Supplementary Materials: How Much Time Does a Farmer Spend to Produce My food? An International Comparison of the Impact of Diets and Mechanization

María José Ibarrola-Rivas, Thomas Kastner and Sanderine Nonhebel

Sensitivity Analysis to Validate the Calculations of the Farm Labour for Food

Our results show that the type of production system has a strong impact on the farm labour for food (Figure 2). These results are based on the selection of two extremely different production systems regarding mechanization and livestock farm scale, and on several assumptions. Production systems vary widely throughout the world, so it is questionable whether our results would have a different outcome by choosing different assumptions. In this section, we investigate whether the choice of different mechanized or non-mechanized systems, and the choice of different assumptions can lead to a different discussion. Table S1 show the results of the farm labour for food by changing the variables of the production systems. The first row shows the results with the assumption chosen in this paper (Figure 2), the following rows show the deviation of these results by choosing a different assumption indicated in the first column. First, we discuss the assumptions for the crop field systems of the vegetable food products in the diet; then, we discuss the assumptions for the feed of the animal food products; finally, we discuss the assumption for the livestock production systems.

The vegetable food products in the diet include 75 food items which were grouped into seven food categories. We have chosen one production system for each food category assuming that only one crop represents each food category. For example, the consumption of cereals includes wheat, maize, rice, and other cereals, and we assumed that the cereals consumption is only wheat. As a result, the combination of the crop yield (kg/ha) and the crop field labour (hrs/ha) of the wheat production system represents all of the cereals production systems. In reality, each food item has different values of crop yields and labour per hectare. For example, according with Pimentel [1,2], mechanized systems in the USA of maize, wheat, and rice have crop yields of 8.7 ton/ha, 2.7 ton/ha and 7.4 ton/ha, respectively, and values of agricultural labour of 11.4 hrs/ha, 7.8 hrs/ha and 24 hrs/ha, respectively. As a result, the labour per kilogram of cereal would be 1.3 hrs/kg if we assume the consumption is only maize, and 3.3 hrs/kg if we assume the consumption is only rice, instead of 2.9 hrs/kg, which is the value of wheat that we used in this paper. Similar variations exist for non-mechanized systems for crops within the same food category [3]. In addition, crop yields vary among years and countries [4] because of climate, geographical conditions, and management practices. Due to all these differences, we evaluated the impact of, first, increasing the crop yields two times and reducing the hours of labour per hectare 1.5 times (row 2), and, second, reducing the crop yields two times and increasing the hours of labour per hectare 1.5 times (row 3). Higher crop yields and lower labour per hectare results in a reduction of the total farm labour for food by 50% for basic diets and 20%–30% for affluent diets (row 2). Lower crop yields and higher labour per hectare increases the farm labour for food by around two times for both basic and affluent diets (row 3).

The feed for livestock is usually a mixture of crops and is different for each livestock animal. We have assumed that only one crop is used as feed for all livestock animals. We chose maize since it is the most common crop, globally, used as animal feed [4]. For the same reasons of diversity of crop systems mentioned above for the vegetable products, rows 4 and 5 of Table 5 show the impact of different values of crop yields and crop field labour of the feed crop. Higher crop yields and lower labour per hectare in mechanized systems result in a reduction of the total farm labour for food by 10% for basic diets and by 20% for affluent diets (row 4). Lower crop yields and higher labour per hectare in this same system increase the farm labour for food by five times for basic diets and two times for affluent diets (row 3). The other assumption for the animal feed is the conversion efficiency factor for livestock products (Table 2). We have chosen the average global values of industrial production systems for each livestock product given by Mekonnen and Hoekstra [5]. However, this efficiency factor is different among livestock animals, type of production system and regions [5,6]. Rows 7 and 8 of Table S1 shows that for mechanized systems, the farm labour for food reduces by around 10% by halving the global conversion efficiency factors for livestock products, and it increases 15% for basic diets and 30% for affluent diets by doubling the factors. The non-mechanized systems are not relevantly influenced by the feed assumption because most of the labour for the feed of the livestock is included in the farm labour (see Section 2).

The livestock production systems also widely vary around the world. Especially for the small-scale systems, the labour requirement is not widely documented and only a limited number of case studies exist evaluating in detail the labour involved in these systems. Additionally, it is difficult to label whether a system is a small scale system since it could depend on the context or reference. For example, a livestock producer is considered to be a "smallholder" if they have only one head of cattle or as many as 50 heads [7]. In addition, the lifespan of the animals is different around the world. In general, in industrial countries it is shorter and in developing countries it is larger resulting in a higher productivity in the former than in the latter [4]. We have analysed the impact of changing the main variables of the production systems: the number of animals per farmer by 1.5 times (rows 8 and 9), lifespan of the livestock animals for meat production by 1.5 times (rows 10 and 11), the amount of food produced per animal by 1.5 times (rows 12 and 13), and the hours of labour per day for managing the small-scale chicken and pig systems by two times (rows 14 and 15). Table S1 shows that the total farm labour for food only changes by 10% to 20% by changing the assumptions and variables described above for the livestock management labour.

To conclude, this sensitivity analysis shows that even by strongly changing the variables of the production systems in accordance with global differences in mechanized and non-mechanized production systems, the order of magnitude of the farm labour for food of the four scenarios is still as strong as shown in Figure 2. Thus, the general discussion led by our results is valid.

Table S1. Impact of the assumptions of the production systems chosen for this paper.

	Assumptions	Mechanized Systems								Non-Mechanized Systems							
		Basic Diet				Affluent Diet				Basic Diet				Affluent Diet			
		Veg Prod	Feed	Arm	Total	Veg Prod	Feed	Arm	Total	Veg Prod	Feed	Arm	Total	Veg Prod	Feed	Arm	Total
		(h/cap)	(h/cap)	(h/cap)	(h/cap)	(h/cap)	(h/cap)	(h/cap)	(h/cap)	(h/cap)	(h/cap)	(h/cap)	(h/cap)	(h/cap)	(h/cap)	(h/cap)	(h/cap)
1	Data and results of this paper	1.3	0.3		**1.9**	1.6	1.2	1.9	**4.7**	290	10.42	68	**369**	246	34.30	608	**888**
2	Crops more efficient: +100% crop yields & −50% hrs/ha	0.4	0.3	0.3	**1.0**	0.5	1.2	1.9	**3.7**	97	10.42	68	**176**	82	34.30	608	**724**
3	Crops less efficient: −100% crop yields and +50% hrs/ha	4.0	0.3	0.3	**4.6**	4.9	1.2	1.9	**8.0**	871	10.42	68	**950**	737	34.30	608	**1379**
4	Feed: Crops more efficient: +100% crop yields and −50% hrs/ha	1.3	0.1	0.3	**1.7**	1.6	0.4	1.9	**4.0**	290	3.47	68	**362**	246	11.43	608	**865**
5	Feed: Crops less efficient: −100% crop yields and +50% hrs/ha	1.3	0.8	0.3	**2.4**	1.6	3.5	1.9	**7.1**	290	31.25	68	**390**	246	102.90	608	**956**
6	Feed: feed-food efficiency lower −100%	1.3	0.1	0.3	**1.8**	1.6	0.6	1.9	**4.1**	290	5.21	68	**364**	246	17.15	608	**871**
7	Feed: feed-food efficiency higher: +100%	1.3	0.5	0.3	**2.2**	1.6	2.3	1.9	**5.9**	290	20.83	68	**380**	246	68.60	608	**922**
8	Farm: +50% more animals/farmer	1.3	0.3	0.2	**1.8**	1.6	1.2	1.3	**4.1**	290	10.42	46	**346**	246	34.30	405	**685**
9	Farm: −50% more animals/farmer	1.3	0.3	0.5	**2.1**	1.6	1.2	2.9	**5.7**	290	10.42	103	**403**	246	34.30	911	**1191**
10	Farm: +50% lifespam meat animals, milk constant	1.3	0.3	0.2	**1.8**	1.6	1.2	1.7	**4.5**	290	10.42	55	**356**	246	34.30	555	**835**
11	Farm: −50% lifespam meat animals, milk constant	1.3	0.3	0.4	**2.0**	1.6	1.2	2.3	**5.1**	290	10.42	89	**390**	246	34.30	687	**967**
12	Farm: +50% kg of meat/animal and kg milk/cow	1.3	0.3	0.2	**1.8**	1.6	1.2	1.3	**4.1**	290	10.42	46	**346**	246	34.30	405	**685**
13	Farm: −50% kg of meat/animal and kg milk/cow	1.3	0.3	0.5	**2.1**	1.6	1.2	2.9	**5.7**	290	10.42	103	**403**	246	34.30	911	**1191**
14	Farm: mechanized:all constant; non mechanized: chicken&pig −100% hrs/day, beef & milk constant	1.3	0.3	0.3	**1.9**	1.6	1.2	1.9	**4.7**	290	10.42	50	**351**	246	34.30	511	**791**
15	Farm: mechanized:all constant; non mechanized: chickenandpig +100% hrs/day, beef&milk constant	1.3	0.3	0.3	**1.9**	1.6	1.2	1.9	**4.7**	290	10.42	104	**405**	246	34.30	801	**1081**

Reference

1. Pimentel, D.; Pimentel, M.H. *Food, Energy and Society*; CRC Press: Boca Raton, FL, USA, 2008.
2. Pimentel, D. Energy inputs in food crop production in developing and developed nations. *Energies* **2009**, *2*, 1–24.
3. Tripathi, R.; Sah, V. Material and energy flows in high-hill, mid-hill and valley farming systems of Garhwal Himalaya. *Agric. Ecosyst. Environ.* **2001**, *86*, 75–91.
4. Food and Agriculture Organization of the United Nations (FAO). *FAOSTAT Statistical Database*; FAO: Rome, Italy, 2013.
5. Mekonnen, M.M.; Hoekstra, A.Y. A global assessment of the water footprint of farm animal products. *Ecosystems* **2012**, *15*, 401–415.
6. Elferink, E.V.; Nonhebel, S. Variations in land requirements for meat production. *J. Clean. Prod.* **2007**, *15*, 1778–1786.
7. Siegmund-Schultze, M.; Rischkowsky, B.; da Veiga, J.B.; King, J.M. Cattle are cash generating assets for mixed smallholder farms in the eastern amazon. *Agric. Syst.* **2007**, *94*, 738–749.