BREAK OUT OF THE SILO:

IMPACTS OF THE AGRO-INDUSTRIAL FOOD SYSTEM ON FOOD SECURITY AND FARMERS' INCOME - A REVIEW

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Introduction

As documented by the recent publication of the EAT-Lancet commission[1], food production is today the single largest cause of global environmental change: agriculture occupies about 40% of global land, and food production is responsible for up to 30% of global greenhouse-gas emissions and 70% of freshwater use; conversion of natural ecosystems to croplands and pastures is the largest factor causing species to be threatened with extinction; overuse and misuse of nitrogen and phosphorus causes water pollution and damages natural habitats across the world.

In order to address these issues, the European Commission has published in May 2020 a key component of the European Green Deal dedicated to making the EU Food system fair, healthy and environmentally-friendly: the "Farm to Fork Strategy"[2].

The main objective of this new strategy is to accelerate the transition towards a sustainable European food system that should[3]:

- have a neutral or positive environmental impact,
- help to mitigate climate change and adapt to its impacts,
- reverse the loss of biodiversity,
- ensure food security, nutrition and public health, making sure that everyone has access to sufficient, safe, nutritious, sustainable food,
- preserve affordability of food while generating fairer economic returns, fostering competitiveness of the EU supply sector and promoting fair trade.

This strategy is unique as it is the first time for the EU food policy to have a comprehensive strategy, encompassing all stages of the food system and putting consumers and producers in the centre.

1 Willett, Walter, Johan Rockström, Brent Loken, Marco Springmann, Tim Lang, Sonja Vermeulen, Tara Garnett, et al. « Food in the Anthropocene: The EAT–Lancet Commission on Healthy Diets from Sustainable Food Systems ». The Lancet 393, n°10170 (2019): 447-92. https://doi.org/10.1016/S0140-6736(18)31788-4

2 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system COM/2020/381 final (European Commission, 2020)

3 https://ec.europa.eu/food/farm2fork_en accessed on May 3rd 2021

It sets out 27 concrete actions to transform the EU's food system by 2030, in order to meet the following goals, inter alia [4]:

- a reduction by 50% of the use and risk of pesticides,
- a reduction by at least 20% of the use of fertilizers – including animal manure,
- a reduction by 50% in sales of antimicrobials used for farmed animals and aquaculture,
- reaching 25% of agricultural land under organic farming, of which the current level is 8%.

This strategy has triggered several reactions expressing concern at the economic and social implications of the Commission's targets and their possible impact on competitiveness, productivity and food supply. Speaking at a recent EURACTIV event, Christiane Lambert, the newly elected chair of farmers association COPA declared that "Without an impact assessment, no decision can be made. And if negative aspects come up, they must be reviewed in the strategy" [5].

As the results of the impact assessment evaluation of the Farm to Fork strategy conducted by the European Commission are under way, this study aims at providing a sound knowledge base of scientific evidence on the current socio-economic, health and environmental impacts of the current EU agricultural models.

It draws upon a combination of official public data and recent academic literature on the subject. Its outputs detailed hereafter can serve as an objectified backdrop to put in context the consistently upcoming demands for an impact assessment of the Farm to Fork strategy as a whole.

4 https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/farm-fork_en

5 https://www.euractiv.com/section/agriculture-food/news/commission-official-farm-to-fork-to-be-steadily-evaluated-in-its-implementation/ accessed on May 3rd 2021

Background context

Since the middle of the 20th century, the development and gradual generalisation of a technically modernized agricultural model based on the combined use of synthetic pesticides, synthetic fertilizers, hybrid varieties and mechanization, has allowed unprecedented productivity gains.

CHANGES IN TOTAL CULTIVATED AREAS, PRODUCTION, WORLD POPULATION AND YIELDS SINCE 1960

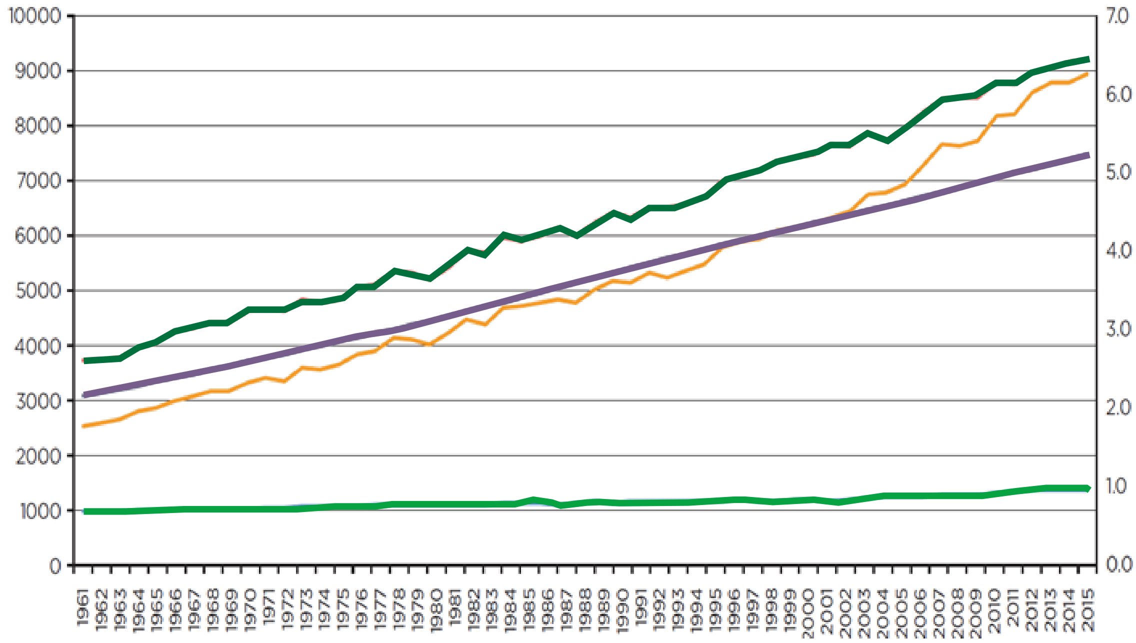


Figure 1. Changes in total cultivated areas, production, world population and yields since 1960
Source: Phillips McDougall, Evolution of the Crop Protection Industry since 1960, 2018

As illustrated above, while cultivated areas have increased by 50% over the period 1960-2016, global average yields across all crops monitored by the FAO have more than doubled (from 2.5 tonnes/hectare to 6.5 tonnes/hectare), thus allowing a 3.4-fold increase in agricultural crop production worldwide (from 2,588 million tonnes in 1960 to 8,923 million tonnes in 2016)[6].

In doing so, agricultural production has grown faster than the world's population, which has slightly more than doubled over the same period, from 3 to 7 billion inhabitants[7].

6 Phillips McDougall. Evolution of the Crop Protection Industry since 1960, 2018
7 Ibid.

The same trend can be observed in European Union, albeit at a much-reduced speed over the past 20 years in the majority of member states.

AVERAGE CEREAL YIELDS IN EUROPEAN UNION SELECTED MEMBER STATES (HG/HA)

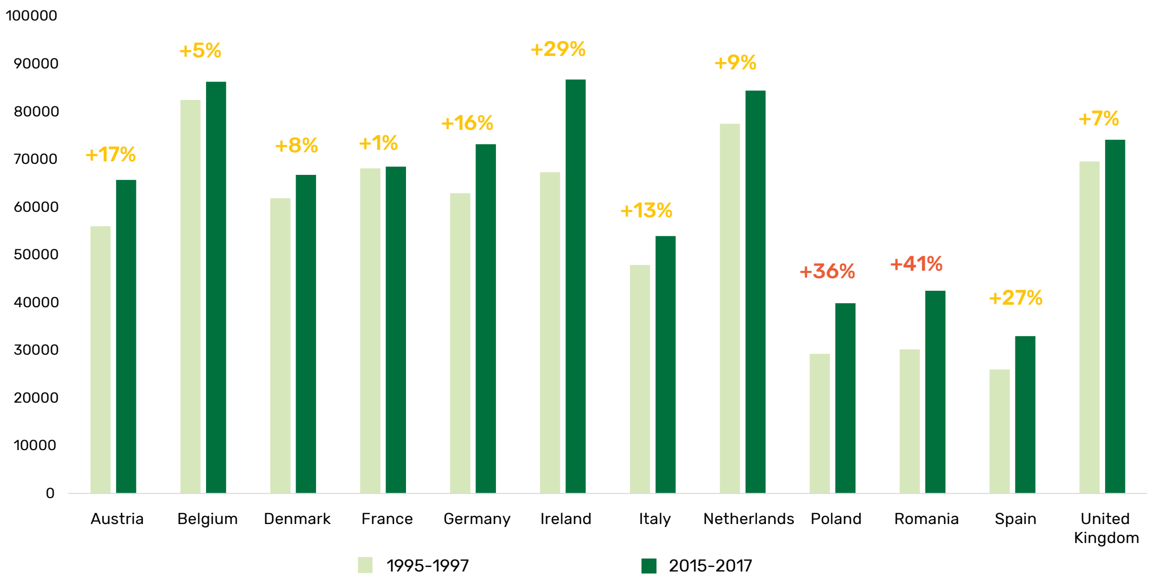


Figure 2. Average cereal yields in a selection of European Union member states in 1995-1997 and 2015-2017
Source: BASIC, based on data from FAOStat
Note: numbers in dark red are bigger than average yield increase at global level for the same period
(& reversely orange are lower)

AVERAGE VEGETABLES YIELDS IN EUROPEAN UNION SELECTED MEMBER STATES (HG/HA)

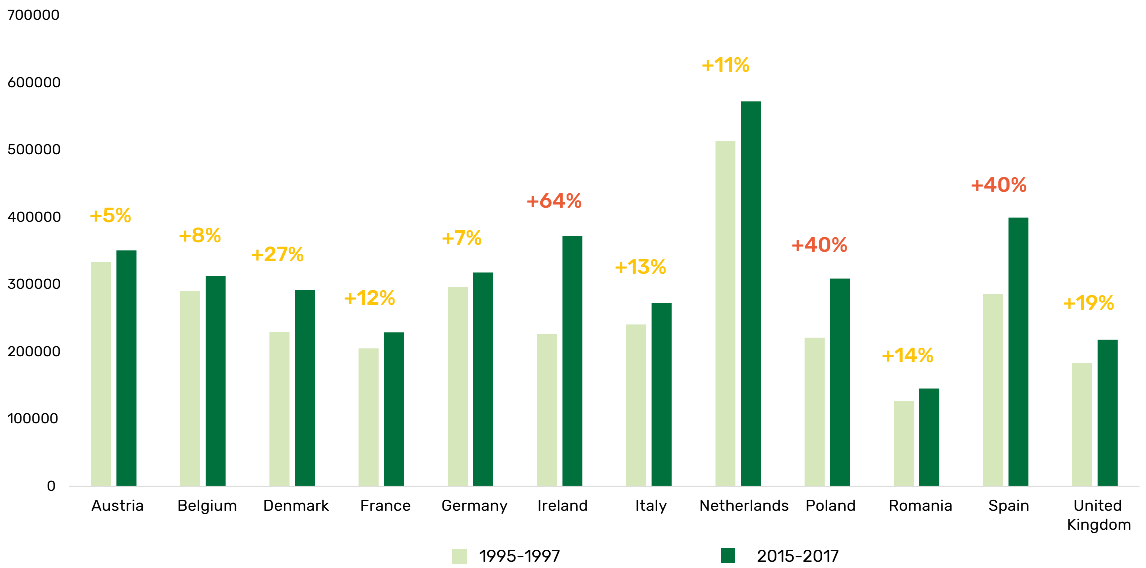


Figure 3. Average cereal yields in a selection of European Union member states in 1995-1997 and 2015-2017
Source: BASIC, based on data from FAOStat
Note: numbers in dark green are bigger than average yield increase at global level for the same period
(& reversely light green are lower)

According to the data of the FAO illustrated in the 2 graphs above, whereas the average yield at global level has increased by 31% since 1995, the main agricultural member states of the European Union have achieved much lower improvements:

- In the field of cereal cultivation, most European countries are characterized by low increases of yields on average (ranging from +1% to +17%) when comparing the periods 1995-1997 and 2015-2017, with the only exceptions of Poland and Romania (with respectively +36% and +41%)
- The situation is similar in the field of vegetable cultivation, most countries achieving mild increases (from +5% to +19%) with the exception of Ireland, Poland and Romania.

These moderate results have been obtained thanks to an acceleration of farms' expenses on pesticides and fertilizers over the past 2 decades.

In order to document this issue, we have investigated the farm expenses on pesticides and fertilizers in the European Union (which enable to offset the limits and bias of volume indicators which do not take into account the concentration and strength of products used, especially pesticides).

Our analysis is based on the statistics of the Farm Accountancy Data Network (FADN). This public database computes and consolidates the information periodically published by the Commission on the annual income and capital of agricultural holdings in Europe. It describes in large detail the economic situation of farmers throughout the European Union, organized by different groups (specialist Cereals Oilseeds and Protein crops, specialist milk, specialist cattle, etc.).

The relevance of this approach has been demonstrated by a researcher from the French National Research Institute of Agronomy (INRA). Working on the case of France in 2011, he proved that the indicator of pesticide expenditures can be used as a proxy for their treatment frequency index (and therefore their use level), because these two indicators maintain a relatively stable correlation and ratio over time for the main crops[8].

To verify this point, we have reproduced the methodology of this researcher to update his data and cross-check that the correlation remained true over the past decade. To do this, we have used the surveys carried out by the French Ministry of Agriculture on the treatment frequency indices of different crops in 2006, 2011, 2014 and 2017; we have then estimated the pesticide expenditure related to these different crops using the French FADN database and the linear regression model developed by the French researcher.

Our results show a stable correlation over time for most major crops from 2006 to 2011, particularly strong for bread wheat and corn[9]. On this basis, we can thus consider that the use of the pesticide expenditure indicator can serve as a proxy for their treatment frequency.

8 Butault J.P., L'utilisation des pesticides en France – état des lieux et perspective de réduction, 2011
9 BASIC, Étude des financements publics et privés liés à l'utilisation agricole de pesticides en France, 2021

AVERAGE PESTICIDES EXPENSES PER HECTARE (€/HA)

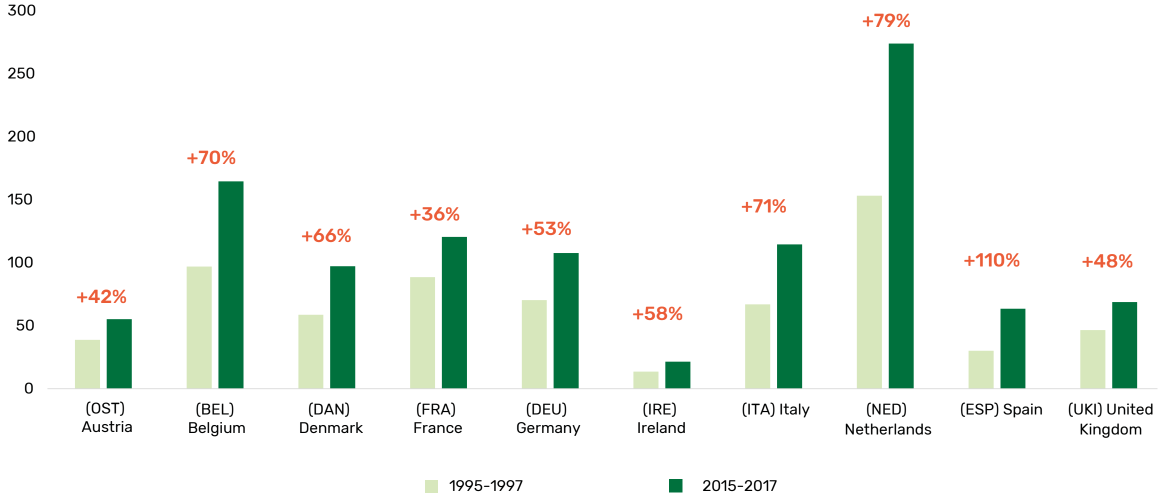


Figure 4. Average pesticides expenses per ha in a selection of European Union member states in 1995-1997 and 2015-2017
Source: BASIC, based on FADN statistics

AVERAGE FERTILIZERS EXPENSES PER HECTARE (€/HA)

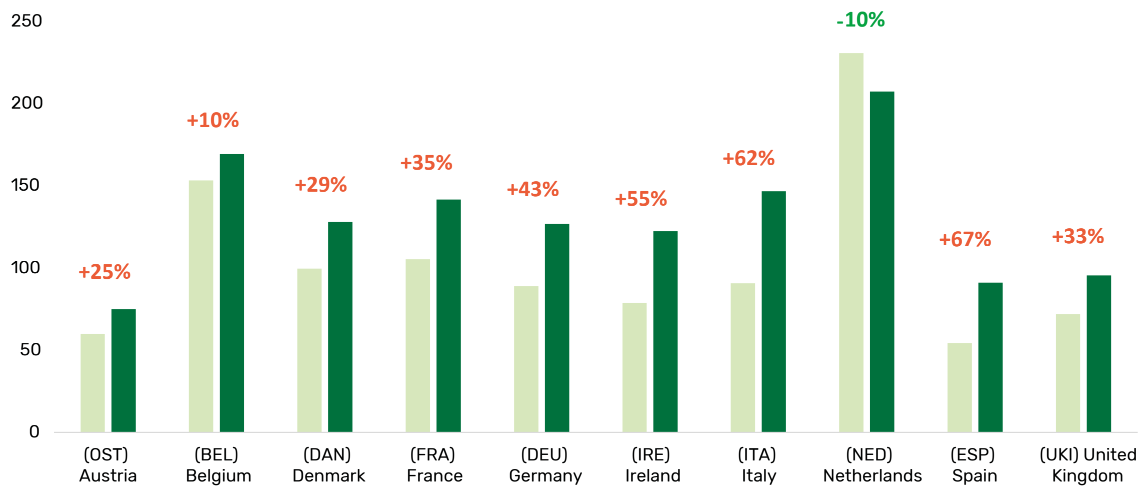


Figure 5. Average fertilizers expenses per ha in a selection of European Union member states in 1995-1997 and 2015-2017
Source: BASIC, based on FADN statistics

In order to correct for the discrepancies in farm sizes across European countries, we have calculated the expenses on pesticides and fertilizers per hectare for each country (see above).

As illustrated in the two graphs above, **there is a significant increase of the expenses of inputs per hectare in almost all of the main agricultural member states of the European Union, much higher than the improvement of yields** detailed earlier:

- In terms of pesticides, the average expenses per hectare have significantly jumped between 1995-1997 and 2015-2017, the increase ranging from +58% in Ireland up to +110% in Spain (to be compared with the much smaller increase in yields over the same period).
- The evolution is similar regarding fertilizers, albeit less rapid, the increase of average expenses per hectare ranging from +25% in Austria up to +67% in Spain between 1995-1997 and 2015-2017. The only notable exception is Netherlands, where these expenses have declined by 10%.

Beyond the potential differences of agricultural specializations between the member states analysed, these quite homogeneous results across all countries draw questions on the socio-economic impacts of this evolution on farmers' income. This issue has been investigated in detail in the following section.

The economic consequences of the currently leading agricultural model

1. Farmers' income, yields and use of inputs

AVERAGE GROSS FARMS INCOME WITHOUT SUBSIDIES/HECTARE (CORRECTED FOR INFLATION - EUR2017)

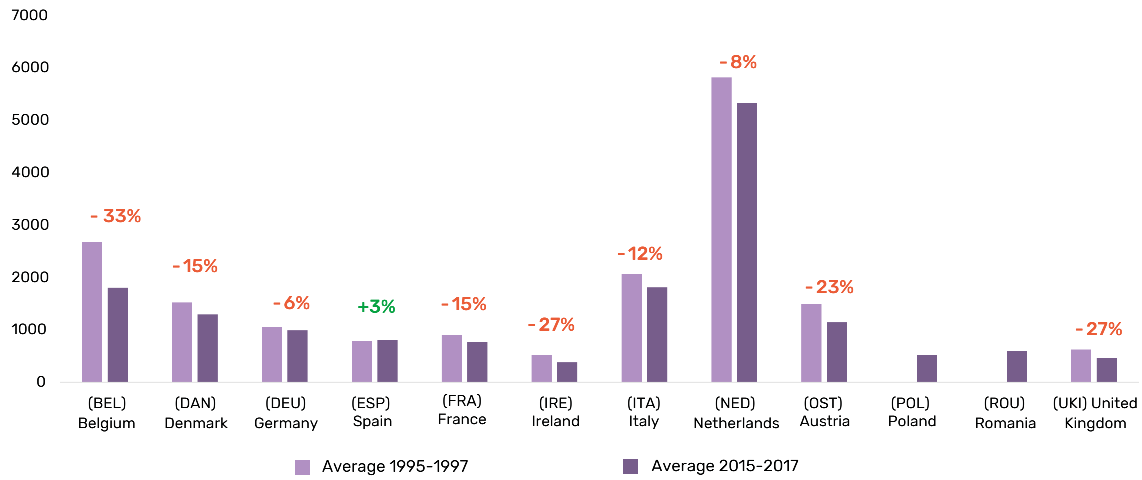


Figure 6. Average gross income per ha without public subsidies in European Union member states in 1995-1997 and 2015-2017
Source: BASIC, based on FADN statistics

In order to analyse the economic performance of farms across Europe, we have used the FADN statistics to calculate their average gross income without public subsidies per hectare. Indeed, this indicator enables to offset the differences in farm sizes between countries, and to document the financial capacity of farmers to generate earnings for their households without government support.

The results are in stark contrast with the figures provided in the previous section: all major agricultural member states of the European Union feature a significant drop of their average gross income, ranging from -6% in Germany down to -33% in Belgium. The only exception is Spain which gross income per hectare has slightly increased by 3%.

These results can then be correlated with the average spending of farms on pesticides and fertilizers in order to analyse the evolution of the economic efficiency of agricultural inputs use since 1995.

AVERAGE GROSS FARMS INCOME WITHOUT PUBLIC SUBSIDIES (€) / AVERAGE PESTICIDES SPENDINGS OF FARMS (€)

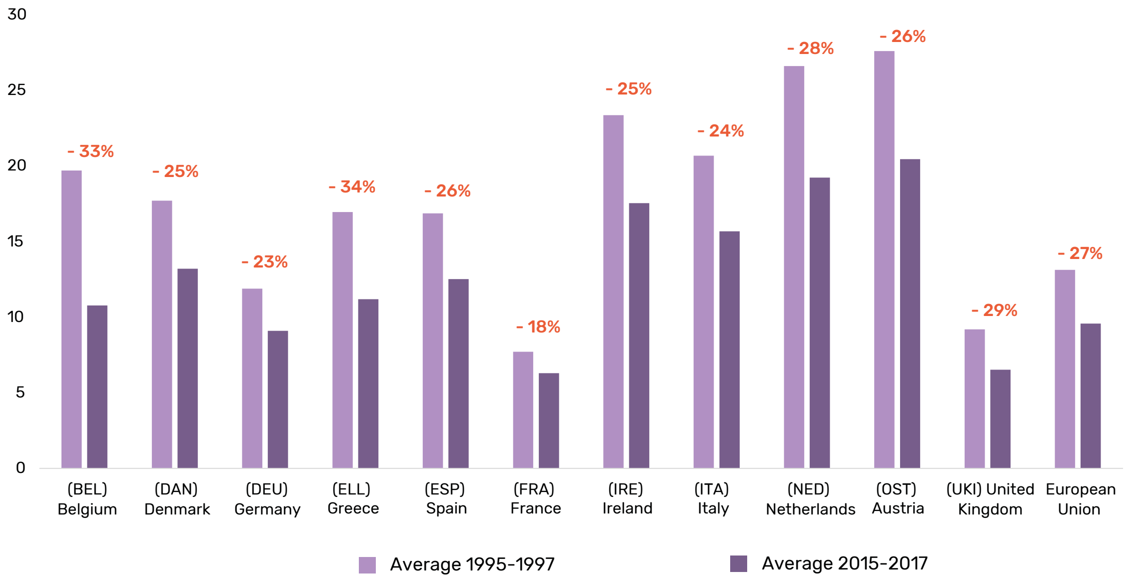


Figure 7. Average gross income per ha without public subsidies divided by average pesticides spending in a selection of European Union member states in 1995-1997 and 2015-2017. Source: BASIC, based on FADN statistics

AVERAGE GROSS FARMS INCOME WITHOUT PUBLIC SUBSIDIES (€) / AVERAGE PESTICIDES SPENDINGS OF FARMS (€)

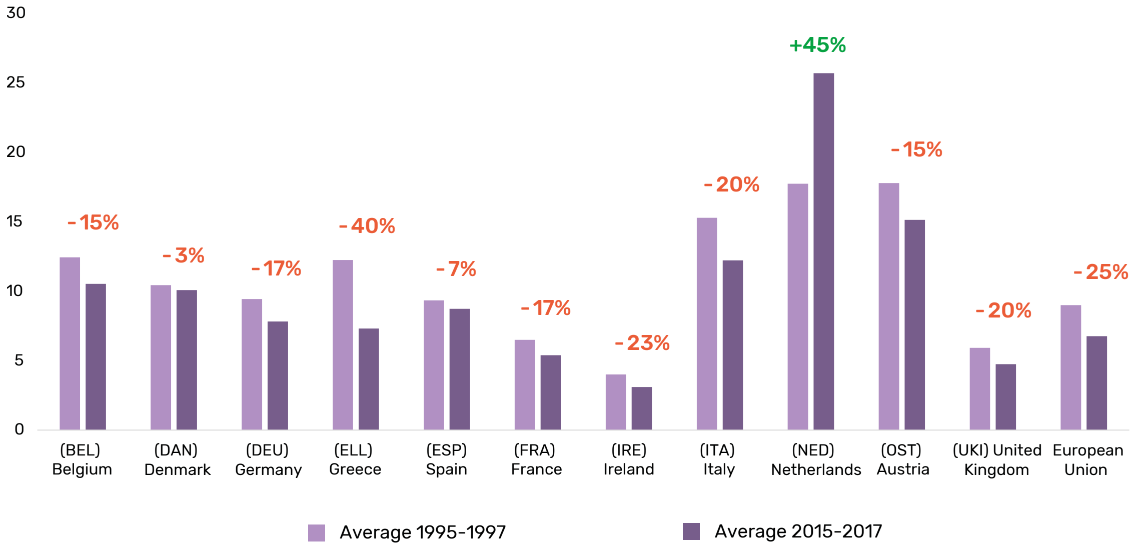


Figure 8. Average gross income per ha without public subsidies divided by average fertilizers spending in a selection of

European Union member states in 1995-1997 and 2015-2017. Source: BASIC, based on FADN statistics

The results of this computation of FADN statistics demonstrate a significant decrease of economic efficiency in both cases:

- The gross income generated by farms for each euro of spending on pesticides has dropped by 27% in the European Union, with decreases ranging between -18% in France to -45% in Belgium.
- The situation is very similar in the case of fertilizers, with a decrease by 25% of the farms' gross income generated for each euro of spending at the European level (ranging from -7% in Spain down to -40% in Greece, with the notable exception of Netherlands which increased by +45%).

Given these economic dynamics, a likely assumption is that the European farmers are locked up in a vicious circle whereby there are spending an ever-increasing amount of money on pesticides and fertilizers in order to try to offset decrease in yields' improvements (compared to the global average trend) while the rising use of these inputs plays a significant role in the decrease of their income.

In this context, the following section explores in more details the drivers of farms income in Europe to help better understand this situation.

2. Role of price levels and stability for farmer's income

To analyse the decrease of farmers' gross income documented earlier, we have compared the parallel evolution of agricultural prices computed by Eurostat with farmer's expenses from the FADN database.

AGRICULTURAL PRICES INDEX IN EUROPEAN MEMBER STATES - BASE 100 = 1995

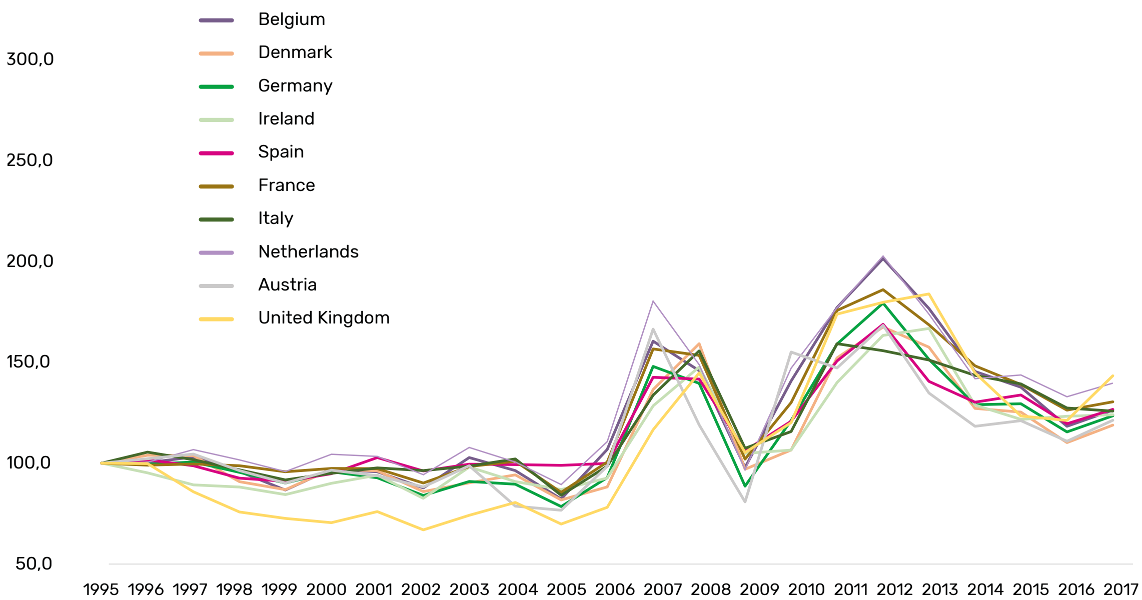


Figure 9. Average agricultural prices index in a selection of European Union member states between 1995 and 2017. Source: BASIC, based on Eurostat statistics

INDEX OF FARMS EXPENSES IN EUROPEAN MEMBER STATES - BSE 100 = 1995

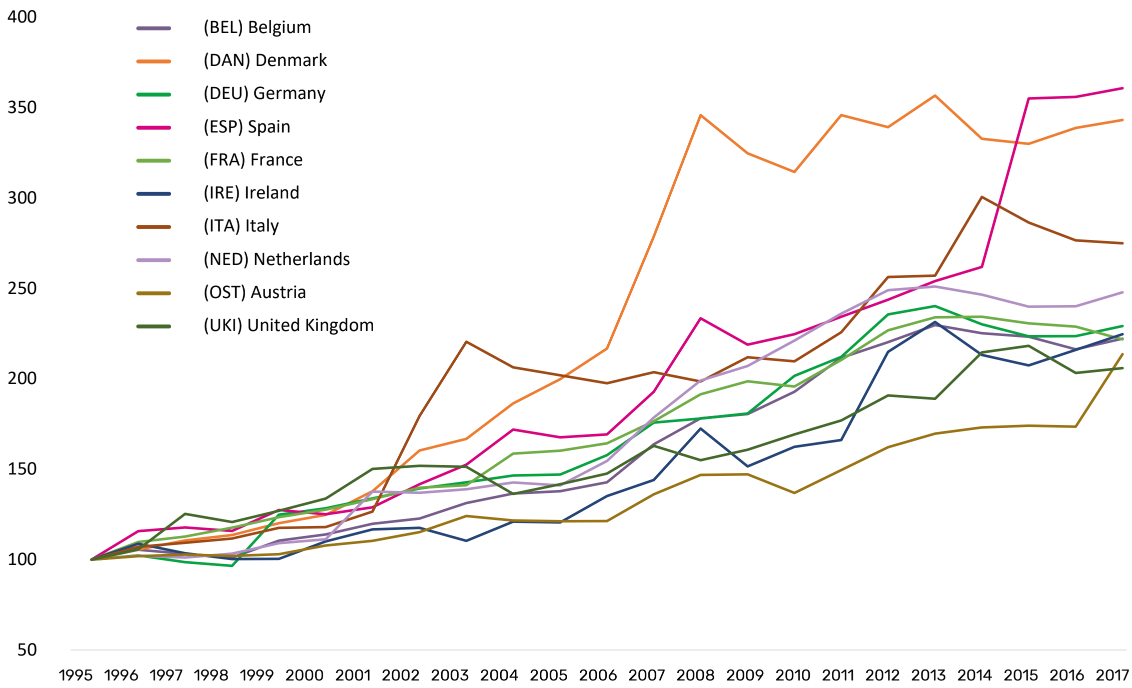


Figure 10. Average farm expenses index in a selection of European Union member states between 1995 and 2017.
Source: BASIC, based on FADN statistics

The comparison between the two sets of data illustrated in the above graphs enables complementary insights on the evolution of European farmers' income in major EU agricultural countries.

Even though the average agricultural prices (across crops and animal products) in all the countries analysed have increased by 30% on average between 1995 and 2017 (ranging from +21% in Austria to +43% in the Netherlands), this improvement has not been sufficient to compensate for the jump in farms' expenses, even when taking into account the average increase in yields detailed at the beginning of the paper (around +10% to +25% in most countries).

Indeed, as recorded by the FADN statistics, the average farms' expenses have jumped sharply between 1995 and 2017 in all major European agricultural member states: from +213% in Austria, up to +360% in Spain. This evolution is not only due to the increased expenses on inputs (pesticides and fertilizers), but also machinery, farms infrastructure, feed and seeds expenses, loan repayments, etc.

Beyond this divergence between ever-increasing farms' expenses and the level of agricultural prices, another critical issue is that of price volatility which also impacts negatively the income of farmers. This has been best exemplified by the case of the European milk market since 2007.

EU EVOLUTIVE* RAW MILK PRICES EVOLUTION (UP TO FEB 2021)

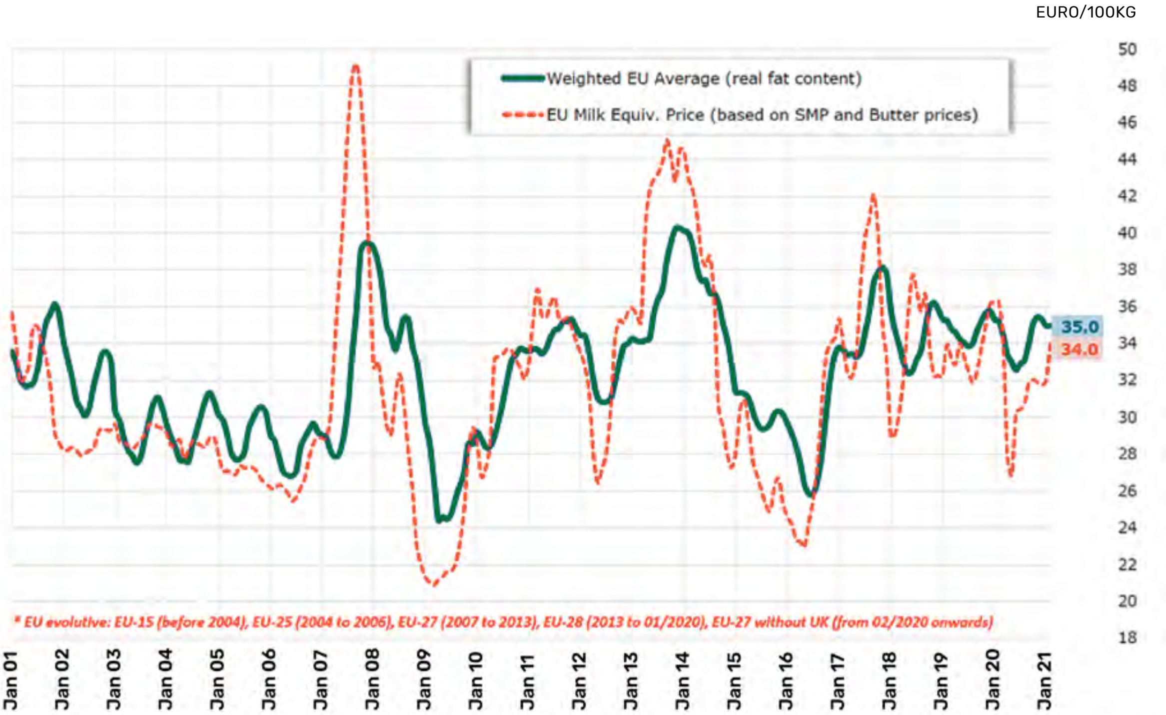


Figure 11. EU Raw Milk Prices Evolution between January 2001 and January 2021.
Source: Milk Market Observatory of the European Commission

In 2003, the Luxembourg agreements decided an additional cut of 10% of the intervention price and the phasing out of the quota system, to be definitively abolished in 2015. The new policy priorities, as stated in Agenda 2000, were to enhance the competitiveness of European dairy farmers and to allow them to thrive in the international markets[10].

The first test for the new policy line came during the world financial and food prices crisis of 2007, when international milk prices suddenly shot up, and later precipitate in 2009 at unprecedented low levels (cf. graph above). During this period the European Union has not established effective anti-cyclical measures to avoid worst consequences for producers, while it has continued the process of liberalization and of reduction of quotas[11].

This sudden fall of prices was a hard hit for milk producers, who saw their revenues fall while no safety net was put in place to help them make their ends meet. Protests and demonstrations spread in Europe and the European authorities called a High Level Group on Milk (HLG) to study the roots of the crisis and possible solutions for avoiding these repercussions of interna-

10 European Commission, Évolution de la situation du marché et des conditions relatives à la suppression progressive du système de quotas laitiers, 2010 http://ec.europa.eu/agriculture/milk/quota-report/com-2010-727_fr.pdf European Commission, Evolution of the market situation for milk and milk products, 2014 http://ec.europa.eu/agriculture/milk/milk-package/swd-2014-187_en.pdf .

11 Souchon R. (2013) «Évolution de la situation du marché Et des conditions relatives à la suppression Progressive du système de quotas laitiers – deuxième Rapport sur l'atterrissage en douceur. Annexe au projet d'avis du Comité des Régions. 101e session plénière du 30 mai 2013.

tional markets instability[12].

The HLG evaluated that prices volatility should be dealt with by the private sector, through the resort to relevant financial instruments, i.e. the establishment of a future market[13]. Prices recovered after 2009 but instability and volatility continued to characterize the milk courses. After a pick in 2014, prices have been falling for the whole 2015 generating a new crisis in the sector.

During both crises, the actors of the lower end of the chain (industry and retailers) managed to put most of the weight of price fluctuations on the upper end side (producers). While in 2007 and 2014, the prices paid to the producers and consumers prices raised alike, the same did not happen when prices fell. Then, consumers' prices decreased much slower and revenues of producers were disproportionally affected, while industrial and retailer groups saw their margins rise[14].

As recognized by the HLG, unequal relations, weakness of producers in negotiation and low transparency in the value chains were singled out as the main factors threatening the good functioning of the value chain and the security of milk producers' livelihoods[15]. This critical issue is further investigated in section 4 below.

3. Agroecological systems and farmers' income

The economic dynamics associated with currently leading agricultural models described in the previous sections are not inevitable, as demonstrated by several recent research work.

One of the most encompassing has been published in 2019 in the Journal of Rural Studies and conducted by more than 25 researchers from different European universities and public institutes[16].

This article discusses the economic dimensions of agroecological farming systems in Europe, drawing upon empirical data from a wide range of countries which document the economic performances of different styles of farming that can be described as agroecological by nature even though they may not necessarily explicitly define themselves as such.

The range of countries, agroecological farming systems and their associated economic benefits are listed in the table below.

Case	Criteria	AE compared to average
Netherlands, 'farming economically'	Labour income/100 kg of milk	+110%
Netherlands, Centre for Research in Dairy Farming (PR)	Employment generated at volume of production of 800,000 kg of milk	+100%
France grassland-based farming	Family income/family worker	+73%
Germany, low concentrate feeding	Income per dairy cow	+60%

12 Ibid.
13 Report of the High Level Group on Milk final version 15 June 2010.
14 Pflimlin A. (2015) Le marche laitier mondial est un piege pour les eleveurs et un pari fatal pour l'union europeenne. Article apparu dans http://www.fourragesmieux.be/
15 Report of the High Level Group on Milk final version 15 June 2010.
16 Jan Douwe van der Ploeg, et al., Journal of Rural Studies, 2019 https://doi.org/10.1016/j.jrurstud.2019.09.003

Case	Criteria	AE compared to average
Switzerland, organic farming	Employment/farm	+27%
Italy, Rossa reggiana	Income per hour	+15%
Poland, dairy farming	Income according to level of self-provisining for feed and fodder (0 compared to 51-99)	+53%
Ireland, beef and milk	Gross margins per hectare	increase in the order of 75-80% in a 3-4 year period
UK, sheep farming	Gross value added/ewe	+10%
Spain, Mediterranean crops	Gross Value Added	+35%
	Decrease in workload	- 75min/ha
Belgium, no tillage crops	Decrease in machine cost	- 60 Euro/ha
Belgium, grass-based farming	Decrease in dependency on subsidies	Subsidies down from more than 60 to only 20% of VA
Portugal, vine growing	Fossil energy consumption/ha	- 30%

Figure 12. Countries, farming systems, economic benefit criteria and related results analysed in 2019 by the research team coordinated by Jan Douwe van der Ploeg. Source: J.D. van der Ploeg et al., Journal of Rural Studies, 2019

This paper demonstrates that the agroecological systems analyzed all generate levels and stability in incomes and employment that are, under current circumstances, superior to those generated by conventional farming.

Another interesting point that emerges from this comparative analysis is that agroecological systems that have been investigated depend much less on subsidies than conventional agricultural systems. This is largely due to the way in which in the EU's agricultural subsidy system is structured, but also reflects the inherent higher income generating potential of these agroecological systems.

Another milestone research was conducted by the International Panel of Experts on Sustainable Food Systems (IPES-Food) in their study "From Uniformity to Diversity: A paradigm shift from industrial agriculture to diversified agroecological systems" published in 2016[17].

Their research work shows that studies are increasingly yielding data on the positive impacts of diversified agricultural systems on farmers' income and livelihoods:

- A study covering 55 organic crops grown on five continents over 40 years found that despite lower yields, organic agriculture was significantly more profitable (22–35%) than conventional agriculture, farmers managing to capture high-value markets and achieving 20-24% higher benefit/cost ratios than conventional agriculture[18].
- An eight-country study conducted in 2014 found that the number of crops that a given farm produces is positively correlated to household income, as well as dietary diversity[19].
- A Dutch study conducted in 1999 concluded that mixed farming systems can lead to a 25% higher labour income/ha without increased environmental pollution[20].

17 IPES Food, From Uniformity to Diversity: A paradigm shift from industrial agriculture to diversified agroecological systems, 2016

18 Crowder, D.W., Reganold, J.P., 2015. Financial competitiveness of organic agriculture on a global scale. Proceedings of the National Academy of Sciences 112, 7611–7616
Reganold, J.P., Wachter, J.M., 2016. Organic agriculture in the twenty-first century. Nature Plants 2, 15221

19 Pellegrini, L., Tasciotti, L., 2014. Crop diversification, dietary diversity and agricultural income: empirical evidence from eight developing countries. Canadian Journal of Development Studies / Revue canadienne d'études du développement 35, 211–227

20 Bos & Van De Ven, 1999

Tableau 3 - Estimation des coûts et bénéfices post-transition vers l'agriculture biologique (toutes subventions exclues)

Étude	Filière		Coûts et bénéfices €/ha/an: MB	MD	EBE	RC
Ecophyto R&D (INRA)	Céréalier Intensif	Centre Poitou	398 (+96%)	385 (+274%)	x	x
		Midi-Pyrénées, Aquitaine, Languedoc	348 (+75%)	331 (+170%)	x	x
		Sud-Est	215 (+36%)	227 (+4%)	x	x
	Céréalier mixte Extensif	Centre Poitou	207 (+50)	309 (+221%)	x	x
		Midi-Pyrénées, Aquitaine, Languedoc	157 (+34%)	255 (+131%)	x	x
		Sud-Est	24 (+176%)	151 (+51%)	x	x
CERFRANCE Agri'Scopie Occitanie		Céréales	40(+6%)	-30(-20%)	x	-70(-52%)
CERFRANCE L'Observatoire économique		Lait	514 (+88%)	241 (+225%)	302 (+2517%)	142 (+51%)
		Spécialisée viande bovine	-197 (-36%)	-202 (-109%)	-178 (-223%)	-173 (-124%)
		Polyculture élevage bovine	123 (+28)	57 (+104%)	177 (+5900%)	124 (+54%)
		Cultures de vente (dont polyculture élevage hors monogastriques)	126 (+35%)	97 (+88%)	133 (+124%)	133(+37%)
Dossier INSEE		Viticulture	x	x	2506 (+72%)	x
		Maraîchage	x	x	594 (+29%)	x
		Lait (€/VL)	x	x	100 (+12%)	x
CERFRANCE Adheo		Pas dendistinction mais part importante d'exploitations en élevage	x	x	64 (+33%)	x

MB = marge brute **MD = marge directe** **EBE = excédent brut d'exploitation** **RC = résultat courant**

Lecture : le tableau présente les bénéfices ou les coûts globaux estimés post-transition en valeur (€/ha/an) et en pourcentage. Les bénéfices les plus importants en valeur sont estimés à partir du plus grand échantillon (échelle France métropolitaine) pour des exploitations viticoles. Ce gain d'EBE est estimé à 2 506 €/ha/an, soit plus de 4 fois celui estimé en maraîchage et 25 fois celui estimé en bovins lait pour des échantillons couvrant la France métropolitaine également. Les bénéfices les plus faibles en valeur sont estimés pour les exploitations en polyculture élevage viande bovine de Bourgogne et de Franche-Comté. Certaines valeurs peuvent paraître surprenantes. On calcule par exemple un bénéfice global sur l'EBE en €/ha hors aides pour 2016 de 2 517 % en lait et de 5 900 % en polyculture élevage viande bovine. Cela s'explique par les performances économiques particulièrement basses des exploitations conventionnelles cette année-là, avec des résultats courants avant impôt négatifs : l'EBE hors aides PAC pour 2016 n'est que de 12 €/ha en conventionnel, contre 314 €/ha en bio pour les exploitations laitières de l'échantillon. En viande bovine polyculture élevage, ce même indicateur atteint 3 €/ha en conventionnel et 180 €/ha en bio. En d'autres termes, hors aides PAC, ces exploitations conventionnelles issues des échantillons dégagent très peu de valeur pour rémunérer l'exploitant, rembourser les annuités d'emprunt et constituer une réserve pour l'autofinancement. Notons que ce résultat est lié à l'année considérée (2016).

Figure 13. Estimation of costs and benefits or the conversion towards organic farming in France.
Source: France Strategie, 2020

Most recently, a research study published in August 2020 by France Strategie, the public think tank affiliated with the French Prime Minister's Office, demonstrated that organic farming is the most efficient agroecological farming model in France from an economic point of view, as well as in terms of environmental requirements (see main results in the above table).

More specifically, this research shows that although the lower use of synthetic pesticides and fertilizers induces a drop in yields and mechanical weeding requires additional labor, these higher costs are offset by higher prices on the organic market, in contrast to the situation in conventional markets[21].

21 France strategie, Les performances économiques et environnementales de l'agroécologie, August 2020

In addition to the better final profitability of organic farming, there is less dispersion and better stability of the operating results of farms within the study samples. This is explained in particular by a greater regularity of the overall yields obtained thanks to the diversification of productions, and by the less volatile prices of the products which are linked to the most often longer-term contracts offered to farmers on the organic markets[22].

4. Value distribution along food chains

Beyond the different trends and drivers analysed in the previous section, the more global analysis of the economic dynamics within the wider food system enables to identify additional structural factors that can explain the evolution of farmers' income over the past decades.

The most important of these factors is the disconnection between agricultural prices at the beginning of the chain and consumer prices at the end of the chain. In order to investigate this phenomenon, we have explored the research work on agricultural prices conducted by David J. Sacks from S. Fraser University, and confronted with the Food Price Index measured and published each year by the FAO.

PRICE INDICES OF AGRICULTURAL COMMODITIES LISTED ON INTERNATIONAL STOCK EXCHANGES - BASE 100 = 1900

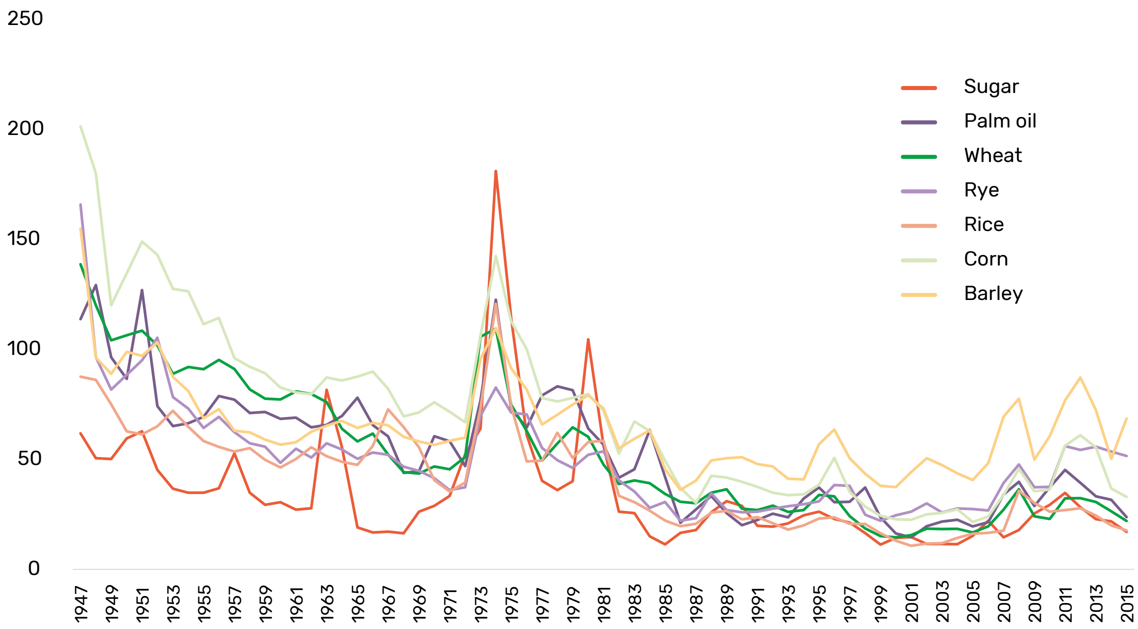


Figure 14. Price index of agricultural commodities on international stock exchanges from 1947 to 2015
Source: D. S. Jacks, From Boom to Bust: A Typology of Real Commodity Prices in the Long Run, 2019

As demonstrated by the statistics consolidated by D. J. Sacks, the annual average prices (not corrected for inflation) of a tonne of wheat, corn, rice, rye, barley and sugar were divided by a factor of 2 to 5 between 1947 and 2015, except for the cyclical "peaks" of periods 1973-1980 and 2007-2013 as illustrated in figure 14.

22 Ibid.

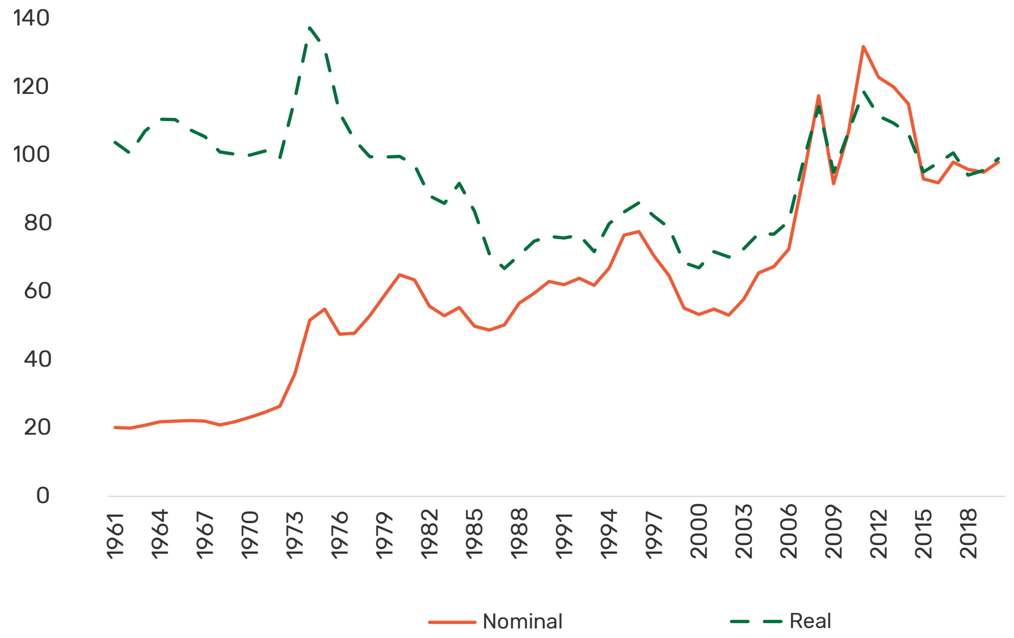


Figure 15. Food Price Index (consumer price level) between 1961 and 2018
Source: FAO

The latter evolution of agricultural commodity prices (in nominal terms) is in stark contrast with the evolution of food prices at the consumer level measured each year by the FAO. As illustrated in the above diagram, the consumer prices – also not corrected for inflation – have been multiplied by 5 since 1961 at global level. This strong increase has been mildly felt by consumers in a majority of countries, as it has mainly followed the evolution of local inflation (cf. evolution of food prices once corrected for inflation showed in blue dotted line).

This increase in consumer prices is mainly linked to the development of processed products and the segmentation of finished products through marketing and "intangible" characteristics (image and brand awareness, advertising investments, etc.), this evolution being as much driven by players in the agri-food industry as by those in the retail sector[23].

The resulting contrast with the substantial decrease in world prices of agricultural commodities indicates that the unprecedented productivity gains of agriculture since 1945 have not benefited farmers, but the other actors in the chain, in particular those in the agri-food industry and mass retail (and to a certain extent also consumers which have had a continuous tendency to lower the share of their budget allocated to food until recently).

This phenomenon was notably demonstrated by the work of J-P Butault of INRA, who compared the evolution of agricultural prices and food prices in France between 1978 and 2005[24].

More recently, this global trend has been further demonstrated by the research team of G. Gereffi, head of the Center on Globalization, Governance and Competitiveness from Duke

23 IPES Food, From Uniformity to Diversity: A paradigm shift from industrial agriculture to diversified agroecological systems, 2016
24 Butault J.P., La relation entre prix agricoles et prix alimentaires. Revue française d'économie, 2008

University[25].

In 2017, G. Gereffi and his team conducted an investigation of the distribution of value-add in agri-food Global Value Chains between 1995 and 2011[26] using WIOD input-output tables which cover 40 countries, including all EU 27 countries and 13 other major advanced and emerging economies.[27]

Drawing on different databases to source country- and firm-level data and statistics, the value-add embedded in a given dollar of food expenditure by consumers in WIOD countries has been estimated and distributed into shares of value that are appropriated in different agri-food value chain segments, ranging from the input & services to farming, intermediates trade, food manufacturing, and distribution & retail in destination countries[28].

DISTRIBUTION OF VALUE IN FOOD GVCS IN 1995 (CHANGES, 1995-2011) [29]

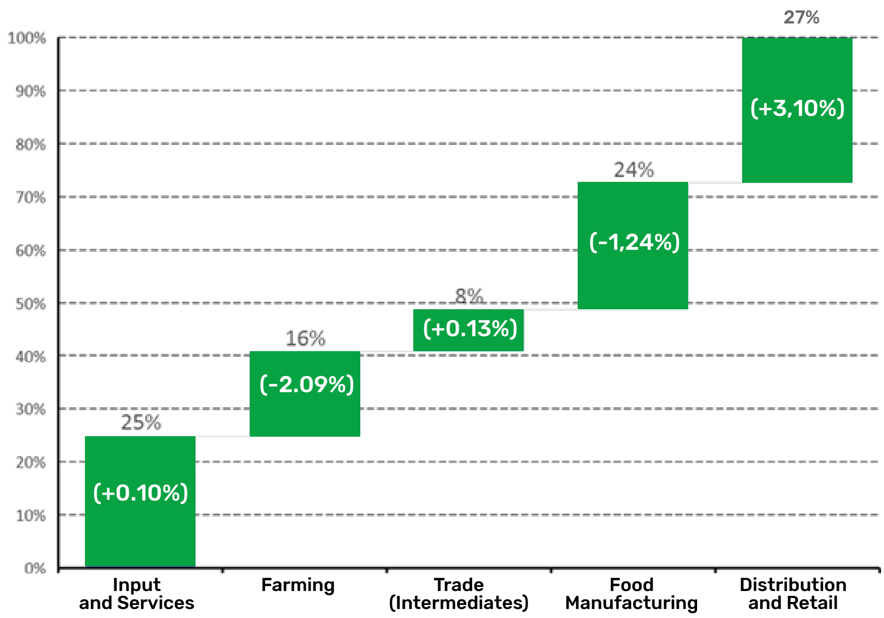


Figure 16. Distribution of Value in Food GVCs in 1995 (Changes, 1995-2011)
Source: G. Gereffi and A.Abdulsaman, 2017

25 The Center on Globalization, Governance & Competitiveness (CGGC), an affiliate of the Social Science Research Institute at Duke University, is built around the use of the Global Value Chain (GVC) methodology, developed by the Center's Director, Gary Gereffi. The Center uses GVC analysis to study the effects of globalization on various topics of interest including: industrial upgrading, international competitiveness, the environment, global health, engineering and entrepreneurship, and innovation in the global knowledge economy. More information about CGGC is available at http://www.cggc.duke.edu/

26 G. Gereffi and A.Abdulsaman, Measurement In A World of Globalized Production What are potential drivers of "unequal" value distribution in agri-food value chains? Center on Globalization, Governance and Competitiveness, Duke University 2017

27 The WIOD provides a time-series of world input-output tables (WIOTs) from 1995 onwards. It covers 40 countries, including all EU 27 countries and 13 other major advanced and emerging economies namely Australia; Brazil; Canada; China; India; Indonesia; Japan; Mexico; Russia; the Republic of Korea; Taiwan, China; Turkey; and the United States. According to statistics from International Monetary Fund (IMF), these countries together in 2011 accounted for 85% of World's gross domestic product and 64% of world's population. The also represent the high value food export markets at a global level.

28 G. Gereffi and A.Abdulsaman, Measurement In A World of Globalized Production What are potential drivers of "unequal" value distribution in agri-food value chains? Center on Globalization, Governance and Competitiveness, Duke University 2017

29 G Note: Value distribution across food GVCs that satisfy domestic consumption in 40 countries included in World Input-Output Database, November 2013 release. Exceptions are: China, Japan, Korea, Mexico, and United States for which margins on distribution and retail were not reported in the respective Supply and Use Tables. Source: Authors based on World Input-Output Database, November 2013 release

At an aggregated global level, farmers accounted for only 16% of the total value-added that was generated in agri-food GVCs in 1995; their share further declined to less than 14% in 2011. This decrease in farmers' share of value contrasts the rising trajectory in pre- and post-farming segments that collectively appropriated 86% of the total value in 2011. Retail segment has increased its value share the most, by more than three percentage points from 1995, and accounted for more than 30% of total value in 2011[30].

CHANGE IN DISTRIBUTION OF FARMERS' SHARE OF VALUE-ADDED IN FOOD GLOBAL VALUE CHAINS, 1995 TO 2011

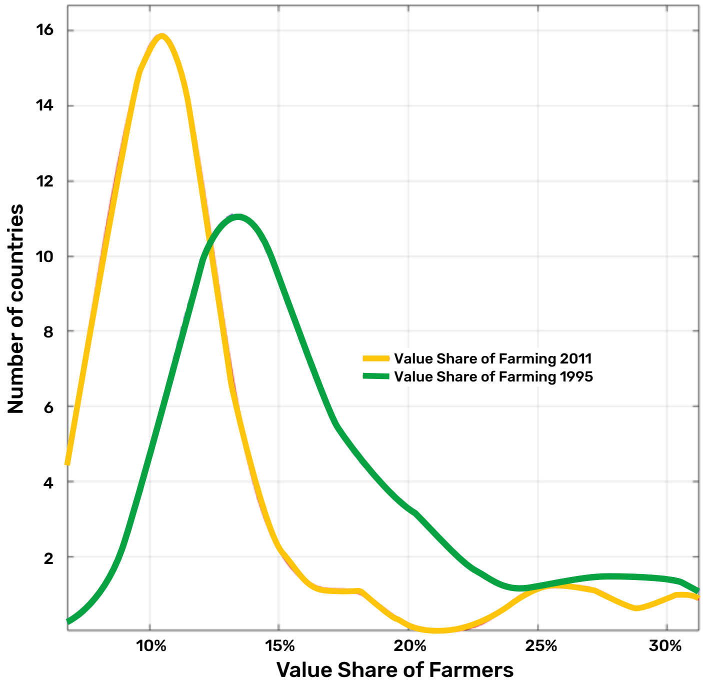


Figure 17. Change in Distribution of Farmers' Share of Value-Added in Food Global Value Chains, 1995 to 2011
Source: G. Gereffi and A.Abdulsaman, 2017

Value shares of farmers across the WIOD countries, however, vary considerably, ranging from 7 to 31% (cf. graph above). Despite inter-country variations, the declining trend in farmers' share of value is almost universal, confirmed by the change in shape and position of the frequency distribution curves between 1995 and 2011. Each of the two curves above depicts variations in farmers' share of value in agri-food GVCs supplying the WIOD countries. The 2011 curve has a relatively left-ward shift which indicates that value share of farmers has decreased compared to 1995.

At an aggregate level, drivers of the decreasing value share of farmers can, therefore, be hypothesized under several scenarios[31]:

- increased trends towards convenience and branded agri-food products would obviously

30 G. Gereffi and A.Abdulsaman, Measurement In A World of Globalized Production What are potential drivers of "unequal" value distribution in agri-food value chains? Center on Globalization, Governance and Competitiveness, Duke University 2017

31 Ibid.

have a lower farm share incorporated in them than their less-processed or fresh counterparts,

- value-adding activities, mostly containing "intangible" or knowledge-intensive 'service' activities are concentrated in the pre- and post-farming segments of the agri-food value chains,
- service functions, such as product development, branding and marketing-- traditionally embedded in integrated food manufacturing sector— have been separated and retained in-house while the most standardized production activities are outsourced.
- Similar economic dynamics have been further demonstrated in the case of France by the French Public Food Sector Price and Margin Observatory (Observatoire de la Formation des Prix et des Marges des Produits Alimentaires) which estimates each year a "Food Euro" measure[32].

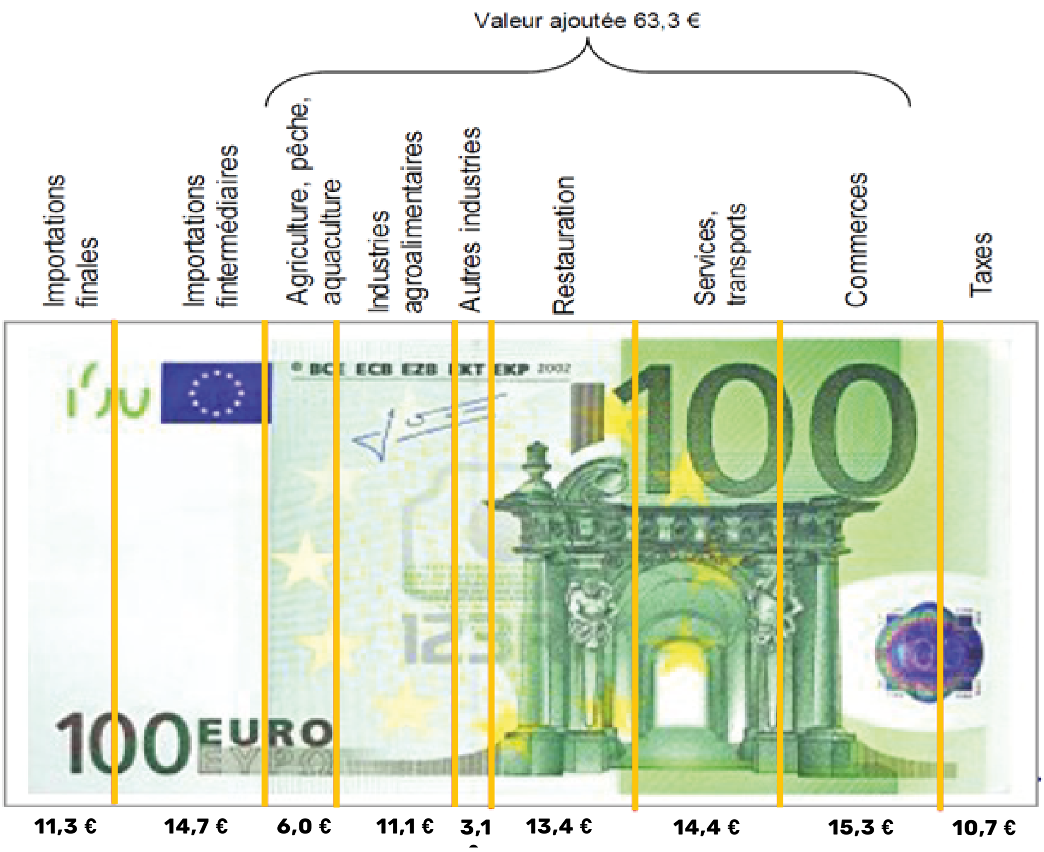


Figure 18. French Food Euro breakdown in 2016
Source: French Food Sector Price and Margin Formation Observatory, 2020

Over 100 euros spent on food-at-home by a French consumer in 2016, 6 euros is arising from French agriculture, 26 euros from importation of food products, 10.7 euros from taxes and the rest corresponds to value created by transformation, retail, restaurants, trade and transportation[33].

32 Observatoire de la Formation des Prix et des Marges des Produits Alimentaires, Rapport au Parlement, 2020
33 Ibid.

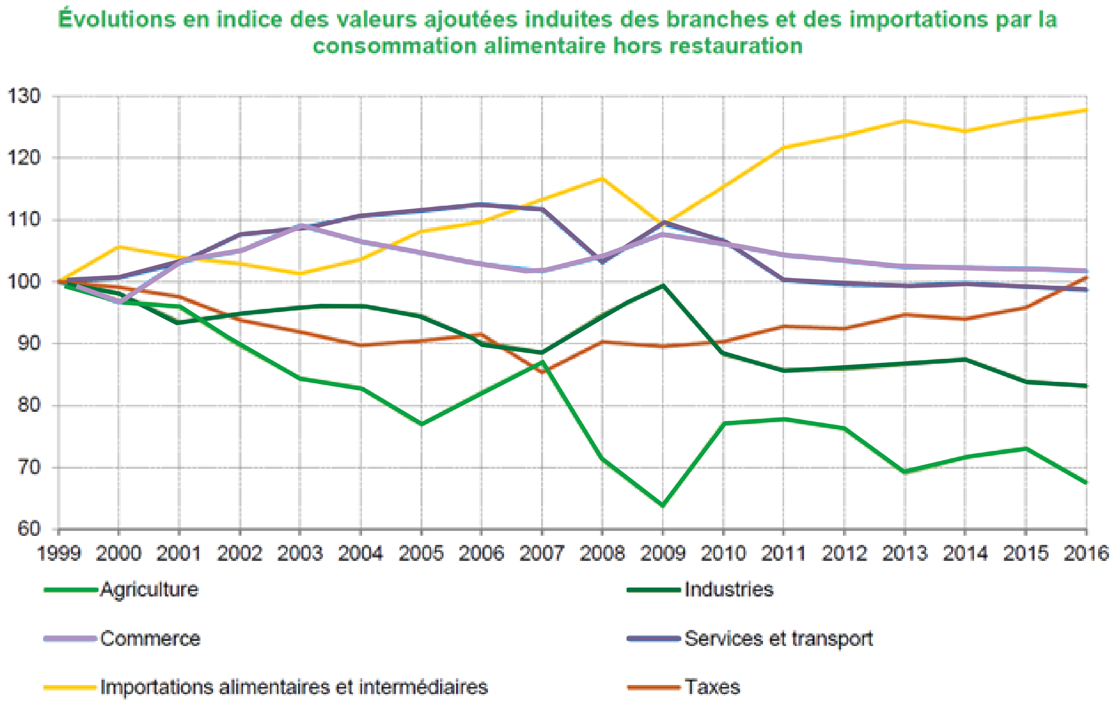


Figure 19. Evolution of the components of the French Food Euro breakdown 1999-2016
Source: French Food Sector Price and Margin Formation Observatory, 2020

According to the research work of the French Observatory, the euro farm share has been steadily decreasing in France since 1995 by more than 30%, whereas other components of the food euro have been on the rise, except for industry share which have declined by 17% (cf. graph on previous page)[34].

34 Ibid.

research work conducted by BASIC in 2017 that investigated the distribution of value:

- across a basket of 12 food products (coffee, cocoa, tea, rice, shrimp, canned tuna, orange juice, banana, table grape, green bean, avocado, tomato)
- purchased from 12 countries of the Global South (Brazil, Ecuador, Colombia, Peru, Morocco, Ivory Coast, Kenya, South Africa, India, Indonesia, Thailand and Vietnam)
- and sold to consumers by retailers in 7 countries (Germany, Netherlands, United Kingdom, USA, Thailand, Indonesia, South Africa).

EVOLUTION OF THE VALUE BREAKDOWN ACROSS FOOD CHAINS FROM THE GLOBAL SOUTH

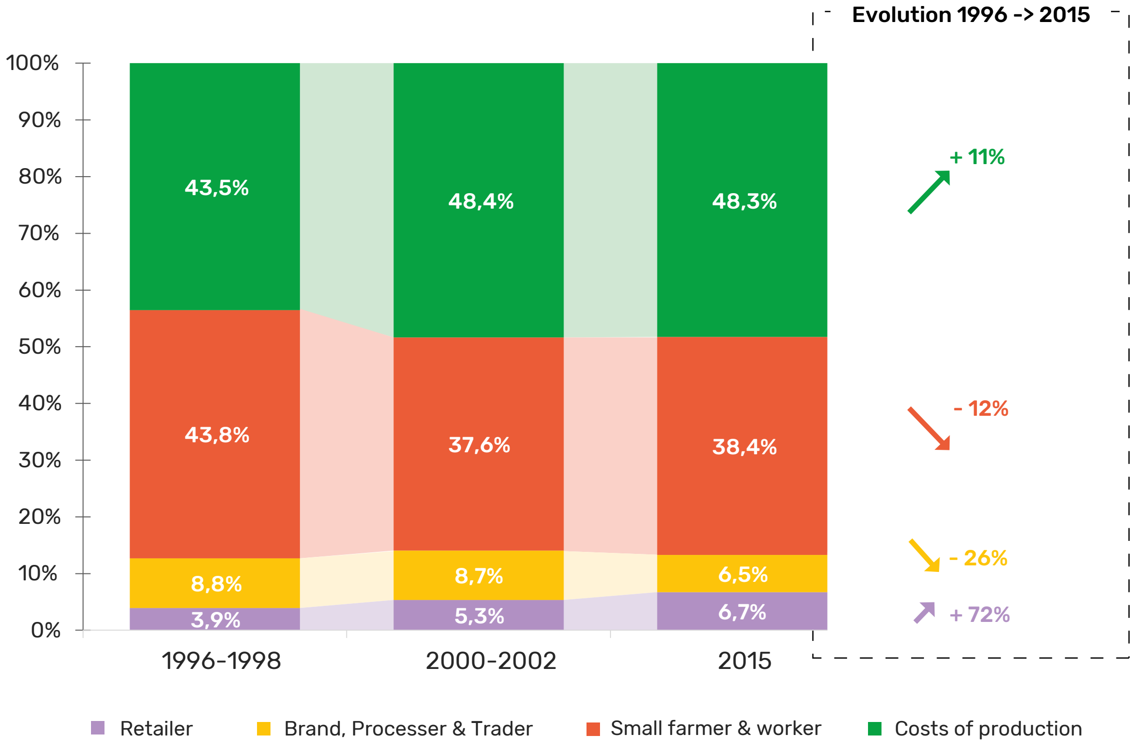


Figure 20. Evolution of the value breakdown across food chains from the Global South across the countries analysed
Source: BASIC, 2017

The results of the estimates of the value breakdown across the basket of products and countries analysed showed two distinct phases over the last two decades:

- at the end of the 1990s and beginning of the 2000s, the retail stage has apparently managed to increase significantly its share of value from 43.5% up to 48.4% on average, while the share of value accruing to processing and trading decreased notably. In this first phase, the share of value of small farmers and workers apparently resisted while the costs of production (fertilizers, pesticides, energy…) increased by 40%.
- Since 2002, the total value allocated to agricultural production has decreased from 14% to 13.2%. More specifically, the value accruing to small farmers and workers has been squeezed from 8.7% down to 6.5% under the combined pressure of increasing costs of production on the one hand, and upstream stages on the other (in particular the processing and trading stage managed to regain some of its lost share of value while the retail stage maintained its share).

As demonstrated in this first section, although the gradual generalisation of technically modernized agriculture based on the combined use of synthetic pesticides, synthetic fertilizers, hybrid varieties and mechanization, has allowed unprecedented productivity gains since the mid-20th century, these gains have significantly eroded over the past 20 years.

In parallel, a strong increase of the expenses of inputs (pesticides and fertilizers) per hectare has occurred in the main agricultural member states of the European Union, much higher than the limited improvement in yields.

In addition, the analysis of the Farm Accountancy Data Network (FADN) shows a clear lowering of farmers' income across EU member states despite increases in yields and use of inputs. This brings to light a likely vicious circle whereby European farmers are spending an ever-increasing amount of money on pesticides and fertilizers in order to try to offset decrease in yields' improvements (compared to the global average trend), while the rising use of these inputs plays a significant role in the decrease of their income.

The improvement of agricultural prices over the past 20 years has indeed not been sufficient to compensate for the jump in farms' expenses and became more and more volatile, thereby generating further negative impacts on the income of EU farmers.

By contrast, a range of recent research studies have demonstrated that agroecological systems– including but not at all limited to organic farming – generate levels and stability in incomes and employment that are, under current circumstances, significantly superior to those generated by conventional farming.

Eventually, recent economic studies on the evolution food value chains over the past decades enable to better understand some of the structural underlying drivers of these findings. In particular, they converge in showing that there has been a long-term growing disconnection between consumer prices and farmers' prices, linked to the commoditisation of agricultural products and the development of mass-consumption, which has led to an increasingly unequal value distribution along food chains at the detriment of farmers in Europe, and even more strikingly of farmers and agricultural workers in the Global South.

The consequences of the focus on agricultural yields on food security, health and the environment

1. Agricultural productivity and undernutrition

In the context of decreasing terms of trade and shrinking share of value accruing to small holders and agricultural workers in globalized food chains, existing estimates demonstrate that the **majority of people suffering from hunger in the world are still farmers**[35].

In 2019, the FAO estimated that 690 million people were suffering from undernutrition in the world, mainly located on the African continent and in South Asia[36].

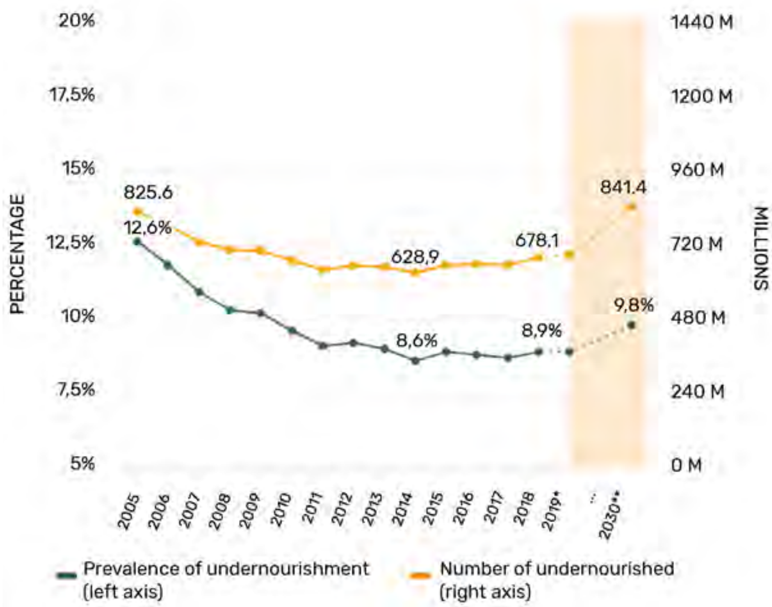


Figure 21. Evolution of the rate of undernutrition and the number of people who suffer from it in the world since 2005, and projections to 2030. Source: FAO, The State of Food Security and Nutrition in the World, 2020 (http://www.fao.org/hunger/en/)

35 INRA, CIRAD. Comité Consultatif Commun d'éthique Pour La Recherche Agronomique, 2009
Borlaug N, Feeding a hungry world. Science 318(5849):359, 2007

36 https://www.who.int/news-room/detail/13-07-2020-as-more-go-hungry-and-malnutrition-persists-achieving-zero-hunger-by-2030-in-doubt-un-report-warns accessed on May 7th 2021

This number has followed a long-term decline since the 1970s, reaching a low point in 2014, but has increased again by 10% since then (see above graph).

According to the FAO, it could exceed 840 million people in 2030 given the dynamics observed since the end of 2019[37]. This estimate does not even take into account the current Covid19 crisis which could cause between 83 million and 132 million additional people suffering from hunger in 2020, due to the economic recession triggered by the pandemic[38].

Looking back over the past 50 years, **the positive results obtained in terms of decline of undernourishment until 2014 were linked to investments in productivity growth in agriculture, coupled with trade liberalization to increase market competitiveness**, which have allowed food to become more abundant and cheaper even as world population more than doubled[39].

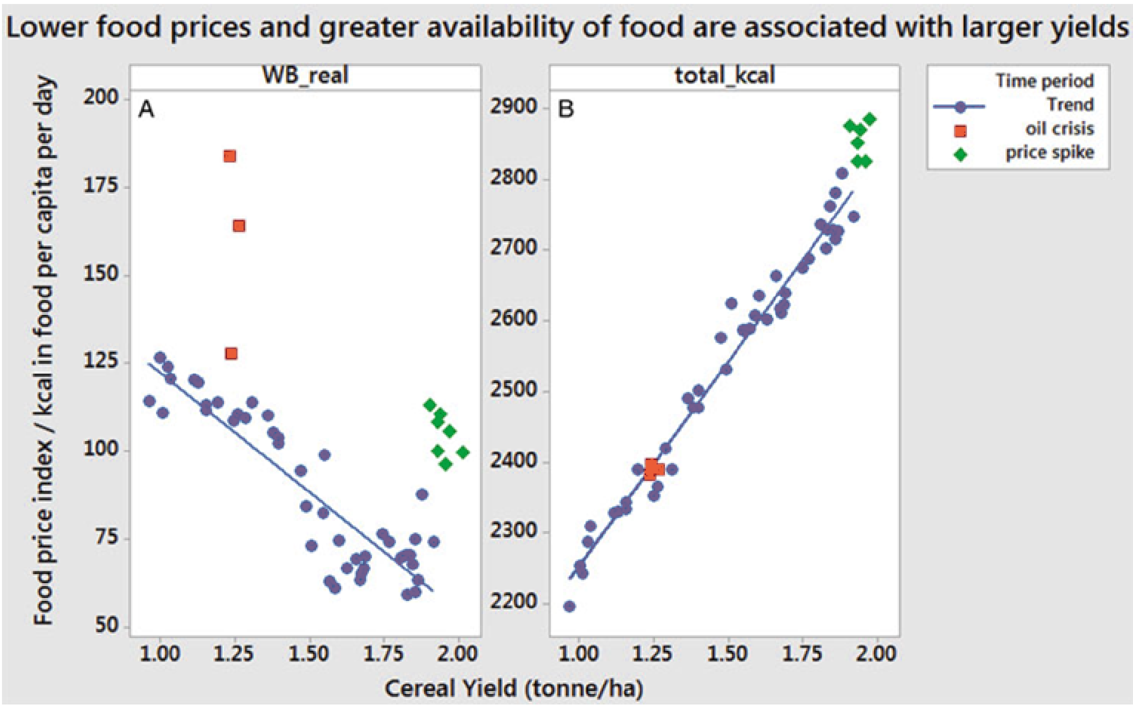


Figure 22. Relationship between average global cereal yields (as a proxy for agricultural productivity), food price and availability. The colour codes represent 'normal' or 'trend' (blue), the 1970s oil crisis (red) and the period from the 2007 food price spike (green).
Source: Benton TG, Bailey R. (Global Sustainability journal, 2019)

This has been objectified in a recent academic paper by Tim Benton and Rob Bailey in the Global Sustainability Journal of Cambridge University press[40]: the data from the World Bank[41]

37 FAO, The State of Food Security and Nutrition in the World, 2020 - http://www.fao.org/hunger/en/ accessed on May 7th 2021
38 https://www.who.int/news-room/detail/13-07-2020-as-more-go-hungry-and-malnutrition-persists-achieving-zero-hunger-by-2030-in-doubt-un-report-warns accessed on May 7th 2021
39 Ercsey-Ravasz, M., Toroczkai, Z., Lakner, Z., & Baranyi, J. Complexity of the international agro-food trade network and its impact on food safety. PLoS One, 7(5), 2012
40 T.G. Benton, R. Bailey, The paradox of productivity: agricultural productivity promotes food system inefficiency. Global Sustainability 2, e6, 1–8, 2019 https://doi.org/10.1017/sus.2019.3
41 cereal production divided by area of cultivation

and FAOSTAT[42] since the 1970s show that cereal yields increase is correlated with declining average food price and increasing calories available per person at global level (cf. above diagram).

2. Consequences on human health and food waste

According to T. Benton and R. Baily, **these correlations are the result of the growing specialization of global agriculture which has become increasingly focused** on a few highly productive commodity crops suited to industrial farming systems and grown at scale in a limited number of areas. As a result, over 50% of the todays' world crop calories come from wheat, rice and maize, and even 76% when adding sugar, barley, soy, palm and potato[43].

According to them, **this evolution has generated several adverse consequences**, in particular[44]:

- the **growth of unbalanced processed foods**, as food manufacturers have formulated more and more products derived from these abundant, low-cost, high-calorie commodities,
- the **rapid growth of the livestock sector and the associated growth in meat and dairy consumption**, thanks to the growth in availability and affordability of animal feeds derived from commodity staples, notably soybean and coarse grains,
- the **decline of the economic incentive to avoid food waste**, as productivity growth and global competition have driven food prices downward.

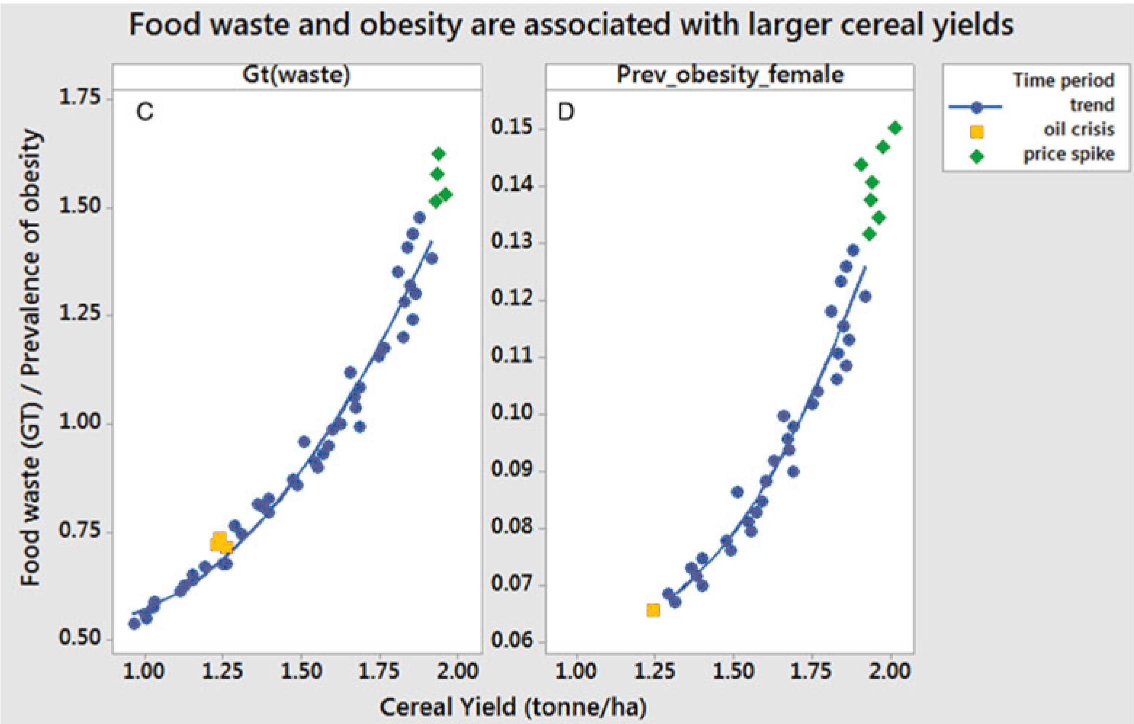


Figure 23. Relationship between average global cereal yields (as a proxy for agricultural productivity), food waste and obesity. The colour codes represent 'normal' or 'trend' (blue), the 1970s oil crisis (red) and the period from the 2007 food price spike (green).

42 deflated food price index
43 T.G. Benton, R. Bailey, The paradox of productivity: agricultural productivity promotes food system inefficiency. Global Sustainability 2, e6, 1–8, 2019 https://doi.org/10.1017/sus.2019.3
44 Ibid.

Source: Benton TG, Bailey R. (Global Sustainability journal, 2019)

To objectify these trends, T. Benton and R. Bailey have used the data from two other recent studies on obesity (NCD-RisC, 2016[45]) and waste (Porter et al., 2016[46]) and demonstrated that[47]:

- **as yields grow, more people become overweight and obese** (cf. above diagram) because calories become cheaper and more available (cf. figure 21 on previous page). The focus on yield growth to reduce hunger is thus contributing to the convergence of world diets towards more uniform food products which are made from a limited number of cheap energy-dense commodities rather than more expensive nutrient-rich fruits and vegetables.
- **as yields grow, waste grows faster** (cf. above diagram) because of the availability of cheap food. In addition, the increasing use of crops for feed in intensive livestock systems creates further inefficiencies through trophic losses (today, over 30% of global calories are used as feed).

Regarding health issues, the WHO estimates that today 39% of the world population is overweight and that 13% suffers from obesity, mainly in the American continent and in the Caribbean (more than 50% of the population is obese or overweight in Brazil, and over 71% in the United States) as well as in Europe and the Pacific[48]. Worryingly, these proportions have more than doubled since 1980, prompting the WHO to say in 2015 that obesity had now reached epidemic levels internationally and that more than half of the world's population could be overweight or obese by 2030[49].

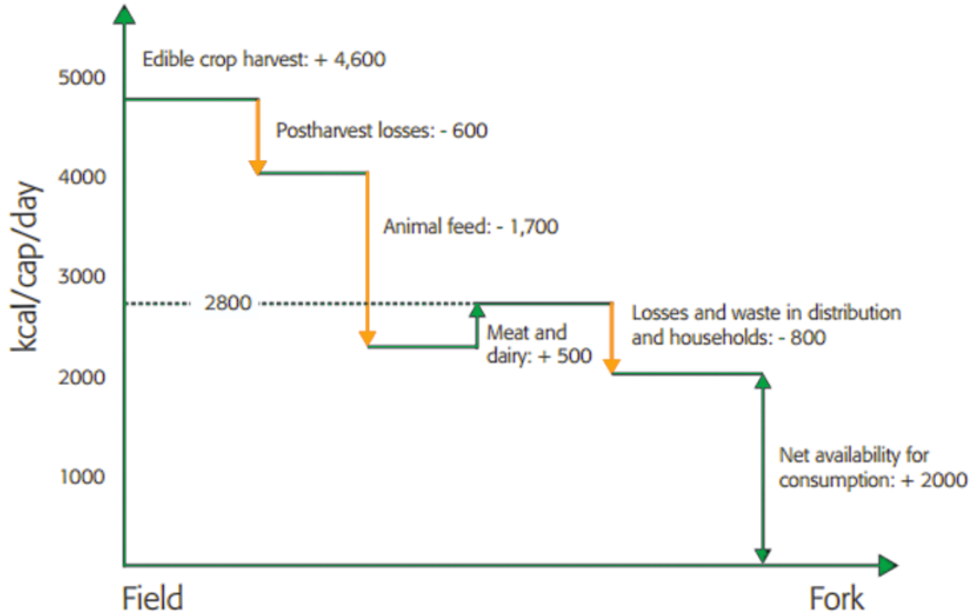


Figure 24. Total number of food calories produced and available per person in the world, and associated losses and inefficiencies Source: Lundqvist, J., de Fraiture, C., Molden, D., Saving water: from field to fork, 2008

45 NCD-RisC. Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19.2 million participants. The Lancet, 387(10026), 1377–1396, 2016

46 Porter, S. D., Reay, D. S., Higgins, P., & Bomberg, E. A half-century of production-phase greenhouse gas emissions from food loss and waste in the global food supply chain. Science of the Total Environment, 571(Supplement C), 721–729, 2016. https://doi.org/10.1016/j.scitotenv.2016.07.041

47 T.G. Benton, R. Bailey, The paradox of productivity: agricultural productivity promotes food system inefficiency. Global Sustainability 2, e6, 1–8, 2019 https://doi.org/10.1017/sus.2019.3

48 WHO, Estimates of the Global Burden of Foodborne Diseases, 2015
Chan M., Obesity and diabetes: The slow-motion disaster. Keynote address at the 47th meeting of the National Academy of Medicine, 2016
NCD-RisC, Trends in adult body-mass index in 200 countries from 1975 to 2014, The Lancet, 2016
Bahia L et al., The costs of overweight and obesity-related diseases in the Brazilian public health system, 2012

49 WHO (Organisation Mondiale de la Santé), Estimates of the Global Burden of Foodborne Diseases, 2015

Regarding the issues of losses, waste and inefficiencies at global level, more than twice as many calories are currently produced by world agriculture than what is ultimately available to consumers (see above graph)[50].

In this context, reducing loss and waste along food chains appears to be a much-neglected key leverage to address the current global food challenge[51]: according to the United Nations, by 2050, the world population is expected to reach 9.2 billion, which would require an additional increase of 60 % of world agricultural production[52].

According to T. Benton and R. Bailey, the current systemic inefficiency is paradoxically a result of the push for efficiency at farm level. The priority given to agricultural yields emerged out of a need to fulfil consumption demand on a global basis, at a time when lack of access to food was a real issue whereas today, malnutrition from overconsumption of calories affects more people than undernutrition[53].

The current focus on agricultural productivity growth is to be put in question, particularly since recent academic research are showing that the yields of the main agricultural crops that have benefited from "agricultural modernization" **have started to stagnate** in several regions of the world, as best exemplified by the cases of maize in Kansas and rice in Hokkaido[54].

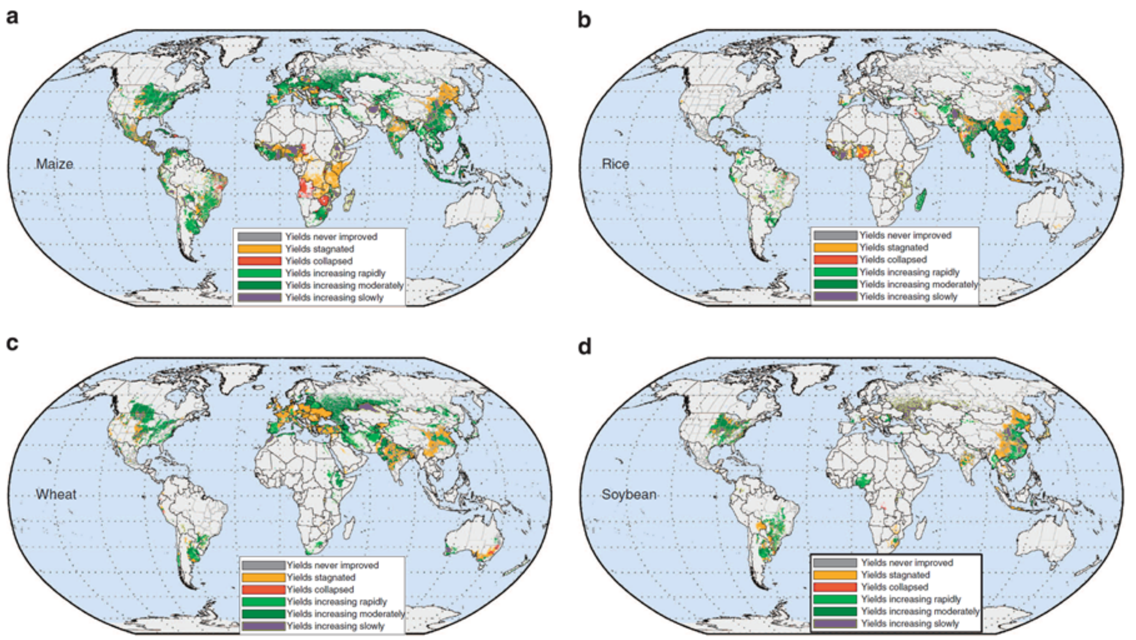


Figure 2 | Global maps of current crop yield trends. At each political unit where (**a**) maize, (**b**) rice, (**c**) wheat and (**d**) soybean crop yields were tracked globally, we determined the status of their current yield trend. The trends were divided into the six categories and colour coded. We show in the maps only those areas in the political unit where the crop was harvested.

Figure 25. Global maps of trends in yields of maize (a), rice (b), wheat (c) and soybeans (d). Source : Ramankutty N., Ray D.K., Mueller N.D., West P.C., Foley J A. Recent Patterns of Crop Yield Growth and Stagnation. Nature Communication, 2012

50 Lundqvist, J., de Fraiture, C., Molden, D., Saving water: from field to fork: curbing losses and wastage in the food chain, 2008

51 IPES Food. From University to Diversity: A Paradigm Shift from Industrial Agriculture to Diversified Agroecological Systems, 2016

52 FAO. Save and grow: A policymaker's guide to the sustainable intensification of smallholder crop production. Rome: Food and Agriculture Organization of the United Nations, 2011

53 T.G. Benton, R. Bailey, The paradox of productivity: agricultural productivity promotes food system inefficiency. Global Sustainability 2, e6, 1–8, 2019 https://doi.org/10.1017/sus.2019.3

54 IPES Food. From University to Diversity: A Paradigm Shift from Industrial Agriculture to Diversified Agroecological Systems, 2016

As revealed by a meta-analysis of the evolution of yields in the world from 1961 to 2008 (see above map), 24% to 39% of areas cultivated with maize, rice, wheat and soybeans at the level global yields did not improve, eventually stagnated or even declined after a period of initial gains[55].

These trends seem to be result from a combination of environmental factors, in particular climate change, land degradation, pesticide resistances, erosion of biodiversity and loss of associated ecosystem functions[56].

3. The inherent impacts of the current food system on the environment

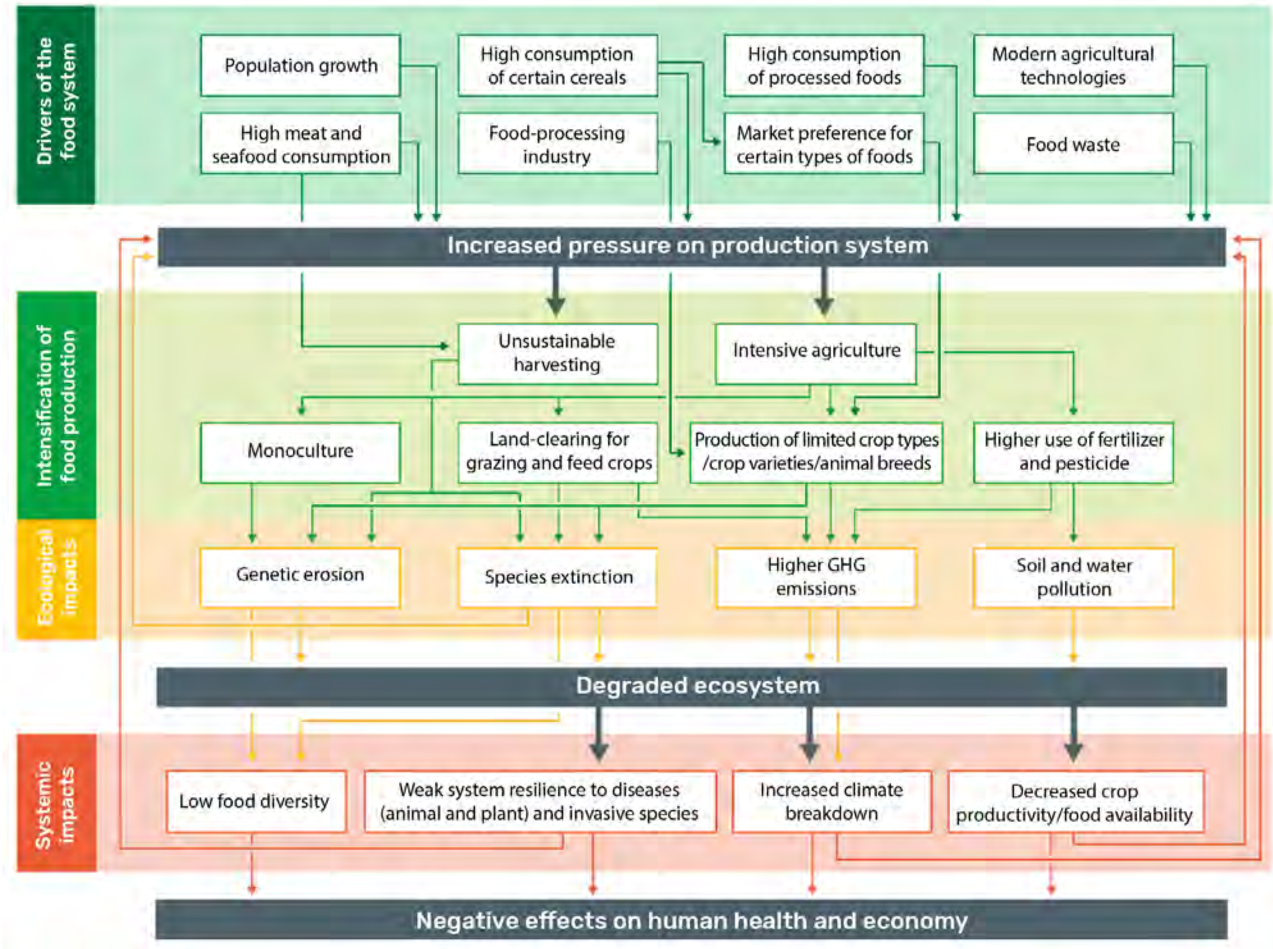


Figure 26. The food system and its impacts on the environment (biodiversity, climate, soil, water, etc.).
Source: Benton et al., Food system impacts on biodiversity loss:
Three levers for food system transformation in support of nature, 2021

55 Ray, D. K.; Ramankutty, N.; Mueller, N. D.; West, P. C.; Foley, J. A. Recent Patterns of Crop Yield Growth and Stagnation. Nature Communication, 2012
56 Ibid.

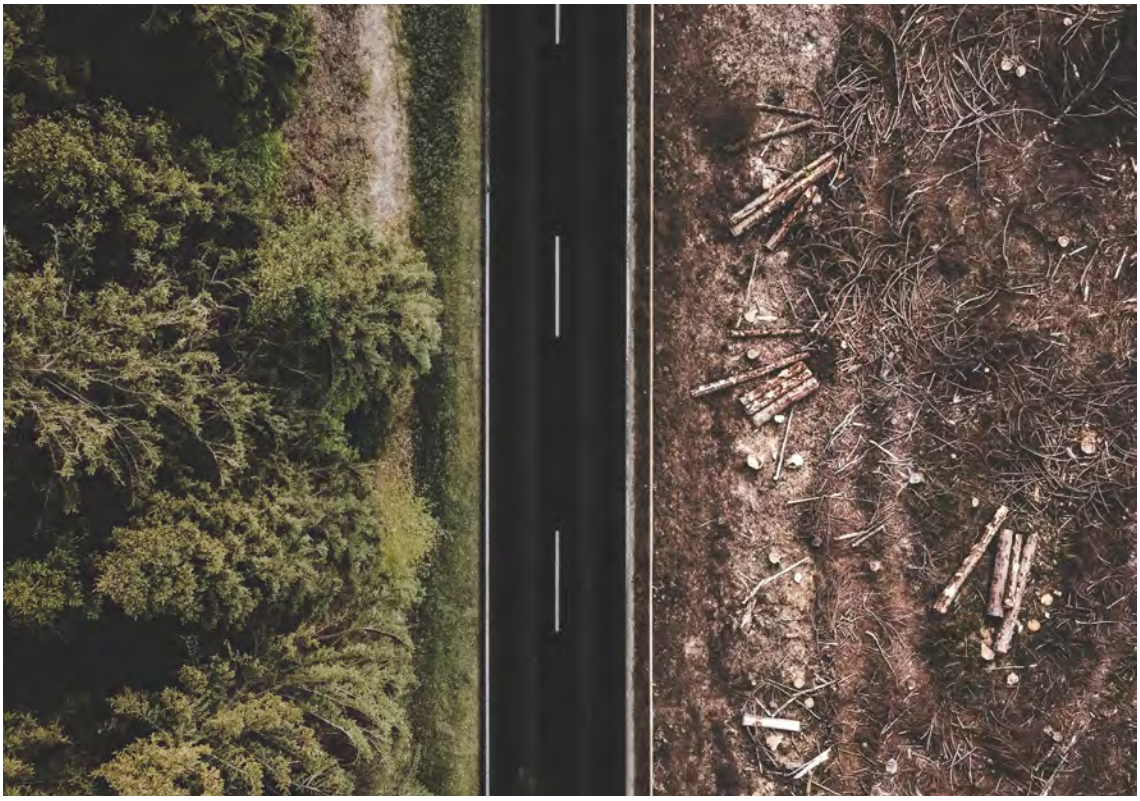
A recent report from the Chatham House published in 2021[57] has demonstrated that it is the current structure of the world's food system, through a combination of factors, which is driving these environmental impacts (see above diagram):

- the way in which food is produced and used,
- the types of food produced,
- the way in which supply, demand and price interact to drive agriculture,
- the privileging of productivity growth over the sustainable use of finite resources.

The authors conclude that the current food system has come to threaten the ecosystems on which it very much depends.

Firstly, agriculture has become the single largest cause of land-use change and habitat destruction, accounting for 80 % of all land-use change globally. As land is converted to crop production for human consumption or farmed animal feed, habitat is lost for wild animals, plants and other organisms[58].

The greatest loss of intact ecosystems in recent decades has occurred in the tropics, the world's most biodiverse regions, because of the conversion of forests for the production of soy, cattle and palm oil. **From 1980 to 2000, 42 million hectares of tropical forest in Latin America were lost to cattle ranching, while 6 million hectares were lost to palm oil plantations in Southeast Asia**[59].



57 Tim G. Benton, Carling Bieg, Helen Harwatt,, Roshan Pudasaini and Laura Wellesley, Food system impacts on biodiversity loss: Three levers for food system transformation in support of nature, Research Paper, Chatham House, 2021

58 Ibid.

59 Ibid.

The impacts of food production on biodiversity are not limited to farm and landscape scale.

Synthetic fertilizers and manure are both important sources of **air pollution in the form of nitrogen oxides (NOx) and ammonium** (NH_3) which in turn help create secondary particulate matter (PM), which contributes to poor air quality and smog[60]. In periods of rain, **excess nutrients and sediment from poorly managed soils can wash into rivers over long distances** and lead to the proliferation of algae covering the water surface and suffocating the aquatic or marine life beneath[61].

Source	Amount	Units
Total global anthropogenic GHGs	52.0 ± 4.5	$GtCO_2e\ y^{-1}$
Agricultural land-use change	4.9 ± 2.5	$GtCO_2\ y^{-1}$
Methane from ruminant animals and soils	4.0 ± 1.2	$GtCO_2e\ y^{-1}$
Nitrous oxide (fertilizer, manure)	2.2 ± 0.7	$GtCO_2e\ y^{-1}$
Transport, manufacturing, cooking etc.	2.4–4.8	$GtCO_2e\ y^{-1}$
Total global food system GHGs	15.0 (10.6–19.4)	$GtCO_2e\ y^{-1}$
	28.9 (20.4–37.3)	**% contribution to total GHGs**

Figure 27. Average (2007–16) annual emissions of greenhouse gases from the food system
Source: IPCC (2019), 'Summary for Policymakers', Climate Change and Land

At the global level, food production also contributes significantly to climate change: when taking into account the emissions associated with agriculture, land-use change for agriculture, as well as the processing and transporting of food, the food system accounts for roughly 30 % of all anthropogenic emissions (see table above). Consequentially, the rising global temperatures are changing habitat suitability throughout the world and prompting the movement of suitable habitats, species either being obliged to move with them or risk extinction[62].

Climate change is not only partly caused by the current structure of the food system, but also affects it increasingly. It reduces crops' yields and nutritional quality across many producing regions, thereby further increasing the pressure to intensify production or convert more land to agriculture. Moreover, as Green House Gas emissions continue to rise, there is an increasing need to sequester carbon in the land as a means to mitigate climate change, including through afforestation/ reforestation, which in turn increase competition for land, further increasing incentives to intensify farming[63].

60 Ibid.
61 Ibid.
62 Ibid.
63 *IPCC, 'Summary for Policymakers', Climate Change and Land*, 2019

4. The hidden costs of the current food system

As demonstrated in the scientific article of T. Benton and R. Bailey, incentives for production, global competition based on price, and long supply chains that reduce transparency together **encourage the externalization of production costs on the environment and society as a whole**. As a result, the farmers that produce food without externalizing costs struggle to be competitive in the market[64].

According to the research work commissioned by the FAO, the environmental costs of agriculture at global level would exceed the market value of production[65]. In the USA, the costs of air pollution alone on human health from agricultural production amount to about half its value[66].

Regarding health issues, the FAO estimated in 2013 that healthcare costs from poor diets might exceed each year 5% GDP[67]. This is likely to be an underestimate as the direct costs of type II diabetes alone could amount in 2025 to 4–5% of GDP[68]. In comparison, the global agricultural added value to GDP was only 3.79% in 2015[69].

As stated by T. Benton and R. Bailey in the conclusion of their article in 2019:
"*A continued myopic focus on agricultural productivity risks perpetuating these problems: the productivity paradox means that increasing agricultural efficiency drives system inefficiency through increased waste, increased environmental costs and increased healthcare costs. A challenge for global development is that endeavouring to 'feed a world of 7–10 billion' in the way we are currently fed will create more problems than it solves through driving the vicious circle. As well as being unsustainable, this is iniquitous because the local and global poor disproportionately pay the costs levies on health and environment. Instead, we should change the narrative to empower people to invest in their nutrition for a healthy life, eating food that is supplied by a sustainable food system. There is an urgent need to move the focus from thinking about agricultural productivity as a proxy for the outcomes society needs, and instead to focus fully on systemic productivity: people fed healthily and sustainably per unit input.*"[70]

64 T.G. Benton, R. Bailey, The paradox of productivity: agricultural productivity promotes food system inefficiency. Global Sustainability 2, e6, 1–8, 2019 https://doi.org/10.1017/sus.2019.3
65 FAO, Natural Capital Impacts in Agriculture: Supporting Better Business Decision-Making, 2015
66 Ibid.
67 FAO, State of Food and Agriculture 2013: Food systems for better nutrition.Rome, Italy, 2013
68 NCD-RisC, Worldwide trends in diabetes since 1980: a pooled analysis of 751 population-based studies with 4.4 million participants. The Lancet, 387(10027), 1513–1530, 2016 https://doi.org/10.1016/S0140-6736(16)00618-8
69 FAO, Natural Capital Impacts in Agriculture: Supporting Better Business Decision-Making, 2015
70 T.G. Benton, R. Bailey, The paradox of productivity: agricultural productivity promotes food system inefficiency. Global Sustainability 2, e6, 1–8, 2019 https://doi.org/10.1017/sus.2019.3

This second section starts with questioning the central role given to agricultural productivity as the main way to tackle undernutrition.

While the number of people suffering from undernutrition in the world has followed a long-term decline since the 1970s, reaching a low point in 2014, it has increased again by 10% since then and is at risk of severely increasing in the wake of the Covid19 crisis.

Furthermore, in the context of decreasing terms of trade and shrinking share of value accruing to small holders and agricultural workers in globalized food chains, the majority of people suffering from hunger in the world are still farmers.

Notwithstanding these inflexions, the current dominating strategy of public policies continues to be driven by investments in productivity growth in agriculture, coupled with trade liberalization to increase market competitiveness.

However, these strategies have led to the growing specialization of global agriculture which is more and more focused on a few highly productive commodity crops suited to industrial farming systems and grown at scale in a limited number of geographical areas.

This evolution has generated several adverse consequences, in particular:

- the growth of unbalanced processed foods (more and more processed food products being derived from abundant, low-cost, high-calorie commodities),
- the rapid growth of the livestock sector and the associated growth in meat and dairy consumption, thanks to the growth in affordability of animal feeds derived from commodity staples (notably soybean and coarse grains),
- the decline of the economic incentive to avoid food waste, as productivity growth and global competition have driven food prices downward.

According to recent studies, these combined evolutions appear to be some of the main drivers of the current development of overweight and obesity (39% of the world population being overweight and 13% suffering from obesity according to the WHO) as well as food waste generation (more than twice as many calories are currently produced by world agriculture than what is ultimately available to consumers).

These findings are not one-offs. Over the past decade, more and more academic research works have been calling into question the current focus on agricultural productivity growth, documenting that yields of leading crops (maize, rice, wheat, soybeans) have started to stagnate in multiple countries and that more profoundly, the current food system has come to threaten the ecosystems on which it very much depends.

At the heart lies a malfunction of the current economic system that need to be fixed: the externalization of costs on the environment and society, which is encouraged by public financial incentives for production, global competition based on price, and long supply chains with very limited transparency.

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