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Agrochemical Long-tail Risks: Can Dead Bees Sting?

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Can Dead Bees Sting?

In court, yes.
Other financial damage for investors, also yes.
Pesticide risks can have very long tails.

Bayer's subsidiary Monsanto[1] will be feeling the sting of litigation losses for some time, although the current issue is cancer, not bees. Two decades ago, glyphosate, originally trade-named Roundup®, was considered "the safest weed killer since the iron plough".[2] Although the science is inconclusive, glyphosate's detractors today mutter its name in the same tone as they pronounce DDT or Agent Orange[3].

It is difficult to imagine how a reliable food supply could be produced without pesticides, whether biological or synthetic. At the same time, the misuse of pesticides may irreversibly damage our health and our environment. How can these trade-offs be measured and managed?

And what do these risks mean for investors?

"The five largest agrochemical companies generate 10% of their income from exporting neonicotinoids and fipronil (toxic to bees), their main markets being developing nations."

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Summary: Persistent Pesticides

Climate, habitats, and water do not respect national boundaries. Increasingly, biodiversity efforts are also crossing borders. Investors and the global community, increasingly concerned about the impacts of climate change, are looking beyond the climate-based ecosystem issues into broadly-defined issues of biodiversity.

As responsible investors, Candriam engages along the full food value chain, especially food retailers. We support better product safety practices for food. If a pesticide is banned in one country but permitted in another, that chemical can still enter the global food chain – especially if it is 'persistent'. For companies such as food retailers, we particularly evaluate reputational risk, given the client-facing nature of the food business. We therefore expect more action on pesticides from companies in the food chain than from agrochemicals producers.

Naturally, biodiversity initiatives are among the more than fifty collaborative investor initiatives in which Candriam participates. We consistently strive to expand our understanding of pesticide issues, given their relevance across multiple topics and industries. Our pesticides Engagement has been very informative in our ESG analysis broadly. Notably, Candriam is part of the *Initiative for Pesticide Use Reduction and Safer Chemicals Management*, launched and led by Mercy Investment Services in 2019.

The investment tail risk can be *very* long. Glyphosate, first marketed in 1974, has been off-patent for over twenty years. It subsequently became the most widely-used pesticide in the world. Only after that did scientists begin to widely publish their concerns. Finally in 2018, the litigation began in the US.

It is worth remembering that DDT, widely-used during World War II, was once a 'miracle chemical'. Agent Orange, also developed during World War II and widely used during the Vietnamese War, ceased being produced even before any litigation was launched (albeit well after many cases of illness and birth defects in Southeast Asia were blamed on the chemical). A famous non-pesticide example of long-tail risks is the the naturally-occurring 'miracle mineral' asbestos. It was widely used for more than 80 years. And remember how that ended.

The pesticide companies with which we engaged were responsive. As a highly-concentrated industry, we were able to engage directly with companies representing more than a third of global pesticide sales. Across industries we dialog to learn, to share information, and to make better investment decisions. In some instances, we dialogue to influence.

Critically, we estimate companies responsible for a combined 30% of global pesticide sales said they see growing demand for reduced-residue or zero-residue crop protection. We would propose that companies involved in pesticides make an additional step towards transparency, and disclose annually any of their products which are on a multinational 'hazardous' list, such as the one published by the Pesticide Action Network.

"Loss of biodiversity poses as great a risk to humanity as climate change."

The Economist newspaper, 19 June, 2021

Cross-border biodiversity efforts are accelerating – will they be in time?

- *Fifteenth meeting of the Conference of the Parties to the Convention on Biological Diversity (CBD) to be held in China in October 2021.*
- *The European Union is developing a 'comprehensive' biodiversity strategy as 'a core part of the European Green Deal'.*
- *Pesticides have specifically been a hot topic in EU recently for their impact on biodiversity (especially bee killing neonicotinoids).*

Social and Environmental Effects: Does the Dose Make the Poison?

'Misuse' of pesticides and herbicides is difficult to define, and more difficult to quantify. Ancient armies mythically salted the ground of conquered territories to poison the soil, yet even today some 'bio' home gardeners use salt to control weeds in driveways.

Concentrations of pesticides in our food and water supply are likely higher than we think. In food, for example, limits are set and measurements are made for each individual chemical. They are not set, nor are they measured, for the full cocktail which might be present – and any potential interactions among the chemical residues are also ignored.

Farming groups and agricultural schools are calling for better pesticide and herbicide practices. These include correct timing of product use, so that the chemicals break down as designed and intended. Agrochemicals are not a stand-alone element, they are part of a complete and complex system. For example, the no-till farming methods of the twenty-first century reduce soil erosion; but require additional herbicides.

"Concentrations of pesticides in our food and water supply are likely higher than we think."

Environment

The misuse of pesticides and herbicides has the potential for serious and irreversible damage to the environment. This includes both incorrect timing as well as excessive use. Various scientific studies provide ample evidence of the impact of pesticides.

• *Damage to soil ecosystems and soil functions.*
Healthy soils circulate chemical elements, water and energy, and are populated by microorganisms such as fungi, bacteria, and protozoa, as well as earthworms and other invertebrates. As the basis of soil life, these organisms are therefore immensely beneficial to humans. Some pesticides can lead to the death of these beneficial organisms. For example, pesticides can disrupt the feeding behaviour of humble earthworms, thus affecting their growth, reproduction and survival.[4]

The Intergovernmental Technical Panel on Soil and the FAO (Food and Agriculture Organization of the United Nations) undertook an extensive review of the body of scientific research examining the effects of pesticide use on soil functions. While remarking that the knowledge on the relationship between pesticides and soil change is incomplete, there is ample *scientific-based evidence of negative impacts of specific pesticides on soil organisms and soil functions.* For example, while organochlorine pesticides are widely used around the world, some suppress symbiotic nitrogen fixation, resulting in lower crop yields.[5] A recent FAO inquiry into soil pollution identified pesticides as one of the main soil pollutants. It also found that agricultural and livestock activities are among the main anthropogenic, or man-made, sources of soil contamination, with pesticide use playing a clear role[6].

• *Persistence*
Pesticide persistence,[7] behaviour and mobility vary dramatically, as do the mechanisms of their degradation and retention in soils. Persistence depends on the product's chemical composition, the application rate, the specific soil type, and local soil organisms, so it is no surprise that studies of the effects of pesticides on soil biodiversity have shown conflicting results.[8]

• *Harm to non-target species*
The most common pesticides are broad-spectrum and tend to affect more than the intended pest, disease or weed target. Declines in bumble bees, managed honeybees, butterflies, and other pollinators, are well-acknowledged examples from the insect world. These problems helped spur the EU ban of some neonicotinoids.

Pollinators are essential to food production. It has been estimated that 71 of the 100 crops which provide 90% of the world's food, such as apples, tomatoes, and strawberries, are pollinated by bees.[9] **The decline in pollinators is a serious threat to food production globally.**

Numerous insect species provide biological pest control, a sort of free ecosystem service that supports agriculture. Ladybirds and hoverfly larvae feed on aphids, while ground beetles feed on pests harmful to cereal crops. This natural pest control benefits crop production worldwide, and the death of beneficial insects through the use of persistent and broad-spectrum pesticides is thought to be the leading cause of pest resurgence, i.e. the reappearance of pest populations.[10]

Similarly, non-targeted plant species are also declining in diversity and richness. Many wild plants that used to grow near croplands and farmland have become rare.

Even bird species once common on farmland are declining, possibly because of the effects of pesticides on earthworms, insects and other invertebrates that the birds hunt for food.[11]

- *Contamination of water.*
  Water contaminated by persistent agrochemicals leads to die-offs of fish and other damage to lakes, rivers, and oceans. Pesticides enter waterways through a variety of mechanisms, including surface runoff, the cleaning and washing of equipment after a spray operation, transport of pesticide-treated soil, aerial spray, accidental spillage, or industrial effluent. Pesticides have been directly linked to fish mortality worldwide, impacting the related food webs as well.[12]

The misuse of pesticides, including excessive use, is linked to loss of biodiversity and reduction in populations of birds, insects and aquatic and soil communities, either through direct exposure or through reduction in food and habitat.[13] These problems might actually be underestimated. A thorough understanding is hampered by the inadequate tracking of pesticides in the environment and the lack of regular monitoring of soil and water. The lack of proper monitoring of many wild species adds to the lack of reliable data for how they are affected.[14]

The very existence of this debate demonstrates that existing regulations may be insufficient. Alternative solutions to reduce the use of agrochemicals requires careful ecosystem management, such as crop rotation and good soil health practices. Integrated Pest Management (IPM) embraces a continuum of practices among farms of all sizes. For instance, an IPM farm may grow pest-resistant crop varieties, use natural predators to control pests, employ mechanical pest traps and eliminate the areas where pests breed. If further control is needed, IPM farmers would employ a targeted approach, with broadcast spraying used only as a last resort.

Figure 1: The FAO Warns of Soil Pollution

The Results are Actually More Complex

Source : UN FAO, Candriam.

Other techniques include cover crops, strategic timing of weeding and tilling, and planting crops early or late to outcompete weeds. All of these practices require careful observation of the on-farm ecosystem and farmers require resources for their implementation.

Environmental protection organizations, agricultural workers, consumers rights groups, and others have been expressing concern for decades. National and international networks have been bringing these stakeholders together, including *Pesticide Action Network* and *Beyond Pesticides*. *Pesticide Action*, founded in 1982, is now global, while *Beyond Pesticides* has been US-based since 1981.

When applied late, chemical residues may remain in the seeds which have been grown as food. *Pesticides can persist in the environment for decades, and threaten the entire global ecological system.*

It is no mystery that an uncontrolled or mismanaged use of pesticides can have important adverse impacts on both public health and the environment. Scientific research proves useful in the risk assessments that are at the basis of the authorization or ban of active substances. All these effects vary based on the properties and quantities of the chemicals, on the soil, organism, pollinator, context, and many other factors.

"Alternative solutions to reduce the use of agrochemicals requires careful ecosystem management, such as crop rotation and good soil health practices."

Human Health

Exposure to pesticides can occur through food, water, air, or direct contact with the substances or their residues. There are no reliable global statistics on the overall number of people who suffer from pesticide exposure. Illnesses are often multi-causal and individuals can be exposed to a variety of chemicals in their daily lives, so establishing a clear link is a challenge.

The most direct impact of a toxic agrochemical is acute poisoning, through either a single or multiple exposures within a short period. Severe cases can lead to loss of sight, seizures, unconsciousness, coma, or death. A recent study of acute pesticide poisoning reveals a dramatic rise. There were about 385 million cases of acute poisonings worldwide per year over the last two decades, up from an estimated 25 million cases per annum in the 1990s. South Asia leads in cases, followed by Southeast Asia and East Africa.[15]

Chronic health problems may not manifest for months or even years after exposure. Long-term exposure to pesticides has been linked to cancer, Parkinson's and Alzheimer's diseases, hormone disruption, developmental disorders, allergies, and sterility. Some substances can cause neurological health effects such as memory loss, or reduced coordination and motor skills. Other effects include asthma, allergies and hypersensitivity.[16]

Certain populations face greater damage from pesticides:

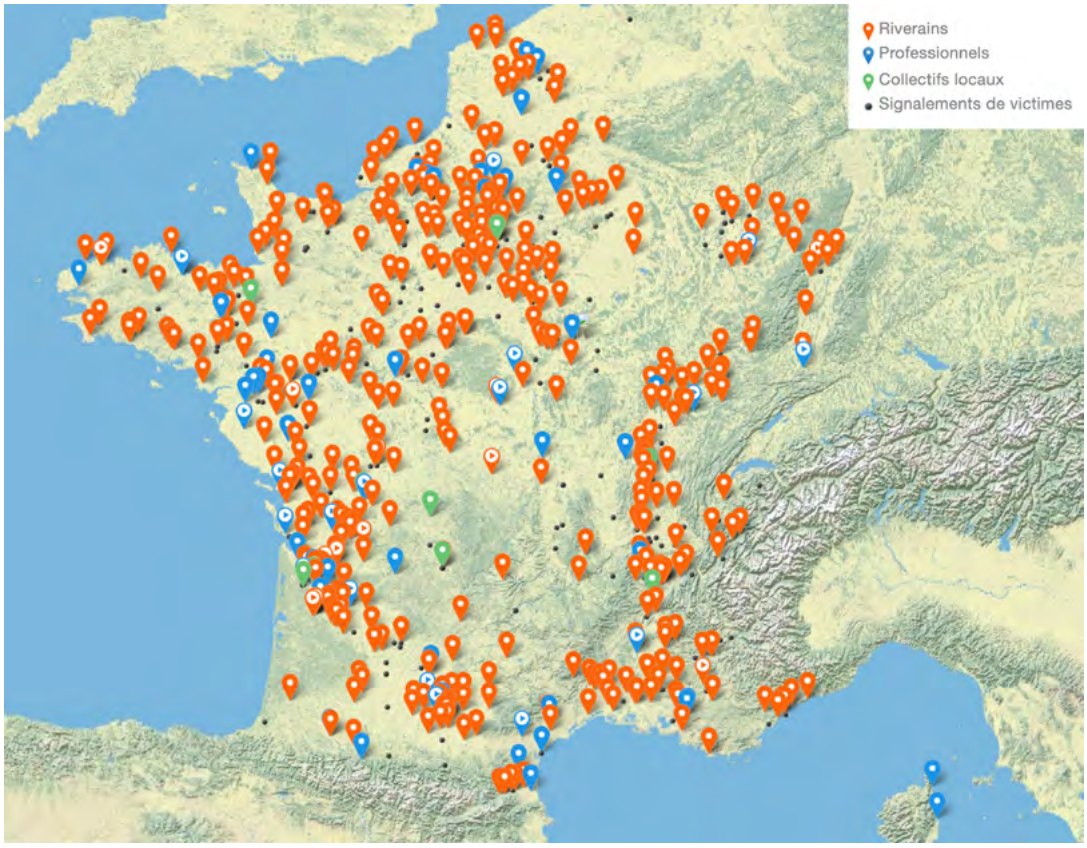
- *Agricultural workers and farmers.* Workers can be regularly exposed to toxic pesticides through spray or drift, through contact with treated crops or soil, from accidental spills or because of inadequate personal protective equipment. In some countries or contexts, poor enforcement of labour regulations, poor knowledge of procedures and lack of health and safety training can elevate exposure risks. A study by the Swiss NGO *Public Eye* showed that personal protective equipment in most low-income countries, especially Africa, is often unavailable for purchase. In some cases, it is not sold because it is unaffordable for the majority of farmers, or because it is unusable in the heat of tropical or subtropical zones[17]. In Europe, the European Federation of Trade Unions in the Food, Agriculture and Tourism (EFFAT) formally reported that monitoring institutions such as labour inspectorates, health services, trade unions, etc. often have inadequate technical knowledge to recognize health problems and are therefore unable to intervene.[18]

• *Communities living in proximity to agricultural lands.*
Members of these local communities are susceptible to contact with pesticides close to their homes, schools and workplaces. Exposure can occur through air, dust, rain, or where drinking water relies on groundwater.

This problem can arise even in countries where regulation is stricter. The website 'Victimes des Pesticides' was created by the French association *Générations Futures* to record pesticide effects in France. While users can register as either professionals or residents, resident entries are by far the most numerous *(Figure 2)*. Each entry describes how pesticide use affected the member's health, and/or the constraints to which they are subject to protect themselves in their daily life.[19]

Figure 2: Pesticide Impacts on French Residents and Farm Workers

(Self-reported)



Source: Générations Futures, Victimes Pesticides France.

• *Consumers.*
Pesticide residues are commonly found in both plant-based and animal-based foods, resulting in significant exposure risks for consumers. For fruits and vegetables, the highest levels of pesticides are often found in legumes, leafy greens and fruits such as strawberries, apples and grapes. While washing and cooking can reduce residues, many pesticides currently in use are systemic. Because systemics are absorbed through the roots and distributed throughout the plant; washing has no effect. Pesticides can also bio-accumulate in farmed animals via contaminated feed. Animal components of human diets such as poultry, eggs and dairy products may contain a range of substances (e.g. insecticides) following bioaccumulation and storage in the fatty tissues of the animals.

Over forty percent of food in all European countries showed pesticide residues in 2018, according to the European Food Safety Authority (EFSA).[20] Residues for each pesticide fell within the limits permitted in the EU legislation for almost the entire sample (96%). But safety standards are set for each individual pesticide, so regulations fail to account for potentially toxic 'cocktails' of pesticides. In daily life, we are rarely exposed to only one pesticide at a time – an individual can come into contact with pesticides through diet, inhalation of air and absorption through the skin, creating a chemical potion in the body. Worse, while the harmful effects of pesticide mixtures are not yet fully understood, it is known that synergistic interactions can occur, leading to even greater toxicity than the sum of each individual chemical risk.[21]

"... because safety standards are set for each individual pesticide, regulations fail to account for potentially toxic 'cocktails' of pesticides..."

Pesticides: The Law of Unintended Consequences

Pesticide History

We use the term 'pesticide' collectively, to include herbicides, defoliants, etc – that is, chemical or biological ingredients intended to repel, destroy or control any pest.[22]

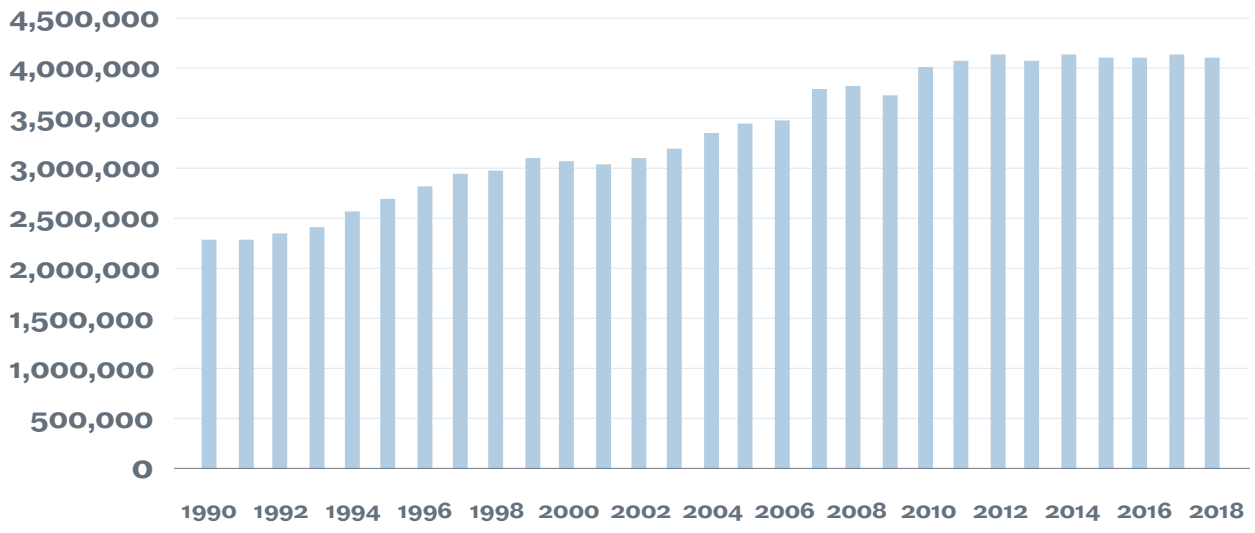
Every pesticide contains at least one active substance, in the form of chemical or biological agent, which is the essential component providing the pesticidal action. Products can be classified in several ways -- by target organism, by application method such as seed treatment, spray, or aerial application, or by chemical structure. The latter discerns between synthetic pesticides created through a chemical process, and bio or biological pesticides, which are a diverse group of products derived from organisms including plants, microbes, fungi, nematodes and other naturally-occurring materials[23].

Farmers have sought to increase yields or reduce crop losses since they branched out from hunter-gatherer into cultivation 12,000 years ago – trying to manage droughts, floods, insects, weeds, and other damage. Records from 4,500 years ago show an early use of sulphur compounds by the Sumerians to kill insects and mites.

Pesticide practices developed slowly until the scientific and technical innovations of the eighteenth century Agricultural Revolution in Europe. Pesticide development was further boosted during WW II. For example, Allied troops used DDT to control insect vectors of malaria and typhus[24] in tropical regions, while the Germans developed organophosphate chemical warfare agents, which led the commercial insecticides parathion and malathion.[25]

This is how chemical companies became involved in pesticide research and products, leading to important discoveries. As the agrochemical industry developed after WW II, pesticide production rose dramatically and the application of synthetic pesticides became an agricultural norm. Along with synthetic fertilizers, hybridization of crops and mechanization, pesticides contributed to another agricultural revolution in the 1950s and 1960s, with a further step-change in improved crop yields.[26] The number of pesticides introduced, both synthetics and bio pesticides, introduced has increased in recent decades. ***The number of active substances registered for use worldwide has doubled since 1980.***

Figure 3: Tonnes of Active Substance Used in/Sold to the Agricultural Sector for Crops and Seeds

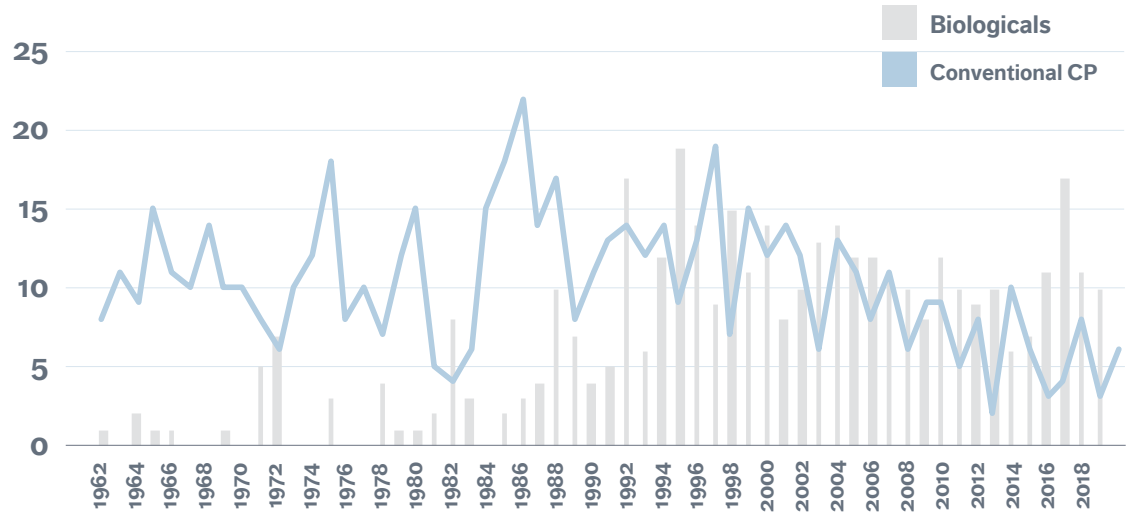


Source: FAT Stat. includes both synthetic and biological pesticides

Pesticides,[27] both synthetic and biological, are essential to meet present and future food demand. [28] The sharp increase[29] in the use of pesticides between 2000 and 2010 was accompanied by changes in such as no-till farming -- which increases the amount of herbicides used -- and improved agricultural productivity in emerging economies.[30]

Almost a decade ago, the FAO estimated that global food production must rise by 60 percent between 2005 and 2050. It is difficult to imagine how a reliable food supply can be guaranteed without the use of pesticides in agriculture. Yet side effects on biodiversity and human health create a trade off.

Figure 4: Annual Rate of New Product Introductions (of Active Ingredients) Biological and Synthetic (Conventional) Crop Protection Products



Source: Phillips McDougall database and analysis

Management of Pesticide Risks

The use of pesticides has enhanced the growth in crop yields over time. Yes alongside the benefit of better and better yields, the growing use of pesticides has also been accompanied by rising evidence of risks to human health and the environment. Given these links, pesticides need careful management throughout their lifecycle.

The International Code of Conduct on Pesticide Management, published by the UN FAO in 1985 and later updated jointly with the World Health Organization (WHO), provides a common framework, technical guidelines, and a risk definition (see box).

The **risk of a pesticide** is defined as

the probability and severity of an adverse health or environmental effect occurring as a function of a hazard and the likelihood and the extent of exposure to a pesticide

$$R = f(H \times E)$$

where **exposure** is

any contact between a living organism and one or more pesticides

and **hazard** is defined as

the inherent property of a pesticide having the potential to cause undesirable consequences (e.g. properties that can cause adverse effects or damage to health, the environment or property).[31]

An alternative description of pesticide risk might be the remark by Paracelsus, the Renaissance 'father of toxicology', that "***The dose makes the poison***". A small exposure to a highly hazardous chemical or a large exposure to a low-hazard substance may lead to similar risk.

Pesticide risk reduction can be achieved in two ways:

- *Reduction in exposure,* which may be human, animal or environmental exposure. Human exposure could be dietary, via contaminated food or water; or it could be direct exposure, such as for agricultural workers, residents, or simply bystanders. Common factors include the frequency of application, the availability and adequacy of personal protective equipment, and/or safe storage practices.

- *Reduction in hazard,* which may involve choosing a less hazardous alternative. This could be a different chemical, a different formulation of the compound, or a non-chemical approach.[32]

These concepts are key because regulation is often risk-based or hazard-based. While initially risk reduction focused on reducing exposure, use of less hazardous alternatives now plays an important role.

The early focus on reducing hazard led to the attempt to identify "Highly Hazardous Pesticides" (HHPs), according to international classification systems such as WHO or the Globally Harmonized System of Classification and Labelling of Chemicals (GHS), or according to other international agreements or convention, or under specific conditions of use. Eight criteria were established by FAO and WHO in in 2007, with the goal of phasing out substances identified as HHPs.[33, 34] **Despite follow-up efforts, there is as yet no official list of active ingredients that match the agreed criteria.**[35]

Pesticide Action Network, an international coalition of NGOs advocating for reduced pesticides use, published a 2009 document called *"PAN List of HHPs"* to provide aid in a progressive ban of HHPs. This list is based on FAO/WHO criteria, but it also enlarges the scope to classifications by other recognized authorities, such as European, American and Japanese agencies. It has been updated several times.[36]

Due to the absence of one single and international standard, some chemicals could be classified widely as HHPs but may be used in those countries where regulation is weaker.

"A small exposure to a highly hazardous chemical, or a large exposure to a low-hazard substance may lead to similar risk."

The Limits of Regulation: Unsafe at any Speed?

International Regime

Despite many false starts, some global agreements have been reached.

For example, the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer included the phase-out of ozone-depleting hazardous pesticides, including methyl bromide, and established a schedule for orderly transition to alternatives. The 1998 Rotterdam Convention and the 1989 Basel Convention[37] had established a framework for information sharing between nations on international trade of certain hazardous pesticides. The 2001 Stockholm Convention on Persistent Organic Pollutants developed the first list aimed at developing global restrictions for a set of hazardous pesticides. *Notably, the US is not a signatory.*

While widely accepted, these conventions fail to regulate many hazardous pesticides throughout their life cycle. A toxic pesticide is only regulated if it meets the narrow criteria of the Stockholm Convention or the Montreal Protocol, which frees the vast majority of hazardous pesticides from control during critical stages of their life cycle.

The consensus-based decision process allows a single country to block the listing of hazardous pesticides, such as paraquat.

As a result, there is no broad and binding international instrument concerning pesticides (the scope of the Stockholm Convention was narrow). Levels of protection therefore diverge widely by region and by country. Glyphosate, originally trade-named *Roundup®*, is a prominent example.

The Montreal Protocol was "perhaps the single most successful international agreement to date."

Kofi Annan, 2003

European Regulation

Chemical manufacturing is the fourth-largest industry in the EU, directly employing approximately 1.2 million people. The EU has several regulations in place for pesticides and other chemicals, but lacks a common set of clearly defined standards around product stewardship.

The EU adopted the *Sustainable Use of Pesticides Directive* (SUD) in 2009 to reduce the risk and impact of pesticides on human health and the environment. All so-called 'Plant Protection Products' (PPP) require dual authorization at the EU level for the active substance, as well as an authorization at Member State level. Registration is valid for a maximum of ten years, with potential renewal for up to 15 years. This allows for ongoing scientific inquiries and risk assessments, especially to answer new questions which may arise.

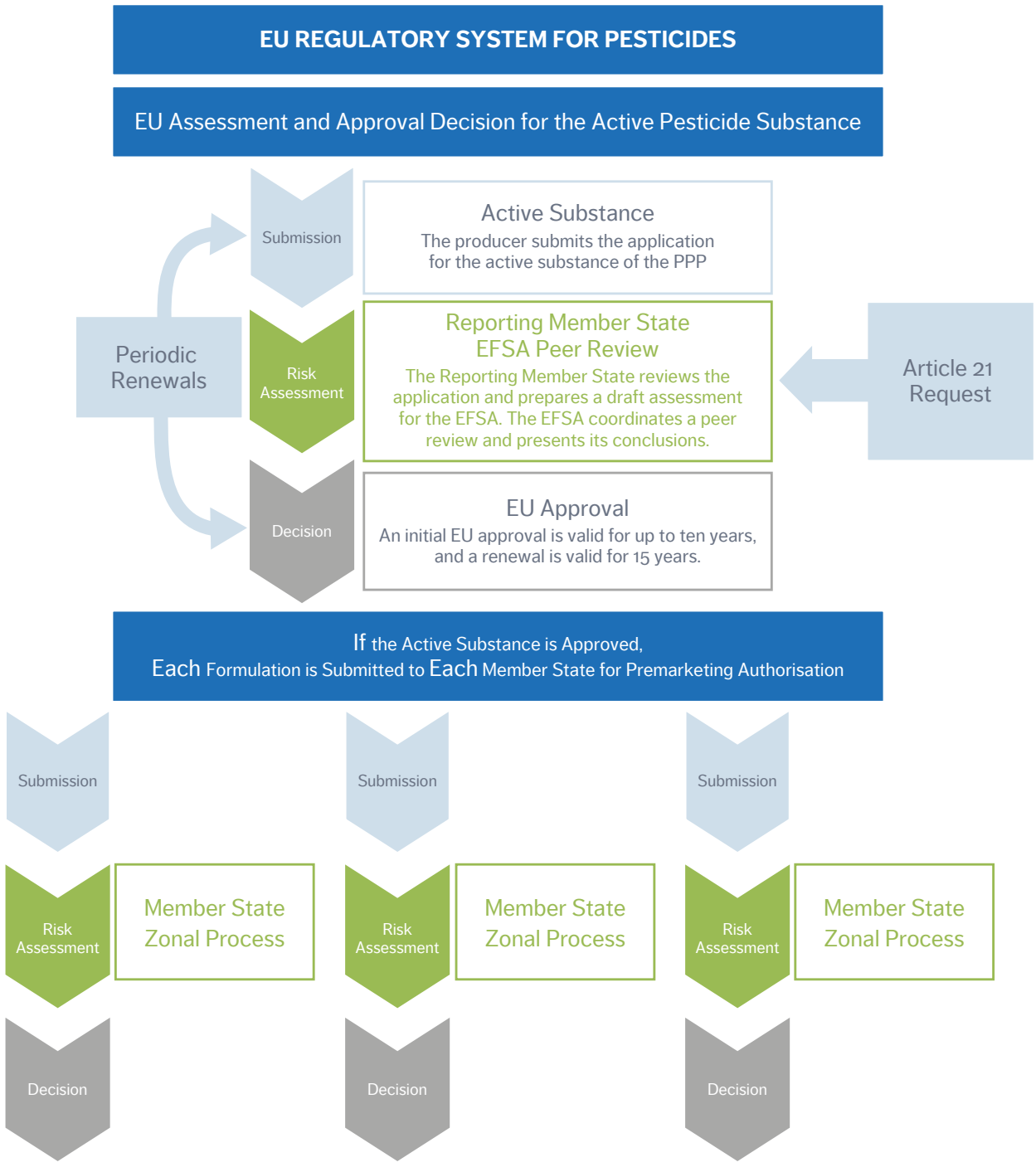
The EU has cut the number of approved active substances in pesticides by half over the last 25 years. Notably, the Commission restricted the use of three neonicotinoid pesticides in 2013, to protect bees. This was upheld by the EU Court of Justice in May 2021, after an appeal from pesticide-manufacturer Bayer. In another protective step, in 2016 the Commission asked EU Member States to limit the use of glyphosate in certain circumstances, such as near parks and playgrounds.

Yet the effectiveness of the SUD has been criticized by the EU institutions in the recent years, and it has been under revision since 2020[38] with an eye towards a 2022 update. This comes in the context of the EU Green Deal and THE Farm-to-Fork strategy, which targets a 50% reduction in the use and risk, of chemical pesticides by 2030.

The core regulatory debate is the methodology for risk assessment. For product authorization, the risk assessment includes both the hazardous potential of the chemicals and the exposure. In case of certain highly hazardous properties -- eg carcinogenic, mutagenic, toxic to reproduction, endocrine disruptive, toxic to bee colonies, and so forth -- the substance is banned regardless of level of exposure. These hazard cut-off criteria follow a precautionary principle, although in certain cases, derogations are permitted.

The EU recognizes the need to "... establish a simpler 'one substance / one assessment' process for the risk and hazard assessment of chemicals". **We are convinced regulation will become more risk-averse, creating a pronounced shift in pesticide use and patterns.**

Figure 5: European Pesticide Regulatory Pathway



Source: EFSA, Candriam.

EU Exports

Exports of chemicals present a separate and significant regulatory issue. EU rules on the export and import[39] of pesticides are designed to promote shared responsibility and cooperative efforts, and to implement the procedures of the 1998 Rotterdam Convention. This includes sharing information, *and awaiting a country's explicit agreement before exporting the product*. Nevertheless, some highly hazardous chemicals, for which use is in the EU is restricted, are permitted to be produced in the EU and exported.

A recent NGO study determined that the main European agrochemical producers[40] generated 27% of their collective revenues in high-income countries from Highly Hazardous Pesticides. For low- and middle-income countries, the proportion rose to 45% of sales. In the most important of these markets, Brazil and India, HHPs constituted 49% and 59% of sales respectively.

In a 2020 press release, the UN Human Rights Council noted that "The practice of wealthy States exporting their banned toxic chemicals to poorer nations lacking the capacity to control the risks is deplorable and must end."[41] The EU responded later that it will prevent "the export of hazardous chemicals, including pesticides, banned in the EU. The Commission is currently considering the various options for implementing this objective, including a revision of the legislation."[42]

"The practice of wealthy States exporting their banned toxic chemicals to poorer nations lacking the capacity to control the risks is deplorable and must end."

United Nations

Glyphosate and Neonicotinoids

The chemical glyphosate, and the chemical class of neonicotinoids, exemplify the issues which can arise in the absence of a clear international standard for highly hazardous pesticides (HHPs). Civil society, academics and some institutional health agencies have been vocal about their dangers. These substances are currently manufactured in large volumes worldwide, because while their sale is restricted in some countries, their export and distribution is not restricted.

Glyphosate

The active ingredient of the world's most-used herbicides, glyphosate is used to combat weeds in agriculture, horticulture and in some non-cultivated areas – for example, on railway tracks. It is typically applied on foliage. As a non-selective herbicide, glyphosate effectively kills or suppresses all types of plants, blocking a specific enzyme pathway which is necessary for their growth.

The first glyphosate-based product was registered by Monsanto in 1974 as a phytotoxic herbicide, trade-named Roundup®. It became popular worldwide in the 1990s with the development of Monsanto's genetically modified (GM) glyphosate-tolerant, or "Roundup Ready® crops" – beginning with Roundup Ready soybeans, followed by GM glyphosate-resistant maize and cotton. However, the use of glyphosate is not limited to GM crops; it is used in all areas of agriculture and weed management.[43]

Roundup® is manufactured by Bayer, which acquired Monsanto in 2018. After the expiration of the US patent in 2000, other manufacturers, such as Syngenta and Corteva Agriscience, began to produce glyphosate-based herbicides. According to the *Glyphosate Task Force*, an industry lobbying group supporting continued registration of the chemical, glyphosate is marketed by more than 40 companies. More than 300 herbicide products containing this active substance are currently registered in Europe.[44]

Is glyphosate hazardous to human health and the environment? Assessments of its carcinogenicity diverge. In 2015 the International Agency for Research on Cancer (IARC) of the WHO classified glyphosate as "probably carcinogenic to humans".[45] Conversely, the European EFSA and ECHA both concluded, based on their own safety assessment methodology, that glyphosate does not pose any carcinogenic risk for humans.[46] Based on EFSA conclusions, in 2017 the European Commission renewed the authorization of glyphosate for five years[47], although by a narrow vote.[48]

There is a lack of consensus in scientific literature. Academic studies have reported a range of adverse results in laboratory animals following exposure to glyphosate alone and to glyphosate-based products -- carcinogenic, genotoxic, reproductive, developmental, endocrinal, and other effects.[49] Many other studies reach opposite conclusions and present glyphosate as safe. The question of scientific independence emerges here -- the 'Monsanto Papers', a set of internal company documents made public in 2017, revealed that the company had interfered with past scientific assessments of glyphosate by both EFSA and EPA. Indeed, Monsanto sponsored several analyses refuting the hazards of glyphosate, and these were integrated in the documentation in support of the approval by regulators.[50]The inconsistency attracted the scientific community, and in 2016 a group of scientists published a "Statement of Concern" in the *Environmental Health Journal*, recommending that the methodology and positive conclusions of the safety assessments be reconsidered.[51]

Numerous organizations worldwide have long advocated for restricting or banning the use of glyphosate. In Europe, over 1.3 million people signed a 2017 European Citizens' Initiative petition calling for a European ban,[52] saying it was "a serious threat to human health" and that "its negative impacts on the environment and biodiversity are clearly documented."

Bayer has been subject to significant litigation in the US from claimants arguing that glyphosate was linked to cancer. In June 2020, the company agreed to settle around 125,000 then known filed and unfiled legal claims linking the herbicide to cases of cancer and seeking compensatory and punitive damages. The company agreed to pay approximately $9.6 billion, including $1.25 billion to address potential future claims, through a separate class agreement between the Monsanto subsidiary and the plaintiffs' counsel[53]. The main settlement did not include any admission of liability or wrongdoing, and allows Bayer to continue to sell the product without adding warning labels about its safety.[54] This proposal for a class settlement on potential future claims was rejected by the judge in May, 2021[55].

The current EU license for glyphosate expires in December 2022. A coalition of chemical companies called Glyphosate Renewal Group submitted its formal application in December 2019 and filed a dossier for EFSA assessment in June 2020. ECHA will also review the classification of glyphosate and contribute to the assessment[56]. EFSA is expected to adopt its conclusions around June 2022.

In the absence of a common European approach to glyphosate, some European countries, regions, and cities have taken steps to restrict or ban glyphosate, as others have worldwide[57]. In France, for example, certain glyphosate-based products were banned for non-professional use in 2019, and the use of glyphosates is being progressively restricted nationally. A group of French mayors instated complete bans in their municipalities. Germany has set phase-out objectives from 2021, with a full ban by 2024. Luxembourg became the first EU Member State to instate a country-wide ban of glyphosate, which took effect in January 2021[58].

If the EU were to deny the authorization of glyphosate after 2022, a significant number of farmers would be forced to either adopt alternative methods and products or face a dramatic decrease in yields, with either option likely to have economic consequences. Furthermore, a European ban could set an important global precedent, given that the EU approaches to pesticides tend to pave the way for the recognition or banning of highly hazardous pesticides at the international level.

“Numerous organizations worldwide have long advocated for restricting or banning the use of glyphosate.”

Neonicotinoids

Neonicotinoids, or 'neonics', are a class of insecticides which act by affecting the central nervous system of insects. Since their discovery in the late 1980s, they have been widely adopted by farmers to manage some of the most destructive insect pests and are used through seed treatment, foliar, and soil applications. The neonicotinoids, including acetamiprid, clothianidin, dinotefuran, imidacloprid, nitenpyram, nithiazine, thiacloprid and thiamethoxam, accounted for one third of the global insecticide market by 2010.[59]

Bayer (imidacloprid, clothianidin, and thiacloprid) and Syngenta (thiamethoxam)[60] are among the developers and manufacturers of these products. [61] As the pioneer of neonicotinoid research, Bayer achieved market share of up to 85% in 1996; following the new competitive products and generic manufacturers, Bayer's market share today is around 20%[62].

Neonicotinoids were initially considered much safer for humans, livestock and birds than other insecticides. over time, it has become evident that these pesticides pose various and poorly understood risks to bees and other non-target invertebrates. Seed treatments in particular originally appeared to be a more targeted and more effective method than spraying, and seemingly less harmful to the environment because this reduced spray applications in the fields. Another example of the long-tailed nature of the risks of pesticides.

“Initially, neonicotinoids were considered much safer ... than other insecticides...Nevertheless, over time, it has become evident that these pesticides pose various and poorly understood risks to bees and other non-target invertebrates.”

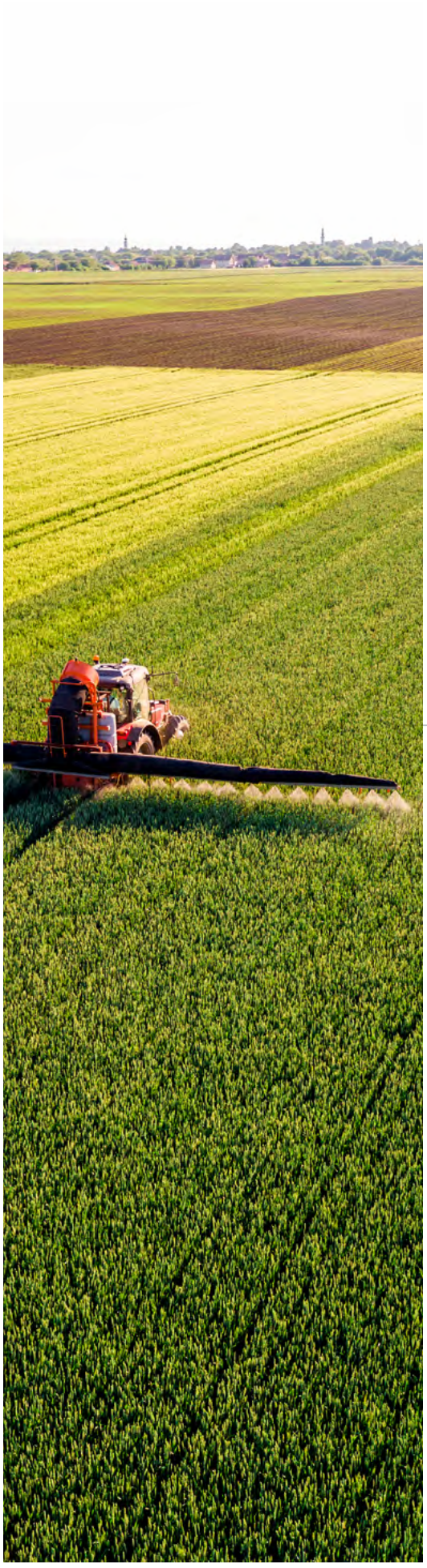
Neonics are *systemic*. In any application, they are distributed throughout the plant to all its tissues, including leaves, flowers, roots and stems, pollen and nectar. Studies show that neonicotinoid *residues accumulate* in pollen and nectar of treated plants, presenting a risk to pollinators. There is serious concern that neonicotinoids play a decisive role in pollinator declines, particularly so given their widespread use.[63] Further, neonicotinoids are *persistent* in the environment. They are powerful at low concentrations -- as little as one seed is enough to kill a songbird. Neonics can contaminate waterways and are highly toxic to aquatic organisms.[64]

In 2013 the EU prohibited the use of the neonicotinoids imidacloprid, clothianidin and thiamethoxam in outdoor bee-attractive crops, banning their use on all open-field crops completely in 2018. Use is permitted only in permanent greenhouses. The authorization for another pesticide in this class, thiacloprid, was not renewed in 2020 and is therefore now also prohibited.[65]

Why discuss neonicotinoid pesticides, if they are being phased out in the EU? Neonicotinoids are still applied worldwide, in spite of both the EU example and the increasingly solid scientific evidence of their dangers.[66] In 2019, FAO and WHO suggested there are strong grounds for classing neonicotinoid insecticides as highly hazardous.[67]

Scientists and organizations are concerned. A recent peer-reviewed study shows that US agriculture is *48 times more toxic* to insect life than before neonicotinoid insecticides were commercialized in the 1990s. Because neonicotinoids are so persistent in the environment, the same study found that they account for 92 percent of total detected insect toxicity.[68]

Organizations such as the global *Friends of the Earth* and the US-based *Beyond Pesticides* continue to press the issue of pesticide-related decline in bees and other pollinators. A recent investigation by the NGOs *Public Eye* and *Unearthed* found that the five largest agrochemical companies generate 10% of their income from exporting neonicotinoids and fipronil (also toxic to bees), their main markets being developing and emerging nations such as Brazil.[69]



Investing: Analysis, Corporate Practice and Investor Engagement

Engagement and Dialogue with Pesticide Producers

At Candriam, stewardship is central to our investment process. We dialog to learn, to share information, and to make better investment decisions. In some instances, we dialog to influence.

The five largest producers of Crop Protection Chemicals (CPCs) hold a combined market share of roughly 70%, which has held remarkably stable over the last twenty years, according to AgroInvestor and Bernstein. This means we were able to engage in one-on-one dialogues with four of these companies, and obtain detailed and specific views from a third of the market.

As is our usual approach, we solicit views and information from multiple types of stakeholders. NGOs are a valuable resource for most of our industry studies and dialogs. Biodiversity effects from a product cannot be isolated; the product becomes part of a complex system. As part of that topic, we engage in ongoing analysis of pesticides, in particular the glyphosate and neonicotinoids debates, to determine not only their risk/reward for their producers, but on other investments or topics.

We concentrated our most recent pesticide dialog on four topics which we considered the most material to the ongoing pesticides debate:

- ***Governance***
  What approach is being taken to biodiversity protection, including lobbying? How are biodiversity issues being implemented in business strategy, for example, development of safer products, or phase-out plans for chemicals of concern?

- ***Regulatory Exposure***
  What exposure do companies have to rising regulation of pesticides, and what is their assessment of their future?

- ***Product Exposure***
  What exposure do companies have to specific agrochemicals of concern, such as glyphosate or neonicotinoids?

- ***Perception***
  What are the companies' perceptions of future demand for peptides, and/or for pesticide-free agricultural products.

We have engaged with two prominent NGOs, *Public Eye* and *Friends of the Earth*, and with four agrochemicals producers accounting for roughly 40% of the pesticides market -- Bayer, BASF, FMC, and Nissan Chemical.

Observations

The pesticides market is one of the most highly-regulated sectors around the world. Regulation is typically national or regional, while the market is global. Perhaps because of these factors, the company responses presented some common patterns.

The Positives

Responsiveness

Most of the companies we contacted were open to discussion about biodiversity, their views, the agrochemicals market, and the debates and concerns surrounding pesticides. Their responses were generally timely and detailed. Responsiveness is an important benefit in controversial situations.

For example, the creation by BASF of a 'Stakeholder Advisory Council' of external experts is a positive step in constructive dialogue with stakeholders, potentially bringing important perspective to the company's Board of Directors.

Disclosure

We see increasing disclosure of the methods companies use to assess the sustainability impacts of their products. This is key for the chemicals sectors broadly, given the wide range of compounds. For example, we think FMC's 'Sustainability Assessment Tool' demonstrates that the company is trying to improve the sustainability profile of its products. FMC has stated that "There is a clear and growing demand for agricultural products that have reduced chemical pesticide residues or to a lesser extent are free of chemical pesticides".

"The pesticides market is one of the most highly-regulated sectors around the world. Regulation is typically national or regional, while the market is global."

The Concerns

Alongside the sector's increasing disclosure, important areas of concern and risks remain.

Data Tilts?

The data offered for product impact on the environment and biodiversity is asymmetrical, and tilted towards positive information. This leaves us unable to formulate a clear view about the exposures of products and companies to regulatory challenges, especially those based on the products' effects on biodiversity. We would like to see more disclosure about how these companies benchmark product hazards; we think additional transparency would reduce investment risk.

Disclosure of Active Ingredients Appearing on Regulatory or NGO Hazard Lists

We would encourage companies to clearly define which of their products that they consider to be highly hazardous, and what benchmark they used. For example, they could list any active ingredients which are contained in the PAN list of HHPs. This could be followed by a concrete policy to phase the hazardous ingredients of their portfolio, with periodic progress reports.

Multiple Risk Assessment

Company risk assessments focus on regulatory risks, and minimal information is offered regarding their own views on actual product risks. One corporate clearly stated that they could be impacted by "the proposal to introduce additional hazard categories into the classification system in Europe (CLP) and the broad application of "generic risk management" which disregards exposure and use considerations, meaning that chemical regulation in Europe could increasingly deviate from the use of risk assessment processes and risk management decisions, based on science".

Given the global context of both the products and the operations, companies recognized that they are subject to different levels of regulations and requirements by market. Following the recent EU conversations to prohibit export of banned pesticides, we would encourage companies to be more proactive, and to adopt identical standards across all geographies.

Integration of pesticides issues into ESG analysis

Candriam participates in the Initiative for Pesticide Use Reduction and Safer Chemicals Management, launched and led by Mercy Investment Services in 2019. We believe that by conducting a chemical footprint of the pesticides used in agricultural supply chains, companies can identify harmful pesticides, set reduction targets, and develop safer and more sustainable alternatives, thus mitigating risks and protecting human and environmental health.

Our pesticides Engagement has been very informative in our ESG analysis broadly, and in Candriam's investment process. For example, we engage along the full food value chain, especially food retailers. We support better product safety practices for food, including more transparency and stricter controls on pesticide residues. We particularly evaluate reputational risk, given the client-facing nature of the food business. With respect to pesticides, we therefore expect more initiative from companies in the food chain than from agrochemicals producers

Given the wide variety of chemicals substances in use, in evaluating their risks to the environment and human health, Candriam evaluates their use and impact in all phases of our ESG company analysis. In the Business Model analysis step, company activity exposure to toxic substances is assessed in two of the five key **Sustainable Challenges** analysed -- **Resource and Waste**, and **Health and Wellness**.

In our **Resource and Waste** pillar, we analyse biodiversity and pollution impacts generated through exploitation of natural resources, or by businesses releasing pollutants into the atmosphere, the soil, and the aquifer. Negative impacts are penalised in our company scoring model. This is particularly the case for agrochemicals companies whose products can be harmful to biodiversity, such as those producing neonicotinoids.

Similarly, scores making up the **Healthy Living and Wellbeing** pillar are penalized for companies whose products may increase the prevalence of disease, including through negative effects on biodiversity. Again, this includes scores of producers of some of pesticides discussed.

In the **Stakeholder Analysis** step of Candriam's proprietary ESG framework, we evaluate each company's long-term strategy with respect to its impact on and management of the environment and human. Companies manufacturing, using, or emitting toxic substances are analysed according to their capacity to manage these issues.

The impact on human health is addressed at the stage involving the analysis of product safety, when Candriam looks at the prevention or removal of serious threats to public health and safety deriving from the consumption/use or disposal of the sold product, e.g., Candriam identifies and negatively rates companies in the Chemicals sector whose revenues are derived from chemicals of concern such as pesticides.

"...companies can identify harmful pesticides, set reduction targets, and develop safer and more sustainable alternatives, thus mitigating risks and protecting human and environmental health."

Conclusion: Ever Vigilant

Candriam's formal Exclusion Policy does not directly prohibit pesticide producers or marketers. Yet, as asset managers, we see a gap between current use of pesticide products, and the potential financial, reputational, and environmental risks which could materialize.

Stakeholders clearly hold strong, and often opposing, views. Clearly some form(s) of crop protection are vital to ensure a reliable global food supply. Engaging with companies, organizations, and other stakeholders is central to our investment analysis, we are grateful for their sharing of information and views.

In our ESG investment analysis of producers and marketers of pesticides, these considerations are part of a broad set of sustainability factors capturing materiality of downside risks related to these products.

The pesticides debate goes beyond investing and crystalizes broader issues such as the relations between science and politics, and the role of society in how we perceive nature, biodiversity, and technology. Pesticides are an example of the interaction between climate change and biodiversity. As investors and citizens of the world, we would like to highlight the importance of not considering these two facets of environmental risks in isolation.

Next steps?

Following our direct engagement, we applaud the prompt responses and information supply of most of the pesticide companies we contacted. We will continue to assess agrochemical companies and be increasingly explicit. We would propose increased transparency; specifically we recommend that chemical companies disclose any substances they manufacture or market which appear on one of the multi-national 'hazardous' lists, such as the one published by the Pesticide Action Network.

And of course we will continue our collaborative engagement efforts with the Initiative for Pesticide Use Reduction and Safer Chemicals Management, and our other collaborative biodiversity efforts.

Financial metrics alone cannot predict the future profitability of companies. As sustainable asset managers, we believe that companies which embrace sustainability-related opportunities and challenges in concert with their financial opportunities and challenges are the most likely to generate long-term shareholder value.

Candriam Biodiversity Initiatives

An Abbreviated List of Biodiversity Efforts

Engagement on antibiotics overuse in livestock supply chains

Sustainable Protein Engagement

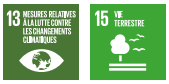
PRI-coordinated Investor Working Group on Sustainable Palm Oil

Investor Statement on Turkmen Cotton

2019-2020 Initiative for Pesticide Use Reduction and Safer Chemicals Management – Grocery Retail

Investor Statement on Deforestation and Forest Fires in the Amazon

Open Letter in support of Amazon Soy Moratorium



Investor Statement on Coronavirus Response

Investors' Policy Dialogue on Deforestation in Brazil

For a full list of Candriam's Collaborative Engagements, please see pages 21-25 of our Stewardship Report.

The pesticides debate goes beyond investing and crystalizes broader issues such as the relations between science and politics, and the role of society in how we perceive nature, biodiversity, and technology.

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