

Envisioning a chemical-safe world

**Environmental and health impacts of pesticides and fertilizers
and ways of minimizing them**

Summary for Policymakers

(Advance Draft)

DRAFT

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Table of Contents

Key findings and options for action3

1 Introduction5

2 Diverse drivers, actors and policies are shaping the use of pesticides and fertilizers6

3 Current and projected patterns of pesticide and fertilizer use are not sustainable.....12

4 Minimizing adverse impacts of pesticides and fertilizers: business-as-usual is not an option.....15

5 Ambitious collaborative action by all stakeholders is needed.....19

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Key findings and options for action

The global goal to minimize adverse impacts of chemicals and waste by 2020 has not been achieved for pesticides and fertilizers. Business-as-usual is not an option.

Key findings

1. Global demand, production and use of pesticides and fertilizers have expanded steadily during the past decades. Combined global sales continue to grow at about 4.1% per year and are projected to reach United States dollars (US\$) 309 billion by 2025.
2. Demand for crops, goods and services are fuelling the production and use of pesticides and fertilizers. Increased food demand is a main driver, but demand for crops used for feed, fibres, fuels and feedstocks is also growing. Nonetheless, only a small fraction of crops are currently certified with sustainability standards.
3. While pesticides and fertilizers provide a range of benefits, current and projected production and use patterns come at the cost of a range of adverse impacts on the environment and health throughout their life cycles. This is not sustainable.
4. Pesticides cause both acute and long-term health impacts. About 385 million cases of non-fatal unintentional pesticide poisonings have been estimated to occur every year, with approximately 11,000 deaths. There is also a significant association between occupational and residential exposure to pesticides and adverse health outcomes, including cancers and neurological, immunological and reproductive effects. Pesticide dietary risks, on the other hand, are reported to be limited.
5. Pesticides and their degraded products are ubiquitous in the environment, including soils and surface and groundwater. They are frequently detected at levels exceeding legal or environmental standards. Adverse impacts of pesticides have been observed on bees and natural enemies of pests, bird populations, aquatic organisms, and biodiversity loss.
6. Adverse impacts of fertilizers are mainly caused by their excessive and inefficient use. This leads to nutrient losses to the environment and other adverse impacts, such as drinking water contamination and eutrophication of freshwater systems and coastal zones. Some fertilizers also impact human lives as a result of unsafe storage practices and affect the food web through toxic trace elements.
7. Important knowledge gaps still exist that hamper a full understanding of some of the mechanisms and processes leading to the adverse impacts of pesticides and fertilizers, together with the effectiveness of some control measures. Yet available evidence provides sufficient justification for additional public and private actions to avoid or reduce potentially serious or irreversible adverse impacts of pesticides and fertilizers.
8. Progress has been made in strengthening management of pesticides, fertilizers and nutrients, including through international agreements. However, these efforts have not been adequate; they have not been sufficient to minimize adverse environmental and health impacts. Without a fundamental change in the course of action, these adverse impacts will increase.

9. To achieve a chemical-safe future with minimal adverse impacts from pesticides and fertilizers, both incremental and transformative actions are required that tackle root causes and shift market demand, coupled with supportive and enabling measures.
10. Stakeholders in the value chain and agri-food system need to scale up their commitment to ambitious targets and road maps, and take urgent actions to minimize the adverse impacts of pesticides and fertilizers.

Options for Priority Actions

The following ***options for priority actions*** are proposed for consideration by all stakeholders to minimize the adverse environmental and health impacts of pesticides and fertilizers:

Priority transformative actions

- Incentivize healthy and sustainable consumer choices and consumption
- Fundamentally change crop management and adopt ecosystem-based approaches
- Use economic instruments to create a level playing field for greener products and approaches
- Promote the use of direct finance to encourage sustainable agriculture
- Adopt integrated and life cycle approaches for sound pesticide and fertilizer management
- Strengthen standards and adopt corporate policies for sustainable supply chain management

Priority actions to strengthen pesticide management

- Strengthen control of pesticide distribution and use and enforcement of related legislation
- Scale up development of international pesticide evaluations
- Minimize or eliminate the risks posed by Highly Hazardous Pesticides
- Strengthen post-registration monitoring of pesticides and their effects
- Prioritize development of and access to low-risk pesticides and bioprotectants
- Address the trade in substandard, illegal and counterfeit pesticides
- Support adoption of extended product responsibility by all pesticide manufacturers and traders

Priority actions to strengthen fertilizer and nutrient management

- Enact comprehensive national policies for quality control of fertilizers
- Promote nutrient circularity
- Fill information and knowledge gaps for effective fertilizer and nutrient management
- Strengthen global policies on sustainable and safe use of fertilizers
- Scale up training of all relevant stakeholders in fertilizer and nutrient management
- Ensure that suitable and affordable fertilizers are accessible

Together we can achieve a world without adverse impacts from pesticides and fertilizers by taking ambitious and urgent action.

1 Introduction

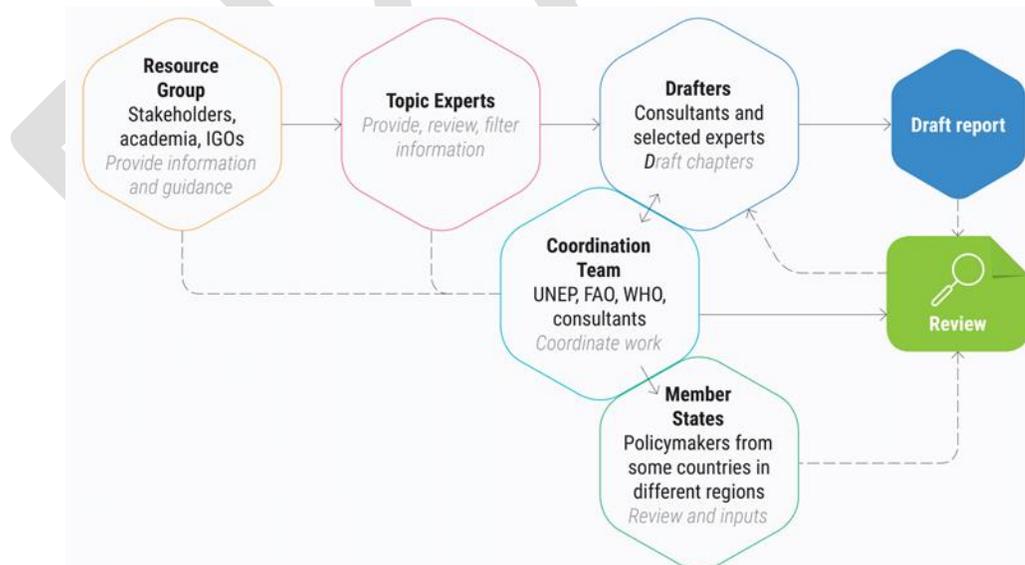
We live in a globalized world, where the needs and demands of a growing population and megatrends, (e.g. urbanization and the growing global middle class) shape the production, trade and consumption of agricultural crops and other goods and services for which pesticides and fertilizers are used in significant quantities.

Unlike most industrial chemicals, pesticides and fertilizers (both inorganic and organic) are deliberately released to the environment to provide specific functions. These releases create potential risks to the environment and health. Yet despite many published scientific studies, data gaps exist and consolidated knowledge about the adverse impacts of pesticides and fertilizers at the global level is lacking.

To help address that gap, UNEA Resolution 3/4 requested “the Executive Director to present a report on the environmental and health impacts of pesticides and fertilizers and ways of minimizing them, given the lack of data in that regard, in collaboration with the World Health Organization, the Food and Agriculture Organization of the United Nations and other relevant organizations by the fifth session of the United Nations Environment Assembly”.

This report was developed by UNEP in close consultation with FAO, WHO and a wide range of experts and stakeholders. A number of physical and online consultations were held between late 2018 and mid-2020 with policymakers from countries in different regions, experts on fertilizers and pesticides including the FAO/WHO Joint Meeting on Pesticide Management, and specialists from intergovernmental and non-governmental organizations and the private sector.

Figure 1: Report development structure



The Summary for Policymakers presents the main findings of the report in a concise form, together with options for action to facilitate global policy considerations in the UNEA process. The main report is a comprehensive publication which is made available on the UNEP website.

2 Diverse drivers, actors and policies are shaping the use of pesticides and fertilizers

2.1 Major trends are driving demand for pesticides and fertilizers

The world population is growing and dietary habits are changing

The world population is expected to grow from about 7.8 billion in 2020 to 9.8 billion by 2050. Global income is increasing, and the global middle class is expanding. With increasing wealth, per capita consumption of meat, refined fats, refined sugars, alcohols and oils is also increasing along with demand for consumer products that depend on agriculture (e.g. certain textiles). Pesticides and fertilizers are therefore being used in significant quantities to provide a wide range of goods and services. [1]¹

Demand for food, feed, fibres, fuels and feedstocks is growing

By 2050 demand for food is projected to grow by 60 per cent, meat production by nearly 70 per cent, aquaculture production by 90 per cent and production of dairy products by 55 per cent. Furthermore, cropland is increasingly used for purposes such as production of livestock feed, fibres, biofuels, and feedstocks for the chemical industry. [1]

Intensification of the agri-food production system continues

Increased demand for crops has led to intensification of agricultural production, which is partly achieved by greater use of pesticides and fertilizers. For example, between 2002 and 2018 the global population increased by about 21 per cent and cereal production by about 44 per cent, while pesticide use per hectare of cropland increased by about 30 per cent and total inorganic fertilizer use by about 33 per cent. [1, 2.4, 7.2, 7.4] Similarly, livestock intensification has been achieved through the use of concentrated feeds, pharmaceuticals and vaccines.

Pesticides and fertilizers provide many benefits

The benefits of pesticides include reduced crop loss, lower prevalence of human vector-borne diseases, longer shelf life of agricultural commodities, higher livestock yields, reduced soil disturbance and better protection of wooden structures. Fertilizers contribute to increased crop yields, are used to improve the quality of food and feed, and reduce the amount of cropland required. [6.2, 7.4, 10.3]

The global market for pesticides and fertilizers is expanding

The pesticides and fertilizers market is expanding steadily. By 2016 about 4.1 million tons² of pesticide active ingredients were used globally, twice the volume applied in 1990. The total value of the pesticides market was estimated at about US\$ 65 billion in 2018. This market is forecast to reach about US\$ 71 billion by 2025, having increased at a compound annual growth rate (CAGR) of 3.7 per cent between 2020 and 2025. [2.4]

About 190 million tons of inorganic fertilizers were used in agriculture in 2018, with demand expected to reach 200 million tons by 2022. The global sales revenue for inorganic fertilizers was about US\$ 151 billion in 2018. The market is projected to grow at a CAGR of 3.8 per cent in the period 2020-2025. While

¹ Numbers in square brackets refer to chapters or sections of chapters in the main report.

² In this report ton indicates a metric ton.

substantial amounts of organic fertilizers are applied, their volumes and monetary value are undocumented. [7.3]

Trade in agricultural commodities is changing

Increasing demand for agricultural products, including from middle income countries, is shaping trade patterns for crops and crop-based goods and, consequently, pesticide and fertilizer use in exporting countries. Since the beginning of the millennium, trade in agricultural products has more than tripled to reach US\$ 1.33 trillion. The geography of global food trade flows has shifted, primarily towards South-South trade, which currently accounts for roughly one-quarter of total agricultural trade flows. [1]

Growing concerns about environmental and health impacts have led to stricter regulations

Public concerns about the impacts of chemicals on the environment and health (along with progress in obtaining scientific insights into chemical risks) have led to stricter legislation and regulations governing the authorization and use of pesticides and fertilizers. Such legislation and regulations have been adopted in high income, but also in low and middle income countries. However, there is still a lack of fertilizer legislation and regulations in many low and middle income countries. [3.2, 3.3, 3.4, 8.5]

Sustainable agriculture is on the rise, but covers only a small share of cultivated land

While use of voluntary sustainability standards in the agriculture sector continues to grow, it is estimated that only about 1 per cent of total agricultural cropland has been certified. Crops that tend to be certified at a relatively high rate include major commodities such as coffee, cocoa, tea and palm oil. Staple foods such as maize, rice and wheat are rarely certified. [2.7]

Pesticides and fertilizers are addressed in major global agreements and policies

The adverse impacts of pesticides and fertilizers are addressed directly or indirectly by global agreements and policies whose purpose is to protect human health and the environment. These include: [3.2, 8.2]

- the United Nations Framework Convention on Climate Change
- the Convention on Biological Diversity
- the United Nations Convention to Combat Desertification
- the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade
- the Stockholm Convention on Persistent Organic Pollutants
- the Strategic Approach to International Chemicals Management (SAICM)
- the United Nations Decade of Action on Nutrition, 2016-2025
- the Rome Declaration on Nutrition

Other international policy drivers can also help advance pesticide and fertilizer management objectives. They include initiatives and policies to advance resource efficiency, a circular economy, and sustainable production and consumption. [3.2, 8.3]

Direct and local drivers also affect pesticide and fertilizer use

Beyond broader trends and policies, more direct drivers can influence the use of pesticides and fertilizers either positively or negatively. They may be agronomic, economic, regulatory, or influenced by environmental, public health or information considerations.

Direct drivers that tend to increase pesticide use include agricultural intensification, pesticide resistance, genetically modified crops (mainly for herbicide tolerance), marketing practices, and commodity prices. Drivers that tend to reduce their use include integrated pest management and crop rotation. [2.7]

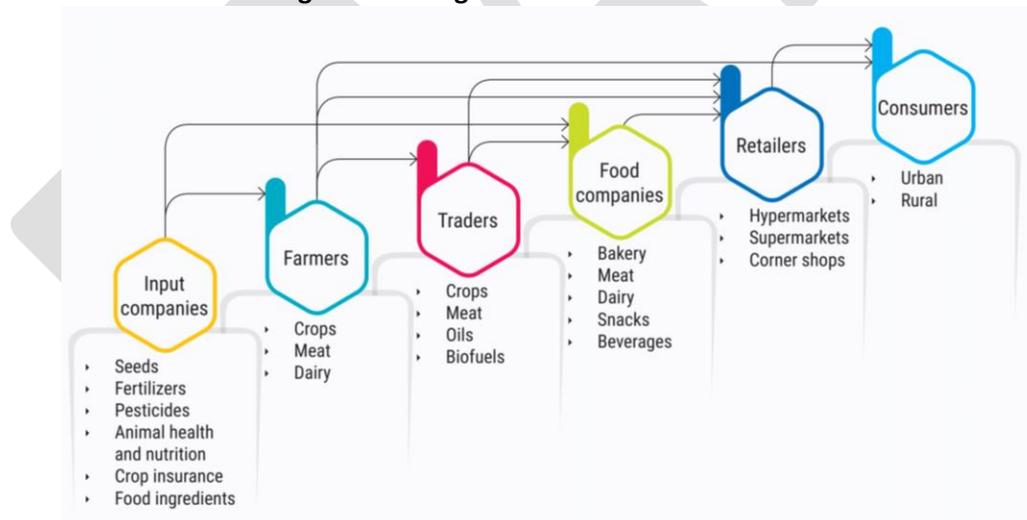
Direct drivers that tend to increase the use of fertilizers include fertilizer subsidies, marketing strategies, credit and markets for produce, and use of information and communication technology. Factors that tend to reduce fertilizer use include policies, practices and technologies that improve nutrient use efficiency, dietary choices, and efforts to reduce food loss. [7.4]

2.2 Key actors in the value chain affecting pesticides and fertilizer use

Diverse actors affect the demand and impact of pesticides and fertilizers

The production and use of pesticides and fertilizers are shaped by diverse actors in the value chain of the global agri-food system and other, non-agricultural value chains. Key actors include consumers, farmers, the pesticide and fertilizer industries, and other corporate actors such as retailers, food companies and textile companies. [1]

Figure 2: The agriculture and food value chain



A small number of corporations control important segments of the global agri-food market. For example, four (conglomerates of) companies currently represent about 60 per cent of the global pesticide market. The same companies also often have important activities in the areas of seeds and biotech crops, leading to a concentration of research, development and marketing capacities with respect to agricultural inputs. [2.5]

Large and small farms face challenges that require distinct solutions

Of the 570 million farms in the world, 84 per cent are smaller than 2 hectares. In most low and lower-middle income countries farm sizes have decreased during the last 40 years, while they have increased in high income countries. About 1 per cent of farms operate 70 per cent of the world's farmland, creating concerns that inequality is growing because agricultural production is increasingly dominated by a few major companies. Access to agrochemicals (including pesticides and fertilizers), as well as knowledge about their proper use, are determined to a large extent by income and geographic location, as is access to relevant technologies. [2.7, 7.3, 7.4]

The ways pesticides and fertilizers are used, and therefore affect human health and the environment, greatly differ between smallholder and industrialized agriculture. Due to continued divergence in farm sizes and wealth status (which is particularly prevalent in low and lower-middle income countries), risk reduction measures need to take into account the specific situations and conditions of smallholder and industrial scale farming.

Pesticide use efficiency has not improved

While global pesticide use has steadily increased during the past decades, both in total volumes and the amounts applied per hectare of cropland, pesticide use per unit crop output has remained unchanged. This indicates that pesticide use efficiency has not improved at the global level even though modern pesticides are more biologically active per gram of active ingredient applied [2.4]

Illegal trade in pesticides is of increasing concern

The growth of the global pesticide market has been accompanied by an important rise in the trade of illegal pesticides. These include banned or otherwise non-authorized pesticides as well as counterfeit, fake or illegally labelled or packaged products. Such pesticides can damage crops, harm human health and contaminate the environment. [2.5]

The market for bioprotectants is expanding

Bioprotectants, also referred to as biological pest control agents, are products that originate from nature. Most bioprotectants are formulated as biopesticides, whose global market is projected to grow significantly. The rate of introduction of new biopesticides has often exceeded that of new conventional pesticides. This trend is likely to continue. [2.4]

Most pesticides are used in agriculture, but other uses are also relevant

The majority of pesticides are used in agriculture. Non-crop uses, such as disease vector control, domestic uses, and amenity and industrial applications, represent only about 10-15 per cent of the global market by value. While such uses represent a small share of the total market, their environmental and health effects are of concern since the pesticides involved are often used by untrained non-professionals including homeowners. [2.4]

Fertilizer use varies in different contexts

The use of inorganic fertilizer and of animal manure has steadily increased, in terms of both the amounts applied per hectare and the total amounts used. Use of fertilizers in crop production tends to be excessive

in some countries. Asia is the largest consumer of inorganic fertilizer, while Africa consumes the least. [7.3]

Significant amounts of nutrients are lost to the environment

Nutrient use efficiencies are less than 40-65 per cent for nitrogen, 15-25 per cent for phosphorus and 30-50 per cent for potassium in the first year of application. In addition to potential environmental and health impacts resulting from these losses, lost nutrients are worth money to farmers. During the past decades nitrogen use efficiency has improved in some countries, but it has declined in others. [7.4]

Pesticides and fertilizers are often not used as intended

In many regions of the world fertilizers and pesticides are not used according to good agricultural practices. Among other factors, this may be due to lack of good practices that are applicable to specific local cropping situations; limited availability and affordability of appropriate agrochemicals or application equipment; inadequate training and information for farmers. In the case of pesticides, poor availability and lack of affordability of appropriate personal protective equipment is another constraint. [2.7, 7.4]

2.3 Policy instruments and initiatives for pesticide and fertilizer management

Global instruments and agreements

During the past decades the international community has put in place a range of legally binding and non-binding policy instruments and initiatives for the management of pesticides and fertilizers. Legally binding instruments include the Stockholm Convention, the Rotterdam Convention and the Basel Convention. Examples of voluntary instruments include the International Code of Conduct on Pesticide Management, the International Code of Conduct for the Sustainable Use and Management of Fertilizers, SAICM and the Codex Alimentarius.

These international instruments have played an important role in reducing some adverse environmental and health impacts within their defined scope. Yet the conventions cover a limited number of chemicals, while effective implementation of codes presents challenges with respect to addressing all important aspects of managing pesticides and fertilizers and minimizing their adverse environmental and health impacts. [3.2, 8.2]

National and regional policy frameworks relevant for pesticides and fertilizers

Both national and regional legislation, policies and collaborative platforms are crucial for effective pesticide and fertilizer use and management. National pesticide legislation and policies exist in most countries in the world, while fertilizer legislation is less well developed, particularly in low and middle income countries. Increasingly, regional collaboration among countries supports sound management of pesticides, while regional fertilizer use and nutrient management appear to be driven more by non-governmental stakeholders such as scientific bodies. [3.3, 3.4, 8.4, 8.5]

Implementing the 2030 Agenda for Sustainable Development

The 2030 Sustainable Development Agenda emphasizes that development should be compatible with all three dimensions of sustainability: economic, social and environmental. Implementing the 2030 Agenda

presents an opportunity for collaborative action by many diverse actors, and at all levels, in order to minimize the adverse environmental and health impacts of pesticides and fertilizers. [1]

Table 1: The interface of the 2030 Agenda and sustainable management of pesticides and fertilizers

Symbol	Pesticides and fertilizer linkages
	<ul style="list-style-type: none"> Increased need for efficient, profitable and sustainable use of pesticides and nutrients
	<ul style="list-style-type: none"> Increased need for effective pest and nutrient management Need to increase quality and sustainable use of fertilizers and pesticides in certain parts of the world Wider adoption of sustainable agricultural production practices
	<ul style="list-style-type: none"> Further reduction of death and illness, mainly from pesticides but also from fertilizers Ensure access to safer and nutritious food, protecting consumers' health
	<ul style="list-style-type: none"> Minimization of water pollution from fertilizers and pesticides
	<ul style="list-style-type: none"> Reduction of occupational risks of handling and using pesticides and fertilizers
	<ul style="list-style-type: none"> Development of innovative and sustainable nutrient and pest management approaches and technologies
	<ul style="list-style-type: none"> Wider adoption of sustainable pest and nutrient management practices Minimization of impacts of pesticides and fertilizers on natural resources Further strengthening of sound management of the entire life cycle of pesticides and fertilizers Further support for and implementation of sustainable pest and nutrient management technologies by the pesticide and fertilizer industries Improvement of information provision about the risks of pesticides and fertilizers and ways to minimize these risks
	<ul style="list-style-type: none"> Minimization of greenhouse gas emissions associated with fertilizer use Wider adoption of integrated practices in agriculture that enhance farmers' sustainable productivity as well as climate resilience

	<ul style="list-style-type: none"> • Minimization of pollution of marine environments by nutrients and pollutants in fertilizers
	<ul style="list-style-type: none"> • Minimization of environmental impacts of pesticide and fertilizer use • Ensuring sustainable control of invasive pest species • Mainstreaming ecosystem and biodiversity values in national and regional nutrient and pest management policies
	<ul style="list-style-type: none"> • Improvement of sharing of pesticide and nutrient management knowledge among relevant stakeholders • Enhancing partnering among UN organizations active in sound management of chemicals

3 Current and projected patterns of pesticide and fertilizer use are not sustainable

Despite a suite of international agreements and management schemes put in place to minimize the adverse impacts of pesticides and fertilizers, their effective implementation is lacking, particularly in low and middle income countries where there are prevailing capacity gaps. The benefits of pesticides and fertilizers therefore come at the expense of adverse impacts not only on the environment and health, but also on agricultural sustainability. In light of these impacts, current and projected patterns of global pesticide and fertilizer use are clearly not sustainable.

3.1 Adverse environmental and human health impacts of pesticides

Pesticide residues are ubiquitous in the environment

Pesticide residues have been detected in a wide range of environmental media, including surface and groundwater, soils and air. They are even found in remote areas such as the Arctic. The detected pesticides include legacy pesticides (e.g. organochlorines), which may not have been authorized for decades in many countries, and current use pesticides. [4.4]

Pesticides continue to cause a range of human health impacts

Adverse effects of pesticides on human health include acute and long-term impacts. According to the reviews cited in this report, about 385 million cases of non-fatal unintentional pesticide poisoning and approximately 11,000 fatalities have occurred every year. Furthermore, 1 to 2 million cases of self-poisoning have occurred annually, resulting in about 168,000 deaths. There is also evidence of significant associations between occupational or residential exposure to specific groups of pesticides (or to pesticides in general) and various adverse health outcomes including cancers and neurological, immunological and reproductive effects. Exposure to pesticides during pregnancy and/or childhood has been associated with leukemia in children. Most of the information currently available on pesticide residues in food, on the other hand, appears to indicate that pesticide dietary risks are low. [4.3]

Pesticides adversely affect non-target organisms

The use of pesticides has been associated with adverse impacts on populations of non-target organisms. Direct effects of (mainly) insecticides have been linked to population reductions of terrestrial insects and aquatic arthropods. Insecticides have also been found to adversely affect pollination and natural pest

control, both of which are important ecosystem services. In some countries the direct effects of pesticides on terrestrial vertebrates appear to have declined over time. Despite limitations in research, it can be concluded that whenever large-scale studies or reviews are available the majority show that pesticide use has adverse effects on biodiversity. [4.4]

Growing pesticide resistance jeopardizes the sustainability of agricultural production

Resistance to pesticides in insects, pathogens and weeds, as well to genetically modified insect-resistant crops, continues to increase despite efforts to put resistance management approaches in place around the world. This development has complicated pest and vector management and resulted in higher costs. Pesticides with new modes of action which can break resistance are being developed at a slow pace. Consequently, reductions in crop yields or loss of quality are occurring. [2.7]

Regulatory control can make a difference

There are many examples of adverse impacts having been reduced through regulatory action addressing pesticides or fertilizers. For example, in countries with strict regulations concentrations of organochlorine pesticides in the environment are decreasing and acute environmental and health effects caused by highly toxic organophosphate and carbamate pesticides have declined. [4]

3.2 Adverse environmental and health impacts of fertilizers

Overfertilization and low nutrient use efficiencies affect ecosystem health

Excess nitrogen and phosphorus contribute to the eutrophication of freshwater systems and coastal areas by encouraging growth of harmful algae blooms and the subsequent formation of dead zones (hypoxia) in many parts of the world. Excess nutrients also cause other types of pollution of surface and groundwater, soil and air. [9]

Fertilizer use contributes to climate change

Fertilizers are associated with greenhouse gas (GHG) emissions to the atmosphere during their production, transport and use. The use of inorganic fertilizers, and manure storage and use, contribute almost 40 per cent of agricultural GHG emissions. [9.3] Better nitrogen management is one of the most effective GHG reduction strategies that farmers can adopt. On the positive side, agricultural intensification has been associated with a reduction of loss of forests which serve as carbon sinks. [10.3]

Human health impacts during certain stages of the fertilizer life cycle may be severe

Direct human health impacts of fertilizers may occur through, for example, inhalation of ammonia and dusts from manure. Storage and transport accidents are rare, but may cause significant loss of human life, as in Tianjin, China in 2015 when 173 people were killed or in Beirut, Lebanon in 2020 when 220 lives were lost. [9.2, 10.2]

Contaminants in fertilizers may have adverse health impacts and enter the food web

Studies have associated nitrates in drinking water with adverse health impacts. Other contaminants in fertilizers (e.g. heavy metals) affect soil quality and may enter the food web through uptake by plants and

ingestion of contaminated food or feed. Toxic trace elements found in fertilizers include mercury, cadmium, arsenic and lead. [9.2]

The planetary boundary for nitrogen and phosphorus flows has been crossed

One of the nine planetary boundaries is biogeochemical flows (that is, flows of nitrogen and phosphorus to the biosphere and the oceans). Disruption of the nitrogen and phosphorus cycles through agricultural production, particularly fertilizer use, has been identified as a major driver for the exceedance of this planetary boundary. [10.2]

3.3 Policies and management systems are not effective enough in minimizing adverse impacts

Risk assessment has improved, but gaps remain

Methods for assessing risks to the environment and health have improved in past decades, as has use of these methods. However, evaluation of some pesticide risks requires further scientific inputs, including the environmental and health risks of pesticide mixtures and endocrine disruptors; human health effects of pesticides during child development; and environmental risks of pesticides in (sub-)tropical and (semi-)arid environments. In the case of fertilizers, risk assessment approaches exist (e.g. evaluation in fertilizer regulation of the environmental risks of contaminants) but their application is not widespread. [4.5, 8.5]

Adverse impacts occur even in the case of authorized pesticides

Of all chemicals, the risks of pesticides are probably among the best evaluated before they are put on the market. Despite the risk assessment and management procedures in place, however, adverse environmental and health impacts occur even in the case of authorized uses. [4.3, 4.4]

Market prices rarely reflect full costs and externalities

Food has become more affordable due to efficiency gains achieved through the fragmentation of production chains, international trade, subsidies, and a range of other factors. At the same time, adverse environmental and health costs are usually not included in food prices. While adequate data for comprehensive cost-benefit analyses are lacking with respect to most pesticide and fertilizer uses, it is estimated that externalities associated with environmental and health effects could be very high, which in some cases might render farming unprofitable. Such costs are currently borne by society as a whole. [6.2, 10.2, 10.3]

Adoption of risk reduction approaches for nutrient and pest management is slow

A number of risk reduction approaches exist, such as integrated pest management (IPM) and integrated nutrient management (INM). However, their rate of adoption has generally been slow. For some of these approaches to be implemented effectively, it is not sufficient to equip farmers with relevant knowledge. The significant financial investments required, together with the large amount and complexity of the data used, make adopting these approaches more feasible for large farmers than for smallholders. [2.7, 7.4]

Identifying specific causes of adverse impacts is challenging

The continued existence of adverse impacts, particularly those due to the use patterns of pesticides, raise questions about the factors that contribute to this situation. For example, current risk assessment

procedures and policies may not provide adequate protection (at least not in certain parts of the world); pesticides and fertilizers may not be used as recommended or authorized; good agricultural practices may not be observed; or risk assessments and policies may be hampered by knowledge gaps. It may also be the case that certain pesticides with known unacceptable risks are still authorized for use, and marketed, for economic or other reasons.

Filling global knowledge gaps

While significant knowledge has been generated about various aspects of pesticide and fertilizer use and impacts, significant knowledge gaps remain. Topics that require further research and data collection include the following:

- Pesticide and fertilizer use statistics for different crops and use situations, especially in low and middle income countries
- Identification of environmental and health impacts of actual use, based on common indicators
- Estimation of the costs and benefits of pesticide and fertilizer use and impacts, including externalities
- Decision support tools for crop production that can help establish a balance between economic and environmental sustainability
- Quantified exposure estimates to assess acute and chronic human health risks under conditions of use in different contexts (e.g. in low income countries)
- Effects of pesticide and fertilizer use on ecosystem health, especially in tropical and hot semi-arid (agro-)ecosystems
- Independent systematic scientific reviews of critical topics relevant to advancing environmental and health risk assessments for pesticides and fertilizers

At the same time, while significant gaps remain, a wealth of scientific knowledge exists which is not widely disseminated or used. Efforts should be strengthened to turn this scientific knowledge into user-friendly knowledge products for different user groups and to inform decision-making.

4 Minimizing adverse impacts of pesticides and fertilizers: business-as-usual is not an option

Adverse impacts of pesticides and fertilizers will increase without fundamental changes

Given the projected growth of markets for pesticides and fertilizers, coupled with prevailing deficiencies in current management systems, adverse impacts of pesticides and fertilizers and inefficient nutrient use will increase in the coming years unless a fundamental change in the course of action takes place. [1]

Both incremental and transformative action is essential

Stakeholders participating in the intersessional process on SAICM and chemicals and waste management beyond 2020 selected the vision of “United for a Chemical-safe Future” as the theme of the 2021 International Conference on Chemicals Management (ICCM5). To achieve a chemical-safe world in regard to pesticides and fertilizers, both incremental and transformative action will be needed, coupled with

supporting measures to ensure that a transition is fair and leaves no one behind. Joint commitment by all stakeholders is required to help achieve a sustainability scenario for pesticides and fertilizers, in contrast to a business-as-usual scenario that perpetuates the unsustainable status quo. [1]

4.1 Fostering transformative changes

Incentivize healthy and sustainable consumer choices and consumption

Consumer choices play a crucial role in fostering a sustainable food system and value chain. Governments may support this transformation by enacting policies that promote greater dietary reliance on sustainably produced grains, fruits, vegetables and dairy products, as well as mandatory use of certification systems and labels which address sustainability considerations throughout the value chain by creating full product transparency. These measures may be complemented by innovative communication campaigns and technologies (e.g. mobile phone apps) that synthesize complex information to allow consumers to make informed choices. [12]

Fundamentally change crop management and adopt ecosystem-based approaches

Shifting from a traditional linear to a more holistic approach to address pest pressure and soil fertility issues in agricultural production is essential. This approach uses environmental knowledge and takes into consideration other plant management factors (e.g. germplasm, water) that influence productivity. Examples of concepts that have been proven effective include integrated pest and vector management, biocontrol, rotation of non-legumes with legumes, and combining cropping with livestock systems. While these concepts exist and have proven effective, their implementation needs to be scaled up.

Providing knowledge and sharing it widely will expand the solution base for farmers and allow adoption of environmentally friendly and sustainable production systems. These fundamental shifts in agricultural production cannot be achieved without the active support by the private sector, while governments will need to create enabling environments and establish boundaries with respect to practices that will be considered undesirable in the future. [12]

Promote nutrient circularity

A large amount of the fertilizer nutrients used in agriculture are not recycled, creating opportunities to advance circularity through collaborations and partnerships of relevant stakeholders. For example, manure recycling is often hampered by spatial separation of livestock and crop production. Taking advantage of synergies between the two systems can make nutrient use more sustainable. [12]

Use economic instruments to create a level playing field for greener products and approaches

The environmental and health costs associated with agricultural production are often not reflected in input and output pricing. Opportunities exist to progressively internalize the hidden costs of pesticide and fertilizer use in order to level the economic playing field for greener/lower-risk products and approaches. This goal may be achieved through the use of taxes or charges or the elimination of certain subsidies. [12]

Promote the use of direct finance to encourage sustainable agriculture

Providing financial support to encourage adoption of technologies and practices that improve the use efficiencies of pesticides and fertilizers can help achieve a shift to more sustainable agriculture. Funds may

be mobilized, for example, through taxes that penalize polluters and reward non-polluters. Where subsidies are used to increase access to fertilizers (e.g. in some low and middle income countries), support for technologies that increase fertilizer efficiency may be more effective. A careful balance is needed between input and technology subsidies, taking regional conditions into consideration. [12]

Adopt integrated and life cycle approaches for sound pesticide and fertilizer management

The current practice of regulating individual pesticides and fertilizers could be transformed by promoting broader sustainable pest and nutrient management solutions. Alternative pest and nutrient management options should be evaluated as part of the decision-making process, together with evaluation of the economic and environmental impacts of these alternatives. Evidence-based and interdisciplinary decision-making should drive pest and nutrient management choices, while explicitly taking into account uncertainties and knowledge gaps in a precautionary manner. [12]

Strengthen standards and adopt corporate policies for sustainable supply chain management

Advancing sustainability standards and sustainable supply chain policies by corporate actors in the value chain (e.g. retailers, food companies, textile companies) can be an important driver for sustainable transformation of “upstream” agricultural practices. Including targets for sourcing organically certified products, and taking a life cycle approach, can enhance the effectiveness of such measures. [12]

4.2 Options to strengthen pesticide management systems

Strengthen control of pesticide distribution and use and enforcement of related legislation

While most countries have pesticide legislation in place, its enforcement is weak, particularly in (but not limited to) low and middle income countries. As a result, hazardous practices are allowed along the entire life cycle of a pesticide. This situation maintains an unequal playing field between those who abide by the law and those who do not. The legal and institutional basis of pesticide legislation, as well as resources for control and enforcement, therefore need to be strengthened in many countries. [6]

Scale up development of international pesticide evaluations

Evaluating the environmental and health risks of pesticides requires considerable resources. These resources are scarce, particularly in low and middle income countries. At the same time, many assessments are applicable beyond national borders. To optimize use of scarce resources, and avoid duplication of work, scientific assessments can be further globalized (e.g. those of hazards and health risks) or regionalized (e.g. those of efficacy and environmental risks). [6]

Strengthen post-registration monitoring of pesticides and their effects

Post-registration monitoring should be an essential element of pesticide regulation and management. However, such monitoring of possible adverse effects on human health and non-target organisms is weak or lacking in most countries. There is an urgent need to establish or strengthen post-registration monitoring of pesticides and their effects and to ensure effective feedback into the regulatory process. [6]

Prioritize development of and access to low-risk pesticides and bioprotectants

Both governments and the private sector can actively prioritize and facilitate the development and registration low-risk chemical pesticides and bioprotectants. Options include financial support for innovative private and public research and development, establishment of fast-track procedures for evaluation and registration, strengthening of extension and other types of information provision, and fiscal measures that reduce costs to farmers. [6]

Address the trade in substandard, illegal and counterfeit pesticides

Substandard, illegal and counterfeit pesticides jeopardize pest control, affect yields, and increase risks to the environment and health. Since their use undermines efforts to promote more sustainable and lower-risk products, it is essential to boost capacity for pesticide quality control, particularly in low and middle income countries. Given the highly international character of trade in illegal and counterfeit pesticides, increased regional and international collaboration among enforcement authorities is required to combat these practices effectively. [6]

Support adoption of extended product responsibility by all pesticide manufacturers and traders

While certain product stewardship activities are carried out by a few, mainly research-based pesticide companies, this is much less the case for firms producing generic pesticides and local or regional pesticide traders. Minimum extended producer responsibility requirements for pesticide trade can be defined internationally, based on the International Code of Conduct on Pesticide Management. Such requirements could then be progressively incorporated into national pesticide legislation to ensure that all actors in pesticide trade undertake essential stewardship of their products. [6]

4.3 Options to strengthen nutrient management

Enact comprehensive national policies for quality control of fertilizers

There are shortcomings in fertilizer quality control in many countries. National policies may have gaps. For example, they may not systematically include organic fertilizers, cover all elements of the fertilizer life cycle, or have provisions to minimize environmental impacts. Policies do not exist in some countries (nor do national monitoring programmes) concerning pollutants that potentially come from fertilizers, food, feed and drinking water. On the other hand, some countries or regions are doing fairly well in this area. Harmonizing policies at regional levels could lower the costs of implementing these policies. [11]

Fill information and knowledge gaps for effective fertilizer and nutrient management

There are large information gaps with respect to fertilizer use. Even in the case of some of the data currently available there are concerns about reliability and about the comparability of data from different studies. Efforts are ongoing in some countries to make data freely available to the public. Strengthening partnerships between research programmes at national, regional and international levels can help exploit synergies among programmes. [11]

Strengthen global policies on sustainable and safe use of fertilizers

Partnerships that encourage information sharing between scientists and global policymakers contributes to filling information gaps at the global level. Examples of such partnerships include the

Intergovernmental Technical Panel on Soils and the Intergovernmental Panel on Climate Change, which provide scientific and technical advice and guidance at the global level. Participation by scientists in such partnerships improves chances that the global policies, decisions and suggestions emanating from them will be implemented. [11]

Scale up training of all relevant stakeholders in fertilizer and nutrient management

There is need to scale up regular training of knowledge disseminators to equip them with up-to-date information (e.g. on new technologies), which they can then transmit to farmers. Development of a joint platform comprising knowledge generators, knowledge disseminators and other relevant stakeholders could help ensure that messages are harmonized. [11]

Ensure that suitable and affordable fertilizers are accessible

Use of fertilizer in some low and middle income countries is low. It is particularly minimal (50 kg/hectare/year) in sub-Saharan Africa, where yields are low and many people do not have access to sufficient and nutritious food. A major reason for lack of access to affordable fertilizer is that fertilizer prices there are higher than in other regions. Provision of affordable fertilizer in all world regions should be accompanied by controls (e.g. on quality and the use of suitable practices and technologies to minimize adverse impacts). [11]

5 Ambitious collaborative action by all stakeholders is needed

The findings of this report point to the need for more ambitious collaborative action by all stakeholders. Putting such collaboration into practice throughout the global agri-food system is essential in order to create needed transformative market shifts that will advance the sustainability of agricultural production, products and services and minimize adverse environmental and health impacts of pesticides and fertilizers.

The public sector has an important role to play not only in regulating pesticides and fertilizers, but also in putting in place enabling policies and actions to foster the required transformation. Relevant measures include phasing out pesticides that pose high risks; supporting green and sustainable chemistry research; promoting sustainable agriculture, integrated pest and vector management and agro-ecologically based approaches; raising awareness of the full cost of unsustainable practices; and providing fiscal incentives to foster market transformation.

Clear vision, ambitious targets, and road maps or action plans developed by specific actor groups (e.g. producers, corporations, research institutions, the public sector), supported by political will and international instruments, can create momentum for results-based action. They may also be developed on specific topics or themes, such as minimizing the adverse impacts of Highly Hazardous Pesticides in a particular context or reducing pesticide and fertilizer run-off in a single watershed.

Together we can achieve a world without adverse impacts from pesticides and fertilizers by taking ambitious and urgent action.