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# Changes in land requirements for food in the Philippines: A historical analysis

Thomas Kastner*, Sanderine Nonhebel

*Center for Energy and Environmental Studies (IVEM), University of Groningen, Nijenborg 4, 9747 AG, Groningen, The Netherlands*

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ABSTRACT

Land for food production is limited. We investigate how land demand for food develops as populations grow, diets change and agricultural practices become more intensive. The Philippines provide an excellent case: during the 20th century population grew tenfold implying similar increases in basic dietary needs. To quantify occurring changes, we link average dietary patterns to their arable land requirements. For this, we utilize data on population, dietary patterns and crop yields from 1910 to 2003. While average per capita food supply improved during the century, the amount of land required to feed a person declined, albeit not continuous: it was at about 2500 $m^2$ in 1910, at 2000 $m^2$ in 1960, at 1000 $m^2$ in 1985, and did not change greatly since then. Accounting for population growth, this translates to a fourfold increase in total land required for food from 1910 to 2003. When investigating what drove the observed developments at national level, we find that in the first half of 20th century population growth was linked to increased land requirements, before strong increases in yields were enabling constant land requirements for about two decades. Recently, the combined effect of dietary change and population growth led again to increased land requirements for food. Different yield developments in individual crops caused shifts in the relative land requirements of different food items. Our findings suggest that developments in land requirements for food and underlying factors are often non-linear. Caution is warranted when discussing futures of global food supply, based on assumptions of linear or continuous trends.



## Introduction

Land for food production is limited. In general, on large scales, land required for food (LRF) depends on population numbers, average diet, crop yields and prevailing conversion efficiencies within production chains. All these factors show different dynamics over time. Globally, there are large disparities between nations and the major determinants of LRF. In countries with lower income levels, population growth is commonly high, while at increasing income levels changes to more affluent food items become a crucial driver of LRF, possibly overriding population growth in importance (Gerbens-Leenes and Nonhebel, 2002). Crop yields are a result of the interplay of prevailing technologies and land quality and availability.

Insights in how dynamics in population, average diets and yields affect total LRF are essential when discussing future global food supply. In addition, LRF are an important driver of changes in land use and land cover, which represent a major part of global environment change, as they are often linked to biodiversity loss (e.g. Wilcove et al., 1998) and alterations in global carbon stocks and flows (Houghton, 2003). A number of studies exist that establish scenarios for future LRF, based on different assumptions (for instance, Kendall and Pimentel, 1994; Penning de Vries et al., 1997 on global scale; Rounsevell et al., 2005 for Europe). In this paper we look backward and present a historical account of LRF. By doing so, we aim to shed light on how different drivers of LRF change over time. Focusing on a developing nation and on temporal dynamics, this historical study is less detailed than studies that investigate, in depth, one moment in time, often for Western systems (e.g. Gerbens-Leenes et al., 2002). At the same time, it is more detailed than many global outlook studies that often use grain equivalents as proxy for agricultural production (e.g. Penning de Vries et al., 1997). The presented work relates to recent studies on historical trajectories in actual societal land requirements (e.g. Krausmann, 2001; Erb, 2004; Guzmán Casado and González de Molina, 2009; Ferng, 2009; and Neset and Lohm, 2005; Deutsch and Folke, 2005 focused specifically on food).

This study presents an account of LRF for the Philippines, for almost 100 years, from 1910 to 2003. The Philippines were chosen as a case study, because a lot of relevant parameters changed rapidly throughout the past century: Firstly, rapid population growth throughout the last century turned the country from a sparsely (8.2 million, or 28 cap/$km^2$ in 1910) into a densely populated nation (81 million, or 273 cap/$km^2$ in 2003). Secondly, high rates of deforestation during much of the century decreased for-

*Abbreviation:* LRF, arable land requirements for food.

* Corresponding author. Tel.: +31 50 363 7177; fax: +31 50 363 7168.
*E-mail address:* t.kastner@rug.nl (T. Kastner).

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**Table 1**
Developments of population, land use, GDP and crop yields in the Philippines during the 20th century.

| | 1910 | 1930 | 1950 | 1970 | 1985 | 2003 |
|---|---|---|---|---|---|---|
| Population [millions] | 8.2 | 13.1 | 20.3 | 36.6 | 54.3 | 81.2 |
| Population density [capita/km$^2$] | 28 | 44 | 68 | 124 | 182 | 273 |
| Forest land [Mha] | 18.9 | 17.2 | 14.8 | 9.9 | 7.5 | 7.1 |
| Per capita [ha/cap] | 2.30 | 1.31 | 0.73 | 0.27 | 0.14 | 0.09 |
| Arable land planted to crops [Mha] | 2.0 | 3.5 | 4.6 | 7.2 | 8.8 | 8.7 |
| Per capita [ha/cap] | 0.24 | 0.27 | 0.23 | 0.20 | 0.16 | 0.11 |
| GDP per capita [1990 International Geary-Khamis $/cap] | 901 | 1476 | 1070 | 1764 | 1981 | 2511 |
| Share of agriculture in GDP [%] | 38% | 39% | 34% | 28% | 25% | 20% |
| Rice yield [t/ha/harvest] | 0.70 | 1.25 | 1.18 | 1.68 | 2.66 | 3.37 |
| Cropping intensity cereals [harvests/ha/yr] | 118% | 118% | 118% | 147% | 166% | 169% |

*Sources*: Population: http://www.populstat.info/Asia/philippc.htm; FAO (2007); land use: refer to Kastner (2007) for detailed sources and discussion; GDP: Hooley (2005) and The Conference Board and Groningen Growth Development Centre (2007). Yields and cropping intensities: refer to data section below.

est cover, from about 70% of the nation's territory in 1910 to less than 25% in 2003 (Kummer, 1992; Bankoff, 2007). Thirdly, from the 1960s onwards, the nation was one of the centers of the Green Revolution, promoting agricultural intensification through the large scale introduction of high yielding varieties highly responsive to increased external inputs (e.g. Hayami and Kikuchi, 1999). And lastly, average income levels in the nation are rather low, but increasing. With regards to this, the country can be considered representative for a large share of the global population presently at low income levels, aspiring for increases in affluence.

These characteristics make the Philippines an outstanding case for our exercise of investigating long term developments of LRF. With this analysis, we will tackle questions like: What was the contribution of different food items to the overall development of LRF? What role did population growth, dietary change, and increased yields play in the trajectory and how did their relevance change over time? The paper will conclude with some implications of the findings for discussions of future food supply scenarios.

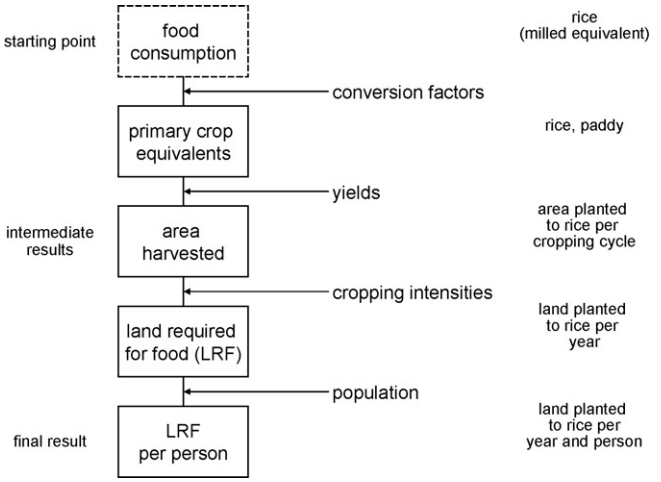


**Fig. 1.** Simplified chart of the calculations flow to link food consumption to land requirements; the right side provides an example for rice; details see text.

## Method and data

### *Linking dietary patterns with crop yield data*

In general, our approach is based on the method described by Gerbens-Leenes et al. (2002), who calculated – in detail – arable land requirements for Dutch food consumption patterns, using data for 1990. They determined land requirements for individual food items, for instance bread and soft drinks, and combined this with household consumption data, i.e. breads and soft drinks per year, to obtain land requirements for food. Compared to their snapshot assessment, the main aim of our study is to analyze long term dynamics. Since detailed data on processed food items and on household consumption in the Philippines were not available for the last century, adaptations to the method of Gerbens-Leenes et al. (2002) were required. The major difference is that this study uses food supply data from FAO Food Balance Sheets as indication of the food consumption; these provide data on wheat instead of bread and on sugar instead of soft drinks.

Fig. 1 shows a basic flow chart of the calculations. Starting point of the approach were the mentioned data on food consumption. As these can refer to processed food items, such as sugar and coconut oil, in a first step, they were converted to primary crop equivalents, such as sugar cane and coconuts. In general, during processing, conversion losses occur and rest streams are created. The latter are deliberately excluded by the used conversion factors, as they serve other valuable functions such as feed and fuel use (see below). Processing losses were not considered as no information on their development over time exists.[1] The calculated crop equivalents were then linked to area requirements through yield data. Yield data refer to production per area harvested. In the Philippines, as in tropical countries in general, it is common to grow more than one crop per year on the same land. Factors on cropping intensities were utilized to arrive at values for land required for food for a given year. In a last step, these total national LRF were divided by population numbers to obtain our final result, a time series of land required to sustain the prevailing average diet.

As the study of Gerbens-Leenes et al. (2002), our research is limited to arable land. This land resource is of crucial value when it comes to providing food for the largest share of the world's population. According to the FAO food balance sheets, in 2003 at least 91% of global food supply originated from arable land; for the Philippines this number was 96%.[2] In addition, in the Philippine setting grasslands cannot be considered to be intensively managed

[1] For the Philippines, the FAOSTAT (FAO, 2007) uses rather crude estimates on waste, applying constant factors, ranging from about 1% to 5% of production, depending on the crop.

[2] These numbers were calculated by subtracting products that originate potentially from other land uses, i.e. ruminant meat, milk and milk products, and aquatic products, from total food supply. With regard to protein supply, other sources play a more pronounced role. In the Philippines about 20% originated potentially from aquatic sources and 5% potentially from grassland throughout time. This leaves still about three quarters clearly from cropland sources, which also is a potential source of feed for aquaculture and ruminants.