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Projected demand and supply for various foods in West Africa: Implications for investments and food policy

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ABSTRACT

This paper (a) summarizes recent evidence of changes in dietary patterns in the 15 ECOWAS countries of West Africa over the past 30 years and the forces driving those changes (In this paper, the term "West Africa" refers to the 15 countries that are members of the Economic Community of West African States (ECOWAS): Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo); (b) uses expenditure-elasticity estimates derived from budget-consumption studies in 8 of these countries (Burkina Faso, Côte d'Ivoire, Ghana, Mali, Niger, Nigeria, Senegal, and Togo) and hypotheses about alternative income growth trajectories to develop scenarios about the evolution of demand for various foods over the period 2010–2040; (c) compares the projected demand growth with projection of production growth in key commodities to identify potential or increasing demand–supply gaps; and (d) derives implications for needed investments and policies regarding different commodities and components of the West African agrifood system, including identifying gaps in the current African Union-led Comprehensive Africa Agriculture Development (CAADP) programs. The analysis shows that in absolute terms, production shortfalls relative to demand for starchy staples (particularly rice and wheat) will continue to pose a major challenge for ECOWAS countries. In relative terms, however, imbalances between domestic production and demand will increase more quickly for foods with high income-elasticities of demand, such as meat, dairy products, seafood, fruits and vegetables and vegetable oils. Urban demand will grow two to four times faster than rural demand, depending on the commodity, putting increased pressure on already stressed urban food marketing systems. Substantial variations in supply–demand gaps across countries suggest that more fluid regional trade could help individual countries cope with these challenges. The findings also suggest that the focus of food policies in West Africa, historically on starchy staples (particularly cereals) needs to broaden to include a range of higher-value products for which demand is likely to increase very rapidly in the near future.

1. Introduction

As in many other regions of the world, food demand has been growing rapidly and changing in its composition over the past 30 years in West Africa. Among the patterns that emerge from an analysis of changes in per capita food availability, as revealed by FAO food balance sheets (FBS) for the 15 ECOWAS countries between 1980 and 2009, are the following (Me-Nsope and Staatz, 2013; Hollinger and Staatz, 2015):

- Increases in calorie availability in 13 out of the 15 countries, ranging from 6% to 64%.[1] The increases were greatest among the countries that experienced the most robust economic growth, such as Ghana and Nigeria.
- Growth in protein availability, with some upgrading of protein quality (increasing share of animal protein and/or high-quality pulse protein) in those countries experiencing strong economic growth.
- Sharp growth in many countries in the per capita availability of fats, oils, and sugar.

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[1] The two countries that experienced declines in per capita calorie availability were Liberia and Côte d'Ivoire, which had among the highest per capita availability at the start of the period and which both experienced civil wars in the 1990s and 2000s.

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- Increasing diet diversity, marked by increased per capita supplies of fruits, vegetables, and range of starchy staples.
- Substantial diversity in these patterns across countries, with increases often, but not uniformly, correlated with income growth and the absence of civil unrest.

While some of the changes in per capita food availability reflected in the FBS data may be an artifact of improved coverage over time of national agricultural statistical systems that generate the production figures incorporated in the FBS (Farnsworth, 1961), other sources of information corroborate this general pattern of dietary change. Household budget-consumption studies carried out in several of the countries in the region (summarized in Hollinger and Staatz, 2015, chapter 6) show patterns of increased and more diversified food expenditures over time, while other data indicate that the percentage of the ECOWAS population suffering from under-nutrition fell from 20% in 1990 to 10% in 2006/08 (FAO, 2011). Moreover, income-elasticities of demand for various food products estimated from these budget-consumption studies (discussed more below) often exceed unity, indicating that an increase in income leads to a more-than-proportionate growth in the demand for these products. These elasticities, when combined with strong per capita income and population growth, imply strong increases in food demand. This strong demand is also reflected in trade statistics. The food trade balance for West Africa, which had been in equilibrium from the mid-1980s, turned sharply negative, starting in 2000, as income growth increased in the region and demand outpaced supply (Fig. 1).

In addition to population and income growth, changes in lifestyles associated with globalization and the region's rapid urbanization appear to be major drivers of changing food demand in West Africa (Hollinger and Staatz, 2015). West Africa is the most urbanized part of Sub-Saharan Africa (with 45% of the population living in cities in 2015) and one of the most rapidly urbanizing areas of the world (UNDESA, 2014). A growing urban middle class (which the African Development Bank (2011) defines as those families living on more than USD 2 per capita per day), combined with increasing time pressures on all urban consumers due to congestion and increased labor-force participation of women outside the home, are boosting the demand for more convenient, processed and prepared foods that are easy to prepare and consume. There is also increasing demand, especially among the middle class, for product attributes such as consistent quality, healthiness and food safety (Bricas and Seck, 1994; Hollinger and Staatz, 2015).

The governments of all 15 ECOWAS member states and ECOWAS as a regional organization have increased their policy emphasis on agricultural growth since the food price spikes of 2008. All are in the process of adopting new investment programs and policy changes aimed at stimulating agricultural growth and food system transformation as part of CAADP. In addition, starting in 2015 ECOWAS countries began instituting a common external tariff (CET), which aims at providing a uniform schedule across member countries of taxation of imported food products. The rapid evolution of food demand in West Africa, however, raises serious questions about how well West African agrifood systems will respond to the changing demand, quantitatively and qualitatively, over the coming 25 years, even with the new ECOWAS CET. If they cannot, the region will become increasingly dependent on food imports and/or face higher domestic food prices. In crafting improved policies and investments for the agrifood sector, it is therefore critical to have a better understanding of how demand is likely to evolve and compare this with likely trends in domestic supply.

The objective of this paper is to provide such information. It compares projected rates of growth in expenditures for major food items, in rural and urban areas, with projected rates of growth in the supply of those items. These projections are made for the ECOWAS region as a whole and for individual West African countries over the period 2015–2040, relative to the baseline of 2010. The comparison is done in five-year increments from 2010 to 2040. This comparison allows us to identify (a) the shifting relative importance of rural and urban areas in total food demand and (b) food items where significant production shortfalls relative to demand may lead to burgeoning imports and/or increases in real prices. Such information will suggest possible areas where current food system development efforts (e.g. in the context of ECOWAP/CAADP) will need to be modified.

2. Literature review and knowledge gap

Economists have long noted that rising per capita incomes and urbanization typically lead to striking changes in dietary patterns (e.g. Bennett, 1954). West Africa is no exception. Since the 1980s, policy makers in the region have been concerned about how urbanization and rising incomes were leading to substitution of rice and wheat—largely imported—for locally produced starchy staples, particularly cereals such as millet and sorghum (CILSS and OECD, 1989). This substitution led to worries that the region's import-dependence for basic staples could reach financially unsustainable levels, and to proposals in the mid-1980s to increase import barriers in order to create a "regional cereals protected zone" (Gabas et al., 1987).

The policy concerns stimulated analyses in the 1980s and early 1990s of the factors driving these shifts (e.g. Delgado and Miller, 1985; Reardon et al., 1998; Delgado, 1989; Rogers and Lowdermilk, 1991). A major conclusion from these analyses was that while declining relative prices for the imports relative to locally produced staples played some role in stimulating the substitution (particularly in the CFA franc countries, where the currency was becoming increasingly overvalued during the 1980s and early 1990s, making imports cheaper for domestic consumers), much of the shift was prompted by urban consumers' desire for convenience. Wheat products (bread, pasta, etc.) are practically ready-to-eat, and rice is much quicker to prepare than traditional West African starchy staples (e.g. millet, sorghum, yams and cassava) when the time-consuming pounding and milling—often by hand—are taken into consideration. Time-pressed urban consumers, many of whom turned to street foods for lunches when urban congestion prevented them from returning home for their noon meal, increasingly also shifted their consumption toward these "convenience foods". Although processed forms of the traditional staples (e.g. packaged millet and sorghum flours and "instant" processed yams) have appeared in West African markets in recent years to try to capture some of this demand, their market share remains small relative to rice and wheat products (Hollinger and Staatz, 2015).

During the 1990s and early 2000s, analysts' attention broadened beyond starchy staples to examine other forms of dietary diversification, including increased consumption of fruits, vegetables, animal products and processed foods, particularly in urban areas, and increased attention to product quality (e.g., Cour and Snrech, 1998). The OECD/Sahel and West Africa Club was particularly active in sponsoring studies examining the possible impacts of urbanization on the structure of West African agriculture and its likely capacity to compete with imports (e.g., OECD, 2014). While some recent studies (OECD, 2014; Bricas et al., 2013; Hollinger and Staatz, 2015) have drawn insights from budget-consumption studies to discuss changing patterns of rural and urban food consumption, none have used income-elasticity estimates from such studies to make quantitative projections of future demand for different food products in West Africa or assess their implications for agricultural policies.

In contrast, Tschirley et al. (2013, 2015) have recently conducted such analyses for East and Southern Africa. Their studies

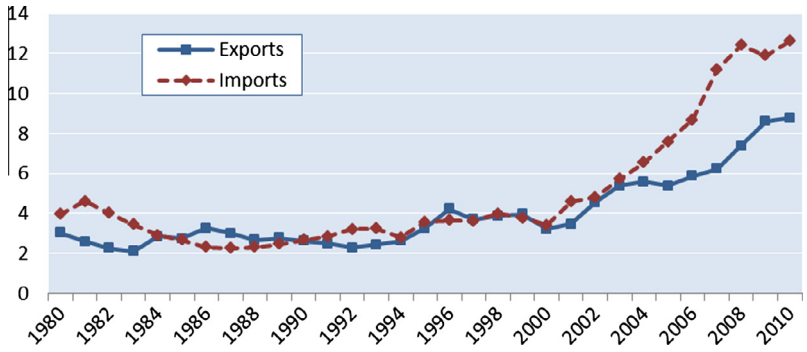

Fig. 1. Food trade balance of West Africa with the rest of the world (billion USD). *Source:* Hollinger and Staatz (2015), based on FAOSTAT data.

show very rapid likely growth in the demand for high-value products such as meats, seafood, dairy products, fruits and vegetables and a wide range of processed products, in response to rising incomes and urbanization. One implication of their results is that the level of investment in infrastructure and human capital in the post-farm parts of the food system (e.g., food processing and marketing), especially of perishables, will need to increase dramatically in the coming years if demand for these high-value products is to be met through local production rather than imports. A contribution of this paper is to provide a similar analysis for the West Africa region, drawing implications for needed policies and investments, particularly in the context of CAADP and the ECOWAS CET.

3. Methods and data

Four steps are involved in carrying out the comparison of the rates of growth of food expenditures with those of the supply of different food items: (1) projecting the increases in per capita expenditures on total food as well as individual food items due to income growth, in both urban and rural areas, for each country for which data are available, under different income-growth scenarios; (2) converting estimates of rural and urban per capita expenditures in a given year into total expenditures by multiplying the per capita figures by the projected rural and urban populations for that year; (3) aggregating expenditure figures across countries to come up with a regional expenditure estimate for the ECOWAS zone and (4) making projections of the growth in supply for each of the future years to compare with the projected expenditures. Each of these steps is explained in more detail in the following paragraphs.

3.1. Projection of per capita expenditures

3.1.1. Expenditure projections: obtaining initial elasticity estimates

For expenditure projections, we used expenditure elasticity estimates for both rural and urban areas calculated from budget-expenditure study data in eight ECOWAS countries: Burkina Faso, Ivory Coast, Ghana, Mali, Niger, Nigeria, Senegal and Togo. For seven of the countries, we used expenditure elasticities estimated by ReSAKSS in collaboration with national research teams (Tayondyandé and Yade, 2012 as reported in Hollinger and Staatz, 2015).[2] As estimates for Nigeria were not available from ReSAKSS, we developed such estimates using based on a Tobit model using 2013 Nigerian LSMS data. The eight countries account for 89% of the total population in West Africa. Table 1 summarizes the expenditure elasticity estimates for 18 food groups in both urban and rural areas. A major advantage of using these elasticity estimates as opposed to those available from USDA (Mohammad et al., 2011) is that the latter are not disaggregated by rural and urban areas. The shifting geographic location of food consumption has major policy implications for West Africa.

All expenditure data are in real per capita US dollars in purchasing power parity (PPP) terms, using constant 2010 international dollars. When the latest data for a given country are before or after 2010, total expenditure values are brought to 2010 levels using the average GDP growth rate between the survey year and 2010.

3.1.2. Adjusting expenditure elasticity estimates to take account of future income growth

One challenge in using expenditure elasticity estimates to project consumption patterns more than a few years into the future is that the expenditure elasticities of demand for food generally decline as total expenditures rise. In other words, as a household's income rises, it typically spends less of each additional dollar on food and more on non-food items, a relationship known as Engel's Law. In mathematical terms, expenditure elasticities for food are generally concave with respect to income levels. Since we are making demand projections over the period 2010–2040, it is very important to estimate how much average expenditure elasticities will decline over this 30-year period, when per capita incomes are expected to rise substantially under all the growth scenarios (see the next section).

To generate reliable elasticity estimates for the future, we followed several steps. First, as described more in detail below, we projected per capita incomes for each of the eight countries over the period 2010–2040 under a range of growth scenarios, based on World Bank and IMF estimates. Second, to see how much the expenditure elasticity estimates for different products would decline as average incomes increased, we used the Nigerian LSMS data to estimate separate expenditure elasticities for each of five income quintiles. The total per capita expenditure for the top quintile in the urban areas is $9.63/day (roughly $3500/year), which is above the future average per capita expenditure levels projected through 2040 in all the other countries except Ghana and Nigeria.[3] For these six countries, we took the expenditure elasticity estimates for the top quintile of the 2012/13 Nigerian LSMS study as the elasticities that would prevail in these other countries in 2040. Using those elasticities and their associated expenditure levels as one

[2] Although the elasticities estimated by ReSAKSS are reported in Hollinger and Staatz (2015), as income-elasticities of demand, the underlying studies upon which they were based used total household expenditures as a proxy for income; thus, in reality, these estimates are expenditure elasticities of demand.

[3] Using the income growth scenarios included in Appendix A, we projected income growth for each 5 year period between 2010 and 2040 for the six countries, using the six growth scenarios described below. These calculations resulted in 432 different observation points for future income levels (6 time periods × 6 countries × 2 zones [urban and rural] × 6 scenarios). In 97% of the cases, the projected income levels fell below US $9.63/day.

Table 1
Expenditure elasticities of demand for food products, by country and place of residence. *Source:* Tayondyandé and Yade (2012) as reported in Hollinger and Staatz (2015), for countries other than Nigeria. Authors' estimates for Nigeria based on 2012/13 LSMS data.

Product	Burkina Faso		Côte d'Ivoire		Ghana		Mali		Niger		Nigeria[a]		Senegal		Togo	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Rice	0.9	1.4	0.4	0.7	1.25	1.17	0.5	1.2	0.8	1.4	0.77	0.92	0.6	0.9	0.8	1.2
Wheat products	1.5	1.7	1	1.2	1.11	1.24	1.3	0.8	1.7	1.5	0.97	1.28	0.7	1.1	1.2	2
Maize	0.4	0.7	0	0.5	0.74	0.81	0.4	0.5	0.8	1.3	0.68	0.58			0.2	0.7
Millet and sorghum	−0.2	0.6				0.19	0.2	0.5	0.5	0.9	0.84	0.44	0.5	0.9	0.5	0.6
Cassava			0.5	0.7	0.98	1.65					0.49	0.85			0.7	1.1
Yam			0.6	0.5	1.27	2.19					0.79	1.22			1	1.4
Banana-plantains			0.6	0.7	0.37	1.31										
Beans/cowpeas									0.6	1.1	[b]	[b]			0.5	1
Pulses							0.7	1.1			0.76	0.87				
Fruits and vegetables	0.9	1	0.8	0.9	0.94	1.31	0.7	0.7	1	1.3	0.78	0.87	1	1.4	1	1.1
Oils and oilseeds	0.9	1.1	0.6	0.7	0.51	0.88	0.7	0.9	1.1	1.2	0.67	0.71	0.6	1	0.8	1
Meat	1.4	1.5	1	1.2	1.16	1.46	1	1.3	1.3	1.3	1.48	1.62	1.3	2.4	1.3	1.6
Fish and seafood	0.9	1.2	0.7	0.8	0.99	0.89	0.6	0.9	0.9	1	0.66	1.08	1	0.9	1	1.2
Dairy products	1.5	1.3	1.3	1.4	1.34	0.51	1.1	1.3	1.2	0.9	1.41	1.42	1.1	2.1	1.7	2.1
Sugar							0.6	0.8			0.94	0.89	0.6	1		
Beverages and stimulants	1	1.1	1.3	1.3	1.81	1.61			1.1	1.4	1.34	1.78			1.3	1.1
Outside dining			3.2	4.3							1.10	1.18			1.6	1.3
Other food products	0.7	1	1.2	1.5	1.67	1.37	0.8	0.9	1	1.1			1	0.9	0.9	0.9

[a] For Nigeria, expenditure elasticities of demand were estimated in more disaggregated form for the following products.
Figures shown in this table are weighted averages means of the individual items (with the weights corresponding to individual items' budget shares), but in expenditure projections reported later in paper, individual disaggregated elasticities were used and resulting amounts for each individual item were aggregated to get total amounts of these "aggregated" commodities:
– Millet and sorghum – each estimated separately.
– Cassava: gari and "other cassava" estimated separately.
– Meat: separate estimates for beef, mutton and goat, poultry and other meat.
– Beverages: separate estimates for alcoholic and non-alcoholic beverages.
[b] Included in pulses and nuts.

end point and the 2010 elasticities and their associated expenditures as the other end point, we estimated a simple log–linear curve to come up with the slope of the downward curvature in the expenditure elasticities as incomes rise. The equation for estimating how the elasticities change as expenditures increase over time is as follows:

$$E_i = E_0 - slope \times (\ln expenditure_i - \ln expenditure_0)$$

where E_0 is the elasticity in the baseline in 2010, E_i is the predicted elasticity in year i, $expenditure_0$ is the baseline total expenditure in 2010, and $expenditure_i$ is the predicted expenditure in year i according to the scenarios.

The average value of the slopes of linear–log functions across all food groups was derived and used for all food groups to predict the elasticities for each scenario for each of the five-year increments from 2015 to 2040.[4] Altogether 30 sets of additional elasticity tables were generated.

Similarly for Nigeria and Ghana, for which future projected income per capita exceeded $9.63 in several of the growth scenarios, we adopted the elasticity estimates for South Africa from a recent study (Tschirley et al., 2013) to calculate the pattern of downward curvature. The per capita expenditure for the top tercile of South Africa is $43.48/day, far above the projected levels of expenditure in Nigeria and Ghana in 2040 under all of our growth scenarios.

The projected change in per capita expenditure for a given item in a given year was calculated relative to 2010 levels by multiplying the estimated expenditure elasticity for the item in that year by the estimated change in per capita income relative to 2010, under six different growth scenarios, as explained below.

[4] The average curvature across all food groups was applied to each of the elasticities rather than separate curvatures for individual food groups. This was done because the small number of observations of elasticities per food group (7 in total—one per country in 2010 plus the 2040 estimate based on the Nigerian data) often made it difficult to get statistically significant curvature results for individual food items.

3.1.3. Growth scenarios

Two key sources of predictive uncertainty regarding the future demand for different food items are the rate of growth in real per capita expenditure and the distribution of that growth (Tschirley et al., 2013). Three main scenarios are developed around per capita income growth: business as usual (BAU), low-case development (LC), and high-case development (HC). LC refers to an outcome resulting from an unfavorable environment while HC indicates a favorable economic climate. Under BAU, the average per capita income growth rates were determined as follows: for the period 2010–15, we take an average of the rates reported in the World Bank's World Development Indicators for 2010–13 and the projections for 2014 and 2015 from the IMF. The average growth rate projections for the period 2016–2040 are based on various IMF country reports (IMF, 2014). All these reports have GDP growth rate projections for 2024 and 2034, which we take as the average growth rate for 2020–30 and 2030–40 respectively (see Appendix A). For the LC scenario, we assume that the annual rate of per capita income growth is 1% less than BAU across countries. For HC, the assumption is that the growth rate is 1% higher than BAU.

To address the issue of income distribution, we created two sub-scenarios of distribution of growth across rural and urban areas for all the scenarios. "Urban bias" implies that the rate of growth in per capita income in urban areas will grow 20% faster than the national average, while "equitable growth" assumes that the growth rates for urban and rural areas are the same. The latter reflects that government policies favor rural development in order to bring down the income disparities between the countryside and cities. These result in six scenarios in total: BAU1 (urban bias), BAU2 (equitable growth), LC1 (urban bias), LC2 (equitable growth), HC1 (urban bias) and HC2 (equitable growth).

For reasons of brevity, we present below results for only three scenarios, which illustrate the range of possibilities: BAU1 (growth in per capita incomes at the levels projected by the IMF, with the current patterns of urban bias continued into the future), LC1 (the national average per capita growth rate 1% lower than the

IMF forecast but with urban incomes continuing to grow faster than rural incomes), and HC2 (growth of per capita incomes 1% higher than the IMF forecast, with urban and rural incomes growing at the same rate).

3.2. Projection of total expenditures by country

For each of the projection years, we multiplied the projected rural and urban per capita expenditures for different food items times the forecast mid-year rural and urban populations. This procedure yielded the projected total daily expenditures for rural and urban areas for the respective years. Adding up the rural and urban figures gives a projection of total daily expenditures for the country. In making these projections, we used the population growth forecasts of the population division of the UN Department of Economic and Social (UNDESA, 2014). The reliability and robustness of the UNDESA data set, particularly regarding urbanization, have the subject of considerable discussion (Potts, 2012; Cohen, 2004; Africapolis Team, 2008). Despite their limitations, the UNDESA figures are the most complete and accessible data available, and we use them for this analysis.

3.3. Projection of regional expenditures

We provide projections of expenditure growth for the entire 15-country ECOWAS zone and not just the 8 countries that are covered by budget-consumption studies. The motivation to provide projections for the zone as a whole arises because ECOWAS is a key player in the design and implementation of agricultural investments and policies in West Africa. As an intergovernmental organization covering 15 countries, it is implementing a free-trade zone within West Africa and a regional agricultural strategy, known as the ECOWAS Agricultural Policy, or ECOWAP. The latter is the West African regional component of the African Union's continent-wide Comprehensive Africa Agriculture Development Programme (CAADP). Under that program, most African governments are implementing national CAADP investment plans. ECOWAP is undertaking investments and implementing policies that are complementary to those envisioned under each of the 15 member states' national programs; in addition, ECOWAS promotes a range of measures aimed at more fluid agricultural trade within the region (Hollinger and Staatz, 2015; Maur and Shepherd, 2015).

Nigeria is by far the largest economy in ECOWAS, accounting for 53% of the total population and 64% of the GDP in 2009/10 (UNDESA, 2014; World Bank, 2011). Therefore, in projecting regional totals, we first calculate the expenditures for Nigeria, based on the elasticities and income growth projections for that country, and then add these to the projected expenditures for the rest of the zone. The non-Nigeria ECOWAS expenditure projections are calculated by taking the sum of total expenditures for the 7 remaining countries for which we have budget-consumption data and inflating them in a given year by those countries' share of the total projected non-Nigerian population of ECOWAS. That share varies between 76% and 79% over the period 2015 and 2040. The inflated figures thus assume that expenditures in the smaller non-Nigerian countries for which we have no budget-consumption data will grow at the same rate as those of the seven countries for which data are available. Adding this estimate for all the non-Nigerian countries to the corresponding projected expenditure for Nigeria yields the estimated ECOWAS regional total.

In the analysis that follows, the levels of food expenditures in the projection years (2015–2040), both in per capita and total terms, are expressed as ratios, showing their level relative to the corresponding expenditures in 2010.

3.4. Projections of supply growth rates

Supply projections are based on production and trade data from FAOSTAT for crop and livestock products and from FAO's FIGIS database for seafood. FAO provides historical data on both volume (tonnage) and value of production and trade of different commodities, with values estimated based on farm-level prices. In making projections of the rate of growth of supply based on these data, one needs to decide: (a) whether to base the projections on volume or value figures, (b) the baseline period used for the projection and (c) whether to simply project past rates of growth or develop a more sophisticated supply model to estimate future supply. With respect to (a), we opted, with one exception, to use volume rather than value estimates, as projecting value estimates based on past data would implicitly assume that the patterns of change in prices of the products in baseline period would continue into the future. Since we had no evidence to support this assumption (particularly with respect to the rapid increase in prices starting in 2008), we opted to project growth rates in volume terms. This approach is the equivalent of projecting the rate of growth of the value of production under the assumption that that the real prices of the different commodities will remain unchanged from those prevailing in the baseline year of 2010. Further implications of this assumption are discussed below. The one exception to the use of volume estimates was the supply projections for fruits and vegetables, for which FAOSTAT only provides trade data in value terms (presumably because of concerns that the highly heterogeneous nature of this food group would make tonnage estimates not meaningful). For this food category, we used FAOSTAT data on value of production and trade.

With respect to the choice of a baseline period, we observe that agricultural growth rates in West Africa vary widely from year to year (Hollinger and Staatz, 2015, chapter 2), in part because production is largely rainfed.[5] Projection of future growth rates based on short periods is subject to considerable variation depending on the period chosen. We therefore opted to calculate growth rates by commodity over a 10-year period (2004–13) rather than a shorter period.[6] We estimated the annual growth rate by following the World Bank methodology (http://data.worldbank.org/about/data-overview/methodologies) of regressing the natural logs of the production data against time. This approach is less sensitive to the choice of beginning and end dates than are alternative measures, such as the average annual or cumulative annual growth rates. For this analysis, we opted for simply projecting past rates of growth forward, with sensitivity analysis of some of the more extreme growth rates to test the robustness of the results. Constructing a full supply model, including incorporating possible impacts of climate change on the production of the various commodities involved, would have been well beyond the scope of the data and time at our disposal.[7]

[5] Only 10% of total cropland in the ECOWAS zone is irrigated (Hollinger and Staatz, 2015).

[6] For comparison, we also calculated growth rates for the more recent period, 2009–13, to see if the rates had changed markedly in the period since 2008, when most West African countries began designing and implementing their CAADP investment programs. The results show for the ECOWAS zone as a whole, there was very little difference in the annual rate of growth for rice production (the area that received the largest attention from West African governments) between the 2004–13 period (7.8%) and the more recent 2009–13 period (7.9%). In the more recent period, the rates of growth of meat and milk production were negative as opposed to positive in the 2004–13 period, perhaps reflecting short-term effects of drought in 2011 in much of the area, but slightly less negative for millet and sorghum production.

[7] IFPRI's IMPACT model (Rosegrant et al., 2012) is a computable general equilibrium model that makes such projections on both the supply and demand side for global and regional markets. Its estimates are based on a different set of elasticity estimates than we use (those of Mohammad et al., 2011), which do not take into consideration differences in rural and urban demand patterns. Using the IMPACT model for these projections would therefore involve forgoing analysis of the shifting nature of demand between rural and urban areas, which is a central focus of this article.

A country's supply of a given product in a given year equals the sum of domestic production and net trade, assuming no net changes in stocks. Therefore, in order to calculate the projected growth in total supply due to the growth in domestic production, we multiplied the projected growth rate in domestic production by the country's self-sufficiency rate (SSR) for that commodity, where the SSR is defined as the domestic production divided by the sum of domestic production plus imports minus exports.[8] Thus, for example, if the estimated annual rate of growth of domestic production of commodity X was 6% and the SSR was 50%, the estimated growth rate of total supply due to the growth in domestic production would be 3%. This figure represents the growth rate of total supply **assuming** that net imports of the good are frozen at 2010 (baseline) levels. The assumption that net imports remain frozen is simply a heuristic device used to calculate the amount by which domestic supply would have to increase beyond its historical growth rate to completely meet the projected increase in demand. As discussed below, in reality the greater the calculated demand–supply gap, the more imports would likely increase and the more domestic prices would increase to close the resulting gap.

3.5. Comparing projections of growth of expenditures and supply

Following the methods described above yields projections of the rate of growth of total expenditures for different food items, expressed as an index relative to 2010 expenditures, and projections of the supply of those items, also expressed as an index relative to 2010 levels, under the initial assumption that all changes in supply are due solely to changes in domestic production. In 2010, each index is equal to 1.0, and expenditures are assumed to equal total supply (domestic production plus net trade). At any point of in the future, if the index for expenditures exceeds that of projected supply, the difference between the two indices represents the degree to which expenditures would exceed supply (assuming no growth in imports and no change in real prices from those prevailing in 2010). This index is expressed as a proportion of the 2010 expenditure on that item. For example, suppose that in 2030 in country X, the projected total expenditures for meat are 1.55 times the amount spent in 2010 while supply is 1.20. This implies a shortfall in supply equal to 0.35 times the 2010 level of meat expenditures. This deficit represents the amount by which imports would have to increase to avoid a real price increase in meat. If imports did not increase by this amount, real prices would increase, which would close the deficit by reducing per capita expenditures (demand response) and increasing domestic supply (likely with a lag). If the index for the supply exceeds that for expenditure, the opposite situation prevails. Comparing the magnitudes of the projected deficits and surpluses across commodities and countries gives a relative picture of the degree to which various food items are likely to face supply–demand imbalances and hence some combination of changing levels of imports and real prices.

In comparing the indices for the growth in expenditures and supply, however, several caveats must be borne in mind. First, the demand projections, being based on budget-consumption studies, reflect only the projected future expenditures for direct human consumption of these items. To the extent that demand for other uses of the commodities, such as animal feed or industrial uses (as might be the case, for example, for cassava), these expenditure projections are likely to underestimate the total growth in demand. The animal feed demand is likely to be strongest for maize, which we have excluded from the tables below so as to focus our analysis on the rising demand for direct human consumption. Second, the "demand" projection is in terms of expenditures while, with the exception of fruits and vegetables, the supply projection implicitly implies no change in the real prices of various food items compared with those that prevailed in 2010. However, as consumers' incomes increase, they typically buy higher quality products (e.g., moving from broken rice to whole-grain rice); therefore, one would expect expenditures to increase more quickly than the physical quantities purchased. So some degree of "apparent deficit" (perhaps 20–30%) could be accounted for by this quality upgrading and thus not represent a physical deficit. Third, we acknowledge that projecting annual growth rates calculated for the 2004–13 decade unchanged through 2040 is fraught with risks. While yields in West Africa have increased in recent years, the bulk of the growth in production in the region since 1980 has been due to area expansion rather than yield increases (Fig. 2), a process that is unlikely to continue over the next 25 years without causing serious environmental costs. In addition, for a few commodities, percentage annual growth rates of production over the 2004–13 decade have been exceptionally high (e.g. for rice), in part because of the small initial production base, and it is unlikely that these high percentage growth rates can be sustained. On the other hand, for a few commodities (notably millet and sorghum in Nigeria), production has fallen, and projecting the decreases onward for 25 years would imply a near end to production of those goods by 2040. In these cases, we use sensitivity analysis of the supply growth rates to examine what are likely more reasonable long-term assumptions on future supply–demand balances. Fourth, our projections of supply–demand balance are based on the assumption of constant real prices. In reality, if significant deficits or surpluses emerged, domestic prices would likely change (assuming that imports are not perfectly price-elastic), inducing responses on both the supply and demand side that would tend to bring supply and demand back into equilibrium.

The bottom line is that our analysis is not intended to provide precise point estimates of future levels of food expenditures and supply. Rather, it is a "what if" analysis that uses explicit elasticity estimates to compare the order of magnitude of supply and demand imbalances that would emerge in if present trends continued. The results therefore suggest areas where changes in current agricultural investments and policies may be needed and, where, absent those, significant changes in food imports and prices will occur.

4. Results

4.1. Growth in per capita expenditures on all foods

Table 2 shows the projection results of per capita per day food expenditure under three main growth scenarios. For BAU1, the level of food expenditure, in by 2020 would grow by 40% in Nigeria and by 86% in Ghana compared to the base year of 2010; by 2040, total expenditures would be over three times higher in those countries than in 2010.[9] The incremental growth in Mali and Niger is the lowest, reflecting the modest rates of income growth projected for

[8] For our analysis, we calculate the SSRs based on the average production and trade data over the period 2006–2010. SSRs vary over time (long-term trends) but show less year to year than production figures; therefore, we opted for a shorter, more recent period for the SSRS (to capture ongoing trends) than the longer 2004–2013 period used for calculating our annual production growth rates.

[9] This growth includes the value of home-produced as well as marketed food. As more and more people will be relying on the market for food over time, the growth in demand for marketing services will grow even faster than these figures imply. For comparison, in the United States over the 11-year period from 2013/14 through 2024/25, domestic demand for wheat is projected to grow by less than 3%, and demand for chicken, one of the food products with the fastest growing consumption, is projected to grow at 23% (calculated from data in U.S. Department of Agriculture, 2015).

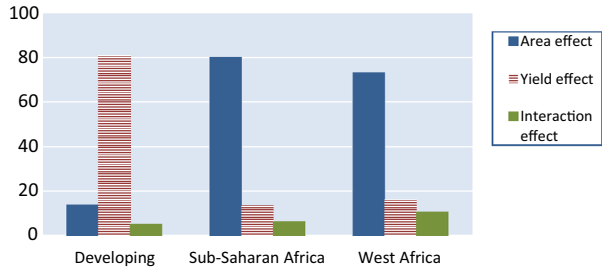

Fig. 2. Contributions of area and yield to agricultural output growth, West Africa vs. other regions: 1980–89 to 2000–09 (%). *Source:* Konandreas (2012).

those countries. Under the LC1 scenario (slower growth, urban-biased), the growth levels are relatively modest, with only Ghana growing more than three times of the initial level. In contrast, under HC2 scenario (higher growth, more equal rural–urban income distribution), the growth ratio between 2010 and 2040 is about 5.8 for Ghana and 4.0 for Nigeria. The average per capita per day food expenditure in Ghana increases from 2.02 USD in 2010 to 11.75 USD in 2040, which is the highest amongst all the selected countries.

Combined with the sub-scenarios for income distribution, the results exhibit clear differences across the six scenarios. Fig. 3 illustrates the changes in three countries, selected to show a range of outcomes. In all the countries, the baseline situation is that the food expenditure is higher in urban areas than rural areas. The projection shows that this will continue to be the case until 2040 across all the six scenarios. However, given the priority that hungry people give to allocating income to acquire food, the disparities in per capita food expenditures between urban and rural areas under the 'equitable growth' setting are considerably reduced compared to those under the urban bias income growth scenarios.

As the total food expenditure grows over the years, the composition of spending across food groups keeps changing. With additional income, households would spend more on starchy staples (cereals, roots and tubers) until such expenditures reach a plateau. Take Côte d'Ivoire as an example (Fig. 4). Its food budget shares are changing from 2010 to 2040 and there are clear differences across the three main scenarios. The budget shares for most staple crops come down while the shares for meat, dairy, beverages and other foods go up.

4.2. Growth in total expenditures on all foods

Using the UN population projections, we calculated the projected total annual food expenditures for the eight countries (Table 3), which reflect the combined effects of higher incomes, population growth and increased urbanization. Under the BAU1 scenario, food demand (approximated by the total food expenditure) is projected to increase more than five times over the period of 2010–40 for Burkina Faso, Ghana, Niger and Nigeria. Notably, total food expenditures in Nigeria and Ghana would increase seven-fold. Even in countries where per capita food expenditure grows relatively slowly such as in Mali and Togo, the overall food demand expansion is remarkable, due to rapid population growth. For example, by 2040 the food demand would be 3.7 times larger in Mali and 4 times bigger in Togo.

Under the HC2 scenario, the situation is more dramatic. The total food demand would grow over eight-fold for Nigeria and Ghana by 2040, driven by their high income growth and shift in consumption toward higher-value products (see Table 3). Burkina Faso and Niger would expect food demand over six times bigger by 2040. These would be remarkable changes. To meet the surge in demand, the region's food and agricultural sector needs a major boost in investment.

4.3. Growth in total expenditures on selected food items, by region and selected countries, compared with projected supply

Table 4 presents the projected growth of expenditures by food category for ECOWAS as a whole, through 2040, expressed as a ratio of the 2010 expenditures in the three scenarios. It also compares the growth of expenditures with the projected growth of domestic supply (as explained above, using parameters shown in Table 5) and calculates the deficit or surplus in 2040, expressed as a proportion of the 2010 level of expenditures. For brevity, the evolution of expenditure for the region as a whole is shown in 10-year increments (2020, 2030 and 2040) rather than 5-year increments.

Several points emerge from Table 4. First, for the region as a whole, projected demand (expenditures) outstrips projected supply for all commodities examined, but the relative gap between the two is greatest for meat, dairy products, vegetable oil and fruits and vegetables. For example, Table 4 projects that under BAU1, expenditures on dairy products will increase by 2040 to 7.94 times the level of 2010 dairy expenditures, yet domestic

Table 2
Per capita per day food expenditure projections for selected countries in West Africa (USD in purchasing power parity (PPP) terms, constant 2010).

	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Niger	Nigeria	Senegal	Togo
Scenario 1: BAU1								
2010	$1.17	$1.04	$2.02	$1.09	$1.00	$1.83	$1.02	$1.25
2020	$1.53	$1.43	$3.75	$1.22	$1.28	$2.56	$1.18	$1.72
2030	$2.05	$1.82	$5.44	$1.41	$1.43	$3.75	$1.56	$2.10
2040	$2.71	$2.33	$8.80	$1.63	$1.62	$5.76	$2.12	$2.63
Growth ratio 2010–40	2.32	2.23	4.37	1.50	1.62	3.14	2.08	2.11
Scenario 2: LC1								
2010	$1.17	$1.04	$2.02	$1.09	$1.00	$1.83	$1.02	$1.25
2020	$1.48	$1.38	$3.54	$1.18	$1.23	$2.45	$1.13	$1.64
2030	$1.84	$1.63	$4.58	$1.28	$1.27	$3.26	$1.36	$1.83
2040	$2.28	$1.94	$6.61	$1.38	$1.33	$4.54	$1.71	$2.09
Growth ratio 2010–40	1.95	1.86	3.28	1.27	1.33	2.48	1.68	1.67
Scenario 3: HC2								
2010	$1.17	$1.04	$2.02	$1.09	$1.00	$1.83	$1.02	$1.25
2020	$1.59	$1.49	$3.96	$1.26	$1.33	$2.69	$1.23	$1.79
2030	$2.28	$2.03	$6.44	$1.56	$1.60	$4.32	$1.77	$2.41
2040	$3.22	$2.80	$11.75	$1.91	$1.97	$7.33	$2.60	$3.29
Growth ratio 2010–40	2.75	2.69	5.83	1.75	1.96	4.00	2.56	2.64

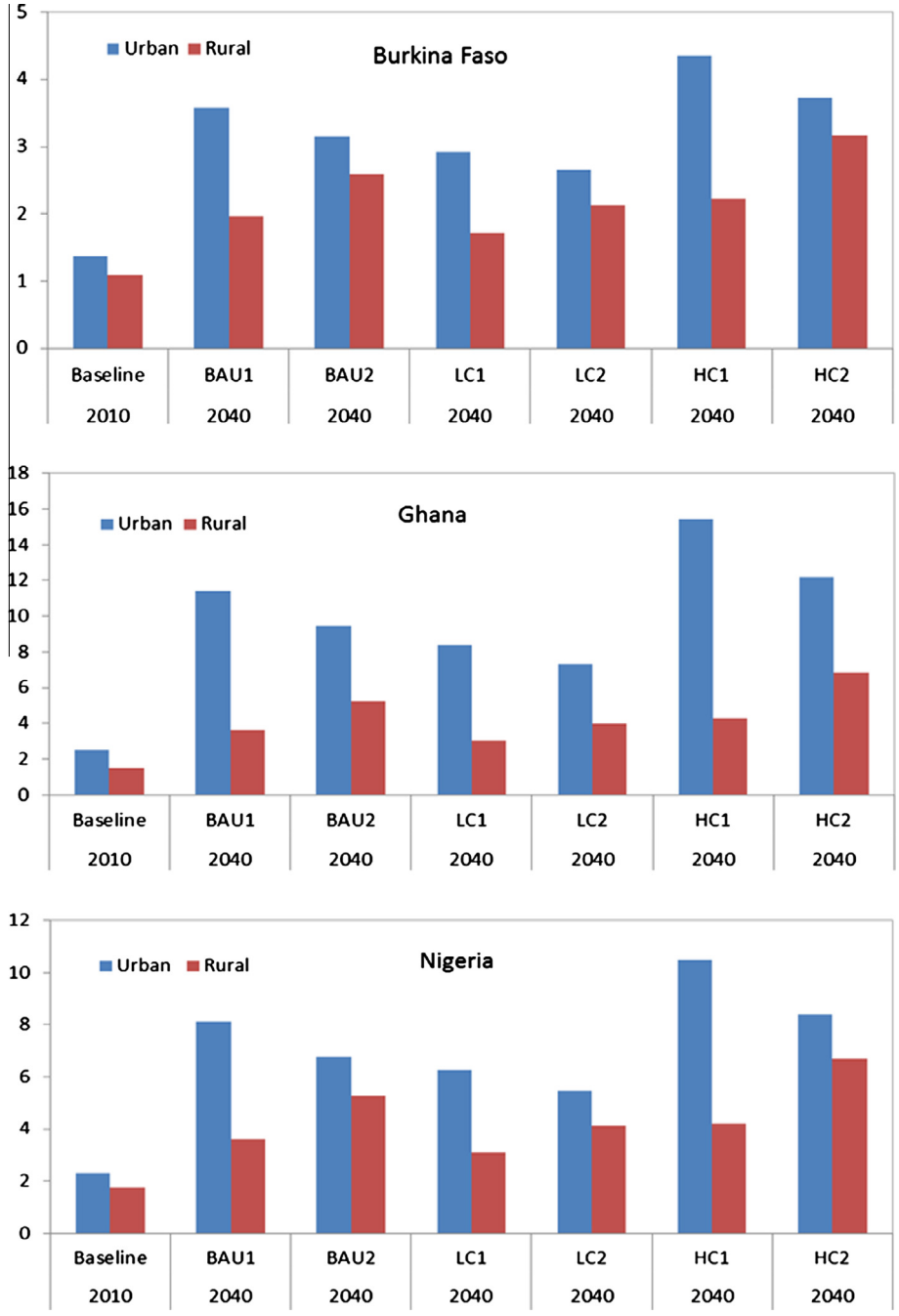

Fig. 3. Urban vs. rural food expenditure growth trajectory under six scenarios (USD, PPP).

supply (holding imports constant) would increase only 1.98 times, leaving a gap equivalent to nearly 8 times the 2010 level of total expenditures on dairy products in the zone. This gap would need to be closed by increased imports and/or higher prices. In contrast, the relative size of the projected deficit in rice is only 2.07 times the 2010 expenditure levels on that commodity. In absolute terms, however, because estimated 2010 expenditures on rice are so much higher than those on dairy products (USD 21.5 billion vs. USD 3.8 billion (PPP)), the value of absolute deficit in rice in 2040 would still be 45% larger than that of dairy products (USD 44.5 billion vs. USD 30.5 billion (PPP), respectively).

Third, the pace and distribution of income growth have a strong impact on the evolution of expenditures, particularly for foods that have a high income elasticity of demand. This is most evident for animal-based foods, where the projected deficits for meat, dairy products and fish under scenario HC2 are roughly double that under LC1.

Fourth, for all commodities, the rate of growth in demand is more rapid in urban areas than in rural areas, in some cases strikingly so. For example, the rate of increase of expenditures on meat products relative to 2010 levels under scenario BAU1 is over four times as rapid in urban areas as in rural areas. Even under HC2, where rural incomes increase more rapidly, the rate of growth of urban demand is double that of rural demand. For a starchy staple like cassava, the pattern is less extreme, but even there projected urban expenditures under BAU1 grow twice as fast as rural expenditures.

The size of the deficit in 2040 for a particular commodity is a function of four variables: the income elasticity of demand for

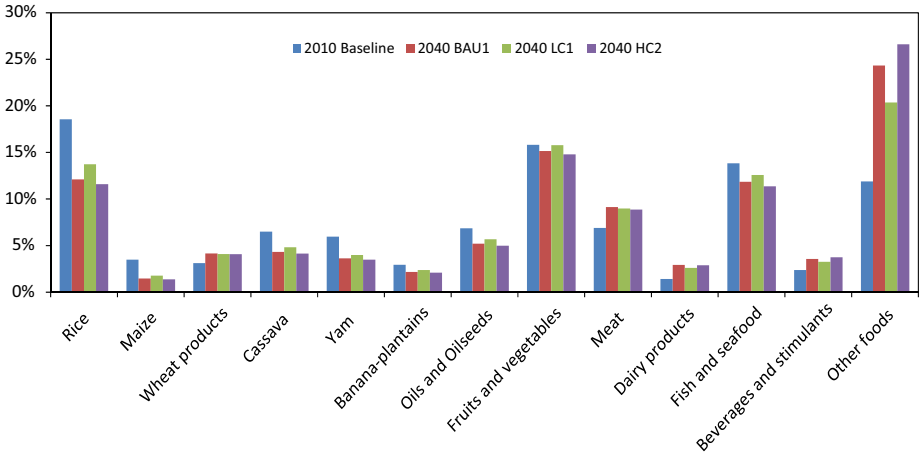

Fig. 4. Food budget shares in Côte d'Ivoire by detailed food groups in 2010 and in 2040 under three scenarios.

Table 3
Total annual food expenditure projections for selected countries (in billions PPP USD, constant 2010).

	Burkina Faso	Côte d'Ivoire	Ghana	Mali	Niger	Nigeria	Senegal	Togo
Scenario 1: BAU1								
2010	$6.64	$7.23	$17.85	$5.56	$5.83	$109.49	$4.80	$2.88
2020	$11.47	$12.44	$45.17	$8.45	$10.95	$200.85	$7.36	$5.06
2030	$19.86	$19.37	$69.98	$13.42	$17.95	$385.41	$12.41	$7.69
2040	$33.17	$30.14	$130.82	$20.73	$29.48	$768.23	$21.01	$11.71
Growth ratio (2010–40)	5.00	4.17	7.33	3.73	5.06	7.02	4.38	4.07
Scenario 2: LC1								
2010	$6.64	$7.23	$17.85	$5.56	$5.83	$109.49	$4.80	$2.88
2020	$11.07	$11.98	$42.66	$8.18	$10.54	$192.12	$7.04	$4.83
2030	$17.83	$17.34	$58.99	$12.15	$16.00	$336.48	$10.87	$6.70
2040	$27.82	$25.09	$98.16	$17.57	$24.23	$610.04	$16.95	$9.31
Growth ratio (2010–40)	4.19	3.47	5.50	3.16	4.16	5.57	3.53	3.24
Scenario 3: HC2								
2010	$6.64	$7.23	$17.85	$5.56	$5.83	$109.49	$4.80	$2.88
2020	$12.28	$12.92	$47.06	$8.82	$12.00	$211.77	$7.79	$5.34
2030	$23.42	$21.29	$78.89	$15.01	$21.86	$439.44	$14.50	$8.84
2040	$41.88	$34.65	$154.67	$24.55	$39.35	$927.38	$26.60	$14.43
Growth ratio (2010–40)	6.31	4.79	8.66	4.42	6.75	8.47	5.54	5.02

the good, the projected rate of income growth and its distribution, the rate of growth of domestic production and the initial level of the self-sufficiency rate for the good (which translates the growth of domestic production into the rate of growth of total supply). For millet and sorghum, demand growth is very modest, but because the 2004–13 growth rate of production for the region is negative (due to a sharp fall in Nigeria), a substantial deficit appears for 2040—the equivalent of 2.66 times the 2010 level of expenditures. But if the annual growth rate in production increased from the baseline level of −3.5% to +3.8% (which is just 63% of the CAADP 6% target for the overall growth rate for agriculture), then the deficit would disappear. For vegetable oil, an annual growth rate of +6.1% would eliminate the deficit, while an increase in the rate for fruits and vegetables from +1.8% to +5.1% would do the same for those commodities. In contrast, the demand for meat and dairy products is projected to grow so fast, and the import dependence for dairy products is so high, that even increasing domestic growth rates of production of each of those commodities to 8%/year would still leave deficits equivalent to 4.2 times the 2010 level of expenditures for meat and 6.2 times for dairy products. The projected deficits for fish would be substantially lower than those for meat; this strongly suggests that in reality the price of fish (currently the most widely consumed form of animal protein in the coastal states of West Africa) would increase relative to meat as consumers shifted even more from meat to fish consumption.

Because Nigeria is the giant in ECOWAS, it is useful to disaggregate the regional results between Nigeria and the rest of the region (Tables 6 and 7). Outside Nigeria (Table 6), the baseline growth rates for production are generally higher (except for fish). As a result, the projected deficits are smaller, and in the case of cassava, there is even a small surplus under the LC1 scenario.[10] Nonetheless, the general patterns noted above for the overall region hold, with larger relative deficits for meats, dairy products, vegetable oils and fruits and vegetables than for starchy staples. As with the regional figures, projected growth in expenditures is more rapid in urban than rural areas and the overall rate and pattern of income growth across the different scenarios have a strong effect on the projected supply–demand balances.

For Nigeria (Table 7), some of the large projected deficits are due to negative growth rates in the 2004–13 baseline periods. For millet and sorghum, projecting the −8.38% growth rate through 2040 results in the near elimination of national production, a clearly unrealistic development. If the growth rate for these commodities could be raised to 4% per annum, the 2040 deficit would be eliminated. Similarly, the baseline growth rate for vegetable oils in Nigeria is also negative (−3.75%/year). This rate would need to

[10] Although if industrial demand for cassava increases, as seems to be occurring in recent years, this surplus could quickly turn into a deficit.

Table 4
Indices of projected total expenditures on and supply of selected commodities in ECOWAS region, 2020–2040 (2010 = 1.00), 2010–2040.

Commodity	Year	Domestic supply index	Indices of projected total expenditures under different growth scenarios								
			BAU1			LC1			HC2		
			Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
	2010	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Rice	2020	1.43	1.84	2.23	1.41	1.77	2.14	1.36	1.93	2.25	1.58
	2030	2.13	3.09	4.14	1.93	2.77	3.67	1.77	3.48	4.25	2.62
	2040	3.16	5.23	7.51	2.70	4.43	6.30	2.35	6.14	7.76	4.34
	2040 deficit/surplus[a]		−2.07			−1.26			−2.98		
Millet & sorghum	2020	0.72	1.45	1.98	1.36	1.42	1.91	1.33	1.54	1.99	1.46
	2030	0.50	2.08	3.79	1.79	1.95	3.44	1.69	2.36	3.86	2.10
	2040	0.35	3.01	6.98	2.33	2.71	6.00	2.14	3.55	7.16	2.93
	2040 deficit/surplus[a]		−2.66			−2.36			−3.20		
Cassava	2020	1.36	1.75	1.75	1.75	1.69	2.01	1.37	1.84	2.09	1.59
	2030	1.91	2.68	3.46	1.90	2.46	3.17	1.75	3.08	3.52	2.63
	2040	2.68	4.15	5.62	2.67	3.67	3.02	2.07	5.11	3.02	2.07
	2040 deficit/surplus[a]		−1.47			−0.99			−2.43		
Meat	2020	1.25	2.20	2.71	1.59	2.06	2.51	1.52	2.37	2.74	1.92
	2030	1.59	4.86	6.79	2.56	3.93	5.37	2.22	5.88	7.10	4.43
	2040	2.03	12.14	18.66	4.39	8.35	12.47	3.45	16.02	19.84	11.48
	2040 deficit/surplus[a]		−10.12			−6.32			−14.00		
Fish & seafood	2020	1.33	1.82	2.21	1.40	1.76	2.12	1.36	1.91	2.22	1.58
	2030	1.83	2.92	3.84	1.90	2.63	3.44	1.74	3.30	3.94	2.61
	2040	2.52	4.74	6.63	2.65	4.07	5.66	2.31	5.66	6.83	4.38
	2040 deficit/surplus[a]		−2.21			−1.55			−3.14		
			Indices of projected total expenditures under different growth scenarios								
			BAU1			LC1			HC2		
			Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
Dairy products (milk equiv.)	2020	1.24	2.20	2.71	1.52	2.07	2.52	1.46	2.32	2.75	1.76
	2030	1.56	4.54	6.23	2.28	3.75	5.03	2.03	5.20	6.52	3.44
	2040	1.98	9.92	14.69	3.52	7.29	10.55	2.91	11.88	15.58	6.91
	2040 deficit/surplus[a]		−7.94			−5.31			−9.90		
Vegetable oil	2020	0.92	1.65	2.01	1.34	1.60	1.94	1.31	1.72	2.02	1.47
	2030	0.85	2.59	3.57	1.77	2.38	3.24	1.65	2.88	3.64	2.25
	2040	0.77	4.05	6.06	2.36	3.57	5.30	2.12	4.67	6.21	3.38
	2040 deficit/surplus[a]		−3.27			−2.80			−3.90		
Fruits & vegetables	2020	1.18	1.85	2.22	1.41	1.77	2.12	1.37	1.94	2.24	1.59
	2030	1.41	3.05	4.03	1.91	2.73	3.56	1.75	3.43	4.15	2.59
	2040	1.69	5.14	7.28	2.64	4.32	6.06	2.30	6.03	7.55	4.25
	2040 deficit/surplus[a]		−3.44			−2.63			−4.33		

[a] Deficit/surplus expressed as a proportion of 2010 expenditures on the item.

Table 5
Supply parameters used in ECOWAS supply projections.

Domestic supply parameters	Domestic production annual growth rate (%)	SSR (%)	Annual growth rate of total supply (%)
Rice	7.82	51.8	4.05
Millet & sorghum	−3.52	101.6	−3.58
Cassava	3.46	113.4	3.93
Meat	2.66	120.5	3.21
Fish & seafood	3.40	112.2	3.82
Dairy products	4.09	58.2	2.38
Veg. oil	−1.10	79.9	−0.88
Fruits & vegetables	1.81	101.1	1.83

increase to +6.7%/year to eliminate the 2040 deficit. In 2011 the Nigerian government announced an ambitious new Agricultural Transformation Agenda. This aims at, among other things, reversing the declines in sorghum and oil palm production and accelerating growth in other subsectors, such as livestock and cassava (Nigeria Federal Ministry of Agriculture and Rural Development, 2011). To the extent that these plans succeed, the deficits shown in Table 7 should be smaller. The one bright spot in the current projections is for fish, which shows a surplus for 2040 under BAU1 and LC1, but which drops to near zero in the case of more rapid and less urban-biased growth (HC2). As with the previous examples, growth in expenditures is much more rapid in urban areas than rural areas under all scenarios.

Space does not permit us to illustrate the full range of variation of demand patterns across all eight countries for which we have done projections. The impact of income growth on the growth of demand, however, is well illustrated by Ghana (Table 8). This country has had very robust economic growth in recent years, including in certain agricultural subsectors such as rice, cassava and export horticulture. Despite the rapid growth in domestic rice production over the baseline period of 2004–13 (over 11%), the high income-elasticity of demand, rapid income growth and low initial rate of rice self-sufficiency result in substantial projected shortfalls by 2040. In contrast, despite tepid growth in domestic production, the lower income-elasticity of demand for millet and sorghum results in a near balance of projected expenditures and supply under all scenarios. The rapid growth of cassava production relative to expenditures for direct human consumption leads to large projected surpluses in 2040, although these could be reduced by increasing demand for cassava for animal feed and industrial products (e.g. starch, flour and beer). Ghana's strong production performance in horticultural products results in a continuing

Table 6
Indices of projected total expenditures on and supply of selected commodities in ECOWAS outside Nigeria in 2040 (2010 = 1.00).

Commodity	Domestic supply index[b]	Indices of projected total expenditures under different growth scenarios								
		BAU1			LC1			HC2		
		Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
Rice	4.02	5.13	7.13	2.73	4.25	5.86	2.32	6.12	7.49	4.46
2040 surplus[a]		−1.11			−0.23			−2.10		
Millet and sorghum	2.56	3.00	4.47	2.79	2.73	4.25	2.51	3.75	4.58	3.64
2040 surplus[a]		−0.44			−0.17			−1.19		
Cassava	4.68	4.67	6.05	2.92	3.91	5.09	2.41	6.05	6.29	5.75
2040 surplus[a]		0.00			0.77			−1.37		
Meat	2.18	6.65	8.55	3.37	5.13	6.52	2.74	8.26	9.30	6.45
2040 surplus[a]		−4.47			−2.96			−6.08		
Fish & seafood	1.54	4.46	6.45	2.17	3.75	5.33	1.92	5.08	6.76	3.15
2040 surplus[a]		−2.92			−2.21			−3.54		
Dairy products (milk equivalent)	2.33	7.30	10.24	3.13	5.51	7.53	2.63	8.76	11.19	5.31
2040 surplus[a]		−4.97			−3.18			−6.43		
Vegetable oil	2.17	3.60	4.82	2.48	3.16	4.24	2.17	4.33	5.02	3.68
2040 surplus[a]		−1.43			−1.00			−2.16		
Fruits & vegetables	2.74	4.84	6.34	2.71	4.03	5.24	2.31	5.79	6.69	4.50
2040 surplus[a]		−2.10			−1.29			−3.05		

[b]Domestic supply parameters	Rice	Millet & sorghum	Cassava	Meat	Fish & seafood	Dairy products	Veg. oil	Fruits & vegetables
Production annual growth rate (%)	9.88	3.20	5.47	3.12	1.52	4.18	3.29	3.29
SSR (%)	49.8	102.8	99.9	87.4	98.2	70.7	82.1	107.7
Annual growth rate of total supply (%)	4.92	3.30	5.47	2.72	1.49	2.96	2.70	3.54

[a] Surplus expressed as a proportion of 2010 expenditures on the item. Negative values indicate a deficit.

Table 7
Indices of projected total expenditures on and supply of selected commodities in Nigeria in 2040 (2010 = 1.00).

Commodity	Domestic supply index[b]	Indices of projected total expenditures under different growth scenarios								
		BAU1			LC1			HC2		
		Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
Rice	2.13	5.41	7.97	2.73	4.64	6.77	2.41	6.29	8.13	4.36
2040 surplus[a]		−3.28			−2.51			−4.16		
Millet and sorghum	0.08	3.11	9.06	1.92	2.77	7.47	1.82	3.45	9.28	2.28
2040 surplus[a]		−3.04			−2.69			−3.38		
Cassava	2.03	4.00	1.73	1.82	3.62	1.73	1.82	4.81	1.73	1.82
2040 surplus[a]		−1.97			−1.60			−2.79		
Meat	1.62	15.10	25.53	4.82	10.09	16.53	3.75	20.18	27.01	13.45
2040 surplus[a]		−13.47			−8.47			−18.56		
Fish & seafood	6.39	5.05	6.92	3.06	4.40	6.05	2.64	6.22	7.03	5.35
2040 surplus[a]		1.33			1.99			0.17		
Dairy products (milk equivalent)	1.35	12.61	19.43	3.94	9.14	13.79	3.23	15.09	20.29	8.47
2040 surplus[a]		−11.26			−7.79			−13.73		
Vegetable oil	0.42	4.39	6.98	2.33	1.67	1.92	1.48	2.25	2.23	2.27
2040 surplus[a]		−3.97			−1.25			−1.83		
Fruits & vegetables	1.25	5.50	8.38	2.65	4.66	7.00	2.35	6.36	8.57	4.17
2040 surplus[a]		−4.25			−3.42			−5.12		

[b]Domestic supply parameters	Rice	Millet & sorghum	Cassava	Meat	Fish & seafood	Dairy products	Veg. oil	Fruits & vegetables
Production annual growth rate (%)	4.68	−8.38	2.47	1.70	7.33	3.54	−3.75	0.78
SSR (%)	56.4	100.9	100.0	98.9	90.1	29.6	78.7	98.3
Annual growth rate of total supply (%)	2.64	−8.45	2.47	1.68	6.60	1.05	−2.95	0.76

[a] Surplus expressed as a proportion of 2010 expenditures on the item. Negative values indicate a deficit.

Table 8
Indices of projected total expenditures on and supply of selected commodities in Ghana in 2040 (2010 = 1.00).

Commodity	Domestic supply index[b]	Indices of projected total expenditures under different growth scenarios								
		BAU1			LC1			HC2		
		Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
Rice	2.51	7.36	9.94	2.52	5.71	7.60	2.16	8.34	10.52	4.23
2040 surplus[a]		−4.84			−3.19			−5.82		
Millet and sorghum	1.26	1.35	1.72	1.22	1.39	1.90	1.21	1.30	10.52	4.23
2040 surplus[a]		−0.09			−0.13			−0.04		
Cassava	8.36	5.55	6.87	3.56	4.54	5.66	2.84	7.40	7.15	7.78
2040 surplus[a]		2.81			3.82			0.96		
Meat	1.36	7.02	8.79	3.11	5.54	6.89	2.55	8.28	9.26	6.12
2040 surplus[a]		−5.66			−4.18			−6.92		
Fish & seafood	0.78	4.67	6.96	2.05	3.91	5.73	1.83	5.25	7.25	2.95
2040 surplus[a]		−3.89			−3.13			−4.46		
Dairy products (milk equivalent)	1.09	9.07	11.23	1.55	6.83	8.37	1.47	9.70	11.96	1.79
2040 surplus[a]		−7.98			−5.74			−8.60		
Vegetable oil	1.02	2.93	3.57	2.03	2.73	3.37	1.82	3.32	3.60	2.91
2040 surplus[a]		−1.91			−1.71			−2.29		
Fruits & vegetables	6.90	5.10	6.50	2.79	4.26	5.42	2.34	6.11	6.75	5.06
2040 surplus[a]		1.80			2.64			0.78		

[b]Domestic supply parameters	Rice	Millet & sorghum	Cassava	Meat	Fish & seafood	Dairy products	Veg. oil	Fruits & vegetables
Production annual growth rate (%)	11.26	0.79	7.59	1.62	−0.87	1.62	0.13	6.69
SSR (%)	28.7	100.8	100.1	66.5	96.6	19.0	67.7	102.9
Annual growth rate of total supply (%)	3.23	0.80	7.60	1.08	−0.84	0.31	0.08	6.89

[a] Surplus expressed as a proportion of 2010 expenditures on the item. Negative values indicate a deficit.

exportable surplus of fruits and vegetables in 2040, although the actual volumes depend on the pace and pattern of economic growth (cf. LC1 and HC2). Like the other cases examined above, rapid income growth, high income-elasticities of demand, and slow growth of domestic production result in very large projected deficits for meat and dairy products, as well as for vegetable oil. In Ghana, the rapid growth in demand for animal protein is also manifested by a 2040 deficit for fish and seafood equal to between 3.1 and 4.5 times the 2010 level of expenditures (depending on the growth scenario). As with the other cases examined thus far, the growth in expenditures is much faster in urban areas than rural areas due to rapid urbanization and urban income growth.

Analysis of the other countries (not shown here due to space constraints) shows broadly similar patterns, with increasing relative deficits for animal protein products, fruits and vegetables and vegetable oils almost everywhere. But there is substantial variation between countries for individual products, depending on initial production levels, projected rates of income growth, and levels of initial self-sufficiency. Mali, for example, is projected to have a modest exportable surplus of meat products in 2040 unless scenario HC2 prevails (more rapid, less urban-biased growth). Such variations between countries point to the important potential role of regional trade in helping countries cope with shortfalls.

A few words are also warranted about the growing demand for processed and prepared products, for which no supply projections are presented here. Wheat products (e.g. breads and noodles) are a major example. They represent a type of "fast food" which urban (and increasingly rural) consumers pressed for time are increasingly substituting for other staples. Consumption of products derived from wheat (almost all of which is imported) has increased sharply in West Africa since the 1980 (Me-Nsope and Staatz, 2013). The estimated expenditure elasticities of demand for such products (Table 1) exceed unity for many of the sample countries, indicating that demand will continue to rise rapidly as long as per capita incomes continue to increase in the region. Similarly, while expenditure-elasticities of demand for prepared food eaten outside of the home are available for only three of the eight sample countries (Table 1), these elasticities are uniformly high, suggesting a potentially explosive growth in the demand for such products as urbanization and income growth continue. These findings suggest a very strong future demand for post-harvest processing and marketing services in West Africa, a finding consistent with that found for Eastern and Southern Africa by Tschirley et al. (2013, 2015).

5. Conclusions and policy implications

Uncertainties are to be expected with any long-term projections; this study is no exception. The demand and supply projections presented here must be used with caution and can be interpreted as indicating orders of magnitude of relative changes in supply–demand balances rather than point estimates. The projected food deficits shown above may be larger than are likely to occur, because of two reasons. First, some of the increased expenditures will go for increased quality of products rather than quantities, which we have had no data to assess. Second, the projected shortfalls would likely induce higher prices, which would in turn temper demand and induce increased domestic production. The food price forecasts are not covered by the present study.

Nonetheless, the relative patterns (which are generally consistent across the eight countries for which budget-consumption data are available) are strongly suggestive of how supply–demand balances are likely to evolve in the coming years and hence pressures on real prices. Bridging the gap between demand and supply for certain starchy staples (notably rice and wheat) will continue to be a challenge in absolute terms. However, in relative terms the demand for other food groups—most notably meats, dairy products, fish, vegetable oils and fruits and vegetables—will increase

Table A1
GDP per capita growth scenarios used in making expenditure projections (annual growth rates in %).

Scenario	Burkina Faso			Côte d'Ivoire			Ghana			Mali		
BAU1 – urban bias	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural
2011–15	3.99	4.64	2.43	3.9	3.67	1.92	5.59	6.81	3.57	0.11	0.1	0.05
2016–20	4.04	4.84	2.54	4.85	5.82	3.05	4.6	5.52	2.89	2.05	2.45	1.29
2021–25	3.67	4.4	2.31	2.89	3.47	1.82	2.92	3.5	1.84	1.75	2.1	1.1
2026–30	3.67	4.4	2.31	2.89	3.47	1.82	2.92	3.5	1.84	1.75	2.1	1.1
2031–35	3.62	4.34	2.28	3.15	3.78	1.98	3.9	4.68	2.45	1.77	2.12	1.11
2036–40	3.62	4.34	2.28	3.15	3.78	1.98	3.9	4.68	2.45	1.77	2.12	1.11
BAU2 – equitable growth	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural
2010–15	3.99	4.64	2.43	3.9	3.67	1.92	5.59	6.81	3.57	0.11	0.1	0.05
2016–20	4.04	4.04	4.04	4.85	4.85	4.85	4.6	4.6	4.6	2.05	2.05	2.05
2021–25	3.67	3.67	3.67	2.89	2.89	2.89	2.92	2.92	2.92	1.75	1.75	1.75
2026–30	3.67	3.67	3.67	2.89	2.89	2.89	2.92	2.92	2.92	1.75	1.75	1.75
2031–35	3.62	3.62	3.62	3.15	3.15	3.15	3.9	3.9	3.9	1.77	1.77	1.77
2036–40	3.62	3.62	3.62	3.15	3.15	3.15	3.9	3.9	3.9	1.77	1.77	1.77
LC1 – urban bias	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural
2010–15	3.99	4.64	2.43	3.9	3.67	1.92	5.59	6.81	3.57	0.11	0.1	0.05
2016–20	3.04	3.64	1.91	3.85	4.62	2.42	3.6	4.32	2.26	1.05	1.25	0.66
2021–25	2.67	3.2	1.68	1.89	2.27	1.19	1.92	2.3	1.21	0.75	0.9	0.47
2026–30	2.67	3.2	1.68	1.89	2.27	1.19	1.92	2.3	1.21	0.75	0.9	0.47
2031–35	2.62	3.14	1.65	2.15	2.58	1.35	2.9	3.48	1.82	0.77	0.92	0.48
2036–40	2.62	3.14	1.65	2.15	2.58	1.35	2.9	3.48	1.82	0.77	0.92	0.48
LC1 – equitable growth	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural
2010–15	3.99	4.64	2.43	3.9	3.67	1.92	5.59	6.81	3.57	0.11	0.1	0.05
2016–20	3.04	3.04	3.04	3.85	3.85	3.85	3.6	3.6	3.6	1.05	1.05	1.05
2021–25	2.67	2.67	2.67	1.89	1.89	1.89	1.92	1.92	1.92	0.75	0.75	0.75
2026–30	2.67	2.67	2.67	1.89	1.89	1.89	1.92	1.92	1.92	0.75	0.75	0.75
2031–35	2.62	2.62	2.62	2.15	2.15	2.15	2.9	2.9	2.9	0.77	0.77	0.77
2036–40	2.62	2.62	2.62	2.15	2.15	2.15	2.9	2.9	2.9	0.77	0.77	0.77
HC1 – urban bias	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural
2010–15	3.99	4.64	2.43	3.9	3.67	1.92	5.59	6.81	3.57	0.11	0.1	0.05
2016–20	5.04	6.04	3.16	5.85	7.02	3.68	5.6	6.72	3.52	3.05	3.65	1.91
2021–25	4.67	5.6	2.94	3.89	4.67	2.45	3.92	4.7	2.46	2.75	3.3	1.73
2026–30	4.67	5.6	2.94	3.89	4.67	2.45	3.92	4.7	2.46	2.75	3.3	1.73
2031–35	4.62	5.54	2.9	4.15	4.98	2.61	4.9	5.88	3.08	2.77	3.32	1.74
2036–40	4.62	5.54	2.9	4.15	4.98	2.61	4.9	5.88	3.08	2.77	3.32	1.74
HC2 – equitable growth	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural
2010–15	3.99	4.64	2.43	3.9	3.67	1.92	5.59	6.81	3.57	0.11	0.1	0.05
2016–20	5.04	5.04	5.04	5.85	5.85	5.85	5.6	5.6	5.6	3.05	3.05	3.05
2021–25	4.67	4.67	4.67	3.89	3.89	3.89	3.92	3.92	3.92	2.75	2.75	2.75
2026–30	4.67	4.67	4.67	3.89	3.89	3.89	3.92	3.92	3.92	2.75	2.75	2.75
2031–35	4.62	4.62	4.62	4.15	4.15	4.15	4.9	4.9	4.9	2.77	2.77	2.77
2036–40	4.62	4.62	4.62	4.15	4.15	4.15	4.9	4.9	4.9	2.77	2.77	2.77
	Niger			Nigeria			Sénégal			Togo		
BAU1 – urban bias	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural
2011–15	1.87	2.63	1.38	2.86	3.44	1.80	0.82	0.98	0.51	3.11	3.45	1.81
2016–20	3.9	4.68	2.45	4.10	4.92	2.58	2.46	2.95	1.55	3.4	4.08	2.14
2021–25	1.1	1.32	0.69	4.00	4.80	2.51	2.89	3.47	1.82	1.8	2.16	1.13
2026–30	1.1	1.32	0.69	4.00	4.80	2.51	2.89	3.47	1.82	1.8	2.16	1.13
2031–35	1.3	1.56	0.82	4.50	5.40	2.83	3.25	3.9	2.04	2	2.4	1.26
2036–40	1.3	1.56	0.82	4.50	5.40	2.83	3.25	3.9	2.04	2	2.4	1.26
BAU2 – equitable growth	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural
2010–15	1.87	2.63	1.38	2.86	3.44	1.80	0.82	0.98	0.51	3.11	3.45	1.81
2016–20	3.9	3.9	3.9	4.10	4.10	4.10	2.46	2.46	2.46	3.4	3.4	3.4
2021–25	1.1	1.1	1.1	4.00	4.00	4.00	2.89	2.89	2.89	1.8	1.8	1.8
2026–30	1.1	1.1	1.1	4.00	4.00	4.00	2.89	2.89	2.89	1.8	1.8	1.8
2031–35	1.3	1.3	1.3	4.50	4.50	4.50	3.25	3.25	3.25	2	2	2
2036–40	1.3	1.3	1.3	4.50	4.50	4.50	3.25	3.25	3.25	2	2	2
LC1 – urban bias	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural
2010–15	1.87	2.63	1.38	2.86	3.44	1.80	0.82	0.98	0.51	3.11	3.45	1.81
2016–20	2.9	3.48	1.82	3.10	3.72	1.95	1.46	1.75	0.92	2.4	2.88	1.51
2021–25	0.1	0.12	0.06	3.00	3.60	1.89	1.89	2.27	1.19	0.8	0.96	0.5
2026–30	0.1	0.12	0.06	3.00	3.60	1.89	1.89	2.27	1.19	0.8	0.96	0.5
2031–35	0.3	0.36	0.19	3.50	4.20	2.20	2.25	2.7	1.41	1	1.2	0.63
2036–40	0.3	0.36	0.19	3.50	4.20	2.20	2.25	2.7	1.41	1	1.2	0.63
LC1 – equitable growth	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural
2010–15	1.87	2.63	1.38	2.86	3.44	1.80	0.82	0.98	0.51	3.11	3.45	1.81
2016–20	2.9	2.9	2.9	3.10	3.10	3.10	1.46	1.46	1.46	2.4	2.4	2.4
2021–25	0.1	0.1	0.1	3.00	3.00	3.00	1.89	1.89	1.89	0.8	0.8	0.8

Table A1 (*continued*)

Scenario	Burkina Faso			Côte d'Ivoire			Ghana			Mali		
2026–30	0.1	0.1	0.1	3.00	3.00	3.00	1.89	1.89	1.89	0.8	0.8	0.8
2031–35	0.3	0.3	0.3	3.50	3.50	3.50	2.25	2.25	2.25	1	1	1
2036–40	0.3	0.3	0.3	3.50	3.50	3.50	2.25	2.25	2.25	1	1	1
GDP scenarios	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural
2010–15	1.87	2.63	1.38	2.86	3.44	1.80	0.82	0.98	0.51	3.11	3.45	1.81
2016–20	4.9	5.88	3.08	5.10	6.12	3.21	3.46	4.15	2.17	4.4	5.28	2.77
2021–25	2.1	2.52	1.32	5.00	6.00	3.14	3.89	4.67	2.45	2.8	3.36	1.76
2026–30	2.1	2.52	1.32	5.00	6.00	3.14	3.89	4.67	2.45	2.8	3.36	1.76
2031–35	2.3	2.76	1.45	5.50	6.60	3.46	4.25	5.1	2.67	3	3.6	1.89
2036–40	2.3	2.76	1.45	5.50	6.60	3.46	4.25	5.1	2.67	3	3.6	1.89
HC1 – equitable growth	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural	National	Urban	Rural
2010–15	1.87	2.63	1.38	2.86	3.44	1.80	0.82	0.98	0.51	3.11	3.45	1.81
2016–20	4.9	4.9	4.9	5.10	5.10	5.10	3.46	3.46	3.46	4.4	4.4	4.4
2021–25	2.1	2.1	2.1	5.00	5.00	5.00	3.89	3.89	3.89	2.8	2.8	2.8
2026–30	2.1	2.1	2.1	5.00	5.00	5.00	3.89	3.89	3.89	2.8	2.8	2.8
2031–35	2.3	2.3	2.3	5.50	5.50	5.50	4.25	4.25	4.25	3	3	3
2036–40	2.3	2.3	2.3	5.50	5.50	5.50	4.25	4.25	4.25	3	3	3

even faster relative to supply if current trends continue. This suggests that food policy in West Africa, which has historically focused primarily on starchy staples (especially cereals) needs to give greater emphasis in the future to a broader range of commodities and post-harvest services for which demand will be rising rapidly. While cereals demand (particularly for maize as an input into animal feed) will continue to increase, so will the demand for a much larger array of products. Many of these—livestock products, fish, fruits and vegetables—are perishable. They therefore require more sophisticated and tightly coordinated marketing systems and key investments such as cold chains to link West African producers effectively to these growing demands. The good news is that if such systems can be developed, the production, processing and marketing of these products is much more labor-intensive than cereal production, offering new employment opportunities for West Africa's burgeoning labor force. Similar comments apply for the growing demand for processed agricultural products and prepared foods (Hollinger and Staatz, 2015).[11]

Fortunately, as part of a 2015 review of ECOWAP's past performance and plans for its next 10 years, ECOWAS and its stakeholders have recognized the importance of broadening the scope of its initiatives to put greater emphasis on perishables such as animal products and fruits and vegetables, for which demand is increasing rapidly (ECOWAS, 2015). One implication of this reorientation is that greater investment is needed in agricultural research in a range of both staple and non-staple foods. Such research is necessary in order to help reduce unit-costs of production, so that production can be expanded without sharp increases in consumer prices, and to adapt production to changing environmental conditions in the region.

Our analysis also shows that demand will be rising much more rapidly (from two to over four times more quickly) in urban areas than in rural areas, due to a combination of rapid urbanization and more rapid urban income growth. This implies enormous stress on already stressed urban food marketing infrastructure, such as public markets, wholesaling systems and retail shops. While national and regional CAADP investment plans do include components to strengthen agricultural marketing systems, the bulk of the emphasis is at the farmer/first handler level. Improving urban marketing systems—and especially the critical role of improved wholesaling systems to link agroprocessors to reliable local supplies of agricultural raw materials—is relatively neglected (ECOWAS, 2015) This analysis strongly suggests the need for much greater policy attention to these urban marketing components, including investments in marketing infrastructure, cold stores, and reliable electricity supplies, which are crucial for the handling and processing of perishable products. In addition, promotion of a business climate that facilitates contracting arrangements between farmer organizations, wholesalers, agroprocessors and modern retailers that allow the downstream sellers more reliable supplies of raw agricultural materials is essential if the growing demand for more consumer-ready products are to be met by local production rather than imports (Hollinger and Staatz, 2015).

Some of the projected shortfalls, particularly for vegetable oil, reflect falling domestic production of commodities for which West Africa historically had comparative advantage. For example, in the 1960s, Nigeria was the world's largest exporter of palm oil, and Senegal was a major exporter of groundnut oil. The analysis suggests that if production can be revived in these commodities, there will be a strong local market for the output.

As the comparison across the three growth scenarios shows, the magnitude of the demand increases, particularly for the products with high demand elasticities, is very sensitive to the pace and distribution of future income growth. To the extent that ECOWAS countries are successful in stimulating more rapid, inclusive growth, they will face rapidly growing supply–demand imbalances for animal-based foods, fruits and vegetables, vegetable oils and processed and prepared foods.

Finally, as noted above, the variation in supply–demand balances across countries in West Africa emphasizes the important role that regional trade can play in helping ECOWAS countries face these coming challenges. Given widespread projected shortfalls across countries, food imports from outside the region are likely to grow, but policy measures aimed at making ECOWAS's official policy of free trade of agricultural products within West Africa a reality could also be an important component in helping its member states deal with the rapid increases in demand for food they will face in the coming 25 years.

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[11] As Tschirley et al. (2013, 2015) point out for East and Southern Africa, exploiting such employment opportunities will require substantially increased investments in labor-force skills for the post-harvest components of the agrifood system, as well as greater investments in marketing infrastructure.

Appendix A

See Table A1.

Appendix B. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.foodpol.2016.04.002.

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