Malnutrition which includes, anaemia among women of reproductive age, stunting amongst children under five and adult obesity, affects most countries (Haddad *et al*., 2014). Although there has been an increase in agricultural productivity over the years, global hunger is still a problem which leads to low dietary diversity and unbalanced diets (FAO, 2013). Research evidence suggest that forests complement agricultural products in providing improved and more nutritive diets (Vinceti *et al*., 2013). Research by Ickowitz *et al*., 2014 showed that populations that live in close proximity to forests cover were more likely to consume forest foods and vitamin A fruits and vegetables which contributed to more diverse diets and better nutritional status. The contributions of forests to human health have rarely been framed in terms of contribution to nutrition (Powell *et al*., 2012). This research seeks to contribute to the body of knowledge linking nutrition and forests by examining the contributions the forest makes to human nutrition focusing on the prevalence of anaemia in one subdivision of Cameroon.

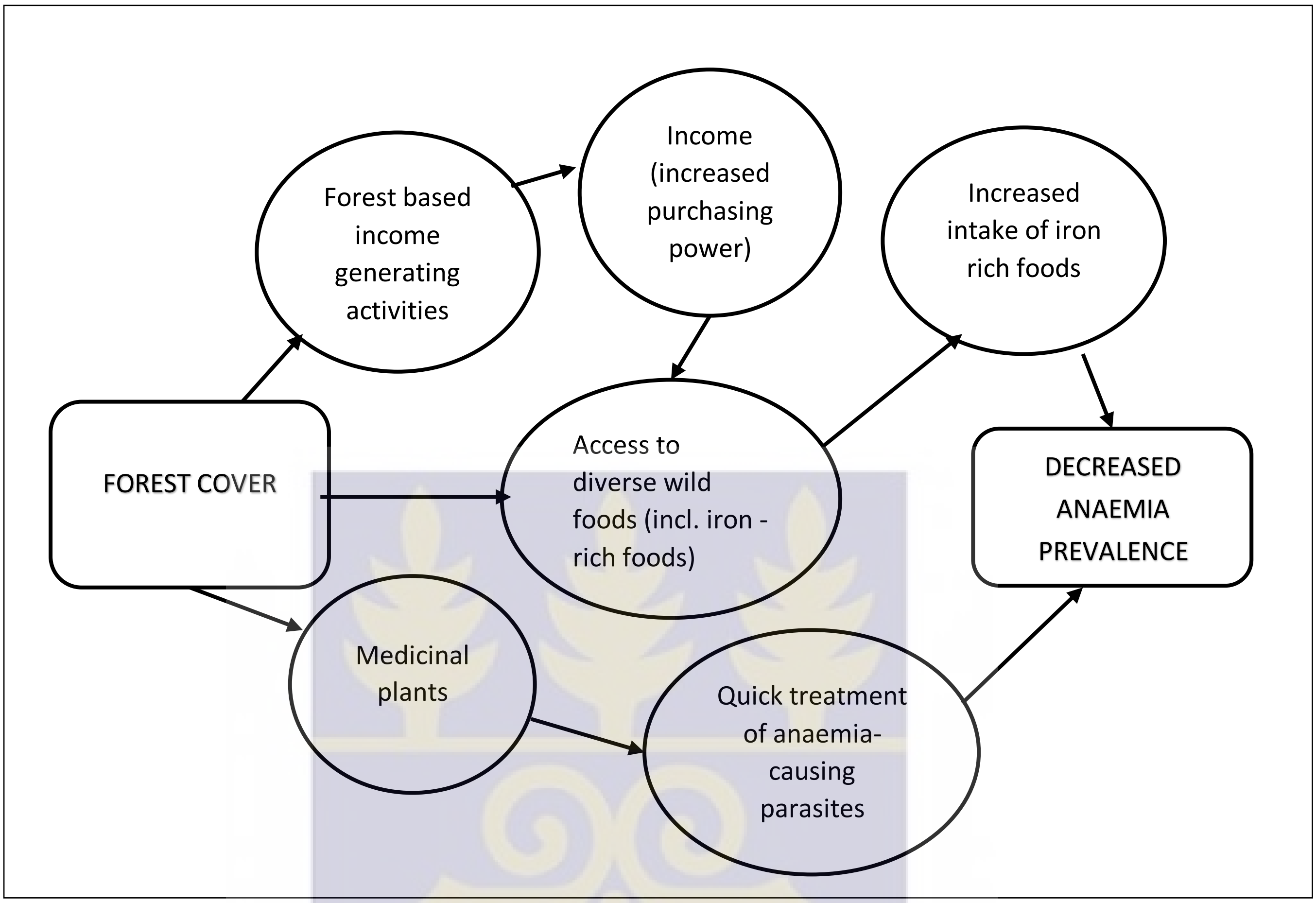

FIGURE 1. CONCEPTUAL FRAMEWORK SHOWING PATHWAYS THROUGH WHICH FOREST COVER MAY BE ASSOCIATED WITH DECREASED ANAEMIA PREVALENCE.

The conceptual framework for the study shows possible pathways by which living near forests may have lower anaemia prevalence among women in low resource settings in Cameroon. The framework suggests that access to forests may influence anaemia prevalence through diet or management of infections. Access to forest cover may increase access to diverse foods from the forest or increase income to purchase food through forest-based income generation activities leading to increased consumption of iron-rich foods such as animal source foods and legumes and nuts and leading to less anaemia in the population.

Forests are also a source of medicinal plants for treatment against anaemia related parasites such as malaria and worm infestation. Having access to these medicines can reduce the burden of anaemia causing parasites resulting in less anaemia.

1.2 Study Rationale

Previous research has shown that populations that live in close proximity to forests or areas with greater tree cover are more likely to consume forest foods which may contribute to more diverse diets and better nutritional status. Although the Southwest region of Cameroon has a significant amount of forest cover, more than one-half of women of reproductive age who live in the region are anaemic which puts them at risk of adverse pregnancy outcomes including low birth weight babies. The relationship between forest cover and nutritional status, particularly iron status of women of reproductive age has not been explored in Cameroon. Understanding the pathways by which living in close proximity to forest cover can confer nutritional benefits can inform nutrition interventions to improve women's nutrition and health in the Southwest region of Cameroon.

This study explored the relationship between living in proximity to forest cover and access to iron rich foods, diet quality and anaemia prevalence among women in the Takamanda low and highlands of Cameroon. The findings from this study may inform interventions to improve women's nutrition and contribute to advocacy to support forest conservation for improved human nutrition.

1.3 Study Objectives

1.3.1 Main Objective

The overall objective was to assess the relationship between forest cover, dietary intake and anaemia prevalence among women of reproductive age in Cameroon.

1.3.2 Specific Objectives

The specific objectives of the study were to:

1. Compare the prevalence of anaemia between women living close to forest cover and those living further away from forest cover.
2. Compare intakes and sources of iron rich foods among women living close to forest cover and those living further away from forest cover
3. Determine predictors of anaemia among women in the study.

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CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Anaemia definition

Anaemia is defined as a reduced amount of haemoglobin (Hb) in the blood. Haemoglobin is a substance in the blood that transports oxygen from the lungs to all parts of the body. Anaemia is a deficiency in the size or number of red blood cells (RBCs) or the amount of Hb they contain (Mahan *et al.*, 2012). Haemoglobin levels vary with age, sex, pregnancy, altitude and smoking. Different levels of Hb are considered normal for different categories of people. For women of reproductive age (15-49 years), a haemoglobin of 12.0g/dL or higher is considered normal. Meanwhile, haemoglobin levels of 10.0-11.9g/dL, 7.9-9.9g/dL and <7.0g/dL are classified as mild, moderate and severe anaemia respectively (WHO, 2011) .

The WHO, uses different cut offs to categorize the severity of anaemia as a public health concern in various countries. Countries with a prevalence of anaemia <5 percent are classified as having no public health problem; those with 5-19.95 percent, are classified as having a mild public health problem; those with 20-39.9%, as moderate public health problem; and those with a prevalence ≥40 percent, as severe public health problem (WHO, 2011)

2.2 Worldwide prevalence of anaemia

Anaemia is the most widespread nutritional deficiency problem worldwide. Globally, the prevalence of anaemia in 2010 was 32.9 percent with about 2.2 billion people affected and iron deficiency accounted for the most cause (Kassebaum *et al.*, 2014).

There is a significant variation in the prevalence of anaemia around the world (WHO, 2008). WHO African, Eastern Mediterranean and South-East Asia regions were recorded as having the lowest mean haemoglobin concentrations and the highest prevalence of anaemia between populations in 2011 (WHO, 2015).

Also, estimates of total anaemia prevalence in high-risk populations may be above 50 percent to 80 percent and close to 10 percent to 20 percent of these people having moderate to severe anaemia (Thomson *et al.*, 2011). Bentley and Griffiths (2003) also show that, females, people with low socioeconomic status and low body weight always have a higher prevalence of anaemia (Bentley & Griffiths, 2003). Moreover global focus on the causes of anaemia have only been tracking iron deficiency in specific areas or regions, but this may lead to misinterpretation of the trends because the variations in severity may be missed (WHO, 2008) (R. J. Stoltzfus, 1997). Kassenbaum *et al.*, (2014) gave the first complete accounting of the global anaemia burden including total and by-severity anaemia prevalence and disability burden for 17 causes of anaemia in 187 countries, from various age groups, including males and females from 1990 to 2010. They found that the prevalence of anaemia had decreased from 40.2 in 1990, to 32.9 in 2010 and despite this decrease, anaemia was accountable for 68.3 million years lived with disability (YLD) in 2010 - more than depression, chronic respiratory disease and total injuries.

2.3 Prevalence in Africa

Countries in Africa have the highest prevalence of anaemia across all population groups (WHO, 2011; Black *et al.*, 2013). In the African region, the children were the highest in percentage of individuals who were affected with anaemia, which stood at 62.3 percent (95% CI: 59.6-64.8). The prevalence of severe anaemia is also very high in the African region with over 3.6 percent of the children affected by it (WHO, 2015; Black *et al.*, 2013).

The prevalence for pregnant women has however dropped to 46.3 percent for women in the WHO African region. And that for non-pregnant women at 37.8 percent (WHO, 2015)

2.4 Prevalence in Cameroon

The Demographic and Health Survey (DHS) and Multi indicator cluster survey (MICS) jointly conducted anaemia tests on 95 percent of the 7811 eligible women in 2011 and revealed that 40 percent of women (15-49yrs) in Cameroon were anaemic (CDHS 2011) Although there is moderate variation by urban-rural residence, differences vary greatly by region, ranging from a high of 54 percent in the South-west region to 23 percent in the Western region (CDHS, 2011). There has been decrease in the national prevalence of anaemia among women in Cameroon over the years. The rate dropped from 46.3 percent in 2000 to 45.3 percent in 2004 and further declined to 40.7 percent in 2011 (Stevens *et al.*, 2013). In 2013 a nationally representative survey of 879 women (15-49years) and 847 children 12 to 59 months in three zones of Cameroon reported 38.8 percent and 57.6 percent anaemia prevalence among children and women, respectively (Engle-Stone *et al.*, 2013). Although anaemia rates are slowly declining in Cameroon the country still has an anaemia problem of severe public health significance based on the WHO cut offs for classifying anaemia as a public health problem (WHO, 2015).

2.5 Causes of anaemia

In most cases, anaemia is caused by nutritional disorders and infections especially in less developed countries. Anaemia has been shown to co-exist with other diseases and will hardly occur on its own (Osungbade & Oladunjoye, 2012). Kassebaum *et al.*, (2014) attributed the main causes of anaemia worldwide to three syndromes: iron deficiency (iron deficiency anaemia, hookworm and schistosomiasis), haemoglobinopathy (sickle cell disorders and thalassemia), and malaria. In Sub-Saharan Africa, malaria and iron deficiency were the top causes of anaemia (Kassebaum *et al.*, 2014).

Iron deficiency anaemia, which is the most common type of anaemia is usually caused by inadequate intake of iron rich foods, poor bioavailability of iron from foods, and or excessive iron loss (R. J. Stoltzfus, 2001). Anaemia is usually the final outcome of nutritional deficiency of iron, folate, and vitamin B_{12}. Other causes of anaemia include malaria, hemorrhage, infection, genetic disorders (haemoglobinopathies), parasite infestation (hookworm), and chronic disease.

Nutritional deficiency, which is as a result of lack of bioavailable dietary iron, is responsible for close to one-half of anaemia cases in the world (Balarajan *et al.*, 2012). Thomson et al. (2011) show that factors which contribute to the cause of anaemia in areas include socioeconomics, climate, health care, and the presence of programs that control and prevent anaemia. In particular countries, the extent of the influence by these factors, depends on the magnitude of malaria epidemics, whether or not the country runs iron supplementation or fortification programs (Thomson *et al.*, 2011).

Malaria and intestinal parasites are particularly important contributors to anaemia in less developed countries (Müller & Krawinkel, 2005). A cross sectional, study carried out among rural school children in southwestern Nigeria revealed an overall prevalence rate of 66.4 percent parasitic infections. They also found that the mean haemoglobin level of plasmodium positive participants without helminth infection was higher than those with intestinal helminth (Akanni *et al.*, 2014).

There are other causes of anaemia which needs more research to be firmly established. Recently, Coffey & Geruso (2015), showed a link between sanitation and anaemia from a case study in Nepal. This was the first paper to investigate a link between open defecation and anaemia. They hypothesized that poor sanitation, significantly contributed to haemoglobin deficiency, by creating a poor disease environment. They investigated a causal relationship between sanitation and haemoglobin by examining improvements in sanitation in areas of Nepal between 2006 and 2011. They found that within particular regions over time, cohorts of children who were exposed to poorer community sanitation recorded lower haemoglobin levels and had higher incidence of anaemia (Coffey & Geruso, 2015). Their study proposes a cause of anaemia that operates in addition to nutritional intake and malaria which is poor local sanitation and specifically, open defecation. Their result may expand the approaches available for targeting anaemia because decision makers as well as researchers, sometimes regard anaemia and other nutritional diseases to be mainly related to food intake. Explained below are the types of anaemia of interest to this study.

2.5.1 Iron deficiency anaemia (IDA)

Iron deficiency is one of the major causes of anaemia and one of the most prevalent nutrient deficiencies in the world, and it said to affect close to two billion people worldwide. The most frequently and severely affected people are young children and pregnant and postpartum women, due to their high demand of iron for the growth of the infant and during pregnancy (Thomson *et al.*, 2011).

Iron deficiency anaemia occurs when there is a severe deficiency in iron supply, so as to reduce the production of red blood cells. This leads to a reduction in the number of red cells in the blood and results in the onset of anaemia (R. Stoltzfus, 2003). Iron is an important component of haemoglobin (Hb), and it is necessary for cellular functions in tissues, especially the brain, the red blood cells and the muscles (WHO, 2002).

Iron deficiency anaemia (IDA) is characterized by the production of erythrocytes and a reduction in the amount of haemoglobin (Mahan *et al.*, 2012). This is usually the final stage of and it signifies the end point of iron deficit (Gibney *et al.*, 2013). With increase in the severity of iron-deficiency there are defects that arise in epithelial cell structure and function.

This is usually seen around the tongue, nails, mouth, and stomach. The skin may also appear pale, and rather than red, the inside of the lower eyelid may be light pink (Brown, 2007). There are a number of risk factors for IDA including low iron intake, poor iron absorption mostly caused by inhibitors in diets like phytates, and the individual's stage of life, when there is very high iron requirement (WHO, 2008). Iron requirements are highest for pregnant women, followed by infants, adolescents, preschool children, non-pregnant women and adult men (Gillespie, 1998). Other risk factors for iron deficiency anaemia may be from physiological and pathological conditions. If the body absorbs less iron than is required, this may result in risk of iron deficiency. Rapid growth in infants and young children (0-15years) places a high demand on iron stores which they had accumulated during gestation, which can in turn lead to iron deficiency (Pizarro *et al.,* 1991).

The WHO estimates that about 50% of anaemia cases worldwide are due to iron deficiency (UNICEF & WHO, 2001), but there are also disparities that exist among regional and sub groups (Eisele *et al.*, 2013).

2.5.2 Folic acid and B_{12} deficiency anaemia

Folic acid and cobalamin (B_{12}) are both group B vitamins that play important roles in a number of cellular processes. When there is a deficiency in any one or both of them it will cause a type of anaemia called megaloblastic anaemia (Castellanos-Sinco *et al.*, 2015)**.** This type of anaemia is usually characterized by the occurrence of megaloblasts, which occur when inhibition of DNA synthesis causes asynchronous maturation between the nucleus and the cytoplasm. This type of anaemia, when caused by deficiency in folic acid is usually due to reduction in the amount of folate in the diet, or to a disparity between the demand of folate and intake (Carmel., *et al.*, 2003). Folate deficiency is known to cause a decrease in red blood cells due to lack of folate. It is associated with tropical sprue, which is a malabsorption disease common in the tropical regions known for abnormal inflammation of the lining of the small intestine. This disease can also affect pregnant women, and also occurs in some infants who are born to mothers with deficiency in folic acid. Neural tube defects may also result in women with folic acid deficiency early in pregnancy (Webster-Gandy *et al.,* 2011). This is believed to be frequently caused by prolonged inadequate diets, malabsorption and increased requirements resulting from growth (Mahan *et al.*, 2012). Rich sources of folate include: green leafy vegetables, mushrooms, roots, tubers, fruits, liver, kidney, meat, and egg yolk (Carmel *et al.*, 2003).

Vitamin B_{12} deficiency is also caused by poor absorption in the intestinal tract (Castellanos-Sinco *et al.*, 2015) and is common among vegetarians (Schlenker & Roth, 2013). It is most commonly from a lack of intrinsic factor (a glycoprotein necessary for the absorption of vitamin B_{12}), and referred to as Pernicious anaemia (Mahan *et al.*, 2012). Megaloblastic anaemia is common in people of European and African descent. Dietary vitamin B_{12} deficiency however, is prevalent in vegetarians (Stabler & Allen, 2004). The magnitude and prevalence of this anaemia is not yet well established in Africa. A study conducted to assess the prevalence of both iron deficiency and megaloblastic anaemia on 461 women attending an antenatal clinic in North Eastern Nigeria showed that 51.8 percent (239) were anemic and from that, 64 percent (155) showed signs of iron deficiency anaemia while only 0.4 percent (1) had signs of megaloblastic anaemia (Bukar *et al.*, 2009). In contrast to this, megaloblastic anaemia accounted for 98 percent in a study in Tunisia when 478 patients were studied (Maktouf *et al.*, 2006).

2.5.3 Vitamin A deficiency and anaemia

Vitamin A deficiency has been said to reduce iron metabolism and thus influences the incidence of anaemia. A comprehensive review done by Semba & Bloem (2002), revealed that vitamin A is involved in a number of ways. Vitamin A enhances growth and differentiation of cells that enhance erythrocyte production, and boots up immunity thus reducing the anaemia of infection, and mobilizes iron stores from tissues. Their analysis further showed that epidemiological surveys revealed a high prevalence of anaemia in populations affected by vitamin A deficiency in developing countries. They concluded that although vitamin A deficiency was recognized to cause anaemia, the actual public health impact was unclear (Semba & Bloem, 2002). Zimmermann *et al.*, (2006), assessed the effect of vitamin A supplementation on haemoglobin, and iron on children with poor iron and vitamin A status using a double blind randomized controlled Vitamin A supplementation trial with 81 Moroccan school children, showed that Vitamin A treatment improved mean haemoglobin by 7 g/L (P 0.02) and also decreased the prevalence of anaemia from 54 percent to 38 percent (P 0.01). The authors concluded that in children who were deficient in vitamin A and iron, vitamin A supplementation mobilized iron from existing stores to support the production of erythrocytes (Zimmermann *et al.*, 2006).

2.6 Women and iron needs

Because of iron losses in menstruation, adolescent girls are predominantly at risk of iron deficiency anaemia (Harvey *et al.*, 2005). Hallberg & Hulthen (2002) show that estimate of women who lose blood in menstruation, are consistently indicating that almost 100 percent of the women lose close to 118mL per cycle, with a mean loss of 44mL and a median loss of 30 mL, which is proportional to 0,7mg and 0.49mg of iron loss a day respectively (Hallberg & Hulthén, 2002). Pregnant women are equally at a greater risk of iron deficiency (Mozaheb *et al.*, 2011). This is because iron needs are tripled during pregnancy due to expansion of maternal red cell mass and growth of the fetus and the placenta. The demands of pregnancy, lactation, menstruation and, in growth in adolescence on iron requirements are not very certain and vary greatly from one individual to another. Women could be at risk of insufficient iron supply due to diets that are low in iron (Hallberg & Hulthén, 2002).

2.7 Consequences of anaemia

Anaemia has been shown to have harmful health implications, especially for mothers and young children. The consequences of anaemia for women include increased risk of maternal morbidity and mortality, and lowered physical activity, mental concentration, and productivity (R. J. Stoltzfus, 2001). Women who are mildly anaemic may experience fatigue and have a reduction in their work capacity (Bentley & Griffiths, 2003). Severely anaemic women may also face difficulties in meeting oxygen requirements near their time of delivery or at delivery particularly if hemorrhaging occurs. This may lead to the death of the mother or prenatal and perinatal loss of the infant (Black *et al.*, 2013). An estimate by WHO in 2004, showed that anaemia accounted for the death of 22 percent of mothers and 24 percent of perinatal deaths occurring annually around the world (WHO, 2010). In fact, anaemic mothers have been seen to report more unfavorable pregnancy outcomes than non-anaemic mothers (Koura *et al.*, 2012).

2.7.1 Effects on cognitive function

Iron-deficiency anaemia (IDA) has been found to be associated with decreased cognitive performance. Carter *et al.*, (2010), examined the effects of IDA on infant cognitive function on 113 healthy infants (9-10mo). The results indicated that infants with IDA were least likely to exhibit object permanence. infants with IDA showed poorer recognition memory than infants without IDA (Carter *et al.*, 2010). Symptoms from IDA result from the reduction in the oxygen supply to the tissues and this usually includes weakness, tiredness, and difficulty in concentrating (Haas & Brownlie, 2001).

2.7.2 Effects on maternal and child health

Iron deficiency anaemia, particularly when severe, is associated with increased risk of preterm labor, low birth weight, and maternal and child mortality and has been strongly associated with renal dysfunction and heart failure (Rasmussen, 2001), (Brabin *et al.*, 2001) (O'Meara *et al.*, 2014). Rahman *et al.*, (2016) conducted a systematic review and meta-analysis aimed at estimating the prevalence of anaemia between maternal anaemia and pregnancy outcomes, and the fraction of the population that these outcomes due to anaemia were attributable to in low-and-middle-income countries. They also performed a meta-regression and stratified analysis to investigate the effects of the study and participants' characteristics on adverse pregnancy risk. Their results showed that 42.7 percent of the women experienced anaemia during pregnancy. These anaemic women also had a greater risk of having low birth weight children (RR: 1.31; 95% CI: 1.13, 1.51), of having a preterm birth (RR: 1.63; 95% CI: 1.33, 2.01) and also neonatal mortality (RR: 2.72; 95% CI: 1.19, 6.25). There was a significantly higher risk of low birth weight, preterm birth, perinatal mortality (RR: 1.51; 95% CI: 1.30, 1.76), in anaemic pregnant women. Generally, in countries that are less developed, maternal anaemia was responsible for up to 12 percent of low birth weight, 19 percent of preterm births, and 18 percent of perinatal mortality (Rahman *et al.*, 2016).

Another recent study that aimed at exploring the effects of maternal anaemia at different stages of gestation on postnatal growth in infants, used a cohort of pregnant Indian women and followed them in the second (n=211) and third trimester (n=178) and also followed the infants to three weeks postpartum (n=147). Their results revealed that infants of non-anaemic pregnant women in the second trimester were 0.26 heavier ($p<0.029$), 0.5 taller ($p<0.001$), and had 0.26 larger head circumference ($p<0.029$) compared to infants of anemic pregnant women (Menon *et al.*, 2016).

2.7.3 Effects on work capacity

A number of papers have shown a direct relationship between haemoglobin concentrations and physical work capacity in humans. The mechanism of this effect has been presumed to be the reduced oxygen transport associated with anaemia, and reduced cellular oxidative capacity of the tissues (Haas & Brownlie, 2001).

Haas & Brownie (2001) evaluated the casual relationship between iron deficiency and work capacity through a systematic review using 29 research articles. Their findings showed that there was a strong causal effect of severe and moderate iron deficiency on aerobic capacity in animals and humans. Endurance capacity and energetic efficiency was affected in iron deficient humans. They concluded that the reduced work productivity they observed in the participants were due to anaemia and reduced oxygen transport. This showed the need for interventions to improve iron status as a way of improving human capital (Haas & Brownlie, 2001). Also, Horton & Levin (2001), assessed the strength of the causal evidence that Haas and Brownlie (2001) presented and found out that both the laboratory and field experiments showed that the evidence is solid and asserted that the potential magnitude of the effect of iron-deficiency anaemia on work productivity is indeed large. However, they also commented that more attention had been paid to the laboratory studies than the human field studies in the Haas and Brownlie study (Horton & Levin, 2001).

Iron deficiency anaemia has also been shown to reduce physical work capacity in adolescent girls as shown by a study in India where the physical work capacity of under privilege anemic school girls were compared with their non-anemic counterparts. They reported using standard methods to assess the haemoglobin of the participants and they assessed physical work capacity using a modified Harvard's Step Test. They found that the non-anemic girls climbed a higher number of steps, and used a short time to revert to the recovery time than the anemic girls ($p<0.01$) (Sen & Kanani, 2006).

2.8 Linking forests to nutrition

The forest plays an important role in the livelihoods of many people by providing food, medicine, fodder, fuels and clean drinking water. It also provides products used for furniture, and construction (FAO, 2010).

Forests and agro-forests have been estimate to significantly contribute to the livelihoods of close to 1.6 billion people around the world (World Bank, 2008), but it has not often been clearly defined how much they contribute and to what extent do communities depend on tree products and services and also how these dependence changes over time is still very unclear. (Byron & Arnold, 1999).

Dietary diversity has been suggested to be one of the channels through which the forest contributes to the nutrition in humans by providing adequate nutrient intake although these links have only been shown in a few studies within the same populations (Powell, 2012).

A study in Tanzania using a cross sectional design of 274 households of mothers and their children under 5, showed that households which had greater tree cover near their homes were more likely to consume more wild and forest foods. This highlights the importance of tree cover and how forest contributes to increases in the amounts of micronutrient intakes (Powell *et al.*, 2011; Johns *et al.*, 2013). Also, Golden *et al*, 2011 examined how access to wildlife as a food source affected the risk of anaemia, and showed that children who consumed a greater quantity of wildlife had higher haemoglobin concentrations (Golden *et al.*, 2011).

Two recent studies have confirmed a link between dietary diversity and tree cover. Using Demographic Health Survey (DHS) data from 21 African countries, Ickowitz *et al.*, (2014) found that children living in communities with higher tree cover had higher dietary diversity. Johns *et al.*, (2013), also using DHS data from Malawi, found that children who lived in areas with no loss in forest cover were significantly more likely to have a diverse diet and to consume vitamin-A rich foods than children who lived in areas with a greater loss in forest cover.

2.8.1 Advantages of forest to nutrition

Forests provide a range of direct and indirect contributions to agriculture at different levels (Ash *et al.*, 2010). At a wide range, forests have been shown to contribute to the recycling of some nutrients, and also the suppression of some agricultural pests, detoxification of toxic chemicals, regulation of hydrological processes and genetic resources (Foley *et al.*, 2011). Forests also contribute to climate change mitigation, through its ability to absorb a significant amount of carbon emission which could positively impact on food production (FAO, 2014). Forests also play a vital role in providing ecosystem services like pollination, (Ricketts *et al.*, 2008) regulation of pests and microclimates (Kort, 1988). The forest also plays a role in preserving genetic diversity of species that are domesticated, wilds foods and also enhance the fertility of the soil thus encouraging agricultural productivity (Boyles *et al.*, 2011). A clear example is illustrated by Gallai *et al.*, (2009) where they report that 75 percent of the most important crop species profit from pollination services accounting for up to 153 billion Euros annually (Gallai *et al.*, 2009).

It has been estimated that farmer managed forest regeneration programs have doubled the yields of agriculture by up to 5 million hectares in African countries (Bromhead, 2012). The forest has also been shown to be an important source compost which is collected from the green foliage. This compost helps in increasing agricultural crop yields. (Sinu *et al.*, 2012). Forests have also been shown to be a direct source of food, fuel, fodder and medicines, which is a benefit for not only people living near it but also for those living far from it (Kuhnlein *et al.*, 2009). Bromhead (2012) estimated that close to 2.4 billion people, constituting almost 40 percent of the population in less develop countries, rely on fuel wood for cooking (Bromhead, 2012).

Forests have also been shown to contribute to dietary diversity. Icowitz *et al.*, (2014) reported higher dietary diversity among households living near forest cover across 21 African countries. A study by Golden et al (2011), showed that bushmeat is often the main source of animal protein available to forest and forest-boundary communities and this served as an important source of iron and fat, and contributed to diversifying diets. Koppert et al., (1996) estimated the hunting of bushmeat to provide 30 to 80 percent of the overall protein intake of rural forest dependent households in parts of Central Africa.

Another study by Nasi et al., (2008) also showed that bushmeat (wild harvested meat) was a significant contributor to protein and fat intake of many regions in Central Africa. The contribution of forest to nutrition, has also been seen in its provision of income for households which is later spent in buying foods in markets (Nasi et al., 2008).

2.8.2 Negative effects of forest to nutrition and health.

There may be negative impacts resulting from forests which influence agricultural production. Some of these include the presence of agricultural pests and disease which may reduce crop yields. Forest may also have pests that directly harm human health. This may lead to low intake of iron rich foods, resulting in inadequate absorption of dietary iron which contributes to the high prevalence of anaemia, especially in cases where it is as a result of infections such as hookworm and malaria (Allen & Gillespie, 2001).

Forest wildlife species like insects and ticks can spread disease pathogens and parasites to livestock and humans, such as malaria, rabies, Ebola, SARS, and many others (Colfer *et al.*, 2008) (Tomalak *et al.*, 2011). Diseases like malaria have been shown to increase or aggravate the severity of anaemia in Sub-Saharan Africa, and have been estimated that between two hundred thousand (200,000) and five hundred thousand (500,000) pregnant women develop severe anaemia resulting from malaria (WHO, 1992). Malaria in pregnancy has been shown to be the primary cause of up to 10,000 maternal anaemia related deaths in sub-Saharan Africa annually (Steketee *et al.,* 2001).

Parasitic infections like flukes, hookworms and whipworm, cause chronic blood loss which leads to iron loss resulting in the development of anaemia (Chitsulo *et al.,* 2000). Onyemaobi & Onimawo (2011) did a cross-sectional study of a total of four hundred children aged 6-60 months with the aim to determine risk factors for anaemia. Their results showed that the risk factors that was most associated with anaemia in children (12-60mo) was helminthic infections (Onyemaobi & Onimawo, 2011).

With the recent Ebola crisis in West African, it has been argued that the risk of being infected with Ebola from the consumption of bushmeat may instead create an opportunity for forest wild life species to be conserve by emphasizing the risk involved in consuming bushmeat (Williams, 2014).

2.9 Management of anaemia in women.

In combating anaemia in women of reproductive ages, it is important to treat the multiple causes of iron deficiency simultaneously. This includes both infections and any coexisting nutritional deficiencies. This is a recommended action before iron supplements should be given.

Fortification of foods with iron has been done in many developing countries (Allen *et al.,* 2006). However countries need to pay careful attention to the selection of fortificants including the oxidative effects of inorganic iron salts and other properties that may affect the organoleptic properties and shelf-life of the product.

Barkley *et al.,* (2015) using logistic regression, modelled the prevalence of anaemia for twelve (12) countries which had undergone flour fortification with iron and twenty countries which had never fortified flour with iron. They controlled for the effects of time, human development index (HDI) and malaria. After they adjusted for malaria and human development index, they found that each year of fortification was associated with a 2.4 percent reduction in the odds of anaemia prevalence (OR 0·976, 95% CI 0·975, 0·978). In comparison to countries that had never fortified flour before, they observed that there was no reduction in the odds of anaemia prevalence over the same period (OR 0·999, 95% CI 0·997, 1·002). Their results show that anaemia prevalence had significantly decreased in countries that fortified their flour with iron, and this did not change in countries that did not fortify their flour (Barkley *et al.*, 2015). There has been an increase in the application of strategies involving multi-micronutrient supplements to address micronutrient deficiencies (Allen *et al.*, 2009). Haider *et al.*, (2013) summarized the evidence on the associations of maternal anaemia and prenatal iron use with pregnancy outcomes; and also to evaluate the exposure-response relation to dose of iron in prenatal period with pregnancy outcomes. They systematically reviewed literature and did a meta-analysis using randomized trials (17 793 women) of prenatal iron use and prospective cohort studies (1851 682 women) of prenatal anaemia. Their results revealed that the mean haemoglobin concentration for mothers who used iron increased 4.59g/L (95% CI: 3.72 – 5.46) compared to women who did not take iron (controls). They also observed a statistically significant reduction in anaemia risk of 0.50 (0.42 - 0.59), also a reduction in iron deficiency of 0.59, (0.46 - 0.79), iron deficiency anaemia of 0.40 (0.26 - 0.60), and finally low birth weight of 0.81 (0.71 to 0.93) among the women who took iron. However they did not find any significant effect of iron on preterm birth (RR 0.84, 0.68 - 1.03). When they performed further analysis only on cohort studies, they found a higher risk of low birth weight and adjusted odds of 1.29 (1.09-1.53), and also of preterm birth 1.21 (1.13-1.30) among women who were anaemic in the first or second trimester. They also observed that with every 10mg - 66mg increase in the dosage of iron given per day, the relative risk of maternal anaemia was as low as 0.88 (0.84-0.92) in their expose response analysis (Haider *et al.*, 2013).

Another study by Fernández-Gaxiola (2011) with the aim to investigate the impact of intermittent oral iron supplementation, used 21 trials with a total of 10,258 women participants. Their results showed that comparing those who had intermittent iron supplementation to those of the placebo group, there was a significant reduction in the risk of having anaemia (RR 0.73; 95% CI 0.56 to 0.95). The iron supplementation also significantly increased the mean haemoglobin concerntration (4.58g/L, 95% CI 2.56 to 6.59) and feritin levels by (8.32 μg/L 95% CI 4.97 to 11.66) of the intervention group. (Fernández-Gaxiola & De-Regil, 2011). This supports the evidence that anaemia in women could be reduced by iron supplementation (WHO, 2015)

In the fight against anaemia and iron deficiency in particular, similar elements may be employed in both developed and developing countries taking into consideration cultural and local contexts as these need particular emphasis. The most important component of the approach to scale down anaemia has to do with minimizing iron loses from helminths and other intestinal parasites. Also, ensuring adequate diets and nutrition in general. It is also important to incorporate effective dietary and iron supplementation (Lutter, 2008).

A study by Richardso *et al.*, (2011) revealed a significant decrease in the frequency of anaemia from 75.8 percent to 49.1 percent with a simultaneous decrease in the prevalence of clinical malaria, indicating decreasing malaria will mitigate anaemia (Richardson *et al.*, 2011).

Governmental programs are needed to support these interventions which will help in achieving the needed results in anaemia reduction. National, regional, and local governments need to recognize the health and socioeconomic benefits in reducing the prevalence of anaemia (Hunt, 2003). Not only the government, but the population could take upon themselves to undertake certain basic health and sanitary measures which could help reduce some of the causes of anaemia.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study sites

The Republic of Cameroon has a total population of 23,925 184 people and a total land area of 475,440 km2 and is bordered by Chad to the north, Nigeria to the west, Congo, Gabon, Equatorial Guinea to the south and has a 350-km stretch of the Atlantic Ocean coastline to the southwest (World Bank, 2016) (Comiskey *et al.*, 2003).

The Takamanda rainforest, located in the northern most corner of the Southwest Region and northeast of the extensive Cross River Valley, is part of the Guinea-Congolean forest. It covers an area of 67,599 hectares and stretches along the eastern border of Nigeria (Gartlan, 1989).

The topography the area is undulating. The Southern part is lowland and the slope increases as one moves northward. The Northern highland areas are very mountainous with very steep hills and slopes. The altitude ranges from about 200m above sea level from the Southern lowlands to about 1700m in the Northern highlands (Mdaihli *et al.*, 2002).

The study was carried out in eight (8) villages in the Takamanda lowlands and highlands in the Southwest Region of Cameroon. The Takamanda area was selected for the study because it is one of the less developed areas of the country with high rates of malnutrition. Furthermore the presence of an on-going nutrition and forestry research project by the Centre for International forestry research (CIFOR) in the area enabled logistic support for the study. The previous study classified villages as either forest villages if they were less than 500m from nearest forest cover or non-forest villages if they were more than 500m from the nearest forest cover. Villages for this study were randomly selected from the nine forest and five non-forest villages that were part of a scoping assessment of the Takamanda area for the CIFOR study. The study sites for the present research included eight villages made up of four villages from the nine forest villages, and four villages from the non-forest villages which were randomly selected.

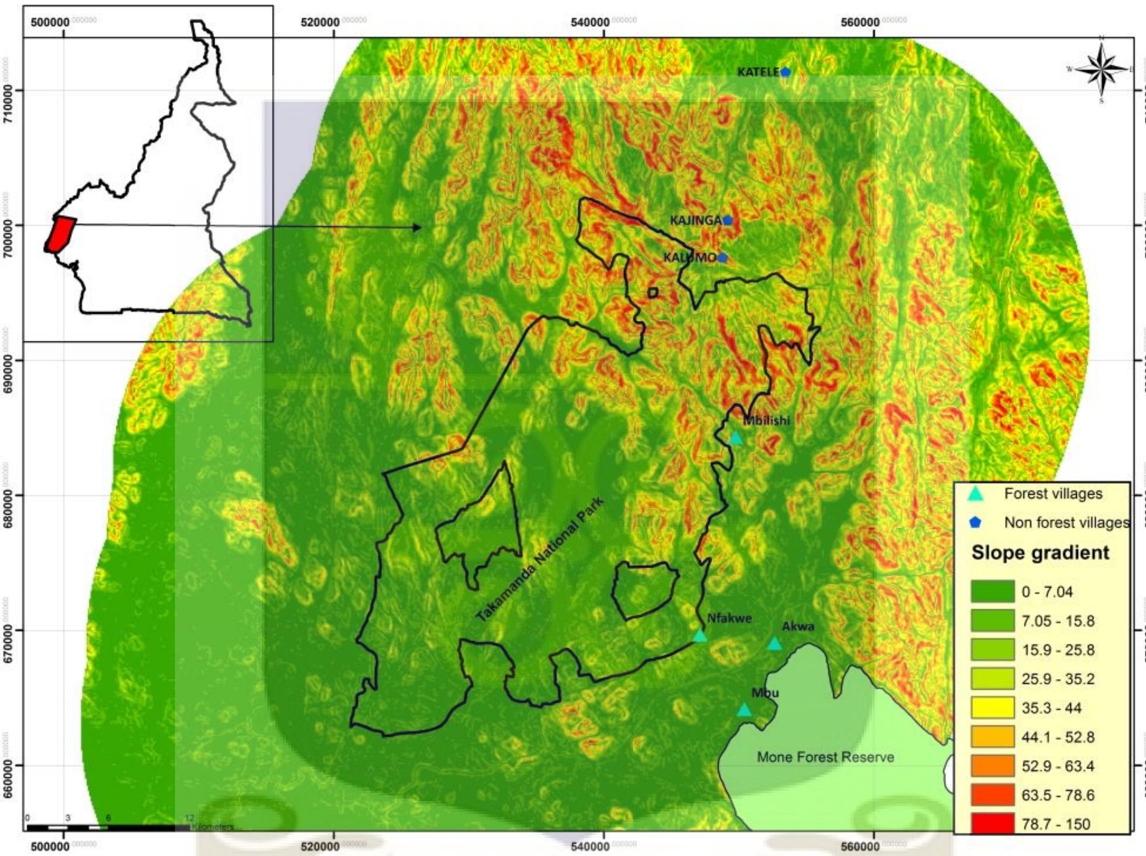

Figure 2. Map of study site

3.2 Study design

The study used a comparative cross-sectional design.

3.3 Study population

The study population was adult women of reproductive age (18-49 years) resident in the selected villages at the time of the study. Participants were considered eligible if there were resident in the area for at least one year, were apparently healthy and willing to participate in the study.

3.4 Sample size determination

The sample size for the study was estimated based on detecting a mean difference in Hb of 0.5g/dl between the two means with a two-sided 5% significance test and 80% power. Using the G-power statistical software (G*Power version 3.1.9.2), an estimated sample size of 110 per group. When we added a 10% contingency per group, a total sample size of 240 (i.e. 120 per group) was obtained.

The number of participants who were recruited from each village was determined using proportionate weighting as follows;

$$\frac{\text{Estimated number of women per village (obtained from census)}}{\text{Total number of women for each area (forest or non-forest)}} \times \text{Total Sample Size}$$

The results for the proportionate weighting are presented in table 1 below.

Table 1. Number of women sampled from each village by weighting

Forest villages	Total N	Sampled No	Non-forest villages	Total N	Sampled No.
Village 1	65	40	Village 1	58	42
Village 2	64	36	Village 2	27	20
Village 3	35	20	Village 3	29	21
Village 4	50	30	Village 4	52	38
Total	**214**	**126**	**Total**	**166**	**121**

3.5 Sample selection

Simple random sampling was used in selection of participants using the list of households obtained from a census of eligible women 21-49 years in each community. Using the census list as a sampling frame, each household was assigned a unique number and were written on pieces of papers. The papers were then thoroughly mixed in a bowl. Then without looking, the researcher selected the required number of households without replacement. The households which were selected were then included in the sample. The list of selected participants was done on the same day of the census for each village. If selected participants were absent, they were replaced by the same method. The objectives, potential risks, voluntary nature of and confidentiality of the haemoglobin testing procedures were explained to each study participant as part of the informed consent process.

3.6 Data collection

Data collection took place from the 8th – 29th of February 2016. Data collection included questionnaire administration, dietary intake assessment, anthropometric measurements and biochemical assessment of anaemia status as detailed below.

3.6.1 Questionnaire administration

A structured questionnaire instrument was used to obtain information from study participants. The questionnaire had four sections; socio-economic, reproductive history, health seeking behaviour, and forest use.

Questions on marital status, occupation, education, size of household, sources of drinking water, type of toilet facility, household assets, and household ownership were asked under the socio-economic section.

Questions about the women's reproductive history which included asking whether the women had ever been pregnant, the number of live births they had, and their current pregnancy status.

Questions on malaria, worm infestation and health seeking behaviour were asked.

Questions relating to the use of forest for the treatment of these diseases and the use of the forest for income (types of forest products collected for income generation) were also asked.

This questionnaire was administered by face-to-face interviews in Pidgin English at the homes of every eligible household after sampling was done. It was administered at the homes of the participants at the time of their convenience. The questionnaires were also pretested in two rural communities before the start of data collection. Each enumerator pretested 3 questionnaires each a month before data collection.

3.6.2 Dietary intake assessment

The 24hour recall method was used to collect information on the women's dietary intake in the last 24-hours. The participants were asked to recall all foods and beverages except water eaten in the past 24 hours. This was a qualitative 24-hour recall based on the FAO guidelines for measuring the minimum dietary diversity for women (FAO, 2016). The minimum dietary diversity, is a dichotomous indicator of whether or not women 15-49 years of age have consumed at least five out of ten defined food groups the previous day or night. The proportion of women who reach this minimum in a population can be used as a proxy indicator for higher micronutrient adequacy (FAO, 2016).

3.6.3 Anthropometric measurements

In each village a workstation was set up at a central location (e.g. Chiefs palace, community hall, or the primary school) for the anthropometric assessments. The women's heights and weights were measured using standard procedures as described by WHO protocol in each village (WHO, 2008). Women's weight was taken to the nearest 0.1 kg using a portable digital Tanita weighing scale and their heights were measured to the nearest 0.1 cm using a portable SECA™ Stadiometer.

3.6.4 Biochemical assessment

Haemoglobin concentrations of the women were determined on site using a battery operated portable HemoCue 201+ analyzer. The middle finger was used for the sampling. The puncture site was cleaned and wiped dry using alcohol swap (70% alcohol). The finger was pressed lightly from the top knuckle to the tip in order to stimulate the flow of blood to the sampling point. A lancet was used to prick the finger. The first drop of blood was wiped away with a dry absorbent pad (cotton wool). This stimulates spontaneous blood flow and to avoid any tissue fluid that may give false readings. The next blood flow (10µl) was used for haemoglobin estimation. Dried cotton wool was put at the pricked area to stop further bleeding. Values were recorded in grams per deciliters (g/dl). Women were classified as having anaemia if they had a haemoglobin level <12g/dl, and <11g/dl for non-pregnant and pregnant women respectively. Results were also given to each study participant. Women with severe anaemia (haemoglobin less than 7g/dl for non-pregnant women or less than 9 g/dl for pregnant women) were provided with a written referral form to the nearest community health center. And also counselled on foods to eat to help build up iron levels.

3.7 Data analysis

Data entry and analysis were done using Statistical Package for Social Sciences (SPSS) version 20.0. Descriptive statistics were summarized as means and standard deviations for continuous variables and frequencies and percentages for categorical variables (Table 2). The prevalence of anaemia was calculated from the Hb results within each group. Independent t-test was used to compare haemoglobin levels of both populations. Cross tabulations (bivariate analyses) were done for each sociodemographic and dietary factor against anaemia. A chi-square analysis was done to test the association for cross tabulations. Variables that were significantly associated with anaemia at 0.1 significance level, were added to the logistic regression model. Since bivariate analyses do not consider confounding effects, the logistic regression analysis was used to determine variables significantly related to anaemia prevalence and the relative contribution of each of the predictors to the total variance was established.

In the logistic regression, anaemia was used as the dependent variable with no-anaemia as the reference category. Sociodemographic factors (educational, marital status, type of toilet, type of community, parity, age etc.) and the dietary factors (consumption of pulses, bushmeat, fish, DGLV and dairy) were considered as the independent variables. In the model, all sociodemographic and dietary factors were entered in one block using one category as a reference category for each factor. For instance regarding consumption of pulses, women who said ‘Yes’ was used as the reference category to which the likelihood of anaemia was compared to those who did not consume pulses. The R^2 of the model and the significance of each predictor variable were obtained. The resulting regression coefficients revealed the decreased or increased chance of being anaemic considering the effect of the independent variables. Thus, the likelihood of being anaemic was reported and interpreted using odds ratios (Exp β) with confidence intervals where estimates of odds greater than 1.0 were indicative of higher risk of anaemia than that of the reference category while odds ratios less than 1.0 indicated a lower risk of being anaemic compared to the reference category.

The minimum dietary diversity score was calculated based on 10 food groups (FAO, 2016). If a woman ate from 5 or more food groups, she was classified as having obtained the minimum diversity score.

Table 2 Summary of data analysis

Objectives	**Variable(s)**	**Analysis**
Descriptive characteristics	Sociodemographic, anaemia, dietary, variables	Means± SD (continuous variables)N (%): (categorical variables)
Compare the prevalence of anaemia between women living in forested and non-forested areas	Hb (g/dl) Hb cutoff for anaemia	T-test Chi-square
Compare intakes and sources of iron rich foods among women living in forested areas and non-forested areas.	Iron rich food groups (ASF, DGLV, Legumes, dairy products) Sources: forest vs. non-forest sources	Chi-square

Identify predictors of anaemia among women in the study.	Dependent – Anaemia (Y/N) Independent – SES, forest vs non-forest residence, Anaemia related morbidity etc.	Logistic regression

3.8 Ethical consideration

This research was approved by the Ethics Committee of Basic and Applied Sciences University of Ghana and the National Ethical committee of research for human health Cameroon (Appendix III).

Community level approval and participation was also sought from village governments. This approval was not used as a substitute or to influence individual prior free and informed consent.

Individual written informed consent was also obtained from all study participants. This was explained in pidgin-English and consent was obtained by a signature or a thump print.

As part of consent, the women were given a tablet of soap to compensate for their time (an equivalent of one dollar).

3.9 Quality control

3.9.1 Enumerators and training

Four Enumerators (3 female and a male) were hired with the help of a local NGO, Forests, Resources and People (FOREP). They were all between the ages of 20-30 years. They all held university degrees and had previous experience in collecting data for nutrition research projects. In order to ensure comparability across sites and the highest quality data possible, before field work all four enumerators were trained, and had to complete 3 pilot questionnaires. During the training, each research tool was reviewed and practiced to ensure familiarity with research goals and harmonization of techniques. The team was also familiarized with the local situation in Takamanda forest and sensitized on local issues.

During the data collection, each questionnaire was reviewed by the principal investigator to check for omissions and any irregularities each day. Enumerators were also provided with a quality assurance logbook to record critical information to ensure the HemoCue machine was maintained in good operating order throughout the survey. The body scale and stadiometer was also calibrated each day before use.

CHAPTER FOUR

4.0 RESULTS

4.1 Socio-demographic characteristics of women in the study

Among the eight villages surveyed, four were from a forest area and four from a non-forest area. Of the forest area, 126 women were interviewed and of the non-forest area, 121 women were interviewed.

The mean age of the women was 29.7 ± 7.03 (Table 3). About 61 percent of the women were married and almost half (46%) of them did not have any formal education with significantly more of the women from the non-forest villages having no formal education ($p<0.001$). Farming was the main occupation for both groups of women. Women from forest-based communities were mostly of Anyang ethnicity while the non-forest village women were predominantly of Becheve ethnicity. Christianity was the dominant religion for both groups of women and more than two thirds of them were part of a savings group at the time of the study. Mean parity was significantly higher for the forest women (5.1 ± 2.6 vs. 4.8 ± 2.3; $p=0.01$) than then non-forest women (range: 0 -11).

Table 3. Sociodemographic characteristics of women in the study

Characteristic	Total (N=247)	Forest (n=126)	Non-forest (n=121)	[1]P-Value
Age (y)	29.7±7.03[2]	28.8± 7.13	29.7±6.96	0.84
Marital status				
Single	60 (24.3)[3]	36 (28.6)	24 (19.9)	0.03
Married	151 (61.1)	74 (58.7)	77 (63.5)	
Cohabiting	36 (14.6)	16 (12.7)	20 (16.5)	
Education				
None	115 (46.6)	24 (19.0)	91 (75.2)	<0.01
Preschool	19 (7.7)	15 (11.9)	4 (3.3)	
Primary or more	113 (45.7)	87 (69.1)	26 (21.5)	
Occupation				
Farmer	224 (90.7)	113 (89.7)	111 (91.7)	0.01
Trader	11 (4.5)	2 (1.6)	9 (7.4)	
Other	12 (4.8)	11 (7.2)	1 (0.8)	
Ethnicity				
Anyang	101 (40.9)	94 (74.6)	7 (5.8)	<0.01
Becheve	113 (45.7)	0 (0)	113 (93.4)	
Basho and other	33 (26.2)	33 (26.2)	0 (0)	
Religion				
Christian	227 (91.9)	115 (91.3)	112 (92.6)	0.24
Traditional belief	18 (7.3)	11 (8.7)	7 (5.8)	
Other	2 (0.8)	0 (0)	2 (1.7)	
Savings group				
No, never	33 (13.4)	16 (12.7)	17 (14.0)	0.91
Yes in the past	26 (10.5)	14 (11.1)	12 (9.1)	
Yes, presently	118 (76.1)	96 (76.2)	92 (76.0)	
Ever pregnant				
Yes	242 (98)	123 (97.6)	119 (98.3)	0.68
No	5 (2)	3 (2.4)	2 (1.7)	
Currently pregnant				
Yes	25 (10.1)	11 (8.7)	14 (11.6)	0.45
No	222 (89.9)	115 (91.3)	107 (88.4)	
Parity	4.7±2.531	5.11±2.642	4.28±2.346	0.01

[1]Significance associated with Independent t-test for continuous variables or Pearson's chi-square for categorical variables, [2]Mean±SD, [3]n (%).

4.2 Household characteristic of women in the study

Household characteristics of the study participants are summarized in Table 4. The mean household size was 8 ± 3.77. Majority of the women lived in extended family compounds and most of their homes had mud walls and floors (93%) and aluminum roofing (57%) and the main type of bed used was mattress. Firewood was the main source of fuel for cooking for almost all the women. However, the forest women spent significantly less time fetching firewood compared to the non-forest women ($p<0.01$). Majority of the households (66.8%) used solar lanterns as their source of light at night, and more women from the forest used solar lanterns than those from the non-forest villages (85% vs. 50%; $p<0.01$). Moreover, most of the households in the non-forest area used the bush for toilet compared to households from the forest areas (57.9% vs. 19%; $p<0.01$). The main source of drinking water was from streams or rivers and only 2 percent of the households treated their water before drinking and significantly more women from the non-forest villages, owned animals than women in the forest villages (96% vs. 80%; $p<0.01$).

Table 4. Household characteristics of study participants

Characteristic	Total (N=247)	Forest (n=126)	Non-forest (n=121)	[1]P-value
Household size	8.18±3.77[2]	8.75±4.31	7.62±3.24	0.02
Number of rooms	3.86±1.75	3.85±1.89	3.88±1.61	0.27
Living arrangement				
Extended family compound	128 (51.8)[3]	60 (47.6)	68 (56.2)	0.27
Owned single family dwelling	118 (47.8)	65 (51.6)	53 (43.8)	
Rented compound	1 (0.8)	1 (0.4)	0 (0)	
Type of house				
Mud	230 (93.1)	111 (88.1)	119 (98.3)	0.01
Other[4]	17 (6.8)	15 (11.9)	2 (1.7)	
Type of roof				
Aluminum	141 (57.1)	61 (48.4)	80 (66.1)	0.01
Thatch	106 (42.9)	65 (51.6)	41 (33.9)	
Type of floor				
Mud	229 (92.7)	111 (88.1)	118 (97.5)	0.01
Cement	18 (7.3)	15 (11.9)	3 (2.5)	
Type of bed				
Mattress	150 (60.7)	82 (65.1)	68 (56.2)	0.15
Mat	86 (34.8)	37 (29.4)	49 (40.5)	
Bare floor	11 (4.5)	7 (5.6)	4 (3.3)	
Type of fuel used in cooking				
Firewood	245 (99.2)	125 (99.2)	120 (99.2)	1.00
Kerosene	1 (0.8)	1 (0.8)	1 (0.8)	
Distance to fuel source (minutes)	87.86±59.25	66.67±47.04	109.05±71.55	<0.01
Source of light				
Solar lanterns	165 (66.8)	107 (84.9)	58 (47.9)	<0.01
Torch	52 (20.8)	4 (3.2)	48 (39.7)	
Kerosene lanterns	30 (12.1)	15 (11.9)	15 (12.4)	
Type of toilet facility				
Private pit latrine	68 (27.5)	53 (42.1)	15 (12.4)	<0.01
Compound pit latrine	84 (30.4)	48 (38.1)	36 (29.8)	
Bush	95 (38.5)	25 (19.8)	70 (57.9)	
Source of drinking water				
River or streams	247 (100)	126 (100)	121 (100)	0.33
Treatment of drinking water				
No Treatment	242 (98.0)	125 (99.2)	117 (96.7)	
Treatment(boil/filter)	5 (2.0)	1 (0.8)	4 (3.3)	0.34
Animal ownership				
Yes	217 (87.9)	101 (80.2)	116 (95.9)	<0.01

[1]Significance associated with Independent t-test for continuous variables or Pearson's chi-square for categorical variables, [2]Mean±SD, [3]n (%). Others[4]; refers to cement and thatch.

4.3 Forest contribution to household income of women

Most of the women (51%) were involved in a forest income generating activity (Table 9). The forest contributed significantly more to the household income of the forest women compared to the non-forest women (96.8% vs. 27.3%; p<0.01). Majority of women carried out this activity by themselves and more than a third (40%) reported getting assistance from their partners. The forest products which were mostly sold for income generation were nuts and seeds (56%), bushmeat (22%), and wild vegetables (4%). The women from the forest villages reported significantly higher amounts of all three products than the non-forest women, p<0.01. They also reported obtaining 25-100% of their household income from the forest compared to the non-forest women (97% vs. 26%; p<0.01).

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Table 5. Forest contribution to household income of women.

Variables	Total Sample (N=247)	Forest (n=126)	Non-forest (n=121)	[1]P-Value
Involved in forest income activities				
Yes	146 (51.1)	121 (96.0)	25 (20.7)	<0.01
Person involved				
Self	138 (55.9)	117 (92.9)	21 (17.4)	<0.01
Spouse/Partner	100 (40.5)	80 (63.5)	20 (16.5)	<0.01
Other[3]	93 (37.7)	83 (65.7)	10 (8.3)	<0.01
NTFPs contributing to HH income				
Bush meat				
Yes	55 (22.3)	45 (35.7)	10 (8.3)	<0.01
Wild vegetable				
Yes	84 (34)	79 (62.7)	5 (4.1)	<0.01
Seeds and Nuts				
Yes	140 (56.7)	119 (94.4)	21 (17.4)	<0.01
Percent contribution to HH income				
None	92 (37.2)	4 (3.2)	88 (72.8)	<0.01
Up to 25%	71 (28.7)	52 (41.3)	19 (15.7)	
26 to 50%	55 (22.3)	42 (33.3)	13 (10.7)	
50 to 100%	29 (11.8)	28 (22.2)	1 (0.8)	

[1]Significance associated with Independent t-test for continuous variables or Pearson's chi-square for categorical variables, [2]n (%), Other[3]referes to children, parents, relatives.

4.4 Dietary intake and minimum dietary diversity of women

Dietary intake of participants are summarized in Figure 3. All of the women in both areas consumed starchy staples such as grains, roots and tubers or plantains in the past 24-hours. Compared to women from non-forest villages; women from the forest-based villages were significantly more likely to have consumed vitamin A rich fruits and vegetables (98% vs. 92%; $p=0.04$), nuts and seeds (88% vs. 46%; $p<0.01$), and bushmeat and fish (84% vs. 68%; $p<0.01$). However, compared to women from forest-based villages; women from the non-forest villages were significantly more likely to have consumed other vegetables (50% vs. 22%; $p<0.01$), and pulses (29% vs. 18%; $p=0.03$). Overall, most of the women (61%) met the minimum dietary diversity score of ≥5 food groups. There was however no difference in meeting the minimum dietary diversity scores between forest and non-forest women. Women from forest-based villages ate from more food groups (8), than the women in the non-forest villages women (7) (Fig. 4). Also, more women from the forest ate from 5 (42%) and 6 (20%) food groups than the non-forest (37%) and (16%) respectively. However, there was no significant difference between the groups.

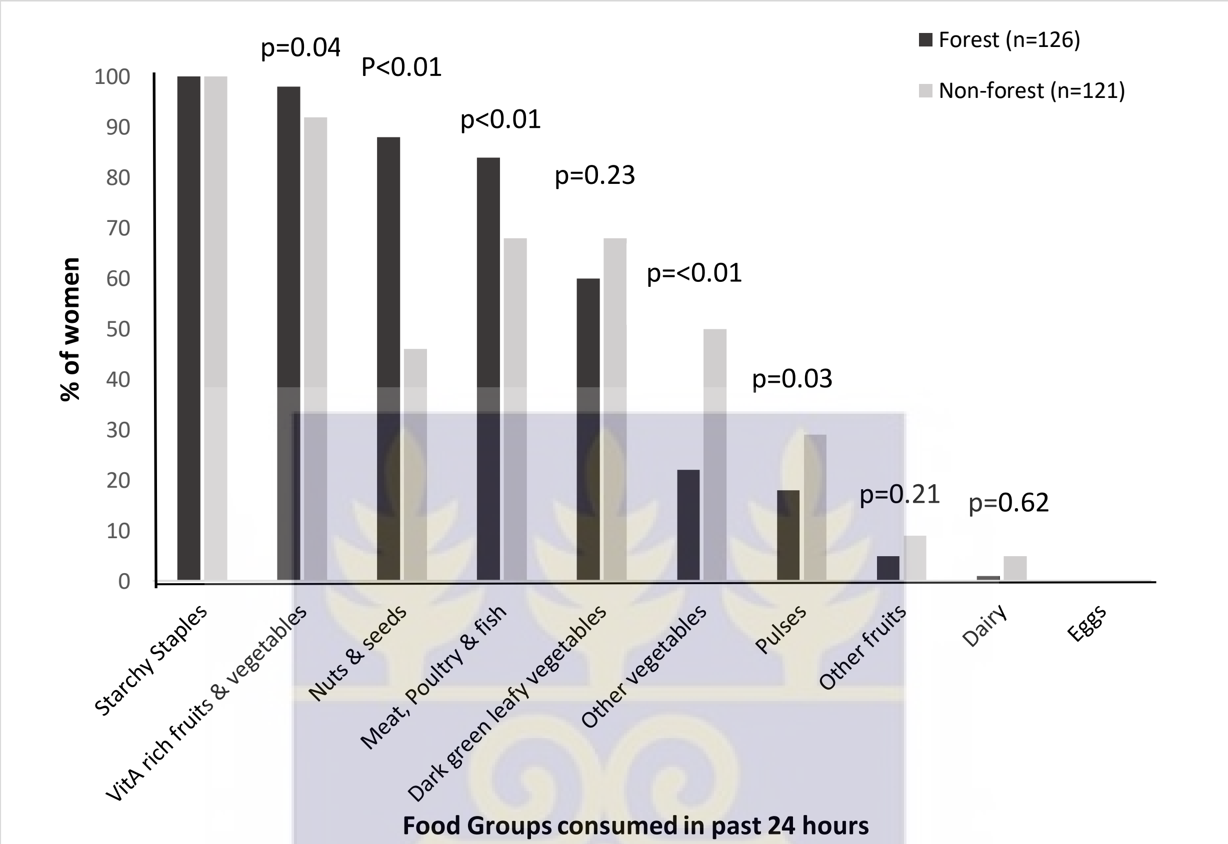

Figure 3. Food groups consumed by women in the past 24 hour

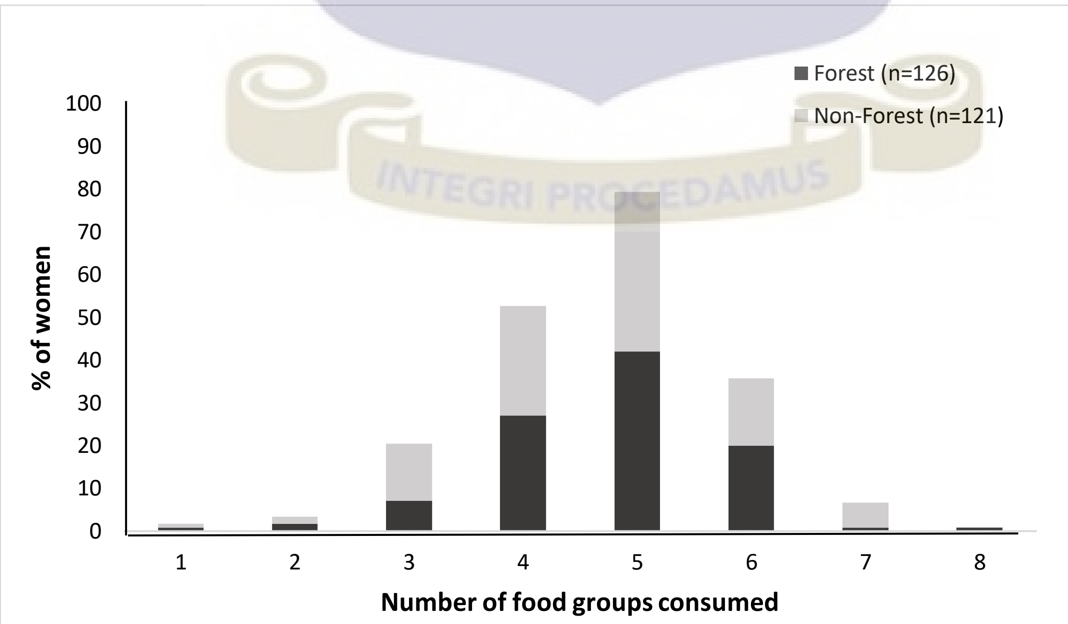

Figure 4. Food groups diversity score (out of 10 groups)

4.5 Sources of Iron rich foods

Sources of iron rich foods consumed in the previous 24-hours included, forest, own farm, purchased, and other sources (gifts) (Fig 5). Animal source foods were mostly purchased in both communities, however, the forest women obtained a significantly higher amount from the forest than the non-forest women (25% vs. 3%; $p<0.01$). For dark green leafy vegetables, the forest women reported obtaining a significantly higher amount from the forest than the non-forest women (70% vs. 1%). The non-forest women mostly obtained the dark green leafy vegetables from farm sources (94%) $p<0.001$. Also, a significantly higher amount (67%) of other vegetables were reported by the non-forest women to have come from farm sources compared to that reported by forest women (67% vs. 37%; $p<0.01$). Also, the forest women reported significantly higher amounts of nuts and seeds sourced from the forest than the non-forest women, whereas these foods were more likely to be from their own farms or purchased by the non-forest women (51% vs. 4%; $p<0.01$). Pulses and Dairy were mostly purchased in both communities, and other fruits mostly came from farm sources.

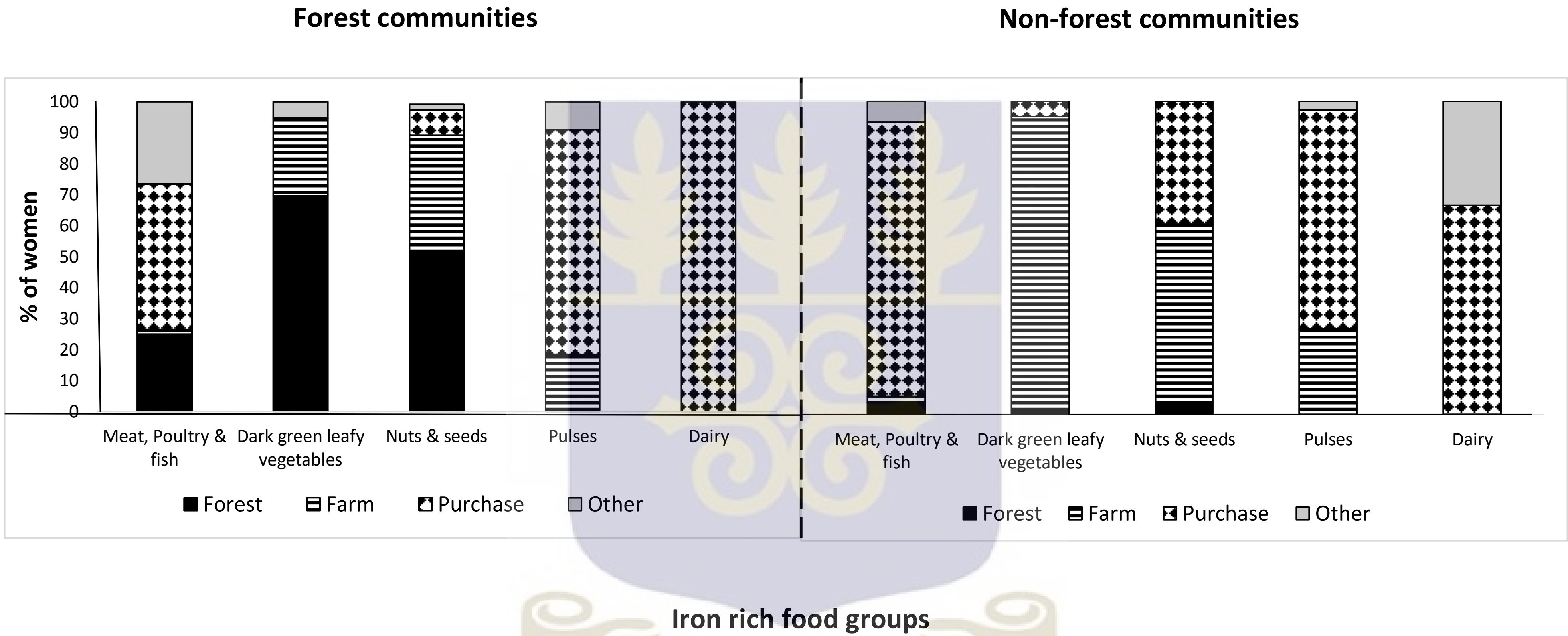

Figure 5. Sources of iron rich food groups for forest and non-forest communities

4.6 Nutritional status of participants

The mean haemoglobin concentration for all women in the study was 10.89 ± 1.54 (Table 5). Compared to women from non-forest villages the forest women had a significantly higher mean haemoglobin level (11.10 ± 1.53 vs. 10.68 ± 1.55; p=0.03. The total prevalence of any anaemia was 75.3% and there was no significant group difference in the prevalence of anaemia among the women. The majority (64%) of the women had moderate anaemia, while about one-third had mild anaemia and less than 5 percent had severe anaemia.

According to the BMI classification, majority of women were normal (71.3%), and about 3 percent of the women were underweight, 22.3 percent of them where overweight and 3.6 percent were obese. There was no statistical difference between the two groups.

Table 6. Nutritional status of women

Characteristic	Total Sample (N=247)	Forest (n=126)	Non-forest (n=121)	[1]p-value
Haemoglobin (g/dl)	10.89±1.54[2]	11.10±1.53	10.68±1.55	0.033
Anaemia classification				
Mild	60 (32.3)[3]	34 (37.4)	26 (27.4)	0.17
Moderate	118 (63.4)	55 (60.4)	63 (66.3)	
Severe	8 (4.3)	2 (2.2)	6 (6.3)	
Presence of Anaemia				
Any Anaemia	186 (75.3)	91 (72.2)	95 (78.5)	0.252
No anaemia	61 (24.7)	35 (27.8)	26 (21.5)	
BMI	24.5 (13.1)	23.5 (4.8)	25.5 (17.9)	
Underweight	7 (2.8)	2 (1.6)	5 (4.1)	0.428
Normal	176 (71.3)	93 (73.8)	83 (68.6)	
Overweight	55 (22.3)	28 (22.2)	27 (22.3)	
Obese	9 (3.6)	3 (2.42)	6 (5.0)	

[1]Significance associated with Independent T-test for continuous variables or Pearson's chi-square for categorical variables, [2]Hb adjusted for altitude, Mean ± SD, [3]n (%).

4.7 Anaemia related morbidity

More than a third (35%) of the women involved in the study reported having had malaria in the two weeks preceding interview. Compared to women from forest-based villages; women from the non-forest villages were significantly more likely to have had malaria (27% vs. 43%; p=0.01), and to have suffered from worm infestation (12.7% vs. 49.6%; p<0.01). Overall 8.5 percent of the women reported to have the sickle cell trait, while 28 percent of the women didn't know their status. Also, about a quarter (23%) of the participants reported to have suffered from blood shortage within the last six months prior to the interview.

Table 7. Anaemia related morbidity of women in the study

	Total (N=247)	**Forest (n=126)**	**Non-forest (n=121)**	**[1]P-Value**
Malaria (past 2 weeks)	87 (35.2)2	34 (27.0)	53 (43.8)	0.01
Worm infestation (past month)	76 (30.8)	16 (12.7)	60 (49.6)	<0.01
Sickle cell trait Yes	21 (8.5)	13 (10.3)	8 (6.6)	0.29
Experienced blood shortage (past 6 months)	55 (22.3)	28 (22.2)	27 (22.3)	0.98

[1]Significance associated with Pearson's chi-square for categorical variables, [2]n (%).

4.8 Health seeking behaviour for the treatment of anaemia related morbidity

More than one half of the women from the forest area reported going to the health post when they had malaria and almost half reported the same for the non-forest area (56% vs. 47; p=0.15). However, most of the non-forest women also reported buying medicine from a village pharmacist when they suffered from malaria than did the forest women (59% vs. 44%; p=0.01). When asked if they used forest based medicine for the treatment of malaria, more than half of the women from the forest area, reported using forest based medicine as compared to a third of the non-forest area (66% vs. 32%; p<0.01). Also, almost all of the women in the study (85.8) reported sleeping in mosquito nets as a means of anaemia prevention and there was no difference between the groups in the use of mosquito nets p=0.31.

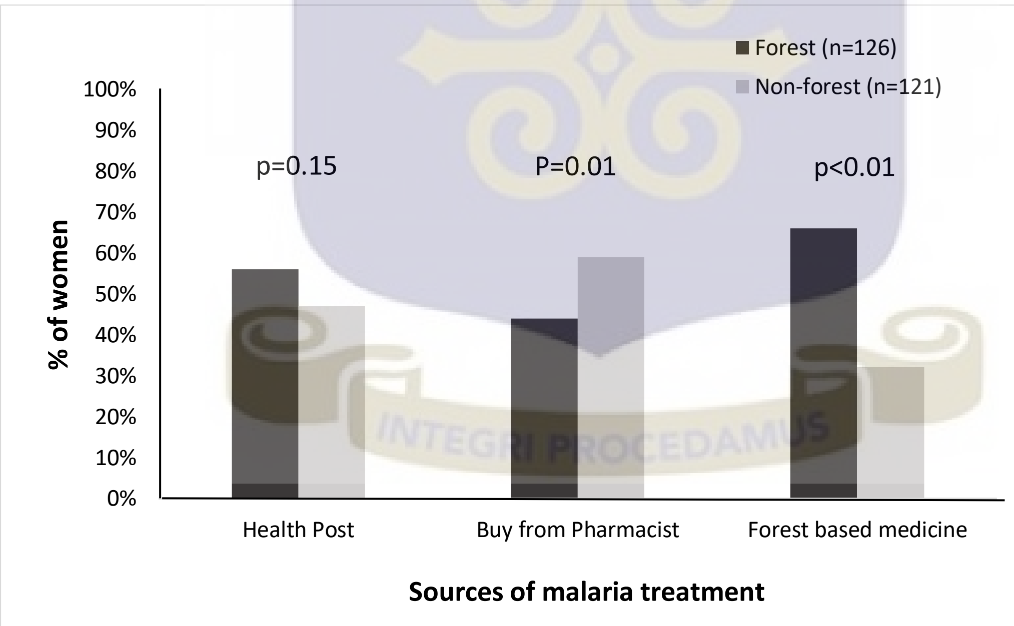

Figure 6. Health seeking behaviour for malaria treatment.

When asked about the methods used in treating worm infestation, about a third (30%) of the women from the forest areas, reported going to the health post as against 26 percent from the non-forest area. Also, 56 percent of the women from the forest area and 51 percent from the non-forest area, reported buying worm medications from a village pharmacist. Only 10 percent of the forest women and 17 percent of the non-forest women reported using herbs or forest based medicine for the treatment of worm. There was no statistical difference between the groups in all three methods of worm treatment.

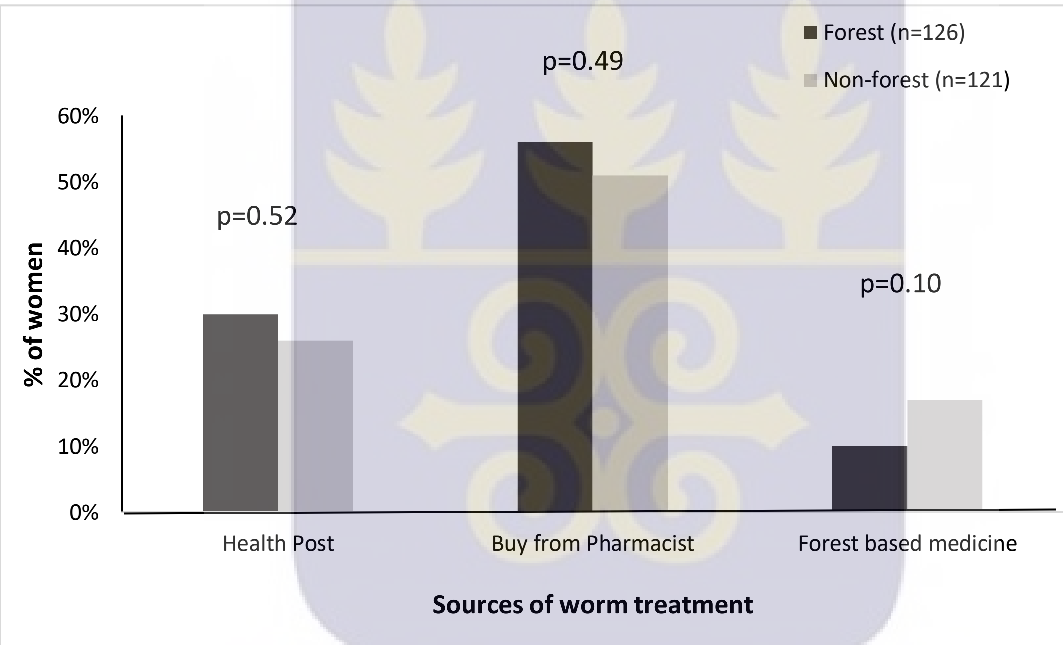

Figure 7. Health seeking behaviour for worm treatment.

4.9 Factors associated with anaemia among women in the study

Sociodemographic and household characteristics significantly associated with anaemia among the women included ethnicity, type of accommodation, and type of toilet facility (Table 8). Dietary factors that were significantly associated with anaemia among the women included consumption of pulses and consumption of other vegetables and fruits $p<0.05$. Other variables like consumption of animal source foods, consumption of dark green leafy vegetables and malaria etc showed no significance with anaemia.

Table 8. Factors associated with anaemia among women in the study.

Variable	Anaemia (n=186)	No Anaemia (n=61)	[1]p-value
Sociodemographic and Household			
Community type			
Non-forest	95 (51.1)	26 (42.6)	0.25
Ethnicity			
Anyang	67 (36.0)	34 (55.7)	**0.03**
Becheve	90 (48.4)	23 (37.7)	
Basho and other	29 (15.6)	4 (6.6)	
Accommodation			
Extended family compound	106 (57)	23 (37.7)	**0.01**
Owned single family	80 (43.0)	38 (62.3)	
Toilet			
Pit latrine	106 (57.0)	46 (75.4)	
Bush	80 (43.0)	15 (24.6)	**0.01**
Health and Morbidity			
Menses			
No	149 (80.1)	44 (72.1)	0.19
SS trait			
No	174 (93.5)	52 (85.2)	0.12
Malaria			
No	121 (65.1)	39 (63.9)	0.84
Worms			
No	125 (67.2)	46 (75.4)	0.23
Dietary			
Meat, poultry and fish			
No	46 (24.7)	13 (21.3)	0.59
Dark green leafy vegetable			
No	68 (36.6)	21 (34.4)	0.76
Pulses			
No	151 (81.2)	39 (63.9)	**0.01**
Other vegetables and fruits			
No	74 (39.8)	34 (55.7)	**0.03**
Fish and sea foods			
No	72 (38.7)	16 (26.2)	0.07
Minimum DD			
No	73 (39.2)	23 (37.7)	0.83

[1]Significance associated with Pearson's chi-square for categorical variables, [2]n (%).

4.10 Odds of having anaemia among women in the study.

Compared to women who owned single family dwellings, those who lived in extended family compounds were 2.4 times more likely to be anaemic (95% CI: 1.27-4.43: p=0.07). Also, compared to those who consumed pulses, those who did not, were 2.6 times more likely to be anaemic and this was also significant (95% CI: 1.32-5.13: p=0.006). Moreover, compared to those who used pit latrine as toilet, those who used open defecation were 2.24 times more likely to be anaemic and this was also significant (95% CI: 1.07-4.67: p=0.03). Also, compared to those who reported not having had worms in the last month, those who had worms were 1.4 times more likely to be anaemic (95% CI: 0.68 – 3.09: p=0.33). Non-forest residence did not show any relationship to anaemia (OR, 1.00, 95% CI: 0.47 – 2.13: p=0.45).

Table 9. Odds of having anaemia among women in the study.

Variable	Odds ratio	95% CI	[1]P-value
Type of accommodation			
Owned single family dwelling	1		
Extended family compound	2.374	1.27 - 4.43	0.007
Consumption of Pulses			
Yes	1		
No	2.60	1.32 - 5.13	0.006
Consumption of animal source foods			
Yes	1		
No	0.91	0.43 – 1.95	0.82
Type of toilet			
Pit latrine	1		
Bush	2.24	1.07 – 4.67	0.031
Worms			
No	1		
Yes	1.45	0.68 – 3.09	0.33
Community type			
Forest	1		
Non-forest	1.003	0.47 – 2.13	0.45

[1]Significance associated with binary logistic regression.

CHAPTER FIVE

5.0 DISCUSSION

Anaemia in women of reproductive age, has been reported to be a public health problem in most developing countries including Cameroon and it is known to be serious in women living in rural areas of low economic status (Stevens *et al.,* 2013). The present study aimed at investigating the relationship between forest cover, dietary intake and anaemia prevalence among women of reproductive ages in two different ecological areas. This discussion will be based on the objectives of the study.

5.1 Background of characteristics of women in the study

Farming was the most important economic activity and almost all the women (90%) reported farming as their main occupation. This is comparable to reports by Mdaihli *et al.,* (2002), in the same population where 80.95% of the adult population where involved in farming and in total, more women than men were involved in farming among the adult population (Mdaihli., *et al.,* 2002). Almost half of the women in this study did not have any form of education, this again is related to the very high percentage of young females (<16 years) reported by Mdaihli *et al.,* (2002) who did not have any form of education and instead assisted their parents on the farm or who had a farm of their own. The DHS 2011 in Cameroon also indicated that more women had never attended any formal education than men (20 percent women and 8 percent men). This may also be explained by the inaccessibility and enclaved nature of the area as reported by (Sunderland et al 2003), making it challenging for children to attend school in other nearby towns or villages. In this study, the average household size was 8.2 which is higher than 5.9 as reported by Mdaihli *et al.,* (2002), but similar to that in the study by Etiendem *et al.,* (2013) who reported an average household size of 7 (Etiendem *et al.,* 2013).

More than half (61%) of the women were married and about a quarter (24%) were single this also is comparable to works done by Mdaihli *et al.*, 2002 in the same general area and reported 63 per cent of the females were married and 20 per cent of them single. This suggests that there has not been a much change in the culture of the people. This study shows that the mean number of live births was 4.7 which is slightly lower than DHS 2011 national reports where the total fertility rate per rural woman was 6.4.

5.2 The prevalence of anaemia among women in the study

The nutritional status of a woman has important implications for her health and that of her children. Women with poor nutritional status have greater risk of adverse pregnancy outcomes as well as underweight babies (Rahman *et al.*, 2016). Our first objective was to compare the prevalence of anaemia between women living close to forest cover and those living further away from forest cover. In this study, women from forest-based villages had a slightly higher mean haemoglobin compared to women from non-forest villages. This could be as a result of the high consumption of animal source foods by the forest women and the low reports of infection (malaria and worm infestation). As these have been shown to have an impact on the haemoglobin status of humans.

Nutritional deficiencies, as a result of a lack of bioavailable dietary iron, account for about one-half of anaemia cases in the world (Balarajan *et al.*, 2012). The overall prevalence of anaemia for women in the study area was 75.3 percent. This is considered a public health problem based on WHO cutoffs, and is not uncommon for developing countries like Cameroon. This prevalence however is significantly higher than that reported by DHS Cameroon (2011) for the Southwest region which was 54%. The trends in anaemia prevalence in Cameroon shows a gradual decrease from 46 percent in 2004 to 40 percent in 2011 among women of reproductive age (CDHS, 2011).

Although more forest women reported consuming animal source foods and had more access to dark green leafy vegetables, the prevalence of anaemia among forest women did not differ from that of the non-forest women (Table 6). These results suggest that among other possible reasons, the anaemia in these populations may not be largely from nutritional deficiencies. Thus it highlights the importance of understanding the multifactorial etiology of anaemia in these populations.

The high prevalence of anaemia in our study, could also be alluded to the very low socioeconomic status of the women in both areas. This is consistent with studies done by Bentley & Griffiths (2003), among rural Indian women. Their results revealed that women who were poor, had the highest rates and odds of being anemic, and the prevalence of anaemia was consistently higher in people with low socioeconomic status, low body weight, and in females who had recently given birth (Bentley & Griffiths, 2003).

5.3 Intakes and sources of iron among women in the study

Diets in rural Africa are usually high in energy derived from the consumption of staples such as cassava, maize, and yam and are not usually high in animal source foods Chauvin *et al.*, (2012). Our second objective was to compare intakes and sources of iron rich foods among women living close to forest cover and those living further away from forest cover. Our results show that all of the women relied mostly on starchy based diets with 100 percent consuming this food group. This is similar to what was observed by Fungo *et al.*, (2016) among forest dependent households in Eastern and Southern Cameroon where rural households were consuming more starchy staple foods than other food groups (Fungo *et al.*, 2016). The high dependence on starchy staples could be as a result of the high production of starchy-based crops like cocoyam, cassava, plantain and yam, which are often used to prepare staple traditional dishes like ‘fufu’ or ‘akpu’ (made from fermented cassava).

In this study, women in the forest areas were also more likely to consume animal source foods (bushmeat, fish and poultry) compared to women in the non-forest areas. Our results are consistent with findings by Fa *et al.*, (2002) which revealed that the primary source of proteins for most rural populations in poor countries were wild animals (bushmeat), particularly for people living within or close to tropical forests of Central Africa (Fa *et al.*, 2002). This is also comparable to a study in rural villages of Gabon by Foerster *et al.*, (2012) who found that the consumption of bushmeat reduced as the distance from the village to the forest increased. In their study, bushmeat was the primary source of protein for all of the households but it was not a primary source of income. It represented an available alternative source of protein for each of the households (Foerster *et al.*, 2012).

Studies have shown that iron deficiency may occur where there is little meat intake and when diets are based mostly on staple foods with people exposed to infections that make them lose blood (Thomson *et al.*, 2011). Although more women from forest-based villages reported consuming animal source foods than the non-forest villages, there was no difference in the prevalence of anaemia. This may be as a result of malabsorption or other underlying causes of anaemia, which our study did not explore. However, the consumption of animal source foods (bushmeat, fish and poultry) is a preferred strategy for improving micronutrient status and therefore help in the growth and cognitive development in children in less developed countries (Neumann *et al.*, 2003). Our results also show that there was no single consumption of egg in the entire survey. Egg is a complete protein, and a good source of iron, a crucial micronutrient needed by women of reproductive age. This result was possibly due to taboos in the villages about women consuming eggs as reported in a previous nutrition study in this same area by CIFOR in 2014.

Vitamin A deficiency is one of the most challenging forms of micronutrient deficiencies with serious effects like blindness and cognitive impairment (Haddad *et al.*, 2014). A study by

Semba & Bloem (2002) suggests that vitamin A improves growth and differentiation of cells that enhance erythrocyte production, and boots up immunity thus reducing the anaemia of infection, and also mobilizes iron stores from tissues. Our results showed that women from the forest were more likely to consumed vitamin A rich foods than women in the non-forest. This this is consistent with findings by Ickowitz *et al.*, (2014) who found that children who lived near areas of no forest loss were significantly more likely to consume vitamin-A rich foods than children who lived in areas with loss in forest cover. This difference in the consumption of vitamin A rich foods, may have influenced the higher haemoglobin levels of the women in the forest areas as our results revealed. This is supported by findings from a study done by Zimmermann *et al.*, (2006), who measure the effect of vitamin A supplementation on haemoglobin in Moroccan children and found that vitamin A improved the mean haemoglobin of the children by 7 g/L ($p=0.02$) compared to those who did not take the supplement.

Our study also showed that more women from the forest-based villages consumed nuts and seeds than women from the non-forest villages. These nuts and seeds were mostly bush mango (*Irvingia garbonensis, irvingia wumbolo*) and Njansang (*Ricinodendron heudelotii*) which are non-timber forest products (NTFPs) which were mostly gathered from the forest. These seeds have been reported to be very nutrient dense and contribute to better nutritional status of the women (Fungo *et al.*, 2016). Contrary to our findings, a study by Termote *et al.*, (2012) revealed that wild edible plants and nuts were rarely consumed and did not contribute substantially to nutrition security or dietary adequacy in dense forest regions of DR Congo (Termote *et al.*, 2012).

The minimum dietary diversity, is a dichotomous indicator of whether or not women 15-49 years of age have consumed at least five out of ten defined food groups the previous day or night. The proportion of women who reach this minimum in a population can be used as a proxy indicator for higher micronutrient adequacy (FAO, 2016). From our results, more than half of the women (61%) consumed at least 5 of the ten food groups the previous day. This shows that the women were likely to meet their micronutrient requirements. This is contrary to the findings of Fungo *et al.*, (2016) who reported a low dietary diversity for rural women in Southern and Eastern Cameroon. The minimum dietary diversity is however a population-level indicator based on a recall period of a single day and night, so although data were collected from individual women, the indicator cannot be used to describe diet quality for an individual woman. This is because of normal day-to-day variability in individual intakes (FAO, 2016).

5.4 Predictors of anaemia among women in the study

In this study, women who lived in extended family compounds were two times more likely to be anaemic than those who owned single family houses. This may be as a result of low socio-economic status which affects the quality of food intake in the house and thus the increased chance of micronutrient inadequacy leading to anaemia. This is consistent with findings by Kim *et al.*, (2014) who found that higher socioeconomic status leads to lower anaemia prevalence and iron deficiency anaemia in adolescent girls in Korea (Kim *et al.*, 2014).

Legumes are rich sources of plant proteins from plants and have provided a protein source for humans. They are often encouraged because of their beneficial nutritional effects and because they are a cheap source of protein. Their iron content and other minerals are generally high (Sandberg, 2002). In our study, women who did not consume pulses (dry grain legumes) were 2.6 times more likely to be anaemic than those who did. This supports a study in Ethiopia by Roba *et al.*, (2015) who found that low pulse food intake contributed to poor nutritional status (underweight and stunting) among adolescent girls (Roba *et al.*, 2015). However, legumes also contain anti-nutritional factors such as proteinase inhibitors and phytate, which lower the nutritional value of food by lowering the digestibility or bioavailability of nutrients (Sandberg 2002).

Our results also showed that those who defecated in the open were also two times more likely to be anaemic than those who owned a pit latrine. This is consistent with research by Coffey & Geruso (2015) who showed that within regions over time, cohorts of children in Nepal exposed to poor sanitation, developed lower haemoglobin levels and recorded higher incidence of anaemia. The possibility of such a link was suggested by Cameron *et al.*, (2013), using a randomized control trial in Indonesia that included a toilet construction and anti-open defecation behaviour change intervention and showed a connection between open defecation and intestinal parasites. They found that reduced rates of open defecation were associated with reduced parasitic infections. These intestinal parasites cause anaemia by causing blood loss in the stool, lack of appetite, and competition for nutrients. They may also cause damage to the intestinal wall and lead to decreased absorption of nutrients, including vitamin B_{12}, iron and folic acid (Crompton, 1993). Open defecation spreads intestinal parasites and also exposes individuals to diseases which alter the lining of the intestine and inhibits absorption of nutrients as a result of ingesting large quantities of fecal pathogens (Lin *et al.*, 2013). Almost 40 percent of the women in our study did not have any toilet facility and the rest of them either used private or compound pit latrines. These results are consistent with recent reports by MICS 2014, which indicated that only 15 percent of households in the rural areas of Cameroon used an improved toilet facility.

In sub-Saharan Africa, anaemia is a clinical sign with a multifactorial etiology. Malnutrition, malaria, and helminth infections are the most common causes of anaemia in populations in Cameroon (Kassebaum *et al.*, 2014). From our study, more than a third of the women suffered from malaria in the two weeks preceding the survey and this was higher in the non-forest villages than the forest villages. This may be due to the high prevalence of mosquitoes in the non-forest areas as suggested by Olson *et al.*, (2010) in their cross-sectional study, which showed that malaria incidence was positively associated with percentage of forest loss within respective districts. They showed that a 4.3 percent change in forest loss was associated with a 48 percent increase in malaria incidence (Olson *et al.*, 2010).

About a third of the women reported to have suffered from worm infestation and this was significantly higher in the non-forest area where half of the women suffered from it compared to the forest area. This could be explained by the very high rate of open defecation recorded in the non-forest areas which is associated with parasitic infections (Cameron *et al.*, 2013). In this present study, both the forest and non-forest areas suffered widely from malaria and helminth infections. The combination of these illnesses undeniably contributes to the high prevalence of anaemia in the area. The high reports of worm infection could also be as a result of drinking untreated water as our results showed that none of the households had access to portable water and only 2 percent treated their water before drinking. This figure is different from the MICS (2014) Cameroon report, which indicated that up to 54 percent of households in rural areas of Cameroon had access to portable water and up to 10 percent of those who obtained water from other sources, treated it before drinking.

5.5 Forest contribution to diet, health and household income of the women.

There was a strong reliance on the forest especially by women in the forest areas. They reported harvesting non timber forest products (NTFPs) for subsistence and trade. This is comparable to what Sunderland *et al.*, (2003) reported on the heavy reliance of these communities on forests for both subsistence use and cross –border trade, and NTFPs, generating an average 80 percent of livelihood income in the region. The most reported NTFPs in our study were bush mango (*Irvingia garbonensis, irvingia wumbolo*) eru (*gnectum africanum*), Njansang (*Ricinodendron heudelotii*) and these continue to be the most heavily exploited as was reported by Ingram (Ingram *et al.*, 2011). Compared to the other NTFPs harvested, bushmeat was the least (22%) reported in the area. This may however be due to the over reliance on the forest for bushmeat resulting in a dwindling in their number in the area as reported by Asaha *et al.*, (2011) in their study on participatory wildlife monitoring and management in Takamanda. Also Ahenkan & Boon (2011), showed that a significant association existed between NTFPs and household food security, nutrition and income and NTFPs contributed significantly to nutrition and health of poor rural forest dependent communities of the Western region of Ghana (Ahenkan & Boon, 2011) .

The results of this study showed that the forest makes an important contribution to the local diet of the women who live near it by way of it acting as a free source of seeds and nuts, dark green leafy vegetables and animal source foods. This finding is related to works done by Powel *et al.*, (2012), where forests within agricultural land made an important contribution to the local diets of rural people in the Usambara mountains of Tanzania (Powell *et al.*, 2012).

From our findings, more than half (66%) of the women from the forest area and more than a third (32%) of the women in the non-forest area, reported using forest based medicine (leaves, backs of trees, herbs) for the treatment of malaria. This is consistent with research done by Ahenkan and Boon (2011), in the Eastern region of Ghana where 90 percent of the population used plant medicine to cure various diseases, which include malaria, typhoid, fever, diarrhea, arthritis, rheumatism, and snake-bites. Also, an ethnobotanical study by Rol *et al.*, (2013), of communities around the Takamanda National Park (TNP) revealed the usage of 39 plant species reported to cure about 45 ailments. Most of the inhabitants of these communities relied on medicinal plants in the treatment of most common diseases like malaria, fever, and body pain (Rol *et al.*, 2013). This reliance may be heightened because of the inaccessible nature of the roads and the lack of health facilities in most of the villages and the long distances covered to the nearest health posts for critically ill patients.

5.6 Limitations of the study

This study failed to adjust for design effect for cluster sampling. This would have given a much larger sample size for a better comparison of groups and detection of differences in anaemia.

Also, this study failed to screen for malaria or worm infection for the women before measuring their haemoglobin level as these factors have been shown to contribute to lower haemoglobin levels in humans.

One of the biggest limitations to this study was the substantial difference in the ethnic groups across forest and non-forest areas. We cannot say for sure if the differences we observed are because of cultural preferences or even genetic differences in relation to anaemia.

Another possible source of experimental error in this study is the interference of self-reported sickle-cell trait with the haemoglobin monitor. In the future, people could be screened for the sickle cell trait before haemoglobin determination to be sure their anaemia status is appropriately ranked.

A multiple 24 hour recall would have given a stronger indication of the dietary intake and habits of the population and thus enabled a better comparison.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Our study showed that there is a very high prevalence of anaemia 75.3 percent among women living near and far from forest cover around the Takamanda National Park.

Despite having a higher mean haemoglobin concentration, women from forest-based communities had similar anaemia prevalence to women living farther from forest cover. Forests were an important source of iron rich foods (ASF, DGLV, nuts and seeds) and the prevalence of consumption of these foods was higher for women from forest communities.

The probability of anaemia occurring increased with women who did not consume legumes; lived in extended family compounds, and practiced open defecation.

6.2 Recommendation

In order to improve health of the women and reduce the high prevalence of anaemia among women in this study, the following recommendations are suggested.

- Nutrition interventions to address the high prevalence of anaemia in both communities should be implemented.
- Given that the forest was an important source of food for the forest communities, continued efforts to prevent loss of forests and maintenance of ecosystem services of forests are warranted to improve nutrition of rural forest dependent communities.
- Interventions to improve water, sanitation and hygiene in both communities and the education of women on hygienic practices such as the avoidance of open defecations, hand washing and hygienic handling of food should be encouraged.

- It is recommended that the public be adequately educated on the epidemiology of helminth and periodic treatment with iron supplementation advocated.
- The Children and elderly were not included in our study, but subsequent studies could include them to gauge the level of health in those populations.

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Appendix I: Individual consent form

UNIVERSITY OF GHANA

Official Use only
Protocol number

OFFICE OF RESEARCH, INNOVATION AND DEVELOPMENT

Ethics Committee for Basic and Applied Science (ECBAS)

PROTOCOL CONSENT FORM

Section A- BACKGROUND INFORMATION

Title of Study:	Assessment of haemoglobin levels of forest and non-forest women in Southwest Cameroon
Principal Investigator:	Dr Esi Komeley Colecraft
Certified Protocol Number	

Section B– CONSENT TO PARTICIPATE IN RESEARCH

General Information about Research

This study seeks to investigate the links between forest cover and haemoglobin levels of women in the South West Region of Cameroon. This is from the hypothesis that women living forested areas might have higher iron than women living in non-forested areas.

If you agree to participant you will be visited in your home by a member of the research team for about an hour.

During our visit to your home you will be interviewed about your background and household characteristics as well as diet and the information you provide will be recorded on a questionnaire, Additionally we will take your weight and height measurement and obtain a small quantity of blood (drop) through a finger prick to test for the level of the nutrient iron in your blood.

Benefits

We will advice you on your anaemia status and where necessary appropriate actions to improve your nutritional status. The information from the study may inform future interventions to improve the nutritional status of women in this region.

Risk of the study

Participation in this study poses no risk to you.

Confidentiality

All the information we obtain from you is for research purposes only and will be kept confidential and your personal information will not be made publically available. The tool we use to document your information will be identified by code and not your name and only the research personnel will have access to personal information linked to the codes. Completed questionnaires and consent documents will be stored in a locked cabinet. No individual references will be made in oral or written reports from the study as all data will be aggregated.

Compensation

You will receive a small token of appreciation (a bar of laundry soap) after completing the interview and measurements.

Withdrawal from Study

Your participation in this study is completely voluntary and you can withdraw from the study at any time without any consequences. If there are questions that you would prefer not to answer then we respect your right not to answer them. Do you consent to be part of this study?

Contact for Additional Information

If you have any questions or concerns about the research or the behavior of the research team, please contact: Caleb Tata Yengo, FOREP, BP 111 Limbe. Tel: (+237) 677639245 (Cameroon); Tel: +233 263302330 (Ghana).

Section C- VOLUNTEER AGREEMENT

"I have read or have had someone read all of the above, asked questions, received answers regarding participation in this study, and am willing to give consent for me, my child/ward to participate in this study. I will not have waived any of my rights by signing this consent form. Upon signing this consent form, I will receive a copy for my personal records."

____

Name of Volunteer

____ ______________________

Signature or mark of volunteer Date

If volunteers cannot read the form themselves, a witness must sign here:

I was present while the benefits, risks and procedures were read to the volunteer. All questions were answered and the volunteer has agreed to take part in the research.

____

Name of witness

____ _______________________

Signature of witness Date

I certify that the nature and purpose, the potential benefits, and possible risks associated with participating in this research have been explained to the above individual.

____

Name of Person who obtained Consent

____ _______________________

Signature of Person who obtained Consent Date

Appendix II: Research Questionnaire

DEPARTMENT OF NUTRITON AND FOOD SCIENCE, UNIVERISTY OF GHANA

ASSESSMENT OF IRON STATUS IN WOMEN

Interviewer name: ____________________ Interviewer code: ____________________Interview date:___________

Participant ID: _______________ Community name: ___________ Community type: 1=Forest 2= Non forest

Distance of community from nearest forest cover: _________ km

I would like to start by asking you some personal questions about yourself.			
Socio-demographic Characteristics			Data entry
01	HOW OLD WERE YOU ON YOUR LAST BIRTHDAY?	Age _________ years	
02	What is your ethnic background?	1=Anyang 2=Becheve 3=Bayangi 4=Other (specify)	
03	How long have you lived in this village?	_________Years	
04	What is your religious affiliation?	1= Christian 2= Muslim 3= Traditional belief 4= Other (specify)	
05	What is the highest level of formal education you have completed?	1=None 2=Nursery 3=Primary 4=Secondary 5=Tertiary	
06	What is your primary source of income	1=Farmer 2=Trader 3=Seamstress 4=Hair dresser 5=Other (Specify) 6=None	

07	What is your current marital status?	1=Single (never been married) 2=Married 3=Divorced 4=Cohabiting 5=Widowed			
08	What does your spouse/partner do for a living?	1=Farmer 2=Trader 3=Other (Specify) 99=Not applicable			
09	What is his highest level of formal education?	1=None 2=Nursery 3=Primary 4=Secondary 5=Tertiary			
10	How many adults and children are in your household (or eat from the same pot)?	No. of adults (≥18 yrs) ________			
		No. of children (< 18 yrs) ________			
		Total household size ________			
11	Is any member of your household engaged in any forest-based income generation activities? (tick all that apply)		YES=1	NO=0	
		Self			
		Spouse/partner			
		Children			
		Parent			
		In-law			
		Other, specify			
12	Which forest derived income generating activities are you or members of your households involved in? (Tick)		YES=1	NO=0	
		Bushmeat			
		Timber			

		Firewood/Charcoal			
		Fruits			
		Vegetables			
		Rattan			
		Medicinal herbs			
		Seeds/nuts			
		Other, specify			
13	In your opinion, about how much of your HH income is contributed by the forest-based income generation activities	1= up to 25%; 2= 26-50%; 3= 51-75%; 4=76-100%; 5=None			
14	Have you ever been part of a savings association or club?	1=Yes in the past 2=Yes presently 3=No, never			
Now I will ask you questions about your household					
Household Characteristics					
15	What is your current living arrangement	1= Extended family compound setting 2= Rented compound setting 3=Rented Single family dwelling 4= Owned single family dwelling 5= Other(please specify)			
16	How many rooms does your home have?				
17	What is the main type of material for the walls (if this can be observed then no need to actually ask the question)	1= Cement 2= Mud 3= Wood 4= Thatch 5= Other (specify)			
18	What is the material of most of the roof?	1= Aluminium sheets 2= Thatch 3= Other (specify)			
19	What type of material is the floor made of?	1=cement 2=mud 3=other (specify)_______________			
20	What type of bed is most commonly used for sleeping?	1=Mattress; 2= Mat; 3= Other (Specify)			
21	What kind of toilet facility does your	1= Private pit latrine; 2= Compound pit			

	household use?	latrine; 3= Bush; 4= Other (specify)		
22	What is your main source of drinking water?	1= Pipe; 2= Well; 3= River/stream; 4= Other		
23	How far is your home from the nearest water source?	1= Within the community 2= Outside the community (>200m)		
24	How do you treat the water before using for drinking?	1=No treatment; 2= Boil, 3= Filter, 4=Sedimentation, 5=Other, specify _______________		
25	What is your main source of light?	1= Electricity, 2=Solar lamb, 3= kerosene lamb, 4= Other, specify_______________		
26	What fuel does your household mostly use in cooking?	1=Firewood 2=Kerosene stove 3=gas 4=charcoal 5=Other, specify _______________		
27	Distance from source of fuel (minutes of walking)			
28	Does your household own any of the following in working condition?		0=NO 1=YES	
		Radio		
		Phone		
		Bicycle		
		TV		
		Motorcycle		
		Chainsaw		
		Generator		
		Car		
		Other items worth ≥$50 ___________________		
		Other items worth ≥$50 ___________________		
29	Does your household rear any of the following animals?		0=NO 1=YES	
		Chicken		
		Ducks		
		Goat		
		Sheep		
		Pigs		
		Cattle		

		Other specify____________		
		Other specify____________		
Now I will ask you questions about your health				
Reproductive History				
30	Have you ever been pregnant?	1=Yes; 2=No		
31	If yes, how many live births have you had?			
32	Are you currently pregnant?	1=Yes; 2=No		
33	Are you currently having your menses?	1=Yes; 2=No		
HEALTH AND FOREST USE QUESTIONNAIRE				
34	Do you have sickle cell trait?	1=Yes; 2=No; 3=don't know		
35	Have you had Malaria in the last two weeks?	1=Yes; 2=No (*If No skip to Q37*)		
36	When you had malaria which of the following do you do to treat it?		0=NO 1=YES	
		Went to the health post		
		Bought medicine from pharmacy/store		
		Used medicine from forest		
		Other specify ____________		
		Other, specify ____________		
37	Have you had any problems with stomach worms in the last month?	1=Yes; 2=No (*If No skip to Q39)*		
38	If yes how did you treat it?		0=NO 1=YES	
		Went to the health post		
		Bought medicine from pharmacy/store		
		Used medicine from forest		
		Other specify ____________		
		Other, specify ____________		
39	Have you taken iron supplements in the last 6 months?	1=Yes; 2=No		
40	Have you experienced blood shortage in the last 6 months?	1=Yes; 2=No		

41	How do you treat it?			
42	What do you do to prevent malaria?		0=NO 1=YES	
		Use a mosquito net		
		Medication		
		Forest based medication		
		Other, specify		
		NONE		
43	What do you do to prevent worm infestation?		0=NO 1=YES	
		Regular deworming		
		Drink treated water		
		Forest based medicine		
		Other, specify		
		NONE		
44	Could you please tick the forest foods that you ate in the last week		0=NO 1=YES	
		Eru		
		Bush Mango		
		Njansang		
		Contri Onion		
		Bush Pepper		
		Okongobong		
		Others (Please Specify)		

DIETARY DIVERSITY QUESTIONNAIRE

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.

Write down all foods and drinks mentioned. When composite dishes are mentioned, ask for the list of ingredients. When the respondent has finished, probe for meals and snacks not mentioned.

Approximate time of eating event	Type of eating event (Meal/Snack)	Actual foods eaten	Source of food: 1=forest, 2= farm, 3 = purchase, 4= other, specify

Write down the SOURCE of each of these foods next to it, e.g. (wild/forest, farm, purchase, other)*When the respondent recall is complete, fill in the food groups based on the information recorded above. For any food groups not mentioned, ask the respondent if a food item from this group was consumed*

SN	Food group	Examples	Sources: 1=Forest,2=farm, 3=purchase,4=other(sp)
1	CEREALS		
2	WHITE ROOTS AND TUBERS		
3	VITAMIN A RICH VEGETABLES AND TUBERS		
4	DARK GREEN LEAFY VEGETABLES		
5	VITAMIN A RICH FRUITS		
6	OTHER VEGETABLES		
7	OTHER FRUITS		
8	ORGAN MEAT		
9	FLESH MEATS		
10	EGGS		
11	FISH AND SEAFOODS		
12	LEGUMES NUTS AND SEEDS		
13	MILK AND MILK PRODUCTS		
14	OILS AND FATS		
15	SPICES, CONDITMENTS, BEVERAGES		
16	BUSHMEAT, CATERPILLARS, INSECTS		

i. Did you eat anything (meal or snack) OUTSIDE the home yesterday? 1=Yes; 2=No ____

ii. Was your food intake typical or unusual yesterday? _

iii. If unusual, please explain.

ANTHROPOMETRY and HB FORM

Name of
interviewer____

Date of interview__________________________ Location (FBV/GBV)

____

Woman's ID

Measurement	Weight (Kg)	Height (cm)	Hb (g/dL)
Measurement 1			
Measurement 2			
Average			

Appendix III: Ethical Approval

UNIVERSITY OF GHANA

ETHICS COMMITTEE FOR BASIC AND APPLIED SCIENCES (ECBAS)

P. O. Box LG 1195, Legon, Accra, Ghana

My Ref. No: ECBAS 007/15-16

11th November, 2015

Mr.Caleb Yengo Tata
Department of Nutrition and Food Science
University of Ghana
Legon - Accra

Dear Mr.Caleb Yengo Tata

ECBAS 007/15-16: RELATIONSHIPS BETWEEN FOREST COVER, DIETARY INTAKES AND ANAEMIA PREVALENCE AMONG WOMEN IN SELECTED COMMUNITIES IN SOUTHWEST CAMEROON.

This is to inform you that the above reference study has been presented to the Ethics Committee for Basic and Applied Sciences for a full board review and the following actions taken subject to the conditions and explanation provided below:

Expiry Date:	30/06/16
On Agenda for:	Initial Submission
Date of Submission:	03/09/15
ECBAS Action:	Approved
Reporting:	Quarterly

Please accept my congratulations.

Yours sincerely,

Professor Daniel Bruce Sarpong
ECBAS Chairperson

Tel: +233-244692728 Email: saddo@staff.ug.edu.gh / ethicsbas@ug.edu.gh

COMITE NATIONAL D'ETHIQUE DE LA RECHERCHE POUR LA SANTE HUMAINE

Arrêté N° 0977/A/MINSANTE/SESP/SG/DROS/ du 18 avril 2012 portant création, organisation et fonctionnement des comités d'éthique de la recherche pour la santé humaine au sein des structures relevant du Ministère en charge de la santé publique

N° 2016/01/688/CE/CNERSH/SP Yaoundé, le 05 janvier 2016

Cnethique_minsante@yahoo.fr

CLAIRANCE ETHIQUE

Le Comité National d'Ethique de la Recherche pour la Santé Humaine (CNERSH), en sa session ordinaire du 17 décembre 2015, a examiné le projet de recherche intitulé : «**Relationship between forest cover, dietary intakes and anaemia prevalence among women in selected communities in Southwest Cameroon**» soumis par **M. Caleb TATA YENGO,** Investigateur Principal, étudiant à l'Université du GHANA.

Le projet est d'un grand intérêt scientifique et social. L'objectif global de cette étude sera d'évaluer la relation entre la couverture forestière, l'apport alimentaire et la prévalence de l'anémie chez les femmes en âge de procréer au Cameroun. La procédure de l'étude est bien documentée et claire. Les risques liés aux prélèvements de sang sont précisés ainsi que les mesures pour les éviter et les minimiser. La notice d'information et le formulaire de consentement éclairé, en français et en anglais, sont bien élaborés et simples à comprendre. Les mesures prises pour garantir la confidentialité des données collectées sont présentes dans le document. Les CVs des Investigateurs les décrivent comme des personnes compétentes, capables de mener à bien cette étude. Pour toutes ces raisons, le Comité National d'Ethique approuve pour une durée d'un an, la mise en œuvre de la présente version du protocole.

Les Investigateurs sont responsables du respect scrupuleux du protocole approuvé et ne devraient y apporter aucun amendement aussi mineur soit-il, sans avis favorable du CNERSH. Les investigateurs sont appelés à collaborer pour toute descente du CNERSH pour le suivi de la mise en œuvre du protocole approuvé. Le rapport final du projet devra être soumis au CNERSH et aux autorités sanitaires du Cameroun.

La présente clairance peut être retirée en cas de non respect de la réglementation en vigueur et des recommandations susmentionnées.

En foi de quoi, la présente clairance éthique est délivrée pour servir et valoir ce que de droit.

Le Président

Pr. Jean Louis ABOMO... KAPTUE

Ampliations

- MINSANTE

N.B : cette clairance éthique ne vous dispense pas de l'autorisation administrative de recherche (AAR), exigée pour mener cette étude sur le territoire camerounais. Cette dernière vous sera délivrée par le Ministère de la Santé Publique.