Environmental Implications of Household Food Consumption in Mexico

(Extended Abstract)

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Agriculture feeds human society and requires large areas of productive lands and freshwater, it has been responsible for biomass appropriation, alteration of the global nitrogen and phosphorus cycles and makes a significant contribution to energy use and greenhouse gas emissions (Kastner et al. 2012, p.6868). In Mexico, it is estimated that 80% of annual deforestation is due to agriculture activities, and almost 46% of wildfires are associated with agricultural cleanings.

Across the world, expansion of agricultural land has been linked to population growth, production systems, and consumption patterns (Kastner et al. 2012, Ramankutty and Foley, 1998). Technological innovation and the expansion of industrial agriculture contributed to the expansion of productive land, but have also off-set population increments by augmenting land productivity (Ramankutty et al. 2008). In recent decades, however, dietary changes are becoming the main factor explaining the expansion of croplands, beyond population growth itself (Kastner et al. 2012, p. 6871)

Economic and demographic changes have transformed households' dietary needs and food preferences in Mexico in recent decades. Aggregated data shows that modern foods are gaining terrain in national consumption, as it has happened in other transitional economies characterized by greater per capita income, higher education, and increasing female labor force participation (Drewnowski et al., 1997). Foods like meat, beverages, oils and sugars are becoming more frequent in the Mexican diet (Barquera et al., 2003), but these foods are also more demanding of productive land and, therefore, have a higher environmental impact (Gerbens-Leenes et al., 2002; Zhen et al., 2010). In contrast, traditional foods like grains and vegetables, which have a lesser land demand, are losing prominence on the average household consumption.

Mexican households, however, exhibit strong heterogeneity in terms of socio-demographic characteristics such as income, household size, education level, female labor force participation, and age structure. Such dissimilarities are likely to give rise to distinct food consumption patterns as a result of different intake needs, as well as household preferences associated to their lifecycle stage, cultural heritage, taste, time and budgetary constraints. In this paper we examine how these multiple characteristics underlay the level and composition of household food intake. We use latent class analysis to identify consumption profiles based on quantities of food consumed, income and demographic characteristics. A second goal is to assess the environmental impact of each food consumption profile. To estimate it we implement a methodology developed by Gerbens-Leenes et al. (2002) that calculates productive land requirements for every food item consumed by the household. The methodology allows us to compare the environmental impacts across dietary patterns.

Food Consumption Profiles

To better approximate the environmental impact of household food consumption, we need a methodological approach that captures the commodity production as well as the demand for food. To that end, we first estimate the land requirements of each food item consumes by the household, we adapt to the Mexican case the methodology developed by Gerbens-Leenes et al. (2002) for the Netherlands. Second, using latent class analysis we categorize consumption patterns considering income and demographic household attributes in order to identify those profiles with higher environmental impacts.

The land productive requirement methodology

We adapted Gerbens-Leenes et al. (2002) approach to the Mexican case. We estimate the land requirements of the main 33 food items in the Mexican diet, as shown in the 2008 Household Income and Expenditure Survey (HIES). Briefly stated, the methodology estimates the land required to produce each food item consumed by the households. We start by estimating the amounts needed for plant-based products and then we move to estimate animal-based and processed foods, which used primary products as inputs. To estimate such land requirements we obtain the consumed quantities of each food item based on household survey data. From economic and secondary sources we estimate cropland and pasture yields, in order to know how much land is required to produce each commodity. National estimates are adjusted by trade balance product (production + imports - exports)[1]. The final calculation is express in squared meters by kilograms, which represent the quantity of land used by the agro-food system to produce the household diet.

Table 1 presents the results, aggregating the 33 items into seven large groups. The first column shows groups' weight in the average household intake base on 2008 HIES data. Grains (corn, beans, wheat, and rice) are the most import food group, representing 36% of household average intake; follow by meat (cattle, pigs and poultry) and dairy products (milk, cheese, and yogurt) with around 17% each. Less important are oils and fats, sugar and fruits. If we consider land requirements, the groups' ranking looks different. Meat products are clearly the most land-demanding group, with an average of 25.56 square meters for every kilogram produced. This a fairly large number compare to the Netherlands (Gerbens-Leenes et al., 2002) and China (Zhen et al., 2010), as a result of extensive livestock production in Mexico. Our estimations show that dairy, oils and fats also demand large amounts of land, while vegetables, fruits and sugar have the smallest demand. The grain land requirements in Mexico are similar to findings in China and just slightly greater than in the Dutch case, partly due to different national productivity in primary production (Gerbens-Leenes et al., 2002, Zhen et al., 2010).

Table 1: Land requirement by food groups

Consumption Patterns

A second section of the paper looks to identify food consumption patterns across Mexican households using latent class models. Household diets reflect differences on members' physiological needs, but also food preferences associated to cultural heritage, ways to organize food provision, time availability, and taste. While we cannot directly observe these dimensions, the covariation between food items quantities, and income and demographic indicators can capture such underlying traits. A latent class model is particularly useful to test hypothesis about unobserved variables that are measured by observed indicators (Rindskopf, 2009). Latent

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[1] The main sources used in this calculation are the 2008 Household Income and Expenditure Survey (HIES), the Agri-food Information System (AISC), the Tariff Information System (TIS), the FAOSTAT website, the Technical Advisory Committee of Rangelands Coefficients (TACRC), and the National Institute of Medical and Nutritional Science (NIMS).

Class model assumes that the latent variable is categorical and the unconditional independence of the observed variables, and it is possible to allocate each observation to one class (Madigson y Vermunt, 2004).

In addition the diet composition, we focus on three variables: a) income; b) family structure and lifecycle, and c) area of residence. Previous studies suggest that income is a strong indicator not only of budgetary constraints, but also taste for a diverse and modern diet in transitional societies; while life-cycle and family structure could speak not only about calorie intakes but also time availability and organizational practices. Area of residence is introduced in the model as a rural/urban dummy and a region variable; they account not only for climate and food availability differences, but also for cultural dietary traditions.

Goodness-of-fit measures point to the presence of 8 distinct consumption profiles, each accounts for unique dietary patterns and socio-demographic characteristics (see table 2). Due to space restrictions, here we only describe patterns 1(**P1**) and 8 (**P8**) in order to illustrate models' results. P1 contains 26% of the households, this pattern is characterized by a traditional diet with high consumption of grains, small meat intake, and limited variety. This pattern is expressed by a 2.9 ration grain to meat, and a variance of 0.67. In contrast, only 1% of the households belongs to P8, it has the largest average food intakes among all patterns, with large proportions of modern foods, particularly meat and beverages, and its composition is highly diverse.

Using the land requirements estimates for each household in the sample, we can observe that each profile translates into distinct environmental implications: while P1 has an average land demand of 1,965 squared meters, P8 requires 5,838 m^2 annually. The smaller volumes of foods consumed by households' members of P1, but also a more traditional diet imply a smaller demand for land. P8 is an omnivorous group, with a large environmental impact. How class membership relates to socio-demographic indicators?

Table 2: Characteristics of food consumption patterns

We present here only preliminary results, we are working in refining our socio-demographic variables in order to will improve our models and analysis. Preliminary results show that low-income households have a high probability of P1 membership and almost null probability of P8 one (Table 3). In contrast, the probability of P8 membership increases with income. The presence of children, teenagers and elderly adults –as indicators of family composition and lifecycle- are less clearly associated to class membership probabilities. P1 households have a higher probability of not having teenagers or elderly than having them, but the pattern for P8 is even less evident. P1 households have a slightly larger probability of being of larger size, while P8 side into the smaller households. Regional differences are apparent, Northern and Southern residence is associated with a higher probability of P1 membership, reflecting more traditional diets than in the central part of Mexico. For pattern 8, regions do not imply large probability differences suggesting an exclusive food pattern equally distributed across Mexico. Also, P1 households have a noticeable higher probability of being rural, but P8 seems to be equally present in urban and rural settings.

Table 3 Conditional probabilities of class membership

Tables and references

Table 1: Land requirement by food groups

Food groups	Relevance in total food intake (%)	Average land requirements (m^2/kg)
Grains	36	3.02
Vegetables	10	0.48
Fruits	6	0.69
Meat	17	25.56
Dairy products	18	17.18
Oils & fats	1	12.83
Sugar	1	0.15
Beverages	11	4.47

Source: Authors' estimates.

Table 2: Characteristics of food consumption patterns

	P1	P2	P3	P4	P5	P6	P7	P8
Proportion of households	26%	23%	16%	15%	7%	6%	6%	1%
Average food intake (Kilograms)	295	311	350	224	700	358	311	795
Average Land requirements (m2)	1,965	2,279	2,598	1,458	5,524	2,696	1,982	5,838
Grains/Meat	2.9	2.3	1.78	3.09	1.08	1.87	2.81	1.94
Diet variety	0.67	0.79	0.85	0.45	0.91	0.94	0.91	1

Source: Authors' estimates.

Table 3 Conditional probabilities of class membership

	Income level.			Household size					Region of residence			Gender of household head	
	Low	Medium	High	1	2	3-4	5-7	7+	North	Central	South	Male	Female
P1	0.36	0.25	0.17	0.24	0.28	0.25	0.27	0.30	0.31	0.18	0.38	0.26	0.26
P8	0.01	0.01	0.03	0.05	0.03	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01

	Female occupational status			Children presence		Adolescence presence		Elderly presence		Residence	
	Out of labor force	At least one employed	All employed	Yes	No	Yes	No	Yes	No	Urban	Rural
P1	0.28	0.24	0.25	0.26	0.26	0.26	0.27	0.25	0.29	0.21	0.36
P8	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.01	0.01

Source: Authors' estimates.

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