Policy Briefings

BASQUE CENTRE FOR CLIMATE CHANGE
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EFFECTS OF INTERNATIONAL TRADE OF FOOD AND FEED AND HUMAN DIET SHIFTS ON FOOD SECURITY AND ENVIRONMENTAL SAFETY: INTEGRATING SCALES

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The global biogeochemical cycle of nitrogen (N) has been deeply altered causing profound effects on biological biodiversity, water, atmosphere and soil environments and leading to an increase in the emission of GHGs. Agricultural activities are responsible for the direct introduction to the ecosystems of more than 85% of the anthropogenic reactive nitrogen (Nr) (Billen *et al.* 2013). This emission is unevenly distributed throughout the world and the negative consequences are observed form the local to the global scale (Billen *et al.* op. cit.).

How to feed an increasing world population while reducing the environmental damage at the same time is currently one of the most important challenges for society. The characteristics of agricultural systems are major drivers of emissions of reactive N to the environment at the farm level. Producing more with less (i.e. Increasing the nitrogen use efficiency of the systems) is a key point.

However, to properly understand this problem it is also important to observe the global agro-food system, its main drivers, leaks and bottlenecks. Other factors such as the increase of animal protein in the human diet, the international trade of food and feed and the high rates of food waste are significant drivers in the availability of food, the self-sufficiency of the countries and the sustainability of the production system. In this policy briefing we synthesize some of the recent scientific contributions to the study of all these drivers at the global scale and regionally with particular emphasis on the social and policy dimensions.

Key Points

- *International trade of food and feed (expressed as protein content) has increased eightfold during the last 50 years. Nowadays a small number of countries are feeding the rest of the world. Population growth but also a change to higher animal-protein diets are important drivers of the observed changes.*
- *The increasing disconnection between crops (land) and livestock is producing a decrease in nutrient use efficiency at the global scale and a rise in pollution issues.*
- *In Spain, a transition from the so-called Mediterranean diet to a diet with very high share of animal protein that is similar to North American and North European diets, that are much unhealthier, is the main driver of a dramatic increase in the nitrogen (N) pollution. The huge production of animal products is fuelled by feed imports that today equal national crop production.*
- *Despite Spain produces commodities for export, the net balance of N_2O emissions of the agricultural system in 2009 indicated that the emissions associated to the production of imported food and feed are higher. A large part of the net N_2O emissions associated with imported agricultural commodities is coming from non-Annex B countries and therefore substantial emission leakage is occurring.*
- *Making the most sustainable use of crop by-products is not necessarily incentivised by policies on agricultural commodity markets, which may have a remarkable and undesired effect on the carbon footprint of livestock products (e.g. milk).*
- *Localization of vegetal and animal production, the reduction of food waste, as well as control of diet, are key factors for world food security and environmental safety*
- *Less intensive farming could be viable if nutrient losses along the food chain are sharply decreased and human diet shifts are also occurring. Linking appropriately policies that deal with food, agriculture, waste, health, climate change, biodiversity and energy are needed to effectively reduce greenhouse gas (GHG) emissions globally.*

Effects of trade, diet and food waste on the global N cycle alteration

Worldwide external dependence on agricultural products has remarkably changed during the last 50 years. During this period the internationally traded amount of food and feed (expressed as protein or nitrogen content[1]) has increased eightfold (Lassaletta *et al.* 2013a). Nowadays, the world is divided into a small group of countries called "net exporters" that are feeding the rest of the countries considered as "net importers". A large share of the global crop production is now internationally traded and used for feeding animals. Soybean products, which are among the main causes of deforestation in South America, represent about half of the exported commodities (Lassaletta *et al.* 2013a).

1. We assume that nitrogen constitutes 16 % of proteins

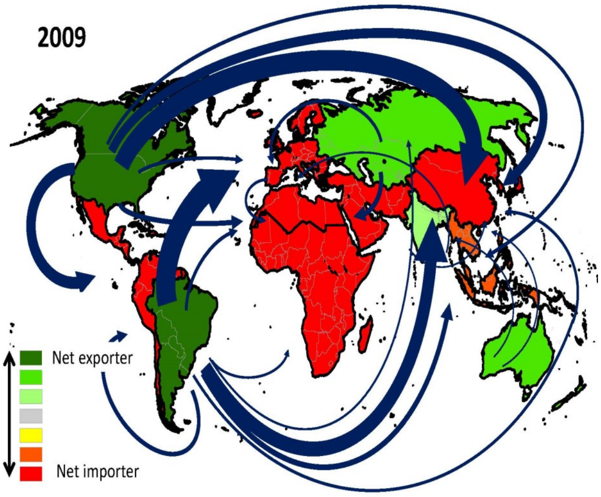

Figure 1: Food and feed traded in the form of protein between 12 world large regions in 2009. Modified from Lassaletta *et al.* (2013a)

Lassaletta *et al.* (2013a), grouping countries into 12 large regions, found that in many of these regions the “net nitrogen importer” or “net nitrogen exporter” character has been exacerbated during the last 50 years (Fig. 1). For example Central & South West America now depends 85% on external N inputs and China has moved from being a net exporter country to depend 22% on international N imports. The 26% of external dependence of Europe has remained almost constant during the last 25 years. The reasons of the observed trends are different for each region. For example, in the case of Maghreb and Middle East countries, the increase in crop production (44%) in the last 50 years has not been enough to offset the increasing demand for food due to a 66% population growth. The case of China is different and the main driver is the rise of the share of animal protein in the human diet (123%).

Human diet, waste along the food chain and biofuels production are amongst the key drivers for an inefficient global agro-food system. Despite 870 million people according to FAO (2013) are still hungry, 2/3 of the food calories go to feed animals (1/3) or are lost (1/3). Moreover, the proportion of animal protein in human diet is unequally distributed in the world (Fig.2). The huge quantity of food wasted every year has also an impact on the global N cycle (Grizzetti *et al.* 2013). The impact of this wasted food is not only associated with the final product (waste at consumption level) but particularly with the N utilised in the production of any commodity that has been previously emitted to the environment (called “virtual nitrogen”[2]). The proportion of nitrogen wasted (real or virtual) is higher for EU-27 countries than for the world average. Regarding climate change, 20% of the reactive N that is produced out of the total food wasted in Europe is emitted to the air as nitrous oxide (N_2O).

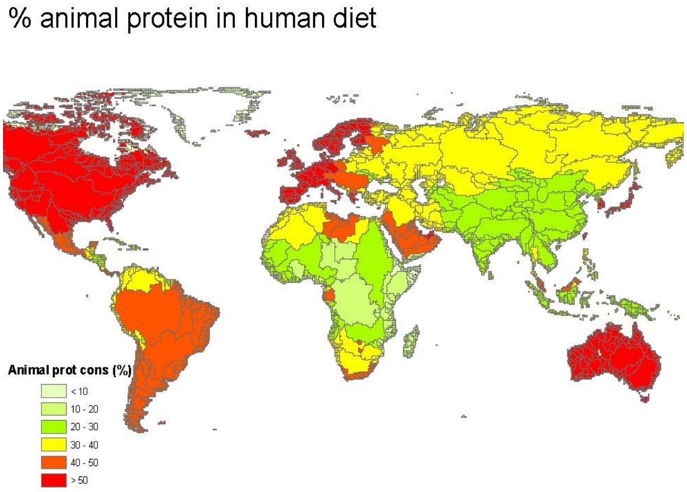

Figure 2: Fraction of animal protein in the total protein intake (Data ++GobalNEWS and FAOstat; Billen *et al.* 2013)

The case of Spain

In Spain, the agro-food system has been deeply transformed during the last five decades (Lassaletta *et al.,* 2013b). In the 1960s Spain was close to being self-sufficient in food and feed and nowadays the amount of net-protein[3] that enters Spain embedded in traded commodities has increased 13-fold. Nowadays Spain needs to net import an amount of food and feed equivalent to the national agricultural production to maintain the current demands of its agro-food system (Fig. 3). A shift from the so-called Mediterranean diet (30-35% of animal protein) to an animal-protein-rich diet similar to the North European and American diets (64% animal protein) is the main driver of such changes. Indeed almost 90% of the current imports are destined to feeding livestock. All these changes in the agro-food system has produced an intensification of the N cycle at the national scale and the amount of reactive nitrogen entering the country every year has increased threefold since 1961. Due to the high rate of nitrogen retention that characterizes the Mediterranean landscapes, the new N is hardly exported to the sea and a large part remains inside the country polluting the air and continental

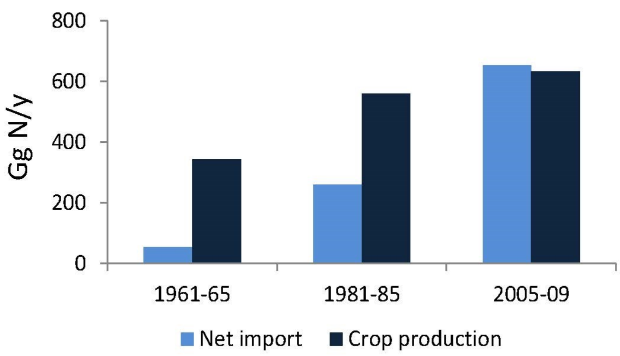

Figure 3: Evolution of crop production of Spanish agriculture and net -import expressed as N content. (Modified from Lassaletta *et al,* 2013b)

2. Virtual nitrogen is any nitrogen that was used in the food production process and is not in the food product that is consumed. (Leach et al. 2012: Environ.Develop.1)
3 We estimate net imports by subtracting yearly total exports to total imports all of them expressed as protein (or nitrogen)

waters (Lassaletta *et al.,* 2013b). These dynamics have also affected N_2O and CO_2 emissions from land use change that are associated with the Spanish agricultural sector. The amount of N_2O associated with the production of imported commodities is significantly larger than the one associated with the agricultural commodities for export produced in Spain (Lassaletta *et al*., under review). Thus, the N_2O emissions associated with the Spanish agro-food system (including consumption) are 36% higher than those coming from the Spanish agricultural production. Much of these emissions are produced in non-Annex B countries and consequently, emissions leakage[4] is being produced in Spain. The EU Common Agricultural Policy (CAP) has been blamed for distorting global agricultural markets. For example, Khatun (2012) points at the absence of tariffs for animal feed as a key driver for fueling EU cheap imports of animal feed from Latin America and consequently, for the effect on land use, land use change, and forestry (LULUCF) outside of the EU and, thereby preventing a huge potential for mitigating climate change by reducing emissions from deforestation and forest degradation (e.g., through REDD+ programmes).

The farm

One consequence of farms' disconnection with land, as found by Del Prado *et al.* (2013) in a recent study using life cycle analysis (LCA) and farm modelling for Basque dairy farms, is the lack of relationship between total GHG emissions and farm forage land area. Moreover, farms imported most of their nutrients as feed, an average of 73% of total feed.

Food producers, e.g. dairy farmers, either by choice, market-driven or via legislation, have been shown to have some potential scope to reduce emissions either through changes in management, whole-system or plant/animal genetics (del Prado and Scholefield, 2008).

Only some practices lead to reduction in both GHG emissions per unit of land and emissions intensity (per unit of product) (del Prado and Scholefield, 2008) and fewer may be practical or economically feasible. The EU Nitrate Directive as a policy instrument has considerably contributed to a reduction in GHG emissions per hectare. However, it is still arguable whether this has also caused a reduction in emissions intensity.

Emissions saved at one component level after application of a "successful" point-measure, may in fact be offset by an increase in emissions elsewhere (del Prado *et al.,* 2010). For example, choosing the right cow diet can help decrease the carbon footprint of produced milk in farms of the Basque Country. Shifting from grass to cereal-based livestock diets may lead to reductions in methane and N emissions at the animal level. However, due to associated land use change from pastures to arable land, soil C and N losses can be much greater than the emission savings at the animal level.

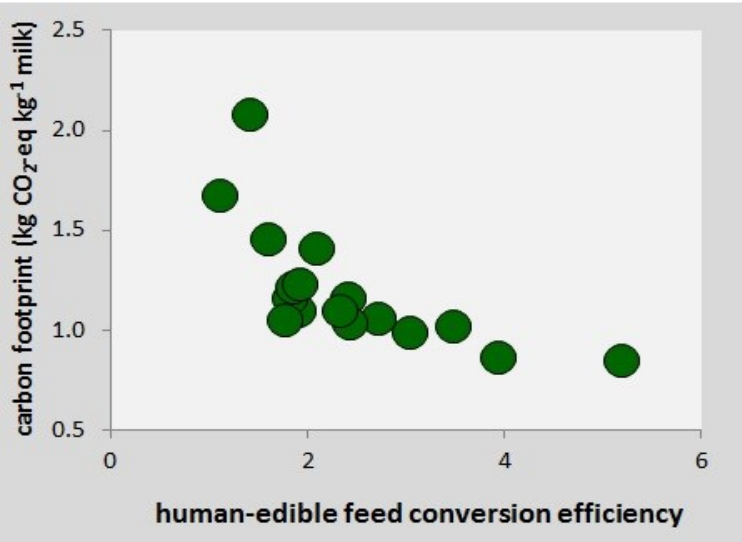

Figure 4: Milk carbon footprint in relation to human-edible feed conversion efficiency (FCEHEF).

Solutions are far from trivial as sometimes measures to reduce emissions may involve trade-offs in other environmental or resource availability issues. Many livestock diets for example, include ingredients that can be eaten directly by humans. Livestock convert forages, arable crops and associated by-products into human-edible food of high nutritional value. Ruminants, when their diets are based on forage (with very poor quality protein) or crop by-products, and in contrast to monogastric livestock which are very inefficient utilising forages, could potentially be net contributors to human-edible food and contribute to reductions in GHG emissions (Figure 4). Unfortunately, some policies (e.g. bio-energy policies) may in fact favour that crop by-products and products themselves, are marketed through pathways (e.g. biomass biodigestion) other than animal feed or food. Legumes do not require fertilization as they biologically fix N_2 into plant protein and sometimes (e.g. clover) do not compete with human-edible food. Organic dairy systems using legumes and organic fertilization have been shown to potentially reduce GHG emissions intensity and expressed per ha (del Prado *et al.,* 2011). Considering that crop establishment for some legumes is sometimes challenging, for years, farmers have preferred importing cheap protein feedstock, which has had a negative effect on the attention that plant breeders may have had on the research and development of potential local legume breeds that could be economically feasible and resilient to the expected changes.

4 Emission leakages are produced when the drop of the emission in one country is replaced by the increase in the emissions in another country. If the second country is not a committer for the Annex B of the Kyoto protocol these emissions disappear in the national inventories but not in the real world.

Conclusion and policy and societal implications

The challenge to produce enough food for feeding an increasing world population while reducing the environmental impacts is complex and the main drivers must been analyzed not only in the agricultural system but also in the agro-food system as a whole. Besides, nowadays local and country scales are not enough to fully understand the system and it is necessary to take the global scale even when studying local issues.

In order to increase the global nitrogen use efficiency, measures oriented to the crop-animal reconnection would be very useful. These practices can be developed not necessarily at the farm level but at a larger scale. Moreover, determined programs and public actions to reduce food waste at the different levels of the food chain including producers, distributers and consumer are imperative in the EU-27 (Grizzetti *et al.,* 2013).

We have seen how in Spain the shift to a diet far to that recommended by the World Health Organization is producing severe environmental impacts and also a completely loss of food self-sufficiency. Similar cases can be observed in other countries such as China. The involvement of the consumers in the environmental and health issues is therefore crucial. Public health-related policies are expected to also be instrumental in order to promote shifts in diets that are both healthier and environmentally greener than current diets. The reduction of the share of animal protein in the human diet of those countries that are eating too much meat is a crucial task. This change must be undertaken by the citizens but should also be encouraged by policy. Regarding the problem of emission leakage, we consider that the proposed actions discusses above will have a positive effect in the reduction of leakages. Since this problem has an international dimension we point out that unilateral national policies not synchronised with foreign ones will be much less effective than global cooperative strategies.

In sum, to feed an increasing population in a sustainable way it is necessary to involve consumers, producers and policy makers and to analyze the different components of the agro-food system from the local to the global scale.

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