PESTICIDES

A MODEL THAT'S COSTING US DEARLY

An initial cost-benefit analysis of the pesticide sector at the European level.

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BASIC
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3 Introdution

4 Economic growth, to the benefit of a few multinationals

A booming international market

Industry concentration

8 The usefulness of pesticides in question

Limits to the race for yields

Food: the challenge of quality and access for all

Gains in productivity… but not for farmers

10 Major negative impacts

Pesticides everywhere…

Systemic effects on fauna and flora

The dawning recognition of the effects on human health

14 A disadvantageous cost-benefit situation

Actual expenditures linked to pesticides twice as high as industry profits

Pesticide manufacturers' influence strategy

17 Polarization of the sector

Double jeopardy for the countries of the South

New technologies, the next driver of growth for agriculture?

20 Notes

Introduction

The growing presence of pesticides in our daily lives is intrinsically linked to the agricultural revolution of the 20th century, through which a new paradigm spread to the four corners of the Earth. It is a paradigm that has been strongly supported by public authorities, who have claimed that its goal is to improve global food security. The paradigm is based on four interdependent pillars[1] : motorized and industrialized agricultural machinery; synthetic fertilizers; hybrid seeds; and, consequently, widespread use of synthetic pesticides.

The increases in yields that ensued from setting up this paradigm have long served to justify the systemic use of pesticides. However, the question of the negative impact of pesticides has gradually become a major topic in public discussions and policies.

In fact, French President Emmanuel Macron even pledged, at the opening of the most recent IUCN Congress, to take advantage of the French presidency of the EU in 2022 to work towards an accelerated phase-out of pesticides[2]. This is theoretically a more radical stance than that of the European Union, which has set a target of a 50% reduction in pesticide use in Member States by 2030[3].

However, this objective is far from receiving unanimous support from the agricultural and food sectors. The major farmers' unions and agribusiness lobbies put forward the economic benefits derived from pesticide production and use, as well as the potential economic risks and losses that they claim could result from pesticide reduction[4].

The debate between pro- and anti-pesticide protagonists is in full swing, and the controversy is all the more complicated because access to economic data on pesticides is limited. Indeed, the pesticide industry publishes few figures, and the business secrets involved make verification difficult, if not impossible.

Against this backdrop, the main goal of our research was **to render the various economic arguments of the debate as objective as possible**, all the while including the socio-environmental issues linked to pesticide use into this analysis.

At a time when the main EU public policies on this topic are being discussed or arbitrated (Common Agricultural Policy, Sustainable Use of Pesticides Directive, etc.), we hope that our findings will help fuel public discussion on these issues and be of aid in drafting recommendations that are consistent with the major social and environmental challenges of the years to come.

4 INTERDEPENDENT PILLARS :

- → MOTORIZED AND INDUSTRIALIZED AGRICULTURAL MACHINERY
- → SYNTHETIC FERTILIZERS
- → HYBRID SEEDS
- → WIDESPREAD USE OF SYNTHETIC PESTICIDES

Economic growth, to the benefit of a few multinationals

A booming international market

The global pesticide market has almost doubled in the last 20 years, reaching **sales of nearly €53 billion in 2020** (US$60 billion). This figure is roughly the same as the GDP of Luxembourg. With more than 60% of total sales made in import-export transactions, it is a globalized market in which the majority of sales are now cross-border[5].

The European Union is one of the biggest consumer markets, with €12 billion in sales to farmers in 2019[6]. It is also the top exporting region, with €5.8 billion in sales that same year[7] and 27,000 jobs linked to the industry[8].

sales multiplied by 2 in 20 years

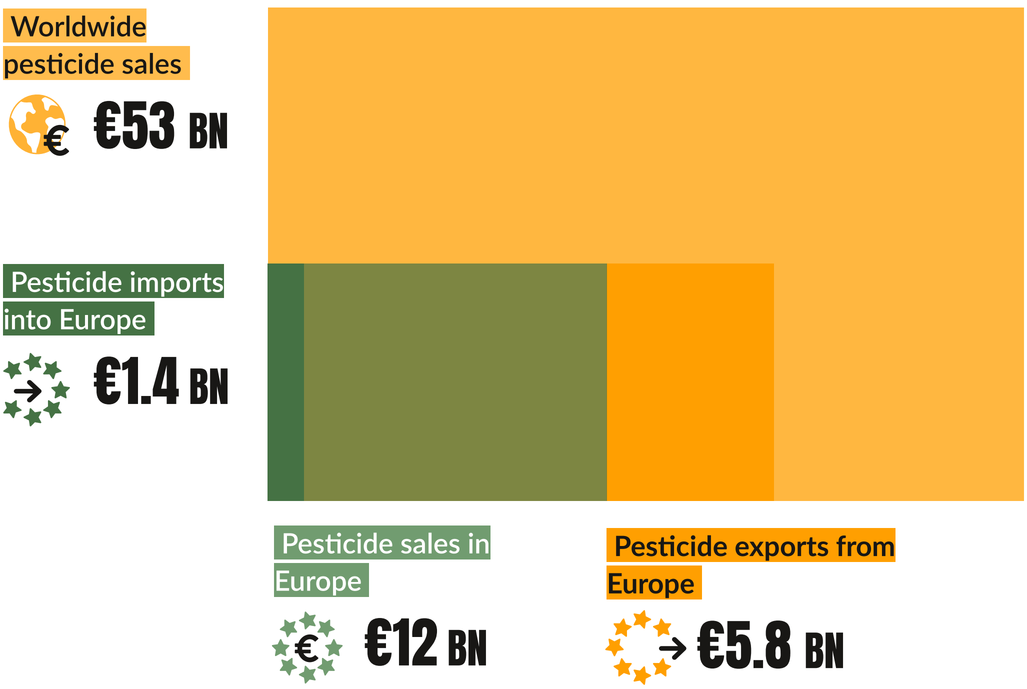


Figure 1. Global and European markets for agricultural pesticides in 2019.
Source: BASIC, based on data from Comtrade, Phillips McDougall and Corteva

Within the European Union, **France is by far the biggest market for agricultural pesticides, accounting for a quarter of total sales and with an estimated value of €3 billion in 2017**[9] - an amount equivalent to the public subsidies received by farmers to protect the environment[10] (around €2.7 billion). Next come Germany, Spain, Italy, the United Kingdom and Poland, which together account for 50% of the European market[11]. Per-farmer expenditure in the EU has also increased significantly over the last 30 years (see below). By country, the top per-farmer expenditures can be found in these same six countries.

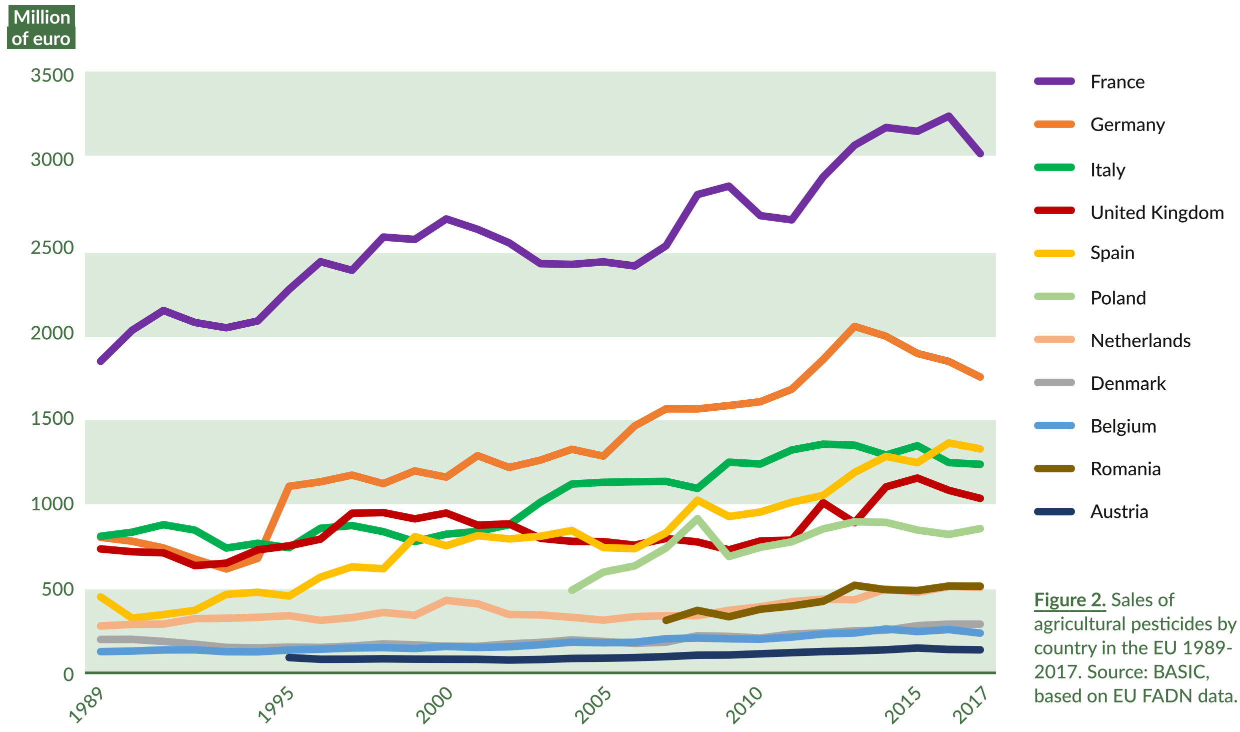


Figure 2. Sales of agricultural pesticides by country in the EU 1989-2017. Source: BASIC, based on EU FADN data.

But most of the sector's growth is now taking place outside Western Europe. Looking at trends in agricultural pesticide sales between 2013 and 2018, the highest growth rates were mainly in the agro-exporting countries of Latin America and Eastern Europe[12]. Argentina, for example, experienced a growth rate of nearly 40% over five years, followed by Russia (+25%), Romania (+15%) and Brazil (+7%).

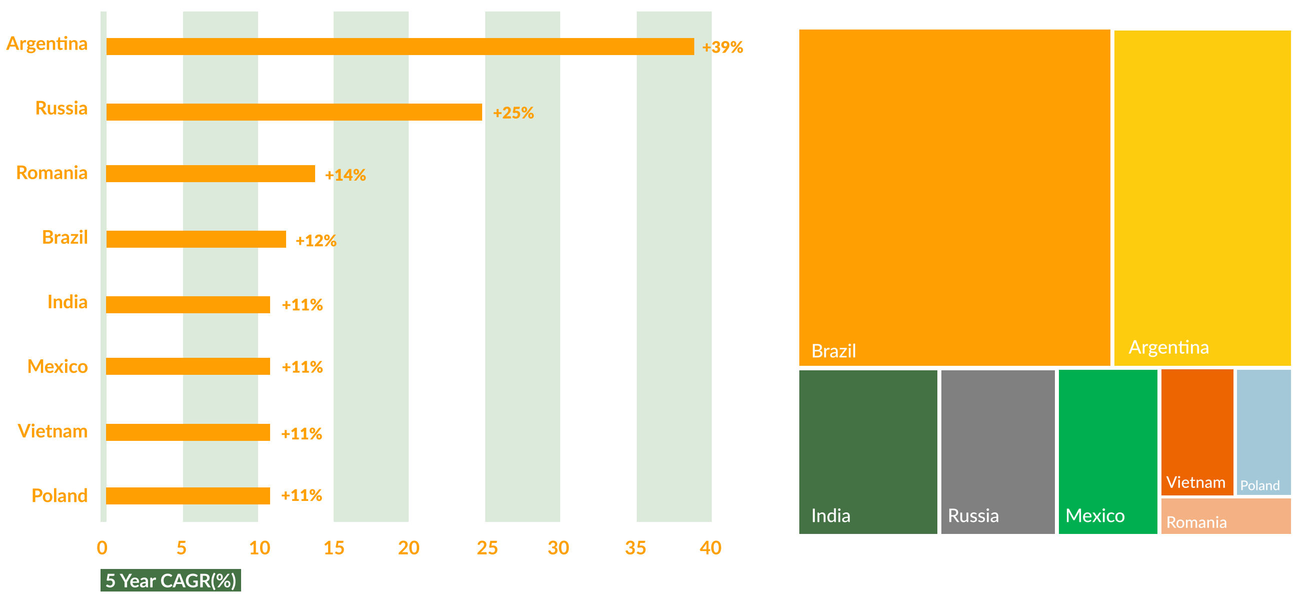


Figure 3. Pesticide use by country and growth 2013-2018 in agricultural pesticide sales by country.
Source : Sales growth : AgbioInvestor - Phillips, M. W. A. Agrochemical Industry Development, Trends in R&D and the Impact of Regulation. Pest Management Science 2019
Pesticide use by country (in tons of active substances) : FAOSTAT
https://www.fao.org/faostat/en/#data/RP/visualize

Industry concentration

IN 1990, 16 FIRMS ACCOUNTED FOR ABOUT 80% OF THE PESTICIDE MARKET. BUT SUCCESSIVE MERGERS AND ACQUISITIONS HAVE LED TO A MARKET WITH FOUR LEADING COMPANIES – BAYER, BASF, SYNGENTA/CHEMCHINA AND CORTEVA – WHICH TOGETHER OCCUPY MORE THAN TWO THIRDS OF THE MARKET[13].

This concentration has gone hand in hand with the combining of pesticide and seed activities, in order to optimize synergies between the two. In this way, the four above-mentioned companies have also become the leaders in the agricultural seed sector, holding **nearly a 60%** share of the global market[14]. This strategy has enabled them to reach a high level of profitability, with profit-to-turnover ratios of 10% to 20%, i.e., 50% above the European manufacturing industry average[15].

At the same time, generic pesticides are becoming increasingly popular[16], as their sales price is four times less that of patented products[17]. In fact, they now account for more than two thirds of global pesticide sales, compared to 25% barely 20 years ago[18]. The large-scale production of these generic products has been made possible by new players having entered the market, mainly from China and India[19], These two countries have become the world's largest and fifth-largest exporters respectively. Their export sales of pesticides have increased more than tenfold since 2000[20].

In addition to the manufacture of generic products, these countries have also become the main suppliers of the active substances used in the formulation of pesticides manufactured in Europe, according to recent findings by the European Commission[21]. As Asian firms grow in power, they take after the major European groups by adopting strategies of merger and acquisition and of vertical integration, in order to better compete with them[22]. In fact, ChemChina, the top Chinese chemical company, which emerged from a wave of fusions among state-owned companies, has recently become the world's leading chemical company, particularly in agrochemicals. This was thanks to its recently finalized merger with SinoChem (another national heavyweight also owned by the Chinese state) and to its 2017 takeover of Syngenta, one of the three traditional leaders in pesticides in Europe[23].

Three of the largest fertiliser and pesticide manufacturers are partly owned by the same five US private equity funds, and the world's leading pesticide company is now fully controlled by the Chinese state.

In terms of shareholders, the three largest fertilizer and pesticide firms (with the exception of Chinese state-owned Syngenta/Chemchina) have in common the fact that they are partly owned by the same five private equity funds: Blackrock, Vanguard, State Street, Capital Group and Fidelity. These funds also own between 10% and 30% or more of the capital of the global leaders in the agricultural and food sector, such as Deere & Co, CF Industries, ADM, Tyson, Kellogg's, Unilever, Nestlé, Mondelez, Cocoa Cola, Pepsi and other[24].

In the end, these trends in the pesticide sector now call into question the capacity of States and their people to ensure their food sovereignty, i.e., the ability to freely and democratically define their agricultural and food policies.

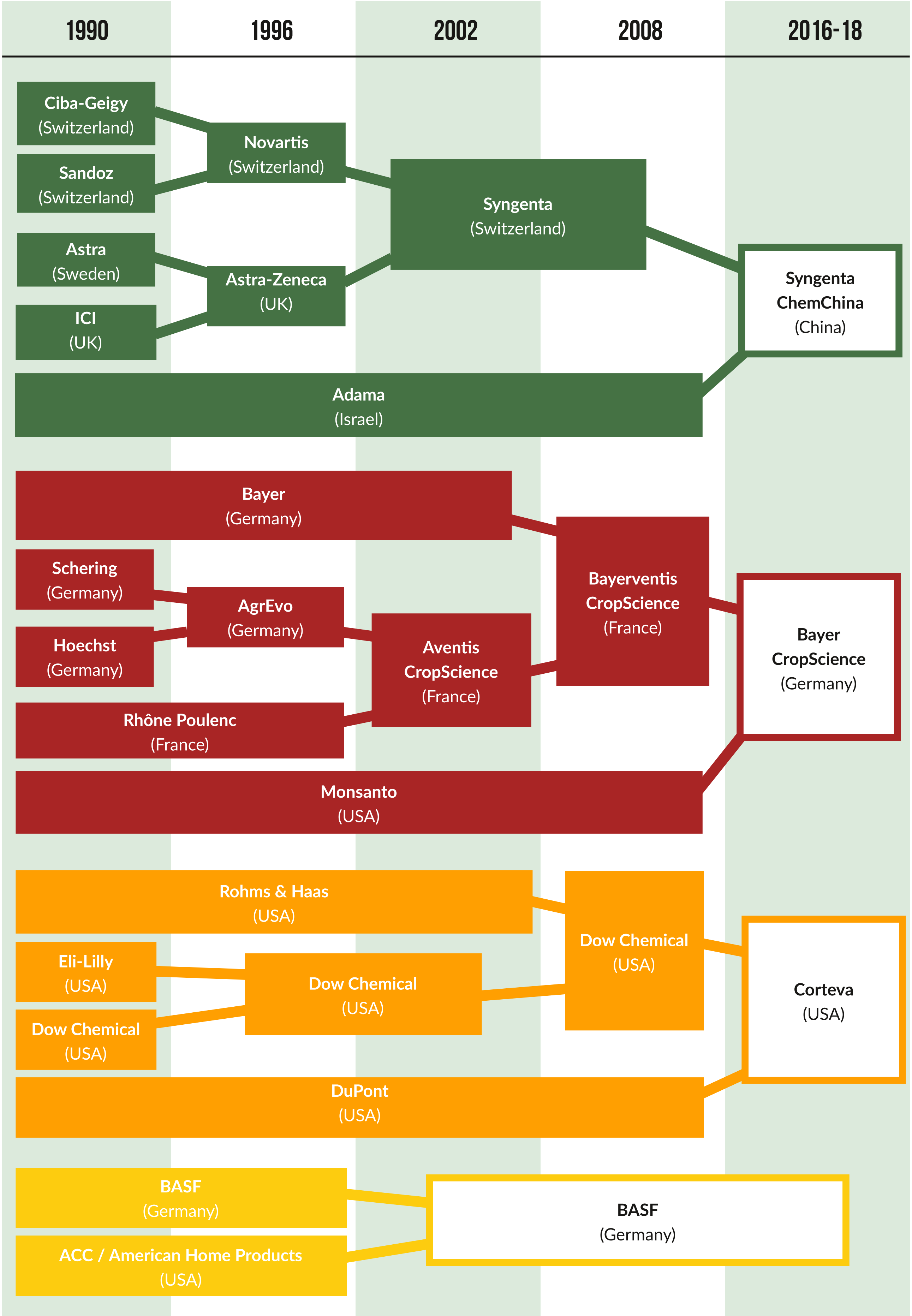


Figure 4. Overview of the leading players in the pesticides sector in 1990, 1996, 2002, 2008 and 2018. Source: BASIC, based on IPES Food ("Too big to feed: Exploring the impacts of mega-mergers, consolidation and concentration of power in the agri-food sector", 2017) and Umetsu & Shirai ("Development of Novel Pesticides in the 21st Century", Journal of Pesticide Science 45, 2020)

The usefulness of pesticides in question

IN A FEW DECADES, THE AGRICULTURAL WORLD HAS BEEN INTEGRATED – IN THE NAME OF GENERAL INTEREST – INTO AN AGRO-INDUSTRIAL SYSTEM AND, MORE BROADLY, INTO AN ECONOMIC SYSTEM GOVERNED BY THE NECESSITIES OF COMPETITION, PROFIT MAXIMIZATION, CAPITAL ACCUMULATION AND REDUCTION OF LABOUR COSTS[25].

Limits to the race for yields

The development of agricultural production systems based on the combined use of machinery, fertilizers, pesticides and hybrid/GMO varieties has had undeniable repercussions in terms of volumes produced and yields. Indeed, while cultivated areas have increased by 50%, average global yields have more than doubled. The result has been a 3.4-fold increase in global crop production[26].

40 %

of the world's population is facing food insecurity

In this new context, synthetic pesticides have made it possible to contain and reduce the risks of agricultural losses[28] (due to increased pressure from diseases and pests, especially associated to agricultural specialization) and at the same time have helped meet growing demands for standardization of agricultural raw materials[29] and for lower consumer prices[30].

However, in the last several years stagnation or even decline in crop yields have been observed in areas which have specialized in growing certain crops. This concerns 24% to 39% of maize, rice, wheat and soybean growing areas worldwide[31]. The suspected causes are the growing phenomenon of pesticide resistance, the degradation of soils and of biodiversity due to intensive agricultural production systems using pesticides, as well as climate change (which is itself worsened by intensive agricultural production systems)[32].

Food:
the challenge of quality and access for all

THE STRATEGY ADOPTED SINCE THE MIDDLE OF THE 20TH CENTURY HAS CONSISTED IN “FEEDING THE WORLD” THROUGH A CONSTANT SEARCH FOR GAINS IN PRODUCTIVITY. HOWEVER, THIS STRATEGY HAS NOT SUCCEEDED IN SOLVING THE PROBLEMS OF FOOD INSECURITY.

While global agricultural production is reportedly sufficient to feed 1.5 times the Earth’s population, 40% continue to face food insecurity. Further, this figure has been steadily increasing for the last six years, especially among farmers[33].

Furthermore, global agricultural production has been concentrated on a limited number of plant varieties, with an emphasis on high-yield ones that provide large quantities of calories at low prices, for both human food and animal feed. This, in turn, has fuelled strong growth in worldwide consumption of animal products and processed foods with high fat and sugar contents[34]. This consumption has led to unprecedented increase in obesity problems, and low food prices mean there is little incentive to avoid waste[35]. In Europe, the surplus calories available are even disposed of as food aid, which is distributed both locally (thereby a factor behind malnutrition among the poorest) and internationally, (where it destabilizes local peasant agriculture)[36].

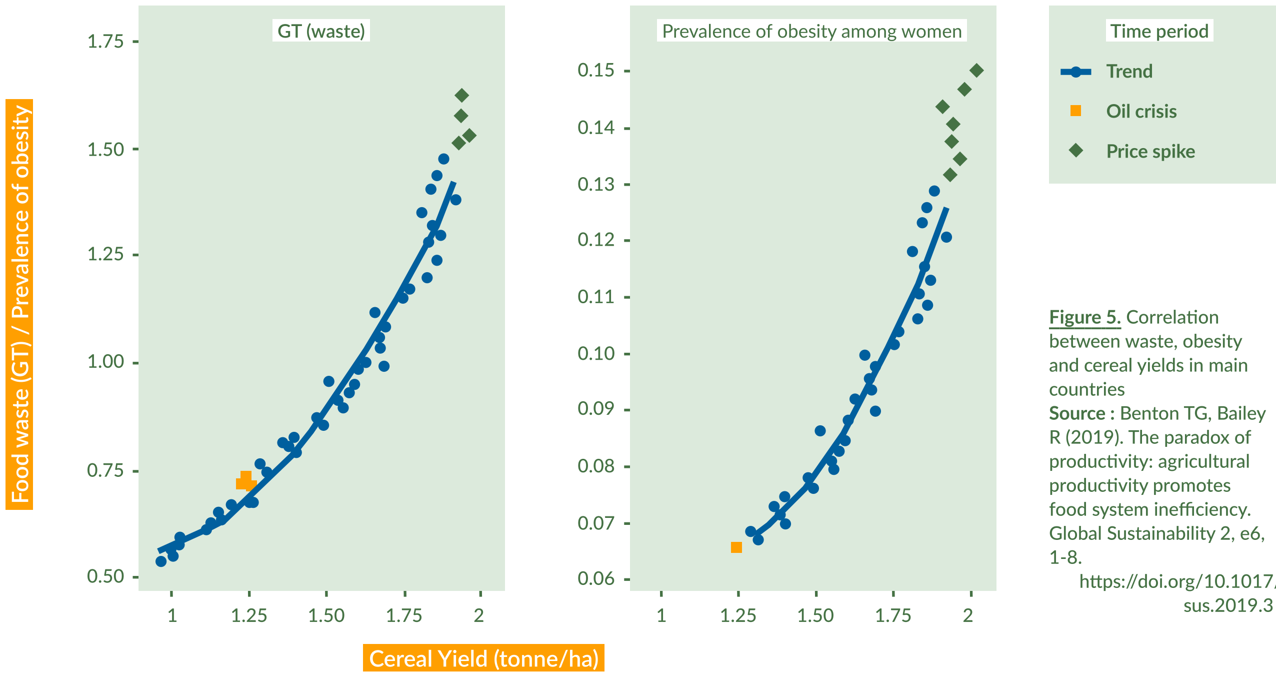


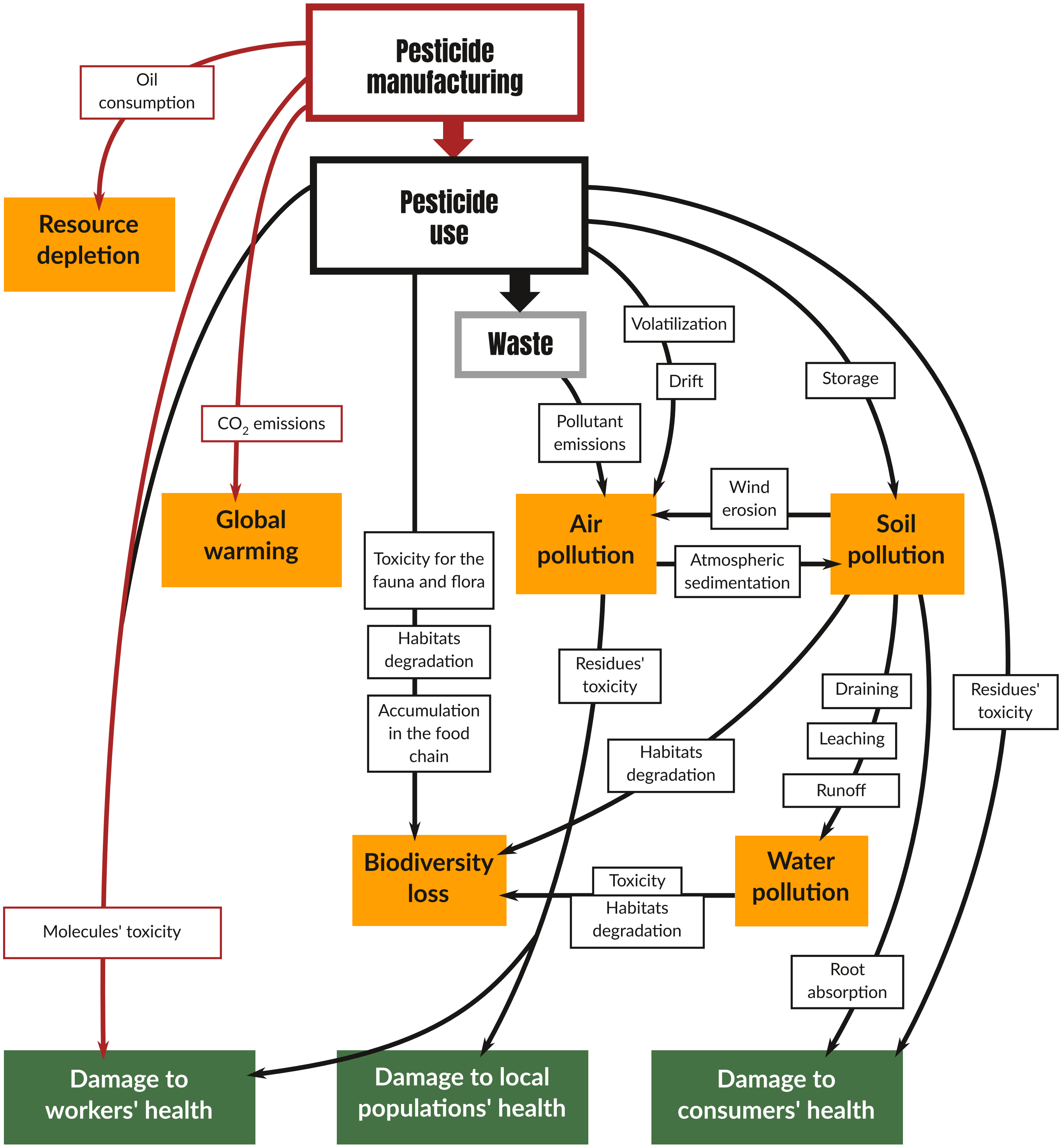
Figure 5. Correlation between waste, obesity and cereal yields in main countries
Source : Benton TG, Bailey R (2019). The paradox of productivity: agricultural productivity promotes food system inefficiency. Global Sustainability 2, e6, 1-8. https://doi.org/10.1017/sus.2019.3

Gains in productivity... but not for farmers

As previously mentioned, the development of agricultural models based on the combined use of machinery, fertilizers, pesticides and hybrid/GMO varieties has generated massive gains in economic productivity in recent decades. The big winners of this trend have been both input manufacturers and downstream players in the food chain (processors, major brands and distributors). Indeed the end price consumers pay for food products has increased fivefold (at current currency) since the 1960s[37]. However, the share of that value earned by farmers is constantly decreasing[38], as they are caught between the decline and volatility of commodity prices on the one hand and the rise in input costs on the other[39]. In Europe, farmers' incomes have depended largely on public subsidies since the early 2000s[40], and millions of agricultural jobs have been destroyed due to the process of intensification and expansion of farms which has been promoted by governments and accelerated by global competition[41].

Since 1950,
Food prices
x 5
Agricultural prices
/ 2

Major negative impacts



Environmental impact | Sanitary impact

Figure 6. Impact from pesticides.
Source : BASIC

PARALLEL TO THE ABOVE-MENTIONED TRENDS, THERE IS INCREASING RECOGNITION OF THE NEGATIVE IMPACT THAT THE MANUFACTURE AND USE OF PESTICIDES HAVE ON THE ENVIRONMENT AND HEALTH.

Pesticides everywhere...

Pesticides are now commonly found in the environment, in most countries of the world. Their presence is due to their use in different forms, to possible leakage throughout the product life cycle, and to leakage during both the manufacturing and disposal stages of products and their containers.

Once pesticides are in the environment, they stay. Indeed, **many pesticide chemicals which have been banned for decades because of their toxicity continue to be detected in waterways, groundwater**[42], soils[43], and more broadly natural ecosystems.[44]

Wild animal and plant life are thereby exposed to pesticides, through contact, inhalation and ingestion of any element likely to be contaminated[45], such as water, soil particles, pollen and nectar, prey, seeds, etc.

Wildlife is exposed to pesticides through contact, breathing and ingestion of anything that might be contaminated.

Finally, it should be noted that the phenomenon of bioaccumulation, whereby pesticides stored in organisms are "passed on" to their successive consumers, makes species at the top of the food chain (i.e., especially human beings) more vulnerable.

Systemic effects on fauna and flora

The harmful effects of pesticides can affect the nervous, immune, endocrine, metabolic, embryogenic and reproductive systems and are often identified at "realistic" levels of exposure, i.e., in accordance with the levels of pesticides observed in the environment after spraying[46].

Even without acute intoxication (large quantities absorbed over a short period of time, e.g., during spraying), chronic exposure to low doses can affect organisms irreversibly. It can cause "sublethal" effects, which do not lead directly to death but alter the nervous, immune or endocrine systems, ultimately causing the populations of the affected organisms to collapse[47].

Researchers have also shown that organisms exposed to multiple pesticides suffer even greater impact. These "cocktail effects" concern most cases of contamination in practice, but they are still not considered in current procedures for putting a product on the market[48].

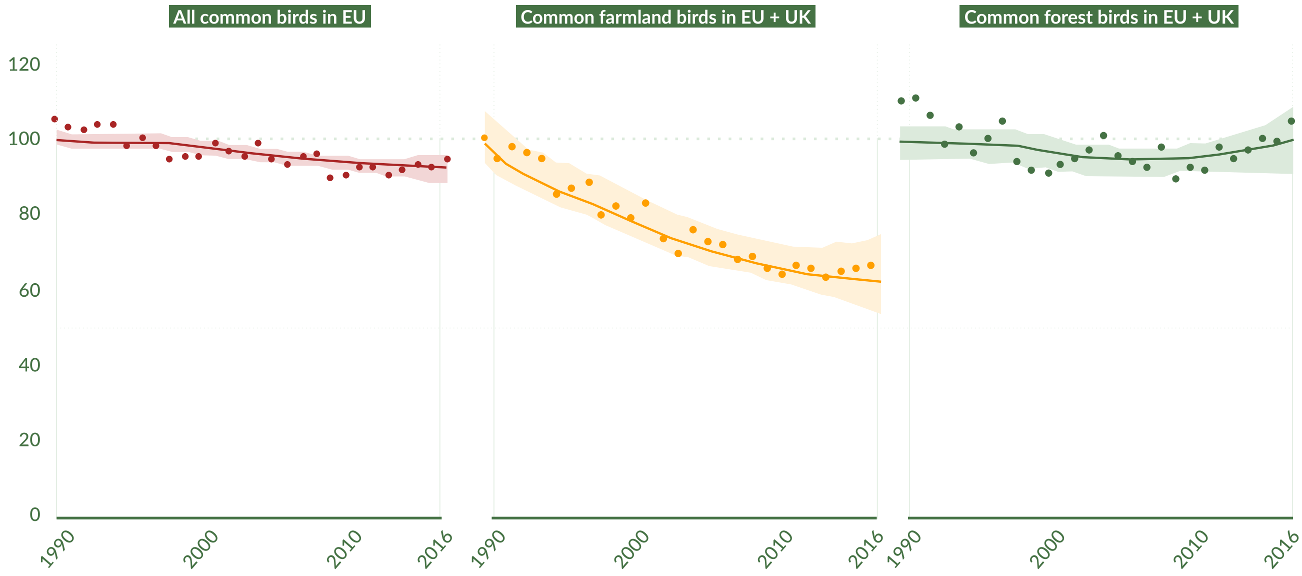


Figure 7. Trends in abundance indicators for all birds, farmland birds and forest birds in the European Union, 1980 to 2018 (1980 figures as 100%). Source: European Environment Agency, 2020

The effects observed in individuals can accumulate to the point where the species is impacted, and they can even put their population renewal into jeopardy. This in turn ultimately affects entire ecosystems[49].

The most recent research indicates that exposure to synthetic pesticides is one of the main causes of the decline in honeybee colonies and in insect and bird populations (see graph above). This worsening degradation of biodiversity is reducing the quality and quantity of the ecosystem services needed for human life. These services include water and soil quality regulation, climate regulation, pest control, and the pollination required for fruit and vegetable production (up to 35% of the global production currently depends on it)[50].

The dawning recognition of the effects on human health

Although doubts persist as to the seriousness of the health impacts on consumers, the responsibility of pesticides in some occupational diseases in the field of agriculture and in their effects on people living near farms has been well researched. Some countries in Europe and North America are beginning to recognize that responsibility, especially for Parkinson's disease, non-Hodgkin's lymphoma and prostate cancer. Meanwhile, new research is underway to better understand the extent of the problem[51].

The responsibility of pesticides in certain agricultural diseases or diseases affecting people living near farms has been widely documented.

STRONG SUSPICION	MEDIUM SUSPICION	WEAK SUSPICION Which may be due to a lack of data establishing a link
Cognitive impairment (average for non-professionals)	Alzheimer's disease (professionals)	Hodgkin's lymphoma
Non-Hodgkin's lymphoma (recognized in France as an occupational disease caused by pesticides)	Anxiety and depression disorders (professionals)	Breast cancer after exposure as an adult (professionals)
Parkinson's disease (recognized in France as an occupational disease caused by pesticides; weak suspicion in non-professionals)	Central nervous system tumours	Endometriosis (non-professionals)
Prostate cancer	Leukaemia	Amyotrophic lateral sclerosis (professionals)
Multiple myeloma	Breast cancer after prenatal exposure or exposure before age 18	Neurodevelopment disorders in children following prenatal exposure (professionals and non-professionals)
Malignant haemopathies, central nervous system tumours in children following prenatal exposure (professionals and non-professionals)	Bladder cancer (professionals; weak suspicion among non-professionals)	Testicular cancer
Congenital malformations following prenatal exposure	Kidney cancer (professionals)	Melanoma
Childhood leukaemia following prenatal exposure	Soft-tissue and visceral sarcomas (professionals)	
	Changes in respiratory health (professionals; strong suspicion for chronic bronchitis)	
	Thyroid pathologies (professionals; weak suspicion among non-professionals)	
	Foetal deaths	
	Fertility disorders and fertility level	

Figure 8. Diseases for which suspicion of a link has been established and taken into account in expertise by INSERM (French National Institute of Health and Medical Research). Source: BASIC, according to INSERM, "Pesticides et effets sur la santé : Nouvelles données", Expertise Collective collection, Montrouge, EDP Sciences, 2021 and INSERM, "Pesticides et effets sur la santé", Expertise Collective collection, Inserm, Paris, 2013.

A disadvantageous cost-benefit situation

The pesticide controversy has been fuelled for years by the opposition between:
- the negative impacts associated with their production and use,
- and the sector's economic importance, which is regularly put forward by the main manufacturers and users.

IN ORDER TO RENDER THIS DEBATE OBJECTIVE AND TO HELP ASSESS THE SUSTAINABILITY OF THE CURRENT PESTICIDE MODEL, WE CONDUCTED A COST-BENEFIT ANALYSIS OF THE SECTOR AT THE EUROPEAN LEVEL.

This innovative analysis – detailed in a scientific article in the process of being published[52], focuses on the real costs generated by pesticides and borne by society, both in terms of the public support received by the sector and the public expenditure linked to the previously mentioned negative impacts of pesticides. To study profits, it examines the book profits of European pesticide manufacturers, as well as the profits of other players in the food system that are generated through pesticides. We were able to make these estimates for France as a case study, because it is for this country that we found the most data available on the impact of synthetic pesticides and the costs they generate.

€372 million
of public expenditure related public to pesticides in 2017 in France

Actual expenditures linked to pesticides are twice as high as industry profits

In France, our calculations indicate that the various public expenditures related to pesticides, including operations for regulation*, depolluting water[53], and health care for occupational diseases[54] , exceeded **€372 million in 2017**. In comparison, €390 million in official support for organic farming was paid out that same year, an amount that is expected to decrease in the new CAP, due to the removal of support to maintenance of organic farming[55].

* "Operations for regulation" corresponds to the budgets of the regulatory authorities assessed proportionally to the share dedicated to pesticide-related activities and not financed by contributions from manufacturers

This minimum calculation does not take into account some significant impacts partially linked to pesticides, because it is not possible to assess the causes of those impacts proportionally. It consequently does not take into account the associated costs: other health expenditures than those related to diseases officially recognized as caused by pesticides[56], expenditures to protect biodiversity and prevent its degradation[57], remedial water-treatment measures[58], as well as official support to agriculture, which indirectly allows farmers to finance their purchases of inputs, including synthetic pesticide[59]. All of these expenditures amounted to **€18.7 billion in France in 2017**.

€2.3 BN
of public public spending directly attributable to pesticides in 2017 in the EU.

On the basis of this assessment, the costs to society were extrapolated at the European Union level based on the specific characteristics of each Member State*. The findings show the following:

* Based on publicly available data on farmers' pesticide expenditures by country, population size, water treatment expenditures, etc.

→ **Public expenditure directly attributable to pesticides in Europe in 2017 is estimated at €1.9 billion, to which must be added €390 million in annual financial support granted to the sector by the Member States*.**

* Which includes reduction in the VAT rate on pesticides in seven Member States and direct subsidies to the pesticide manufacturers listed in the European Commission's register.

→ **Expenditures partly attributable to pesticides would amount to nearly €106 billion in Europe in 2017.**

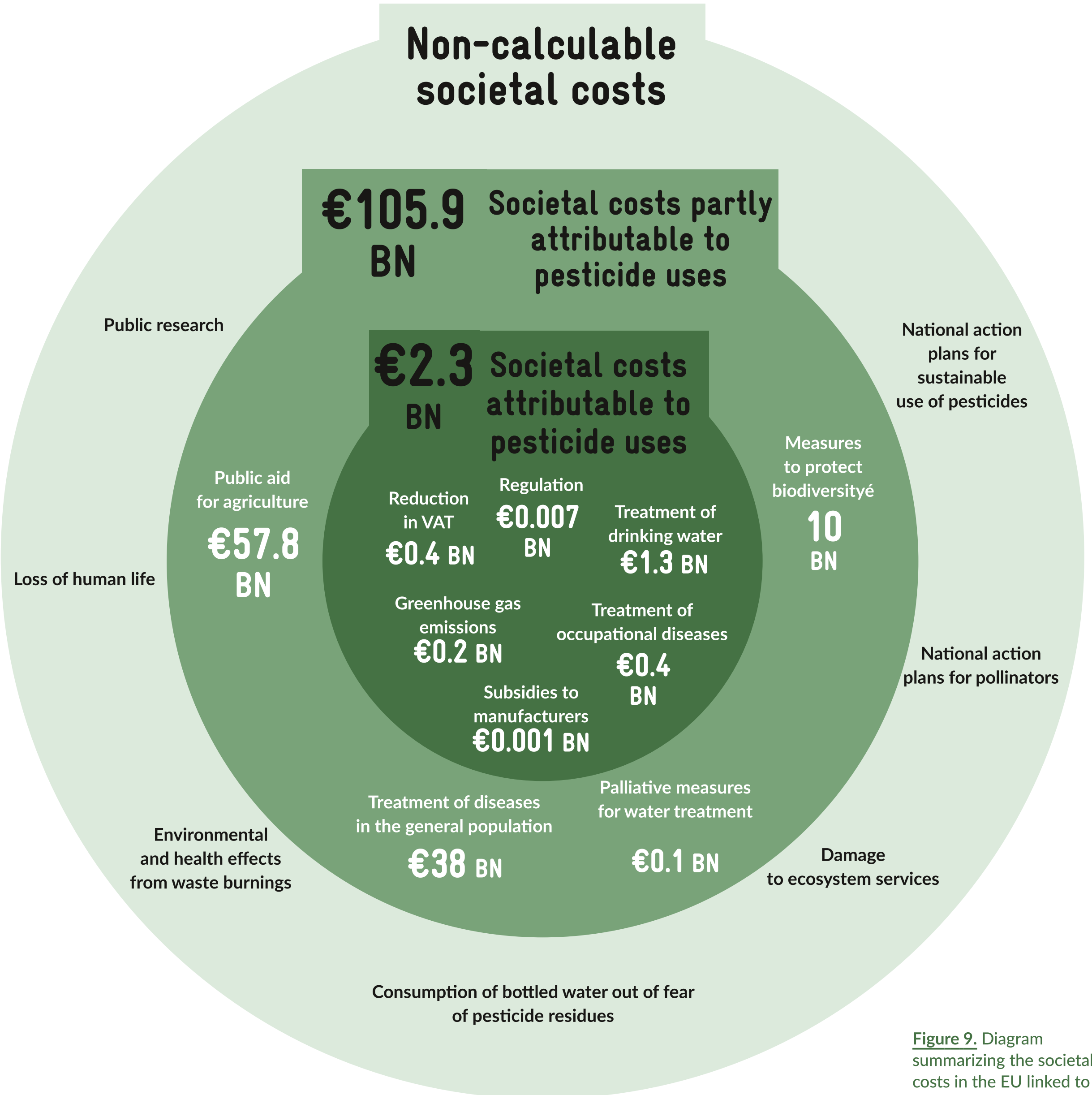


Figure 9. Diagram summarizing the societal costs in the EU linked to synthetic agricultural pesticides analyzed in the study. Source: BASIC

Compared to these costs, we estimated the profits – before taxes, depreciation and debt repayment – of the major firms in the pesticide manufacturing sector.

In France, the profits from sales of synthetic agricultural pesticides were **€211 million in 2017**. Europe-wide, the corresponding profits reached nearly **€940 million that same year**[60].

THUS, IN FRANCE, THE COSTS DIRECTLY ATTRIBUTABLE TO PESTICIDES ARE NEARLY TWICE AS HIGH AS THE PROFITS OF THE SECTOR. IN THE CASE OF THE EUROPEAN UNION, THEY ARE 2.5 TIMES HIGHER.

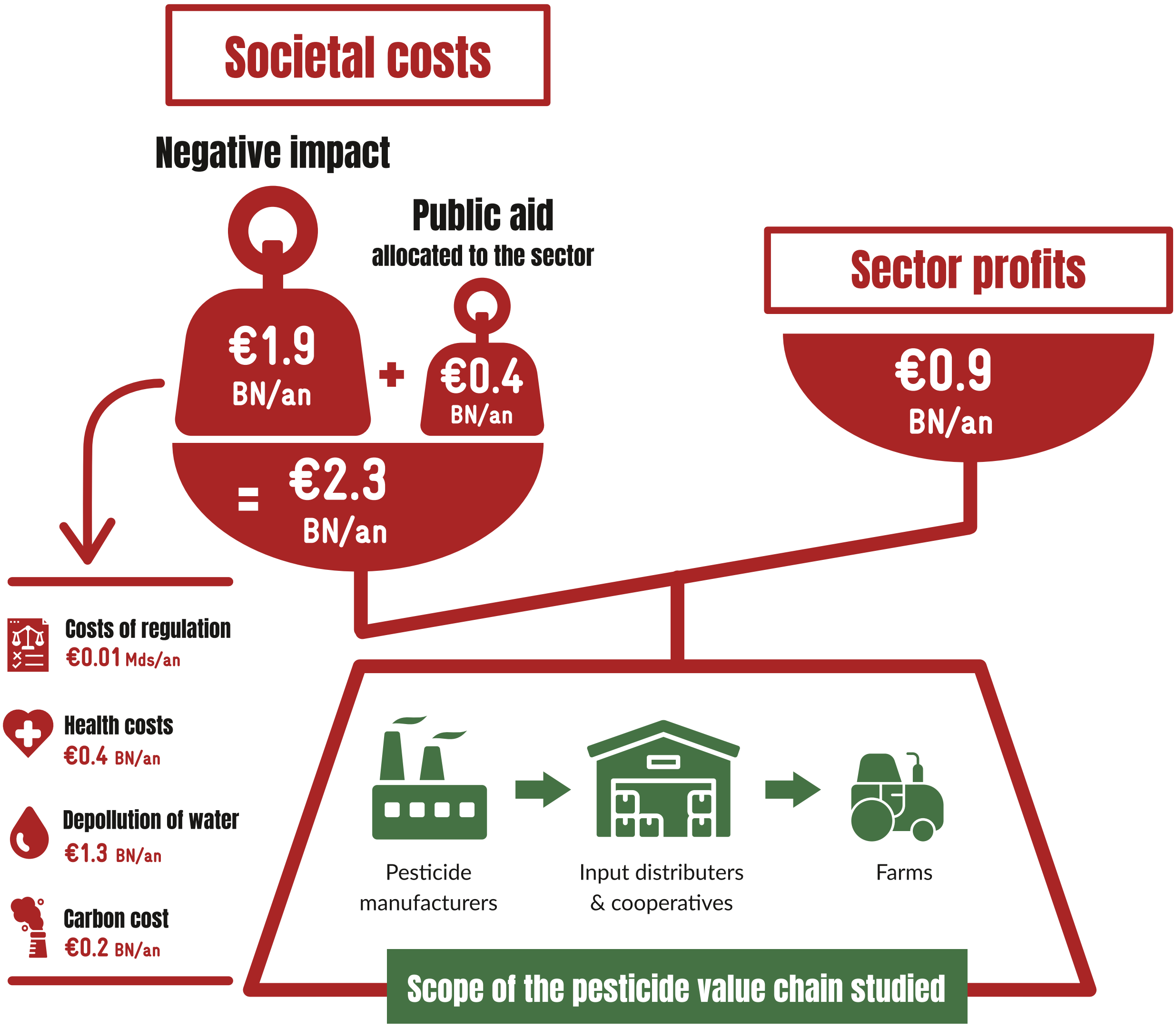


Figure 10. Diagram summarizing the value creation and societal costs in the EU linked to synthetic agricultural pesticides analyzed in the study.
Source : BASIC

THESE FINDINGS SHOW THAT THE PROFITABILITY OF THE PESTICIDE SECTOR IS MADE POSSIBLE BY OFFICIAL SUPPORT TO THE SECTOR AND THE COLLECTIVE PAYMENT OF COSTS LINKED TO ITS NEGATIVE CONSEQUENCES.

Pesticide manufacturers' influence strategy

The traditional major pesticide firms lobby public authorities to defend their economic interests, which is the main reason why this situation continues. Their influence strategy enables them to avoid paying for the expenses linked to the negative impacts of the products they market – and thus ultimately to benefit from financial support from society as a whole. **Expenditures related to these lobbying activities are close to €10 million per year just for the European market. This amount is greater than the budget of the European Food Safety Authority (EFSA), which works to regulate pesticides**[61].

€10 millions in lobbying by pesticide manufacturers in Europe.

But their activities do not stop there. Indeed, some of these firms fuel doubts about the potential impacts of their products. For example, internal documents made public by the Monsanto Papers revealed a halt to funding for some studies likely to demonstrate the negative impacts of glyphosate, as well as the fact that certain scientific articles had been ghostwritten by employees of the company[62]. The case of glyphosate illustrates more generally the problematical links between the pesticide industry and the regulatory authorities, and the fact that the latter rely mainly on private research and that their public decisions are affected by economic and financial pressures from the sector[63].

Polarization of the sector

This negative economic assessment aside, looking at the sector from a different angle shows that it is undergoing polarization:

→ On one end: a mass market, mainly in emerging countries, where demand is growing strongly. It is fuelled by both cheap generic products produced in Asia and products that are more toxic, due to laxer regulations,

→ On the other: a high-tech market, whose goal, for pesticide manufacturers, is to meet the environmental and health expectations of citizens and authorities. However, most farmers, even in Europe, may not be able to afford those technologies.

Double jeopardy for the countries of the Global South

As explained earlier, emerging countries are now the most dynamic markets for pesticide manufacturers. This trend is due to their need to secure the yields of their agro-export model, a need which is becoming all the more critical due to growing resistance by pests and the worsening of climatic events. In response, the sector has strongly developed its generic product offer, and, over the years, it has relocated an increasing proportion of the production of active substances to Asia.

At the same time, and due to often laxer regulations, a large proportion of the pesticides used by people in the South are classified as "extremely dangerous". Moreover, some come from factories in the European Union, where their sales are nonetheless prohibited[64]. **In 2018, sales of these pesticides in Brazil (the top importer worldwide) and India (6th importer worldwide) thus accounted for at least half of the turnover of the five industry leaders (Bayer, BASF, Syngenta, Corteva and FMC) in these countries[65].**

There are consequently greater health risks in those countries, especially as the farming population is much larger, and the most basic protective equipment is often lacking[66]. For example, in 1990 the WHO estimated that about 25 million pesticide poisonings occur each year, mostly in developing countries. No further estimates have been published since then[67].

In high-income countries, 27% of CropLife sales were of Highly Hazardous Pesticides (HHPs). But in low- and middle-income countries, the proportion of HHPs in total sales was 45%.

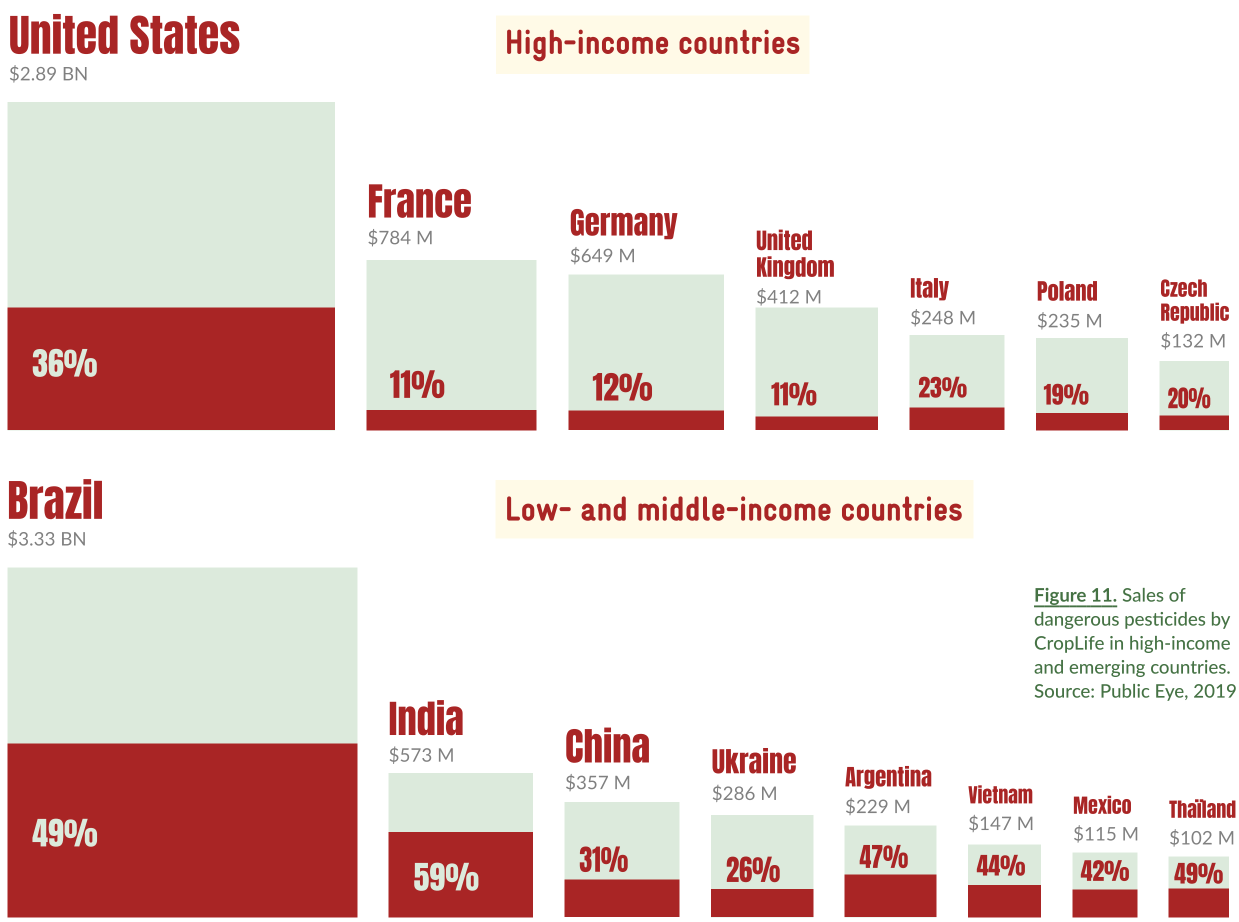


Figure 11. Sales of dangerous pesticides by CropLife in high-income and emerging countries. Source: Public Eye, 2019

New technologies, the next driver of growth for agriculture?

Meanwhile, the leaders of the sector have started work on digital agriculture and new genetic engineering technologies, with the claimed aim of "feeding the planet" while reducing their impact on the environment and on people's health.

Their idea is to combine the existing offer of pesticides and seeds with the use of new tools, such as digital data collection using sensors installed in fields and on agricultural machinery, and drones and satellites. The data obtained are then used to indicate directly to farmers what seeds to plant and what pesticides and fertilizers to use, with details on the quantities and the periods, etc.[8]

In economic terms, the companies are seeking to switch from a model of industrial manufacturers to that of full-service providers. These services would include agricultural counselling which would thereby short-circuit traditional pesticide sales networks (cooperatives in particular) by being in direct contact with farmers, with the goal of regaining a high level of profitability[69].

This trend is accompanied by growing investment in new genetic engineering technologies, based on advances made in DNA medicine, to devise solutions for large-scale control or even eradication of plant or animal species considered harmful to crops[70]. For ChemChina, this is even a strategy fully supported by the Chinese government: as a self-proclaimed "pioneer of the agriculture of the future", the company now invests twice as much as the USA in public research into new genetic technologies for agriculture[71].

the Chinese government is self-proclaimed "pioneer of the agriculture of the future"

In so doing, the current trend in the pesticide and seed sector towards high technology is generating new controversies that are for now not an active topic of public discussion. The issues include concentration of power by the dominant players; risk of loss of empowerment for farmers; large-scale investments unaffordable for many farmers, including in Europe; not to mention the great uncertainty about the real scale of environmental gains that can be made through these new tools if the agricultural model remains unchanged[72]. All these aspects cast doubt on the ability of these new technologies to deliver on their promise to transform the current system towards one of greater sustainability. Especially since a growing number of scientific studies show that the challenge is not to optimize existing production models[73], but to make it possible for models across territories and sectors to change and adapt, in order to ensure the sustainability and resilience of the food systems.

For these changes to occur, we must first collectively define a new paradigm for our agricultural and food systems, in which farmers do not face alone the risks and potential costs associated with them.

Notes

1 Tassel, M., “La « Troisième Révolution Agricole » : une révolution épistémologique ?”, Masters thesis, 2018.

2 https://www.lemonde.fr/planete/article/2021/09/03/aires-de-protection-en-mediterranee-pesticides-les-promesses-d-emmanuel-macron-a-l-uicn_6093349_3244.html and https://www.lefigaro.fr/sciences/ue-vers-une-initiative-forte-pour-sortir-des-pesticides-annonce-macron-20210903 accessed 21 October 2021.

3 https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/farm-fork_en accessed 21 October 2021.

4 https://www.arc2020.eu/farm-2-fork-eu-has-caved-to-eco-lobby-complains-big-ag/ accessed 21 October 2021.

5 BASIC, based on data from Phillips McDougall and IHS Markit.

6 BASIC, based on data from the EU Farm Accountancy Data Network (FADN). https://agridata.ec.europa.eu/extensions/FarmEconomyFocus/FarmEconomyFocus.html

7 BASIC, based on data from Comtrade. https://comtrade.un.org/data/

8 European Commission, Directorate-General for Internal Market, “Cumulative Cost Assessment for the EU Chemical Industry”, 2016.

9 BASIC, based on data from the EU Farm Accountancy Data Network (FADN). https://agridata.ec.europa.eu/extensions/FarmEconomyFocus/FarmEconomyFocus.html

10 These subsidies include “green payments” and the agri-environmental and climate measures that are part of the Common Agricultural Policy, as well as subsidies for organic farming (for conversion and maintaining status). Source: BASIC, “Étude des financements publics et privés liés à l’utilisation agricole de pesticides en France”, 2021.

11 Ibid.

12 Phillips, M.W.A., “Agrochemical Industry Development, Trends in R&D and the Impact of Regulation”, Pest Management Science, 2019.

13 BASIC, based on IPES Food (“Too big to feed: Exploring the impacts of mega-mergers, consolidation and concentration of power in the agri-food sector”, 2017) and Umetsu & Shirai (“Development of Novel Pesticides in the 21st Century”, Journal of Pesticide Science 45, 2020).

14 IPES Food, Too big to feed: Exploring the impacts of mega-mergers, consolidation and concentration of power in the agri-food sector, 2017

15 This ratio is calculated by dividing the profits made before tax payment and debt repayment by the turnover of the same year. We calculated the ratio for each of the four companies based on their 2018 financial report and compared it with the estimates of the same indicator for the entire manufacturing industry in the European Union produced by Eurostat. (https://ec.europa.eu/eurostat/fr/data/database)

16 PhillipCapital. Agriculture Inputs: On Course for Secular and Structural Growth, 2019

17 https://www.croplife.com/management/rebound-crop-protection-industry-seen-2017/ accessed 21 October 2021

18 BASIC, based on data from Comtrade, Phillips McDougall, AgbioInvestor and PhillipCapital & CCPIA.

19 PhillipCapital, "Agriculture Inputs: On Course for Secular and Structural Growth", 2019, op. cit.

20 BASIC, based on data from Comtrade https://comtrade.un.org/data/

21 European Commission, Directorate-General for Health and Food Safety, "Controls on the Marketing and Use of Plant Protection Products: Overview Report", 2017.

22 BASIC, based on data from Phillips McDougall, AgbioInvestor and PhillipCapital & CCPIA.

23 Lyer S., Liu L, Tailor B., Tiwan S., Agrochemical Industry in China: From Self-Reliance to Export to Discovery & Development. Grainews. 2020
https://www.yicaiglobal.com/news/sinochem-chemchina-merge-to-form-world-biggest-chemical-giant- and https://www.chemistryworld.com/news/government-clears-merger-of-sinochem-and-chemchina/4013530.article accessed 21 October, 2021.

24 Clapp, J., "The Rise of Financial Investment and Common Ownership in Global Agrifood Firms", *Review of International Political Economy* 26, 2019.

25 Tassel, M., "La « Troisième Révolution Agricole » : une révolution épistémologique ?", Masters thesis, 2018, op. cit.

26 Phillips McDougall. "Evolution of the Crop Protection Industry since 1960", 2018.

27 Ibid.

28 Oerke, E.C., "Crop Losses to Pests", 2006.

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

30 Benton T.G., Bailey R., "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

31 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.

32 Ibid.

33 FAO, "The State of Food Security and Nutrition in the World", 2021. http://www.fao.org/hunger/en/

34 Benton T.G., Bailey R., "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 op. cit.

35 Ibid.

36 IPES Food, "Towards a Common Food Policy for the European Union: The Policy Reform and Realignment That Is Required to Build Sustainable Food Systems in Europe", 2020.

37 BASIC, based on FAO data (Food Price Index between 1961 and 2018). https://www.fao.org/worldfoodsituation/foodpricesindex/en/

38 Gereffi, G., Abdulsaman, A., "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.

Observatoire de la formation des prix et des marges des produits alimentaires (French Observatory on pricing policies and margins of food products), Report to the French Parliament, 2020.

Butault, J.P., "La relation entre prix agricoles et prix alimentaires", *Revue française d'économie*, 2008.

39 Ibid.

40 BASIC, based on data from the EU Farm Accountancy Data Network (FADN). https://agridata.ec.europa.eu/extensions/FarmEconomyFocus/FarmEconomyFocus.html

41 BASIC, based on OECD data: https://data.oecd.org/emp/employment-by-activity.htm

42 Commissariat Général au Développement Durable, "Les pollutions par les engrais et les produits phytosanitaires : coûts et solutions", 2015.

43 Silva, V., Mol, H.G.J., Zomer, P., Tienstra, M., Ritsema, C.J., Geissen, V., "Pesticide residues in European agricultural soils – a hidden reality unfolded", Science of The Total Environment 653, 2019.

44 Carvalho, F.P., "Pesticides, environment and food safety", 2017, and Agence Eau Seine Normandie, 2014.

45 Matthews, G., *Pesticides: Health, Safety and the Environment*, 2nd edition, 2016; INRA, "Pesticides, agriculture and the environment", 2005.

46 IPBES, "The regional assessment report on Biodiversity and Ecosystem Services for Europe and Central Asia", 2018.

Köhler and Triebskorn, "Wildlife ecotoxicology of pesticides: can we track effects to the population level and beyond?", 2013

Task Force on Systemic Pesticides, Worldwide integrated assessment of the impacts of systemic pesticides on biodiversity and ecosystems, 2015.

Cullen et al, “Fungicides, herbicides and bees: A systematic review of existing research and methods”, 2019

47 Ibid.

48 Brühl, C.A. and Zaller, J.G., “Biodiversity Decline as a Consequence of an Inappropriate Environmental Risk Assessment of Pesticides”, 2019.

49 Köhler and Triebskorn, “Wildlife ecotoxicology of pesticides: can we track effects to the population level and beyond?”, 2013, op. cit.

50 Task Force on Systemic Pesticides, Worldwide integrated assessment of the impacts of systemic pesticides on biodiversity and ecosystems, 2015. op. cit.

51 INSERM, “Pesticides et effets sur la santé : Nouvelles données”, *Expertise Collective collection*, Montrouge, EDP Sciences, 2021.

INSERM, “Pesticides et effets sur la santé”, *Expertise Collective collection*, Inserm, Paris, 2013.

ANSES, “Expositions professionnelles aux pesticides en agriculture”, Volume n°1 : volume central, Rapport d’expertise collective, 2016.

52 Scientific article to be published in the peer-reviewed journal Frontiers in Sustainable Food Systems.

53 Commissariat Général au Développement Durable, “Les pollutions par les engrais et les produits phytosanitaires : coûts et solutions”, 2015, op. cit.

54 Castet, Deprost, Eslous, Toussaint, “La préfiguration d'un fonds d'aide aux victimes de produits phytopharmaceutiques”, 2018.

Gustavsson et al., “Cost of disorders of the brain in Europe”, 2010.

Mounié et al., “Real-world costs of illness of Hodgkin and the main B-cell Non-Hodgkin lymphomas in France”, 2019.

55 BASIC, “Étude des financements publics et privés liés à l’utilisation agricole de pesticides en France”, 2021.

56 Olesen et al., “The economic cost of brain disorders in Europe”, 2012.

Luengo-Fernandez et al., “Economic burden of cancer across the European Union: a population-based cost analysis”, 2013.

Luengo-Fernandez et al., “Economic burden of non-malignant blood disorders across Europe: a population-based cost study”, 2016.

57 IEEP, “Tracking Biodiversity Expenditure in the EU Budget: Part 1, Guidance on Definition and Criteria for Biodiversity Expenditure in the EU Budget”, 2015.

58 Commissariat Général au Développement Durable, “Les pollutions par les engrais et les produits phytosanitaires : coûts et solutions”, 2015, op. cit.

59 BASIC, based on data from the EU Farm Accountancy Data Network (FADN). https://agridata.ec.europa.eu/extensions/FarmEconomyFocus/FarmEconomyFocus.html

60 BASIC, based on Eurostat data available at https://ec.europa.eu/eurostat/web/main/data/database (structural business statistics and in particular annual detailed enterprise statistics of industry and construction (sbs_ind_co / sbs_na_2a-dfdn)

61 Lobbying expenditure data were obtained through an extensive search of the European Lobbying Transparency Register portal https://ec.europa.eu/transparencyregister/public/consultation/displaylobbyist.do?id=3523776801-85 and its French counterpart, both accessed 7 October 2020. The search was made on these two websites using the names of all the subsidiaries that Bayer, BASF, Syngenta and Corteva declared in their last annual financial report, as well as using additional keywords (e.g., "pesticides", etc.).

62 https://corporateeurope.org/en/food-and-agriculture/2018/03/what-monsanto-papers-tell-us-about-corporate-science, accessed 21 October 2021.

63 Corporate Europe Observatory, LobbyControl e.V., "Tainted Love: Corporate Lobbying and the Upcoming German EU Presidency", 2020.

64 https://www.publiceye.ch/fr/thematiques/pesticides/analyse-ventes-pesticides-2018, accessed 21 October 2021.

65 Ibid.

66 Jepson et al., "Measuring pesticide ecological and health risks in West African agriculture to establish an enabling environment for sustainable intensification", 2014.

PAN Asia Pacific, "Highly hazardous pesticide use and impacts in Asia: the need for legally binding protocols beyond 2020", 2019.9

Public Eye, "Ces pesticides qui empoisonnent les agriculteurs: les ventes de pesticides à la toxicité aiguë", 2019.

67 https://www.publiceye.ch/fr/thematiques/pesticides/analyse-ventes-pesticides-2018/toxicite-aigue, accessed 21 October 2021.

68 BASIC and Carasso Foundation, "Enjeux et problématiques de la numérisation dans les filières agricoles et alimentaires", 2021.

69 Ibid.

70 Courtier-Orgogozo, V., Morizot, B., Boëte, C., "Agricultural Pest Control with CRISPR-based Gene Drive: Time for Public Debate: Should We Use Gene Drive for Pest Control?" EMBO Reports, 2017.

https://corporateeurope.org/en/food-and-agriculture/2018/05/embracingnature, accessed 21 October 2021.

71 https://www.sciencemag.org/news/2019/07/feed-its-14-billion-china-bets-big-genome-editing-crops, accessed 21 October 2021.

72 BASIC and Carasso Foundation, "Enjeux et problématiques de la numérisation dans les filières agricoles et alimentaires", 2021, op. cit.

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