

## **Hunger and Obesity: the “double burden” of malnutrition in a SIMPLE framework**

Growing per capita incomes in most parts of the world are expected to lead to reductions in the prevalence of undernutrition in the coming decades. However, this same income growth, and the associated changes in diets, are expected to lead to significant increases in the incidence of over nutrition and obesity in many developing countries. Indeed, this is a serious concern, since childhood and adult obesity are a major risk factor on non-communicable diseases, such diabetes, cardiovascular diseases and some types of cancer. Rates of childhood overweight and obesity are increasing in most regions of the world and, for adults, in virtually all regions. In 2016, 41 million children under five years of age were overweight (FAO, 2017 b); furthermore, the global prevalence of obesity among adults more than doubled between 1980 and 2014 (FAO, 2017 b). In 2016 FAO reported the estimation of 3.4 million people that are dying each year due to overweight and obesity (Nutrition Report, 2016). Overnutrition and obesity have a significant impact on economic development by affecting worker productivity (Gates, Succop, Brehm, Gillespie, and Sommers, 2008; Tsai, Ahmed, Wendt, Bhojani, and Donnelly, 2008) and by increasing health care costs (Mokdad, Ford, Bowman, Dietz, Vinicor, Bales, and Marks, 2003; Seidell, 1995; Lehnert, Sonntag, Konnopka, Riedel-Heller, and König, 2013).

The double burden of malnutrition (DBMN) is already present in almost all developing countries and the DBMN ratio (i.e., overweight/underweight) has increased as income per capita has increased (Abdullah, 2015). For example, while stunting (31.2%) and wasting (7.4%) among children remain high in most parts of Africa, obesity rates in that region have steadily increase in recent decades reaching 11.2% of the adult population in 2014 (FAO, 2017 b). Most of the Latin America and Caribbean (LAC) countries are facing a similar situation. While malnourishment and hunger have significantly decreased, obesity and overweight have strongly increased throughout the LAC region. At least half the population of all countries in the region are overweight, with the exception of Haiti where overweight reaches 38.5% of the population, Paraguay with 48.5%, and Nicaragua with 49.4% (FAO, 2017 a). Available food in the LAC appears to be sufficient to ensure food security of its entire population; however, there are some disturbing trends in the nutritional composition of the LAC region’s food supply. On one hand, the sugar availability is higher in LAC than in developed regions and the availability of fats per capita is above the recommended ranges for a healthy diet. On the other hand, fish availability per capita is lower in LAC than in all other

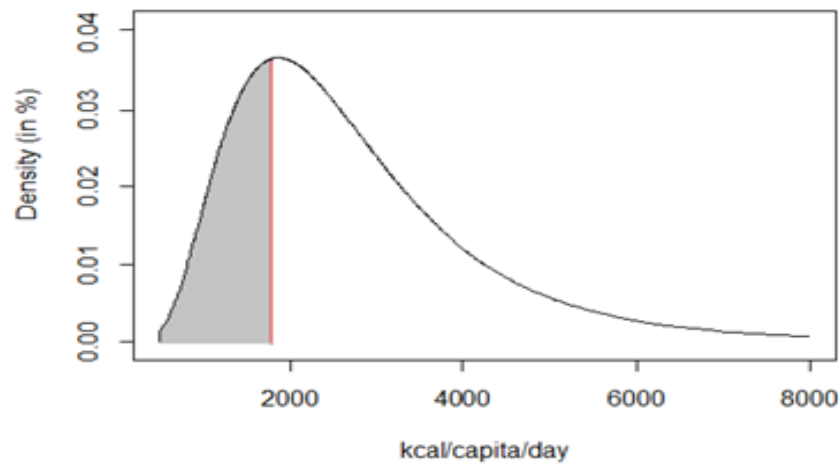
regions of the world. (FAO, 2017 a). In this context, there is a need to better understand the linkages between sources of food supply and evolving incomes and preferences for food consumption. This is of particular interest in developing regions, such as Africa and LAC; where overnutrition and obesity have been sharply risen while a large share of the population still face food insecurity.

This paper aims to shed light on the linkages between the future drivers of the global agriculture and the food system with the overweight and obesity prevalence. The research focuses on developing regions, particularly in the Sub Saharan Africa and LAC, using the Simplified International Model of Prices, Land and Use of the Environment (SIMPLE). SIMPLE is a partial equilibrium model designed to facilitate analysis of the drivers behind the long run supply and demand for food (Baldos and Hertel 2013). This framework has been used in studies related to nutrition outcomes, focusing on undernutrition and has been shown to reproduce broad patterns of change in undernutrition from 1991 onwards (Baldos and Hertel 2014). The food security module in SIMPLE models the full distribution of caloric consumption, determining undernutrition as the portion of the population falling below a critical level of intake. In the current paper, we extend this approach to look at the high end of caloric intake – excess consumption – in order to shed light on future rates of obesity. In doing so we will factor in current estimates of food waste, following the approach recently proposed by the FAO. The research starts by replicating the study of Baldos and Hertel (2014), who examined the impact of agricultural productivity growth and climate change on undernutrition. We extended their analysis by incorporating an excess-nutrition module, allowing us to examine the historical period through this additional lens. We will then seek to predict the future incidence of obesity under alternative scenarios about population, economic growth, agricultural productivity, and climate change. In this extension, we will include estimates for food waste, which are essential to avoid overestimating future calorie consumption.

## **Methodology**

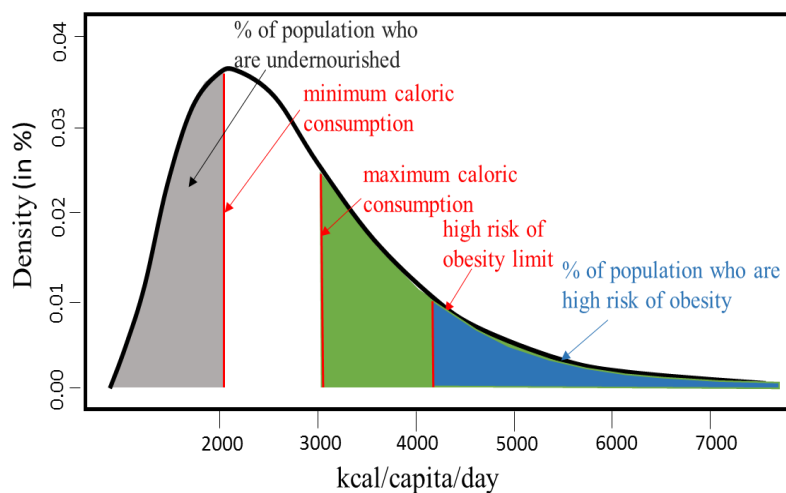
The SIMPLE model is designed to facilitate the analysis of the drivers behind the long run supply and demand for land in agriculture. The extension of the food security module included in the SIMPLE model was developed following FAO's methodology for the measurement of food deprivation (FAO 2008). Under this framework, a lognormal distribution of caloric consumption was assumed as showed in figure 1.

FIGURE 1. Daily caloric intake lognormal distribution.



Given the minimum dietary energy requirement (red line), food security module allows to calculate the malnutrition index (MAL\_INDEX) which is proportion of the population below the MDER line. The MAL\_INDEX quantifies the fraction of population whose daily dietary energy intake is below the minimum requirement for a healthy diet (grey area), and the malnutrition headcount multiplying the malnutrition index by the global/regional total population. The extension of the food security module follows the same framework; in order to quantify overnutrition and I focused in the right side of the caloric intake distribution as described in the figure 2.

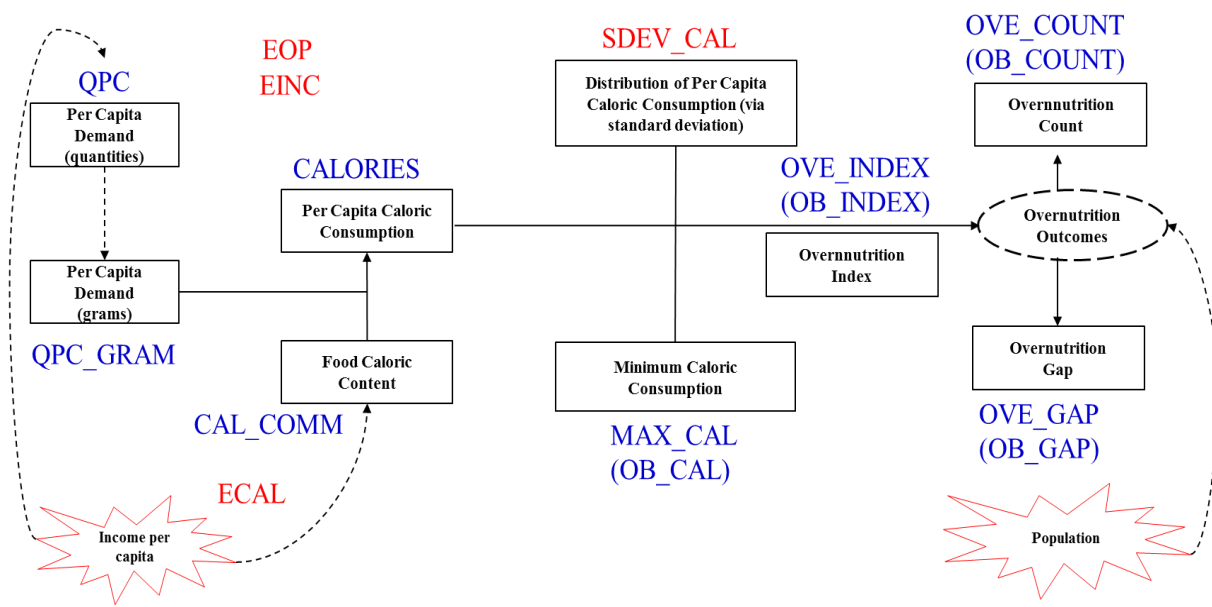
FIGURE 2. Daily caloric intake lognormal “right hand side”.



The **OV\_INDEX**, **OV\_COUNT**, and **OV\_GAP** were developed by concentrating on the right hand side of the integral. Similarly: **OB\_INDEX**, **OB\_COUNT**, and **OB\_GAP**

In order to avoid over estimation of the caloric intake, we controlled for food waste. By extending the food security module included in this version of SIMPLE, we were able to achieve

three primary functions. First, characterizes the distribution of dietary energy consumption (DEC) within each region allowing to calculate the over nutrition index (OV\_INDEX) and the obesity index (OB\_INDEX) which are the percentage of the population whose daily caloric intake is above the maximum caloric intake in order to maintain a Body Mass Index under the overweight and obese limits respectively. Secondly, the methodology allows obtaining the over nutrition and obesity headcounts by multiplying the respective index by the population, as well as the gap indices in each income regions. Finally, given the experiment is based on the food security module on SIMPLE it links the food caloric content to the per capita income as is described in figure 3.

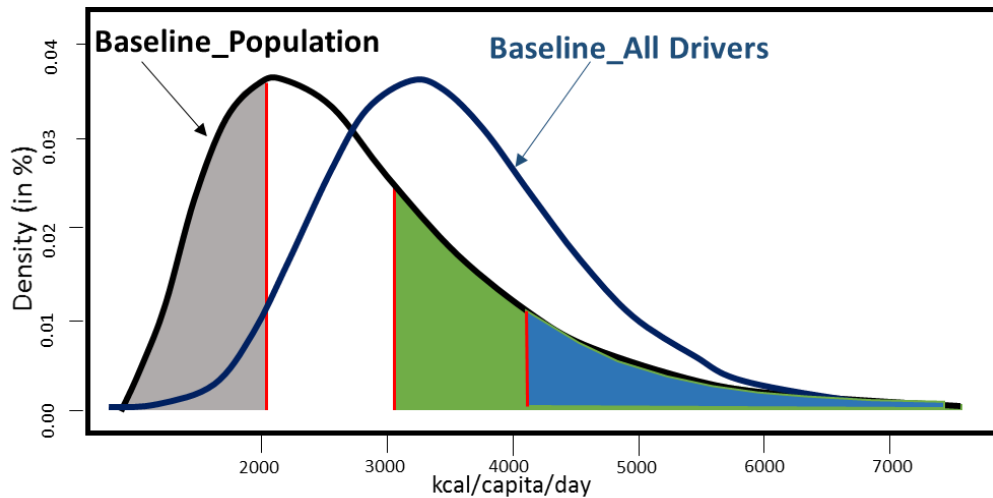


The experiment was designed to capture the impact on overnutrition and obesity prevalence toward 2050 giving the current trends in all major drivers interacting at the same time. This baseline of the model includes shocks on: Regional population and per capita income, based on Shared Socioeconomic Pathways 2 (SSP Database, Version 1); biofuel projections from World

Energy Outlook by the IEA (2008, 2012); and production related shocks on global TFP growth in crop production taken from Ludena et al (2007).

The figure 4 illustrates how changes mean caloric intake was affected, when the Baseline\_All Drivers's shocks were introduced into the SIMPLE partial equilibrium model.

FIGURE 4. Daily caloric intake distribution, Baseline\_Population vs. Baseline All Drivers



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