

**ReSAKSS Working Paper No. 23**

December 2008

**A Spatial Analysis of Child Nutrition  
in West Africa**

Christopher Legg

**Regional Strategic Analysis and Knowledge  
Support System  
(ReSAKSS)**

**ReSAKSS Working Paper No. 23**

December 2008

**A Spatial Analysis of Child Nutrition  
in West Africa**

Christopher Legg

## **About ReSAKSS**

The Regional Strategic Analysis and Knowledge Support System (ReSAKSS) is an Africa-wide network of regional nodes supporting the Common Market of Eastern and Southern Africa (COMESA), the Economic Community of West African States (ECOWAS), and the Southern African Development Community (SADC), in collaboration with the International Food Policy Research Institute (IFPRI) and the Africa-based centers of the Consultative Group on International Agricultural Research (CGIAR), to facilitate the implementation of the AU/NEPAD Comprehensive Africa Agriculture Development Program (CAADP) and other regional agricultural development initiatives in Africa.

The ReSAKSS nodes offer high-quality analyses to improve policymaking, track progress, document success, and derive lessons for the implementation of the CAADP agenda. ReSAKSS is jointly funded by the United States Agency for International Development (USAID), the UK Department for International Development (DFID), and the Swedish International Development Cooperation Agency (SIDA). The nodes are implemented by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the International Institute of Tropical Agriculture (IITA), the International Livestock Research Institute (ILRI) and the International Water Management Institute (IWMI), in collaboration with regional and national partners.

### **About the Working Paper series**

The goal of the ReSAKSS Working Paper series is to provide timely access to preliminary research and data analysis results that relate directly to strengthening ongoing discussions and critical commentaries on the future direction of African agriculture and rural development. The series undergoes a standard peer review process involving at least one reviewer from within the ReSAKSS network of partners and at least one external reviewer. It is expected that most of the working papers eventually will be published in some other form and that their content may be revised further.

For more information, contact:

Coordinator  
Regional Strategic Analysis and Knowledge Support System-West Africa (ReSAKSS-WA)  
Oyo Road, PMB 5320  
Ibadan, Oyo State  
Nigeria  
Telephone: +234 (2) 241 2626  
E-mail: [resakss-wa@cgiar.org](mailto:resakss-wa@cgiar.org)  
[www.wa.resakss.org](http://www.wa.resakss.org)

## The author

Christopher Legg is a GIS Consultant to ReSAKSS-West Africa.

Legg, Christopher.2008. *A Spatial Analysis of Child Nutrition in West Africa*. ReSAKSS Working Paper No. 23, ReSAKSS-West Africa.



Except where otherwise *noted*, this work is licensed under a [Creative Commons Attribution 3.0 License](https://creativecommons.org/licenses/by/3.0/).

## Table of Contents

Abstract.....	5
Introduction .....	6
Child Nutrition in Context .....	6
Data Sources for West and Central Africa .....	8
DHS Data .....	8
MICS .....	9
CIESIN .....	10
Sub-National Agricultural Production Statistics .....	11
Population Data.....	11
Climate Data .....	12
Comparison of DHS, MICS and CIESIN datasets.....	13
Spatial Aspects of Child Nutrition.....	15
Child Nutrition and Climate .....	21
Child Nutrition and Agricultural Production .....	24
The Role of Livestock.....	31
Child Nutrition and Development Domains .....	36
The Temporal Dimension of Child Nutrition in West Africa .....	38
Suitability for Crop Diversification .....	43
Conclusions and Recommendations.....	46
References.....	52

## **Abstract**

Data on child nutrition in West and Central Africa from Measure DHS and Multiple Indicator Cluster Surveys undertaken between 1992 and 2006 has been mapped and analysed in relation to climatic zones, development domains and agricultural production.

Child malnutrition is most serious in the more arid parts of the region, where more drought-tolerant crops such as millet, sorghum and maize are dominant. The more humid areas, where root crops are dominant, show generally lower child malnutrition. Population densities do not have a significant influence on malnutrition rates, although actual numbers of malnourished children are highest in areas of very high population density. Counter-intuitively, areas with best access to markets show higher incidence of child malnutrition. High densities of cattle and small ruminants do not normally result in improved child nutrition. The potential for improved nutrition and food security offered by mixed livestock and cropping systems appears not to have yet been realized through most of the region. Although there have been some local improvements in child nutrition in the region since the early 1990's, the overall situation is either near-static or declining. Agricultural development directed at improved nutrition appears not to have been effective.

More data is required in order to refine this study. DHS-type surveys need to be undertaken at finer spatial resolution in some countries, especially Nigeria, where population densities are very high. More detailed and timely agricultural production and food consumption data is needed for many countries in order to better target agricultural development efforts. Improved biophysical data on climatic requirements of improved varieties of staple crops would help to identify areas where introduction of new varieties might contribute to better nutrition.

## Introduction

One of the objectives of the Strategic Analysis and Knowledge Support System (SAKSS) is to assist in targeting investment in agricultural research for development to those areas where it is most needed and where impact will be highest. The nutritional status of children is a most important indicator of the health of a community, and can predict the future health and vigor of society. The methodology for conducting regular demographic and health surveys which use sampling techniques to measure a wide range of indicators of mother, child and family health and well-being is now highly developed, and Measure DHS and MICS surveys are now undertaken in many countries of Africa at intervals of eight years or less. These surveys have become spatially more detailed and are disaggregated to the 2<sup>nd</sup> administrative level (province or region) in most countries, and even to the third level (district or state) in some countries. The West Africa node of SAKSS (ReSAKSS-WA) is accumulating up to date disaggregated agricultural production data for most countries in the region, and this permits an analysis of relationships between agricultural production, farming systems and child nutrition. GIS analysis can also be carried out of the spatial distribution of child malnutrition in relation to climatic zones and development domains in order to highlight those areas where malnutrition is most prevalent, and where development assistance can have greatest impact in alleviating malnutrition. This report presents results to date in this ongoing study.

## Child Nutrition in Context

Child malnutrition, more specifically under-nutrition, since malnutrition includes over-nutrition which is predominantly a problem in more developed countries, and is also growing amongst the urban elite of less-developed countries, is a global problem. However, of the 40 countries with a child stunting prevalence of 40% or more, 23 are in Africa, 16 in Asia, and one in Latin America (Black et al 2007). Figure 1 shows the global distribution of infant mortality, usually a consequence of poverty and malnutrition, and highlights the concentration in Africa. Ahmed et al (2007) comment “As it is, the ultra poor are overwhelmingly concentrated in one region—Sub-Saharan Africa is home to more than three-quarters of the world’s ultra poor. Sub-Saharan Africa is also the only region in the world in which there are more ultra poor than medial or subjacent poor.” In 2004, 121 million Sub-Saharan Africans lived on less than a meager \$0.50 a day. Hunger is a challenge to human dignity and human rights. But hunger is also a threat to security and stability, and to the ability of nations to prosper socially and economically. Most deaths from hunger do not occur in high-profile emergencies but in unnoticed crises, in areas and populations that are the most destitute and vulnerable. The poorest and most marginalized people—the so-called bottom billion—cling to survival on less than US\$1 a day, often below the level at which development work can meaningfully begin. Higher rates of child malnutrition and child mortality are found in poor households. Poor families not only struggle to put a sufficient quantity of food on the table, but are also prone to food insecurity with regard to the quality of their diets: even when dietary energy requirements are met, their diets may lack essential micronutrients such as iron, iodine, zinc, and vitamin A.

Because undernourished people are less productive and child malnutrition has severe and permanent consequences for physical and intellectual development, poverty and hunger can become entwined in a vicious cycle. Babies born to severely undernourished and anemic mothers are at higher risk of being underweight and dying soon. If they survive, they will never make up for the nutritional shortfalls at the very beginning of their lives. Adults who were malnourished as children are less physically and intellectually productive, have lower educational attainment and lifetime earnings, and are affected by higher levels of chronic illness and disability. Poverty is a key factor affecting the underlying determinants of household food security, caring capacity, and health environments. Poor households and individuals are unable to achieve food security, have inadequate resources for care, or cannot utilize resources for health on a sustainable basis (Smith and Haddad 2000).

Despite a global trend of poverty shifting toward urban areas, the incidence of poverty is still higher in rural areas. The poorest and most undernourished households are located furthest from roads, markets, schools, and health services. In Sub-Saharan Africa, overall progress in the 1990s was slow. The proportion of people who were food-energy deficient decreased, but there was very little improvement in underweight in children and in the under-five mortality rate.

While remarkable progress has been made in some regions (notably East Asia and the Pacific), progress has been slow in regions where poverty and hunger are severe. As a result, the first MDG goal (halving the proportion of people living on less than \$1 per day by 2015) seems far out of reach for most of Sub-Saharan Africa.

**Table 1. Some Development and Nutrition Indicators in SAKSS regions in Sub-Saharan Africa.**

Region	Low Birth Weight %	Global Hunger Index 2003	Safe water access %	Rural Sanitation %	Life Expectancy	U5 Mortality per 000	Infant mortality per 000	HIV infection %	Malaria deaths per 000	Stunting %	U Weight %
WA-SAKSS	15	23.75	39	28	46.3	187	105	3.5	171	36.7	28.3
SA-SAKSS	14	19.65	58	39	43.0	126	84	16.6	234	43.3	24.0
EA-SAKSS	16	29.68	40	26	48.0	128	80	4.2	139	41.3	31.8

Data from World Bank, 2008, SCF 2007

Figure 1 shows that, although most indices of child nutrition are high throughout Sub-Saharan Africa, there are considerable differences between countries. When indices are re-calculated for the three SAKSS regions of Africa, weighted for population in each country, the differences between the regions are not as great as between countries, as shown in Table 1. The Southern Africa region (SA-SAKSS) shows higher levels of physical development than the others, with higher percentages of people having access to safe water and improved sanitation, although child stunting and malaria deaths are higher and life expectancy lower, possibly as a result of significantly higher HIV infection. Highest Global Hunger Index and incidence of underweight children is in the East African region, while highest rates of under-5 and infant mortality are found in West and Central Africa.



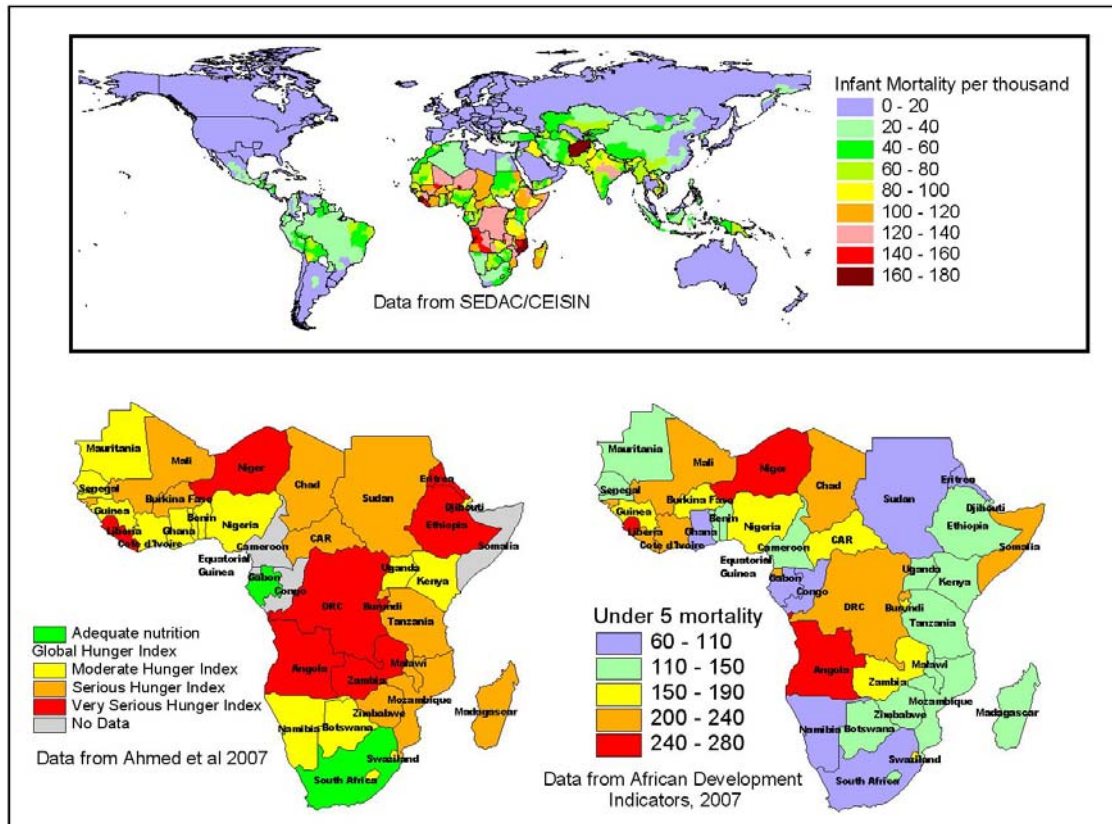


Figure 1. Global and Sub-Saharan African distribution of child health from various indicators.

## Data Sources for West and Central Africa

### DHS Data

Three indices of child nutrition are presented in the Measure DHS country reports (DHS, 1988; DHS, 1989; DHS, 1992,A,B; DHS, 1993; DHS, 1994, a, B, C; DHS, 1995; DHS, 1996; DHS, 1997; DHS, 1998; DHS, 1999, A, B, C; DHS, 2000, A, B, C, D; DHS, 2001, A, B; DHS, 2002, A, B; DHS, 2004; DHS, 2005, A, B; DHS, 2006, A, B, C; DHS, 2007). Each of these indices—height-for-age (TPA), weight-for-height (PPT), and weight-for-age (PPA)—gives different information about growth and body composition used to assess nutritional status. The height-for-age index is an indicator of linear growth retardation. Children whose height-for-age Z-score is below minus two standard deviations (-2 SD) from the median of the reference population are considered short for their age (stunted) and are chronically malnourished. Children who are below minus three standard deviations (-3 SD) from the median of the reference population are considered severely stunted. Stunting reflects failure to receive adequate nutrition over a long period of time and is also affected by recurrent and chronic illness. Height-for-age, therefore, represents the long-term effect of malnutrition in a population and does not vary according to recent dietary intake.

The weight-for-height index measures body mass in relation to body length and describes current nutritional status. Children whose Z-scores are below minus two standard deviations (-2 SD) from the median of the reference population are considered

thin (wasted) for their height and are acutely malnourished. Wasting represents the failure to receive adequate nutrition in the period immediately preceding the survey and may be the result of inadequate food intake or a recent episode of illness causing loss of weight and the onset of malnutrition. Children whose weight-for-height is below minus three standard deviations (-3 SD) from the median of the reference population are considered severely wasted.

Weight-for-age is a composite index of height-for-age and weight-for-height. It takes into account both acute and chronic malnutrition. Children whose weight-for-age is below minus two standard deviations from the median of the reference population are classified as underweight.

The DHS estimates of percentages of stunted, wasted and underweight children under five years can be further classified for purposes of inter-country comparison. Table 2 presents a classification proposed by FAO.

**Table 2. FAO classification of Child Malnutrition**

Indicators	Low	Moderate	High	Very High
Stunting	<20%	20-30%	30-40%	>40%
Wasting	<5%	5-10%	10-15%	>15%
Underweight	<10%	10-20%	20-30%	>30%

The size of administrative unit on which DHS surveys are based varies widely from country to country, but is normally the “Province” or equivalent unit, rather than the “district”. This means that the total population in each unit varies between half a million and four million across most of the region. Nigeria is anomalous in this respect. DHS sampling in Nigeria was based on six “regions”, which are extremely large for the population density, and thus have between 15 million and 30million people in each unit. In order for the Nigeria DHS results to be comparable in terms of sampling levels and representativity to the other countries in the region, the sampling units should have been much smaller, possibly based on States rather than regions.

## **MICS**

The Multiple Indicator Cluster Survey (MICS) is a household survey programme developed by UNICEF to assist countries in filling data gaps for monitoring the situation of children and women. Many of the data collected are essentially identical to Measure-DHS, particularly the child nutrition indicators, and MICS is capable of producing statistically sound, internationally comparable estimates of these indicators. MICS was originally developed in response to the World Summit for Children to measure progress towards an internationally agreed set of mid-decade goals. The first round of MICS was conducted around 1995 in more than 60 countries. A second round of surveys was conducted in 2000 (around 65 surveys), and resulted in an increasing wealth of data to monitor the situation of children and women (MICS 2000, A, B, C, D and E). For the first time it was possible to monitor trends in many indicators and set baselines for other indicators. The current round of MICS is focused on providing a monitoring tool for the World Fit for Children, the Millennium Development Goals (MDGs), as well as for other major international commitments, such as the UNGASS on HIV/AIDS and the Abuja targets for malaria. 21 of the 48 MDG indicators can be collected in the current round of MICS.

## CIESIN

The Center for International Earth Science Information Network (CIESIN) through its Socio-Economic Data and Applications Center (SEDAC) has produced compilations of global data on child malnutrition and mortality (CIESIN 2005). The Global Sub-national Prevalence of Child Malnutrition dataset consists of estimates of the percentage of children with weight-for-age z-scores that are more than two standard deviations below the median of the NCHS/CDC/WHO International Reference Population. Data are reported for the most recent year with sub-national information available at the time of development. The data products include a shapefile (vector data) of percentage rates, grids (raster data) of rates (per thousand in order to preserve precision in integer format), the number of children under five (the rate denominator), and the number of underweight children under five (the rate numerator), and a tabular dataset of the same and associated data. This dataset is produced by the Columbia University Center for International Earth Science Information Network (CIESIN).

The Global Sub-national Infant Mortality Rates consists of estimates of infant mortality rates for the year 2000. The infant mortality rate for a region or country is defined as the number of children who die before their first birthday for every 1,000 live births. The data products include a shapefile (vector data) of rates, grids (raster data) of rates (per 10,000 live births in order to preserve precision in integer format), births (the rate denominator) and deaths (the rate numerator), and a tabular dataset of the same and associated data. Over 10,000 national and sub-national units are represented in the tabular and grid datasets, while the shapefile uses approximately 1,000 units in order to protect the intellectual property of source datasets for Brazil, China, and Mexico.

These data sets have been compiled from DHS data plus UNICEF and WHO data sets, and include all data collected before 2000. For West Africa they are less detailed (in terms of the minimum size of administrative units covered) than the most recent DHS and MICS data-sets. In some cases (for example Chad) there is no sub-national disaggregation. The data is available as grid or shape files from <http://sedac.ciesin.org/povmap/>

**Table 3. Current Availability of Agricultural Statistics, DHS and MICS Data**

Country	agric data	Source	DHS child nutrition	MICS child nutrition
Benin	2000	Agromaps	1996, 2001, 2006	
Burkina Faso	2004	Govt Statistics	1993, 1999, 2003	
Cameroon	2003	Govt Statistics	1991, 1998, 2004	2000
Central African Republic			1994 (not sub-national)	2006 (not sub-national)
Chad			1997, 2004	2000 (not truly sub-national)
Congo			2005 (not truly sub-national)	
Cote d'Ivoire			1994, 1999 (not sub-national)	2000 (not sub-national), 2006
DRC	1996	Agromaps		2001
Gabon			2000	
Gambia	1998	Agromaps		2000 2006
Ghana	2003	Govt Statistics	1988, 1993, 1998, 2003	2006
Guinea			1999, 2005	
Guinea Bissau	1992	Agromaps		2006

Country	agric data	Source	DHS child nutrition	MICS child nutrition
Mali	1993	Agromaps	1987, 1996, 2001, 2006	
Mauritania			2001	
Niger	2005	Govt Statistics	1992, 1998, 2006	2000 2006
Nigeria	2006	Govt Statistics	1990, 1999, 2003 (not truly sub-national)	
Senegal	1997	Agromaps	1986, 1993, 2005	2000
Sierra Leone	2002	OCHA/SLIS		2000 2006
Togo			1988, 1998	2000 (not sub-national), 2006

### Sub-National Agricultural Production Statistics

A primary source of sub-national agricultural production data for Africa is the AgroMaps database, prepared by the International Food Policy Research Institute (IFPRI), FAO and SAGE (George, Nachtergaele and Koochafkan, 2003). The shortcomings of existing data and an increasing necessity to have better global land-use data to support their respective programs, led IFPRI, FAO and SAGE to set up in early 2002, the Agro-MAPS (**M**apping of **A**gricultural **P**roduction **S**ystems) Initiative. The institutions agreed to pool their resources and to jointly prepare, with the support of national and regional institutions, the Agro-MAPS database. It was agreed that the database would contain selected agricultural statistics (viz. crop production, area harvested and crop yields) aggregated by sub-national administrative districts. These statistics represent a limited, yet very important component of agricultural land use.

AGROMAPS data has been supplemented with more recent agricultural statistics for Burkina Faso, Cameroon, Ghana, Niger, Nigeria and Sierra Leone, as listed in Table 2, and new shapefiles have been prepared to supplement AGROMAPS for West Africa. Additional data is currently being collected by ReSAKSS-WA, and this report will be updated as new data becomes available.

### Population Data

This was obtained in two forms from <http://sedac.ciesin.org/gpw/index.jsp>. Gridded Population of the World (GPWv3) is the third edition of a large-scale data product that demonstrates the spatial distribution of human populations across the globe (Balk and Yetman, 2004). The purpose of the GPWv3 project is to provide a spatially disaggregated population layer that is compatible with datasets from social, economic, and earth science fields. The output is unique in that the distribution of human population is converted from national or sub-national spatial units (usually administrative units) of varying resolutions, to a series of geo-referenced quadrilateral grids at a resolution of 2.5 arc minutes.

The Global Rural-Urban Mapping Project (GRUMP) provides a new suite of data products that add rural-urban specification to GPWv3. This project was developed out of a need for researchers to be able to distinguish population spatially by urban and rural areas (Balk et al 2004). The central data product resulting from GRUMP is a Gridded Population of the World with Urban Reallocation in which spatial and population data of both administrative units and urban extents are gridded at a resolution of 30 arc-seconds.

The gridded population data, divided into rural and urban populations, was used to calculate the number of malnourished children, according to the DHS and MICS indicators, per square kilometer across the WA-SAKSS region.

### Climate Data

Analysis of the distribution of child malnutrition by agro-ecozones has been aided by the use of gridded data on precipitation and temperature produced by the Climate Research Unit of the University of East Anglia (New et al 2000, New et al 2002), downloaded from <http://www.cru.uea.ac.uk/cru/data/hrg.htm> . The climate data was also used to calculate suitability for different staple crops.

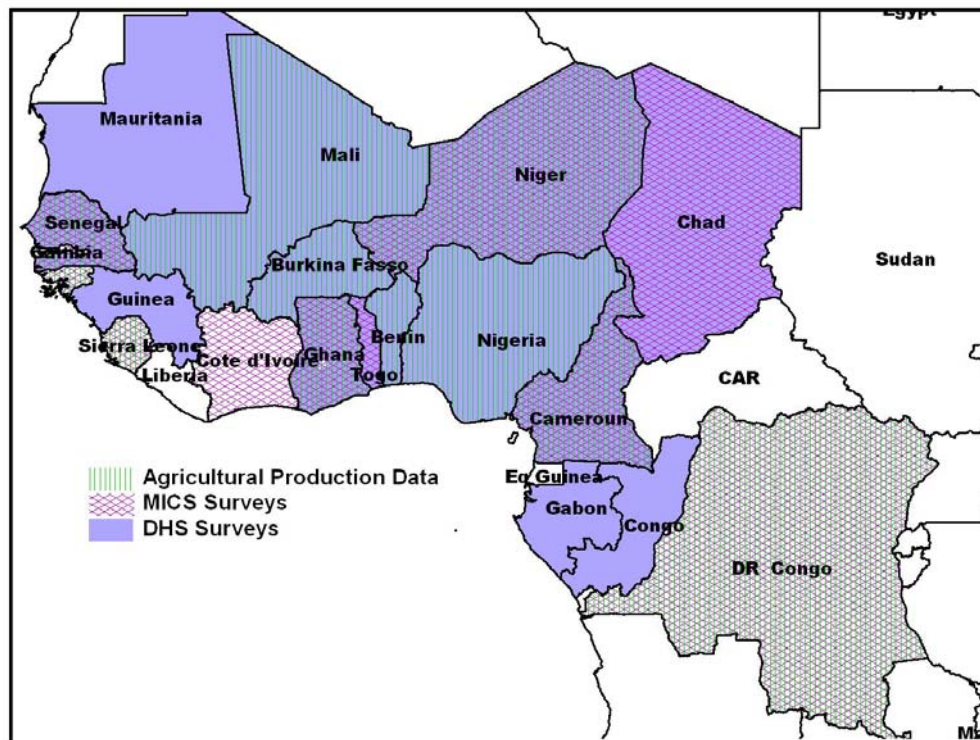


Figure 2. Available DHS, MICS and Agricultural Production Data

The areas in West Africa covered by recent disaggregated DHS and MICS surveys, and where sub-national agricultural production statistics are available, are shown in Figure 2. DHS data is also available for Mauritania, Central African Republic, Congo and Gabon, but only at very coarse resolution. Cote d'Ivoire was covered by early national DHS surveys, and a disaggregated survey was recently undertaken by MICS. Liberia has not been covered by either DHS or MICS surveys. Sub-national agricultural statistics are not yet available to the author for Chad, Guinea, Cote d'Ivoire, Liberia or Togo.

## Comparison of DHS, MICS and CIESIN datasets

Table 4. Mean National Indicators from DHS and MICS

Country	Stunt DHS	Stunt MICS	Waste DHS	Waste MICS	U/W DUS	U/W MICS
Ghana	29.9	23	7.1	5	22.1	18
Niger	41.1	40	20.7	14	49.6	40
Cote d'Ivoire	25.2	23.4	7.8	7.2	21.2	20.5
Togo	21.7	23.7	12.3	14.3	25.1	26.8

The DHS and MICS datasets on child nutrition should be broadly comparable, since the methodology was designed to be the same, and the sample sizes were similar. Only three countries (Ghana, Senegal and Niger) were sampled by both DHS and MICS at the same levels of disaggregation. Cameroon, Chad and Togo were also sampled by MICS, but results for child nutrition are not yet available on their website. The dates of the MICS and DHS surveys in Senegal and Niger were different; both countries were sampled by MICS in 2000, while the most recent DHS survey in Senegal was in 2005 and in Niger in 2006. Despite the date differences, the results of the two surveys were broadly similar, as shown in Table 4 (Mean national values for DHS and MICS surveys in nearest years) and Charts 1 and 2 (disaggregated data).

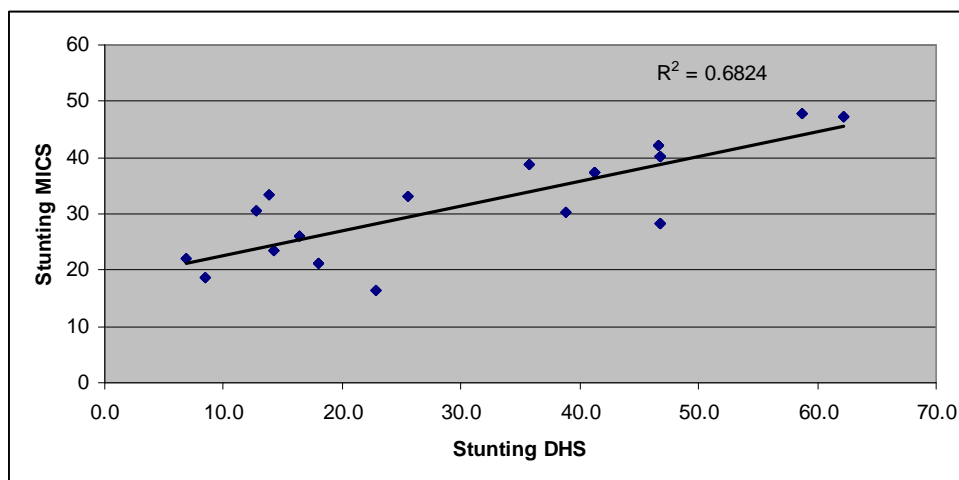
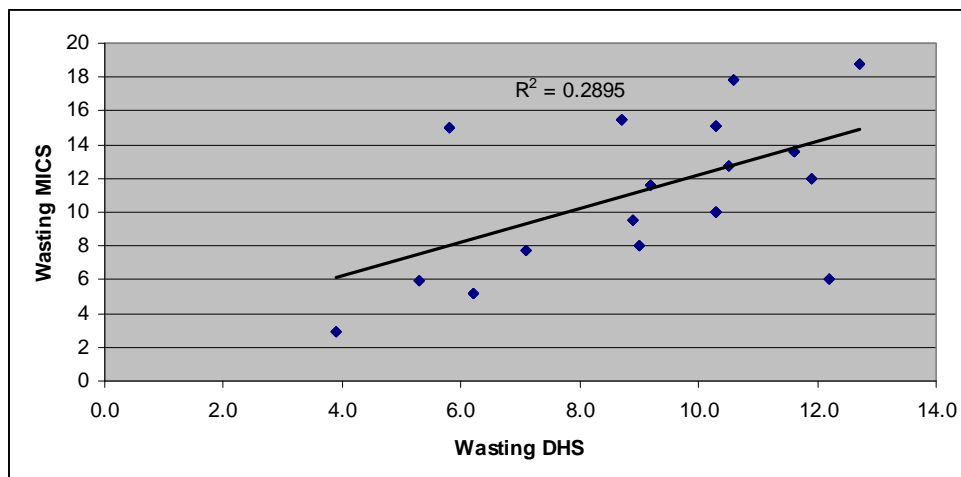


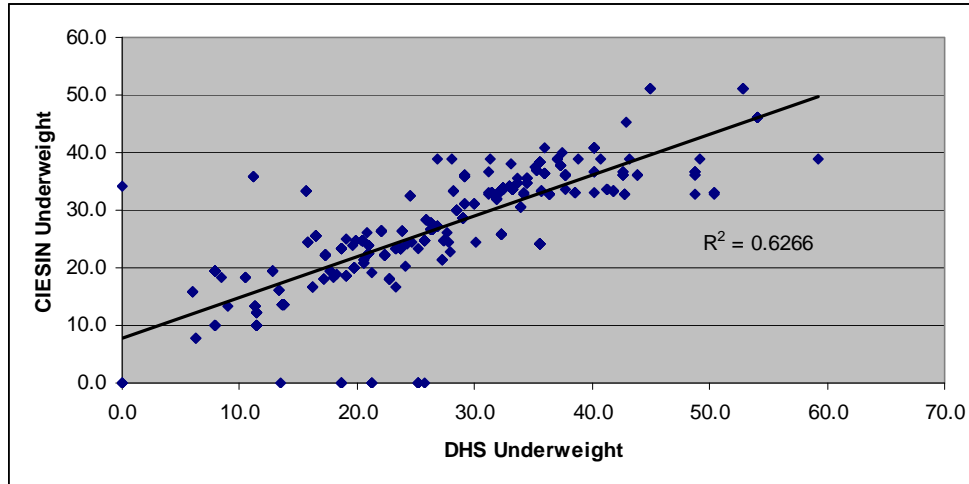
Chart 1. Correlation between DHS and MICS child stunting, Senegal and Niger



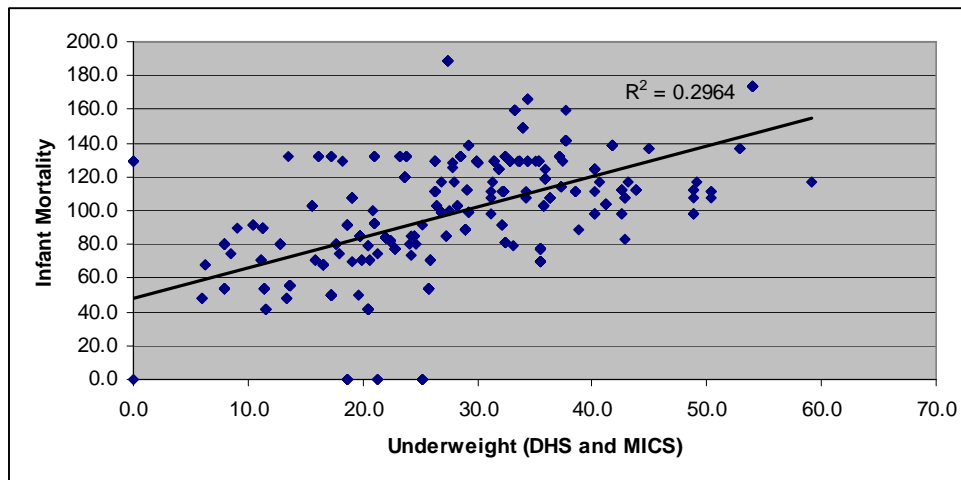
**Chart 2. Correlation between DHS and MICS child wasting, Senegal and Niger**

Differences between the two sets of results are no greater than between different year surveys by the same agency (See section 10 below). We can therefore use both data sets (MICS and DHS) for regional studies in west and central Africa, taking advantage of the fact that the two surveys did not normally duplicate each others efforts in the same country. This effectively increases the number of study countries from 11 if only DHS data are used, to 16 when MICS data is added. Although the MICS survey appears to have been planned essentially as a “one-off” in 2000 for the Millenium Assesment, some countries were sampled again in 2006. Time-series of MICS child nutrition indicators are not available for most countries covered only by MICS surveys, although MICS data can complement DHS data in countries covered by both surveys.

The CIESIN / SEDAC child underweight and infant mortality data is generally at a lower spatial resolution than the most recent DHS and MICS data, but has effectively global coverage. Earlier DHS data sets contributed to this compilation in West Africa, so it is not surprising that correlations between the two data sets are good. Chart 3 shows the correlation between reported child underweight percentages from CIESIN/SEDAC and underweight percentages from combined DHS and MICS data. The two data sets correlate well, with an R squared of better than 0.6. This means that the CIESIN/SEDAC data can be used as a proxy for DHS/MICS in countries where full DHS surveys have not been carried out recently. It is unfortunate that CIESIN/SEDAC only mapped child malnourishment, and not the more specific stunting and wasting indicators.



**Chart 3. Correlation between Two Sets of Child Underweight data**



**Chart 4. Correlation between Infant Mortality and DHS/MICS Child Underweight**

There is weak correlation between CIESIN/SEDAC infant mortality and the DHS/MICS child nutrition indicators (infant mortality is not quantified in the DHS reports), as shown by the example in Chart 4. The relationship is weak because the child nutrition indicators are for children aged less than 5 years, while infant mortality concerns children less than one year old only, and also infant mortality is strongly influenced by mothers health and nutrition as well as the general incidence of disease, rather than just by child nutrition.

## Spatial Aspects of Child Nutrition

The three main indicators of child malnutrition in West and Central Africa – stunting, wasting and underweight, can be mapped on a regional scale to highlight trends in malnutrition and areas of greatest concern. Figures 3, 4 and 5 map the three main indicators, classified according to the FAO recommendations presented in Table 2. There are significant differences between and similarities among the distribution of the three indicators. It should be remembered that stunting is an indicator of long-term dietary deficiency, while wasting is a shorter-term effect, exaggerated in years of poor



harvests with relatively fast recovery in good years. This means that differences in the timing of DHS/MICS surveys in different countries can be expected to have a greater effect on the wasting indicator than on stunting.

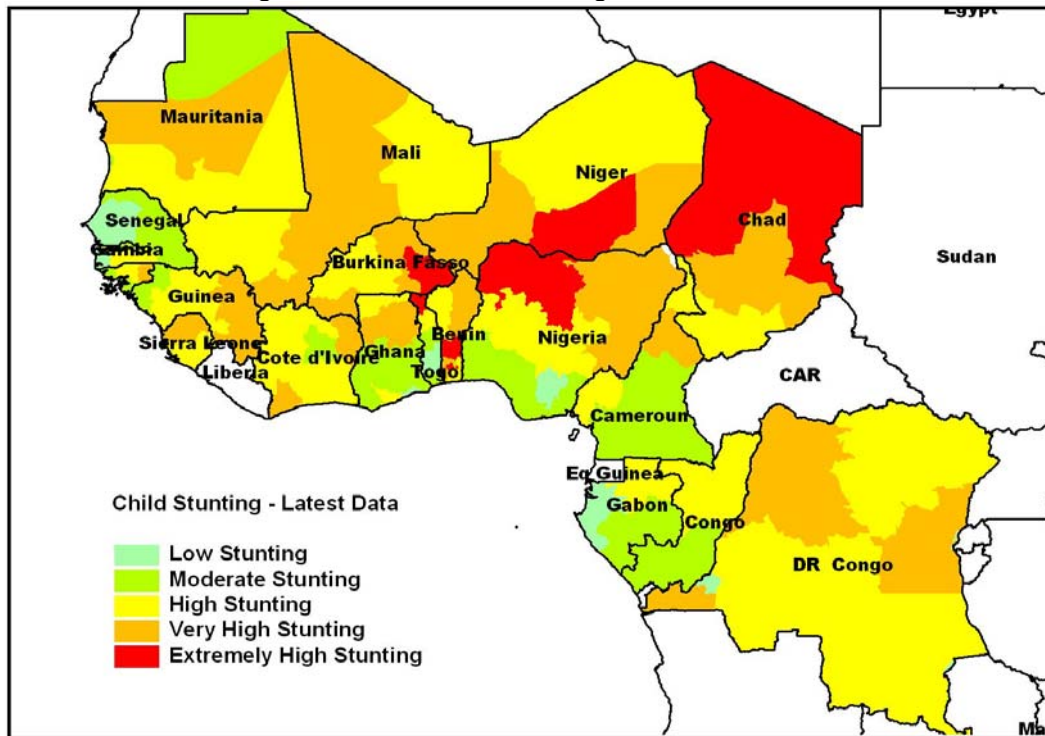


Figure 3. Child Stunting in West and Central Africa

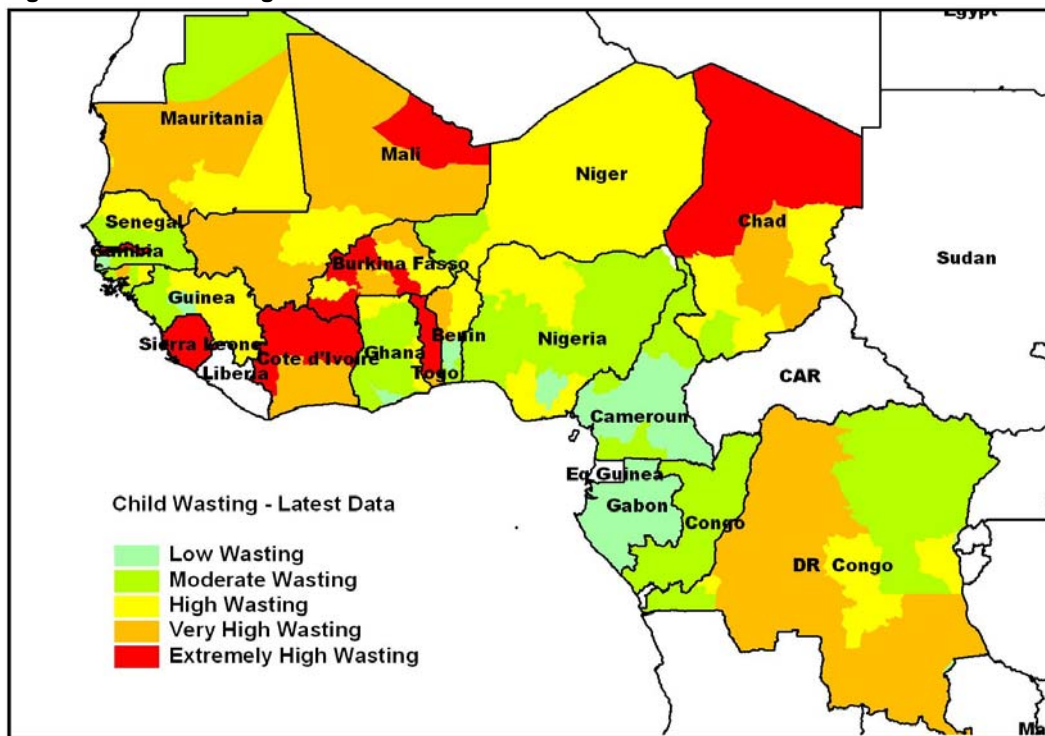


Figure 4. Child Wasting in West and Central Africa

Stunting in children under 5 years (Figure 3) shows a marked belt of very high and extremely high (more than 50% of children stunted) incidence stretching from Chad westwards through southern Niger, north-western Nigeria, Burkina Faso to northern Ghana and southern Mali. Another area of very high stunting incidence is found in Eastern DRC. Child wasting (Figure 4) is extremely high (more than 25% of children wasted) in parts of Burkina Faso, and is also very high in much of Chad, Mali, DR Congo and Guinea Bissau.

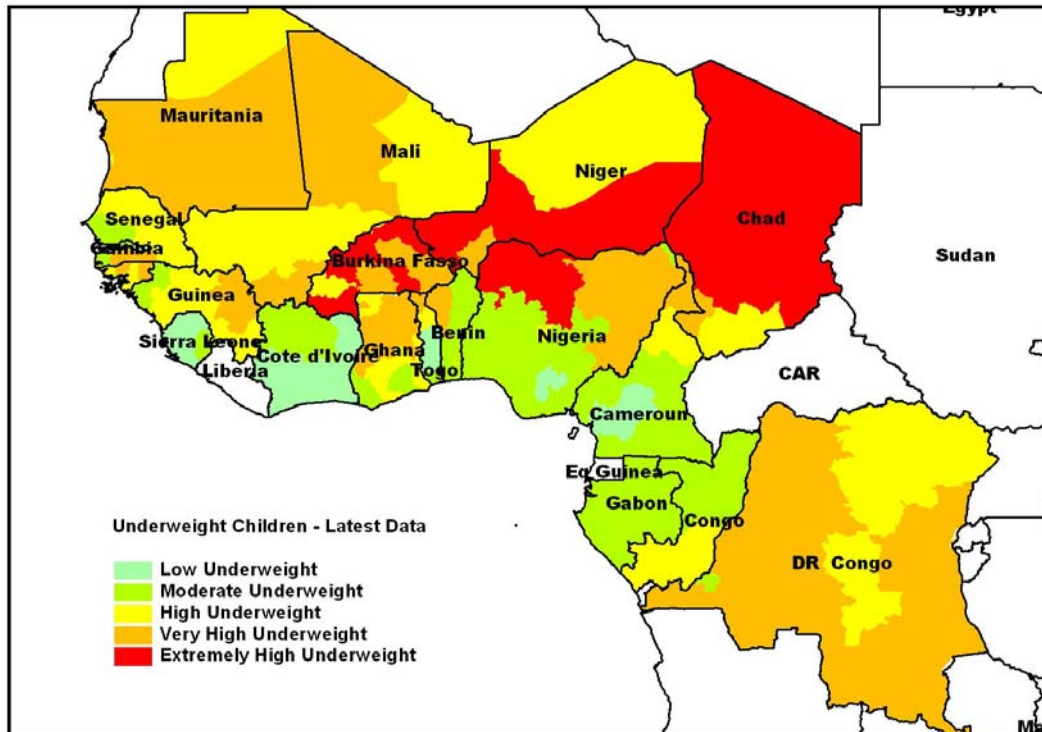


Figure 5. Underweight Children in West and Central Africa

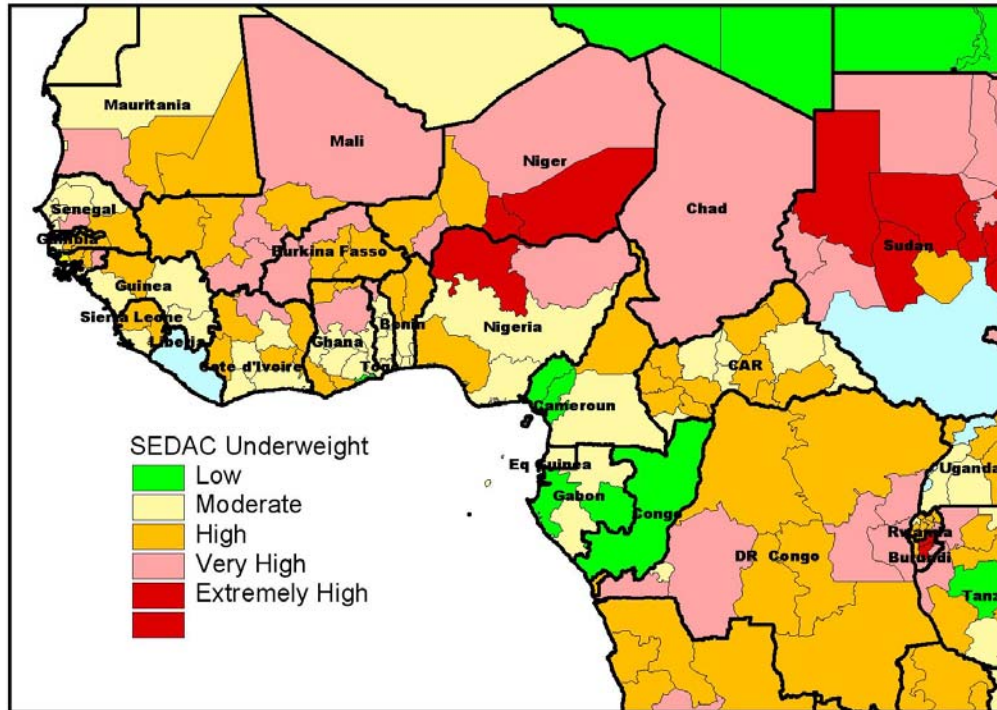


Figure 6. Underweight children in West and Central Africa from CIESIN/SEDAC map

The distribution of underweight children (basically a composite of stunting and wasting) as mapped from DHS and MICS data is shown in Figure 5. There are pockets of extremely high underweight incidence in Burkina Faso, while the northern half of Chad and southern Niger also show extremely high incidence. High incidence of underweight children can be seen in central Ghana, eastern Mali, western Niger, north-western Nigeria and southern Chad. The regional picture is confirmed in the lower-resolution SEDAC data shown in Figure 6, although this does not show the extremely high incidence in parts of Burkina, possibly because the lower resolution moderates extreme values, or perhaps because of different years of data collection.

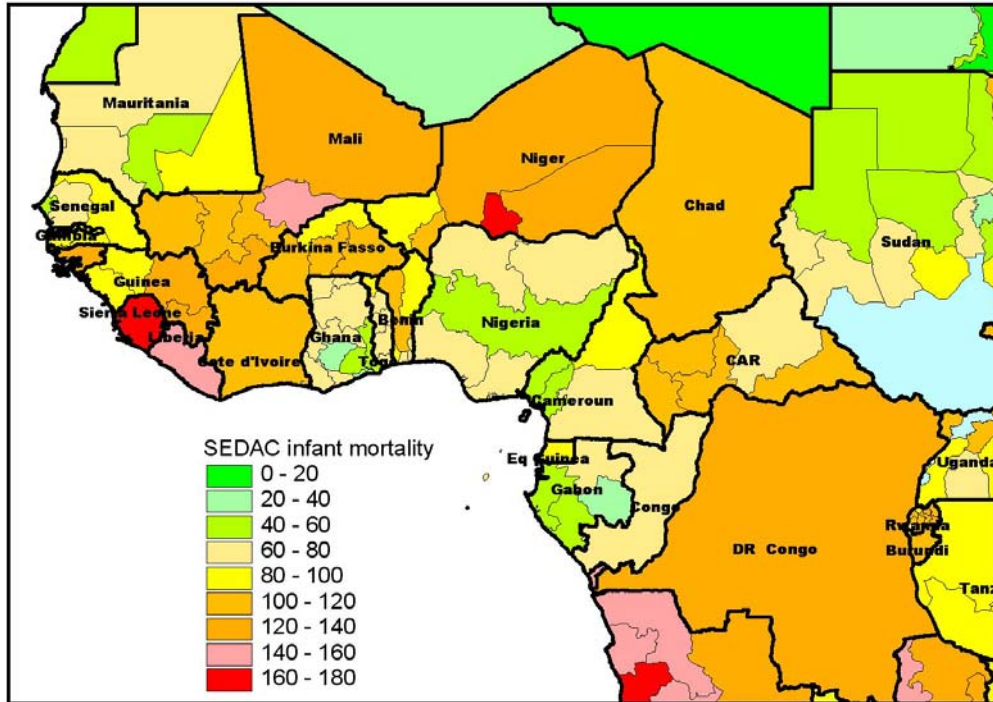


Figure 7. Infant Mortality in West and Central Africa

The distribution of infant mortality, derived from the CIESIN/SEDAC data, is shown in Figure 7. The highest incidence in the region is in Sierra Leone and in southern Niger, while Liberia and central Mali also have high infant mortality. Within the countries covered by WA-SAKSS, lowest values of infant mortality are found in Mauritania, Senegal, south-eastern Ghana, central Nigeria, western Cameroon and Gabon.

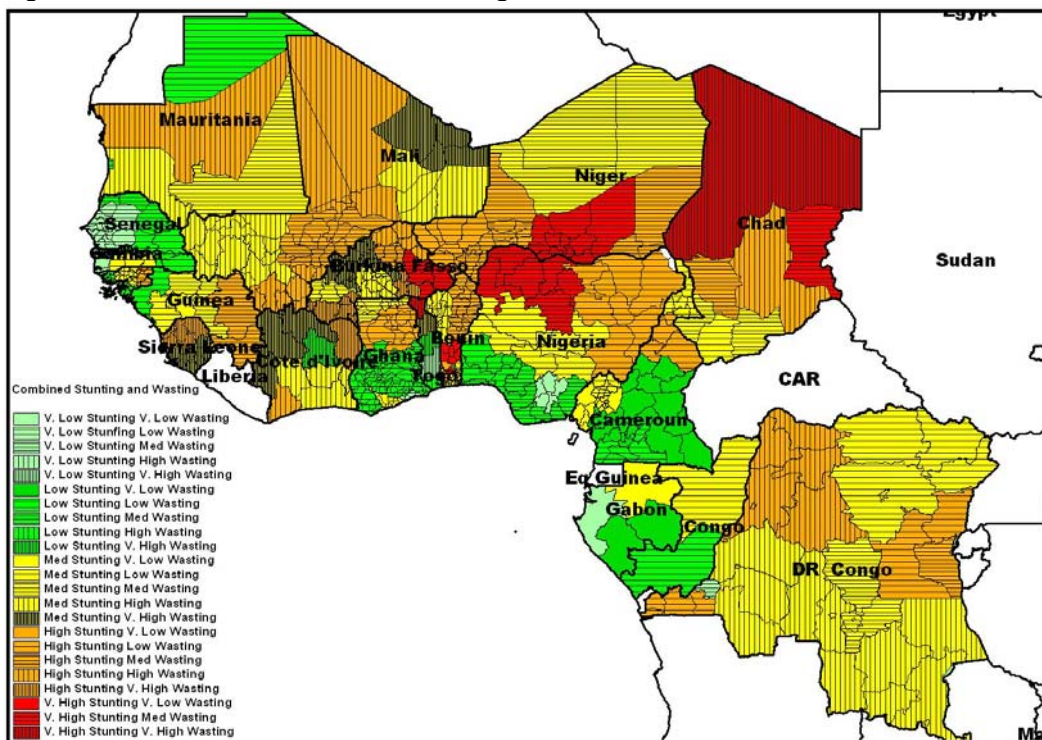


Figure 8. Combined Stunting and Wasting

In order to highlight areas where children are both chronically and acutely malnourished, it is useful to map combined stunting and wasting, as shown in Figure 8. Based on the FAO classification (Table 1) stunting and wasting are each divided into five classes. This provides a potential 25 classes combining the two indicators. Not all these possible classes exist, and the 18 classes observed in West Africa are shown in the map. Lowest combined incidences of stunting and wasting are generally found in more humid coastal districts, with the exception of Sierra Leone and DRC, while highest combined incidence is seen in central Mauritania, northern Mali, northern and eastern Burkina, southern Niger and Chad, and north-western DRC. In countries with a marked climatic gradient such as Ghana, Nigeria and Cameroon, the combined incidence increases strongly from south to north.

The DHS and MICS surveys provide child malnutrition indicators as percentages of the population in every survey area, but for the purposes of targeting agricultural development assistance it is sometimes useful to know the absolute numbers of children affected. When considering impact of assistance, a very high incidence of child stunting in a relatively unpopulated area may translate to very few children, while a more moderate incidence in a very densely populated area might be a more practical target.

In order to calculate the actual numbers of malnourished children, the percentage of affected children in each administrative unit must be multiplied by the actual number of children. The DHS reports summarise the demography of each unit, so that the percentage of the population under 5 years of age is known. The Gridded Population of the World (GPW3) data from CIESIN (Balk, 2004) is used to calculate the numbers of stunted and wasted children per square kilometer from the DHS statistics. Urban areas are separated from rural using GRUMP maps (Balk et al 2004), and malnutrition indices are adjusted for urban areas using urban/rural ratios from the DHS and MICS surveys. Figure 9 shows the spatial distribution of stunted children calculated from the DHS and MICS data.

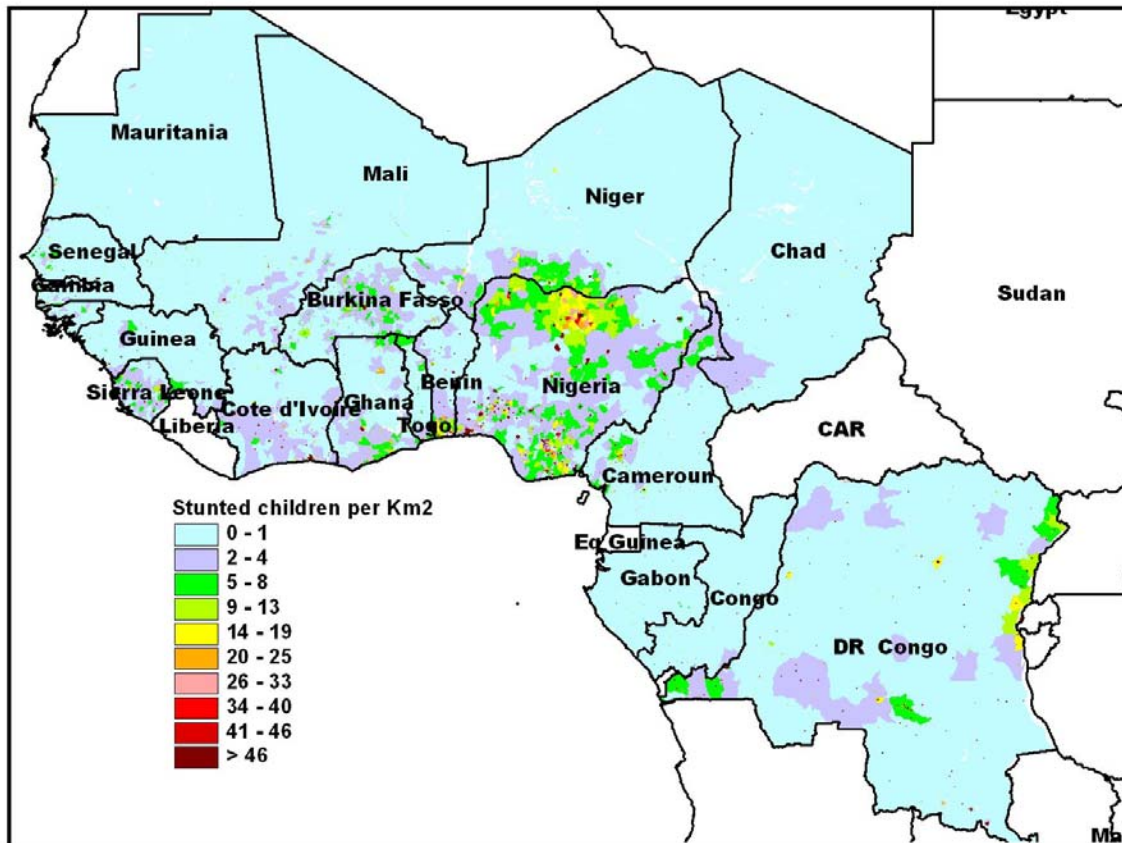


Figure 9. Distribution of Stunted Children in West and Central Africa

As might be expected, the distribution of numbers of malnourished children is strongly controlled by population density. The extremely high population densities in Nigeria, as compared to most of the other countries in the region, result in very high numbers of stunted children in north-central Nigeria, and in the southern coastal regions, despite percentage incidence of stunting being relatively low in Nigeria. Other concentrations are seen in central southern Niger, central Burkina Faso, southern Benin Republic, southern Ghana and coastal Senegal.

## Child Nutrition and Climate

The main climatic factors controlling agriculture in West and Central Africa are the amount and temporal distribution of rainfall. Minimum temperatures are rarely a control, since there are no extensive areas of highland over 1500 metres elevation in the area (with the exception of Eastern DRC). A useful indicator of possibilities for agriculture is the Length of Growing Period (LGP) a composite of rainfall, humidity and soil physical properties, which indicates the number of days in the year when normal crop growth will occur. Lengths of growing period can be conveniently grouped into zones, usually known as Agro-ecozones, within which agricultural conditions are relatively constant (See Figure 10). Apart from length of growing period, these zones are also classified on the basis of elevation into lowland, mid-elevation and high elevation zones, but in West Africa the only significant mid-elevation zones are in central and western Cameroon and in the Jos Plateau of Nigeria.

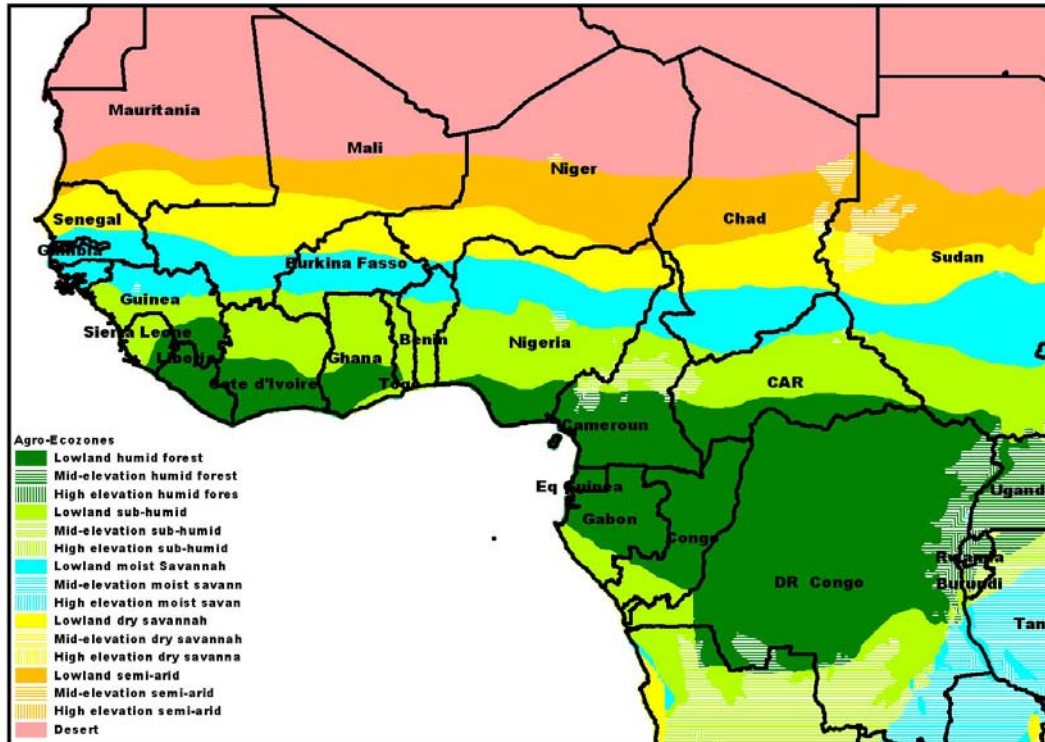


Figure 10. Agro-Ecological Zones of West and Central Africa (Legg,2004)

The distribution of administrative areas with high incidence of child stunting and wasting can be analysed in relation to the agro-ecozones in which they lie, in order to determine whether climatic factors have any influence on child nutrition in the region. Table 5 present a matrix of the numbers of administrative areas by nine categories of combined stunting and wasting and six ecozones. Zones with relatively low combined incidence of stunting and wasting are numbered in black, those with elevated values of one or other indicator in blue, and those with high incidences of both stunting and wasting in red.

It can be seen that high incidence of both stunting and wasting is more common in drier ecozones than in the most humid. All areas in the semi-arid ecozone show high incidence of both stunting and wasting, while in the dry savanna ecozone 70% of areas show elevated values. In the humid forest ecozone, in comparison, only 20% of administrative areas have high incidences of stunting and wasting. The sub-humid and moist savanna ecozones are intermediate, with about 60% of areas having high incidence. The correlations are not very strong however, except that the two extreme ecozones, humid forest and desert, show much lower incidences of stunting and wasting than the other zones.

Table 5. Matrix of numbers of administrative districts by malnutrition class and agro-ecozone

Nutrition Class	Agro-ecozone					
	desert	semi-arid	dry savanna	moist savanna	sub-humid	humid forest
low stunting low wasting					1	2
low stunting medium wasting			4	2	1	
low stunting high wasting			1		1	
medium stunting low wasting					1	5
medium stunting medium wasting	1			6	5	5

Nutrition Class	desert	semi-arid	dry savanna	moist savanna	sub-humid	humid forest
medium stunting high wasting	3		1	1	3	1
high stunting low wasting					2	4
high stunting medium wasting			2	6	10	1
high stunting high wasting		9	11	15	7	2

Another way of looking at relationships between malnutrition and eco-zones is to calculate the total numbers of malnourished children, according to the three indicators, in each ecozone. Charts 5 and 6 show the results of such a calculation. Chart 5 shows the totals for all countries in the region, suggesting peaks of all three indicators in the moist savanna and sub-humid ecozones. Chart 6 shows the total numbers of children when Nigeria is excluded from the calculation. This shows the very strong effect of the extremely high population in Nigeria. Highest numbers of stunted children are now shown to be in the dry savannah and sub-humid ecozones, while numbers of wasted children are greatest in the dry and moist savannas. The difference between different eco-zones is not marked except for the desert and semi-arid ecozones, where numbers of affected children are small.

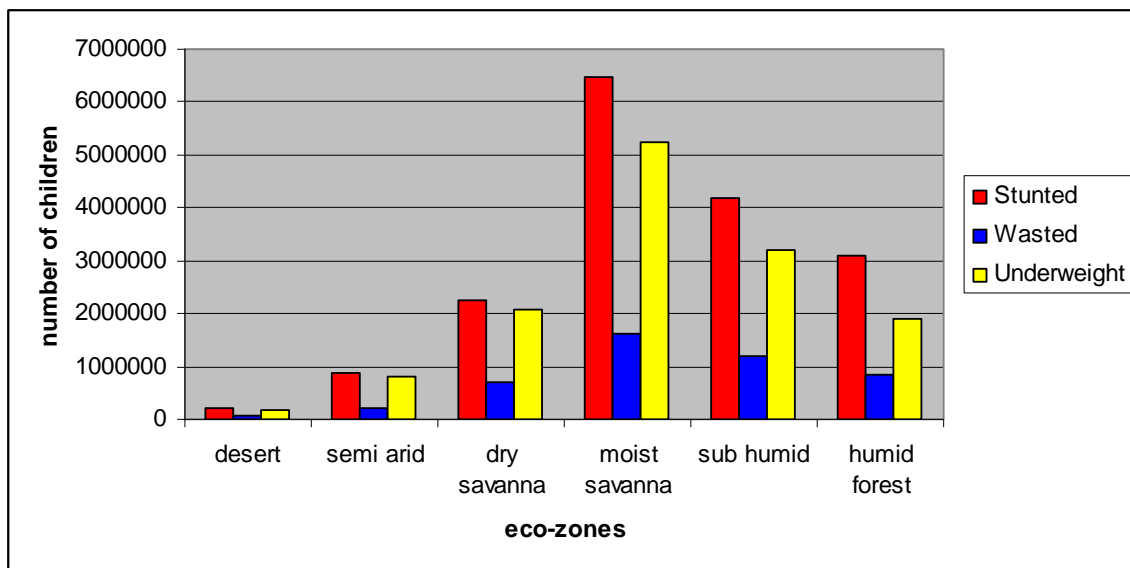


Chart 5. Distribution of malnourished children by three indicators in agro-eco-zones



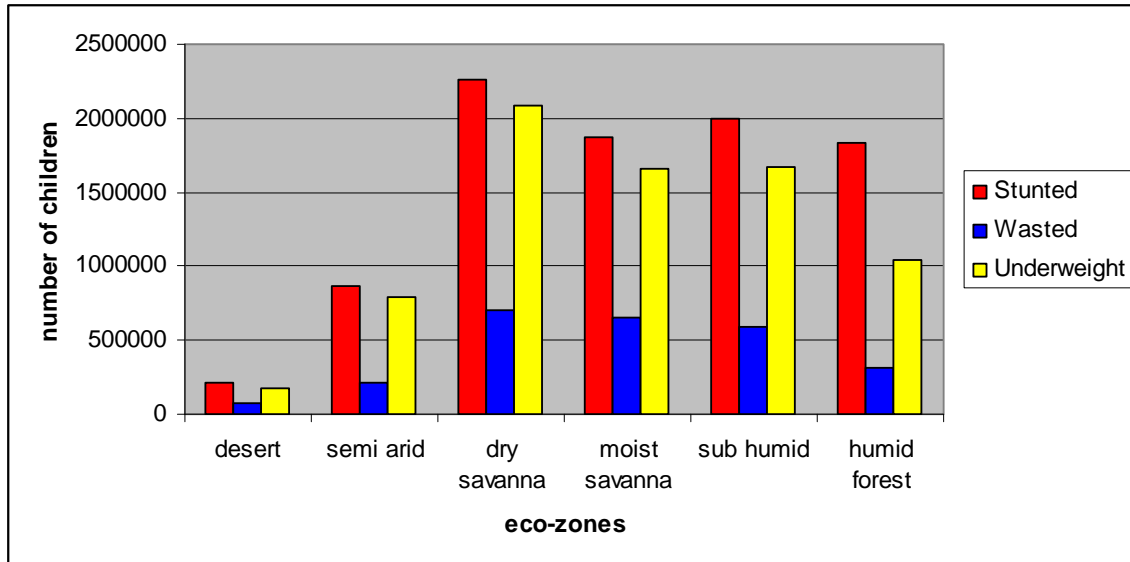


Chart 6. Distribution of malnourished children by agro-ecozones omitting Nigeria

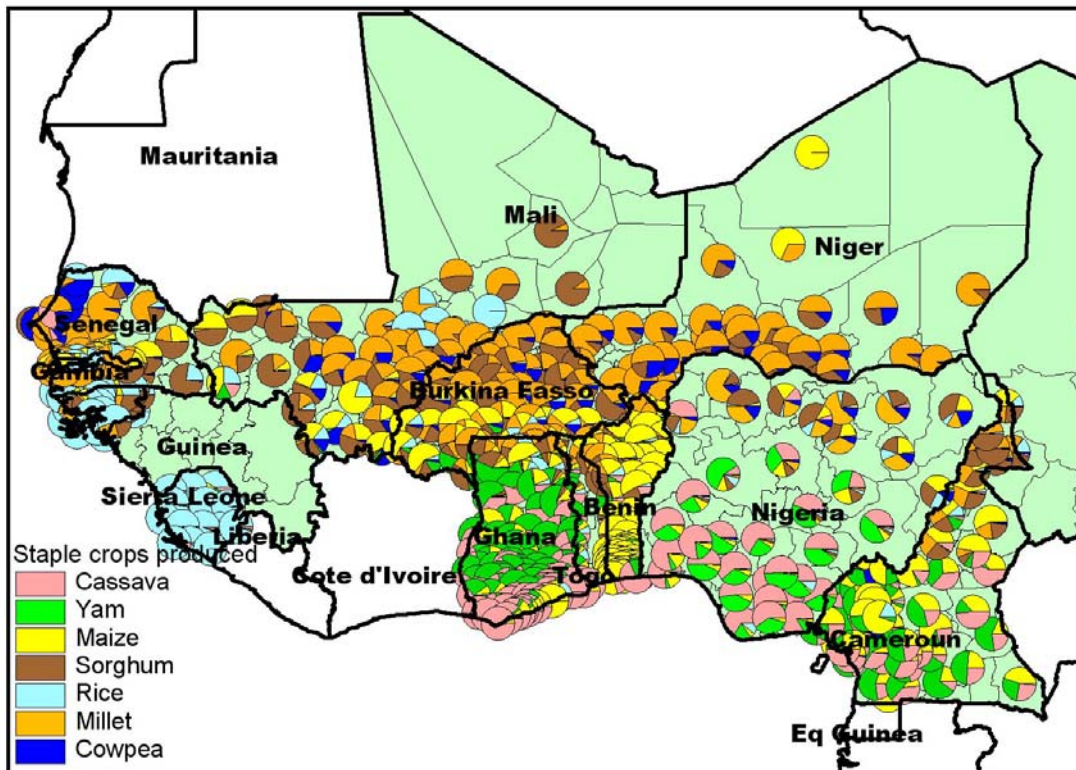
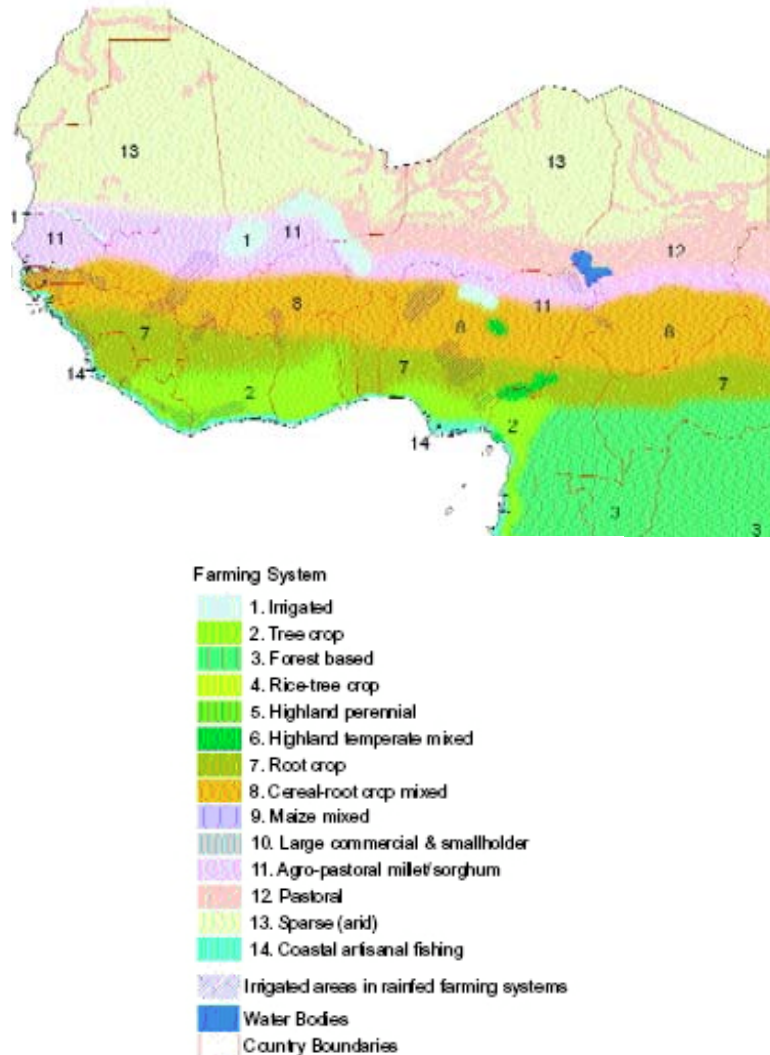


Figure 11. Relative Proportions of Staple Crops in West Africa

## Child Nutrition and Agricultural Production

The relative proportions of the main staple food crops grown in West Africa, according to available sub-national production statistics, are shown in Figure 11. The transition from dominantly cassava and yams in the humid coastal regions, through a maize-dominated

zone to millet, sorghum and cowpea in the inland more dry areas is clear, and closely follows the farming systems identified by Dixon et al (2001) and shown in Figure 12. The main exceptions to the general picture are Sierra Leone and Guinea Bissau, where rice cultivation is dominant.



**Figure 12. Farming Systems in West Africa. From Dixon et al (2001)**

This distribution of staple food crops is governed mainly by rainfall, and to a lesser extent by tradition. A comparison of Figures 11 and 12 with the agro-ecozones shown in Figure 10 shows that root and tuber crops are confined mainly to the humid and sub-humid ecozones, while millet, sorghum and cowpea are crops of the dry savanna and semi-arid zone. A mixture of maize, root crops and more drought tolerant cereals is characteristic of the moist savanna.

The nutritional status of children is mainly governed by food consumption, both quantity and nutritional quality, and disease. Food consumption quantity depends on availability of food either from family production, or purchased if household funds permit. Food quality depends also on family finances, but can also be cultural, where traditional foods may be inferior nutritionally to novel crops. Availability of home-grown food and of money

to purchase food is governed by numerous factors, including climate, land availability, land tenure systems, markets and the financial status of the country. Climate can be extremely variable, with periodic droughts severely affecting food production, and unexpected floods also having disastrous consequences.

Data on food consumption are not yet available for the WA-SAKSS countries in sufficiently disaggregated form to enable direct comparison with indicators of child nutrition. Agricultural production statistics at province or district level are now available for most countries in the region, although some are rather out of date. These can be used as a proxy for food consumption in rural areas, since most production of food staples is by smallholder farmers, and a significant proportion of food production is usually consumed at home. There will obviously be some anomalies, with sales of food crops by farmers to markets in their area and even far away, and purchase by farmers of some of their food requirements.

Within West and Central Africa, there is no significant correlation between any of the child nutrition indicators and food production, measured either as the potential total per capita calorie intake from own production (total calories in annual crop production divided by population\*365) or as the proportional contribution of each major staple crop to the total calorific production.

Within individual countries, especially large countries which cross many eco-zones and farming systems, some very interesting correlations can be observed between child nutrition indicators and the proportion of total food production contributed by specific crops. In Nigeria, even though DHS sampling was very coarse, dividing this very large and populous country into only six zones, some very significant correlations can be seen.

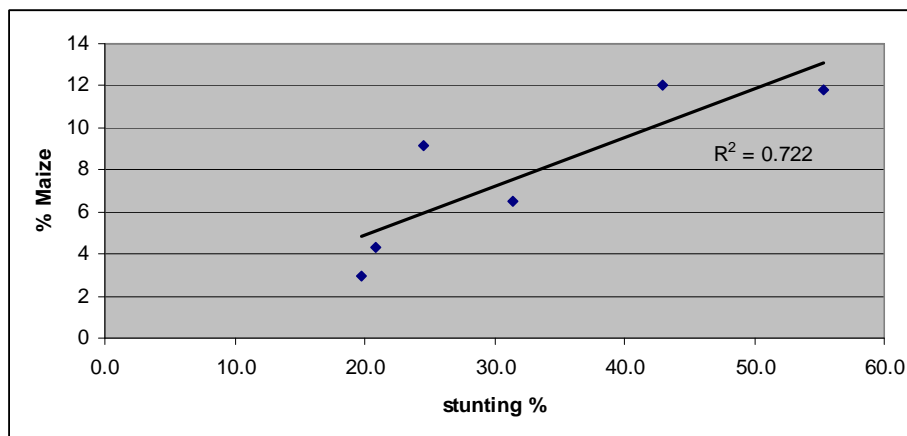
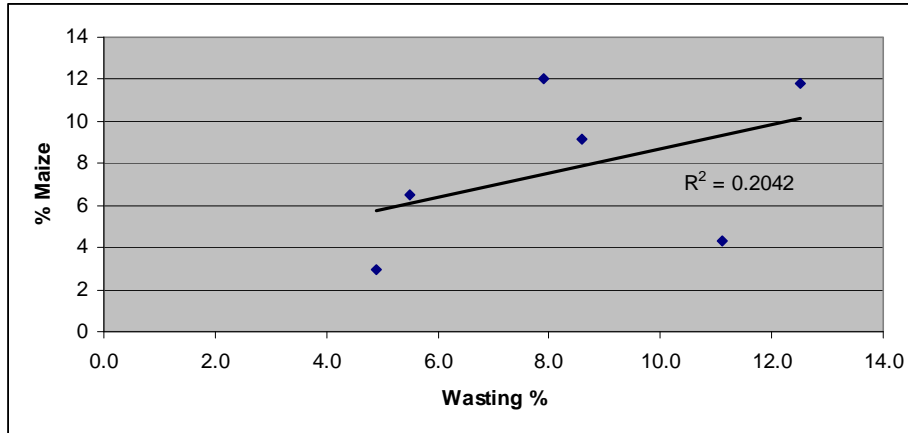
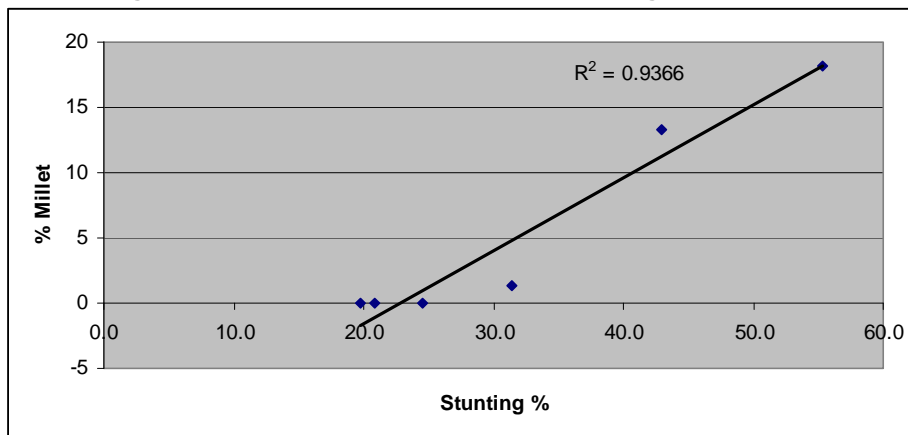


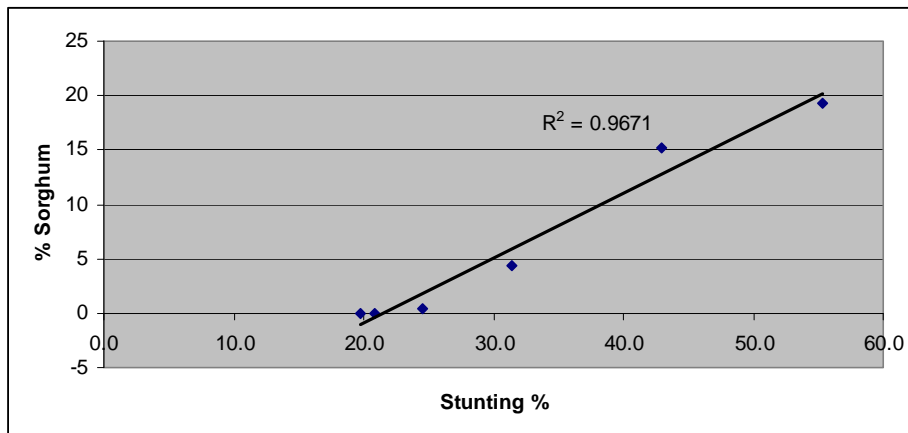
Chart 7. Child Stunting and Proportion of Maize in Staple Crops, Nigeria



**Chart 8. Child Wasting and Proportion of Maize in Staple Crops, Nigeria**



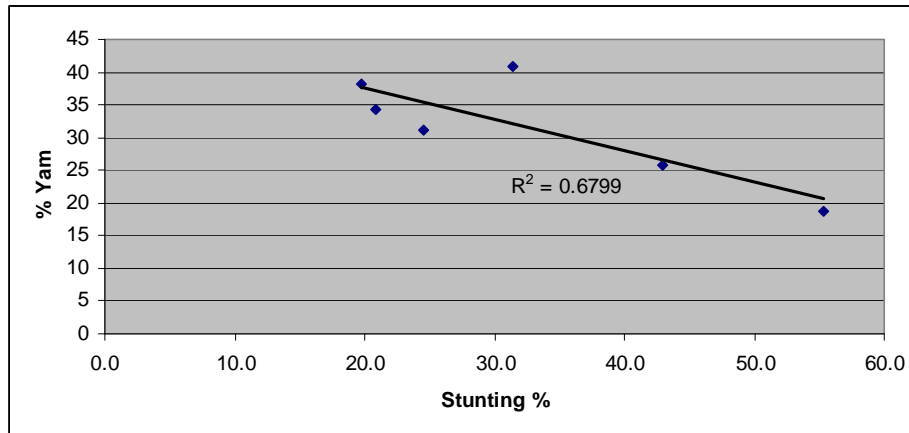
**Chart 9. Child Stunting and Proportion of Millet in Staple Crops, Nigeria**



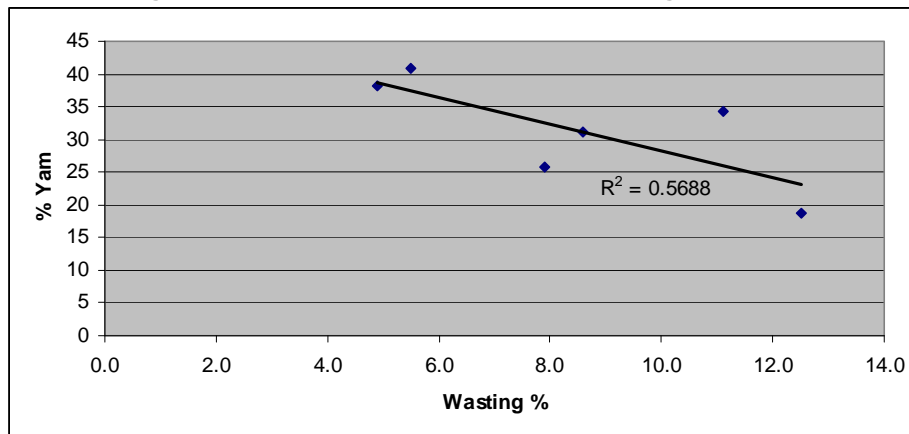
**Chart 10. Child Stunting and Proportion of Sorghum in Staple Crops, Nigeria.**

As shown in Charts 7, 9 and 10, there is a strong positive correlation between child stunting and the relative proportions of maize, millet and sorghum in total agricultural production, while charts 11 and 13 show strong negative correlations between stunting and the proportions of yams and cassava. Correlations with child wasting are less strong, as shown in charts 8, 12 and 14. This does not suggest that maize, millet and sorghum are intrinsically less nutritious than yams and cassava (calorifically speaking, and in terms of micro-nutrients, the reverse is actually true), but rather that the more humid eco-zones where cassava and yams are dominant food crops are more fertile,

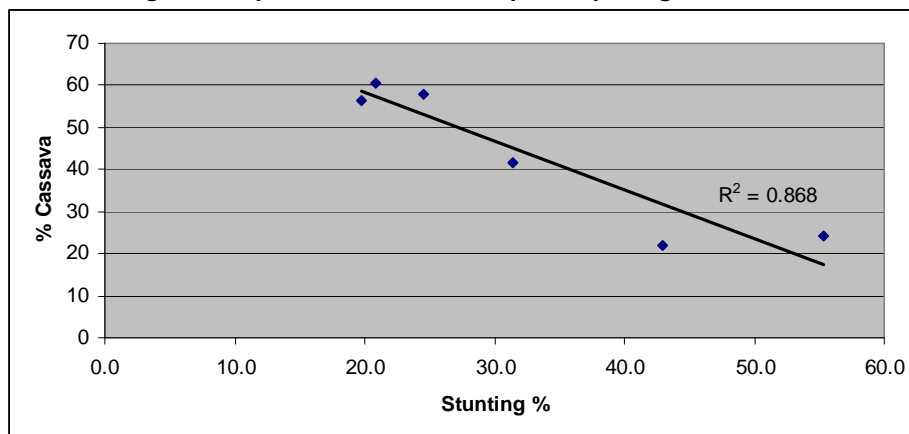
with more reliable climate and less soil degradation, than the drier eco-zones where maize, millet and sorghum are dominant. In many countries, population densities are also lower in the humid zones than in drier savannas, so more land per household is available for farming. Similar, but less significant, correlations are seen in other countries which cross eco-zones, for example Cameroon, as shown in Charts 15, 16 and 17. Ghana shows similar trends, while countries such as Burkina Faso, which are essentially within only a single agro-ecozone, show no correlations.



**Chart 11. Child Stunting and Proportion of Yams in Staple Crops, Nigeria**



**Chart 12. Child Wasting and Proportion of Yams in Staple Crops, Nigeria**



**Chart 13. Child Stunting and proportion of Cassava in staple crops in Nigeria**

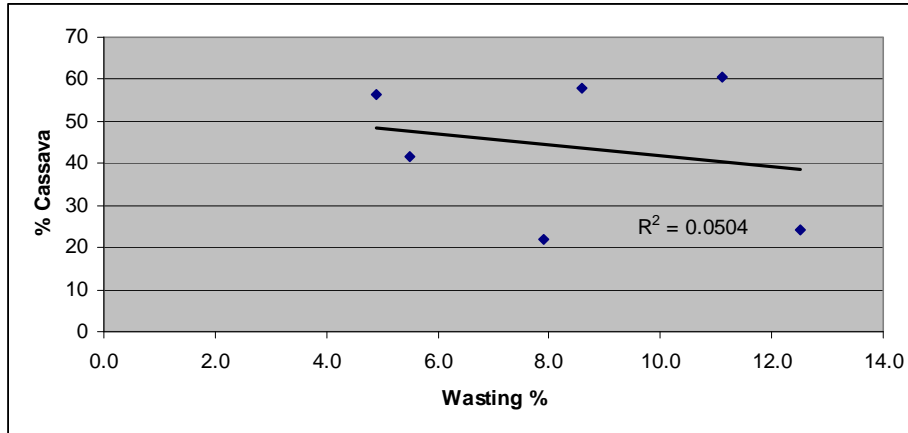


Chart 14. Child Wasting and proportion of Cassava in staple crops in Nigeria

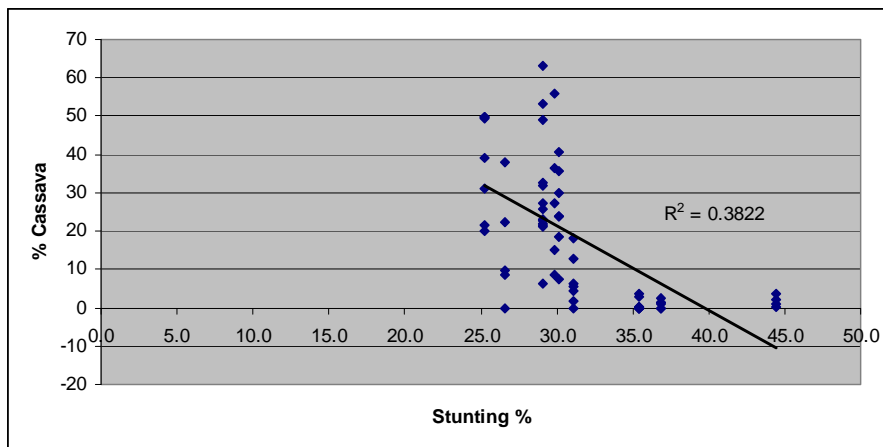


Chart 15. Child Stunting and proportion of Cassava in staple crops in Cameroon

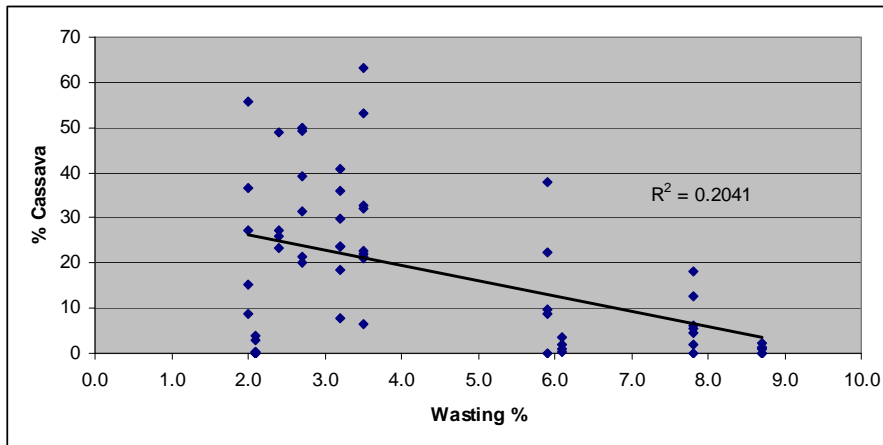
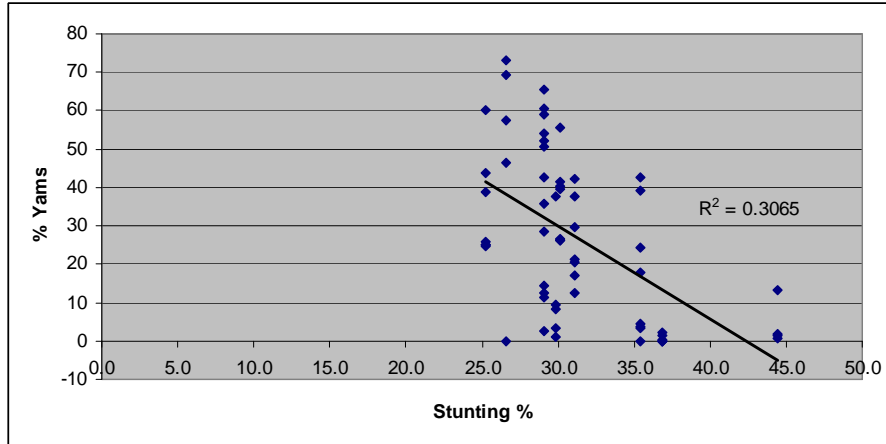
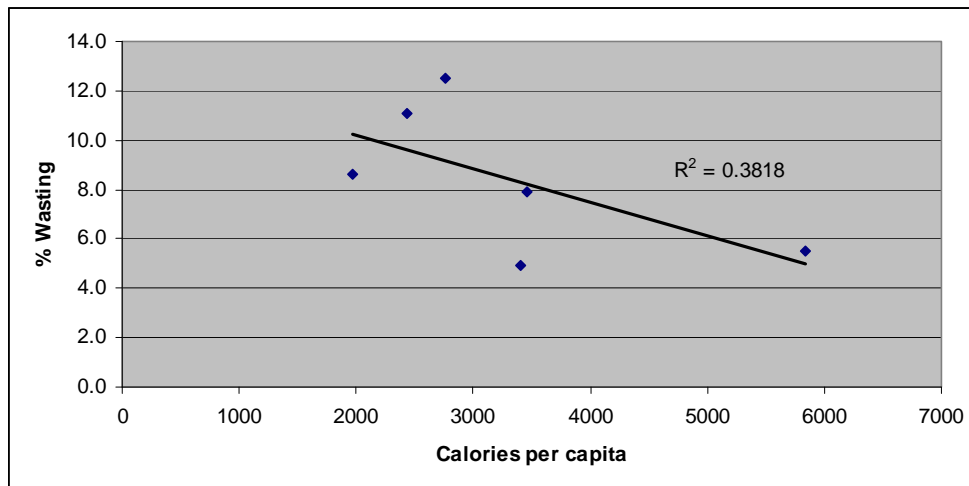


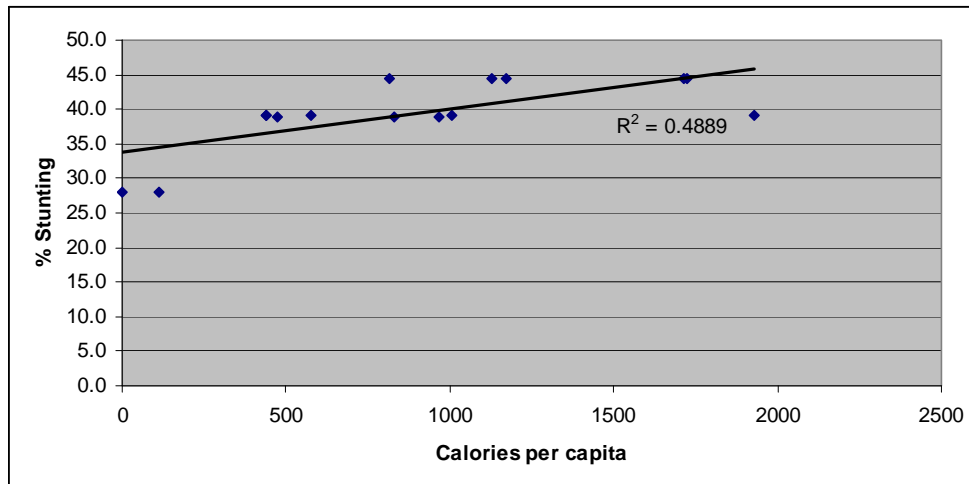
Chart 16. Child Wasting and proportion of Cassava in staple crops in Cameroon



**Chart 17. Child Stunting and proportion of Yams in staple crops in Cameroon**



**Chart 18. Child Wasting and potential per capita calorie intake from own production, Nigeria**



**Chart 19. Child Stunting and potential per capita calorie intake from own production, Sierra Leone**

The potential per capita calorie intake from own production can be calculated from agricultural production statistics and population data. Theoretically, higher calorific intake should lead to lower incidence of child malnutrition. In most countries of the region, there

is no significant correlation between potential calorific intake and malnutrition, but in the case of Nigeria there is a clear relationship between child wasting and potential calorie intake, as shown in Chart 18. There is no significant correlation between stunting and calorific intake. In Sierra Leone, on the other hand, there is a positive correlation between child stunting and potential calorific intake, as shown in Chart 19. This relationship is difficult to explain, but could result from unknown levels of food imports.

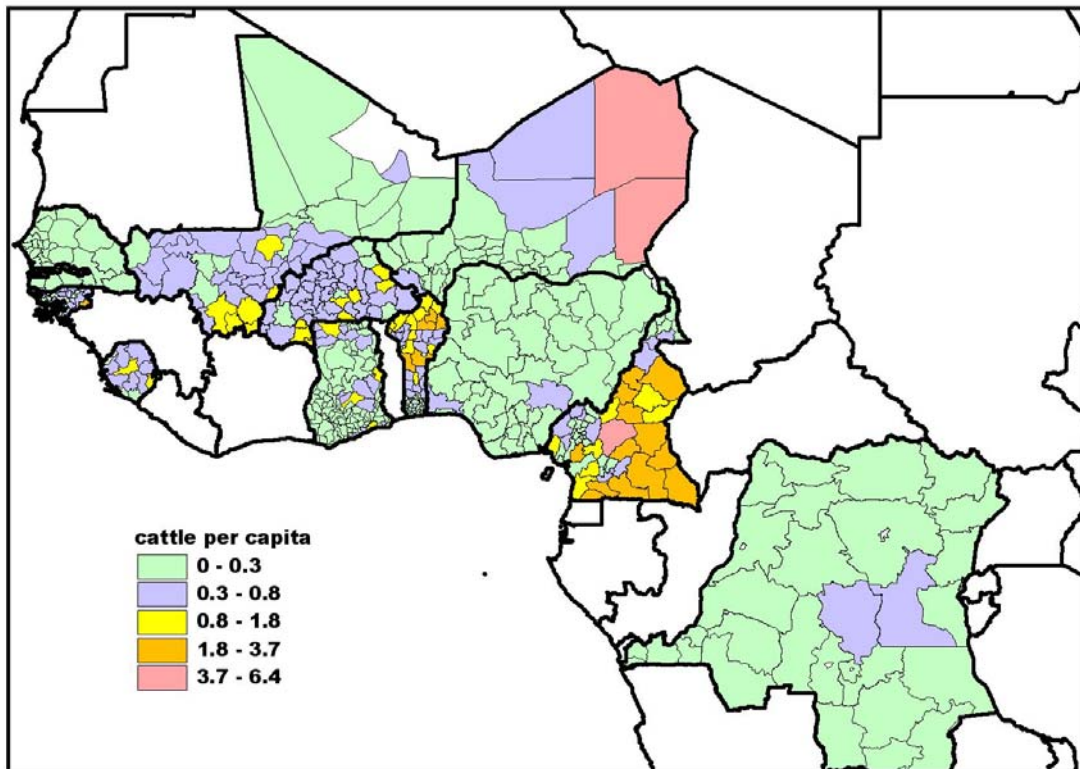


Figure 13. Numbers of cattle per capita

## The Role of Livestock

In parts of West and Central Africa, livestock are extremely important culturally and as sources of food and income. This is especially true in the less humid parts of the region, as shown in figures 13 and 14, the distribution of cattle and small ruminants (sheep and goats) per human capita, derived from FAO/ILRI data sets (Thornton et al, 2002; Steinfeld et al, 2006). The original grids of livestock numbers, produced by ILRI, have been aggregated to the administrative units used for child nutrition surveys, and then divided by the population of humans for each unit to give livestock numbers per capita. As shown in Figure 15, cattle are proportionally more important than small ruminants in the arid and moister portions of the region (exemplified by northern Niger and Northern Mali and the Congo basin respectively), while small ruminants are particularly important in the semi-arid areas in a zone stretching from northern Nigeria through Niger, central Mali and into Senegal. Within the small ruminants, the ratio of sheep to goats is quite variable (Figure 16), and may reflect cultural heritage rather than specific selection based on climate.



The numbers of cattle and small ruminants per human capita in the 616 administrative units in the study area can be grouped into quartiles. The upper quartile for each livestock group are classed as “very important” and the third quartile “significant”. This results in eight categories of relative combined importance of cattle and small ruminants, as shown in Figure 16. In Senegal, Northern Mali, southern Niger and northern Nigeria, small ruminants are very important and cattle relatively insignificant, while in some humid areas like Guinea Bissau, Sierra Leone, south-eastern Cameroon and central DRC cattle are very important and small ruminants insignificant. Cattle also dominate over small ruminants in northern Niger, the far south of Mali, and areas in central Ghana and Benin. There are large areas where both cattle and small ruminants are very important, notably a zone from south-central Mali through Burkina Faso into northern Ghana and Benin, most of Cameroon, and central Niger. Other areas show less important, and often mixed, livestock concentrations.

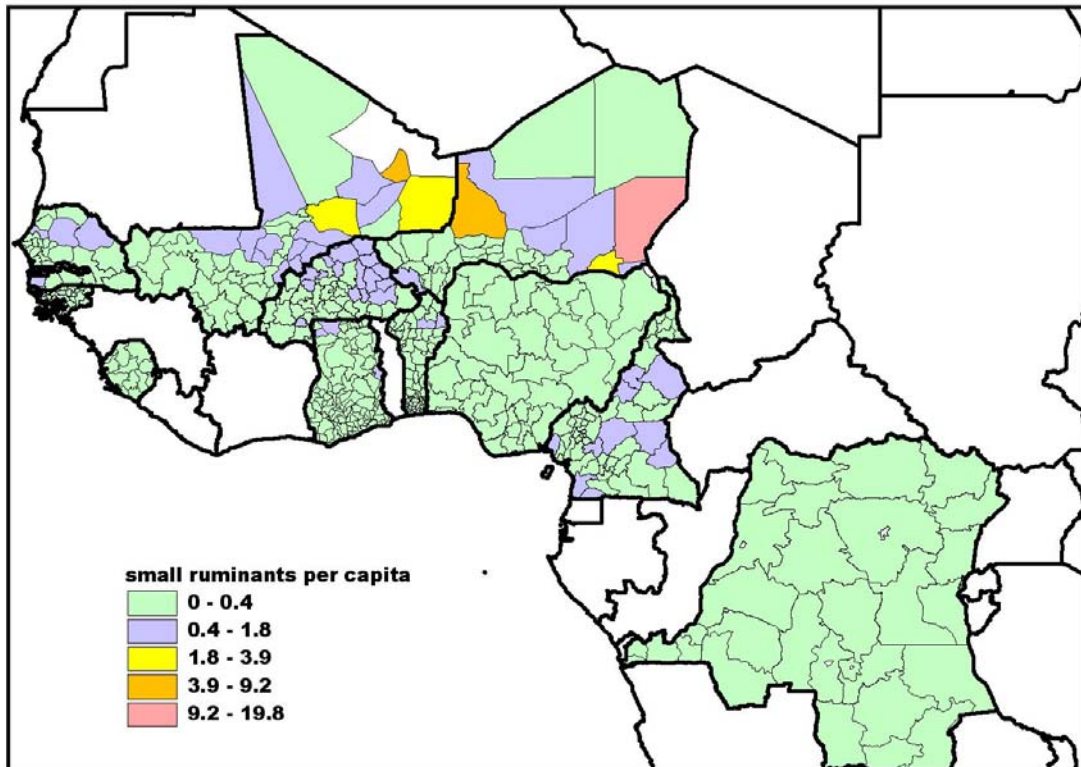


Figure 14. Numbers of small ruminants per capita

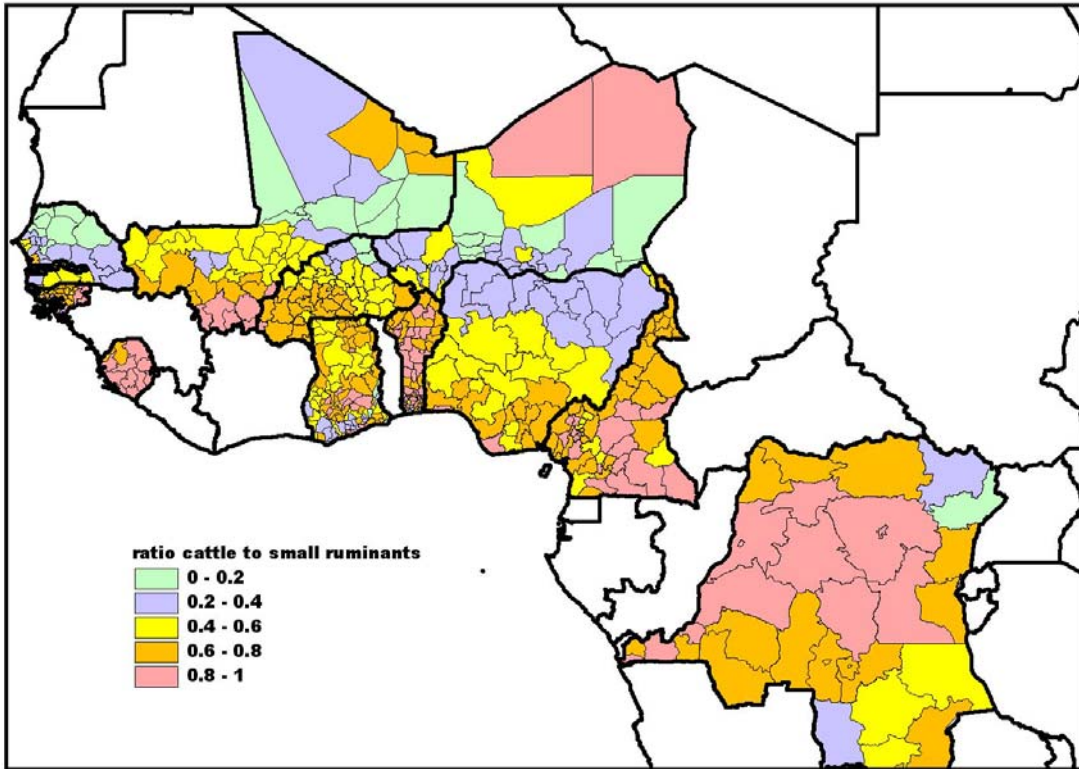


Figure 15. Ratio of Cattle to Small Ruminants

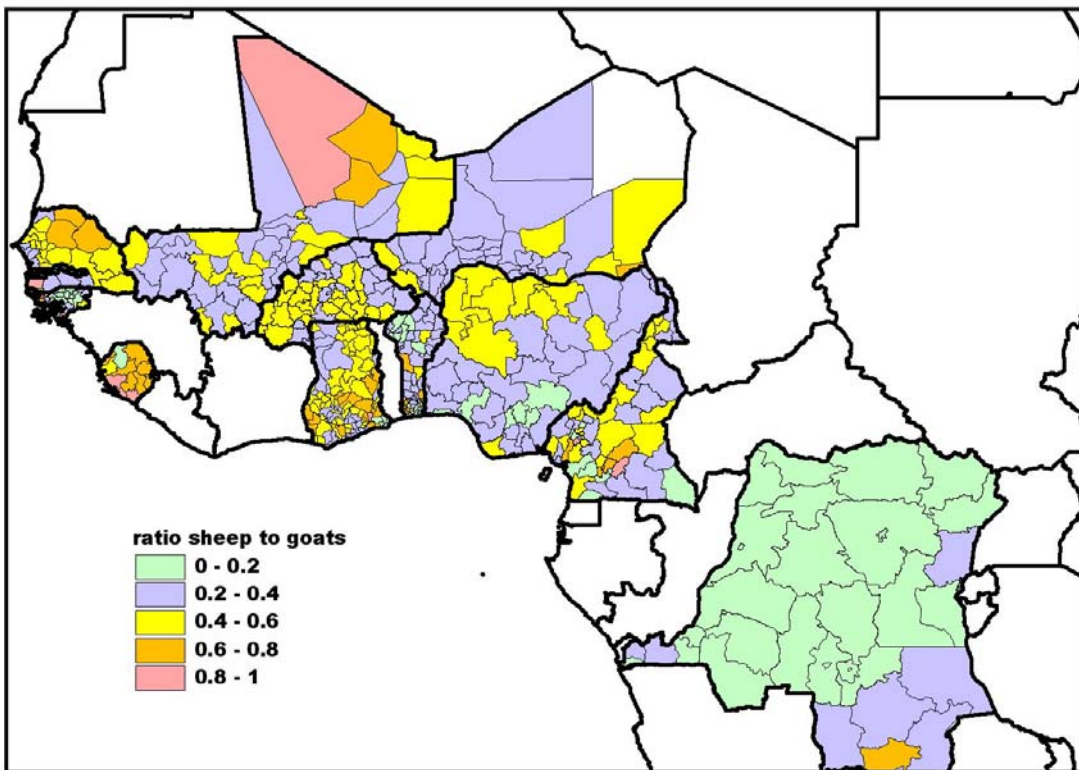
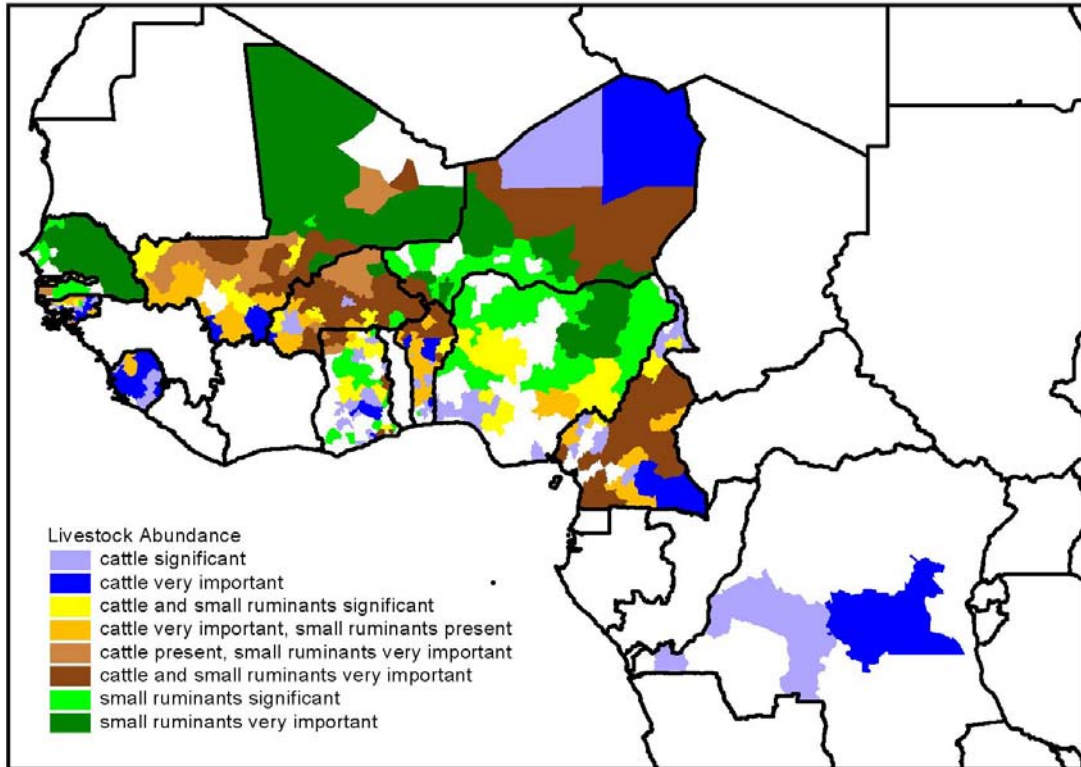


Figure 16. Ratio of Sheep to Goats



**Figure 17. Distribution of Livestock Systems**

In order to examine more closely the connections between farming systems, including livestock, and child nutrition, a new classification of the region into five basic farming systems has been developed, based on declared agricultural production for each administrative unit, divided by the population of the unit in order to normalize production to population density. A total of eight crops – rice, maize, millet, sorghum, yams/sweet potatoes, cassava, cowpeas and groundnuts – were used in the classification. The results were simplified into four main zones based on dominant crops. The root crop zone is dominated by cassava, yams and sweet potatoes, with minor production of other crops. The mixed cereal and root zone produces maize, cassava and yams as dominant crops, with minor sorghum, cowpea and groundnut. The moist cereal zone produces maize, millet, sorghum, cowpea and groundnut with insignificant root crops, while the dry cereal zone produces the same cereals but without maize. A fifth farming system has rice as the dominant crop, with insignificant production of anything else. The geographic distribution of these farming systems is shown in Figure 18.

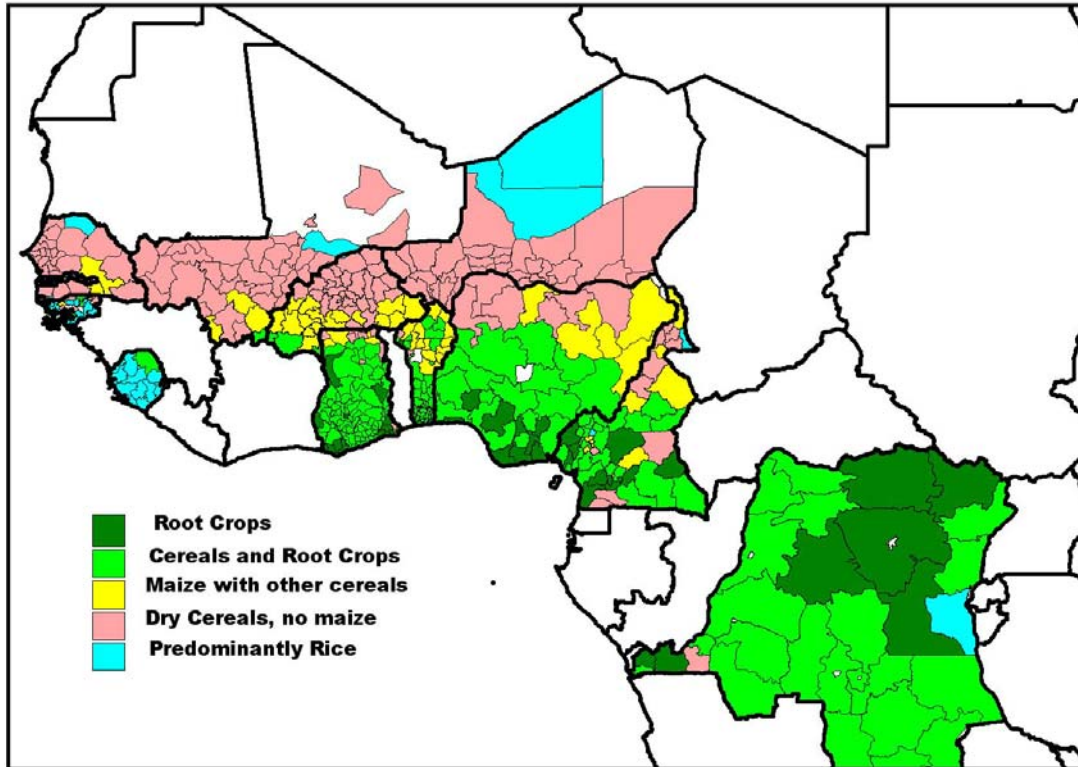


Figure 18. Farming Systems based on per capita agricultural production

Table 6 shows the calculated mean values for the main indicators of child nutrition by farming system, further sub-divided by livestock densities. The mean values for the five main farming systems suggest that child nutrition, as measured by stunting and wasting, becomes progressively worse from root crops through cereals and roots to moist and dry cereals, with stunting increasing from 28.6% to 37.3% and wasting increasing from 7.8% to 11.4%. Infant mortality increases from 76.4 per thousand to 108.9 per thousand. The farming system dominated by rice shows intermediate values for stunting and wasting, but very high infant mortality. Stunting, wasting and infant mortality show divergent trends when averaged on livestock densities. Lowest values for stunting and wasting (best nutrition) - 30.6% and 7.6% respectively - are found in areas with no significant livestock. Highest stunting incidence (38.7%) is seen in areas with moderate concentrations of small ruminants, but it is also high in areas with abundant cattle. Highest incidence of wasting is seen in areas with abundant cattle. The unexpected general conclusion is that keeping livestock leads to poorer child nutrition and increased infant mortality. The worst stunting of all is in moist cereal areas with moderate concentrations of small ruminants (50%) and root crop areas with abundant cattle (45.5%), the worst wasting is seen in moist cereal areas with moderate cattle and abundant small ruminants (16.6%) and dry cereal zones with abundant cattle and small ruminants (16%), and worst child mortality is in rice-growing areas with abundant cattle (148.5 per thousand).

**Table 6. Matrix of Child Nutrition Indicators and Farming Systems and Livestock**

Farming System	Mean	No Livestock	cattle	CATT LE	Cattle + sr	CATTLE + sr	Cattle + SR	CATT LE + SR	sr	SR
Root crops	<b>28.6</b> <b>7.8</b> <b>76.4</b>	29.0 <b>7.8</b> <b>76.2</b>	29.1 <b>7.6</b> <b>81.9</b>	45.5 <b>9.5</b> <b>129.0</b>	22.5 13.0 60.6	30.4 5.4 82.3		25.2 6.1 69.3	32.9 6.5 66.5	
Cereals and Roots	<b>31.5</b> <b>7.5</b> <b>81.9</b>	31.0 <b>7.2</b> <b>82.1</b>	31.8 <b>7.3</b> <b>76.9</b>	32.4 <b>9.3</b> <b>89.3</b>	32.2 8.2 85.6	32.3 9.0 103.2	33.1 10.3 90.8	30.3 8.0 88.6		
Moist Cereals	<b>36.6</b> <b>11.5</b> <b>94.4</b>	30.5 <b>5.1</b> <b>65.9</b>	40.8 <b>8.7</b> <b>97.2</b>	41.9 <b>11.1</b> <b>106.5</b>	32.2 13.5 102.0	32.7 12.3 102.5	31.9 16.6 105.9	37.8 13.8 99.2	50.0 10.1 87.3	37.2 8.3 81.3
Dry Cereals	<b>37.3</b> <b>11.7</b> <b>108.9</b>	31.0 <b>9.1</b> <b>92.0</b>	35.8 <b>9.3</b> <b>103.9</b>	33.9 <b>11.9</b> <b>124.0</b>	33.1 10.5 104.0	39.2 11.3 116.8	37.6 12.8 113.2	40.1 16.0 113.5	41.8 10.4 114.4	35.9 10.9 106.7
Rice	<b>33.0</b> <b>9.4</b> <b>134.7</b>	30.0 <b>7.5</b> <b>120.9</b>	36.1 <b>10.5</b> <b>144.0</b>	35.5 <b>9.6</b> <b>148.5</b>	27.8 8.6 120.7	41.7 12.3 137.7	27.6 8.5 132.0	35.7 10.0 143.4		22.9 11.9 85.2
Means		<b>30.6</b> <b>7.5</b> <b>84.1</b>	<b>33.2</b> <b>8.2</b> <b>93.1</b>	<b>35.2</b> <b>9.9</b> <b>116.2</b>	<b>31.7</b> <b>10.2</b> <b>94.6</b>	<b>35.0</b> <b>10.2</b> <b>108.5</b>	<b>35.5</b> <b>12.3</b> <b>113.7</b>	<b>36.5</b> <b>13.1</b> <b>103.5</b>	<b>38.7</b> <b>9.3</b> <b>99.9</b>	<b>36.6</b> <b>11.7</b> <b>109.2</b>

Notes to Table 6. Nutrition indicators colour-coded as Stunting %, **Wasting %** and **Infant Mortality per thousand**. Livestock density classes – lower case indicate third quartile of cattle or small ruminant abundance per capita human population, UPPER CASE fourth quartile.

## Child Nutrition and Development Domains

The concept of “development domains”, sometimes known as “recommendation domains”, is central to GIS targeting for agricultural development (Place, et al, 2006; Pender et al, 2006). Certain areas have a combination of favorable factors, for example climate, soil quality, population density and access to markets, which increases the probability of successful outcomes and maximises the number of farmers benefiting from the intervention. GIS can be used to overlay digital maps of the different positive and negative factors, to assign weights to them, and to produce new maps of the most favorable areas for different kinds of agricultural development. Ease of access to markets, in terms of cost or of time, can be quantified within a GIS based on locations of markets and maps of transport routes and barriers to travel (Deichmann, 1997; Black et al, 2004; Thornton et al 2006). A study undertaken for the West Africa SAKSS node in 2006 (Chamberlin, Legg and Sonder, in Prep) combined population density and market access to classify West and Central Africa into twelve different development domains based on four classes of population density and three classes of market access as shown in figure 19.

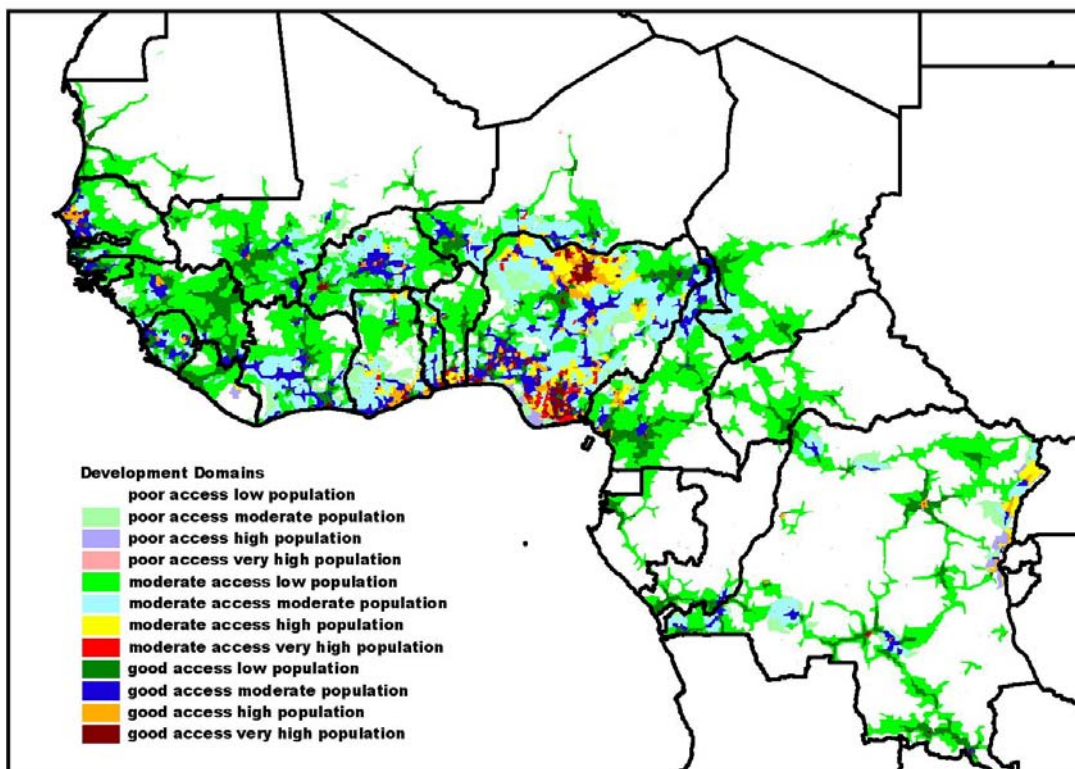


Figure 19. Development Domains in West and Central Africa (Chamberlin, Legg and Sonder, in Prep)

Development domains are then overlain with the administrative areas used for child nutrition studies, and the dominant development domain identified for each area. Mean values of child nutrition indicators are calculated for each of the ten development domains occupying significant areas in the region (domains with poor market access and high to very high population density are insignificant). The results of this analysis are summarised in Table 7.

Table 7. Matrix of Development Domains and Child Nutrition Indicators

Development Domain	Low population density	Moderate population density	High population density	Very high population density
Poor market access	31.9 <b>9</b> 26.5 96.1	32.4 <b>10.2</b> 26.4 92.5		
Moderate market access	36.1 <b>11.1</b> 30.1 105.5	33.4 <b>10.9</b> 30.3 96.2	34.9 <b>8.9</b> 26.4 85.2	28.0 <b>8.4</b> 23.1 81.8
Good market access	35.0 <b>9.1</b> 26.2 105.9	35.0 <b>9.8</b> 28.9 100.8	29.0 <b>7.3</b> 20.9 72.5	27.7 <b>8.0</b> 20.9 82.0

Key:- 31.9 = % stunting **10.2 = % wasting** 26.4 = % underweight 92.5 = infant mortality per thousand

The results of this analysis are to some extent counter-intuitive. They suggest that most indicators of child nutrition deteriorate as market access improves. In low population

density domains, stunting increases from 31.9% to 36.1% and 35% as market access improves, while in zones of moderate population density stunting percentage increase from 32.4% to 33,4% and 35%. Infant mortality in the same zones increases from 92.5 per thousand to 96.2 per thousand and 100.8 per thousand as market access improves. All indicators decline significantly as population density increases, although it should be remembered that these figures are not weighted for actual populations in each area, and the high population density domains will actually have much greater numbers of malnourished children than the low population density domains

## The Temporal Dimension of Child Nutrition in West Africa

Some countries in the region have been covered by three or more surveys (DHS or MICS) at sub-national level during the past 20 years. Burkina Faso, Cameroon and Benin have been covered by three surveys, while Mali, Niger and Senegal have had four surveys each and Ghana had five surveys. This enables preliminary studies of variations of child stunting and wasting over time at a sub-national level.

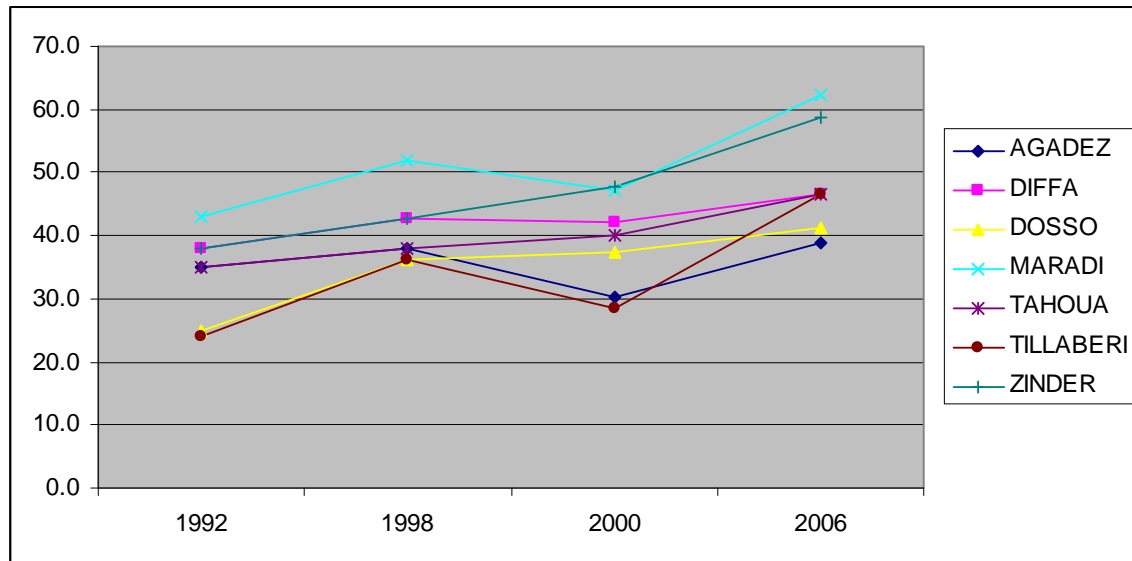
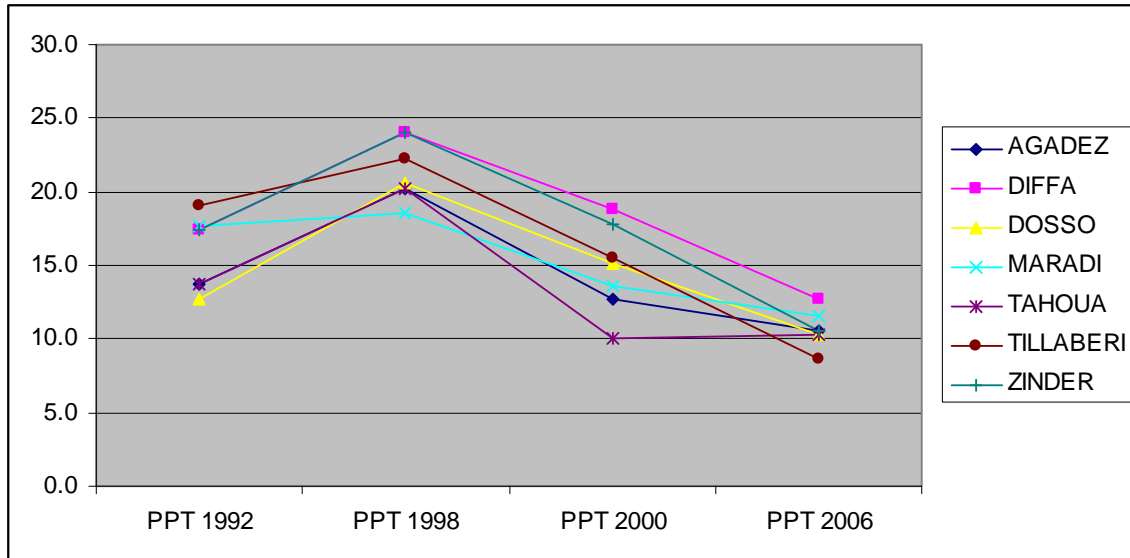


Chart 20. Child Stunting in Niger



**Chart 21. Child Wasting in Niger**

Changes in nutritional indices with time can be studied graphically or in maps. Four countries with four or more years of DHS and MICS surveys (Niger, Mali, Senegal, Ghana) have been selected for initial study. For each country, graphs have been prepared showing child stunting and wasting levels for each administrative district surveyed and for each year of surveys.

Charts 20 and 21 present changes in child stunting and child wasting in Niger between 1992 and 2006. All districts show an overall increase in the percentage of stunted children during this time period, although two areas showed an improvement between 1998 and 2000, followed by another decline before 2006 (which could be related to the 2004 drought). The percentage of wasted children increases between 1992 and 1998, and then decreases steadily after 1998. The difference in direction of the trends is surprising, with stunting becoming steadily worse (higher incidence) while wasting improves (lower incidence).



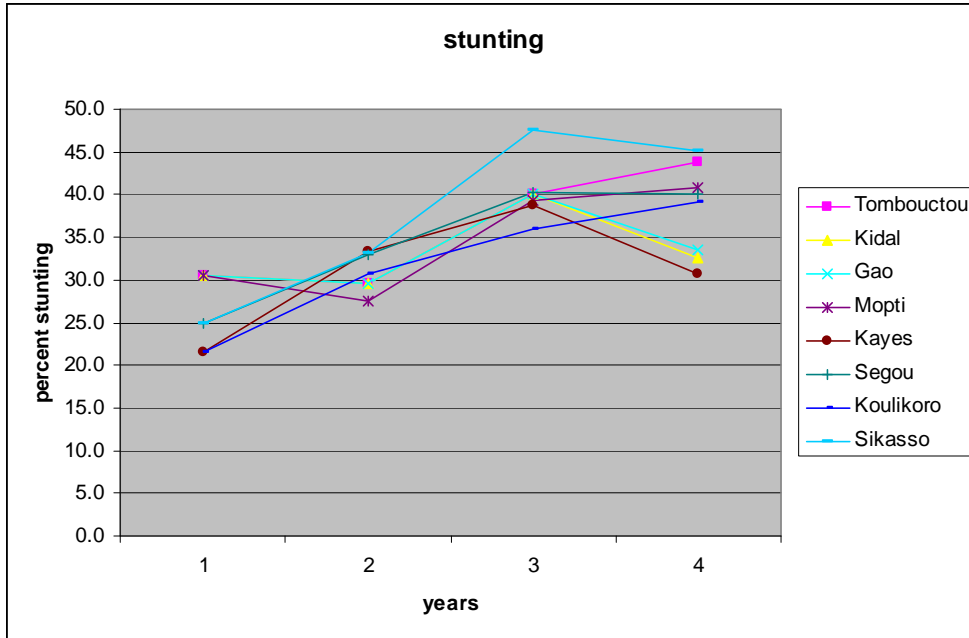


Chart 22. Child Stunting in Mali, 1987, 1996, 2001, 2006

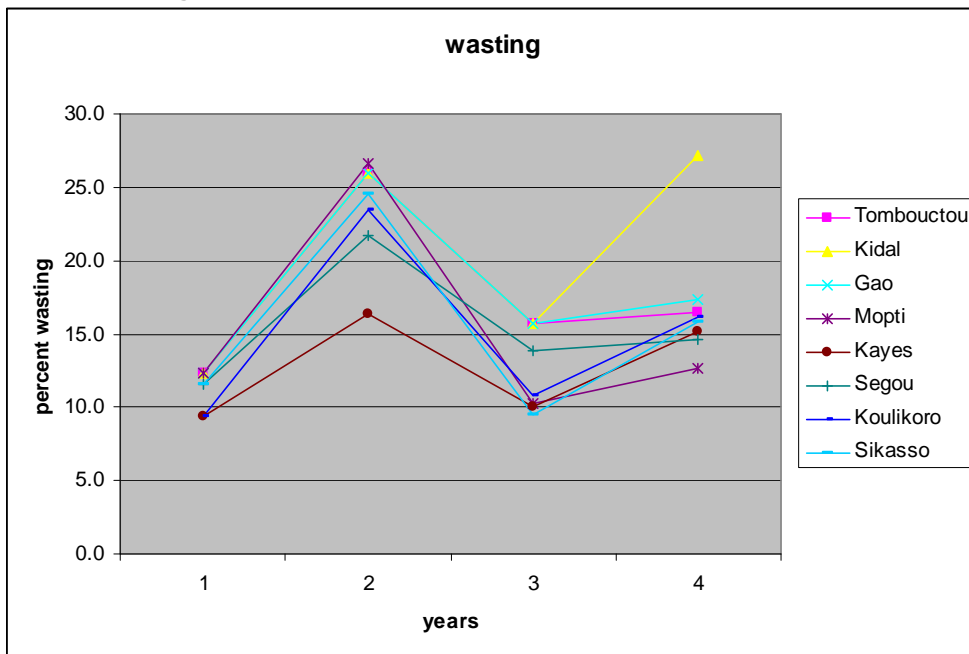
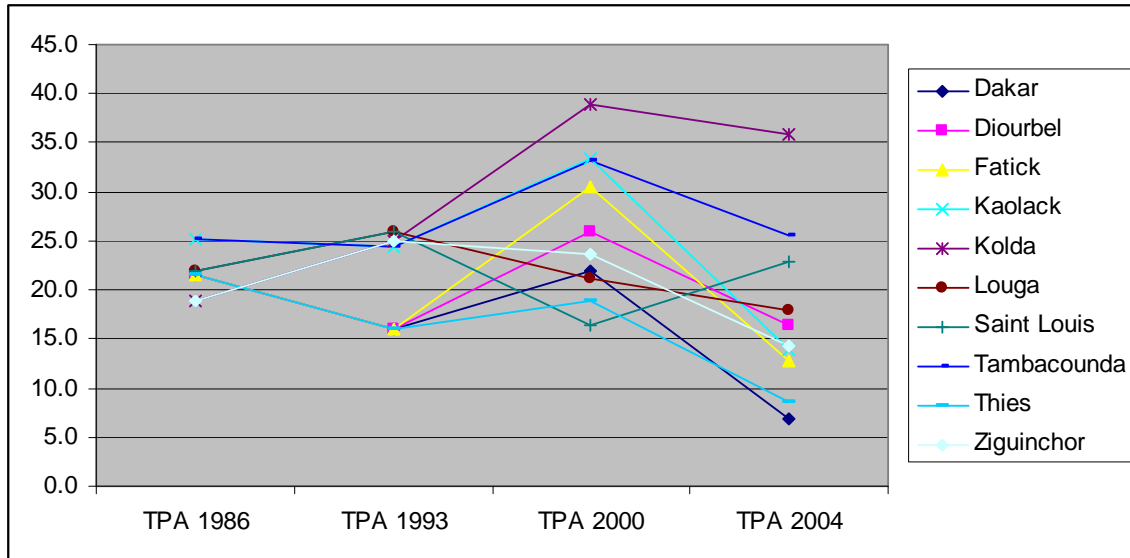
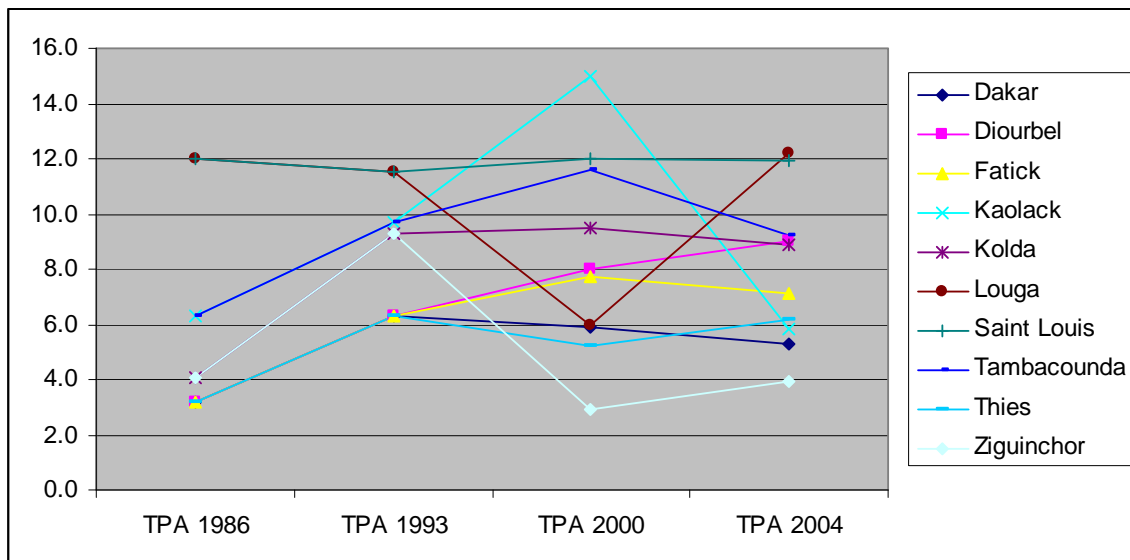


Chart 23. Child Wasting in Mali, 1987, 1996, 2001, 2006

Changes in Mali between 1987 and 2006 are shown in Figures 22 and 23. Stunting shows a progressive increase in all areas between 1987 and 2001, with a significant decrease in three districts by 2006. Wasting shows a peak in 1996, followed by declines in all areas to 2001 and an increase again by 2006.



**Chart 24. Child Stunting in Senegal**



**Chart 25. Child Wasting in Senegal**

Changes in stunting and wasting in Senegal between 1986 and 2004 are shown in charts 24 and 25. For the 1986 and 1993 surveys, the country was sub-divided into only four regions, while the 2000 and 2004 surveys were sampled for ten regions. The percentage of stunted children shows a net decrease in all administrative districts except Kolda and Tambacounda between 1986 and 2004, but in most of the country there was an increase in the percentage between 1993 and 2000, followed by a further decrease by 2004. In two areas, Tambacounda and Thies, there has been a net increase of percentage wasting over the period, but the general trend has been flat to slightly downward. All areas showed an increase in the percentage of wasted children between 1986 and 1993.

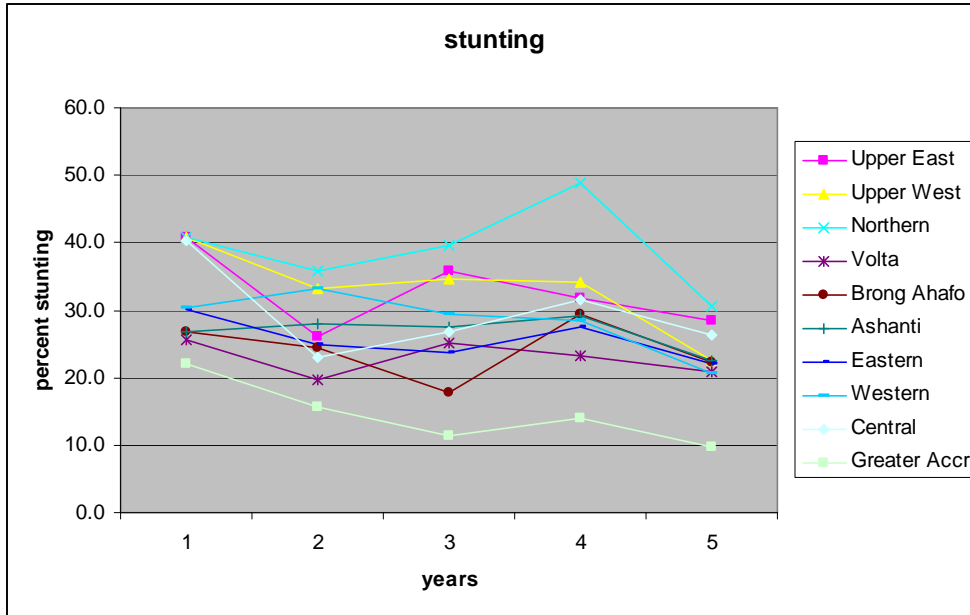


Chart 26. Child Stunting in Ghana, 1988, 1993, 1998, 2003 and 2006

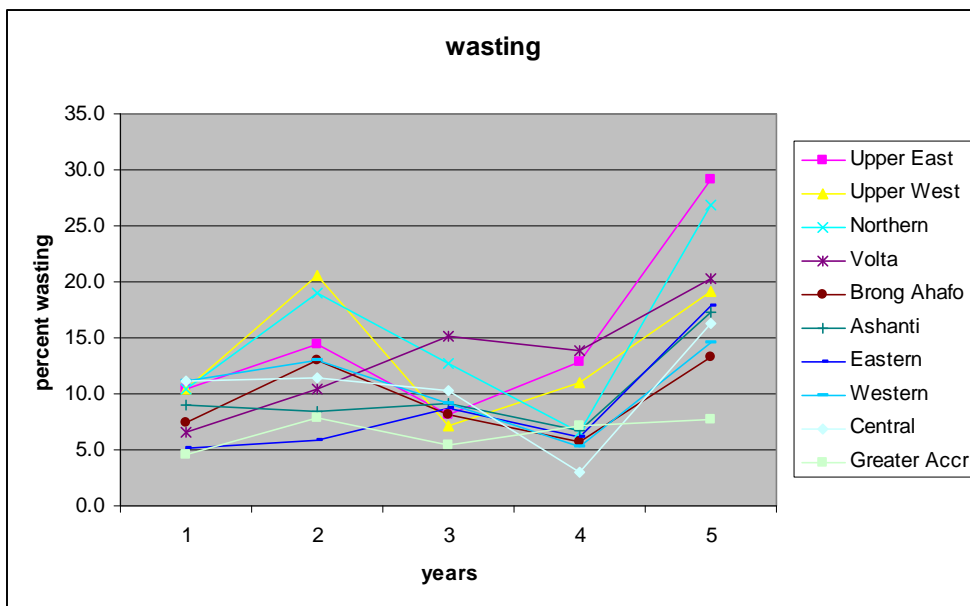


Chart 27. Child Wasting in Ghana 1988, 1993, 1998, 2003 and 2006

Charts 26 and 27 show temporal profiles of child stunting and wasting in Ghana. Stunting shows a general but consistent downward trend through the period 1988 to 2006 in most districts, with the greatest decline in percentage stunting in Greater Accra and an increase in the Northern province in 2003. Many provinces show a general decline in wasting incidence over the period, with a marked increase between 2003 and 2006.

Because child stunting is an indicator of long-term malnutrition, the trends in stunting are most significant, and it is depressing that the percentage of stunted children is still increasing in many of the countries for which we have times-series of data. Variations in

wasting are often more erratic, and probably reflect shorter-term fluctuations in food supply due to drought or similar factors.

Because of the fact that DHS surveys in different countries of the region were conducted in different years, a regional overview of trends in child nutrition can only be obtained by grouping survey results into two epochs: 1995-1999 and 2000-2006. Figure 20 presents changes in percentage stunting between the 1995-1999 epoch and the 2000-2006 epoch for those countries where DHS and MICS surveys were undertaken in both time periods, against a background of the most recent stunting and wasting data. Green arrows indicate decrease in the index (improvement) while purple arrows indicate increase (deterioration). The size of the arrows indicates the extent of the change. The greatest improvements with regard to stunting are seen in Nigeria, Senegal and western Burkina Faso.

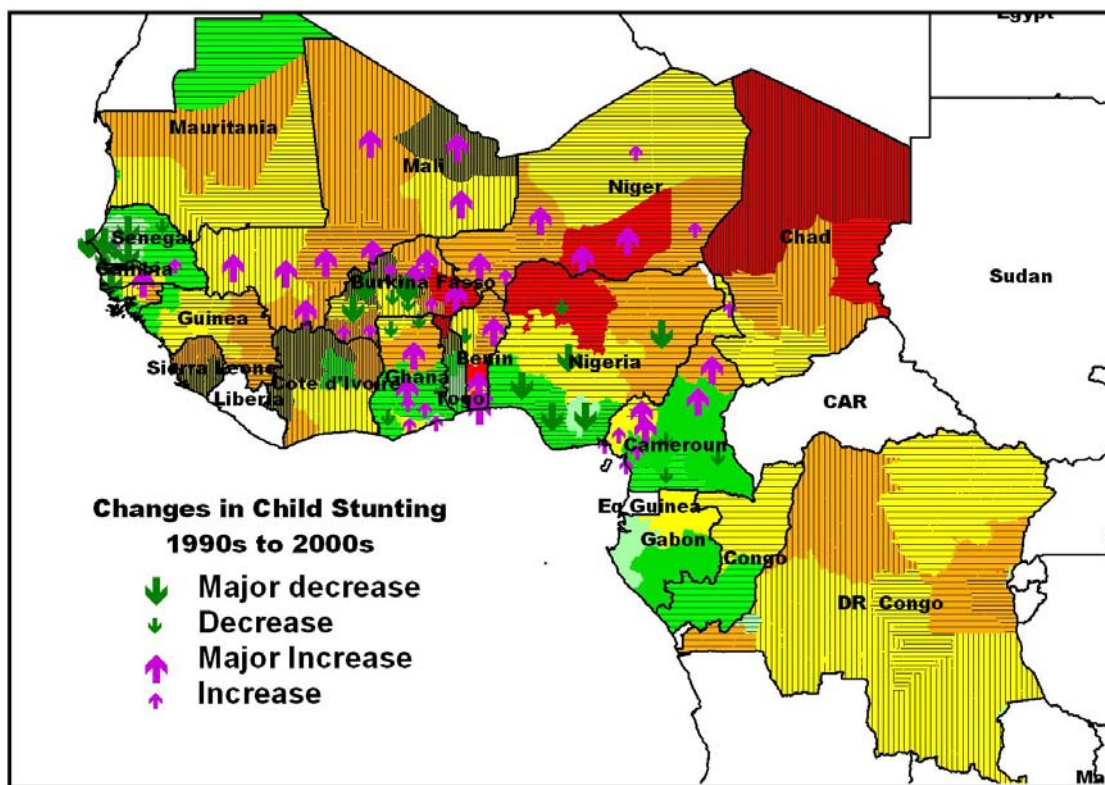


Figure 20. Changes in Percentage Stunting between 1995-1999 and 2000-2006

All of Mali and Niger, parts of Ghana and Benin Republic and northern and western Cameroon show significant increases in the incidence of stunting.

### Suitability for Crop Diversification

If enough is known about the growing requirements of crops, in terms of rainfall amount and temporal distribution, minimum and maximum temperatures, and soil chemistry and physical properties, then a GIS can be used to predict the geographical areas most suitable for growing the crops. A database has been prepared by FAO giving the necessary parameters for more than 1200 crop varieties, and the DIVA GIS software (Hijmans et al, 2001) uses this ECOCROP database to generate suitability maps.

Unfortunately, the database does not contain data on most of the new, and often more climate-tolerant varieties of major African crops developed by IITA and other institutes, and we do not have sufficient high-quality soils data, so this software can only be used to provide a broad indication of the suitability for basic crop varieties. These suitability maps can be combined with maps of actual crop production to indicate potential new areas for introduction of crops, or to highlight crops for which the suitability data need to be improved.

Predicted suitability for three major staple crops is compared with actual production in Figures 21, 22 and 23. The data for millet (Figure 21) shows that actual millet production occurs far outside the envelope predicted by DIVA software from the ECOCROP database. This suggests that the growth tolerance data for millet does not include the wide range of climate-tolerant varieties now grown in West Africa. Millet appears to be grown in all areas where ECOCROP suggests that conditions are suitable. The data for cassava (Figure 22) show a closer match between prediction and production, although areas in northern Nigeria and Sierra Leone show production outside of the main zones of suitability. Production data are not yet available for Cote d'Ivoire and Guinea, where cassava suitability is high, but the map suggests that cassava could be introduced to south-western Burkina Faso and southern Mali to increase calorific intake and improve food security. Potential and actual Maize production are shown in Figure 23, and it is apparent that the ECOCROP data for maize does not include the high-rainfall tolerant varieties that are grown through the Congo basin. In less humid areas, the match between prediction and production is good, and there do not appear to be any climatically suitable areas where maize is not already grown.

There is an urgent need for updating of the ECOCROP database with climatic tolerance data for a wider range of crop varieties so that more reliable predictions can be made. The method could then be used to target specific improved varieties to areas where child nutrition is poor, in order to increase yields and thus food availability, and also to indicate which new crops could be introduced to improve food security and broaden diets, and well as providing cash income.

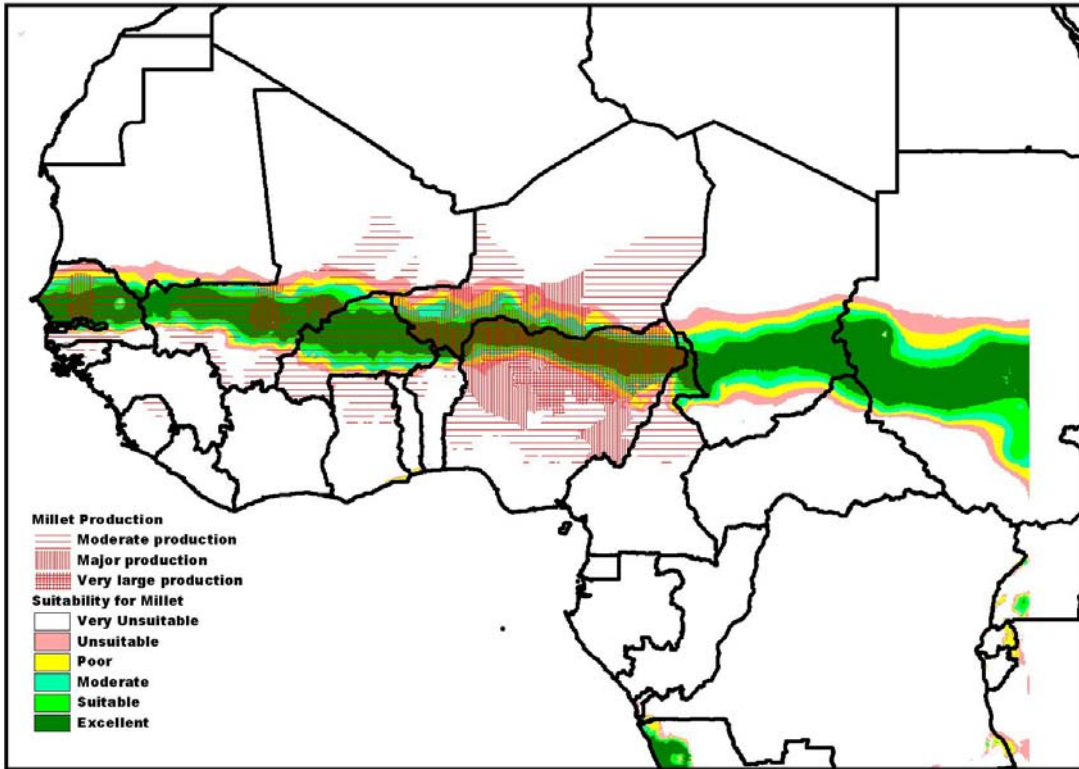


Figure 21. Potential and Actual Millet Production

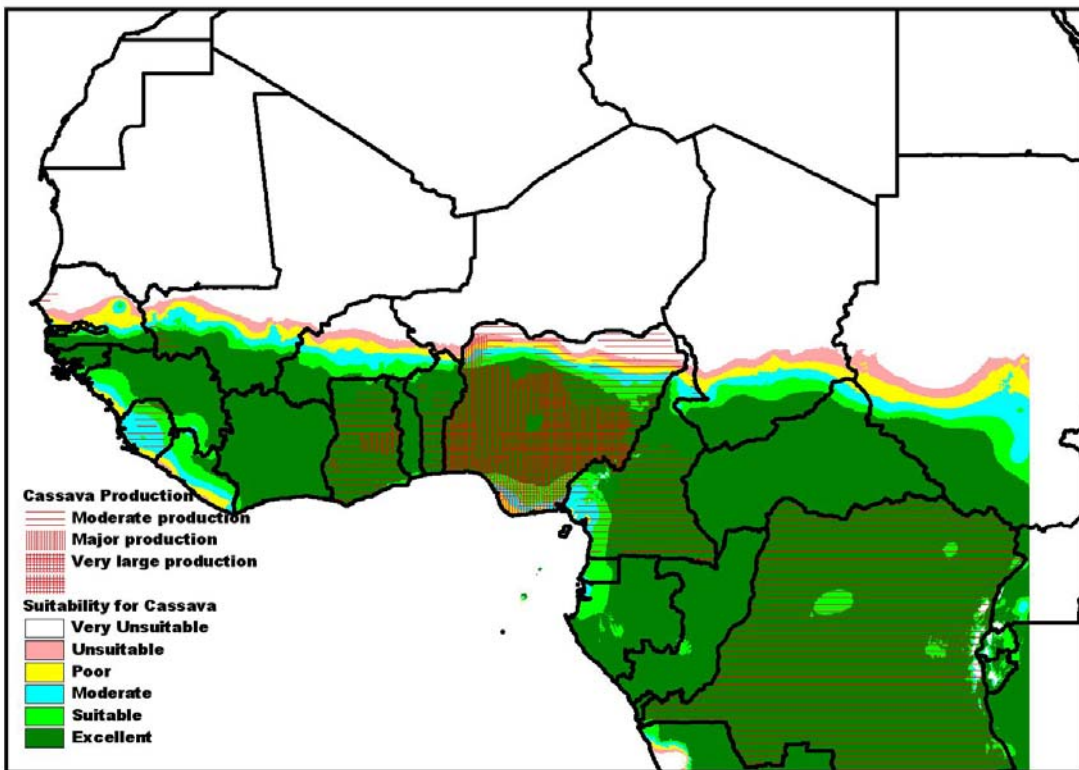


Figure 22. Potential and Actual Cassava Production

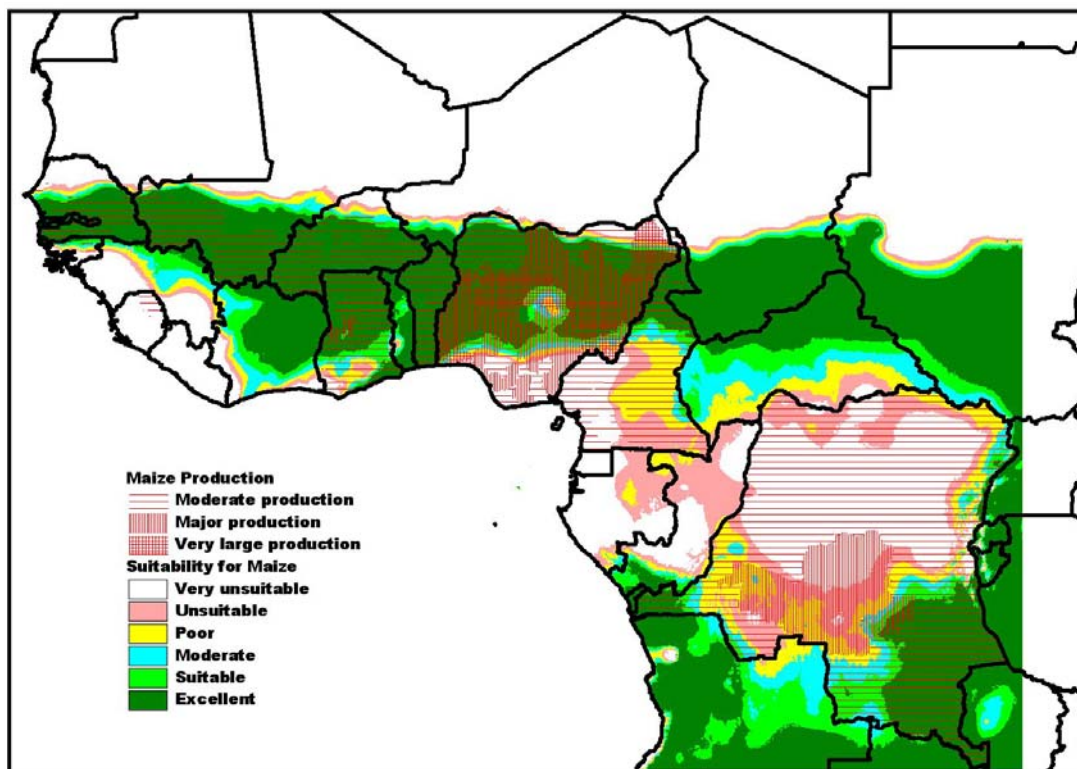


Figure 23. Potential and Actual Maize production

## Conclusions and Recommendations

This report has demonstrated that the distribution of child malnutrition in West Africa is definitely not uniform. Incidences of wasting and stunting vary from province to province and from country to country, and also over time. Analyses of relationships between child nutrition indicators and possible contributing factors such as climate, agricultural production, population density and access to markets shows that where correlations exist, they are rarely dominant, and may only apply for some countries.

Table 8. Countries in West and Central Africa Ranked by GDP

Country	Human Development Index (HDI) 2005	Life Expectancy at birth 2005	Adult Literacy Rate 1995-2005	GDP per capita (PPP US\$) 2005
Equatorial Guinea	0.642	50.4	87.0	7,874
Gabon	0.677	56.2	84.0	6,954
Cape Verde	0.736	71.0	81.2	5,803
Ghana	0.553	59.1	57.9	2,480
Guinea	0.456	54.8	29.5	2,316
Cameroon	0.532	49.8	67.9	2,299
Mauritania	0.550	63.2	51.2	2,234

Country	Human Development Index (HDI) 2005	Life Expectancy at birth 2005	Adult Literacy Rate 1995-2005	GDP per capita (PPP US\$) 2005
Sao Tome and Principe	0.654	64.9	84.9	2,178
Gambia	0.502	58.8		1,921
Senegal	0.499	62.3	39.3	1,792
Côte d'Ivoire	0.432	47.4	48.7	1,648
Togo	0.512	57.8	53.2	1,506
Chad	0.388	50.4	25.7	1,427
Congo	0.548	54.0	84.7	1,262
Central African Republic	0.384	43.7	48.6	1,224
Burkina Faso	0.370	51.4	23.6	1,213
Benin	0.437	55.4	34.7	1,141
Nigeria	0.470	46.5	69.1	1,128
Mali	0.380	53.1	24.0	1,033
Guinea-Bissau	0.374	45.8		827
Sierra Leone	0.336	41.8	34.8	806
Niger	0.374	55.8	28.7	781
Congo Democratic Republic	0.411	45.8	67.2	714

Data from UNDP Human Development Report, 2007

Distinctions must be made between the geographic distribution of child malnutrition in terms of percentage incidence of stunting or wasting in populations, and the actual numbers of malnourished children. The almost overwhelmingly large population of Nigeria means that more malnourished children live in Nigeria than in any other country of the region, but the percentage incidence of stunting and wasting in Nigeria is less than in most other countries. Aid donors and implementing agencies need to decide whether their prime targets are reductions in the total numbers of malnourished children, which could best be achieved by targeting densely populated areas, even though they had relatively low percentage incidence, or reductions in percentage incidence of malnutrition in the most affected areas, even though total numbers of affected children are less.

It could be argued that development aid should be given first to those countries least able to feed themselves, either through internal production or purchase of internationally traded food. Table 8 ranks countries in west and central Africa on the basis of GDP. Only three countries (Equatorial Guinea, Gabon and Cape Verde) have GDP's of above US\$5000 per person per year, while a further five (Ghana, Guinea, Cameroon, Mauritania and Sao Thome/Principe) have GDPs between US\$2000 and US\$5000. Equatorial Guinea, Gabon and Sao Thome/Principe are important oil producers with very small populations, and although child malnutrition is probably a problem, at least in Equatorial Guinea (see Tables 8 and 9), international development assistance is probably not required. Cape Verde, although poor in natural resources, benefits from a huge and dynamic émigré population whose remittances boost the national economy.



Ghana, Guinea, Mauritania and Cameroon are important recipients of international development aid, and also have serious problems of child nutrition.

**Table 9. Nutrition Indicators. Countries ranked by Child Stunting**

Country	% total population undernourished	U/WChildren (% < age 5)	StuntedChildren (% < age 5)	low birthweight (%)
	2002/04	1996-2005	1996-2005	1998-2005
Niger	32	40	54	13
Chad	35	37	45	22
Central African Republic	44	24	45	14
Congo Democratic Republic	74	31	44	12
Burkina Faso	15	38	43	19
Mali	29	33	43	23
Nigeria	9	29	43	14
Equatorial Guinea		19	43	13
Mauritania	10	32	40	
Guinea	24	26	39	16
Benin	12	23	39	16
Sierra Leone	51	27	38	23
Guinea-Bissau	39	25	36	22
Cameroon	26	18	35	13
Sao Tome and Principe	10	13	35	20
Côte d'Ivoire	13	17	32	17
Congo	33	15	31	
Togo	24	25	30	18
Gabon	5	12	26	14
Gambia	29	17	24	17
Senegal	20	17	20	18
Cape Verde		14		13

Data from UNDP Human Development Report, 2007

This study has been mainly concerned with sub-national distribution of child malnutrition in the region, but national statistics for undernourishment, child wasting and stunting, and low birth-weights are summarised in Table 9, where countries in west and central Africa are ranked according to child stunting (height for age or TPA). Apart from total percentage undernourishment, the figures are all averages of the period 1995 to 2005, and so may differ from the single year data analysed earlier in this report. More than 40% of children under five years are stunted in Niger, Chad, Central African Republic, DRC, Burkina Faso, Mali, Nigeria, Equatorial Guinea and Mauritania, while more than 30% of children under five years are wasted (low weight for age) in Niger, Burkina Faso, Chad, Mali, Mauritania and DRC. The most serious child malnutrition, in terms of combined indicators of stunting and wasting, is thus predominantly in Sahelian countries,

with relatively low and uncertain rainfall, with the exception of the Democratic Republic of Congo, where the climate is humid but years of warfare and poor governance have probably been the main factors influencing child nutrition.

The main geographic trends in child nutrition indicators have been described in detail in Section 4 of this report. Stunting in children under 5 years, an indicator of chronic (long-term and usually irreversible) malnutrition, shows a marked belt of very high and extremely high (more than 50% of children stunted) incidence stretching from Chad westwards through southern Niger, north-western Nigeria, Burkina Faso to northern Ghana and southern Mali. Another area of very high stunting incidence is found in Eastern DRC. Child wasting, indicating acute (short-term and potentially reversible) malnutrition, is extremely high (more than 25% of children wasted) in parts of Burkina Faso, and is also very high in much of Chad, Mali, DR Congo and Guinea Bissau. Lowest combined incidences of stunting and wasting are generally found in more humid coastal districts, with the exception of Sierra Leone and DRC, while highest combined incidence is seen in central Mauritania, northern Mali, northern and eastern Burkina, southern Niger and Chad, and north-western DRC. In countries with a marked climatic gradient such as Ghana, Nigeria and Cameroon, the combined incidence increases strongly from south to north with decreasing rainfall. Considering infant mortality, the highest incidence in the region is in Sierra Leone and in southern Niger, while Liberia and central Mali also have high infant mortality. Within the countries covered by WA-SAKSS, lowest values of infant mortality are found in Mauritania, Senegal, south-eastern Ghana, central Nigeria, western Cameroon and Gabon.

Analysis of child nutrition indicators in relation to agro-ecozones shows that high incidence of both stunting and wasting is more common in drier ecozones than in the most humid. All administrative units in the semi-arid ecozone show high incidence of both stunting and wasting, while in the dry savanna ecozone 70% of areas show elevated values. In the humid forest ecozone, in comparison, only 20% of administrative areas have high incidences of stunting and wasting. The sub-humid and moist savanna ecozones are intermediate, with about 60% of areas having high incidence. The correlations are not very strong however, except that the two extreme ecozones, humid forest and desert, show much lower incidences of stunting and wasting than the other zones.

Analysis of sub-national child nutrition data in relation to development domains defined by population density and market access suggest that most indicators of child nutrition deteriorate as market access improves. All indicators decline significantly as population density increases, although it should be remembered that these figures are not weighted for actual populations in each area, and the high population density domains will actually have much greater numbers of malnourished children than the low population density domains

On a regional level, there is no significant correlation between any of the child nutrition indicators and food production, either measured as potential total per capita calorie intake from own production or as proportions of different staple crops, but within individual countries, especially large countries which cross many eco-zones and farming systems, some very interesting correlations can be observed between child nutrition indicators and the proportion of total food production contributed by specific crops. In Nigeria, Cameroon and Ghana there is a strong positive correlation between child stunting and the relative proportions of maize, millet and sorghum in total agricultural

production, and strong negative correlations between stunting and the proportions of yams and cassava. Correlations with child wasting are less strong. This does not suggest that maize, millet and sorghum are intrinsically less nutritious than yams and cassava, but rather that the more humid eco-zones where cassava and yams are dominant food crops are more fertile, with more reliable climate and less soil degradation, than the drier eco-zones where maize, millet and sorghum are dominant. Analysis of nutrition indicators by farming system reinforces this. Stunting, wasting and infant mortality become progressively worse from root crops through cereals and roots to moist and dry cereals.

Stunting, wasting and infant mortality show divergent trends when averaged on livestock densities. Lowest values for stunting and wasting (best nutrition) - 30.6% and 7.6% respectively - are found in areas with no significant livestock. Highest stunting incidence (38.7%) is seen in areas with moderate concentrations of small ruminants, but it is also high in areas with abundant cattle. Highest incidence of wasting is seen in areas with abundant cattle. The unexpected general conclusion is that keeping livestock leads to poorer child nutrition and increased infant mortality.

Detailed studies of temporal changes in child malnutrition indicators could only be carried out in a few countries. In Niger, all districts showed an overall increase in the percentage of stunted children between 1992 and 2006, while the percentage wasting increased between 1992 and 1998, and then decreased steadily after 1998. In Senegal, the percentage of stunted children showed a decrease in most administrative districts between 1986 and 2004, while all areas showed an increase in the percentage of wasted children between 1986 and 1993. In Ghana, stunting remained relatively constant through the period 1988 to 2003 in most districts, while many showed a general decline in wasting incidence over the period. A regional study, examining temporal changes over long periods based on fewer surveys, indicated that the greatest improvements with regard to stunting were seen in Nigeria, Senegal and western Burkina Faso, while the greatest increase in child stunting is seen in Cameroon, Benin Republic and eastern Burkina. All of Mali and Niger and most of Ghana showed slight increases in the incidence of stunting. With regard to wasting, the greatest improvement during the period was in Niger, while all of Mali, Nigeria and Benin Republic showed a moderate improvement. Senegal, Burkina, Ghana and Cameroon presented a mixed picture, with some provinces showing a marked increase in percentage wasting while others showed modest declines.

The main conclusions to be drawn from the results so far can be summarized as follows:

a) Child malnutrition, as indicated by incidence of stunting and wasting, and also by infant mortality rates, is most serious in the more arid parts of the region, where more drought-tolerant crops such as millet, sorghum and maize are dominant. The more humid areas, where root crops are dominant, show generally lower child malnutrition, except in the case of the Democratic Republic of Congo, where years of internal strife have resulted in severe child malnutrition.

b) Population densities do not have a significant influence on malnutrition rates, although actual numbers of malnourished children are highest in areas of very high population density. Counter-intuitively, areas with best access to markets show higher incidence of child malnutrition.

c) High densities of cattle and small ruminants do not normally result in improved child nutrition. The potential for improved nutrition and food security offered by mixed livestock and cropping systems appears not to have yet been realized through most of the region.

d) Although there have been some local improvements in child nutrition in the region since the early 1990's, the overall situation is either near-static or declining. Agricultural development directed at improved nutrition appears not to have been effective.

## References

- Ahmed, A. U., Hill, R. V., Smith, L. C., Wiesman, D. M. and Frankenberger, T. 2007. The World's Most Deprived; characteristics and causes of extreme poverty and hunger. IFPRI 2020 Discussion Paper 43.
- Balk, D and Yetman, G.2004. The global distribution of population: Evaluating the gains in resolution refinement. Centre for Earth Science Information Network, Columbia University, New York.
- Balk, D., Pozzi, F., Yetman, G., Deichmann, U. and Nelson, A. 2004. The distribution of people and the dimension of place: Methodologies to improve the global estimation of urban extents. CIESIN, Columbia University.
- Black M., Ebener S., Najera Aguilar P., Vidaurre M., El Morjani Z. (2004): "Using GIS to Measure Physical Accessibility to Health Care", Paper presented during the 2004 International Health Users conference, Washington DC .
- Black, R. E., Allen, L. H., Butta, Z. A., Caulfield, L. E., de Onis, M., Ezzati, M., Mathers, C. and Rivera, J. 2008. Maternal and child undernutrition: global and regional exposures and health consequences. Lancet series of Maternal and Child Undernutrition., Paper 1.
- Center for International Earth Science Information Network (CIESIN), Columbia University 2005. Poverty Mapping Project: Global Subnational Prevalence of Child Malnutrition Palisades, NY: CIESIN, Columbia University. Available at: <http://www.ciesin.columbia.edu/povmap/>
- CIESIN (Center for International Earth Science Information Network) Columbia University, 2006. Where the poor are: an atlas of poverty. Palisades, New York. Available at <http://www.ciesin.columbia.edu/povmap/>
- Deichmann, U. 1997. *Accessibility Indicators in GIS*. Department for Economic and Social Information and Policy Analysis, UN Statistics Division, New York, NY, USA
- DHS, 1988. Enquête Démographique et de Santé au Sénégal 1986 Ministère de l'Economie et des Finances Direction de la Statistique Division des Enquêtes et de la Démographie et Institute for Resource Development/Westinghouse
- DHS, 1989. Ghana Demographic and Health Survey 1988 Ghana Statistical Service Accra, Ghana Institute for Resource Development/Macro Systems, Inc. Columbia, Maryland USA
- DHS, 1992. Enquête Démographique et de Santé Cameroun 1991 Direction Nationale du Deuxième Recensement Général de la Population et de l'Habitat Yaoundé, Cameroun Macro International Inc. Columbia, Maryland USA
- DHS, 1992. Nigeria Demographic and Health Survey 1990 Federal Office of Statistics Lagos, Nigeria IRD/IVlacro International Inc. Columbia, Maryland USA
- DHS, 1993. Enquête Démographique et de Santé Niger 1992 Direction de la Statistique et des Comptes Nationaux Direction Générale du Plan Ministère des Finances et du Plan Niamey, Niger Macro International Inc. Columbia, Maryland USA
- DHS 1994. Enquête Démographique et de Santé Burkina Faso 1993 Institut National de la Statistique

- et de la Démographie Ouagadougou, Burkina Faso Macro International Inc. Calverton, Maryland USA
- DHS, 1994. Ghana Demographic and Health Survey 1993 Ghana Statistical Service Accra, Ghana  
Demographic and Health Surveys Macro International Inc. Calverton, Maryland USA
- DHS, 1994. Enquête Démographique et de Santé au Sénégal (EDS-II) 1992/93 Ministère de l' Economie,  
des Finances et du Plan Direction de la Prévision et de la Statistique Division des Statistiques  
Démographiques Dakar, Sénégal Macro International Inc. Calverton, Maryland USA
- DHS, 1995. Enquête Démographique et de Santé République Centrafricaine 1994-95 Direction des  
Statistiques Démographiques et Sociales Division des Statistiques et des Études Économiques  
Ministère de l' Économie, du Plan et de la Coopération Internationale Bangui, République  
Centrafricaine Macro International Inc. Calverton, Maryland USA
- DHS, 1996. Enquête Démographique et de Santé Mali 1995-1996 Cellule de Planification et de Statistique  
Ministère de la Santé, de la Solidarité et des Personnes Âgées Direction Nationale de la Statistique  
et de l'Informatique Bamako, Mali Macro International Inc. Calverton, Maryland USA
- DHS, 1997. Enquête Démographique et de Santé 1996. Ministère du Plan, de la Restructuration  
Économique et de la Promotion de l'Emploi Institut National de la Statistique et de l'Analyse  
Économique Bureau Central de Recensement Cotonou, Bénin Macro International Inc. Calverton,  
Maryland USA
- DHS, 1998. Enquête Démographique et de Santé Tchad 1996-1997 Bureau Central du Recensement  
Direction de la Statistique, des Études Économiques et Démographiques Ministère du Plan et de l'  
Aménagement du Territoire N'Djaména, Tchad Macro International Inc. Calverton, Maryland  
USA
- DHS, 1999. Enquête Démographique et de Santé Cameroun 1998 Bureau Central des Recensements et des  
Études de Population Ministère des Investissements Publics et de l' Aménagement du Territoire  
Yaoundé, Cameroun Macro International Inc. Calverton, Maryland USA
- DHS, 1999. Ghana Demographic and Health Survey 1998 Ghana Statistical Service Accra, Ghana  
Macro International Inc. Calverton, Maryland, USA
- DHS, 1999. Enquête Démographique et de Santé Niger 1998 CARE International Niamey, Niger  
Macro International Inc. Calverton, Maryland USA
- DHS. 2000. Enquête Démographique et de Santé Burkina Faso 1998-1999 Institut National de la  
Statistique et de la Démographie Ministère de l'Économie et des Finances Ouagadougou, Burkina  
Faso Macro International Inc. Calverton, Maryland USA
- DHS, 2000. Enquête Démographique et de Santé Guinée 1999 Direction Nationale de la Statistique  
Ministère du Plan et de la Coopération Conakry, Guinée Macro International Inc. Calverton,  
Maryland USA
- DHS, 2000. Nigeria Demographic and Health Survey 1999 National Population Commission Abuja,  
Nigeria
- DHS, 2000. Enquête Sénégalaise sur les Indicateurs de Santé (ESIS) 1999 Ministère de la Santé Direction  
des Études, de la Recherche et de la Formation Dakar, Sénégal Macro International Inc. Calverton,  
Maryland, USA Groupe SERDHA Services d' Études et de Recherche pour le Développement  
Humain en Afrique Dakar, Sénégal
- DHS, 2001. Enquête Démographique et de Santé Gabon 2000 Ministère de la Planification, de la

- Programmation du Développement et de l'Aménagement du Territoire Direction Générale de la Statistique et des Études Économiques Fonds des Nations Unies pour la Population ORC Macro
- DHS, 2001. Enquête Démographique et de Santé Mauritanie 2000-2001 Office National de la Statistique Nouakchott, Mauritanie ORC Macro Calverton, Maryland USA
- DHS 2002. Enquête Démographique et de Santé au Bénin 2001 Institut National de la Statistique et de l'Analyse Économique Cotonou, Bénin ORC Macro Calverton, Maryland USA Juin 2002
- DHS, 2002. Enquête Démographique et de Santé Mali 2001 Cellule de Planification et de Statistique Ministère de la Santé, de la Solidarité et des Personnes Âgées Direction Nationale de la Statistique et de l'Informatique Bamakô, Mali Macro International Inc. Calverton, Maryland USA
- DHS, 2004. BURKINA FASO Enquête Démographique et de Santé 2003 Institut National de la Statistique et de la Démographie Ministère de l'Économie et du Développement Ouagadougou, Burkina Faso ORC Macro Calverton, Maryland, USA
- DHS, 2004. Ghana Demographic and Health Survey 2003 Ghana Statistical Service Accra, Ghana Noguchi Memorial Institute for Medical Research Legon, Ghana ORC Macro Calverton, Maryland, USA
- DHS, 2004. Nigeria Demographic and Health Survey 2003 National Population Commission Federal Republic of Nigeria ORC Macro Calverton, Maryland, USA
- DHS, 2005. Enquête Démographique et de Santé Cameroun 2004 Institut National de la Statistique Ministère de la Planification, de la Programmation du Développement et de l'Aménagement du Territoire Yaoundé, Cameroun ORC Macro Calverton, Maryland, USA
- DHS, 2005. Enquête Démographique et de Santé Tchad 2004 Septembre 2005
- DHS, 2006. ENQUÊTE DÉMOGRAPHIQUE ET DE SANTÉ DU CONGO (EDSC-I) 2005 Ministère du Plan, de l'Aménagement du Territoire, de l'Intégration Économique et du NEPAD Centre National de la Statistique et des Études Économiques (CNSEE), Brazzaville et ORC Macro, Calverton, Maryland
- DHS, 2006. Enquête Démographique et de Santé Guinée 2005 Direction Nationale de la Statistique Ministère du Plan Conakry, Guinée ORC Macro Calverton, Maryland, USA
- DHS, 2006. Enquête Démographique et de Santé Sénégal 2005 Ministère de la Santé et de la Prévention Médicale Centre de Recherche pour le Développement Humain Dakar, Sénégal ORC Macro Calverton, Maryland, USA
- DHS, 2007. RÉPUBLIQUE DU NIGER Enquête Démographique et de Santé et à Indicateurs Multiples 2006 Institut National de la Statistique Ministère de l'Économie et des Finances Niamey, Niger Macro International Inc. Calverton, Maryland, USA
- Dixon, J., Gulliver, A. and Gibbon, D. 2001. Farming Systems and Poverty; Improving farmers livelihoods in a changing world. FAO and World Bank. Rome and Washington DC.
- ECOCROP <http://www.fao.org/AG/agL/agll/ecocrop.htm>
- Fan, S., P. Hazell, and T. Haque. 2000. Targeting public investments by agroecological zone to achieve growth and poverty alleviation in rural India, *Food Policy* 25 (4): 411-428.
- FAOSTAT <http://faostat.fao.org/default.aspx>

- Federal Ministry of Agriculture and Water Resources, 2007. Production by Smallholder Farmers in Nigeria, 2002-2006. PCU Report
- George, H., Nachtergaele, F. and Koohafkan, P. 2003 Agro-MAPS: A global spatial database of sub-national agricultural land-use statistics. Land and Water Development Division, Food and Agriculture Organization of the United Nations, Rome, Italy
- Hijmans, R. J., Guarino, L., Cruz, M. and Rojas, E. 2001. Computer tools for spatial analysis of plant genetic resources data. 1. DIVA-GIS. Plant Genetic Resources Newsletter, No. 127. 15-19
- Jones, P.G., and P.K. Thornton. 2003. The potential impacts of climate change on maize production in Africa and Latin America in 2055. *Global Environmental Change* 13: 51-59.
- Jones, P. and Thornton, P. 2004. Length of growing period predictions for Africa 2025 and 2050. Consultancy report for ILRI/IITA SSA-CP Spatial Analysis Working Group
- Legg, C. A. 2004. A new agro-ecozonal map of Africa. IITA Internal Report
- Lipton, M. (2001) Challenges to meet: food and nutrition security in the new millennium. Proceedings of the Nutrition Society, 60, 203-214.
- MICS2 (2000) The Status of Women and children in Sierra Leone: a household survey report. Central Statistics Office, Ministry of Development and Economic Planning, Government of Sierra Leone. Available at <http://www.childinfo.org/MICS2/natlMICSrepz/MICSnatrep.htm>
- MICS2 (2000) Enquete a indicateurs multiples de la de la decennie. Republique du Niger, UNICEF. Available at <http://www.childinfo.org/MICS2/natlMICSrepz/MICSnatrep.htm>
- MICS2 (2000) Multiple Indicator Cluster Survey Guinea Bissau. National Institute of Statistics and Census, Ministry of Planning, Guinea Bissau, UNICEF. Available at <http://www.childinfo.org/MICS2/natlMICSrepz/MICSnatrep.htm>
- MICS2 (2000) The Gambia Multiple Indicator Cluster Survey Report, 2000. The Government of The Gambia in collaboration with UNICEF. Available at <http://www.childinfo.org/MICS2/natlMICSrepz/MICSnatrep.htm>
- MICS2 (2000) Enquete Nationale sur la situation des enfants et des demmes. MICS2/2001.Republique Democratique du Congo. Available at <http://www.childinfo.org/MICS2/natlMICSrepz/MICSnatrep.htm>
- New, M., Hulme, M. and Jones, P.D., 2000: Representing twentieth century space-time climate variability. Part 2: development of 1901-96 monthly grids of terrestrial surface climate. *Journal of Climate* 13, 2217-2238
- New, M., Lister, D., Hulme, M. and Makin, I., 2002: A high-resolution data set of surface climate over global land areas. *Climate Research* 21
- Pender, J., Ehui, S. and Place, F. 2006. Conceptual Framework and Hypothesis. In "Strategies for Sustainable Land Management in the East African Highlands", Editors Pender, J., Place, F. and Ehui, S. IFPRI, Washington.
- Place, F., Kristjanson, P., Staal, S., Kruska, R., deWolff, T., Zomer, R. And Njuguna, E. C. 2006. Development Pathways in Medium- to High-Potential Kenya: A Meso-Level Analysis of Agricultural Patterns and Determinants. In "Strategies for Sustainable Land Management in the East African Highlands", Editors Pender, J., Place, F. and Ehui, S. IFPRI, Washington.



- Save the Children Fund (2007). State of the World's Mothers, 2007.
- SCN, 2004. 5<sup>th</sup> Report on the World Nutrition Situation. United Nations Standing Committee on Nutrition. <http://www.unsystem.org/scn/>
- Smith, L.C., and L. Haddad. 2000. Explaining child malnutrition in developing countries: A cross-country analysis. Research Report 111. Washington, D.C.:International Food Policy Research Institute.
- SRTM <http://srtm.usgs.gov/> and <http://srtm.csi.cgiar.org/>
- Steinfeld, H, Gerber, P, Wassenaar, T, Castel, V, Rosales, M and de Haan, C. 2006, Livestock's Long Shadow. Livestock, Environment and Development (LEAD) Initiative, FAO. 390 pp
- Thornton, P. K., Kruska, R. L., Henninger, N., Kristjanson, P. M., Reid, R. S., Atieno, F., Otero, A. N. and Ndegwa, T. 2002. Mapping Poverty and Livestock in the Developing World. International Livestock Research Institute. Available at:- <http://www.ilri.org/InfoServ/Webpub/Fulldocs/Mappoverty/index.htm>
- Thornton P K, Stroud A, Hatibu N, Legg C, Ly S, Twomlow S, Molapong K, Notenbaert A, Kruska R and von Kaufmann R (2006). Site selection to test an integrated approach to agricultural research for development: combining expert knowledge and participatory Geographic Information System methods. International Journal of Agricultural Sustainability (in press)
- UNDP 2007. Human Development Reports. Available at <http://hdr.undp.org/en/>
- Wood, S., K. Sebastian, F. Nachtergaele, D. Nielsen, and A. Dai. 1999. *Spatial aspects of the design and targeting of agricultural development strategies*. Environment and Production Technology Division Discussion Paper 44. Washington, D.C.: International Food Policy Research Institute.
- World Bank, 2008. African Development Indicators, 2007.

For more information, contact:

Coordinator  
Regional Strategic Analysis and Knowledge Support System, West Africa  
(ReSAKSS-WA)  
Oyo Road, PMB 5320  
Ibadan, Oyo State  
Nigeria  
Telephone: +234 (2) 241 2626  
E-mail: [resakss-wa@cgjar.org](mailto:resakss-wa@cgjar.org)  
[www.wa.resakss.org](http://www.wa.resakss.org)