UNIVERSITÁ DEGLI STUDI ROMA TRE

Facoltà di Economia

Masters in Human Development and Food Security

2010/2011

Thesis:

Agricultural Biodiversity, Dietary diversity, and child nutritional status: Linkages; social, economic, and cultural conditioning factors in the Lokossa district of Benin

In collaboration with Bioversity International

Edgar Wabyona

November 2011

Advisors:

Simon George-Adré (Roma Tre - Master HDFS)

Jessica Fanzo (Bioversity International)

Acknowledgement

Completion of this work has depended on the advice, support and encouragement of my advisors George Simon and Jessica Fanzo to whom special thanks are conveyed. I wish to equally thank the following people for their technical input during the development of this work; Federico Mattei (Bioversity – Rome), Robert Fungo and Raymond Vodouhe (Bioversity - Benin) and Dossou Traore (FAO statistics division – Rome).

Table of Contents

Preface

The world still grapples with persistently high levels of food insecurity commonly manifested as over- and under nutrition in both the rich and poor countries. Efforts to reverse these trends were revitalized by the Millennium Development Goals in the year 2000 which justified an array of projects aimed at combating malnutrition. Mixed results have since been registered, much to the dissatisfaction of the development community. One criticism to current food and nutrition interventions has been the use of a 'treatment' rather than 'development' approach to nutrition problems. Amidst concerns about the programmatic incongruence between the agriculture and health sectors, scholars, researchers, and development practitioners have advanced the food system approach as the most appropriate for tackling global malnutrition. This approach is credited with including such aspects as sustainability, innovativeness, and multidisciplinary integration to confront malnutrition. In developing countries, agriculture is a source of livelihood for many and its cohesion with nutrition and other sectors offers an opportunity to achieve and sustain goals related to poverty reduction and nutrition.

This paper is based on a baseline research study conducted by Bioversity International in the Mono province of Benin prior to an agrobiodiversity and nutrition intervention. The initial objective of this study was to provide empirical evidence of how agricultural biodiversity can be translated into more varied diets and improved nutrition in poor rural and urban communities. This study proposed to investigate how agricultural biodiversity can be mobilized to improve local diets and potentially, nutritional outcomes in communities within African local food systems. It also explored how combined agriculture-nutrition interventions based on local food, ecosystems and human resources can provide sustainable solutions to malnutrition. The conceptual framework was based on a starting premise that environment, health, income generation, and socio-cultural factors are all interconnected and as such offer several entry points for a durable strategy that employs agricultural biodiversity to improve livelihoods. The research identified the actual and potential contribution of local biodiversity, and attempted to identify and mobilize biodiversity resources and stakeholders by working together with local communities (particularly women), drawing on local and outside expertise in health, agriculture, environment and development.

Together with a team of scientists from Bioversity International and through the organization’s thesis research mentorship programme, we undertook to further analyse the data from the baseline research study in order to discern the linkages between agricultural biodiversity, dietary diversity, and nutrition status of children under five in the study area. This will complement efforts to gather evidence on how agricultural biodiversity can improve diets and livelihoods for sub-Saharan Africa. The findings from this study will be disseminated through various channels and will be used to guide subsequent research and interventions by Bioversity, other organizations, and the academia. The current paper has been submitted to Universita’degli studi Roma Tre in partial fulfillment of the requirements for the award of the Masters degree in Human Development and Food Security.

Abstract

Introduction: *Utilisation of agricultural biodiversity is declining, straining the ease of diet diversification in households, thus leading to persistent hunger, micronutrient deficiencies, and seemingly to the coexistence of over nutrition in urban areas. In Benin, under nutrition is un-acceptably high, with a stunting rate of over 30%. Agricultural based solutions have been proposed to complement the existing health based approaches.*

Objective: *The study explores the linkages among households' agrobiodiversity, dietary diversity, and nutritional status of children 6 – 59 months, and the socioeconomic mediating factors in Benin.*

Methods: *Cluster and random sampling led to selection of 4 villages and 374 households in Lokossa district. Edible plant species were identified at village and household level. Food prices and diversity in markets were recorded over 12 months. Food-intake recall and anthropometric indices were used to establish children's dietary diversity and nutritional status respectively. Correlation analyses, consumer price index, T-tests, and ANOVA were used to explore the linkages.*

Results: *Agrobiodiversity is higher in rural areas ($p<0.001$). 88% of children had consumed food from at least 4 food groups 24-hours prior to the assessment. Food diversity is higher in urban than rural markets, but prices are volatile (CPI up to 4000). Dietary diversity is significantly higher in agrobiodiversity rich areas ($P<0.001$). There were differences in prevalence of low HFA and WFA ($P<0.001$) but not WFH ($P>0.05$). Spouse's involvement in income activities affects DDS ($R=-0.16$) yet their education reinforces DDS ($R=0.25$) especially if the household head is educated.*

Conclusion: *Agricultural biodiversity is a prerequisite for diet diversification in rural and urban areas. Deliberate efforts targeted at smoothing price volatilities are needed. Synergies between on-farm and market food diversity suggest potential for agrobiodiversity interventions to simultaneously improve livelihoods. Mechanisms to promote the utilization of indigenous foods should be instituted for improved nutrition.*

Introduction

Normal body functioning requires a balanced intake of various macro- and micro- nutrients. Supplementation and fortification strategies have been successful for common micronutrient deficiencies in some contexts but these are unlikely to ensure a sustainable improvement of diets worldwide (Burchi *et al.,* 2011) as they are expensive and accruing benefits have sometimes succumbed to receding economies (Underwood, 2000). In the times past, most rural and urban communities in developing countries enjoyed nutritious diets from an assortment of local foods, cultivated and wild, that were also crucial for their livelihoods. However this is often no longer the case. Agricultural biodiversity (agrobiodiversity) has steadily declined with a corresponding increase in dependence on a small number of food crops (Moore, 2010). According to Frison *et al*. (2006) and FAO (1999b), only three plant species (maize, wheat, and rice) currently supply the bulk of protein and energy needs for both developing and developed country populations.

In the face of the global nutrition transition (Popkin, 2001), easy-to-prepare and refined, energy dense foods have gained dominance in diets at the expense of traditional and more nutritious foods. Consequently, urban and rural communities in developing and developed countries are experiencing the coexistence of hunger, micronutrient deficiencies, and excess intake of calories leading to overweight and obesity, also known as the 'triple burden' of malnutrition (Pinstrup-Andersen, 2011). This change in diets has however been catalysed by a web of other factors associated with globalization of food production and markets. Broadly, these include the seemingly harmonized emphasis on staple crop production, the rush for high yield varieties, an increase in the use of petroleum-based inputs, extension of intellectual property rights to living organisms, replacement of local varieties with exotic types (FAO, 2004) coupled with a change in farmers' and consumers' perceptions and preferences that have seen a drift towards more trendy, fast foods.

Declining on-farm agrobiodiversity has been one of the reasons for the increasing attention to dietary diversity particularly because the latter is often thought to be a logical result of the former (Binayak *et al.,* 2010; Toledo and Burlingame, 2006). A similar relationship has been suggested between food diversity in markets and dietary diversity in urban and peri-urban centres (FAO, 2011). In effect diversification on-farm and in markets has been a core priority for nutrition interventions seeking to improve nutrition outcomes using a development (vs. traditional therapeutic) approach. Even though the link between agrobiodiversity and diet diversity is not automatic (Burchi *et al.*, 2011), it is agreeable that the diminution of agrobiodiversity, to some extent, places considerable strain on the ease with which households are able to enjoy diversified, balanced diets. Accordingly, a number of initiatives have come forth in recognition of the importance of diversified diets notably the International Conference on Nutrition, ICN (1992), the 2003/2004 joint Food and Agriculture Organization/World Health Organization (FAO/WHO) consultations and the Scaling Up Nutrition framework (2010), all of which acknowledged, explicitly or implicitly, the indispensable role of diet diversification for enhanced food security and nutrition outcomes.

Food system interventions that involve carefully formulated multi-sectoral activities along the food chain - from food production to consumption and utilization (Burchi *et al.,* 2011) have been advanced as key to sustaining gains being made by short-term micronutrient control measures because they simultaneously address multiple nutrient and phytochemical needs for optimal health (Underwood, 2000). Agrobiodiversity presents a practical entry point for these interventions because of its potential role in improving dietary diversity (and quality), enhancing farmers' livelihoods (Lockie and Carpenter, 2010; Gari, 2004), and improving nutritional status (Haddad, 2000). Considerable work has been done to characterize the relationship between dietary diversity and nutritional health and a positive relationship has been found between them (Arimond and Ruel, 2004; Torheim *et al.*, 2004). What is still not clear though is how on-farm agrobiodiversity and food diversity in markets are related to dietary diversity, and the factors that mediate this relationship in rural and urban settings. This study will attempt to explore the relationship between households' on-farm agro biodiversity, market food diversity, dietary diversity, and nutritional status of children 6 – 59 months alongside the household socio-cultural, economic, and demographic factors affecting agrobiodiversity and dietary diversity in rural and urban households using data gathered from an International Development Research Centre (IDRC) agrobiodiversity intervention in the Lokossa district of Benin.

Significance of the study

Under nutrition persists among a significant proportion of children in Benin like many other countries in sub-Saharan Africa and south Asia (Grebmer *et al.*, 2011). In the wake of the food prices crisis in the last trimester of 2007, when prices of traditional foods such as cereals, tubers, legumes, and vegetables rose by up to 55% (rice) and 135% (maize) (De Schutter, 2009), about 12% of Beninese households were food insecure by the end of 2008. Over 30% of children 6 to 59 months suffer from chronic malnutrition that is more widespread among children in rural areas (40.4%) than urban (29.9%) (AGVSAN, 2009). Despite the plethora of factors known to perpetuate this situation, the solutions are still widely seen to lie in the agriculture and health sectors. The results of this study will serve to implore multidisciplinary cohesion in the development of agricultural and nutrition interventions against child hunger in Benin and other regions affected by hunger.

Conceptual framework

On-farm agrobiodiversity directly increases access to nutritious foods for farm households and through markets for both rural and urban households. In fact where markets are functioning, they provide an avenue through which to channel surplus on-farm production and, in a virtuous circle, transmit signals of demand for a diverse range of foods to the farm households (**Figure 1**).

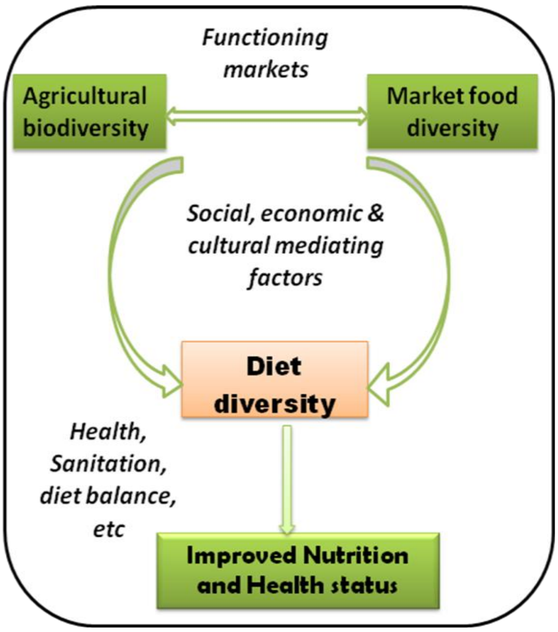


Figure 1: Socioeconomic and cultural factors mediate the translation of on-farm and market food diversity to dietary diversity (Source: Author).

The link between on-farm agrobiodiversity and optimal nutrition status is rather complex and not yet fully understood. It is mediated by numerous factors some of which may (or may not) have synergistic associations. Nonetheless there is prospect for a two way relationship between agrobiodiversity and nutrition status arbitrated by dietary diversity. On the one hand, good utilization of a diverse diet would inevitably contribute to improved human nutrition and development thus enabling increased production, and participation in agricultural biodiversity conservation practices. This relationship is mainly governed by factors such as the individual's health and physiological status beyond the scope of this study. On the other hand agrobiodiversity and market food diversity are a prerequisite for the selection of a diverse diet. This relationship is influenced by factors in the social, cultural, environmental, and economic spheres which may also influence on-farm diversification at household level (Gittelsohn and Vastine, 2003). In this respect, dietary diversity becomes a determining factor in the relationship between agrobiodiversity and nutrition status.

Overall objective

To explore the relationship between households' on-farm agrobiodiversity, market food diversity, dietary diversity, nutritional status of children, and household socioeconomic factors affecting agrobiodiversity and dietary diversity in rural and urban households of Lokossa district in Benin.

Specific objectives

1. To determine the level of on-farm agro-biodiversity, dietary diversity, and child nutritional status in urban and rural areas.
2. To establish the relationship between on-farm agrobiodiversity and dietary diversity
3. To determine the socio-economic factors affecting the translation of on-farm and market food diversity into dietary diversity

Hypotheses

1. Household on-farm agrobiodiversity, market food diversity, dietary diversity, and child nutrition status vary significantly in rural and urban areas.

Research questions

a. What is the on farm agrobiodiversity level in the study area?

b. What is the variation of market food diversity over a period of one year?

c. What is the proportion of malnourished children in the study area?

d. What is the dietary diversity of children 6 – 59 months in the study area?

e. What are the social-economic characteristics of the households in the study area?

2. Households located in areas that are rich in agrobiodiversity are more likely to have diverse diets than their counterparts in low agrobiodiversity regions

Research questions

a. What is the relationship between on-farm agrobiodiversity and dietary diversity?

b. What are the most important socioeconomic factors influencing the selection and consumption of a diverse diet from existing on-farm agrobiodiversity?

3. Socioeconomic and cultural factors affect the level of agrobiodiversity and dietary diversity in the rural and urban contexts

Research questions

a. How is on-farm agrobiodiversity compared to food variety in markets?

b. What is the difference between dietary diversity in rural and urban households?

c. What socioeconomic factors are affecting agrobiodiversity and dietary diversity in rural and urban areas?

Literature review

Agroecology and Agrobiodiversity

Calls for environmentally sustainable and socially just modes of agricultural production have popularized agroecology - the application of ecological science to the study, design and management of sustainable agroecosystems. Agroecology includes the set of agricultural practices that seek to enhance agricultural systems by mimicking natural processes, thereby creating beneficial biological interactions and synergies among the components of the agroecosystem (De Schutter, 2010). Thus agrobiodiversity is a technique based on the agroecological perspective. Specifically, agrobiodiversity refers to the variety and variability of animals, plants and micro-organisms used directly or indirectly for food and agriculture (FAO, 1999a). Measures of biodiversity, commonly at genus, species, or ecosystem levels, may represent variety, quantity and quality, and/or distribution (Millennium Ecosystem Assessment, MEA, 2005).

Trends in agrobiodiversity

Modern agricultural and development processes have impaired the recognition, conservation, use, and improvement of agrobiodiversity (Gari, 2004) threatening locally varied food production systems, including local knowledge, culture, and skills of farmers (FAO, 2011). Agrobiodiversity continues to be depleted through rapid land use change as biodiverse farming practices are continually replaced (Lockie and Carpenter, 2010). Local varieties usually grown in traditional mixed farming systems are being substituted with improved, genetically uniform, high-yielding, and commercialized varieties and species in monoculture systems hence accelerating the genetic erosion of crops (FAO, 2011; FAO, 1999b). In effect, ecosystems have changed more rapidly and extensively over the past 50 years than in any comparable period of time in history (MEA, 2005). Of the more than 80,000 plant species available to humans, only three (maize, wheat, and rice) supply the bulk of protein and energy needs (Frison *et al.*, 2006). With the disappearance of harvested species, varieties, and breeds, a wide range of un-harvested species also disappear (FAO, 2011). Consequently, the world is increasingly dependent on a relatively small number of commercially grown crops for its food security (Moore, 2010).

These changes are in part due to a lack of market acknowledgement of traditional farming practices. Gari (2004) attributes this to the narrow focus of development policies and projects which promote commercial agriculture, characterized by the extensive use of material inputs, aimed at increasing the yields of staple crops. Very often macroeconomic policies provide incentives such as tax concessions, subsidies, and price controls for specific crops (Lockie and Carpenter, 2010; MEA, 2005) effectively discouraging diversification. The extension of industrial patenting and other intellectual property systems to living organisms has aggravated the trend and led to the widespread cultivation and rearing of fewer varieties and breeds, also contributing to a more uniform, yet more competitive global market. Consequently there have been changes in farmers' and consumers' perceptions, preferences and living conditions; marginalization of small-scale, diverse food production systems; reduced integration of livestock in arable production, etc. (FAO, 2011). In sum, Lockie and Carpenter (2010) and other authors seem to agree that the greatest threat to agrobiodiversity comes not from its exploitation or explicit destruction but from its non-use as farming systems become more homogenized and specialized. Altieri *et al.* (2000) trace homogenization back to the post world war II period when research in response to the scare of dwindling food resources and a fast growing population brought forth high yielding varieties, and with them, the green revolution. The new varieties tended to displace traditional farmers' varieties and hence result in erosion of the very genetic resources on which the green revolution was based (Moore, 2010).

Importance of agrobiodiversity

Farmers in environments where high-yield crop and livestock varieties do not prosper rely on a wide range of indigenous types to maintain their livelihoods amidst uncertainties such as pathogen infestation, rainfall and price fluctuations, and socio-political disruption (FAO, 2011). Agrobiodiversity thus plays a pivotal role in the livelihood and wellbeing of agricultural communities regardless of resource endowment or geographical location. It provides the basic resources farmers need to adapt to varying conditions in marginal environments, and to increase productivity in favourable areas (Lockie and Carpenter, 2010). Even minor or underutilized crops are frequently grown alongside the main food staple or cash crops and play an important role in local food production and trade systems (FAO, 2011). Agrobiodiversity makes farming systems more stable, robust, and sustainable, and diversifies products and income opportunities in addition to nutrition and medicinal functions (FAO, 2011; Kruijssen and Mysore, 2010). Mobilization and improvement of these agrobiodiversity resources is thus instrumental in expanding the options and means of small farmers to enhance their agricultural and livelihood systems. The advantage is that plant resources are locally available, affordable, easy to deploy, versatile and remarkably connected to the ecological and cultural realities of small farmers. They are essential to devise agroecological practices that can improve natural resource management, household nutrition and the engagement of farmers in agricultural innovation (Gari, 2004).

Agrobiodiversity and nutrition

A human diet requires at least 51 nutrients in adequate amounts consistently. It has been argued that changes in agricultural systems from diversified to simple, cereal based cropping systems have contributed to poor diet diversity, micronutrient deficiencies, and resulting malnutrition (Burchi *et al.,* 2011). Frison *et al.* (2006) examined homestead gardening programs (sometimes combined with nutrition education) that promoted increased production and consumption of β-carotene–rich fruits and vegetables in Bangladesh, India and Tanzania. They found corresponding increases in daily consumption of these fruits and vegetables by the children in the intervention households, occasioned by sale of excess produce. This seemingly straightforward relationship between diversity in agricultural production and nutrition outcomes is perhaps responsible for the reluctance to test any related hypotheses. It is however understood that a complex relationship exists between production, income, and nutrition. The growing consensus is that the union between agriculture and nutrition requires cultural-economic and social conditioning factors (Berti *et al.*, 2003). Building on the premise that some potentially influential factors can be positively altered through nutrition education, Berti *et al.* (2003) follow an investigation that assessed differences between agriculture only and agriculture plus nutrition education and find no basis to substantiate the widely held assumption that agriculture interventions result in sustainable nutrition benefits, especially if they strengthen financial capital, but do find that agriculture gives a dietary benefit when nutrition education is included. Given the enormous diversity within the human community and that individual food requirements are not homogenous, this calls for the need to adapt nutrition and health interventions to the diversity of need of individuals and communities (Toledo and Burlingame, 2006).

Dietary diversity and nutritional status

The role of micronutrients in health and well-being, and the synergies in their physiological functions have been increasingly recognized, supporting the notion that micronutrient deficiencies rarely occur in isolation (Frison *et al.*, 2006). The World Declaration and Plan of Action for Nutrition adopted at the ICN (1992) recommended the promotion of dietary diversity and the use of locally available nutrient-rich indigenous and traditional foods as a vital strategy against food insecurity, malnutrition, and disease. Empirical evidence suggests positive links between overall dietary quality and nutritional status, and between dietary diversity and anthropometric indices (Frison *et al.*, 2006). This is in agreement with Arimond and Ruel (2004) who found a similar relationship between child dietary diversity and nutritional status that is independent of socioeconomic factors and concluded that individuals consuming more diverse diets were more likely to meet their nutrient needs. This demonstrates the utility of dietary diversity indicators to predict adequate intake of micronutrients in the diets of young non-breast-feeding children (Moursi *et al.*, 2008; Gina *et al.*, 2007). Arimond and Ruel (2004) and Berti *et al.* (2003) however warn that depending on local diet patterns, high diversity scores may be more or less nutritionally meaningful with the reason that if many food groups are given but in extremely small quantities, diversity scores are less nutritionally meaningful.

Challenges to dietary diversification

Most challenges cited lean towards the socio-cultural and economic spheres. According to Arimond and Ruel (2004), low diet diversity is particularly a problem among poor populations in the developing world, where diets are based predominantly on starchy staples and often include few or no animal products and only seasonal fruits and vegetables. This is ironic given that these areas also double as the hubs of agricultural production. Urbanization and changing lifestyles have equally been implicated in changing dietary patterns. With urbanization come changes in employment patterns, particularly for women, which increases the opportunity cost of women's time due to involvement in hired labour or self-employment away from home. This leads to replacement of traditional foods by "convenience" foods. Similarly locally available indigenous and traditional foods that require some form of processing, usually tedious and time consuming, before their final use in food preparation are replaced in the diet by crops such as maize, wheat, rice, and potatoes that are easier to prepare (Frison *et al.*, 2006).

Method

Study area and design

The study was conducted in the rural and urban areas of Benin's Lokossa district in the Mono province. A combination of cluster sampling in which the population was grouped into villages (Benin's smallest administrative units in the districts) and random sampling led to selection of 4 study villages in Lokossa district. Two of these (Tozounmè and Agnito) were rural and another two (Glo-guinkomey and Agnïvèdji) were urban environments. A random sample of 374 households was involved in the study which used a cross-sectional research design.

Data collection and analysis

Quantitative methodology involving questionnaire-based surveys were used in the study. The parameters measured included on-farm and market food diversity, dietary diversity, and nutrition status of children under five, and household socioeconomic and demographic characteristics.

Socioeconomic and demographic characteristics

Data on socioeconomic and demographic characteristics (**Table 1**) was collected as an integral component to the agrobiodiversity and nutrition components of the study. A focus group approach was used to identify criteria for household wealth measurement in the rural and urban areas. Wealth status variables identified were land, transportation vehicle (motorcycle or car), oil palm plantation ownership, and involvement in income generation activities such as trade and oil palm extraction in urban areas. In rural areas, involvement in trade of foodstuffs including oil palm and traditional leafy vegetables, house ownership, and the capacity to hire labour for farming activities were identified as wealth status indicators. Based on these criteria, three wealth groups (poor, moderately rich, and rich) were defined.

On-farm agro biodiversity

An inventory of edible plant species, cultivated and wild, was carried out in 2008-2009 to assess their diversity and availability at village level. Circular plots of 18m radius were established in the village lands in both cultivated and uncultivated areas for the inventory of trees with diameter greater than 10 cm. Four squared sub-plots of 2x2m and one circular subplot of 4m radius were established within each plot respectively for the inventory of herbs and shrubs. In the plot, both local and scientific plant names of every tree, shrub and herb species present were noted. At household level, edible plant species available on-farm were identified and recorded during the study. Focus groups were organized with local populations to investigate the uses of every species and probe for useful species which were not recorded during the field inventory in the plots. A count of the number of genera and species found was obtained and these were grouped, by area, according to whether they were cereals, grain legumes, roots & tubers, traditional leafy vegetables (TLV), other traditional vegetables, exotic vegetables, local cultivated fruit, wild fruits or exotic fruits.

Food diversity in markets

Two markets were selected, one in an urban area (Lokossa market) and the other in a rural area (Tozoumè market). Twelve food categories were defined prior to the survey and these were cereals, grain legumes, roots & tubers, traditional leafy vegetables (TLV), other traditional vegetables, exotic vegetables, local cultivated fruit, wild fruits, exotic fruits, meat-fish-poultry and derivatives, fats and oils, and spices and condiments. Trained extension workers collected information on the species diversity (and when possible the varietal diversity) in each food category along with their unit prices. Scales were used to weigh the food in order to have standardized units or give an estimation of the local measurement units. Prices from many vendors in different stalls of the markets were recorded and average prices reported for each food product. The data was collected from these markets on a bi-weekly basis (during the market days) for a period of 12 months (September 2009 to August 2010) to observe price variations.

Pearson's correlation analysis was used to postulate price substitutability among different species in the same food group. The consumer price index (CPI) was used to depict the monthly movements in food prices, alongside a food availability calendar showing periods when certain foods were in short supply during the study period. Monthly average prices were computed for each commodity except when the commodity was completely out of supply for the month in question. The CPI was computed using September 2009 average prices as the base prices. All food items were taken to be equally important thus an un-weighted index was calculated. The index excludes processed/transformed food items because they were supposed to have different demand and supply patterns compared to locally grown foods. Single item CPI was calculated as $CPI_{item} = {P_t}/{P_o} * 100$ and the food group CPI as $CPI_{group} = \frac{\sum_{i=1}^{i=n} Pt/Po * 100}{n}$ where P_t is the prevailing average price of the item during the month and P_o the base price.

Dietary diversity

A food frequency questionnaire was administered at the household level in all four study areas. Foods consumed in the 24 hour, 7 day, and 30 day periods preceding the survey were recorded and subsequently categorized according to the food groups previously defined. Dietary diversity scores (DDS) obtained as a count of the number of food groups were re-classified into Low DDS (≤ 3), Medium low DDS (4 – 5), Medium high DDS (6 - 7) and high DDS (≥ 8) for analysis purposes.

Nutritional status

Age, Weight and height measurements of children 6 – 59 months in the four study areas were recorded. The data was analysed by the calculation of the weight-for-age (WFA), height-for-age (HFA), and weight-for-height (WFH) indices that were expressed as Z-scores (WHZ, HAZ and WAZ respectively). Descriptive statistics for Z-scores and their cut-offs as defined by WHO (2006) standards were used to describe the nutritional status per village and to compute the prevalence of severe and moderate under nutrition. Spearman's correlation was used to describe the relationships among agrobiodiversity (at species level), dietary diversity, and select socioeconomic variables such as ethnicity, education level, wealth status and cultivated land size. The t-test (independent samples) was used to test for the difference in dietary diversity between rural and urban households while the one-way ANOVA was used to determine differences in dietary diversity among the four study villages.

Descriptive statistics were used recurrently to describe the distributions of the variables measured. Analyses were conducted at village and household levels, as well as rural and urban areas using a combination of ENA (version 2010), MINITAB (version 15), and SPSS (version 18) software.

Ethical considerations

Each component included an informed consent protocol that was reviewed by an independent ethical review committee to ensure that privacy, dignity, and integrity of human subjects are protected.

Results

Socioeconomic and demographic characteristics of the study population

Table 1: Some socioeconomic and demographic characteristics of the study population

		Rural (%)	Urban (%)
Gender	Male	55.7	54.2
	Female	44.3	45.8
Ethnicity	Adja	0.0	19.2
	Aizo	1.1	0.0
	Bariba	0.0	0.6
	Cotafon	73.9	48.8
	Dendi	1.1	0.6
	Fon	4.5	7.0
	Goun	0.0	0.6
	Mina	1.1	1.7
	Sahoue	18.2	19.8
	Wachi	0.0	1.7
Education level	no education	73.9	47.6
	primary	21.6	27.1
	secondary	4.5	22.9
	tertiary	0.0	2.4
Marital Status	married	97.7	95.8
	single	0.0	3.0
	separated/divorced	2.3	1.2
Main source of income	farming	40.9	4.8
	casual labour	18.2	7.2
	business	11.4	9.0
	employed	14.8	35.9
	students	0.0	2.4
	Taxi driver	10.2	14.4
	Crafts men	4.5	23.4
	Unemployed	0.0	3.0
Water source	piped	96.6	98.2
	well	3.4	0.0
	rain water	0.0	1.8
Roofing material of HH	straw	67.0	2.4
	Metal sheet	33.0	96.4
	tile	0.0	0.6
	Concrete/slab	0.0	0.6
Type of floor	cemented	18.2	95.2
	earth floor	81.8	0.0
Type of walls	Earth/clay	95.5	29.5
	Timber	1.1	69.3
	Brinks	3.4	1.2
Access to services[1]		100.0	100.0

[1]Services considered were public transport, primary market, supply shop, and health centre

There were differences in the distribution of socioeconomic and demographic characteristics between rural and peri-urban areas (**Table 1**). Cotafon, Adja, Sahoue, and Fon were the largest ethnic groupings. While the latter two groups were fairly distributed between rural and urban areas, disparities were pronounced among the Cotafon and Adja. Except among the

Cotafon, there were always higher proportions of these ethnic groups in the urban areas. Rural areas had the highest number of uneducated people whose proportions decreased with increasing levels of education. The reverse was observed in the urban areas where the proportion of educated persons was always higher than in the rural areas. While not shown, it was observed that the education level of the household head was almost always higher than that of the spouse. There were consistently lower proportions of people engaged in skilled labour in the rural areas vis-à-vis urban areas; farming was the most frequently mentioned activity in rural areas (40.9%) versus formal employment in urban areas (35.9%). All respondents had access to services such as public transport and health care, and a remarkably high percentage (>96%) in both rural and urban areas reported use of piped water with only a few having used rain water (only urban areas) and the well (only rural areas). There were however marked differences in asset holdings (type of roof, floor, and wall) between rural and urban households suggesting income differences.

Agrobiodiversity status in the study area

81 edible plant species belonging to 66 genera were identified in the four study areas. About 73% of these crops were cultivated at household level while the rest were wild or semi-wild. Although these food plants were also used for medicinal purposes, an extra 59 species were found to be exclusively used as medicines.

Table 2: Summary of identified species by food category

	Rural		**Urban**	
	Agnito	**Touzoume**	**Agnivedji**	**Glo - guinkomey**
Grain legumes	1	3	2	2
Cereals	1	1	1	1
Roots & tubers	4	5	2	5
Fruits	20	11	12	16
Vegetables	38	27	19	16
Medicinal	57*	46*	25*	34*
Others	3	2	2	2
Total	**67**	**49**	**38**	**42**

*Figures excluded from calculation of the total because of their overlapping nature with the other groups

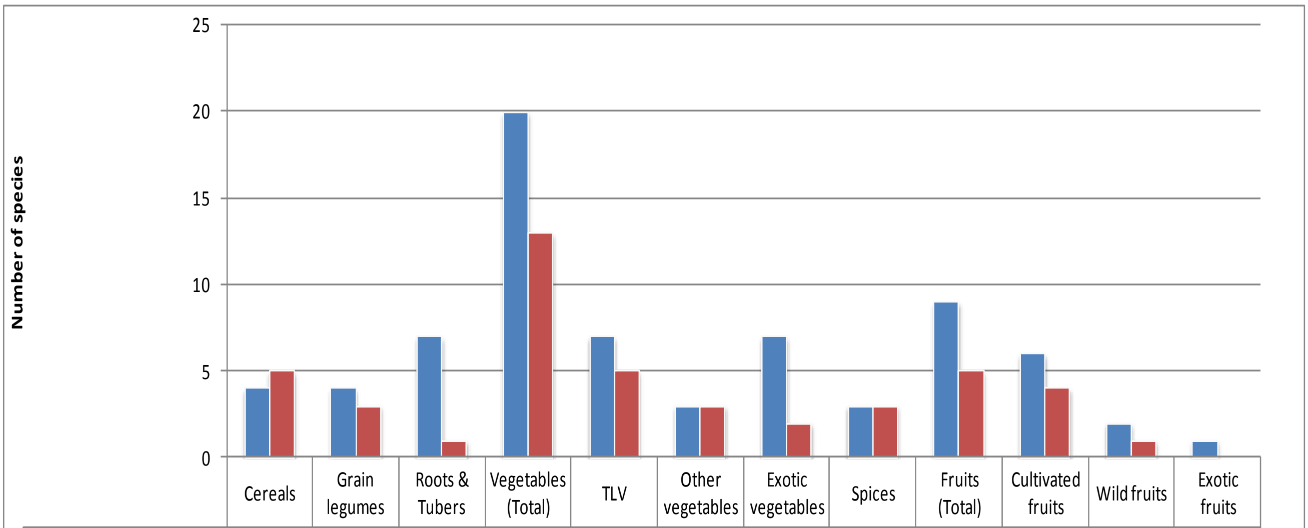
These results compare with Dansi *et al*. (2009) findings in all Benin where 187 plant species belonging to 141 genera were found of which 25.13% were cultivated. The level of diversification was higher in some villages such as Agnito and lower in others such as

Agnivedji. In general, villages located in urban environments had considerably lower levels of agrobiodiversity compared to their rural counterparts (**Table 2**). Species diversity was lowest in the cereals group where just one species, *Zea mays* (Maize), was identified in all four study areas. A similar trend was observed for grain legumes and roots and tubers. There was however a high level of diversification observed among fruits and vegetables where all four areas had at least 11 species of fruit and 16 species of vegetables (**Appendix 1**). The species were mostly used as food in different ways (staple dishes, sauces, snacks etc.) and as medicines.

Differences in agrobiodiversity at village level trickled down to the household level. Rural households were found to have higher levels of on-farm agrobiodiversity compared to urban households. A t-test (independent samples) was conducted to compare on-farm agrobiodiversity in rural and urban households. Analysis showed a significant difference in the number of species available per household between rural areas and urban areas ($t = 4.53$, $d.f = 46$, $p<0.001$). This suggests that rural households are more likely to grow a wider range of species compared to urban households.

Food diversity in markets

Level of diversification in markets



	Cereals	Grain legumes	Roots & Tubers	Vegetables (Total)	TLV	Other vegetables	Exotic vegetables	Spices	Fruits (Total)	Cultivated fruits	Wild fruits	Exotic fruits
Lokossa market (Urban)	4	4	7	20	7	3	7	3	9	6	2	1
Touzoume market (Rural)	5	3	1	13	5	3	2	3	5	4	1	0

Figure 2: Food diversity in Lokossa and Touzoume markets

There were generally low levels of diversity in cereals, grain legumes, and roots and tubers in both markets but with higher diversity in the urban Lokossa market. Considering that low on-farm agrobiodiversity was observed for these species at village and household level in rural and urban areas, findings suggest that low on-farm agro-biodiversity leads to lower levels of market food diversity. In fact vegetable species, the most abundant in markets for both rural and urban areas, were consistently more diverse on-farm in all four areas. It was curious to note that some varieties of Maize (yellow) and Rice (local and improved) were only available in rural Touzoume market. Whereas the rural market had Traditional Leafy Vegetable (TLV) species as the most common, the urban market equally showcased exotic vegetable species, all of which were higher than those in rural markets as shown in **Figure 2**. Similar observations were made for fruits in which urban markets were found to have generally more species of fruits compared to rural areas. In both cases however, cultivated fruits were the most abundant followed by wild fruits. Only one exotic fruit species (Apple) was found in urban markets, while none was available in the rural market during the study period.

Species supply in the markets

Food supply in the urban Lokossa market was found to be generally stable with only seven food crop species of all those traded having registered inconsistent supply during the study period (**Figure 3a**). Among these, Taro (*Colocasia esculenta*), Pasteque (*Citrullus lanatus*) and velvet tamarind (*Dalium guineense)* were the least available during the year. In contrast, supply of most food items in rural Touzoume market was highly unstable except for some exotic vegetable species such as tomatoes (**Figure 3b**). Interestingly, most of the commodities found to have erratic supply in Touzoume had all year round availability in Lokossa market. Yet all the food commodities that had inconsistent supply in Lokossa market were virtually absent from Touzoume market in the study period.

Unit price levels of observed foods

Price statistics for some food commodities are presented in **Table 3.** Prices were higher for the majority of foods in urban Lokossa market than in rural Touzoume market. However *Vernonia* spp and *Corchorus* spp were uniquely more expensive in rural areas with a price difference of about 14 and 11 CFA respectively. Interestingly, the former had constant prices in Touzoume with CV of zero compared to 36.8% in Lokossa, while the latter had constant prices in Lokossa but high variation (CV 53.9%) in Touzoume.

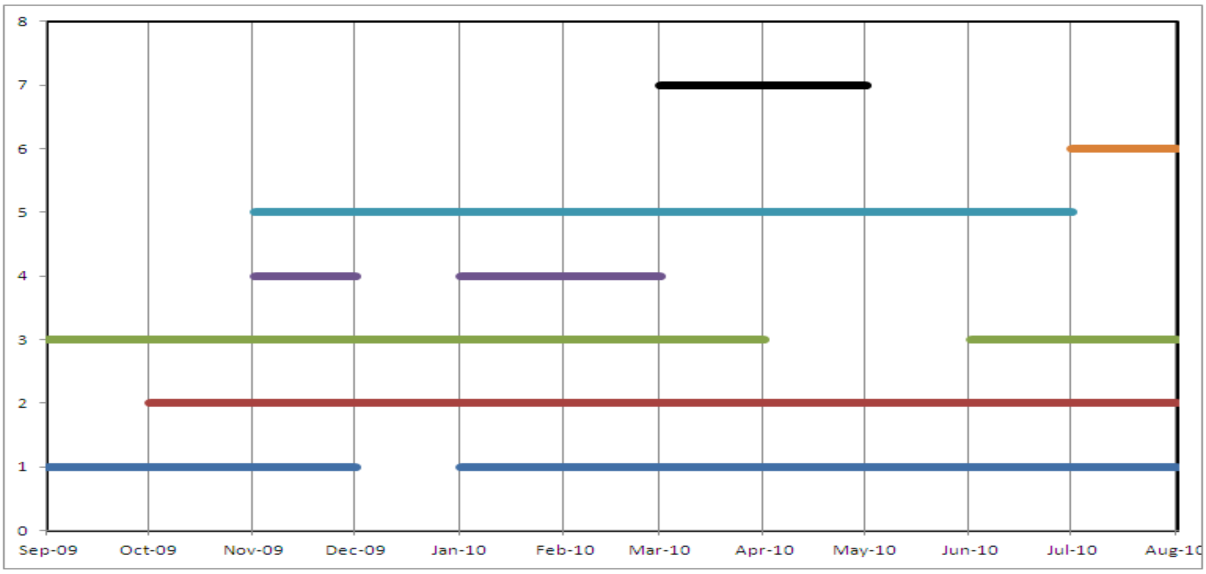


Figure 3a: Food commodities supply[1] in Lokossa market: 1. Sorghum, **2.** Cassava, **3.** Sweet potato, **4.** Taro, **5.** Mango, **6.** *Pasteque* (water melon) and **7.** *Dalium guineense* (Velvet tamarind).

Table 3: A summary of unit prices[2] of common food items in Lokossa and Touzoume markets

	Lokossa market (Urban)		**Touzoume market (Rural)**	
	Mean ± SD	**CV (%)**	**Mean ± SD**	**CV (%)**
Maize-white (F/bowl of 2.5kg)	421.2 ± 40.68	9.66	276.45 ± 26.94	9.75
Cowpea-white (F/bowl of 1.5kg)	530.5 ± 43.28	8.16	478.77 ± 50.57	10.56
Cowpea-dark (F/bowl of 1.5kg)	438.1 ± 40.35	9.21	418.9 ± 65.75	15.7
Soybean (F/bowl of 1.5 kg)	320.4 ± 78.08	24.37	266.7 ± 50	18.75
Sweet potato (F/bowl of 80L)	2420.0 ± 264.1	10.91	1773 ± 428	24.14
Solanum spp. (F/lot of 5)	50.0 ± 0	0	32.84 ± 11.68	35.59
Corchorus o. (F/lot)	10.0 ± 0	0	20.76 ± 11.18	53.87
Vernonia spp. (F/lot)	11.2 ± 4.126	36.77	25 ± 0	0
Okra (×10F/bowl of 1 L)	268.0 ± 128.8	48.05	19.302 ± 5.323	27.58
Onion (×10 F/lot of 40)	1724.0 ± 2086	120.99	70 ± 35.57	50.82
Tomato (×100F/bowl of 80L)	2808.0 ± 5093	181.35	41.44 ± 18.75	45.24
Hot pepper (F/bowl of 1L)	598.3 ± 140.6	23.5	577.3 ± 386.4	66.94
Garlic (F/lot of 0.10-0.15kg)	500.0 ± 0	0	328.8 ± 229.4	69.77
Pepper (F/bowl of 1kg)	5616.3 ± 587.5	10.46	3846 ± 2886	75.03
Oranges (× 10 F/lot of 40)	313.8 ± 389.6	124.18	32.26 ± 18.39	56.99
Banana (× 10 F/bunch)	398.0 ± 433.4	108.9	365.4 ± 234.4	64.16
Palm oil (F/L)	532.8 ± 93.2	17.48	387.03 ± 79.45	20.53

For comparison purposes, only food items common to both markets have been selected for inclusion

[1] Only food commodities with differences in supply have been shown. There were less food commodities with irregular supply in Lokossa market.

[2] Prices indicated in West African Franc CFA (XOF). 1US$ = 489 CFA

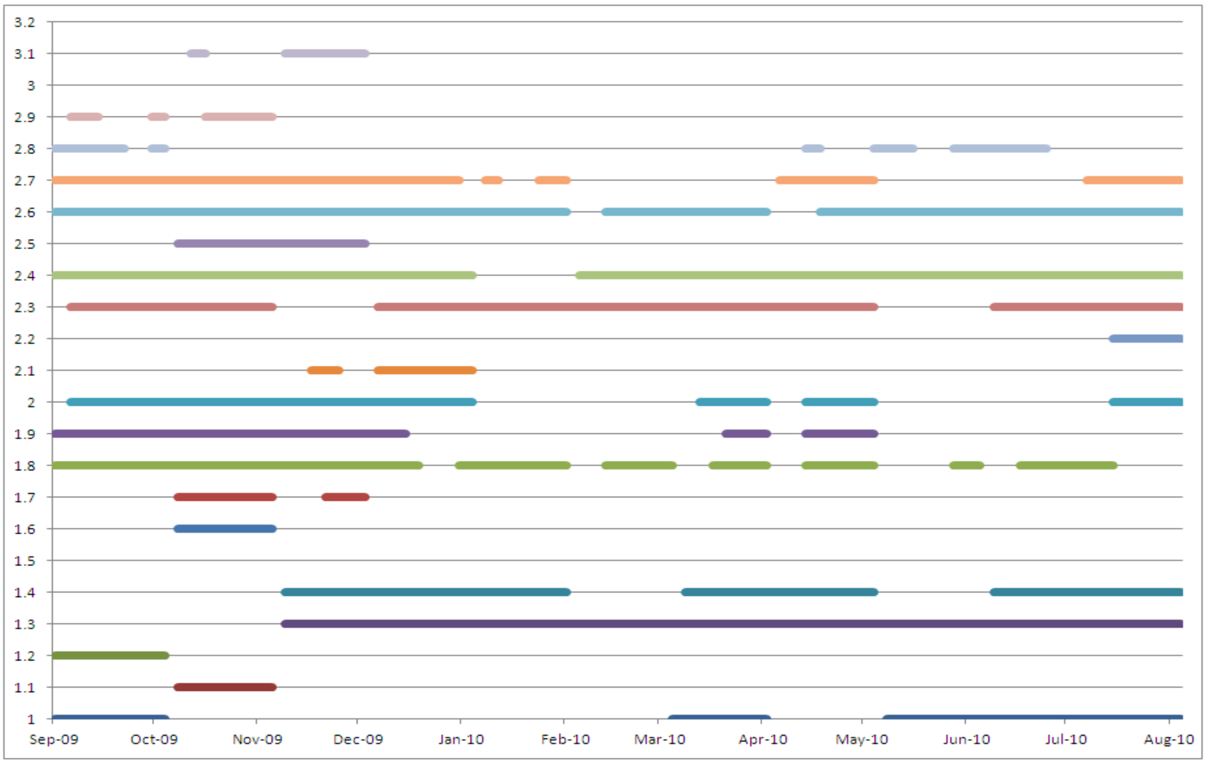


Figure 3b: Food commodities supply in Touzoume market: 1. Maize (yellow); **1.1** Rice (local); **1.2** Rice (improved); **1.3** Rice (imported); **1.4** Cowpea var. 1 (white); **1.6** Soybean; **1.7** Sweet potato; **1.8** *Solanum* spp **1.9** *Vernonia* spp (Bitter leaf); **2.** *Moringa oleifera* **2.1** Cowpea var. 2 (dark) **2.2** Cowpea var.3 **2.3** *Egusi*; **2.4** Onion; **2.5** Sweet pepper; **2.6** Tomato; **2.7** Oranges; **2.8** Banana; **2.9** Plantain; and **3.1** Vitex doniana

Price variation was high for most commodities in both markets during the study period led by tomatoes in Lokossa (CV 181%) and pepper in Touzoume (CV 75%). The pattern of variation was however less consistent between rural and urban areas and within food groups. Variation was more prominent for some commodities such as tomatoes and plantain than for others e.g. garlic (urban) and *Vernonia* spp (rural) which had constant prices throughout the year.

In Lokossa, most foods had a roughly similar tendency in the single item food price index, as they all showed fairly stable price changes with exception of plantain and tomatoes whose indices spiked to over 1000 and 4000 respectively between April and July 2010 (**Figure 4a**). This was different in Touzoume market where virtually all food commodities were found to have erratic price fluctuations throughout the study period (**Figure 4b**). The consumer price index (CPI) for food groups showed similar tendencies with the single item food index. In both Lokossa and Touzoume markets the CPI exotic vegetables, other vegetables, and cultivated fruits was the most varied clearly influenced by tomatoes, okra, and plantain respectively (**Figures 4c and 4d**). Correlation analyses on the prices of different food commodities showed that in Lokossa market, the prices of maize and rice were negatively correlated with millet (r = -0.42 and -0.5 respectively). Prices of the two varieties of cowpeas rise simultaneously (r = 0.78) but are negatively correlated with soybean (r = -0.53).

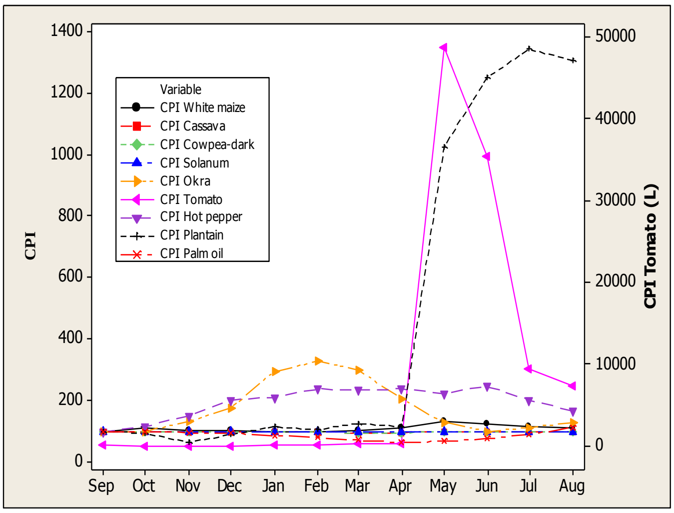


Figure 4a: Single item consumer price index (unweighted) in Lokossa Market, Benin

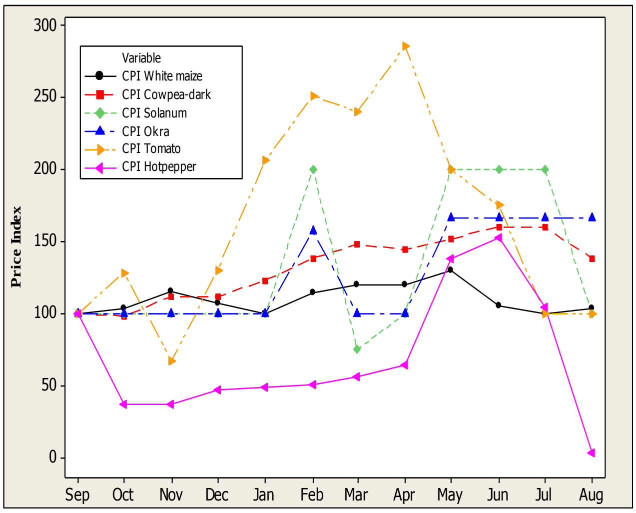


Figure 4c: Single item price index for some foods in Touzoume market, Benin

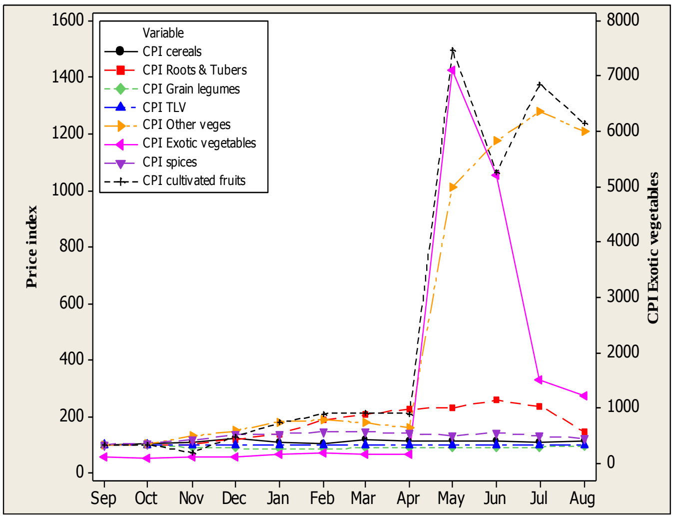


Figure 4b: Consumer price index for food categories in Lokossa market Benin

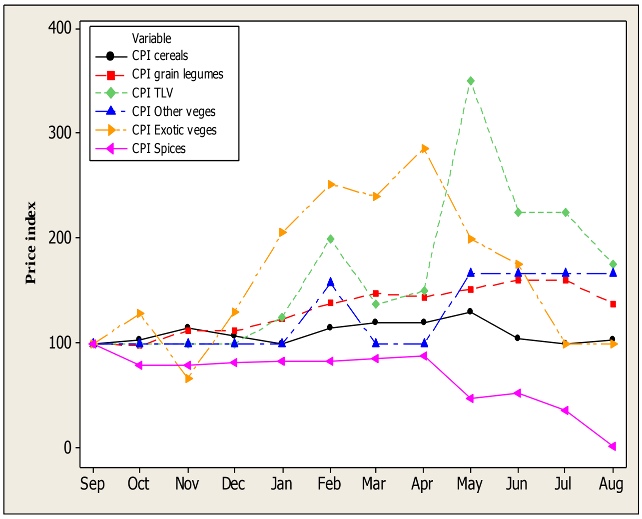


Figure 4d: Consumer price index for food categories in Touzoume market Benin

Among roots and tubers, all three different varieties of yams available and sweet potatoes were found to be positively correlated (r ≥ 0.8). Majority of vegetables prices were negatively correlated e.g. carrot vs. okra (r = -0.5). This category was unique because most prices were fairly constant, rendering correlation analysis unnecessary. In Touzoume, negative correlations were obtained for yellow and white maize varieties (r = -0.29) and between white maize and improved rice (r = -0.26) but not between yellow maize and improved rice (r = 0.354). Like Lokossa, a similar though weaker relationship was observed between the two cowpea varieties (r = 0.29) and between the cowpea varieties and soybean (r = -0.33 and – 0.38 respectively).

Dietary diversity

Dietary diversity was found to increase with the length of the recall period. In the 24hour recall, majority of the study population had medium low to medium high dietary diversity scores (both 44.4 %) with very few having low DDS (7.2%) and high DDS (4%). There were more children with high DDS in urban areas (5.2%) than rural areas (1.6%). This trend was maintained for the 7 day and 30 day recall periods. Glo-guinkomey registered the highest percentage of children with high DDS (6.9%) for the 24 hour recall. As the recall period increased, households graduated from lower to higher levels of dietary diversity (**Figure 6**). There were no children with low DDS for the 7 day recall, and all children (both in rural and urban areas) had medium to high DDS for the 30 day recall.

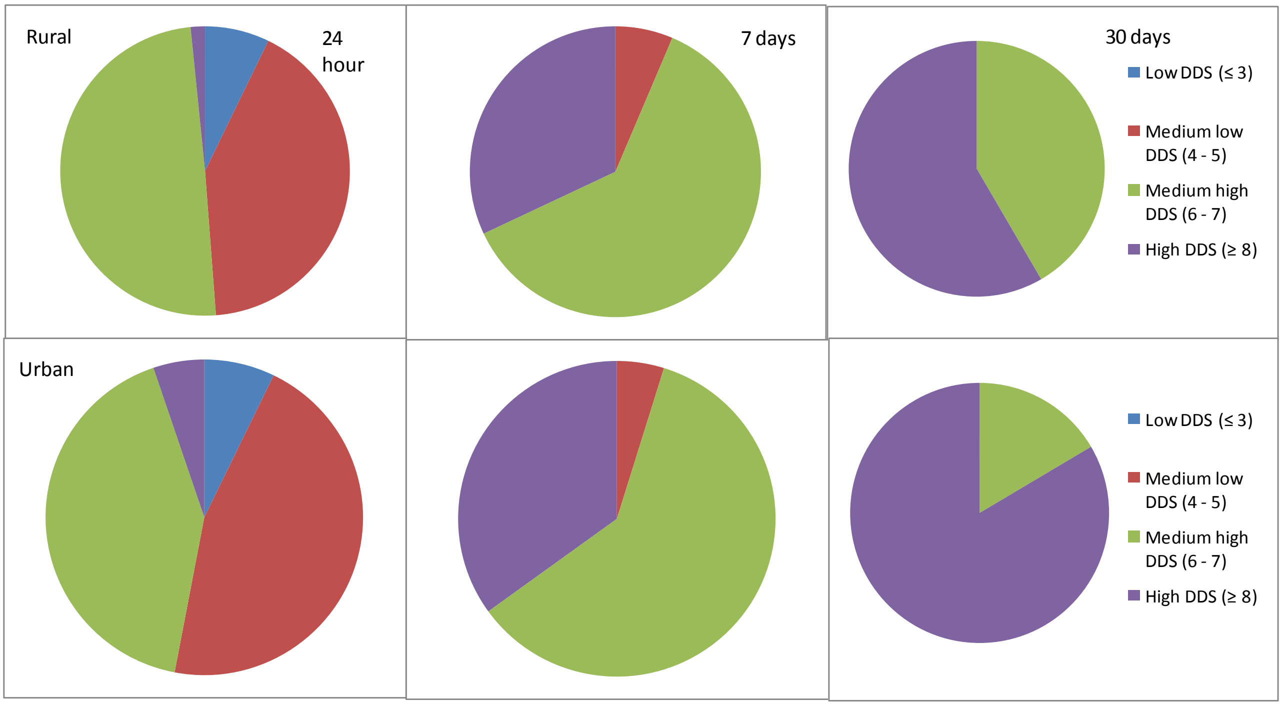


Figure 6: Variation of dietary diversity scores with recall period

To test the impact of living in an agrobiodiversity-rich environment on dietary diversity, the dietary diversity scores of children in areas that had higher agrobiodiversity levels were compared to those in areas with lower agrobiodiversity. The t-test of independent samples between Agnivedji (urban) and Touzoume (rural), two villages which had smaller absolute differences in levels of on-farm agrobiodiversity (38 and 49 species respectively) showed no significant difference in DDS among households for the 24 hour and 7 day recall ($p>0.05$) but returned a significant difference ($t = 2.01$, d.f. = 160, $p<0.05$) among households when compared against the 30 day recall. Further comparison of all rural versus all urban households returned similar results ($t = 5.58$, d.f = 372 $p<0.001$). This attaches importance to apparently small differences in species diversity to child nutrition. Using a one-way ANOVA, the four areas were also compared against the 30 day dietary diversity scores and results maintained a significant difference ($F_{3, 370} = 21.38$, $p < 0.001$). Children in Glo-guinkomey had higher 30 day dietary diversity scores than the other 3 villages. Post hoc comparisons using Tukey’s test showed that Glo guinkomey was statistically different from Agnivedji, Agnito, and Touzoume but the latter were not different with regard to 30 day DDS. Tentatively, it can be argued that although Glo-guinkomey had relatively lower on-farm agrobiodiversity, it is located in an urban setting and thus complements on-farm agrobiodiversity with food diversity in markets.

Nutrition status of children 6 – 59 months

The severity of under nutrition in the study area could be classified as medium (WFH, WFA) and high (HFA) (WHO, 1997). The proportion of children affected was higher for underweight and stunting than for the wasting measure (**Table 4**). Prevalence of stunting was highest among children 30-41months (47.7%) and so was underweight (26.1%), both different from wasting which was highest among children 6 – 17 months of age (9.5%). Prevalence obtained were comparable to those reported by EDSB (2006) which put stunting at 43% of children under five (22% severely), wasting at 8% (3% severe), and moderate and severe underweight at 14% and 5% respectively at national level. Mean Z-scores of all the three indices, especially HFA and WFA, were well below zero, the expected value, suggesting a generalized condition of poor nutrition. These were especially pronounced for Agnivedji WFA (-1.44) and HFA (-2.02) but not for WFH (-0.42).

Table 4: Under nutrition among children 6 – 59 months in the study area

Area	Mean Z-score ± SD		
	HFA	**WFA**	**WFH**
Agnito	-1.18 ± 1.507	-0.66 ± 1.107	-0.05 ± 0.947
Tozoume	-1.68 ± 1.146	-1.13 ± 1.1	-0.33 ± 1.014
Agnivedji	-2.02 ± 1.188	-1.44 ± 1.176	-0.42 ± 1.282
Glo-guinkomey	-0.88 ± 1.667	-0.57 ± 1.1303	-0.13 ± 1.097
Rural	-1.47 ± 1.33	-0.93 ± 1.124	-0.21 ± 0.992
Urban	-1.29 ± 1.606	-0.88 ± 1.219	-0.24 ± 1.174
Prevalence (%)			
$-3 \geq$ **Z** < -2	19.0	14.1	5.2
Z ≤ -3	14.7	4.1	1.6
Total	**33.7**	**18.2**	**6.8**

There were marked differences in the prevalence of under nutrition in the four study areas. Agnivedji and Touzoume showed the highest level of under nutrition in all 3 anthropometric indices while Glo-guinkomey had the lowest prevalences for the underweight and stunting indicators. There was no significant difference between rural and urban areas in the HFA, WFH, and WFA measures ($P > 0.05$). However one way ANOVA among villages returned significant differences for the HFA ($F_{3, 367} = 12.52$, $P < 0.001$) and WFA ($F_{3, 369} = 13.01$, $P < 0.001$) but not for WFH ($P > 0.05$). Tukey's post hoc analyses confirmed that Agnivedji had significantly higher prevalence of low HFA and low WFA while Glo-guinkomey had a significantly lower prevalence of these measures. While differences were pronounced between these two urban villages, there were no differences between the two rural villages of Agnito and Tozoume.

Socioeconomic and demographic influences on agrobiodiversity and dietary diversity

Initial correlation analyses to examine the association between socioeconomic variables and agrobiodiversity found that the number of species (species) at household was only significantly related to the ethnicities of the head of household (r = -0.44) and of the wives (r = -0.46) (**Table 5a**). However, on controlling for wealth status, results showed stronger negative relationship between the species and ethnicities of the head of household (r = -0.52) and spouse (r = -0.49) that increased with the level of wealth. In addition, negative relationships were obtained with the number of wives (r = - 0.61) and land cultivated by household head (r = -0.73).

Table 5a: Socio-cultural and economic factors influencing agricultural biodiversity

	Number of species		
	All	**Rural**	**Urban**
Number of wives	-0.611* (w_3)	0.853* (e_0)	0.644* (w_2)
Ethnicity of HOH	-0.444**		
	-0.518* (w_2)		
Ethnicity of wives	-0.456**		
	-0.493* (w_2)		
	-0.627* (w_3)		
Household size	-0.646* (e_2)		
Land cultivated by HOH	-0.734* (w_3)		0.558* (w_2)

*. Correlation is significant at level 0,05 (2-tail). **. Correlation is significant at level 0,01 (2-tail). (N = 330). (e_0) Illiterate head of household; (e_2) Head of household with at least secondary education; (w_2) moderately rich households; (w_3) Rich households. Only significant correlation values shown

Table 5b: Socioeconomic and cultural factors influencing dietary diversity

	24hr DDS		7day DDS			30day DDS		
	All	**Rural**	**All**	**Rural**	**Urban**	**All**	**Rural**	**Urban**
HH size							0.289** (e_0)	
Age of HOH		-0.253*						
		-0.402** (e_0)						
Age of Spouse	-0.118*	-0.241*						
		-0.396** (e_0)						
Ethnicity of HOH		0.287**		0.393**			0.292**	
		0.268* (e_0)		0.341** (e_0)			0.247** (e_0)	
Education HOH			0.13*			0.119*		
Education wives			0.16**			0.127*		
			0.251* (e_2)					
HOH main income source			0.229**			0.164*		
			0.309** (e_0)		0.265* (e_1)	0.227** (e_0)		0.238* (e_1)
HOH secondary income source			0.128**			0.11*		
			0.196** (e_0)			0.161** (e_0)		0.247* (e_1)
Spouse income source			-0.161**			-0.156**		
Land cultivated by HOH			-0.2** (e_0)			-0.161* (e_0)		

*. Correlation is significant at level 0,05 (2-tail). **. Correlation is significant at level 0,01 (2-tail). (N = 330). (e_0) Illiterate head of household; (e_1) Head of household with primary education; (e_2) Head of household with at least secondary education; Only significant correlation values shown

Interestingly, the species was positively correlated with the number of wives (r = 0.64) and land cultivated (r = 0.56) only in urban areas, when wealth was a controlling variable. When analysis was repeated while controlling for education level of the household head, the number of wives was positively correlated with species in rural households where the head had no education.

Dietary diversity scores (7 days, 30 days) for children were found to be positively, though weakly, associated with education level of the head of household (r = 0.13, 0.12) and of the spouse (r = 0.16, 0.13), main income activity (r = 0.23, 0.16) and secondary activity (r = 0.13, 0.11) of the head of household but negatively with the activities for women (r = -0.16, -0.56) (**Table 5b**). Separate analyses between rural and urban areas revealed more influences on dietary diversity; 24 hour DDS was negatively related to ages of the head of household (r = -0.25) and of the spouse in rural areas (r = -0.24), and this relationship was stronger (r = -0.4) where the head of household had no education. Unlike its relationship to agrobiodiversity, ethnicity was found to have a positive association with dietary diversity for all three recall periods (r = 0.29, 0.4, and 0.29) but only in rural areas. This relationship was however only significant among households whose heads were illiterate. Yet another interesting finding was that in general, education of wives was more strongly positively associated with children's 7 day DDS where the head of household had attained at least secondary level education. Whereas the head of household's main and secondary income sources were always positively correlated with child dietary diversity, these activities seem to be more important where the heads of household are uneducated and, specifically for urban areas, where the head of household had primary education. Among uneducated heads of household, there was a negative relationship between land cultivated and children's dietary diversity.

Discussion

Agrobiodiversity status

The agrobiodiversity observed in the study area is within expectations for the study area's agroecological profile described by Achigan-Dako *et al.* (2011). A readily commercialized and widely promoted staple elsewhere, Maize was the most common crop grown/intercropped with others among respondents in all villages. This might be a manifestation of simplifying agricultural systems in South West Benin or a matter of 'disadvantage' resulting from agro-ecological predisposition. Sodjinou (2006) reports large variations where more cereals such as millet are grown in North Benin and not in the South. The picture is different with fruits and vegetables probably because they have less management and input requirements (Fassil *et al.*, 2000) and cultivated species are easily complemented by wild species which made up to 38% and 28% of vegetable and fruit species respectively in some villages. This presence of wild species in the community indicates, according to Dansi *et al*. (2009), the dependence on nature for food thus reiterating the need for environmental conservation. Differences between rural and urban areas could stem from the negative impact urbanization seems to have on agriculture, perhaps because the urban populace is often inclined towards other economic activities (**Table 1**), not to mention the constraints regarding access to other production factors such as limited land and expensive labour

In most African societies, it is common for households to share best agricultural practices and exchange seeds through different fora in the villages. It is no surprise therefore that households in agrobiodiversity rich villages had higher on-farm agrobiodiversity compared to their counterparts. Besides, agroecological and socioeconomic conditions among the villages may vary, favouring additional species in some but not others. For Achigan-Dako *et al.* (2011), the diversity of vegetables in Benin and their widespread utilization in rural communities offers an opportunity for diversification of the rural and urban economy.

This on-farm agrobiodiversity represents an affordable and easily accessible source of nutrition (Fassil *et al*., 2000) allowing the urban population to reduce dependence on the market and diversify the means of access to food (Maxwel *et al.*, 1998). AGVSAN (2009) reports that Beninese households with livestock, cash crops and food crops meet from 30 to 40% of their food needs through their own production and depend less on markets, thus present lowest levels of expenditure per capita on food. Diversity also presents opportunities to reduce synthetic input use while maintaining yields through natural pest control and fertilization, is a fundamental resource for the development of new crop varieties, and an insurance mechanism against unpredictable environmental and market downturns. Species diversity is therefore essential for food security and poverty alleviation (Lockie and Carpenter, 2010; Gari, 2004). It however remains to be determined to what extent agrobiodiversity can serve as a cushion in this regard.

Markets

Naturally market traders tend to source food commodities from neighbouring villages to minimize costs. Thus the likelihood that deficits in production of specific food crops are transmitted to the markets is high. Sure enough, low on-farm agrobiodiversity observed with cereals, grain legumes, and roots and tubers is prominently expressed by the low species diversity in the markets. However, it’s also possible that there is no market demand for other varieties for a multiplicity of reasons including sociocultural barriers and prohibitive costs when the foods are available etc. Despite the diversity, many of these traditional food plant species are viewed as “low-status” and as a result have been and are being displaced from traditional production systems (Fassil *et al., 2000*). Urban markets are more likely to have higher diversity than rural markets because producers and middle men get higher monetary gain from the transactions. Besides, the traders in urban markets are usually in a better position to access foods and obtain food commodities from more than one village unlike rural markets that may not be integrated, sourcing commodities from individual farmers who often double as traders. This explains the observed species diversity (higher than all villages combined), and their steady supply in urban Lokossa market.

These findings demonstrate the importance of markets both for on-farm agrobiodiversity and dietary diversity. Attractive producer prices are a powerful incentive for the conservation of agrobiodiversity among farmers (Kruijssen and Mysore, 2010) while favourable consumer prices permit household diet diversification. This is of practical significance for Beninese households where the aggregate share of expenditure on food is 46.3% spread proportionately among the different food groups, and households predominantly obtain food consumed from the markets irrespective of the standard of living, department, area of residence, the expenditure quintiles or classes of food security (AGVSAN, 2009). Despite marked differences in diversity between rural and urban markets, certain species (yellow maize, local and improved rice varieties) were found exclusively in the rural market. These are probably produced in smaller, not easily marketable quantities and/or are thought to be inferior by the urban populace who prefer exotic varieties, evidenced by the almost year round availability of imported rice varieties in Lokossa market. Hellin *et al.* (2010) suggest use of new scientific evidence related to species' intrinsic properties to stimulate their market demand.

Whereas market liberalization is taking root in most African economies, majority of the agricultural produce, except for a few such as maize, is not internationally traded (Haddad, 2000). It is therefore plausible to say that the price levels and movements of these commodities on the market are determined by local conditions. The usually greater demand in urban versus rural areas is easily the reason for the generally higher unit food prices in Lokossa market, with due regard to seasonal variations, exploitative tendencies, poor market information, high transaction costs, and weak institutional structures that often characterizes the marketing of these products (Kruijssen and Mysore, 2010; Hellin *et al.*, 2010).

If households in similar settings have a consistent aggregate demand pattern over time, thus accounting for a predictable portion of price variability, erratic price variations (**Figure 5**) are then attributable to supply differences also associated with the fore mentioned factors. Indeed, Lokossa market had a higher level of prices, stable supply, and lower price variation while Touzoume market had lower price levels, unstable supply, and correspondingly high price variability. This price volatility compromises markets' ability to guarantee dietary diversity as households are often unable to cope with price changes either due to high food purchase prices or low producer prices that restrain the household budget. De Schutter (2009) attributes food insecurity in Benin not to the country's inability to produce sufficient quantities of food, but to the increase in prices during the lean season. Price volatility affects rural and urban households alike since majority, including agriculturally-based rural households are linked to markets (Hellin *et al.*, 2010; AGVSAN, 2009) and makes both smallholder farmers and poor consumers increasingly vulnerable to poverty due to their effect on real incomes while also negatively impacting development (SOFI, 2011). Needless to say sustainable diet diversification requires simultaneous improvement of on-farm agrobiodiversity and of markets' ability to assume a complementary role through mechanisms that, for example, maintain the supply of seasonal or perishable wholesome foods.

Negative price correlations among foods in the same group were interpreted as indication of substitutability[3] and positive correlations to suggest strain on consumers in the acquisition of these foods in case of rising prices. Positive correlation is not ideal as it could potentially lead to exclusion or limited consumption of these foods. Substitutability was observed among cereals (maize, rice, and millet), grain legumes (cowpeas, soybean) and vegetables but not roots and tubers. Food diversity in markets provides households with alternative foods and hence insulation against price surges of specific food commodities that could potentially reduce children's consumption of key nutrients during the first 1000 days of life from conception, leading to a permanent reduction of their future earning capacity (SOFI, 2011). The lack of substitutability among roots and tubers, a usually important staple energy source, is therefore a threat to dietary diversity that needs to be addressed.

Dietary diversity

Though resource constrained households may not easily achieve high DDS on a 24 hour basis, it is important that they do so over time as this is a significant predictor of diet quality and adequate micronutrient intake (Moursi *et al.,* 2008; Gina *et al.,* 2007), and is more strongly associated with HAZ among children who are no longer breast-fed (Arimond and Ruel, 2004). T-test and ANOVA results show that households in agrobiodiversity-rich villages are more likely to diversify diets, and that on-farm agrobiodiversity is an important factor influencing dietary diversity. This is in line with Dansi *et al.* (2009) findings that people sharing a common geographical space and/or cultural identity or origin seem to consume almost the same types of TLVs and corroborates the finding that rural and urban households in areas of rich agrobiodiversity have better nutrition status for children under 5.

While there is no agreed classification of DDS, much less for different recall periods, the patterns observed in agrobiodiversity, market food diversity and dietary diversity raise the expectation of lower under nutrition levels than observed, implying limits to the utility of DDS as a measure of nutrient intake. Remans *et al.* (2011) propose the nutritional functional diversity metric which summarizes and compares the diversity of nutrients available based on plant species composition on-farm and the nutritional composition of these plants. It is not

[3] This substitutability is anticipated in terms of prices but not necessarily nutritional value

supposed, however, that socioeconomic and cultural factors such as food proscriptions and prescriptions (Gittelsohn and Vastine, 2003), income, and gender have no bearing on the translation of observed richness in agrobiodiversity to dietary diversity and child nutritional status.

Nutrition status

Results depict the nutrition situation in the study area as better compared to Benin's aggregate nutrition status indicators (EDSB, 2006). The high prevalence of wasting among children 6-17 months is probably due to gaps in the transition from exclusive to complementary feeding. The remarkably high prevalence of underweight and stunting is inconsistent with the level of dietary diversity observed and might be indicative of chronically inadequate diets, suggesting that diet diversity is not necessarily sufficient if the right quantities are not consumed. Poor hygiene and sanitation conditions also contribute to nutrition. AGVSAN (2009) reports that only 10.2% of mothers and guardians of children under five wash their hands with soap at critical times, and that hygiene practices are less adequate in rural areas than urban areas. Ultimately children are exposed to the hidden consequences of inadequate nutrition that compromise immune function, cognitive development, growth, reproductive performance, and work productivity (Underwood, 2000).

This inadequate feeding regime seems to persist as children grow. The highest stunting level was observed among children 30-41 months, just outside the 0-2 year's window of opportunity to eliminate child chronic under nutrition (SUN, 2010). EDSB (2006) confirms that the proportion of stunted children increases regularly and rapidly with age. This situation may also be the result of micronutrient losses from foods consumed between harvesting and consumption. The most common preparation methods for the diversity of leafy vegetables in Benin involves shredding of leaves followed by thorough washing and boiling in water (Dansi *et al.*, 2009), which are known to cause micronutrient losses. Nutrition can be improved through attention to such traditional storage and food-preparation and cooking practices, with a view to improving their effectiveness in maintaining levels of nutrients derived from different plants (Fassil *et al.*, 2000).

Building linkages among on-farm agrobiodiversity, dietary diversity and nutritional status

Differences in agrobiodiversity between rural and urban areas were not clearly expressed in the nutrition status of the children but were consistent with AGVSAN (2009) findings; Children in Glo-guinkomey, an urban area with low on-farm agrobiodiversity, had the highest dietary diversity and lowest prevalence of underweight and stunting compared to Agnito, a rural area, which had the highest level of on-farm agrobiodiversity (**Table 6**). Differences were however evident among villages of the same kind; rural villages that had higher levels of on-farm agrobiodiversity also had lower prevalence levels in all three nutrition indicators than those with low levels of on-farm agrobiodiversity. The same trend was observed among villages in the urban areas.

Table 6: Agricultural biodiversity, dietary diversity and nutritional status linkages

Area	Number of species (% of total)	Rank	Mean 30 day DDS	Rank	Nutritional status (mean Z scores) HFA	WFA	Rank
Agnito[r]	67 (83)	1	9.12	3	-1.18	-0.66	2
Tozoume[r]	49 (60.5)	2	9.08	4	-1.68	-1.13	3
Agnivedji[u]	38 (47)	4	9.29	2	-2.02	-1.44	4
Glo-guinkomey[u]	42 (52)	3	9.32	1	-0.88	-0.57	1
Rural	**78 (96.3)**	**A**	**9.09**	**B**	**-1.47**	**-0.93**	**B**
Urban	**51 (63)**	**B**	**9.31**	**A**	**-1.29**	**-0.88**	**A**

[r]Rural; [u]Urban; A>B

This is evidence of a link between on-farm agrobiodiversity and nutrition status that is mediated differently between rural and urban areas. Maxwel *et al.* (1998) attests to this positive association with findings from urban Uganda where it was noted that the prevalence of stunting and being underweight was significantly lower among children in farming households, particularly in the lowest socioeconomic status groups. These findings express the fact that rural households mostly consume what they produce and suggest that on-farm agrobiodiversity might be more important for dietary diversity in rural than urban areas where market diversity seemingly plays a greater role. This implies urban households could potentially obtain just as much or even more nourishment from market and complementary on-farm sources thus advancing the indispensable complementary role of on-farm agrobiodiversity and market food diversity in nutrition. Attention is however also drawn to the fact that the confluence of factors determining translation of on-farm diversity to dietary diversity and nutritional status in rural and urban areas is significantly different.

Socioeconomic, cultural, and demographic factors influencing agricultural biodiversity and dietary diversity

Agrobiodiversity and nutrition cannot be divorced from cultural diversity, local knowledge (Lockie and Carpenter, 2010), and socioeconomic standing as these greatly influence individual, household, and society decisions. Ethnic groups tend to preserve unique aspects of their heritage including growing and consuming certain unique varieties of foods, settling in distinct geographical areas endowed with specific agroecological features (Achigan-Dako *et al.*, 2011). Such social arrangements lead to variation in the number of species recorded per ethnic group varies (Dansi et al., 2009) and determine food classification systems commonly invoked when making decisions about food selection, preparation, serving, and consumption Gittelsohn and Vastine (2003). It's not surprising therefore that on-farm species diversity was significantly related to the ethnicities of the head of household and of the wives. Wealth seems to aggravate ethnicity's negative influence on on-farm diversity perhaps because of the possibility that wealthier households resort to the cultivation of a few commercialized crops such as cotton and maize.

The relationship between number of wives and level of on-farm agro biodiversity is only visible when attention is given to the area of residence and wealth status. It should nonetheless be interpreted cautiously because of the possibility that these wives don't necessarily live in the same household, and is subject to other considerations. In general, a negative relationship exists between number of wives and species available probably because the aforementioned effect of wealth or because of a likely different role women play in farming as wealth status changes. In rural areas, the dynamics are different as number of species increases with the number of wives but only among illiterate heads of household perhaps because the dominant economic activity for such households is more likely to be subsistence farming with, with higher dependence on on-farm sources of food which implores diversification. It seems education influences on-farm diversification in rural areas, while wealth has a similar effect in urban areas. The negative relationship between land cultivated and number of species among the rich and the specific positive relationship among the moderately rich in urban areas is equally difficult to fathom. The fact that that 91% of households engaged in agriculture or gardening in Mono province own the land they cultivate (AGVSAN, 2009) dispenses of land tenure rights as a possible cause. In general, it seems that wealthy households tend towards monocropping, focussing on marketable crops. Two reasons can be advanced for the positive relationship obtained in urban areas. First, the rich can afford extra land on which to grow more varieties that complement market food purchases and second, the relationship would probably turn out negative were it not for the fact that the benchmark levels of agrobiodiversity in the rest of the urban households are generally lower vis-à-vis the study area combined.

As earlier alluded to, ethnicity is bound to influence children's dietary diversity hence the positive relationship observed. Interestingly this relationship was only found in rural areas. This might be a suggestion of stronger cultural norms related to food in rural areas whose application is probably influenced by the on-farm availability of the foods in question (higher in rural areas) and other demographic factors such as education. Dansi *et al.* (2009) observe that some TLVs are known and consumed by all or many ethnic groups while others e.g. *Manihot glaziovii* (tree cassava) are ethnospecific. From these ethnic roots stem taboos that play an important role in diets. In the southwest of Benin (of which Mono province is part), the fact that a member of a household is a disciple of the divinity ‘‘Sakpata’’ means other members of this household never prepare *Launea taraxacifolia* (wild lettuce) even if it is their most preferred leafy vegetable (Dansi *et al.,* 2009), while *Cleome gynandra* (Cat's whiskers) is prohibited to the followers of Aguessi (Achigan-dako *et al.,* 2009) to mention but a few. Yet both plants have been found to have good nutritional and medicinal properties (Sakpere and Aremu, 2008; Chweya and Mnzava, 1997). The DDS cannot, however, tell the disadvantages arising from an ethnic group's choice to grow (or consume) a given species over another in the same food category. This deserves further investigation using the functional diversity metric in which the use of one species and not another may cause differences in the functional diversity score because of the differences in the nutrient composition of the species (Remans *et al.,* 2011).

Results uphold the fact that education and nutrition are positively linked as in fact, dietary diversity was found to be positively associated with education of both the head of household and the spouse. Education allows guardians to make informed dietary choices for children and to overcome detrimental cultural norms. This is probably why the positive relationship between ethnicity and diet diversity was only significant among households where the head was illiterate. Similarly, land cultivated was negatively related to diet diversity only among uneducated heads of household, and the negative correlation between diet diversity and age of the head of household and of the spouse was stronger where the head of household had no education. In sum, AGVSAN (2009) reports that the prevalence of food insecurity in Benin is higher among households headed by people with no education or simply literate, and it decreases as the level of education of household head increases. In rural Benin, it seems equally important that the head of household is educated, demonstrated by the stronger association a mother's education has on children's dietary diversity when the head of household has attained at least secondary level education.

In a rather straight forward relationship, the head of household being engaged in some income generating activity makes diet diversification more likely as this frees up other household resources and makes purchase of other foods not available on-farm possible, while also reducing the need to sell on-farm produce. Involvement in income activities turned out to be more important among uneducated heads of household probably because these activities are the only sources of cash income compared to their more educated counterparts who have access to employment and other opportunities on which they depend for food provision. This is also probably why in urban areas, where the majority of the more educated heads of household live, the relationship between income activities and dietary diversity was only noted among heads of household with primary education, now at a comparative disadvantage compared to those with secondary or higher education.

Surprisingly, involvement of women in come activities negatively affected children's dietary diversity. This is an expression of the exceptional importance of the care role women play in households and implicates the time burden of rural women's domestic unpaid work and the lack of substitutability of female labour in household work by men which limits women's choices with regards to accessing paid employment. Patriarchal ideologies, steeped in traditional customs and culture, lead to unequal employment opportunities and gender differentiated welfare (FAO/IFAD/ILO, 2010). In this context therefore, it follows that engaging women in other economic activities compromises their ability to care for the children as less time is devoted to child care (Haddad, 2000). While this may spell doom for the women empowerment movement, it is actually an opportunity to advocate for the recognition of women's care giving role as a productive rather than reproductive role.

Conclusions and recommendations

Agricultural biodiversity is a prerequisite for diet diversification in rural and urban areas. Rural areas (and households) are more likely to have higher levels of on-farm agricultural biodiversity compared to their counterparts in urban areas. Nonetheless on-farm agrobiodiversity remains an important source of nutritious foods in urban areas because of the complementary relationship with market food diversity. Dietary diversity is higher among households with access to higher food diversity (on-farm and markets). Prevalence of under nutrition is lower among rural and urban areas where there is greater presence of agricultural biodiversity. Nutritional status remains generally poor among children in the study area, attributable to a gap in infant feeding, inadequate food intake, and social, economic, and cultural conditioning factors. These strongly influence both the level of agricultural biodiversity and dietary diversity. Dietary diversity is increased by education of women, whose ability to achieve this effect is in turn dependent on the level of education of the head of household. Efforts to engage women in productive activities outside the normal caring role should take care not to disrupt the nutritional well being of the children.

The study unearthed the dependence on one food staple (maize) as the main dietary energy source. This is a threat to food security because of the heightened vulnerability to environmental and market related risks. This is more so because maize is an internationally traded and highly commercialized commodity, thus sole dependence on it suggests exposure to the misgivings of the national and global food markets. Interventions to diversify cereal and root crop production, and to promote their consumption, are therefore long overdue. Findings also suggest the necessity for agricultural biodiversity intervention objectives to stretch beyond input provision and yield boosts to facilitate the inclusion of a variety of indigenous, neglected, and underutilized crops in rural and urban food trade systems. The synergistic relationship between on-farm and market food diversity suggests that these interventions can also be used to improve the livelihoods of communities in Benin and the rest of sub-Saharan Africa.

These should not however justify a technocratic rush for solutions. Rather, what is needed is to craft context specific policies/interventions using participatory methodologies so that the core problems are addressed and people have the chance at promoting their values, in accordance with their norms, customs, and beliefs. This is even more important in light of the ethnic diversity observed. Efforts to promote commercialization of specific crops, while beneficial in regard to augmenting farmer's incomes, may actually be detrimental in the long run. Streamlining a nutrition component that pays equal attention to perishable but nutritious foods could potentially counter this effect. De Schutter (2009) and AGVSAN (2009) recognise the importance of storage and conservation of agricultural products, and their processing into foodstuffs at local, national or regional level as an important factor in enhancing food security. In addition to linking the agriculture, health, and environment disciplines, sustainable diet diversification requires deliberate efforts targeted at smoothing downsides in the market most especially the observed price volatilities for example through innovations that streamline marketing of perishable produce.

This study however limited agricultural biodiversity to plant diversity thus excluding animal source foods which are a major source of proteins and micronutrients in the diet and whose absence from the diet could significantly affect nutrition status. In regard to market food diversity, it was assumed that consumers actually purchase on the basis of quality rather than quantity but this was difficult to tell as there was no data collected on actual food purchases from the markets.

Linkages between agrobiodiversity, dietary diversity, and nutrition status remain to be investigated further. Future studies seeking to explore this relationship should complement dietary diversity with the nutritional functional diversity measure to account for nutrient variation in different varieties of the same species. This calls for concerted efforts to establish the nutrient composition of indigenous foods in these communities. Future studies should also explicitly target different ethnic groups as this could unmask other important socio-cultural factors governing access to food. Similarly, wealth status did not return a significant association with other variables despite having been demonstrated otherwise in different areas. There is need to change the measure from an asset based index used in this study to a holistic approach that incorporates people's capabilities in the wealth index.

Appendix 1: Plant species identified in the study area

	Rural		Urban	
	Agnito	**Touzoume**	**Agnivedji**	**Glo - guinkomey**
Grain legumes	*Vigna unguiculata* [1]	[1], *Cajanus cajan, Phaseolus sp*	[1], *Glycine max*	[1], *Arachis hypogea*
Cereals	*Zea mays* [2]	[2]	[2]	[2]
Roots & tubers	*Colocasia esculenta* [3], *Dioscorea alata, Dioscorea dumetorum* [4], *Manihot esculentus* [5]	[3], [4], [5], *Dioscorea alata, Dioscorea dumetorum, Ipomoea batatas,*	[3], [5]	[3], [4], [5], *Dioscorea alata, Dioscorea praehensilis*
Fruits	*Annanas comosus, Annona muricata, Annona senegalensis, Artocarpus heterophyllus, Blighia sapida, Carica papaya* [11], *Citrus aurantium* [6], *Cocos nucifera* [7], *Elaeis guineensis, Mangifera indica* [8], *Musa sapientum* [9], *Passiflora edulis, Passiflora foetida, Persea americana* [12], *Psidium guajava* [10], *Solanum torvum, Spondias monbin, Sterculia foetida, Uvaria chamae, Vitex doniana*	[6], [7], [8], [9], [10], [12], *Annona muricata, Annona squamosa, Blighia sapida, Citrus aurantiifolia, Uvaria chamae*	[6], [7], [8], [9], [10], [11], [12], *Adansonia digitata, Annanas comosus, Chrysophyllum albidum, Citrus aurantiifolia, Terminalia catappa*	[6], [7], [8], [9], [10], [11], *Achras sapota, Annona muricata, Artocarpus heterophyllus, Borassus aethiopum, Cananga odorata, Citrus aurantiifolia, Dialium guineense, Elaeis guineensis, Spondias mombin, Terminalia catappa*
Vegetables	*Amaranthus cruentus* [13], *Amaranthus spinosus* [14], *Bidens pilosa, Capsicum annum, Cassia occidentalis, Cassia podocarpa, Celosia argentea, Cissus populnea, Cleome ciliate, Cleome gynandra* [15], *Corchorus olitorius* [16], *Crateva adansonii, Deinbollia pinnata, Ehretia cymosa, Fleurya aestuans* [17], *Heliotropium indicum* [18], *Hibiscus sabdarrifa, Hibiscus esculentus* [19], *Jatropha curcas* [20], *Launea taraxacifolia* [21], *Lycopersicum esculentus* [22], *Manihot esculentus* [23], *Moringa oleifera* [24], *Ocimum basilicum, Ocimum gratissimum, Pergularia daemia, Ritchiea erecta, Solanum macrocarpum* [25], *Stachytarpheta indica* [26], *Sterculia tragacantha, Talinum triangulare, Telfairia occidentalis, Tylophora camerounica, Vernonia adoensis, Vernonia amygdalina* [27], *Vernonia colorata* [28], *Vigna unguiculata* [29], *Vitex doniana*	[13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26], [27], [28], [29], *Abelmoschus sp, Capsicum annum, Cassia obtusifolia, Crassocephalum rubens, Ocimum basilicum, Ritchiea erecta, Sida carpinifolia, Solanum aethiopicum, Talinum triangulare, Telfairia occidentalis*	[13], [14], [15], [16], [18], [19], [21], [23], [24], [25], [26], [27], [29], *Amaranthus dubius, Bidens pilosa, Crateva adansonii, Ocimum gratissimum, Ritchiea erecta, Solanum nigrum,*	[14], [15], [16], [17], [18], [19], [20], [22], [23], [24], [25], [26], [27], [28], [29], Ocimum gratissimum
Others	*Cymbopogon citrates* [30], *Saccharum officinarum* [31], *Solanum tabacum*	[31], *Solanum tabacum*	[30], [31]	[30], [31]

[Number] indicates species common among 3 or more study areas

References

Achigan-Dako, E., Pasquini, M., Assogba-Komlan, F., Sognigbe, N., Dansi, A. and Ambrose-Oji, B. (2009). Traditional vegetables in Benin: Diversity, distribution, ecology, agronomy and utilisation. Darwin initiative and IFS.

Achigan-Dako, E.G., Sognigbe, N.D., Assogba-Komlan, F., Ambrose-Oji, B., Ahanchede, A. and Pasquini, M.W. (2011). Diversity, geographical, and consumption patterns of traditional vegetables in sociolinguistic communities in Benin: Implications for domestication and Utilization. *Economic Botany, 65(2), pp.129-145.*

Altieri, A. M., Rosset, P. and Thrupp, L. A. (2000). The Potential of Agroecology to Combat Hunger in the Developing World. Retrieved July 11, 2011 from: http://www.cnr.berkeley.edu/~agroeco3/the_potential_of_agroecology.html

Analyse Globale de la Vulnérabilité, de la Sécurité Alimentaire et de la Nutrition, AGVSAN (2009). République du Bénin, Program Alimentaire Mondial (PAM), UNICEF, FAO. PAM, Rome – Italy.

Arimond, M. and Ruel, T.M. (2004). Dietary Diversity Is Associated with Child Nutritional Status: Evidence from 11 Demographic and Health Surveys. *J. Nutr. 134: 2579–2585, 2004*.

Berti, P.R., Krasevec, J. and FitzGerald, S. (2003). A review of the effectiveness of agriculture interventions in improving nutrition outcomes. *Public Health Nutrition: 7(5), 599–609.*

Binayak, S., Purnima, M., Akhter, U. A., and Fatema, P. C. (2010). Food Utilization and Nutrition Security. Bangladesh Food Security Investment Forum, 26–27 May 2010, Dhaka. Retrieved July 13, 2011 from: http://www.bids.org.bd/ifpri/food_utilization3.pdf

Burchi, F., Fanzo, J., and Frison, E. (2011). The Role of Food and Nutrition System Approaches in Tackling Hidden Hunger. *Int. J. Environ. Res. Public Health* 2011, *8*, 358-373

Chweya, A. and Mnzava, N.A. (1997). Cat's whiskers Cleome gynandra L. Promoting the conservation and use of underutilized and neglected crops. 11. IPGRI, IPK

Dansi, A., Adjatin, A., Adoukonou-Sagbadja, H., Falade, V., Yedomonhan, H., Odou, D., and Dossou, B. (2009). Traditional leafy vegetables and their use in the Benin Republic. Genet Resour Crop Evol (2008) 55:1239–1256

De Schutter, O. (2010). Promotion and protection of all human rights, civil, political, economic, social and cultural rights, including the right to development. Report submitted by the Special Rapporteur on the right to food to the Human Rights Council Sixteenth **session** Agenda item 3. Retrieved from July 12, 2011 from http://www.srfood.org/images/stories/pdf/officialreports/20110308_a-hrc-16 49_agroecology_en.pdf

Enquête Démographique et de Sante, EDSB-III (2006). Institut National de la Statistique et de l'Analyse Économique (INSAE) Avec la collaboration du Programme National de Lutte contre le Sida (PNLS) Cotonou, Bénin. Macro International Inc. Calverton, Maryland, USA.

FAO (1999a). Agricultural Biodiversity: Multifunctional Character of Agriculture and Land Conference, Background Paper 1. Maastricht, Netherlands. September 1999.

FAO (1999b). Women: Users, preservers and managers of agrobiodiversity. (Available at www.fao.org/FOCUS/E/Women/Biodiv-e.htm).

FAO (2004). What is agrobiodiversity? Retrieved July 16, 2011 from: ftp://ftp.fao.org/docrep/fao/007/y5609e/y5609e00.pdf

FAO (2011). Biodiversity for Food and Agriculture: Contributing to food security and sustainability in a changing world. Outcomes of an Expert Workshop held by FAO and the Platform on Agrobiodiversity Research from 14–16 April 2010 in Rome, Italy

FAO/IFAD/ILO (2010). Gender dimensions of agricultural and rural employment. Differentiated pathways out of poverty. Status, trends, and gaps. Rome, Italy.

FAO/WHO (2003). Diet, nutrition and the prevention of chronic diseases. Report of a Joint FAO/WHO Expert Consultation. WHO Technical Report Series No. 916. Geneva.

FAO/WHO (2004). Promoting fruit and vegetable consumption around the world. Fruit and vegetables for health. Report of a Joint FAO/WHO Workshop, 1–3 September, 2004, Kobe, Japan.

Fassil, H. L., Guarino, S. S., BhagMal, T. H., and Iwanaga, M. (2000). Diversity for food security: Improving human nutrition through better evaluation, management, and use of plant genetic resources *Food and Nutrition Bulletin*, vol. 21, no. 4 © 2000, The United Nations University.

Frison, A., Ifeyironwa, F. S., Johns, T., Cherfas, J. and. Eyzaguirre, P.B. (2006). Agricultural biodiversity, nutrition, and health: Making a difference to hunger and nutrition in the developing world**.** *Food and Nutrition Bulletin*, vol. 27, no. 2 © 2006, The United Nations University

Gari, J.A. (2004). Plant diversity, sustainable rural livelihoods and the HIV/AIDS crisis. UNDP/FAO; Bangkok (Thailand)/Rome (Italy). Retrieved July 9, 2011 from: http://www.undp.org/hiv/docs/alldocs/Asia%20%20Plant%20Diversity,%20Sustainable%20Rural%20Livelihoods%20and%20the%20HIV-AIDS%20Crisis%20(2004).pdf

Gina, L.K., Pedro, M.R., Seghieri, C., Nantel, G. and Brouwer, I. (2007). Dietary Diversity Score Is a Useful Indicator of Micronutrient Intake in Non-Breast-Feeding Filipino Children. *J. Nutr. 137: 472–477, 2007.*

Gittelsohn, J. and Vastine, A. E. (2003). Sociocultural and Household Factors Impacting on the Selection, Allocation and Consumption of Animal Source Foods: Current Knowledge and Application. *J. Nutr. 133: 4036S–4041S, 2003*

Giuliani, A.(2007). Developing Markets for Agrobiodiversity. Securing livelihoods in dryland areas, Earthscan, London.

Grebmer, V., K., Torero, M., Olofinbiyi, T., Fritschel, H., Wiesmann, D., Yohannes, Y., Schofield, L., and Von Oppeln, C. (2011). 2011 Global Hunger Index. The Challenge of Hunger: Taming Price Spikes and Excessive Food Price Volatility. Bonn, Washington, DC, Dublin: Deutsche Welthungerhilfe, International Food Policy Research Institute, and Concern.

Haddad, A.L. (2000). Conceptual framework for assessing agriculture–nutrition linkages. *Food and Nutrition Bulletin,* vol. 21, no. 4 © 2000, The United Nations University

Hellin, J., Higman, S. and Keleman, A. (2010). Value chain coordination of agrobiodiversity conservation. In: Lockie, S., and Carpenter, D. (Eds.) (2010). Agriculture, biodiversity and markets: Livelihoods and agroecology in comparative perspective. Washington DC, Earthscan.

Ifeyironwa, F.S. (2010). Micronutrient interventions: Options for Africa *Food and Nutrition Bulletin,* vol. 21, no. 4 , The United Nations University.

International Conference on Nutrition, ICN (1992). World declaration and plan of action for nutrition: USAID Food Security and Nutrition Monitoring Project, 1992. Island Press, Washington, DC.

Kruijssen, F. and Mysore, S. (2010). Integrating biodiversity conservation and livelihood improvement: The role of markets for mango varieties and *Garcinia* species in India. Bioversity International, March 2010. India.

Lockie, S., and Carpenter, D. (Eds.) (2010). Agriculture, biodiversity and markets: Livelihoods and agroecology in comparative perspective. Washington DC, Earthscan.

Maxwell, D., Levin, C. and Csete, J. (1998). Does urban agriculture help prevent malnutrition? Evidence from Kampala. Food Policy 1998;23:411–24.

Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-being: Synthesis*.

Moore, G. (2010). Multilateral and national regulatory regimes for agrobiodiversity. In: Lockie, S., and Carpenter, D. (Eds.) (2010). Agriculture, biodiversity and markets: Livelihoods and agroecology in comparative perspective. Washington DC, Earthscan.

Moursi, M.M., Arimond, M., Dewey, K. G., Serge, T., Ruel, M. T. and Delpeuch, F. (2008). Dietary Diversity Is a Good Predictor of the Micronutrient Density of the Diet of 6- to 23-Month-Old Children in Madagascar. *J. Nutr. 138: 2448–2453, 2008*.

Pinstrup-Andersen, P. (2011). The food system and its interaction with human health and nutrition. Leveraging agriculture for improving nutrition and health. IFPRI 2020 conference brief.

Popkin, B.M. (2001). The nutrition transition and obesity in the developing world. *J. Nutr. 131: 871S–873S, 2001.*

Remans, R., Fanzo, J., Flynn, D.F.B., DeClerck, F., and Diru, W. (2011). Assessing Nutritional Diversity of Cropping Systems in African Villages. PLoS ONE 6(6): e21235. doi:10.1371/journal.pone.0021235

Report of the UN *Special Rapporteur on the right to food*, Olivier De Schutter. Addendum - Mission to Benin (A/HRC/13/33/Add.3) Human Rights Council, Thirteenth session, Agenda item 3. Promotion and protection of all human rights, civil, political, economic, social and cultural rights, including the right to development 22 Dec 2009 Page 24/69 ReliefWeb report — *http://reliefweb.int/node/347395*

Sakpere, A.M.A. and Aremu, O.A. (2008). The growth of Launea taraxacifolia (Asteraceae) and its response to shading. Research Journal of Botany 3(2): 90-96, 2008

Siebert, R. (2010). The 'Green Box': Multifunctionality and biodiversity conservation in Europe. In: Lockie, S., and Carpenter, D. (Eds.) (2010). Agriculture, biodiversity and markets: Livelihoods and agroecology in comparative perspective. Washington DC, Earthscan.

Sodjinou, R.S.(2006). Evaluation of food composition tables commonly used in Benin: Limitations and suggestions for improvements. *Journal of Food Composition and Analysis 19 (2006) 518–523*

SUN framework (2010). A road map for Scaling-Up Nutrition. First edition, September 2010.

The state of Food Insecurity in the world, SOFI (2011): How does international price volatility affect domestic economies and food security? Food and Agriculture Organization of the United Nations, Rome.

Toledo, A. and Burlingame, B. (2006). Biodiversity and nutrition: A common path toward global food security and sustainable development. *Journal of food composition and analysis 19: 477-483*

Torheim, L.E., Ouattara, F., Diarra, M. M., Thiam, F.D., Barikmo, I., Hatloy, A. and Oshaug, A. (2004). Nutrient adequacy and dietary diversity in rural Mali: association and determinants. *European Journal of Clinical Nutrition (2004) 58, 594–604*

Underwood, B. A. (2000). Overcoming micronutrient deficiencies in developing countries: Is there a role for agriculture? *Food and Nutrition Bulletin,* vol. 21, no. 4 © 2000. The United Nations University

WHO (1997). Global database on Child Growth and Malnutrition. World Health Organization, Geneva.